MARROW ED8

Anaesthesia

Comprehensive Question Bank

Contents

History and Ethical Aspects of Anaesthesia

Question 1:

On a historical day, performing surgeries without the torture of pain was demonstrated successfully for the first time at Massachusetts General Hospital, the home of Harvard Medical School. This is celebrated as the 'World Anesthesia Day' every year on which day?

a) December 1st

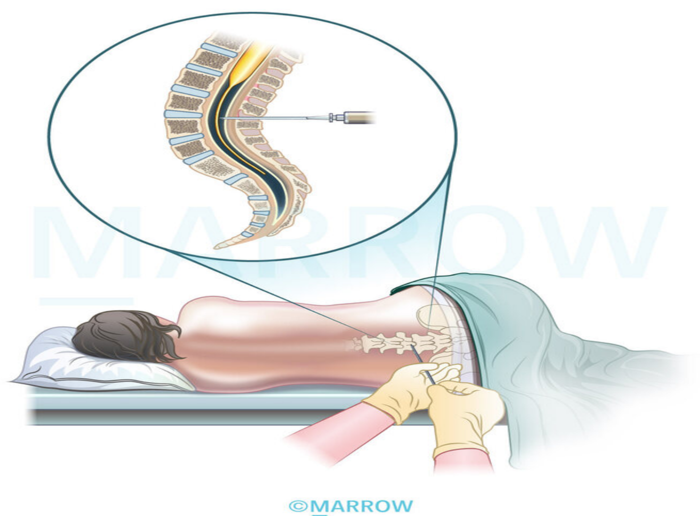
b) April 7th

c) October 16th

d) July 11th

Question 2:

You are assisting your senior resident who is performing the procedure shown in the image. He engages you with some historical trivia and asks you who performed this procedure first. What would your answer be?



a) John Lundy

b) August Bier

c) Carl Koller

d) Oliver Wendell

Question 3:

The prototype of the device shown in the image below was originally named after which personality?

a) John Lundy

b) Carl Koller

c) Edmund Boyle

d) Oliver Wendell

Question 4:

The term "balanced anaesthesia" was coined by the same person who lobbied in 1939 to get anaesthesia recognized as a speciality by the American Medical Association. Who is this individual?

a) John Lundy

b) James Simpson

c) Edmund boyle

d) Oliver Wendell

Question 5:

Why is October 16, 1846, important in the history of anaesthesia?

a) Demonstration of ether anesthesia

b) Demonstration of nitrous oxide as anesthetic

c) Discovery of local anesthetic action of cocaine

d) Discovery of chloroform as anaesthetic

Question 6:

Who proposed the term anaesthesia?

a) William Morton

b) Oliver Wendell Holmes

c) Joseph Priestley

d) John Lundy

Question 7:

In 1884, a paper on the local anaesthetic action of cocaine in ophthalmic surgery was published and was lauded by ophthalmologists all over the world. Who proposed it?

a) Carl Koller

b) Joseph Priestley

c) Humphry Davy

d) William Morton

Question 8:

Who is considered the "Father of Anesthesia"?

a) William Morton

b) Joseph Priestley

c) August bier

d) John Snow

Question 9:

Who was the first person to synthesize nitrous oxide?

a) Horace Wells

b) Joseph Priestley

c) Humphry Davy

d) William Morton

Question 10:

Passive euthanasia was recently made legal in which of the following countries?

a) India

b) Netherlands

c) Belgium

d) Luxembourg

Answer Key

Question No.	Correct Option
1	c
2	b
3	c
4	a
5	a
6	b
7	a
8	d
9	b
10	a

Detailed Explanations

Solution to Question 1:

October 16th is celebrated every year as "World Anesthesia Day" or "Ether day" to commemorate the first successful demonstration of diethyl ether anesthesia to perform painless surgeries.

On this day in 1846, William Thomas Green Morton gave the first successful public demonstration of ether anaesthesia at Massachusetts General Hospital, Harvard Medical School.

The first public demonstration of surgical anesthesia:

On this day, W.T.G. Morton administered ether to Gilbert Abbott for the removal of a tumor from his jaw by the surgeon Dr. John Collin Warren. At the end of the procedure, Dr. Warren uttered his iconic words “Gentlemen, this is no humbug.” This was the dawn of modern anesthesia.

Dates	Event
1772	Nitrous oxide first introduced by Joseph Priestly.
1800	Humphrey Davy published nitrous oxide.
1844	Horace Wells administered nitrous oxide for dental analgesia.
1846	William Morton public demonstration of diethyl ether at the Massachusetts general hospital.
1847	James Young Simpson administered chloroform for general anesthesia in England.
1853	John Snow administered chloroform to Queen Victoria for the birth of Prince Leopold.
1857	Claude Bernard discovered the effects of curare located at the myoneural junction.

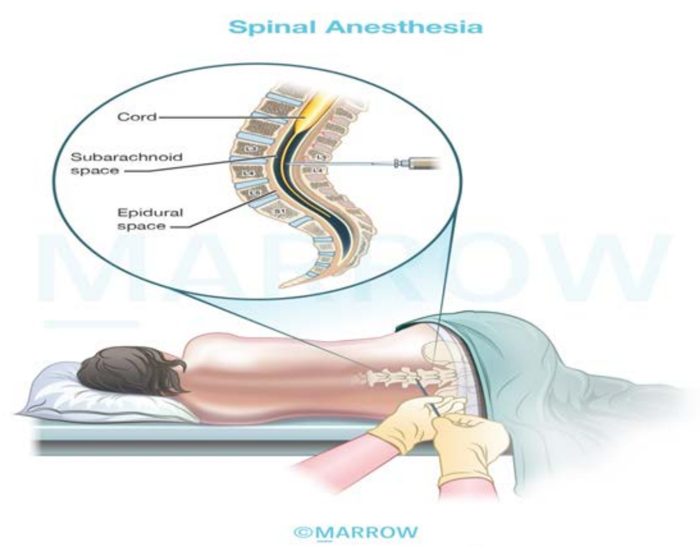
Dates	Event
1884	Carl Koller introduced the use of cocaine for ophthalmic surgery.
1898	August Bier performed the first surgical spinal anesthesia.

Solution to Question 2:

The procedure shown in the above picture is spinal anesthesia.

The first case of spinal anesthesia in humans was performed by August Bier in 1898. He performed spinal anesthesia using the local anesthetic cocaine.

Spinal anesthesia involves the administration of a local anesthetic into the spinal subarachnoid space to provide motor and sensory blockade. Another contribution by August Bier is 'Bier's block' or IVRA (intravenous regional anesthesia).



John Lundy: coined the term balanced anesthesia.

Carl Koller: proposed local anesthetic property of cocaine.

Oliver Wendell: coined the term anesthesia.

Solution to Question 3:

The image shown above is the anesthesia workstation.

The prototype of this device is Boyle's machine which was first invented by Edmund Gaskin Boyle in 1917. Boyle’s machine, which is used to provide anaesthesia, has evolved over the years into anesthetic workstations, which are currently in use.

John Lundy: coined the term balanced anesthesia.

Carl Koller: proposed local anesthetic property of cocaine.

Oliver Wendell: coined the term anesthesia.

Solution to Question 4:

John Lundy coined the term balanced anaesthesia in 1926.

He was instrumental in the formation of the American Board of Anesthesiology and chaired the American Medical Association's Section on Anesthesiology for 17 years.

Balanced anaesthesia involves the use of multiple anaesthetic agents and techniques to produce the different components of anaesthesia, i.e.:

• Analgesia

• Amnesia

• Muscle relaxation

• Abolition of autonomic reflexes

Option B: James Young Simpson introduced chloroform

Option C: Edmund Boyle invented the anaesthetic machine

Option D: Oliver Wendell coined the term anaesthesia

Solution to Question 5:

October 16th 1846 is significant due to the demonstration of ether anesthesia by William Thomas Green Morton at Ether Dome at Massachusetts General Hospital.

The first public demonstration of surgical anesthesia:

On this day, W.T.G. Morton administered ether to Gilbert Abbott for the removal of a tumor from his jaw by the surgeon Dr. John Collin Warren. At the end of the procedure, Dr. Warren uttered his iconic words “Gentlemen, this is no humbug.” This was the dawn of modern anesthesia.

Dates	Event
1772	Nitrous oxide first introduced by Joseph Priestly.
1800	Humphrey Davy published nitrous oxide.
1844	Horace Wells administered nitrous oxide for dental analgesia.
1846	William Morton public demonstration of diethyl ether at the Massachusetts general hospital.
1847	James Young Simpson administered chloroform for general anesthesia in England.
1853	John Snow administered chloroform to Queen Victoria for the birth of Prince Leopold.
1857	Claude Bernard discovered the effects of curare located at the myoneural junction.
1884	Carl Koller introduced the use of cocaine for ophthalmic surgery.
1898	August Bier performed the first surgical spinal anesthesia.

Solution to Question 6:

Oliver Wendell Holmes in 1846 was the first to propose the term anesthesia.

He used the term anesthesia to denote “the state that incorporates amnesia, analgesia, and narcosis to make painless surgery possible”

The term anesthesia refers to “no senses”

William Morton: Introduced ether anesthesia.

Joseph Priestley: First synthesized nitrous oxide.

John Lundy: Coined the term balanced anesthesia.

Solution to Question 7:

Cocaine was the first topical anaesthetic and was discovered by Carl Koller in 1884.

He first introduced cocaine as a topical anaesthetic for ophthalmologic surgery of the cornea. Thereafter, cocaine was used for intradermal infiltration and nerve blocks by William Halsted.

Joseph Priestley: First synthesized nitrous oxide.

Humphrey Davy: Experimented with nitrous oxide and named it laughing gas.

William Morton: Introduced ether anaesthesia.

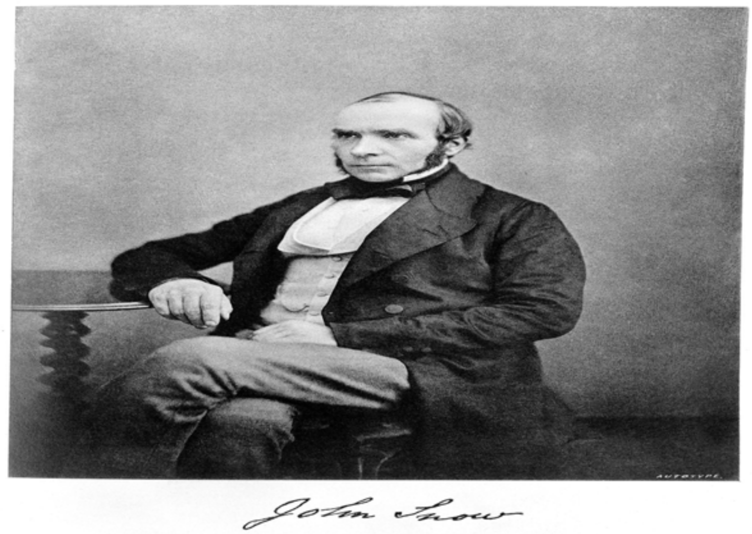
Solution to Question 8:

John Snow is the Father of Anesthesia.

He administered chloroform to Queen Victoria at the birth of her eighth son, Leopold in 1853 and performed the same procedure when her daughter Beatrice was born in April 1857.

William Morton is considered the father of modern anesthesia for his public demonstration of ether anesthesia.

John Snow



(Autotype from a Presentation Portrait, 1856, and Autograph facsimile.—B. W. R.)

John Snow is considered one of the founders of epidemiology for his work identifying the source of a cholera outbreak in 1854. He was a firm believer of 'germ' theory of disease which was not widely accepted until the 1860s.

Broadwick Street showing the John Snow memorial and public house. John Snow had the handle of the pump removed following a cholera outbreak in August 1854.

Solution to Question 9:

Joseph Priestley first synthesized nitrous oxide in 1772.

Joseph Priestley, an English chemist is well known for his experiments and observations on different kinds of air. He is most famously known for the discovery of "dephlogisticated air," which was later named oxygen by Lavoisier.

Humphry Davy, in 1800, first noted the analgesic properties of nitrous oxide.

Horace Wells studied the analgesic properties of nitrous oxide and put into clinical use in 1844 for dental extraction but it was less potent than ether.

William Morton introduced ether anesthesia.

Solution to Question 10:

Passive euthanasia is legal in India, since 9 March 2018. Prior to this, it was legal only in Netherlands, Belgium, and Luxembourg.

Euthanasia involves the administration of medication by someone other than the patient for the purpose of ending the patient's life in the belief that it is best for the patient (but not necessarily at the specific request of the patient).

Involuntary euthanasia, which is done against the patient's consent, is illegal in all countries and amounts to murder.

Types of euthanasia:

• Active euthanasia: Direct administration of a lethal substance to the patient by another party with merciful intent

• Passive euthanasia: Withholding or withdrawing of life-sustaining treatment either at the request of the patient or when prolonging life is considered futile

• Indirect euthanasia: Prescription of painkillers that may be fatal in an attempt to relieve suffering

• Physician-assisted suicide: A medical professional aiding a patient in terminating their life upon the patient's request/

Preoperative Evaluation

Question 1:

A 50-year-old man with well controlled hypertension has been scheduled for surgery. What is his ASA-PS classification?

- **a)** ASA-PS Class I
- **b)** ASA-PS Class II
- **c)** ASA-PS Class III
- **d)** ASA-PS Class IV

Question 2:

A known diabetic with an HbA1c value of 9% should be classified under which ASA-PS classification?

- **a)** ASA 1
- **b)** ASA 2
- **c)** ASA 3
- **d)** ASA 4

Question 3:

You would use all of the following as part of airway assessment in a patient except?

- **a)** Thyromental distance
- **b)** ASA-PS classification
- **c)** Cormack-Lehane classification
- **d)** Neck circumference

Question 4:

Which of the following features in a patient would prompt you to anticipate a difficult intubation?

- **a)** 1 and 5

b) 1, 3 and 5

c) 2, 3 and 4

d) 5 only

Question 5:

Which of the following statements is true regarding the American Society of Anaesthesiologists - Physical Status (ASA-PS) classification?

a) It is used to assess difficulty in intubation

b) Brain dead patients come under ASA class V

c) A patient with anaemia without symptoms comes under ASA class III

d) ASA-PS grading strongly correlates to the peri-operative risk

Question 6:

Which of the following statements is false about the modified Mallampati score?

a) It is used to assess oral cavity before intubation

b) In class II, tonsillar pillars cannot be visualized

c) Higher scores are associated with higher risk of sleep apnea

d) In class III, only hard palate is visible

Question 7:

A patient is posted for Whipple's procedure. During preoperative preparation, you note that his medical history is significant for ankylosing spondylitis for which he has been taking aspirin. What is the next best step for this patient?

a) Continue aspirin

b) Administer half the dose of aspirin with pre-op bleeding time monitoring

c) Stop aspirin 3 days before surgery

d) Stop aspirin and replace with clopidogrel

Question 8:

A 60-year-old patient on regular low dose aspirin requires a CABG procedure. What would be your advice regarding aspirin before the procedure?

a) Continue aspirin

b) Stop aspirin and replace with heparin

c) Stop aspirin and give a platelet transfusion

d) Cancel the surgery as he cannot be operated on

Question 9:

A patient on clopidogrel is scheduled to undergo an elective procedure. What would be your advice regarding the drug?

a) Continue as usual

b) Continue but omit the morning dose

c) Stop 1 day before surgery

d) Stop 1 week before surgery

Question 10:

A 76-year-old woman has been scheduled for hip replacement surgery. She has a history of non-valvular atrial fibrillation resulting in a stroke 2 months back and is on warfarin since then. Which of the following is the correct advice regarding warfarin?

a) Stop warfarin 4-5 days preoperatively and check INR

b) Stop warfarin 4-5 days preoperatively and continue LMWH till a day before surgery

c) Stop warfarin on the day of surgery

d) Continue warfarin

Question 11:

Which of the following drugs can not be continued on the day of surgery?

a) Antithyroid drugs

b) Oral anticoagulants

c) Beta blockers

d) Anti convulsants

Question 12:

A patient on tablet levothyroxine is posted for surgery. How many days prior to surgery is the tablet stopped?

a) 1 day

b) 1 week

c) 5 Days

d) Tablet should be continued without stopping

Question 13:

Which of the following drugs cannot be safely continued on the day of surgery?

a) Furosemide

b) Propylthiouracil

c) Digoxin

d) Prednisolone

Question 14:

Which of the following drugs should not be continued on the day of surgery?

a) Asthma medications

b) Oral hypoglycemics

c) Anticonvulsants

d) Beta blockers

Question 15:

A 20-year-old patient has been on tablet fluoxetine for depression for the past 3 months and is now scheduled to undergo elective surgery. What would you advise him?

a) Withhold Fluoxetine for 3 weeks prior to surgery

b) Withhold fluoxetine for 3 days prior to surgery

c) Withhold fluoxetine and replace with monoamine oxidase inhibitors

d) Continue fluoxetine

Question 16:

A 50-year-old hypertensive patient, on tablet amlodipine, is posted for elective open cholecystectomy. What would your advice be regarding the use of amlodipine?

a) Withhold amlodipine on the day of surgery

b) Continue amlodipine at a lower dose

c) Continue the same dose of amlodipine

d) Replace amlodipine with enalapril

Question 17:

Which of the following drugs should be discontinued 24-hours before the surgery?

a) Sildenafil

b) Statins

c) NSAID

d) Warfarin

Question 18:

A 45-year-old chronic smoker is diagnosed with an inguinal hernia. The surgeon briefs him about the elective laparoscopic hernia repair. What is the minimum duration for which he should stop smoking to reduce the risk of postoperative complications?

a) 3- 4 days before surgery

b) 1-2 weeks before surgery

c) 2-4 weeks before surgery

d) 6-8 weeks before surgery

Question 19:

While filling the preoperative diet recommendations on the chart of a 22-year-old patient scheduled to undergo elective surgery, you would recommend fasting of at least

a) 4 hours for solids, 2 hours for clear liquids

b) 2 hours for solids, 4 hours for clear liquids

c) 8 hours for solids, 2 hours for clear liquids

d) 2 hours for solids, 8 hours for clear liquids

Question 20:

Which of the following is a preoperative fasting recommendation for an adult patient after a light meal?

a) Fasting not required

b) 2 hours

c) 8 hours

d) 6 hours

Question 21:

You are a junior resident in the pediatric surgery department and an infant in your unit is scheduled for a surgical correction of the ASD. Which of the following would you ask the mother to follow regarding the preoperative fasting?

a) 6 hours for solids , 4 hours for breast milk

b) 4 hours for solids , 6 hours for breast milk

c) 4 hours for solids, 2 hours for breast milk

d) 2 hours for solids , 4 hours for breast milk

Question 22:

A 60-year-old male is set to undergo knee replacement surgery. He has a history of consumption of herbal supplement tablets every day for the past 6 months. Ideally, how many days before surgery should it be stopped?

a) Can be continued

b) 1 day before surgery

c) 1 month before surgery

d) 1-2 weeks before surgery

Question 23:

A difficult airway is least likely to be associated in a patient with __________

a) Rheumatoid arthritis

b) Reactive arthritis

c) Scleroderma

d) Downs syndrome

Answer Key

Question No.	Correct Option
1	b
2	c
3	b
4	b
5	d
6	d
7	c
8	a
9	d
10	b
11	b
12	d
13	a
14	b
15	d
16	c
17	a
18	d
19	c
20	d
21	a
22	d
23	b

Detailed Explanations

Solution to Question 1:

A well-controlled hypertensive patient falls under the ASA-PS Class II category.

ASA-PS Class II - A patient with a mild systemic disease such as well-controlled diabetes mellitus or hypertension or a current smoker.

Solution to Question 2:

A patient with poorly controlled diabetes should be classified as ASA-PS Class III.

ASA-PS Class III: A patient with severe systemic disease and substantial functional limitation. Poorly controlled diabetes mellitus or hypertension or complicated diabetes is included under ASA-PS Class III.

Note: If the question was about well-controlled diabetes or mild diabetes without complications, the answer would be ASA-PS Class II.

Solution to Question 3:

ASA-PS classification is used to quantify patient risk for anesthesia and not for assessment of the airway.

Solution to Question 4:

The following are indicators of difficult intubation:

• Mallampati class 3 and 4 airways

• Thyromental distance <6cm with neck extension

• Neck circumference >17 inches in men and 16 inches in women

• An inability to extend the neck at the atlantooccipital joint

• A history of previous difficult intubation.

Solution to Question 5:

ASA-PS classification describes a patient's preoperative medical status and strongly correlates with the perioperative risk.

The ASA classification system alone does not predict the perioperative risks, but when used with other factors like the type of surgery, frailty and level of deconditioning of the patient, it can be helpful in predicting perioperative risks.

Option A: ASA-PS is used to quantify the risk for patients who require anaesthesia, not assess intubation difficulty.

Option B: Brain dead patients are classified as ASA-PS class Vl.

Option C: A patient with anaemia without functional limitation (no symptoms) is classified as ASA-PS class ll.

Solution to Question 6:

In class III of Mallampati score, both hard and soft palates are visible.

Option A: Mallampati score is used to predict difficult tracheal intubation based on the size of the tongue base relative to the oropharyngeal space.

Option B: In class II, only soft palate, fauces, and the portion of uvula are visualized, tonsillar pillars can't be visualized.

Option C: Higher Mallampati scores (class III and IV) are associated with a greater incidence of difficult intubation and sleep apnea.

Solution to Question 7:

Aspirin should be discontinued 3 days before surgery in this patient to mitigate potential intraoperative bleeding.

However, low dose aspirin should be continued to prevent cardiovascular thrombotic events in the following cases:

• Patients with a prior PCI (Percutaneous coronary intervention)

• Patients with coronary artery disease

• Patients with stroke in the past 9 months

In addition, aspirin should be continued in patients requiring CABG. This is due to associated increased in-hospital mortality if discontinued.

Duration for which other antiplatelet drugs should be stopped before surgery-

Antiplatelets	Waiting period
Ticlopidine	10-14 days
Clopidogrel	5-7 days
Abciximab	48 hr
Eptifibatide	8 hr

Solution to Question 8:

Aspirin should be continued in patients requiring CABG procedure.

Discontinuation of aspirin in patients requiring CABG procedure is associated with increased in-hospital mortality. Hence aspirin is continued before the procedure.

The approach for most surgical patients is to discontinue aspirin temporarily for 3 days before surgery to mitigate potential intraoperative bleeding. However, the drug should be continued to prevent cardiovascular thrombotic events in the following:

• Patients with a prior PCI (Percutaneous coronary intervention)

• Patients with coronary artery disease

• Patient with stroke in the past 9 months.

Note: The use of heparin may paradoxically increase platelet aggregation and is not recommended.

Solution to Question 9:

Clopidogrel is an antiplatelet drug and is stopped 1 week prior to surgery to avoid the risk of increased surgical bleeding.

Antiplatelets	Waiting period
Ticlopidine	10 days
Clopidogrel	5-7 days
Abciximab	48 hr
Eptifibatide	8 hr

Solution to Question 10:

Since the patient has increased thromboembolic risk (stroke), warfarin is stopped 4-5 days pre-operatively and LMWH (low molecular weight heparin) is used till the day before(24 hours) surgery.

In patients at high risk for thrombosis (e.g., those with certain mechanical heart valve implants or with atrial fibrillation and a prior thromboembolic stroke), warfarin should be stopped and replaced by UFH or LMWH to minimize the risk.

Patients at lower risk for thrombosis may have warfarin discontinued 4-5 days preoperatively and then reinitiated after successful surgery.

Warfarin may be continued in patients posted for cataract surgery without a bulbar block.

Solution to Question 11:

Oral anticoagulants are discontinued prior to surgery.

Anticoagulant	Minimum interval between t he last dose and the surgery
Warfarin	4-5 days
Unfractionated heparin	6 hours
LMWH - prophylactic d ose	12 hours
LMWH - therapeutic do se	24 hours

Solution to Question 12:

All antithyroid drugs and thyroxine supplements are continued on the day of surgery.

Solution to Question 13:

Furosemide should not be continued on the day of surgery.

All diuretics are discontinued on the day prior to surgery due to the risk of volume depletion and hypokalemia, except thiazide diuretics (e.g., hydrochlorothiazide, chlorthalidone).

Propylthiouracil, digoxin, and prednisolone can be continued safely.

Solution to Question 14:

Oral hypoglycemic agents are generally withheld on the day of surgery except for minor, short procedures.

SGLT-2 inhibitors are stopped 24 hours before elective surgery and 72 hours before intermediate to high-risk surgeries.

Solution to Question 15:

Fluoxetine is a selective serotonin reuptake inhibitor (SSRI), an antidepressant, and is to be continued on the day of surgery to avoid exacerbation of symptoms.

Abrupt withdrawal of short-acting SSRIs should be avoided, as it can cause a discontinuation syndrome including dizziness, chills, muscle aches, and anxiety.

Solution to Question 16:

Antihypertensive medications like amlodipine are continued at the same dose.

Note: Due to the risk of intraoperative hypotension, ACE inhibitors and ARB drugs are discontinued on the morning of surgeries. But in patients with heart failure or poorly controlled hypertension, we continue them to avoid further exacerbation.

Solution to Question 17:

Sildenafil is discontinued 24 hours prior to surgery.

Solution to Question 18:

Smoking should be discontinued for at least 6–8 weeks before the operation so as to decrease airway secretions and thereby decrease the risk of pulmonary complications.

Time after smoking	Physiological effects
12-24 hrs	Fall in CO and nicotine levels
48-72 hrs	COHb normalizes
1-2 weeks	Decreased sputum production
4-6 weeks	PFT improves
6-8 weeks	Normalization of immune function; decreased postoperative pulmonary complications
6 months	Risk similar to that of non-smokers

Solution to Question 19:

Recommended preoperative fasting periods for all above 1 year of age are

- 2 hours for clear liquids
- 6 hours for light meal/milk
- 8 hours for fried, fatty food

Recommended preoperative fasting period for neonates and infants are

• 4 hours for breast milk

• 6 hours for solids/formula feeds/cow's milk

Preoperative fasting is intended to reduce the risk of pulmonary aspiration.

Solution to Question 20:

For adults, a fasting period of 6 hours after a light meal is recommended; this period may have to be increased to 8 hours or more if the meal includes fried or fatty foods.

Solution to Question 21:

Recommended preoperative fasting period for neonates and infants are

• 6 hours for solids/formula feeds/cow's milk

• 4 hours for breast milk.

Recommended preoperative fasting periods for all above 1 year of age are

• 2 hours for clear fluids

• 6 hours for a light meal

• 8 hours for fried, fatty food.

Solution to Question 22:

Herbal medicines should be discontinued at least 1-2 weeks before surgery.

Herbal medications may have effects that could be deleterious in the perioperative period, including clotting abnormalities and interactions with anesthetics.

Commonly used herbal medicines include echinacea, ephedra, garlic, ginger, Ginkgo biloba, ginseng, green tea, and St. John's wort.

Note: A recommendation to stop herbal medicines at least 2 weeks prior to surgery is given by the American Association of anesthesiologists.

Solution to Question 23:

Cervical spine involvement in reactive arthritis is relatively rare. Hence, it is not a risk factor for a difficult airway.

The other 3 conditions - rheumatoid arthritis, scleroderma, and Downs syndrome are considered as risk factors for a difficult airway

CNS and CVS Monitoring in Anaesthesia

Question 1:

In a patient undergoing surgery, which of the following would not be used to monitor the cardiovascular system?

a) Radial artery cannulation

b) Capnography

c) Transthoracic echocardiography

d) Pulmonary artery catheterization

Question 2:

A patient with heart failure in the ICU is being administered fluids. Which is the method of non-invasive cardiac monitoring used to titrate the treatment for this patient on a regular basis?

a) Radial artery cannulation

b) Pulmonary artery catheterization

c) Transesophageal echocardiography

d) Transthoracic echocardiography

Question 3:

In a patient requiring invasive BP monitoring, which is the preferred artery used for canulation and measurement?

a) Ulnar

b) Radial

c) Brachial

d) Femoral

Question 4:

A 25-year-old is admitted to the ER after being involved in a road traffic accident. Which type of IV cannula would achieve the maximum flow rate to provide fluid resuscitation?

a) Orange

b) Blue

c) Pink

d) Green

Question 5:

Which of the following nerves is popularly used in clinical anaesthesia to monitor neuromuscular blockade?

a) Ulnar Nerve

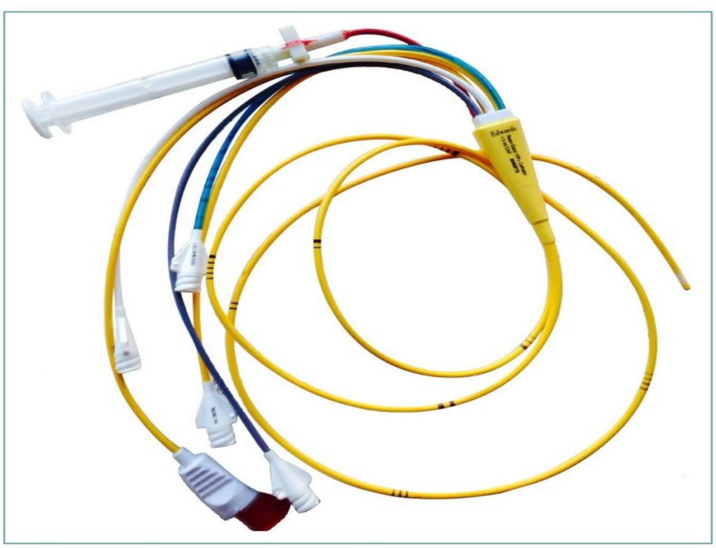
b) Median Nerve

c) Radial nerve

d) Mandibular nerve

Question 6:

You observe the catheter shown in the image being used by your attending in the ICU. Which of the following procedures is it used for?



a) Gastro-Esophageal varices

b) Embolectomy

c) Pulmonary artery catheterization

d) Urinary catheterization

Question 7:

What is the most common complication of pulmonary artery catheterization?

a) Infection

b) Thromboembolism

c) Arrhythmia

d) Pulmonary artery rupture

Question 8:

You are assisting your attending in conducting a pulmonary artery catheterisation for a patient in the ICU. You are asked to explain your understanding of the procedure in brief. Which of the following statements would be incorrect?

a) It involves direct measurement of left atrial pressure.

b) Swan ganz catheter is used.

c) Cardiac arrhythmia is the most frequent complication.

d) It estimates cardiac output.

Question 9:

In a patient undergoing pulmonary artery catheterisation, which of the following would denote entry into the pulmonary artery?

a) Increase in systolic pressure

b) Decrease in systolic pressure

c) Increase in diastolic pressure

d) Decrease in diastolic pressure

Question 10:

A patient who is planned for cardiac surgery requires central venous pressure (CVP) monitoring. What is the preferred site for central venous cannulation?

a) Left internal jugular vein

b) Right internal jugular vein

c) Subclavian vein

d) Axillary vein

Question 11:

Cardiac output can be determined using the following except?

a) Thermal dilution technique

b) Capnography

c) Esophageal doppler

d) Echocardiography

Question 12:

In a patient undergoing surgery, which is the single best lead in the ECG to diagnose arrhythmias?

a) Lead I

b) Lead V2

c) Lead II

d) Lead V5

Question 13:

In a patient undergoing mitral valve repair, which is the most sensitive indicator of myocardial ischemia?

a) ECG – Lead V5

b) Pulmonary artery catheterisation

c) Thoracic bioimpedance

d) Transesophageal echocardiography

Question 14:

Which of the following investigations provides the most accurate prognostic information with respect to predicting risks of perioperative cardiac complications?

a) Exercise ECG testing

b) Dobutamine stress echocardiography

c) Myocardial perfusion scintigraphy

d) Coronary angiography

Question 15:

You are a junior resident conducting research on the efficacy of different methods to monitor the depth of anaesthesia. Which of the following methods will be not be considered for evaluation in your research?

a) EEG

b) Capnography

c) Bispectral index

d) Auditory evoked potential

Question 16:

After administering the induction agent for a patient, the anaesthesia junior resident is observing the EEG machine to check the depth of anaesthesia. He observes β waves on the EEG. What does it signify?

a) Light anaesthesia

b) Profound hypothermia

c) Deep anesthesia

d) Arousable state

Question 17:

A young boy is scheduled for a sigmoidoscopy. He has a history of epilepsy and aggressive behaviour. The procedure was conducted under general anaesthesia when an isoelectric pattern was observed on the EEG monitor. Which of the following is not a differential diagnosis?

a) Normally during anesthesia

b) Profound hypothermia

c) Profound hyperthermia

d) Anesthetic induced coma

Question 18:

In a patient who is under anaesthesia, which is the most common method used to evaluate intraoperative awareness?

a) Capnography

b) EEG

c) Bispectral index

d) Transesophageal echocardiography

Question 19:

In a patient who is under general anaesthesia, what are the recommended bispectral index (BIS) values?

a) 20-40

b) 40-60

c) 60-80

d) 80-100

Question 20:

Which among the following is most commonly used to monitor the depth of anaesthesia?

a) EEG

b) Provoked lower oesophageal contractility

c) Entropy

d) Bispectral index

Question 21:

A young boy developed masseter spasm and tachycardia after being administered succinylcholine for RSI. Which of the following is the best site for monitoring core body temperature in this patient?

a) Oral cavity

b) Esophagus

c) Axilla

d) Rectum

Question 22:

Which of the following sites most accurately measures the brain temperature?

a) Oral

b) Tympanic membrane

c) Nasopharynx

d) Distal esophagus

Question 23:

Which thermoregulatory mechanism is best preserved during anesthesia?

a) Shivering

b) Sweating

c) Vasoconstriction

d) Non shivering thermogenesis

Question 24:

Which of the following is a true statement regarding Allen's test?

a) Used to confirm Ryle's tube position

b) Used to confirm tracheal intubation

c) Used to diagnose wrist dislocation

d) Used to assess adequacy of collateral blood flow

Question 25:

You are an intern posted in the ICU. While taking a blood sample for ABG, which of the following steps would you not do?

a) Normal ph can't rule out acid base disorder

b) Add 0.5 ml Heparin to the syringe before taking blood

c) If modified Allens test is negative, alternate site is chosen

d) Radial artery is the preferred site

Answer Key

Question No.	Correct Option
1	b
2	d
3	b
4	a
5	a
6	c
7	c
8	a
9	c
10	b
11	b
12	c
13	d
14	b
15	b
16	a
17	c
18	c
19	b
20	d
21	b
22	b
23	b
24	d
25	b

Detailed Explanations

Solution to Question 1:

Capnography is used to assess ventilation in the perioperative period and to confirm the correct placement of an endotracheal tube.

Cardiovascular monitoring involves the use of:

Hemodynamic parameter	Methods	
Heart rate	Manual, ECG	
Pulse rate	Manual, ECG, pulse oximeter plethysmography	
Blood pressure	Non-invasive:PalpationDoppler probeAuscultationOscillometryArterial tonometry	Invasive:Reference standard for arterial pressure monitoringArterial cannulation (radial, femoral, dorsalis pedis etc.)
Central venous pressure	Central Venous Cannulation	
Pulmonary capillary wedge pressure	Pulmonary Artery Catheterization	
Cardiac Output	ThermodilutionDye dilution using indocyanin greenLithium dilutionPulse contour devicesEsophageal DopplerThoracic bio impedanceEchocardiography (Transesophageal and transthoracic)	

Solution to Question 2:

Transthoracic echocardiography (TTE) is the noninvasive form of cardiac monitoring that can be used in this patient.

Option C: Transesophageal echocardiography (TEE) is a minimally invasive procedure and could be associated with serious complications like oesophagal rupture and mediastinitis in the presence of oesophagal injury or disease. In the absence of oesophagal disease, the risk is low.

Solution to Question 3:

Radial artery is the preferred artery for invasive blood pressure monitoring because of ease of cannulation, presence of collateral blood flow and less associated complications.

Before cannulating the radial artery, it is essential to perform a modified Allen's test in order to determine the adequacy of collateral flow to the hand.

The other arteries which can be used for invasive blood pressure monitoring are ulnar, brachial, axillary, and femoral arteries and less commonly dorsalis pedis, posterior tibial, and superficial temporal arteries.

Solution to Question 4:

The orange cannula (14 Gauge) has the maximum flow rate of 270 mL/min.

Solution to Question 5:

Ulnar nerve stimulation at wrist is popularly used to assess the adequacy of neuromuscular blockade.

Neuromuscular blockade is measured using a peripheral nerve stimulator.

Nerve	Response
Ulnar nerve	Contraction of adductor polli cis
Facial nerve	Contraction of orbicularis oc uli
Posterior tibial nerve	Contraction of flexor hallucis brevis

Solution to Question 6:

The image shown above is the Swan-ganz catheter which is used for pulmonary artery catheterization. It is also called the pulmonary artery catheter. The standard pulmonary artery catheter is 110 cm long with a 7.0 – 9.0 Fr circumference.

Uses of Swan-ganz catheter:

• Measurement of pressures in right atrium, right ventricle and pulmonary artery

• Indirect measurement of left atrial pressure through pulmonary capillary wedge pressure

• Cardiac output

• Oxygen saturation- pulmonary samples to rule out left-right shunt

• Monitoring left ventricle filling pressure

• Differentiate cardiogenic from non cardiogenic pulmonary edema

Solution to Question 7:

The most common complication of pulmonary artery catheterization is arrhythmias and are usually self-limiting.

Since the occurrence of these arrhythmias is so common, it is considered as an indicator of the placement of the catheter in the corresponding cardiac chamber.

Complications of pulmonary artery catheterization:

• Catheterization related:

• Arrhythmias, ventricular fibrillation

• Right bundle branch block, complete heart block

• Catheter residence related:

• Mechanical, catheter knots

• Thromboembolism

• Pulmonary infarction

• Infection, endocarditis

• Endocardial damage, cardiac valve injury

• Pulmonary artery rupture

• Pulmonary artery pseudoaneurysm

• Others:

• Misinterpretation of data

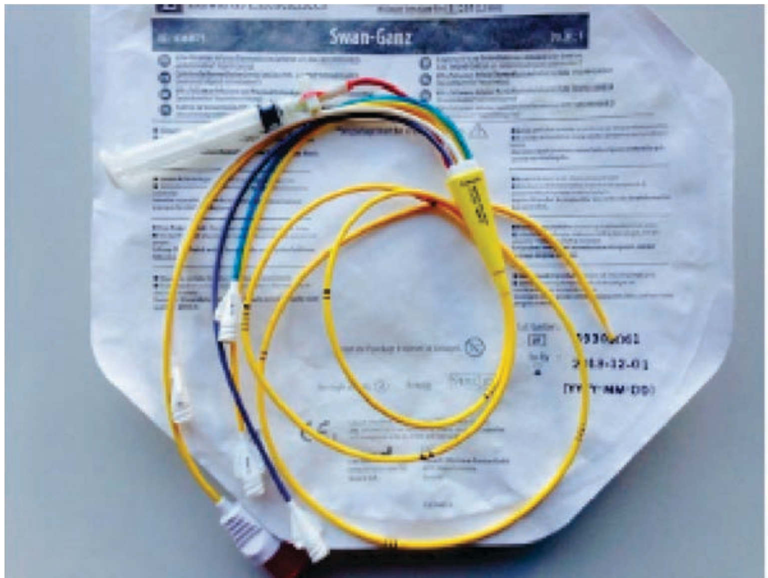
• Misuse of equipment

Solution to Question 8:

Left atrial pressure (LAP) is indirectly measured through pulmonary capillary wedge pressure (PCWP).

LAP has been the gold standard for evaluating mitral stenosis and decompensated congestive heart failure.

Option B: Swan-Ganz catheter is used for pulmonary artery catherization.



Option C: Cardiac arrhythmias are the most frequent complication.

Option D: The catheter is incorporated with thermistors that can be used to measure cardiac output, from which a multitude of hemodynamic values can be derived.

Solution to Question 9:

Entry into the pulmonary artery is indicated by an increase in diastolic pressure.

Pulmonary artery catheterization involves the use of a Swan-Ganz catheter.

Solution to Question 10:

The right internal jugular vein is the most preferred vein for central venous cannulation.

Reasons for preference:

• Absence of valves

• Consistent anatomic location of the internal jugular vein

• Easily identifiable surface landmarks

• Direct communication with the right atrium.

Other sites for central venous cannulation:

• Subclavian vein: greater risk of pneumothorax

• Left internal jugular vein: greater risk of pleural effusion & chylothorax

• Femoral vein: increased risk of thromboembolic complications, infection, and vascular injury.

Triple-lumen central venous catheterization of right IJV

Solution to Question 11:

Capnography is a measurement of end-tidal CO2, which is used to confirm tracheal intubation and assess ventilation in the perioperative period.

Cardiac output measurements technique:

- Thermodilution
- Dye dilution, using indocyanine green
- Lithium dilution
- Pulse contour devices
- Esophageal doppler
- Thoracic bioimpedance
- Echocardiography

Note: Thermal dilution method uses a non-toxic liquid of temperature different from the blood. This fluid is injected into a vein and is detected on the arterial side using a catheter with a temperature sensor. The rate of flow of this liquid is used to calculate the cardiac output.

Solution to Question 12:

Lead II is the best for detecting arrhythmias and inferior wall myocardial infarction.

Lead V5 is th best for detecting anterior and lateral wall myocardial infarction.

For arrhythmia, oesophagal leads are better than lead II but they are not yet put into wide use.

For myocardial ischemia, new regional wall motion abnormalities and decreased systolic wall thickening on transesophageal echocardiography are more sensitive than ECG.

Solution to Question 13:

Transesophageal echocardiography is the most sensitive indicator of myocardial ischemia.

New regional wall motion abnormalities (RWMA) and decreased systolic wall thickening on transesophageal echocardiography are more sensitive than ECG.

Ischemia may be indicated clinically by a sudden onset intraoperative arrhythmia or conduction block.

Solution to Question 14:

Among the given investigations, dobutamine stress echocardiography provides the most accurate prognostic information with respect to predicting risks of perioperative cardiac complications.

Preoperative cardiac stress testing can help identify the presence and severity of preexisting CAD. The prognostic performance of these tests is better assessed based on positive and negative likelihood ratios. Among all the given options, dobutamine stress echocardiography has the maximum positive likelihood ratio and hence provides the most accurate prognostic information.

Even though coronary angiography is considered the gold standard, it may not absolutely risk-stratify patients because many perioperative cardiac events may be related to noncritical coronary lesions.

Solution to Question 15:

Capnography is not considered as it cannot be used to monitor the depth of anaesthesia.

Capnography is a quantitative measure of end-tidal carbon dioxide that is used to assess ventilation in the perioperative period and confirm the correct placement of an endotracheal tube.

Monitors used to assess the depth of anaesthesia:

- Electroencephalography (EEG)
- Bispectral index (BIS)
- Entropy
- Evoked responses (EP) - Motor EP, sensory EP (Auditory, visual, brain stem evoked potential)
- Patient state index
- Narcotrend.

Solution to Question 16:

Beta waves on EEG signify light anesthesia.

Beta waves on EEG are seen in awake state and during initial stages of inhalational anesthesia.

EEG wave s	Freque ncy	Depth of anesthesia
Alpha	8–13 H z	Resting adult with eyes close d, arousable state of sedation
Beta	13-30 Hz	Concentrating individuals, u nder anesthesia during initial stages
Theta	4–7 Hz	Sleeping individuals and duri ng anesthesia maintenance
Delta	0.5–4 Hz	Brain injury, deep sleep, and anesthesia maintenance
Iso electri c		Anesthesia induced coma, pr ofound hypothermia

Solution to Question 17:

Isoelectric EEG is not seen during hyperthermia and hence is not a differential diagnosis for this patient.

Causes of isoelectric EEG:

• Brief periods during normal maintenance of anesthesia

• Anesthetic induced coma

• Profound hypothermia

Interpretation of an EEG:

• ° , β oscillations : arousable state of sedation

• ° , θ oscillations with δ dominance: surgically anesthetized state

EEG wave s	Freque ncy	Depth of anesthesia
Alpha	8–13 H z	Resting adult with eyes close d, arousable state of sedation
Beta	13-30 Hz	Concentrating individuals, u nder anesthesia during initial stages
Theta	4–7 Hz	Sleeping individuals and duri ng anesthesia maintenance
Delta	0.5–4 Hz	Brain injury, deep sleep, and anesthesia maintenance

EEG waves	Frequency	Depth of anesthesia
Iso electric		Anesthesia induced coma, profound hypothermia

Solution to Question 18:

The bispectral index (BIS) is the most commonly used method, which helps to monitor the depth of anaesthesia and intraoperative awareness.

It processes the EEG and provides an index value between 0 and 100 that indicates the patient's level of consciousness.

BIS index range:

• 100– Awake (Response to normal voice)

• 65-85- Sedation

• 40-65- General anaesthesia

• < 40 - Cortical suppression

• 0- Flatline EEG (Deep coma)

Recommended range of BIS index values for anaesthesia- 40-60.

Solution to Question 19:

Recommended range of bispectral index (BIS) values for general anaesthesia is 40-60.

BIS helps to monitor the depth of anaesthesia and prevent intraoperative awareness. It processes the EEG and provides an index value between 0 and 100 that indicates the patient's level of consciousness.

BIS index range:

• 100– Awake (Response to normal voice)

• 65-85- Sedation

• 40-65- General anaesthesia

• < 40 - Cortical suppression

• 0- Flatline EEG (Deep coma)

Solution to Question 20:

The bispectral index is the most commonly used method to monitor the depth of anesthesia.

Note: Middle latency auditory evoked potential is the most sensitive indicator to evaluate the depth of anesthesia.

Solution to Question 21:

The clinical features are suggestive of malignant hyperthermia in this patient and the distal oesophagus is the best site for core temperature monitoring in this condition.

Pulmonary artery is the most accurate site for temperature measurement but it is not used routinely due to a higher incidence of complications. It is useful in patients already on Swan-Ganz catheter.

Option A: Oral cavity (sublingual) readings can be influenced by mouth breathing, tachypnea, and ambient temperature.

Option C: Axilla readings are influenced by contact with probe, skin perfusion, environment, etc.

Option D: Rectum readings are higher than central sites due to heat-producing flora in feces.

Other sites for core thermal monitoring:

- Tympanic membrane
- Nasopharynx
- Trachea
- Skin

Solution to Question 22:

The tympanic membrane measures the brain temperature most accurately.

The tympanic membrane and the hypothalamus share a common blood supply. Hence, measuring the temperature at this site reflects thermal information at the primary site of thermoregulation.

Disadvantages are trauma during insertion and cerumen insulation, so it is not routinely used.

Solution to Question 23:

Sweating is the best preserved thermoregulatory mechanism during anesthesia.

Option A and C: General anesthetics decrease the thresholds (triggering core temperatures) for vasoconstriction and shivering by 2°C to 3°C.

Option D: Nonshivering thermogenesis does not occur in anesthetized patients.

Solution to Question 24:

Allen's Test is used to test the adequacy of collateral blood flow to the hand. It mandatory before radial artery cannulation and sometimes, before drawing blood for arterial blood gas (ABG) analysis.

Method:

It is performed by occluding the radial and ulnar arteries and asking the patient to make a tight fist so as to exsanguinate the palm.

Then, the patient is asked to open the hand and the occlusion over the ulnar artery is released. If the palm remains pale for more than 6-10 seconds, it indicates reduced ulnar collateral flow.

Solution to Question 25:

0.5 ml of Heparin is not added to the syringe before taking blood.

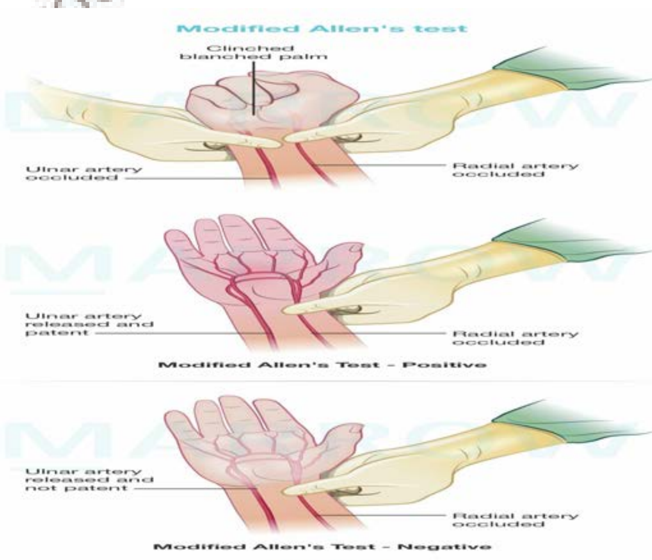
Very little heparin is needed in the sample to prevent clotting; 0.05 to 0.10 ml of a dilute solution will help prevent coagulation of 1 ml of blood without affecting its pH. This is achieved by drawing 0.5 ml into the syringe and flushing it out. The residue that remains adherent to the syringe is sufficient for the procedure.

Heparin must be added to the syringe as an anticoagulant. Because the pH of heparin is near 7.0, and the Po_2 and Pco_2 of the heparin solution are near room air values, excess heparin can alter ABG measurements. After flushing the syringe with heparin, a sufficient amount usually remains in the dead space of the syringe and needle for anticoagulation without distortion of the ABG determination.

Note:

• Modified Allen's test positive indicates that the collateral blood flow is normal

• Modified Allen's test negative indicates that the collateral blood flow is abnormal and an alternate site must be chosen.



Respiratory Monitoring in Anaesthesia

Question 1:

In a patient who is scheduled for a laparoscopic cholecystectomy, which of the following cannot be used for perioperative respiratory monitoring?

a) Capnography
b) Pulse oximetry
c) Radial artery cannulation
d) Impedance pneumography

Question 2:

Which of the following is measured by the device shown in the given image?

a) Oxygen saturation
b) Oxygen content of the blood
c) Partial pressure of oxygen
d) Amount of inspired oxygen

Question 3:

While examining a patient you record low oxygen saturation on pulse oximetry. Which of the following conditions would you not suspect?

a) Severe anemia

b) Carbon monoxide poisoning

c) Increased systemic vascular resistance

d) Shock

Question 4:

Which among the following is the best device to detect abnormal hemoglobins?

a) Pulse oximeter

b) CO-oximeter

c) Capnogragh

d) Spirometer

Question 5:

A patient sustained an epidural bleed in a car accident and is brought to the ER. On examination, he has a GCS of 8 and requires immediate intubation. What would be the surest sign of correct placement of the ET tube?

a) Pulse oximeter

b) Capnography

c) Auscultation of chest and epigastrium

d) Chest radiography

Question 6:

In an intubated patient, which of the following is ideal for monitoring apnea?

a) Co- oximetry

b) Pulse – oximetry

c) Capnography

d) Impedance pulmonometry

Question 7:

In a patient being operated on, which of the following values is monitored using capnography?

- **a)** Amount of inspired oxygen
- **b)** Amount of expired oxygen
- **c)** Arterial carbon dioxide level
- **d)** Amount of expired carbon dioxide

Question 8:

You are observing the ET CO_2 monitor of the patient in the OT. Your attending asks you what the plateau phase in the waveform represents. What should be your answer?

- **a)** Air in trachea
- **b)** Air in bronchi
- **c)** Transition gases between airways and alveoli
- **d)** Alveolar air

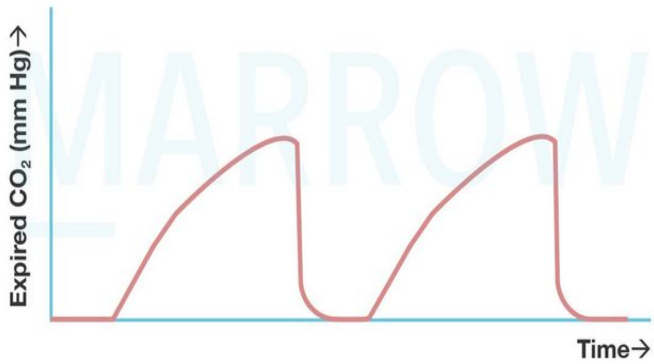
Question 9:

When a patient is being operated on, which of the following can lead to a decrease in end-tidal CO_2 ($ETCO_2$)?

- **a)** Thyrotoxicosis
- **b)** Fever
- **c)** High spinal anesthesia
- **d)** Cardiac arrest

Question 10:

A patient who is under general anaesthesia shows the following finding on the ET CO_2 monitor. Which condition can lead to this characteristic waveform on capnography?



a) Malignant hyperthermia

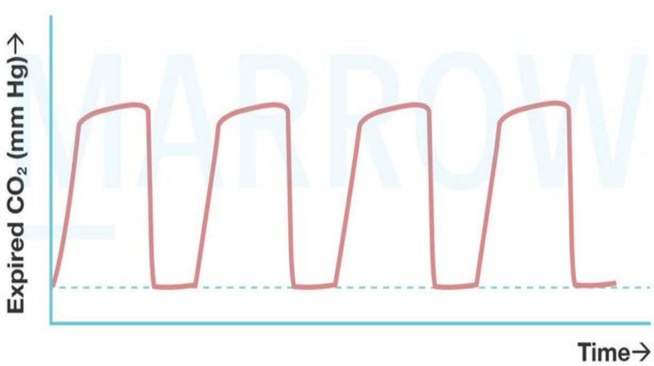
b) Bronchospasm

c) Rebreathing

d) Accidental extubation

Question 11:

In which of the following conditions does this capnographic waveform appear?



a) Malignant hyperthermia

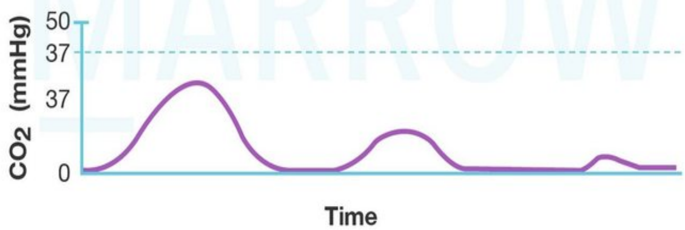
b) Bronchospasm

c) Rebreathing

d) Accidental extubation

Question 12:

In which of the following conditions does this capnographic waveform appear?



©MARROW

a) Malignant hyperthermia

b) Esophageal intubation

c) Rebreathing

d) Tracheal intubation

Question 13:

A patient with masseter spasm after succinylcholine administration shows the following pattern on capnography. What is the most likely condition causing this waveform?

©MARROW

a) Malignant hyperthermia

b) Rebreathing

c) Tracheal intubation

d) Esophageal intubation

Question 14:

The following capnographic waveform is most likely seen in which of the following conditions?

©MARROW

a) Tracheal intubation

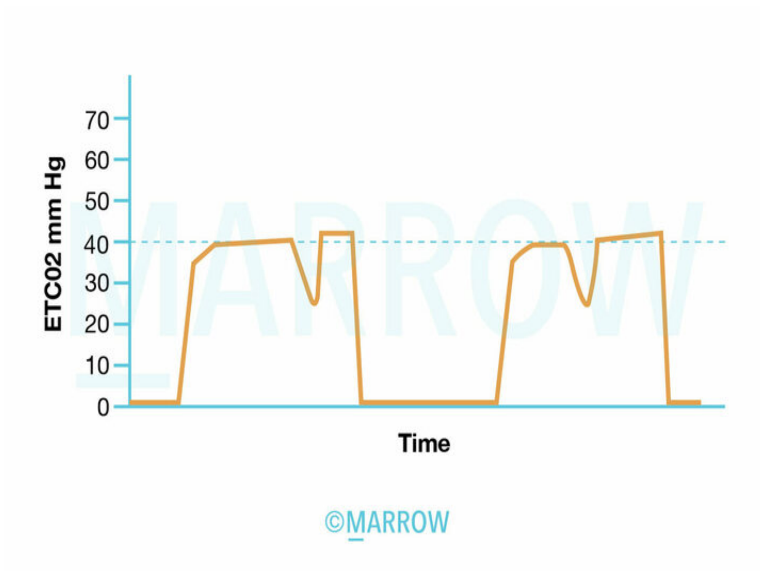
b) Malignant hyperthermia

c) Rebreathing

d) Esophageal intubation

Question 15:

A capnograph obtained from an intubated patient undergoing controlled ventilation is given below. Which of the following is a likely cause of the finding seen?



a) Esophageal intubation

b) Inspiration with cardiac oscillations

c) Bronchospasm

d) Spontaneous respiratory effort

Answer Key

Question No.	Correct Option
1	c
2	a
3	b
4	b
5	b

6	c
7	d
8	d
9	d
10	b
11	c
12	b
13	a
14	a
15	d

Detailed Explanations

Solution to Question 1:

Radial artery cannulation is an invasive method of blood pressure monitoring and cannot be used for perioperative respiratory monitoring.

Respiratory monitoring involves the use of:

• Capnography

• Pulse oximeter

• Anaesthetic gas analysis (oxygen analysis, piezo electric analysis)

• Spirometry

• Impedance pneumography is a method of monitoring apnea

Solution to Question 2:

The given image depicts a pulse oximeter. Pulse oximetry is used for monitoring pulse rate and oxygen saturation of a patient.

A small sensor is placed on the finger, toe, earlobe, or another convenient place. The relative absorption of light by oxyhemoglobin (HbO_2) and deoxyhemoglobin is assessed by measuring the amount of red and infrared light emerging from tissues traversed by light rays and processed by the device, producing an oxygen saturation level.

Pulse oximetry does not measure the absolute content or the partial pressures of oxygen or carbon dioxide.

A pulse oximeter is not always reliable as it reads:

• Falsely high - carboxyhemoglobinemia

• Falsely low - severe anemia, low cardiac output states, hypovolemia, increased systemic vascular resistance

• 80% to 85%, irrespective of the arterial oxygen saturation - methemoglobinemia

Solution to Question 3:

Carbon monoxide poisoning is associated with a falsely high O2 saturation and least likely to show low oxygen saturation values.

• Oxyhemoglobin (HbO2) absorbs more infrared light (940 nm)

• Deoxyhemoglobin absorbs more red light (660 nm)

• Carboxyhemoglobin (COHb) and HbO2 absorption spectrum is similar

• Thus in patients with carbon monoxide poisoning, a falsely high SpO2 of 95% is seen irrespective of the actual SpO2 value.

Severe anemia, low cardiac output states, hypovolemia, and increased systemic vascular resistance are associated with falsely low oxygen saturation values.

With normal SaO2, anemia has little effect on SpO2. However, in the presence of hypoxia, SpO2 readings underestimate SaO2 in anemic patients.

Solution to Question 4:

CO-oximeter is the best device to detect abnormal hemoglobins.

CO-oximeter utilizes an eight wavelength sensor (unlike pulse oximeter which uses two wavelengths) to distinguish between oxygenated blood, deoxygenated blood and blood containing CO.

CO-oximeter is useful in measuring:

• Carboxyhemoglobin

• Methemoglobin

Solution to Question 5:

End-tidal CO2 measured by capnography is the surest sign of tracheal intubation.

It also assesses the adequacy of ventilation in the perioperative period. It can rule out oesophagal intubation where initially carbon dioxide may be detected due to swallowed air but later on ceases.

It cannot reliably rule out endobronchial intubation, which is indicated by a sudden rise in peak inspiratory pressure.

Option C: Physical examination methods such as auscultation of chest and epigastrium, visualization of thoracic movement, and fogging in the tube are not sufficiently reliable to confirm endotracheal tube placement.

Options A and D: Similarly, pulse oximetry and chest radiography are not reliable as sole techniques to determine endotracheal intubation.

Solution to Question 6:

Capnography is ideal for monitoring apnea in an intubated patient.

Impedence pulmonometry is most commonly used for apnea monitoring in a non-intubated patient and is also used in home monitoring of neonatal apnea.

Pulse oximetry and CO-oximetry is used to assess oxygenation.

Solution to Question 7:

Capnography is used to measure the amount of expired carbon dioxide (end tidal CO_2).

It is used to confirm tracheal intubation and to assess the adequacy of ventilation in the perioperative period.

Arterial carbon dioxide level ($PaCO_2$) is accurately measured using arterial blood gas analysis. The gradient between $PaCO_2$ and $EtCO_2$ (normally 2–5 mm Hg) reflects alveolar dead space (alveoli that are ventilated but not perfused).

Although $EtCO_2$ reflects arterial carbon dioxide level ($PaCO_2$), any significant reduction in lung perfusion (eg, air embolism, decreased cardiac output) increases alveolar dead space, thus increasing the gradient between $PaCO_2$ and $EtCO_2$. Hence D is the best answer.

Solution to Question 8:

In a capnographic waveform, the plateau phase corresponds to alveolar air.

The normal waveform has four different phases:

Phase I: Inspiratory baseline, represents the CO_2-free gas from the airways (anatomical and apparatus dead space).

Phase II: Expiratory upstroke, mixing of dead space gas with alveolar gas.

Phase III: Alveolar plateau, represents CO_2-rich gas from the alveoli. The last of the alveolar gas is sampled to measure $ETCO_2$.

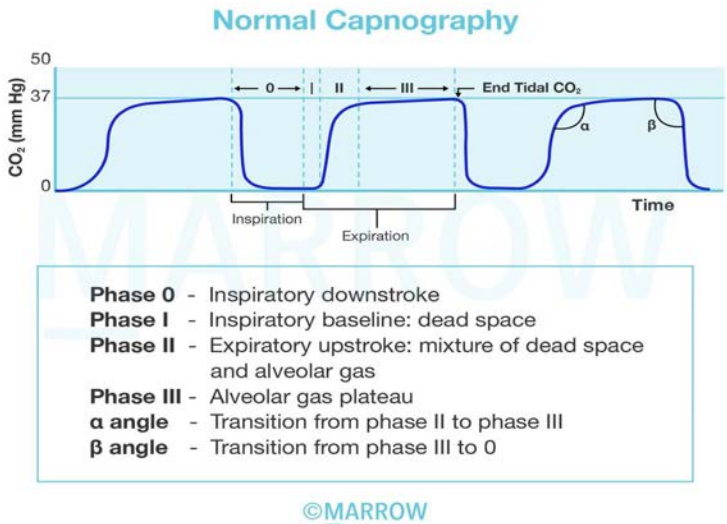
Phase 0: Inspiratory downstroke and the beginning of inspiration.

Alpha angle: The transition from phase II to III.

The alpha angle can be used to assess the ventilation/perfusion of the lung. V/Q mismatches will have an alpha angle greater than 90 degrees.

Beta angle: The transition from phase III to 0.

The beta angle can be used to assess rebreathing. If rebreathing occurs, the angle is greater than 90 degrees.



Solution to Question 9:

Fall in ETCO2 (end-tidal carbon dioxide) is seen in cardiac arrest due to decreased blood flow to the lungs.

Increased ETCO2 is seen in thyrotoxicosis, fever (increased CO2 production) and high spinal anesthesia (alveolar hypoventilation).

Factors affecting ETCO2

Increased ETCO2	Decreased ETCO2
MetabolismHyperthermiaFeverThyrotoxicosisPainShivering	MetabolismHypothermiaMetabolic acidosis
RespiratoryHypoventilationRespiratory depressionCOPDPartial airway obstructionRebreathing	RespiratoryHyperventilationTotal airway obstructionExtubation
CirculatoryIncreased cardiac output (ROSC after cardiac arrest)Hypertension	CirculatoryHypotensionCardiac arrestPulmonary emboli

Increased ETCO2	Decreased ETCO2
Apparatus malfunctionExhausted CO2absorberInadequate fresh gas flowVentilatory malfunction	Apparatus malfunctionCircuit disconnectionLeak in samplingVentilatory malfunction

Solution to Question 10:

The above capnographic waveform depicts bronchospasm.

Shark fin appearance - Prolonged phase II, increased ° angle, and steeper phase III suggest bronchospasm or airway obstruction.

Solution to Question 11:

The above capnographic waveform shows an elevated inspiratory baseline, which depicts rebreathing.

Rebreathing of CO_2 may occur due to exhausted soda lime or incompetent expiratory valve in closed-circuit breathing systems.

Option A: Malignant hyperthermia shows progressive rise in ETCO2

Option B: Bronchospasm shows a shark fin appearance

Option D: Accidental extubation shows flat ETCO2 trace

Solution to Question 12:

The image given in the question shows a capnograph with some carbon dioxide detected initially followed by absence of carbon dioxide- this is typical of esophageal intubation.

Swallowed air in the stomach would cause the initial detection of CO_2 which is soon washed out and the ETCO2 comes to zero.

Option A: Malignant hyperthermia – progressive rise in CO_2.

Option C: Rebreathing of CO_2 - elevated inspiratory baseline.

Option D: Tracheal intubation - normal capnograph.

Solution to Question 13:

The clinical features seen in the patient, associated with a capnograph with a sudden and progressive increase in ETCO2 are suggestive of malignant hyperthermia.

This is considered to be one of the earliest and most sensitive indicators of malignant hyperthermia.

Option B: Rebreathing of CO_2 would result in failure of the inspired CO_2 to return to zero in the capnograph.

Option C: Tracheal intubation would show a normal capnograph.

Option D: Esophageal intubation would initially detect some CO_2 because of swallowed air in the stomach which later returns to zero.

Solution to Question 14:

The image shown is that of normal capnography seen during controlled mechanical ventilation seen in tracheal intubation.

Option B: Malignant hyperthermia shows a progressive rise in CO_2.

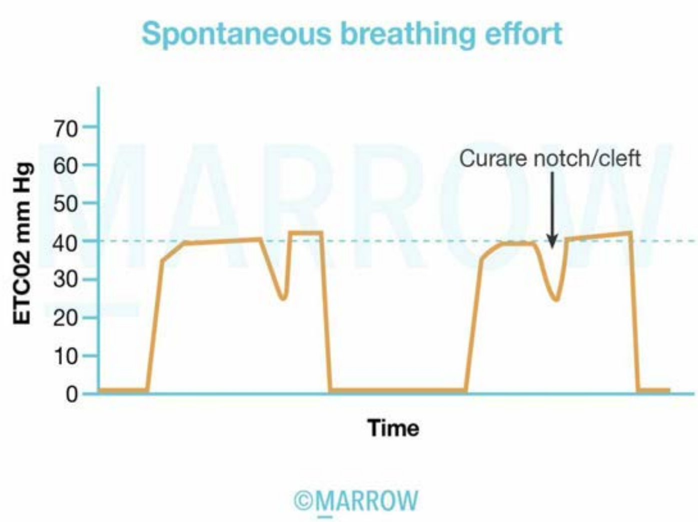
Option C: Rebreathing of CO_2 shows an elevated inspiratory baseline.

Option D: Esophageal intubation can initially detect some CO_2 which later returns to zero.

Solution to Question 15:

The curare notch in the plateau phase of the capnograph indicates that the patient is trying to breathe spontaneously. The patient's inspiratory effort causes some fresh gas to be sucked in the capnometer, resulting in a lower carbon dioxide concentration and a notch.

Image below shows a capnograph with clefts during phase III which indicates spontaneous breathing efforts by the patient during controlled mechanical ventilation. It is also known as a curare notch or cleft.



Airway Devices

Question 1:

You are a certified BLS provider showing your junior how to perform bag and mask ventilation on a mannequin. While applying the face mask, where would you place the fifth digit of your hand?

- **a)** Bridge of the nose
- **b)** The mask device
- **c)** Ramus of mandible
- **d)** Angle of mandible

Question 2:

In which of the following situations can bag and mask ventilation be performed?

- **a)** Obese individual with a difficult airway
- **b)** Emergency laparotomy requiring rapid sequence induction
- **c)** Severe facial trauma
- **d)** Diaphragmatic hernia following blunt trauma to chest

Question 3:

You are a resident posted in the medicine ward. A patient who has been previously diagnosed with epilepsy has an episode of seizures and becomes unconscious. You immediately call a code. The patient is unresponsive and chest rise is not appreciable but you can feel a pulse. You suspect that this is due to falling back of the tongue and decide to secure the airway using the device shown. What landmarks would you use before selecting the appropriate size?

a) Incisor teeth and tragus of the ear

b) Corner of mouth and angle of mandible

c) Tip of nose and angle of mandible

d) Ala of nose and angle of mandible

Question 4:

Which of the following statements is true regarding the airway adjunct shown in the image given below?

a) It is used only in unconscious patients

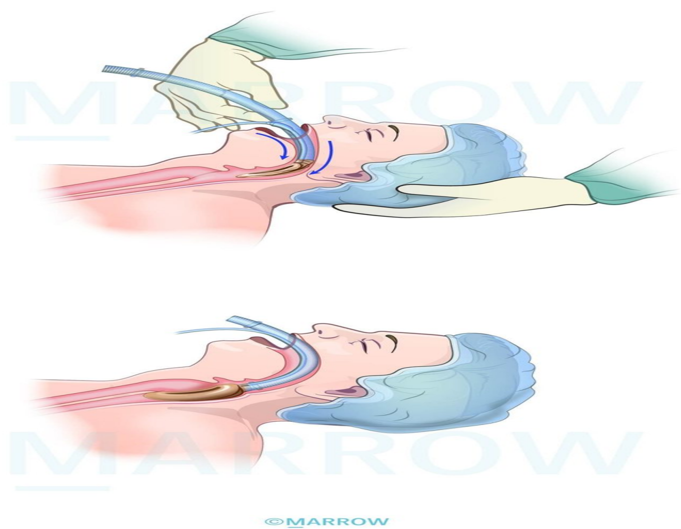
b) Prevents falling back of tongue post-extubation

c) Prevents tongue bite during seizure activity

d) Can be used in patients with central facial fracture

Question 5:

The image shown below is the technique of insertion of?



a) Oropharyngeal airway

b) Nasopharyngeal airway

c) Laryngeal mask airway

d) Endotracheal tube

Question 6:

What size LMA would you choose for a man weighing 75 kgs?

a) 3

b) 4

c) 4.5

d) 5

Question 7:

Laryngeal mask airway of size 3 would be appropriate for a person with a weight of _________.

a) 3 kg

b) 10 kg

c) 30 kg

d) 70 kg

Question 8:

In which of the following patients would you prefer to use an LMA for securing the airway?

a) A term G2P1L1 woman previously diagnosed with pre-eclampsia planned for elective Cesarean section

b) A 30-year-old patient to be taken up for repair of hiatus hernia

c) A middle-aged man with a history of diabetes diagnosed with pharyngeal abscess

d) A 40-year-old woman planned for laparoscopic cholecystectomy, having Mallampatti class III airway

Question 9:

A 55 year old woman, presents to the pre-anaesthetic clinic. She has been advised to undergo an elective laparoscopic hysterectomy. On further evaluation, her BMI is calculated to be 31 and she has a Mallampatti class III airway. The anaesthetist then decides that a Proseal laryngeal mask airway would be ideal for this patient. Identify the false statement about this device?

a) Single use second generation airway device

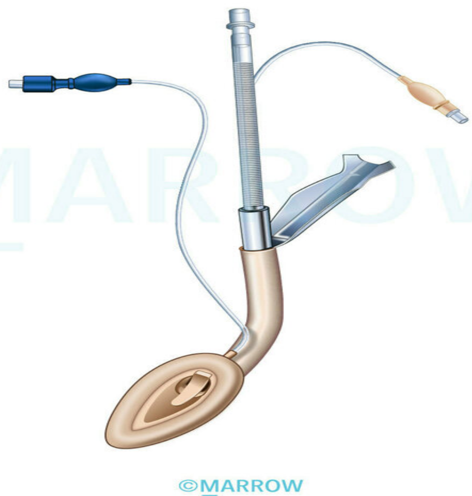
b) Built in bite-block

c) Gastric drainage tube to remove secretions

d) Can be used in surgery requiring prone position

Question 10:

What is the advantage of the following device?



a) Has a port for orogastric tube

b) Can facilitate endotracheal intubation

c) Ideal for infants alone

d) Suction tube to remove secretions

Question 11:

Laryngeal mask airway has the following advantages over endotracheal intubation except ______.

a) Less invasive

b) Muscle relaxation not required

c) Low risk of laryngeal trauma

d) Low risk of aspiration

Question 12:

Which of the following is the most common complication following the use of a laryngeal mask airway?

a) Recurrent laryngeal nerve palsy

b) Damage to the teeth

c) Sore throat

d) Lingual nerve palsy

Answer Key

Question No.	Correct Option
1	d
2	a
3	b
4	b
5	c
6	d
7	c
8	d
9	a
10	b
11	d
12	c

Detailed Explanations

Solution to Question 1:

The fifth digit of the hand should be placed at the angle of mandible while holding a face mask.

One hand technique: C-E technique

One hand technique: C-E technique

The anesthetist holds the mask in his left hand using C-E technique. C is formed by the thumb and the index finger, and E is formed by the remaining 3 fingers.

• The thumb and index fingers form a C around the collar of the connector

• The third and fourth digits are placed on the body of the mandible

• The fifth digit is placed on the angle of the mandible

The thumb and index finger ensure a tight mask seal, while the remaining digits provide jaw thrust to aid with airway patency.

Solution to Question 2:

Bag and mask ventilation can be performed in patients with difficult airway.

Bag and mask ventilation serves as a rescue technique to provide oxygenation and ventilation in patients with difficult airway until tracheal intubation is achieved.

Contraindications of bag and mask ventilation:

Patients at greater risk of aspiration such as patients with diaphragmatic hernia and those undergoing rapid sequence induction and intubation. This is because air can enter the stomach leading to raised intragastric pressure which increases the risk of aspiration.

Mask ventilation should also be performed with caution in patients with severe facial trauma and in patients in whom head and neck manipulation must be avoided (e.g., those with an unstable cervical spine fracture).

Solution to Question 3:

The image shows oropharyngeal airway or Guedel airway of various sizes. The landmarks used for measuring the appropriate size of this device are the corner of the mouth and the angle of the mandible or tragus.

An oropharyngeal airway is an airway adjunct which keeps the tongue from falling back onto the posterior pharynx.

It is essential to choose the correct size since inappropriately sized ones may aggravate airway obstruction.

These airways should not be used in conscious patients as they may come into contact with the epiglottis and base of tongue. This can cause coughing, retching or laryngospasm if the pharyngeal and laryngeal reflexes are not blunted with local anaesthetic.

Note: Nasopharyngeal airway size is chosen by measuring the distance between the tip of the nose and tragus of the ear. These airways, when well lubricated and inserted with proper technique, can be used in conscious patients to secure an airway.

Solution to Question 4:

The image shows nasopharyngeal airway and its insertion. The true statement is that it is used to prevent falling back of tongue post-extubation especially in obese patients.

Nasopharyngeal airways are less stimulating than oropharyngeal airways as it bypasses the gag reflex. Thus, it can be used in conscious patients as well.

It does not prevent tongue bite unlike the oropharyngeal airway which has a bite block. It can prevent falling back of the tongue in patients with seizures.

It is contraindicated in

• Basilar skull fractures, central facial fractures, CSF rhinorrhea - risk of meningitis

• Patients on anticoagulants, coagulopathies, epistaxis - risk of bleeding

• Relatively contraindicated in pregnancy (increased vascularity leading to bleeding), deformity of the nose.

Solution to Question 5:

The image shown above is the technique of insertion of laryngeal mask airway.

Laryngeal mask airway (LMA) is a supraglottic airway device that is positioned in the hypopharynx.

Classic Laryngeal Mask Airway

Supraglottic airway devices are used with both spontaneously and ventilated patients during anesthesia.

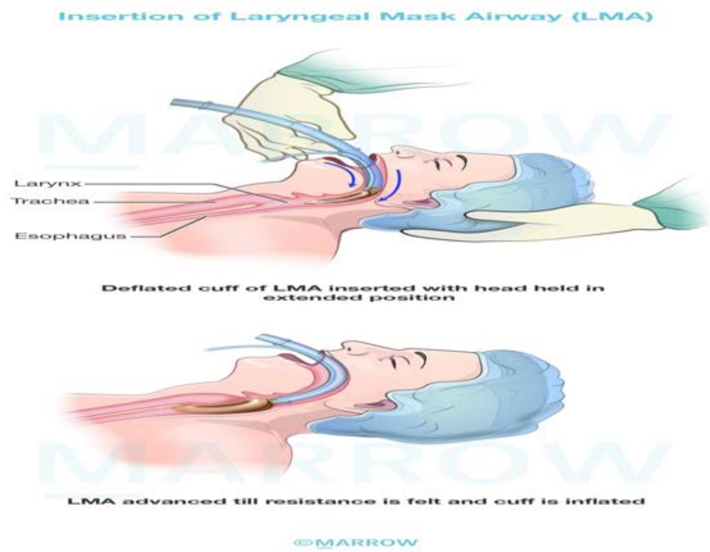
LMA has advantages of being used in many settings, including the operating room (alternate route of ventilation), the emergency department (difficult intubation), and out-of-hospital care (paramedics).

This is because it is easy to use, quick to place even for the inexperienced provider and has a very high success rate.

The technique of insertion:

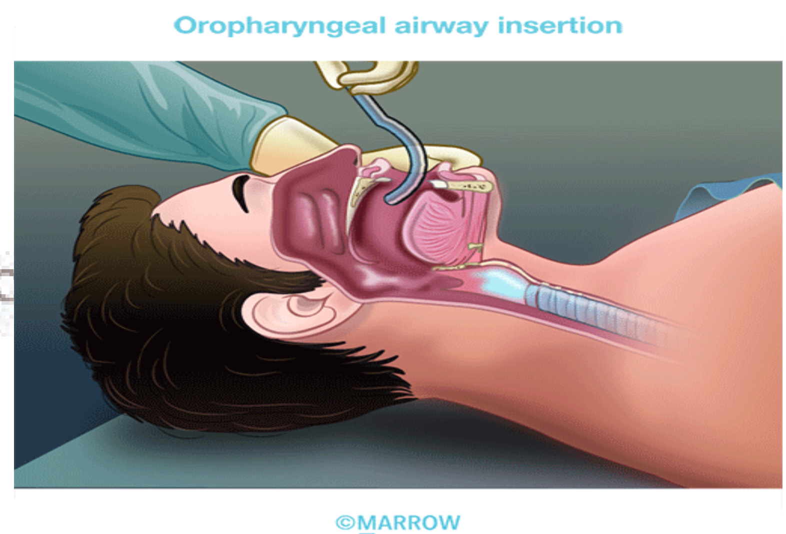
• The deflated cuff of LMA is lubricated and inserted blindly into the hypopharynx so that, once inflated, the cuff forms a low-pressure seal around the entrance to the larynx.

• Correct placement of the tube is confirmed by giving gentle positive pressure ventilation while checking for chest rise and ETCO2 using capnography.



Note:

Oropharyngeal airway: inserted in the patient's mouth with concavity towards hard palate. As the airway is inserted it is rotated 180 degrees (concavity towards the tongue) until the flange comes to rest on the patient's lips.



Nasopharyngeal airway: inserted through the nostril (after lubrication) along the natural curvature of the floor of the nasal cavity with the bevel pointing towards the septum. Once the device is inserted the flange should rest on the nostril opening.

Endotracheal tube: inserted infraglottically after visualising the vocal cords with direct laryngoscopy.

Solution to Question 6:

The appropriate size of laryngeal mask airway for a man weighing 75 kg is 5.

Laryngeal mask airway is a supraglottic airway device, which is placed in the hypopharynx and protects the larynx from pharyngeal secretions.

Solution to Question 7:

Laryngeal mask airway of size 3 would be most appropriate for individuals weighing about 30 kgs.

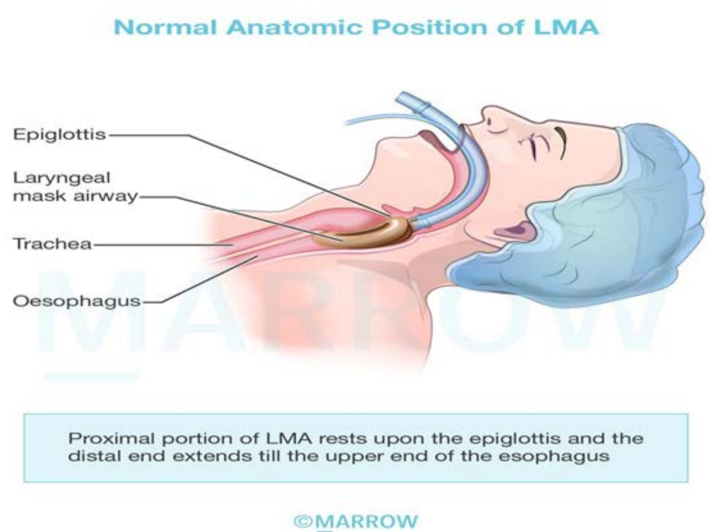
Solution to Question 8:

Laryngeal mask airway (LMA) is indicated in cases with difficult airway where endotracheal intubation is not possible or not available. It can be used as an alternative to an endotracheal tube for ventilating and oxygenating the patient.

LMA is relatively contraindicated in conditions that are associated with increased risk of aspiration (e.g.: Hiatal hernia, pregnancy, inadequate NPO). LMA may protect the larynx from pharyngeal secretions but not from gastric secretions. The presence of a pharyngeal pathology such as an abscess or tumor, or a pharyngeal obstruction is also a relative contraindication of LMA insertion.

The normal anatomic position of the LMA.

The proximal portion of the LMA rests upon the epiglottis, whereas the distal end or, the tip extends into the pharynx at the upper end of the esophagus. The opening on the laryngeal mask overlies the laryngeal inlet.

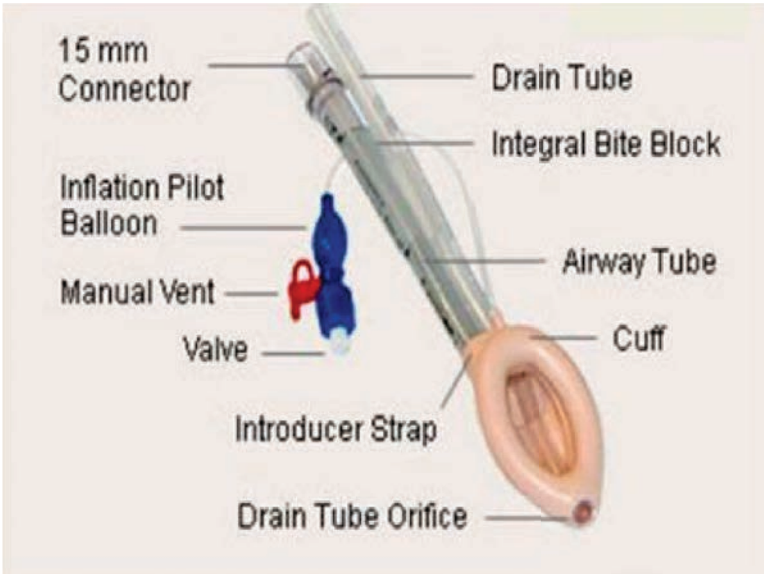


Solution to Question 9:

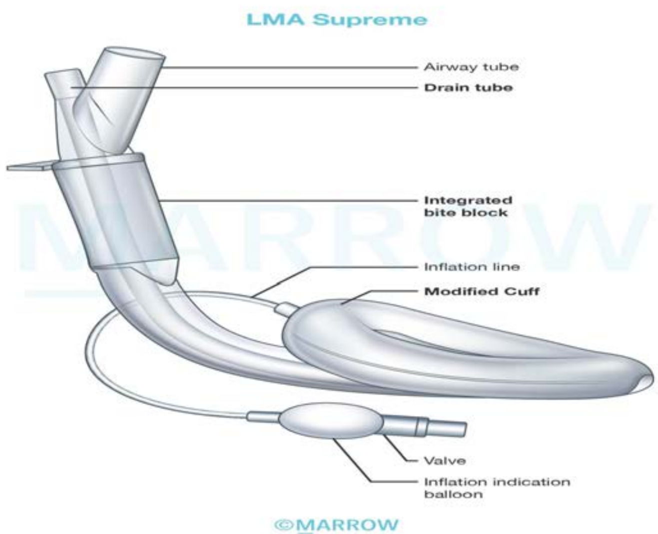
Proseal laryngeal mask airway (LMA) is a re-usable second-generation supraglottic airway device, not a single-use device.

It also has an integrated bite block, a drainage tube to remove gastric secretions, and an improved cuff design. This reduces the risk of aspiration.

Hence it may be suitable in non-supine positions (e.g., lateral, prone), laparoscopic surgery (e.g., cholecystectomy, gynaecological surgery), and in patients who are obese.



All these features are also present in LMA Supreme, except that it is a single-use second generation supraglottic device.

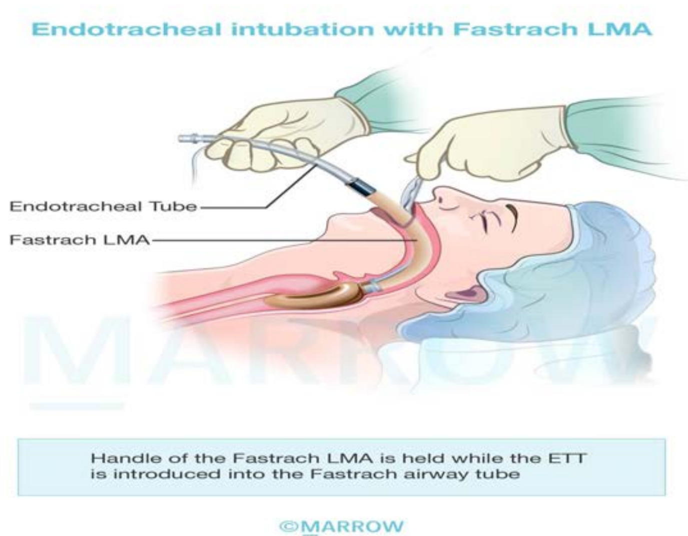


Solution to Question 10:

The image shown above is the Fastrach laryngeal mask airway (LMA) or intubating LMA with an endotracheal tube within its lumen.

It has a distinct advantage over other LMA designs as it can facilitate endotracheal intubation through the LMA device.

It has a rigid handle and an epiglottis elevator.



LMA Proseal and LMA Supreme are second-generation LMA devices that have integrated bite blocks, an orogastric tube to remove gastric secretions, and an improved cuff design.

Solution to Question 11:

There is an increased risk of aspiration of gastric contents with laryngeal mask airway.

The laryngeal mask airway (LMA) is a supraglottic airway device that sits in the hypopharynx and partially protects the larynx from pharyngeal secretions, but not gastric regurgitation.

Advantages:

• Easy and rapid

• Less invasive

• Better hemodynamic stability

• Very useful in difficult intubations

• Less tooth and laryngeal trauma

• Does not require muscle relaxation

• Does not require neck mobility

Disadvantages:

• Increased risk of gastrointestinal aspiration

• Less safe in prone or jack-knife positions

• Less secure airway

• Greater risk of gas leak and pollution

• Can cause gastric distention

Solution to Question 12:

Sore throat is the most common symptom following the use of a laryngeal mask airway with an incidence of 10-20%.

Injury to the lingual, hypoglossal, and recurrent laryngeal nerves are rare.

These complications can be minimized by using an adequate sized device and avoiding high cuff pressures.

Intubation

Question 1:

In what position would you place a patient prior to direct laryngoscopy?

a) Cervical flexion with atlanto-occipital flexion

b) Cervical extension with atlanto-occipital extension

c) Cervical flexion with atlanto-occipital extension

d) Cervical extension with atlanto-occipital flexion

Question 2:

You are the 2nd year Anaesthesia PG on call. You are paged to the COVID ICU. A 50 year old patient who was on non-invasive ventilation is desaturating rapidly. The anaesthetist instructs you to intubate the patient with an endotracheal tube. What is the most commonly used laryngoscopic blade for this procedure?

a) Miller

b) Macintosh

c) Wisconsin

d) Magill

Question 3:

Sara, a 6 year old child, was brought to the ER by her parents with a history of fever, cough, and body pain for the past 3 days. On examination, she was lethargic and had difficulty in breathing. She was desaturating despite trying non-invasive positive pressure ventilation. What is the most appropriate next step of management in this scenario?

a) Intubation using Miller's blade

b) Needle cricothyrotomy

c) Intubation using Macintosh blade

d) Percutaneous transtracheal jet ventilation

Question 4:

In which of the following devices is Murphy's eye seen?

a) Nasopharyngeal airway

b) Laryngoscope

c) Bronchoscope

d) Endotracheal tube

Question 5:

Appropriate sized endotracheal tube for an adult is _______.

a) 3.5

b) 5.5

c) 6.5

d) 7.5

Question 6:

A 4 year old child is brought to the casualty in respiratory distress. In order to intubate this child, which is the appropriate size of endotracheal tube to be used?

a) 4 mm

b) 5 cm

c) 4 cm

d) 5 mm

Question 7:

A 6-year-old child requires endotracheal intubation. Which is the correct length of the tube to be chosen?

a) 6 cm

b) 10 cm

c) 12 cm

d) 15 cm

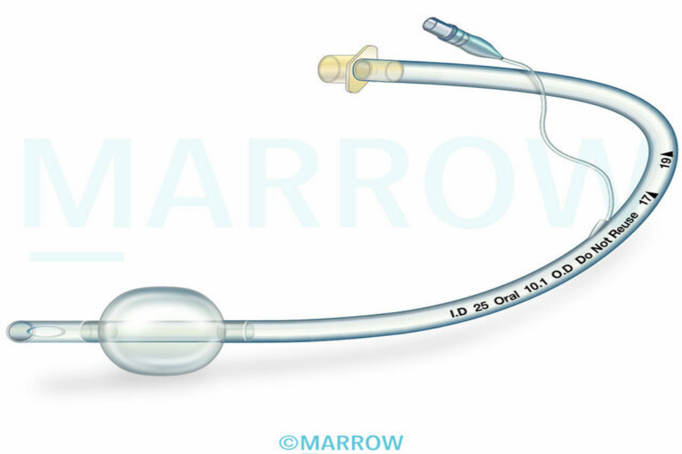
Question 8:

A 60-year-old patient is being taken up for a cervical discectomy. The surgeon had planned a posterior approach that required the patient to lie in a prone position under anesthesia. What is the advantage of the armored endotracheal tube required for this procedure?

- **a)** Longer length
- **b)** LASER resistance
- **c)** Less kinking
- **d)** Double lumen

Question 9:

What procedure is the following device most suitable for?



- **a)** Head and neck surgery
- **b)** Nasal surgery
- **c)** Laryngeal surgery
- **d)** Thoracic surgery

Question 10:

Which of the following is the most preferred type of cuff of an endotracheal tube?

- **a)** Low volume, low pressure
- **b)** High volume, high pressure
- **c)** Low volume , high pressure

d) High volume , low pressure

Question 11:

What is the maximum cuff pressure that you can use to inflate the cuff of an endotracheal tube?

a) 5 cm of water

b) 15 cm of water

c) 25 cm of water

d) 35 cm of water

Question 12:

Which of the following situations is least suitable for performing nasotracheal intubation?

a) A 35 year old patient with unstable c-spine injury requiring awake intubation

b) A 60 year old man with a tumor of the oral cavity

c) A 28 year old woman with fracture of ramus of mandible

d) A 40 year old man with fracture of the base of skull

Question 13:

A 40-year-old man was being prepared for an emergency laparotomy and an endotracheal tube was inserted. Following intubation, end-tidal carbon dioxide was detected. However, his oxygen saturation dropped to 60% and breath sounds were not audible over the left hemithorax. What could be the cause of this?

a) Endobronchial intubation into left main bronchus

b) Esophageal intubation

c) Endotracheal tube blockage

d) Endobronchial intubation into right main bronchus

Question 14:

A 3-year-old unconscious child, is rushed to the ER. She is found to have complete upper airway obstruction. An emergency invasive airway procedure is planned to save her. Which among the following cannot be performed?

a) Endotracheal intubation

b) Retrograde intubation

c) Needle cricothyrotomy

d) Percutaneous transtracheal jet ventilation

Question 15:

A 26-year-old term primigravida is taken to the operation theatre for an emergency cesarean section due to sudden fetal distress. The anaesthetist wants to prevent chances of pulmonary aspiration and decides to intubate using rapid sequence intubation. Which of the following steps is not performed in this technique?

a) Preoxygenation

b) Cricoid pressure

c) Bag and mask ventilation

d) Propofol infusion

Question 16:

The time required for preoxygenation before tracheal intubation?

a) 1 min

b) 3 min

c) 5-7 min

d) 5 min

Question 17:

A case of hiatus hernia is posted for surgery. What will be ideal choice of muscle relaxant that will be used for intubation?

a) Rocuronium

b) Succinylcholine

c) Vecuronium

d) Cisatracurium

Question 18:

Which of the following local anaesthetic is commonly used in topicalization of airway for awake intubation?

- **a)** Bupivacaine
- **b)** Benzocaine
- **c)** Prilocaine
- **d)** Lidocaine

Question 19:

What is the commonly used local anaesthetic for awake nasotracheal intubation of a patient set to undergo maxillofacial surgery?

- **a)** Cocaine
- **b)** Lidocaine
- **c)** Benzocaine
- **d)** Bupivacaine

Question 20:

Glycopyrrolate is used as a pre-anesthetic agent for:

- **a)** Reducing the secretions
- **b)** Sedative effect
- **c)** Skeletal muscle relaxant
- **d)** Anxiolytic

Question 21:

The given set of instruments are used in:

a) Central line insertion

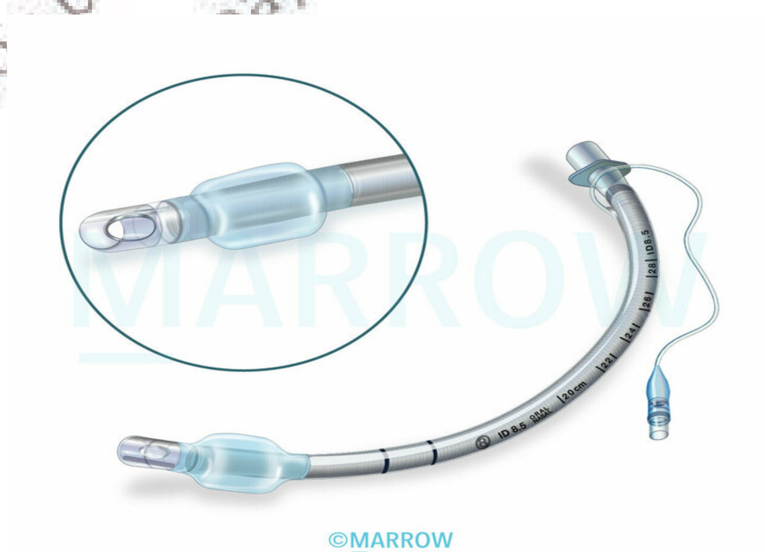
b) Arterial line insertion

c) Airway management

d) Umbilical catheter insertion

Question 22:

The following endotracheal tube is preferred for _________



a) Head and neck surgery

b) Nasal surgery

c) Laryngeal surgery

d) Thoracic surgery

Question 23:

Which of the following is an indicator of endobronchial intubation?

a) Sudden Rise in end tidal Carbon dioxide

b) Sudden fall in end tidal carbon dioxide

c) Sudden rise in peak inspiratory pressure

d) Bilateral breath sounds

Answer Key

Question No.	Correct Option
1	c
2	b
3	a
4	d
5	d
6	d
7	d
8	c
9	b
10	d
11	c
12	d
13	d
14	a
15	c
16	b
17	a
18	d
19	b
20	a

21	c
22	a
23	c

Detailed Explanations

Solution to Question 1:

Prior to direct laryngoscopy and intubation, the patient is placed in the sniffing position, which consists of flexion at the lower cervical spine with extension at the atlanto-occipital joint.

This is to ensure a line of sight from the mouth to the larynx so that intubation can be performed with ease.

Cervical flexion of 35 degrees is provided by elevating the patient's head by 7-9 cm (folded sheet under the head). This aligns the pharyngeal and laryngeal axes.

Atlanto-occipital extension is provided by the head tilt. This brings into alignment the visual axis of the mouth with that of pharyngeal and laryngeal axes.

Adequacy of head elevation can be estimated by checking the horizontal alignment between external auditory meatus and sternal notch.

Solution to Question 2:

The most commonly used laryngoscopic blade for endotracheal intubation in adults is Macintosh.

Laryngoscopic blades can be:

Macintosh - curved laryngoscopic blade. It is preferred for use in adults.

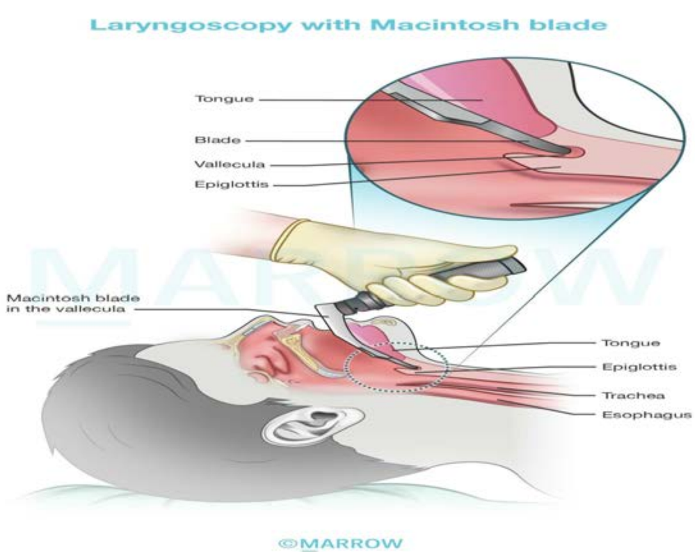
Miller - straight laryngoscopic blade. It is used in

• Neonates, infants and young children

• Adults with short thyromental distance and long floppy epiglottis.

The advantage of a curved Macintosh blade is that there would be greater room available for the passage for an endotracheal tube and significantly less damage to the teeth.

Macintosh laryngoscopic blade

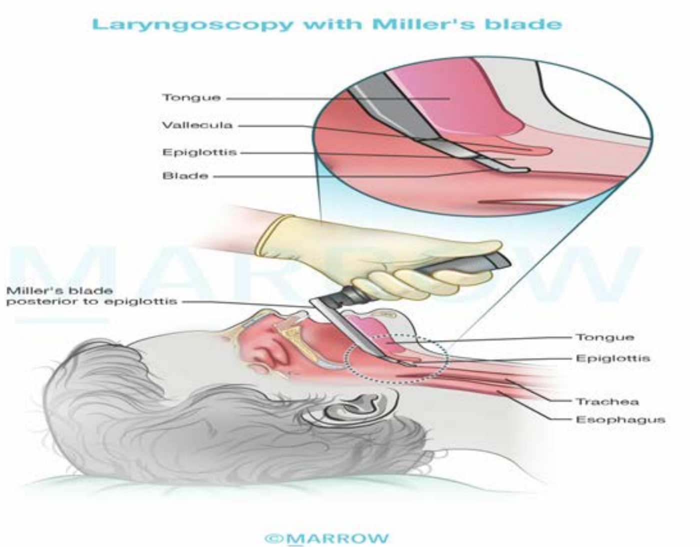


Solution to Question 3:

The next step of management in this scenario would be attempting to secure the airway by endotracheal intubation. The most commonly used laryngoscopic blade for endotracheal intubation in infants and young children is Miller's laryngoscopic blade.

Macintosh laryngoscopic blade is preferred in adults. Needle cricothyrotomy and percutaneous transtracheal jet ventilation are invasive airway accesses and are only performed when intubation fails.

Miller's laryngoscopic blade

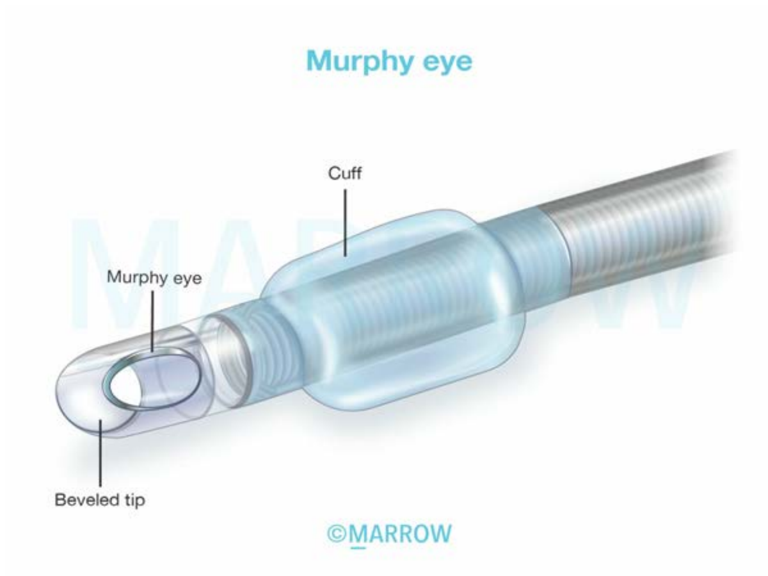


Solution to Question 4:

Murphy's eye is seen in the endotracheal tube (ETT).

Murphy's eye refers to the distal opening in the side wall of the ETT.

If the distal end of the lumen of the tube is blocked by secretions, Murphy's eye serves to provide an alternate route for ventilation.



Solution to Question 5:

Appropriate sized endotracheal tube for an adult is 7.5 mm.

Size of an endotracheal tube usually refers to the internal diameter in mm.

Usually a 7-7.5 mm is used for women and an 7.5-9 mm ETT is used for men.

Solution to Question 6:

Appropriate size of an endotracheal tube for a 4 year old child is 5mm.

Size of an endotracheal tube usually refers to the internal diameter in mm.

According to the Penlington formula, size of the endotracheal tube in the pediatric population is calculated by:

<6 years: 3.75 + [Age/3]

>6 years: 4.5 + [Age/4]

The appropriate size of the endotracheal tube for this child is 5 mm (3.75 + [4/3]) = 3.75 + 1.33 = 5.05.

Age	Internal diameter (mm)	Length (cm)
Full term infant	3.5	12
Child	4+(Age/4)	12+ (Age/2)
Adult female	7.0–7.5	20-22

Age	Internal diameter (mm)	Length (cm)
Adult male	7.5–9.0	22-24

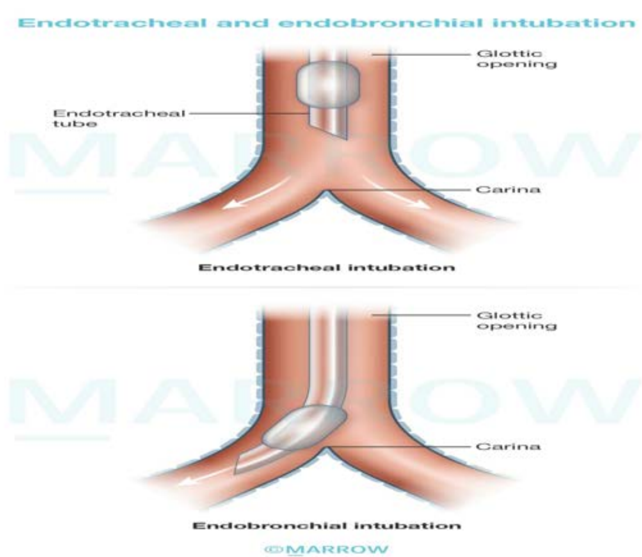
Solution to Question 7:

The appropriate length of the endotracheal tube for a 6-year-old child is 15 cm.

The formula to estimate endotracheal tube length is: 12 + (Age/2) = Length of tube (in cm)

If the ETT is inserted too deep, it can lead to endobronchial intubation. If inserted too shallow, it can lead to accidental extubation.

An adequate sized tube should be placed with its tip midway between the vocal cords and the carina.



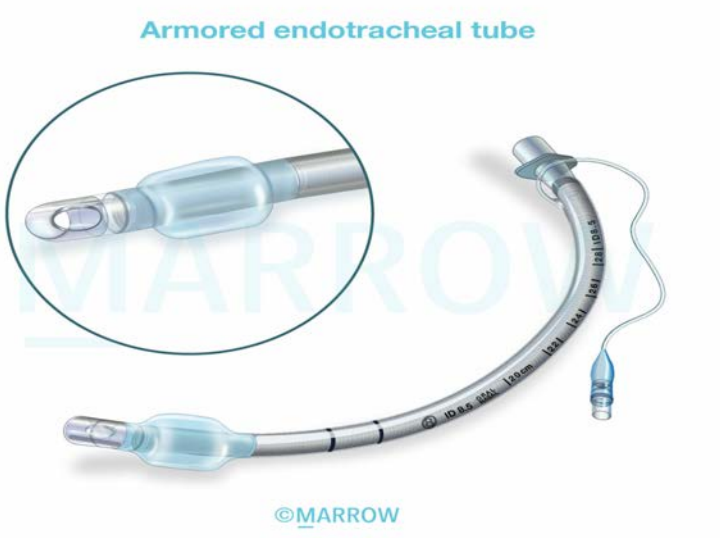
Solution to Question 8:

The advantage of an armored endotracheal tube is less kinking.

Armored tubes (a.k.a. reinforced tubes, flexo-metallic tubes) are flexible, spiral wound tubes that are reinforced with metal coils. This minimizes kinking of the tube.

They are useful in surgeries of head and neck and surgeries performed with the patient in the prone position.

Armored or Flexo-metallic endotracheal tube:



Other specialized endotracheal tubes include:

• Microlaryngeal tubes: have smaller internal diameters and longer lengths which makes them useful for laryngeal surgeries.

• Metal tubes: are LASER resistant and are used for laser airway surgery to reduce fire hazards.

• Double-lumen tubes: have two lumens (tracheal and bronchial) to facilitate lung isolation and one-lung ventilation in thoracic surgeries.

Solution to Question 9:

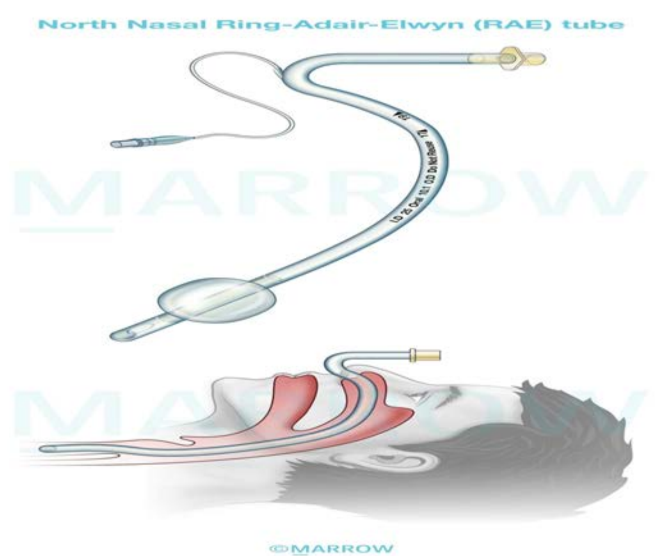
The device shown in the image is the south oral Ring-Adair-Elwyn (RAE) endotracheal tube.

It is preferred for nasal and ophthalmic surgeries because it has a preformed right-angle bend at the level of the teeth so that it does not disrupt the surgical field.

The image below shows south faced oral RAE tube used for surgery.

The image below shows a north nasal RAE tube.

It is preferred in oral surgeries as the tube connector faces towards the patient's head after placement, and the surgical field is not disrupted.



Other specialized endotracheal tubes and their uses:

- Flexometalllic (Armored or reinforced tubes): head and neck surgery
- Microlaryngeal tubes: laryngeal surgery
- Double-lumen endotracheal tubes: thoracic surgery

Solution to Question 10:

The most preferred type of cuff of an endotracheal tube is high volume, low pressure.

Advantage of high-volume, low-pressure cuff is lesser incidence of tracheal mucosal damage.

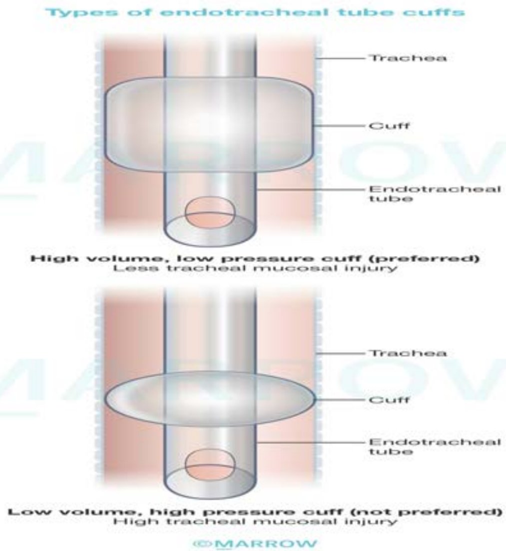
Disadvantages of high-volume, low-pressure cuff include:

• Sore throat (due to larger mucosal contact area)

• Aspiration

• Spontaneous extubation

• Difficulty in insertion (because of the floppy cuff)



Solution to Question 11:

Cuff pressure should not exceed 25 cm of H_2O since excess cuff pressure can lead to tracheal mucosal injury and recurrent laryngeal nerve palsy.

Cuff should be inflated to the minimum volume at which no air leak is seen.

If nitrous oxide is used in general anesthesia, then cuff pressure should be monitored periodically as nitrous oxide can diffuse into the cuff causing the cuff pressure to rise.

Solution to Question 12:

Nasotracheal intubation is contraindicated in base of skull fractures as there is a chance for the tube to enter the cranial vault.

The nasotracheal route is preferred in the following:

• When intubation via the oral route is difficult or not possible - large oral cavity tumors or abscess, conditions restricting mouth opening like temporomandibular joint ankylosis, fracture mandible etc.

• Surgeries of the oral cavity

• Awake intubation as it bypasses the gag reflex and is more tolerable by a conscious patient.

Solution to Question 13:

Detection of end-tidal CO_2 but dropping oxygen saturation with absent breath sounds over the left hemithorax points to endobronchial intubation into the right main bronchus.

Signs of endobronchial intubation:

• Elevated peak inspiratory pressure (first sign)

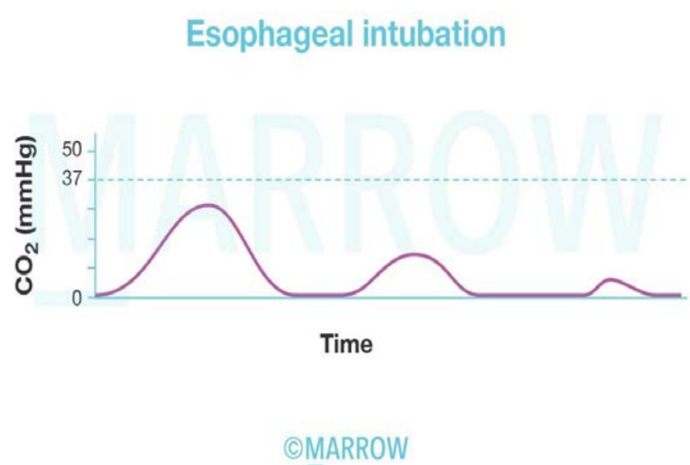
• Asymmetric chest expansion

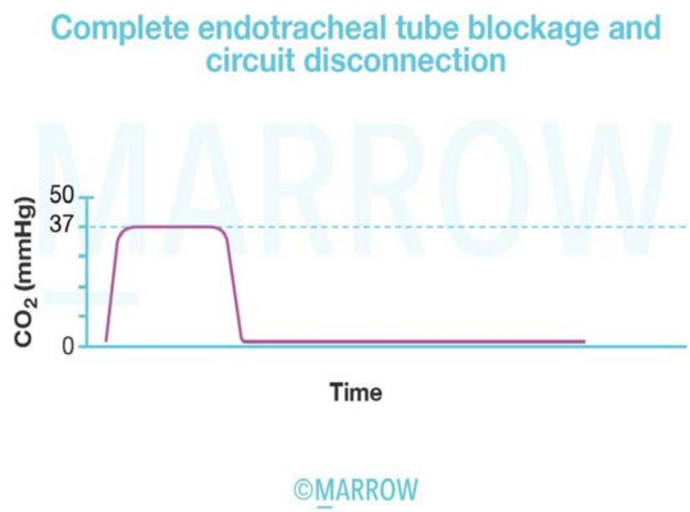
• Unilateral breath sounds

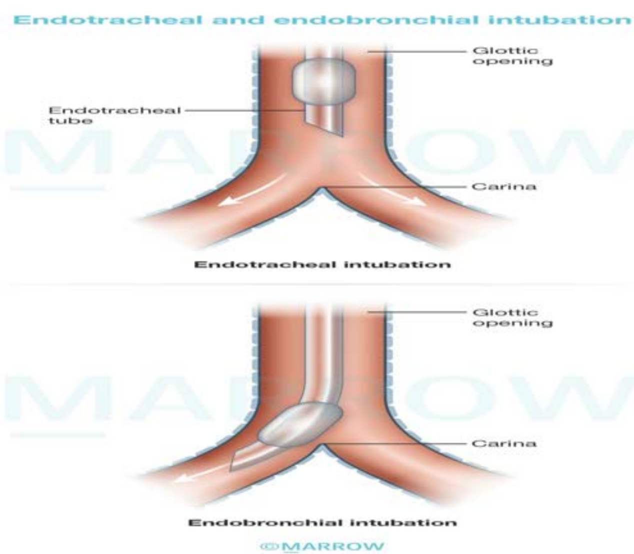
• Drop in oxygen saturation

Capnography and detection of end-tidal CO_2, though the surest confirmation for an advanced airway placement, does not differentiate endotracheal from endobronchial intubation.

Esophageal intubation: initial end-tidal CO_2 may be detected due to swallowed air but later becomes zero. There would be the absence of breath sounds bilaterally with the presence of breath sounds in the epigastrium.







Solution to Question 14:

Endotracheal intubation cannot be performed in this patient due to complete upper airway obstruction.

Contraindications of endotracheal intubation:

• Severe airway obstruction or trauma (critical airway obstruction).

• Fractures of the jaw or skull.

• Presence of a laryngeal tumour.

Note :

In this case, invasive airways such as needle cricothyrotomy and percutaneous transtracheal jet ventilation are preferred to secure the airway when the obstruction is above the level of the vocal cords.

If the obstruction is either partial or more distal to the vocal cords, intubation can be attempted to secure the airway. This pushes the foreign body towards one of the bronchi such that there is ventilation from the unobstructed opposite side. Then the foreign body can be extracted by endoscopic removal.

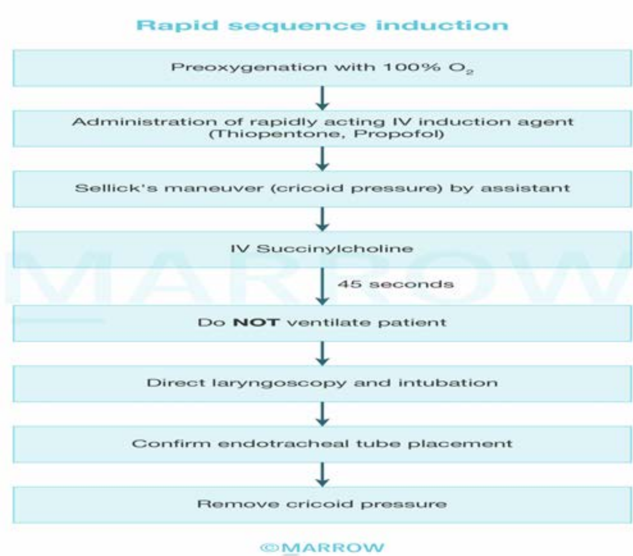
Solution to Question 15:

Bag and mask ventilation is avoided in rapid sequence intubation because it leads to stomach inflation and increases the risk of aspiration.

Indications of Rapid sequence intubation:

RSI is done when the patient is at increased risk of pulmonary aspiration as in:

- pregnancy
- full stomach
- intestinal obstruction
- hiatus hernia
- encephalopathy
- morbid obesity
- diabetic gastroparesis.



Solution to Question 16:

Preoxygenation with tidal volume breathing of 3 mins is required before tracheal intubation.

Preoxygenation or denitrogenation is the process of replacing nitrogen in the lungs with oxygen.

This delays the onset of critical hypoxia during the period of apnea by 5-8 minutes.

This lengthened apnea time provides an improved margin of safety while the anesthesiologist secures the airway and resumes ventilation.

Solution to Question 17:

Rapid sequence intubation for a patient with a hiatus hernia should be facilitated by the use of a non-depolarizing muscle relaxant such as rocuronium, to prevent an increase in the intragastric pressure (IGP).

Succinylcholine is usually the muscle relaxant of choice for RSI since it has a rapid onset and short duration of action. However, regurgitation and aspiration of gastric contents are likely, due to fasciculations of the abdominal skeletal muscles. Hence, endotracheal intubation may be facilitated with rocuronium before succinylcholine to decrease this risk.

Generally, an IGP > 28 cm H2O is required to overcome the competence of the gastroesophageal junction. However, when the normal oblique angle of entry of the esophagus into the stomach is altered, the IGP required for regurgitation is much lesser.

Conditions that predispose to raised IGP are:

• Pregnancy

• Ascites

• Bowel obstruction

• Hiatus hernia

Solution to Question 18:

Lidocaine is the local anesthetic of choice to provide topical anesthesia of airway prior to awake intubation. It is preferred since it has a rapid onset and a high therapeutic index.

Bupivacaine is not formulated for topical use.

Benzocaine and Cetacaine (a topical application spray containing benzocaine, tetracaine, and butamben) had been used but greater incidence of methemoglobinemia due to benzocaine has discouraged their use.

Prilocaine is usually available as a combination with lidocaine in Eutectic mixture of local anesthetic (EMLA) to provide topical anesthesia to intact skin.

Solution to Question 19:

Nowadays, a mixture of Lidocaine 3% and Phenylephrine 0.25% is most commonly used in awake nasotracheal intubation. This is used in addition to conscious sedation with low doses of midazolam and fentanyl. Phenylephrine is added to this mixture due to its vasoconstrictive property.

Option A : Topical cocaine has vasoconstricting properties and hence is ideal for anesthesia of the nasal mucosa during awake nasotracheal intubation. However, its use has been discouraged due to toxicity and abuse potential.

Option C : Benzocaine and Cetacaine (a topical application spray containing benzocaine, tetracaine, and butamben) was previously used but a greater incidence of methemoglobinemia due to benzocaine has discouraged its use.

Option D : Bupivacaine is not formulated for topical use.

Solution to Question 20:

Glycopyrrolate is used as a pre-anesthetic agent for reducing the secretions.

Anticholinergic drugs e.g. atropine, glycopyrrolate are routinely administered with anticholinesterases in order to attenuate the undesirable muscarinic effects. Glycopyrrolate is usually preferred because it has less vagolytic effects than atropine at doses that inhibit secretions and does not cross the blood-brain barrier. It should be administered as early as possible to maximize its effectiveness.

Glycopyrrolate 0.2 mg IV, is administered to dry airway secretions before flexible scope intubation of the trachea, during the bronchoscopic examination.

Solution to Question 21:

The image shows a tray in an airway cart with the instruments necessary for airway management.

An airway cart may include:

• Laryngoscope blades of various sizes, including a rigid fibreoptic.

• Tracheal tubes of various sizes, and tracheal tube guides such as semirigid stylets, ventilating tube changer, light wands, and forceps that are required to manipulate the distal portion of the tracheal tube.

• Masks of various sizes.

• Laryngeal mask airways of various sizes.

• Flexible fiberoptic intubation equipment.

• Retrograde intubation equipment.

• At least one device to perform emergency noninvasive airway ventilation such as esophageal tracheal tube, a hollow jet ventilation stylet.

• Equipment required for emergency invasive airway access.

• An exhaled CO_2 detector.

Solution to Question 22:

The image shown is of an armored tube (a.k.a. reinforced, flexo-metallic endotracheal tube). It is useful in head and neck surgeries and when the patient is in a prone position.

An armored tube is a flexible, spiral wound tube which is reinforced with the metal coil so as to minimize kinking. The metal coil is better made out in the second image.

Other specialized endotracheal tubes include:

- South oral Ring Adair Elwin: Nasal surgery
- Micro laryngeal tubes: Laryngeal surgery
- Double-lumen endotracheal tubes (Carlen, Robertshaw): Thoracic surgery

Note: The tip of the armored endotracheal tube is 2 cm distal to the distal-most metal ring, and this portion may not be visualized in radiography.

Solution to Question 23:

Sudden rise in peak inspiratory pressure is an indicator of endobronchial intubation.

Signs of endobronchial intubation:

- Elevated peak inspiratory pressure (first sign)
- Asymmetric chest expansion
- Unilateral breath sounds
- Hypoxemia

Breathing Systems

Question 1:

On your first day in the operation theater, you notice the following machine. What type of machine is this?

a) Continuous flow machine

b) Intermittent flow machine

c) Intermittent at low flows and continuous at high flows

d) Continuous at low flows and intermittent at high flows

Question 2:

What is the most commonly used Mapleson circuit?

a) Type B

b) Type A

c) Type F

d) Type D

Question 3:

Which of the following is not a co-axial circuit?

- **a)** Jackson Rees
- **b)** Lack
- **c)** Bain
- **d)** Penlon

Question 4:

You observe the following breathing circuit being used to ventilate a brain-dead patient who is being shifted to the OT for organ procurement. Which type of Mapleson circuit does this belong to?

- **a)** Mapleson A
- **b)** Mapleson B
- **c)** Mapleson C
- **d)** Mapleson D

Question 5:

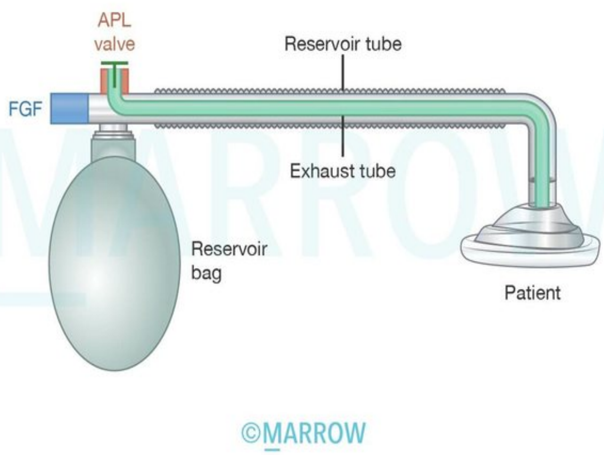
Which of the following components is not seen in a Bain circuit?

- **a)** Fresh gas inlet
- **b)** Reservoir bag
- **c)** Carbon dioxide absorber

d) Pressure limiting valve

Question 6:

Identify the device shown below:



a) Magill's circuit

b) Lack's circuit

c) Bain's circuit

d) Jackson and Rees' circuit

Question 7:

You are an anaesthesia resident posted in the pediatrics OT. A spontaneously breathing 6 year old child is set to undergo a minor elective procedure. Which of the following circuits would be the best choice for ventilating this patient?

a) Magill's circuit

b) Ayre's T piece

c) Water's to and fro circuit

d) Jackson Rees circuit

Question 8:

What is the type of circuit shown in the image?

a) Mapleson E

b) Mapleson C

c) Mapleson B

d) Mapleson F

Question 9:

What is the most effective circuit for anaesthesia under spontaneous breathing?

a) Mapleson A

b) Mapleson B

c) Mapleson C

d) Mapleson D

Question 10:

A 25-year-old athlete with left apical primary spontaneous pneumothorax was posted for thoracoscopic bullectomy under anesthesia with spontaneous ventilation. Which of the following breathing circuits would be the most effective for this purpose?

a) Mapleson A

b) Mapleson B

c) Mapleson C

d) Mapleson D

Question 11:

For a patient with respiratory failure requiring controlled ventilation, which of the following is true about the order of efficiency of Mapleson circuits?

a) D>E>F>A

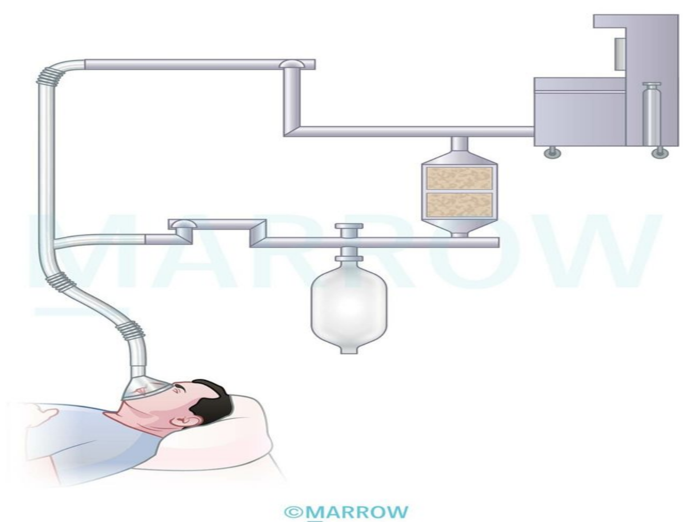
b) A>D=F>C

c) D=F>B>A

d) A>B=C>D

Question 12:

During an elective operation, you observe the following breathing circuit is used to provide anaesthesia. Which of the following is not true regarding this system?



a) Unidirectional gas flow

b) Rebreathing of anaesthetic gases

c) Increased air pollution

d) Removal of carbon dioxide

Question 13:

A surgeon was performing a procedure that was going on for more time than predicted. Suddenly the automatic ventilation and scavenger systems failed. What is the maximum safety limit for the concentration of nitrous oxide in the OR after which adverse health effects may develop in those exposed?

a) 2 ppm

b) 10 ppm

c) 15 ppm

d) 25 ppm

Answer Key

Question No.	Correct Option
1	a
2	d
3	a
4	d
5	c
6	b
7	d
8	a
9	a
10	a
11	c
12	c
13	d

Detailed Explanations

Solution to Question 1:

The machine shown in the image is Boyle's machine. It is a type of continuous flow machine.

Types of anesthesia machine:

Continuous flow: Gas flows during both inspiration and expiration

• Boyle's apparatus

• Foregger

• Heidbrink

Intermittent flow: Gas flows only during inspiration

• Entonox apparatus

• McKesson's apparatus

Boyle's machine was invented by Henry Edmund Gaskin Boyle in 1917. Although a lot of changes have been made for the original Boyle's apparatus, the basic structure of anesthesia workstation still remains the same.

Solution to Question 2:

The most commonly used Mapleson circuit system is Mapleson circuit type D.

Mapleson classified the semi-closed anesthetic breathing system according to

• The position of the expiratory valve

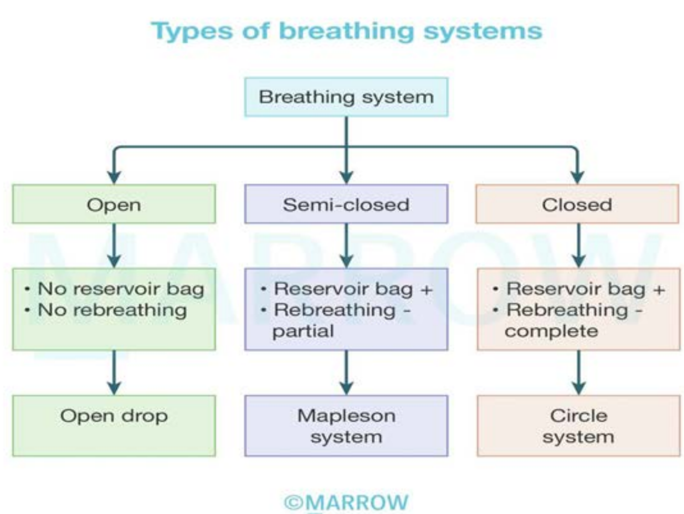
• The fresh gas flow inlet

• Position/presence of the reservoir bag

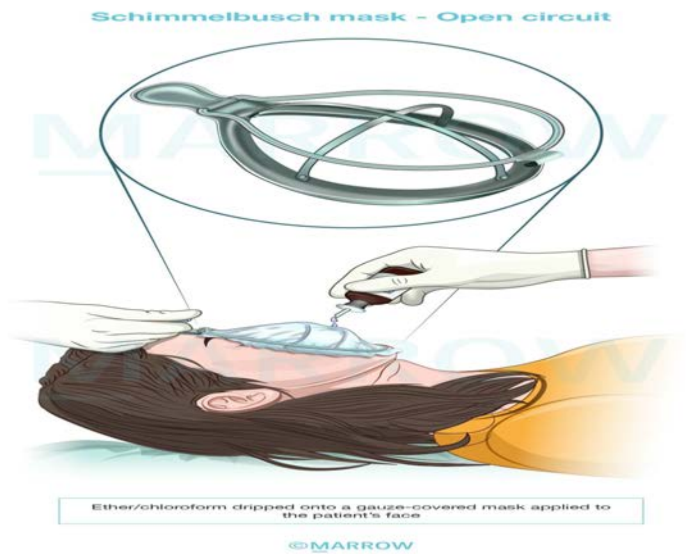
Mapleson's system includes Type A, B, C, D, E, and F.

Mapleson circuit type D is the circuit of choice for controlled ventilation.

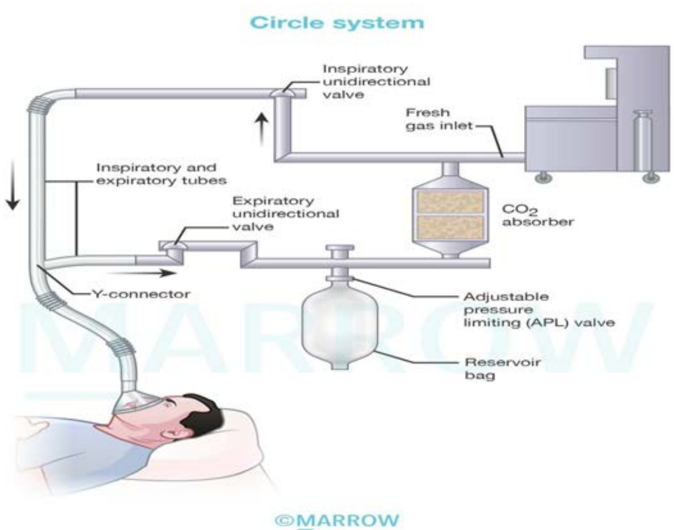
Note: The Bain circuit is a coaxial version of the Mapleson D system that incorporates the fresh gas inlet tubing inside the breathing tube. Bain circuit, unlike Mapleson D, can also be used for spontaneous ventilation.



Schimmelbusch mask used for open drop method of anesthesia



Closed or Circle system



Solution to Question 3:

Jackson Rees circuit (Mapleson F) is not a co-axial circuit. It is a modification of Ayre's T piece.

Co-axial circuits have two tubings, one inner and one outer tubing (arranged co-axially).

Examples of co-axial circuits:

• Lack's circuit: co-axial modification of Mapleson A

• Bain's circuit: co-axial modification of Mapleson D

• Penlon circuit: co-axial modification of Mapleson D or modification of Bain's circuit

Solution to Question 4:

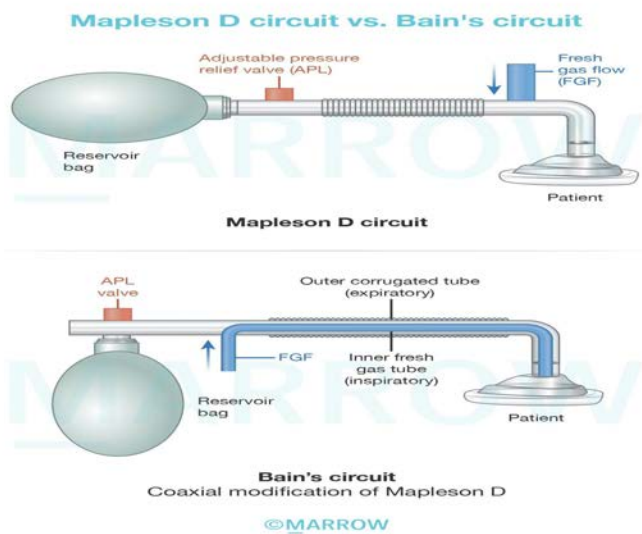
The given circuit is the Bain's circuit which is a coaxial modification of the Mapleson D circuit.

Co-axial circuits have two tubings, one inner and one outer tubing (arranged co-axially).

Bain's circuit has

- Inner inspiratory tubing: carries fresh gas flow to the patient
- Outer expiratory tubing: carries exhaled gases out through APL (adjustable pressure limiting) valve

Bain's circuit is often called a universal circuit as it can be used for adult and pediatric patients, for spontaneous and controlled ventilation.



Mapleson's D vs Bain's circuit

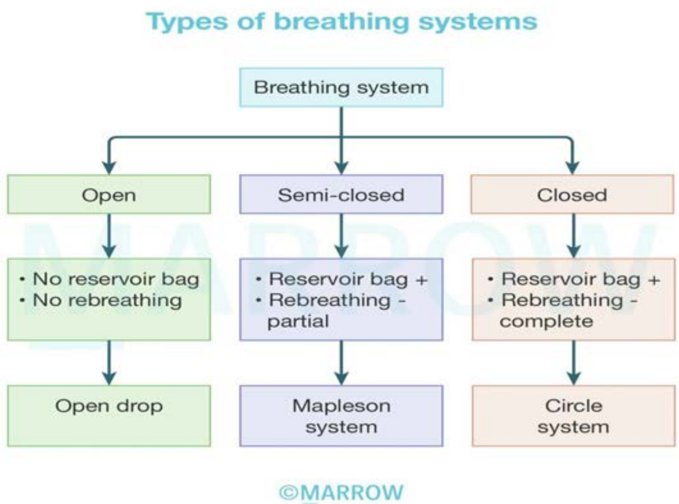
Solution to Question 5:

Bain circuit belongs to Mapleson's semi-closed breathing system, which lacks carbon dioxide absorber.

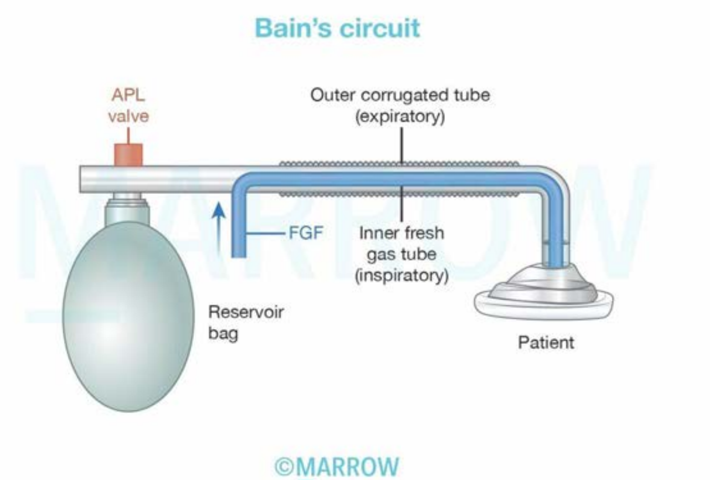
Components of Mapleson's system are

- Breathing tube
- Fresh gas inlet
- Adjustable pressure limiting (APL) valve
- Reservoir bag

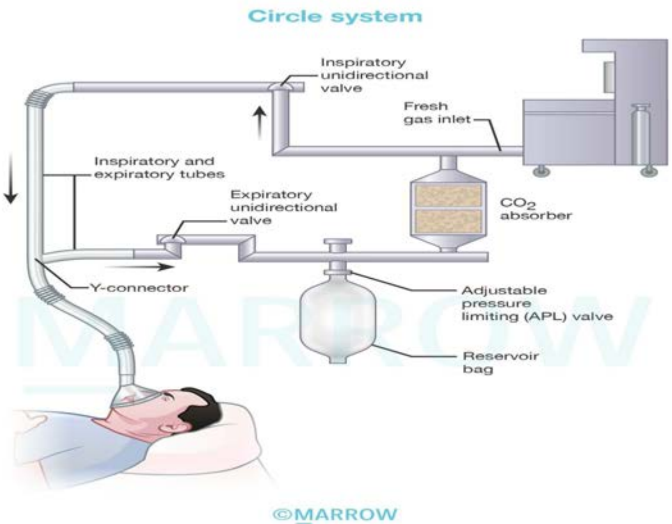
Carbon dioxide absorber (e.g. soda lime) is a component of the closed or circle system. This allows rebreathing of anesthetic gases after the removal of exhaled carbon dioxide.



Classification of breathing system



Bain's circuit with its components, fresh gas inlet, corrugated breathing tubes, APL valve and reservoir bag.



Circle system with its components, CO2 absorber, fresh gas inlet, an inspiratory uni-directional valve and inspiratory breathing tube, a Y-connector, expiratory uni-directional valve and expiratory breathing tube, APL valve and reservoir bag.

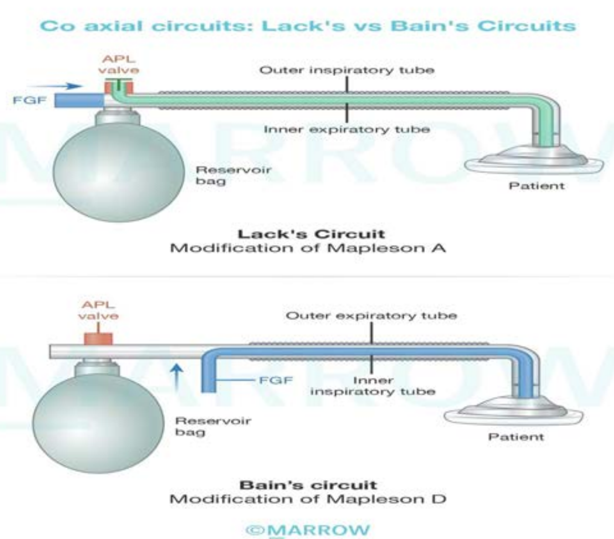
Solution to Question 6:

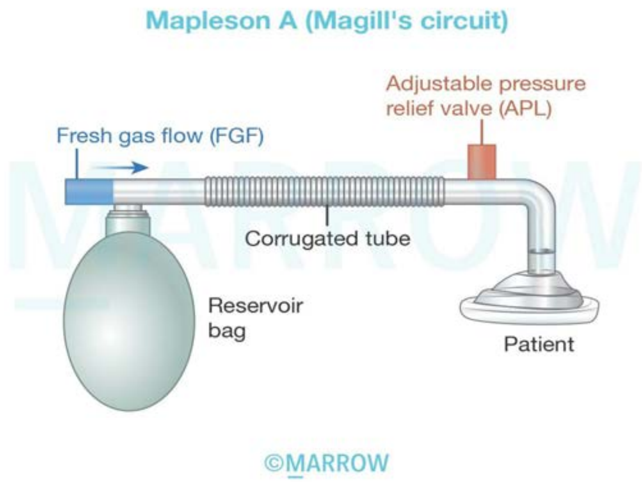
The image shown above is of Lack's circuit, which is a co-axial modification of Mapleson's A circuit.

Co-axial circuits have two tubings, one inner and one outer tubing (arranged co-axially).

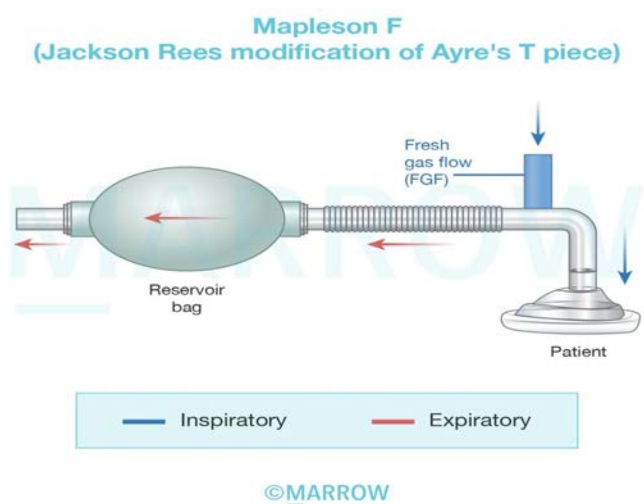
Lack's circuit has:

- Inner expiratory tubing: carries exhaust gases out through APL valve
- Outer inspiratory tubing: carries fresh gas flow to the patient





Magill's circuit (Mapleson A) designed by Sir Ivan Magill, best suited for spontaneous ventilation.



Jackson and Rees circuit (Mapleson F) is a modification of Ayre's T piece. Best suited for children under 20 kg.

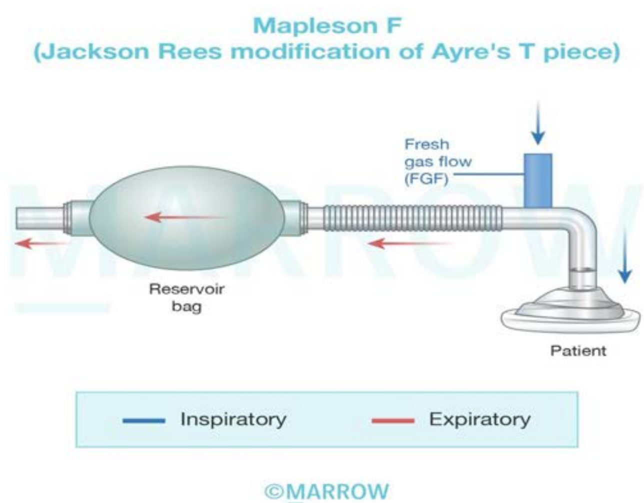
Solution to Question 7:

Jackson Rees modification of Ayre's T piece is the circuit of choice for ventilating a spontaneously breathing child during anesthesia.

Jackson Rees modification of Ayre's T piece is classified as a Mapleson's F system, although it was not included in the original description by Prof Mapleson.

It is used in children <6 years or <20 kgs.

Mapleson Circuit	Comments
Type A (Magill's circuit)	Circuit of choice for spontane ous ventilation
Type B	Obsolete
Type C (Water's to and fro)	Obsolete
Type D (Bain's circuit)	Circuit of choice for controlle d ventilation. Most commonl y used circuit.
Type E (Ayre's T piece)	Circuit of 2nd choice in child ren
Type F (Jackson Rees Modifi cation)	Circuit of choice in children (<20 kg)

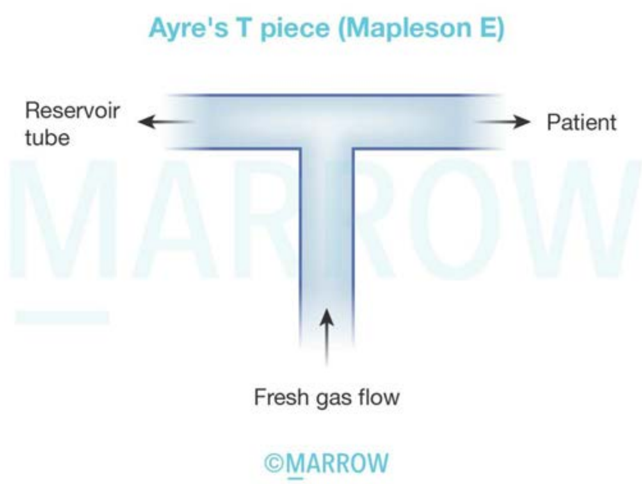


Jackson Rees modification of Ayre's T piece.

FGI - Fresh gas inlet; RB - Reservoir bag; P - Patient

Solution to Question 8:

The above image is Ayre's T piece, which is a type of Mapleson's E circuit.



Ayre's T piece

Suitable for use in neonates and children due to low dead space and low resistance.

Solution to Question 9:

The most effective circuit for anesthesia under spontaneous breathing is Mapleson A or Magill's circuit.

When the Mapleson A circuit is used for spontaneous ventilation, the fresh gas flow rate of the circuit is closest to the physiological minute ventilation of the patient. Hence it is preferred over other circuits.

Solution to Question 10:

Mapleson's A or Magill circuit is the circuit of choice for spontaneous ventilation.

Modified co-axial variety of Type A - Lack's circuit.

SMAL - For Spontaneous, Magill's circuit, Mapleson's Type A, Lack's co-axial circuit

Solution to Question 11:

From the above options, the order of efficiency of Mapleson circuits in controlled ventilation is D=F>B>A.

When the Mapleson D circuit is used for controlled ventilation, the fresh gas flow rate of the circuit is closest to the physiological minute ventilation of the patient.

Solution to Question 12:

The circle system is not associated with increased air pollution.

The incidence of air pollution: Open>Mapleson>Circle system.

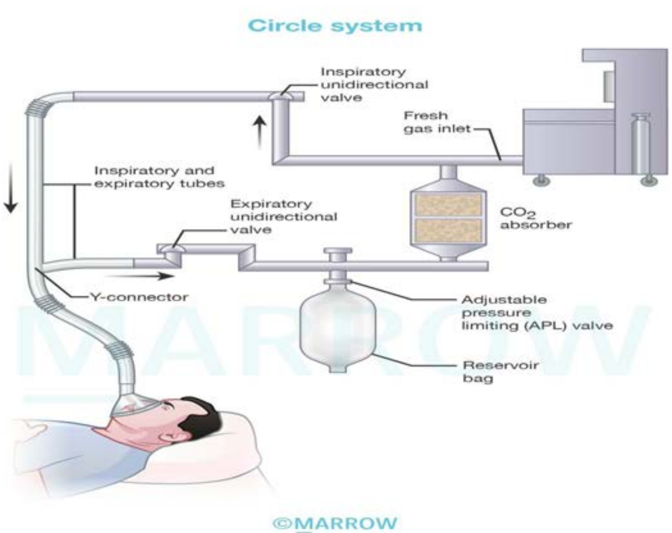
The ability to scavenge exhaled gases is also maximum with a closed system. Scavenging is the process of removal of waste anesthetic gases from both the anesthesia machine and the anesthetizing location (operation theatre). Thus minimizing operating room pollution.

Components of the circle system:

- CO_2 absorber
- fresh gas inlet
- uni-directional valves (inspiratory and expiratory)
- Breathing tubes (inspiratory and expiratory)
- Y-connector
- APL valve
- Reservoir bag.

The circle system allows for a uni-directional flow of anesthetic gases.

Carbon dioxide absorber (eg soda-lime) allows rebreathing of anesthetic gases after the removal of exhaled carbon dioxide. This conserves anesthetic gases and thus reduces air pollution.



Solution to Question 13:

Maximum safety limit for the concentration of nitrous oxide in the operating room environment is 25 ppm and for the halogenated anesthetic is 2 ppm.

National institute for occupational safety and health (NIOSH) guidelines:

Anesthetic Gas	Maximum Concentration (ppm)
Halogenated agent alo ne	2
Nitrous oxide	25

Anesthesia Workstation

Question 1:

Which of the following is not a part of the high pressure section of an anesthetic workstation?

a) Flowmeter
b) Oxygen cylinder
c) Yoke assembly
d) Cylinder pressure gauge

Question 2:

Which of the following is the most commonly used carbon dioxide absorbent in a closed circuit?

a) Amsorb
b) Sodasorb
c) Soda lime
d) Baralyme

Question 3:

How much carbon dioxide can be absorbed by 100 gm of soda lime?

a) 3L
b) 13 L
c) 23 L
d) 33 L

Question 4:

Which of the following statements is true regarding sodalime?

a) 2 and 3
b) 3 and 5

c) 2 and 4

d) 1 and 3

Question 5:

An anaesthetist notices that the soda lime is exhausted and requests for it to be changed. If the indicator used is ethyl violet, what would be the color change observed?

a) Pink to white

b) Purple to white

c) White to Pink

d) White to Purple

Question 6:

What is the action of silica when added to soda lime?

a) Humidifying agent

b) Hardening agent

c) Catalyst

d) Indicator

Question 7:

What is the ideal size of the carbon dioxide absorbent granules?

a) 1 mesh

b) 2 mesh

c) 3 mesh

d) 4 mesh

Question 8:

Which of the following statements is true concerning Compound A?

a) Degradation product of desflurane

b) Neurotoxicity is the major concern

c) Less common with Amsorb absorbent

d) Seen predominantly with high flow techniques

Question 9:

Which of the following statements regarding baralyme is false?

a) More efficient than soda lime

b) Performs better in dry climate

c) Less caustic than soda lime

d) Greater tendency to produce carbon monoxide

Question 10:

An ICU patient who is dependant on oxygen support requires an MRI. What material is used to build the medical gas cylinder which can be used in this scenario?

a) Stainless steel

b) Molybdenum steel

c) Aluminium

d) Hard plastic

Question 11:

In order to identify an oxygen cylinder correctly, what colour would you expect the shoulder of the cylinder to be?

a) White

b) Black

c) Blue

d) Yellow

Question 12:

What gas is the following cylinder used to carry?

a) Entonox

b) Air

c) Oxygen

d) Nitrous oxide

Question 13:

During a routine evaluation of the operating room before an operation, you hear an alarm from the anesthesia workstation. Assuming it to be due to a leak from the oxygen cylinder, you immediately check the pressure gauge. What would be the maximum pressure that is normally expected in this medical gas cylinder?

a) 750 psig

b) 1500 psig

c) 2000 psig

d) 2500 psig

Question 14:

Nitrous oxide cylinder at 100%, 50%, and 25% volume respectively would show the pressure (in PSI) of

a) 750, 750, 750

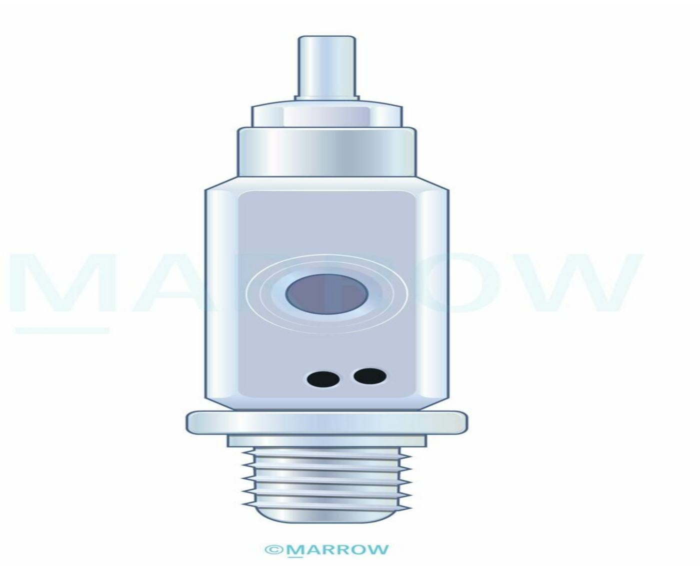
b) 2200, 2200, 2200

c) 750, 375, 162.5

d) 2200, 1100, 550

Question 15:

Identify the gas cylinder based on the pin index shown.



a) Oxygen

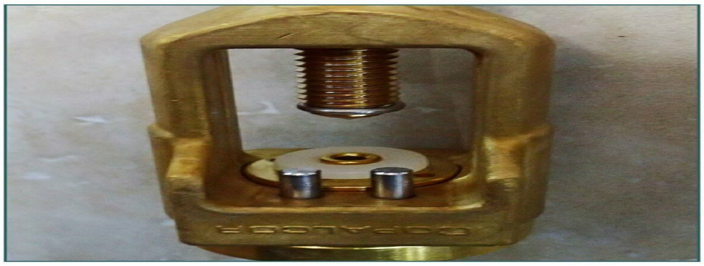
b) Air

c) Nitrous oxide

d) Entonox

Question 16:

An overworked OT technician brings an oxygen gas cylinder instead of an air cylinder to the theater. However, he realizes his mistake when he is unable to attach it to the hanger-yoke assembly because of the Pin index safety system. What would be the Pin index of the cylinder he is holding?



a) 2, 5

b) 1, 5

c) 3, 5

d) 7

Question 17:

What is the normal hospital pipeline supply of air?

a) 60 psig

b) 100 psig

c) 600 psig

d) 2000 psig

Question 18:

Which of the following is prevented by the Diameter Index safety system?

a) Contamination of the anesthetic environment

b) Delivery of hypoxic gases

c) Incorrect cylinder attachment

d) Incorrect pipeline attachment

Question 19:

The blue pipeline in the operation theatre is used for delivering which of the following gases?

- **a)** Oxygen
- **b)** Nitrous oxide
- **c)** Air
- **d)** Vacuum

Question 20:

In a flowmeter sequence, which of the following cylinders is placed downstream?

- **a)** Nitrous oxide
- **b)** Oxygen
- **c)** Air
- **d)** Any cylinder

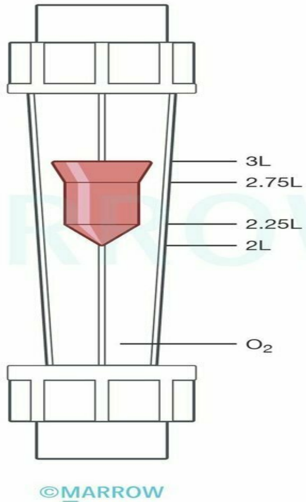
Question 21:

What is another name for the flow tubes used in rotameters?

- **a)** Bornholm tubes
- **b)** Pascal tubes
- **c)** Thorpe tubes
- **d)** Morton tubes

Question 22:

Read the flow rate of the oxygen depicted in the flow meter.



a) 2 L

b) 3 L

c) 2.25 L

d) 2.75 L

Question 23:

The Heidbrink meter in Boyle's machine

a) Reduces pressure of gases

b) Is a fixed orifice meter

c) Indicates flow of gases

d) Indicates humidity of gases

Question 24:

Which of the following combinations is incorrect regarding the vaporizers of the anaesthesia workstation?

a) Enflurane - Green

b) Halothane - Red

c) Isoflurane - Purple

d) Sevoflurane - Yellow

Question 25:

You notice this specialized vaporizer being used in the OT. Which of the following gases would you expect it to contain?

a) Desflurane

b) Sevoflurane

c) Halothane

d) Isoflurane

Question 26:

What is the maximum pressure allowed in an anesthesia reservoir bag?

a) 20 cm H2o

b) 40 cm H2o

c) 60 cm H2o

d) 100 cm H2O

Question 27:

In a patient with a tracheostomy, you notice the following device is used in addition to the breathing circuit. Which of the following statements is false concerning this device?

- **a)** Conserves heat
- **b)** Active humidifier
- **c)** Artificial nose
- **d)** Filters bacteria

Question 28:

Which anesthetic breathing system has the maximum ability to scavenge exhaled gases?

- **a)** Insufflation
- **b)** Open drop
- **c)** Mapleson
- **d)** Circle

Question 29:

The end product of the reaction of soda lime with CO_2 is

- **a)** $Na_2CO_3+H_2O$
- **b)** H_2CO_3+NaOH
- **c)** $Ca(OH)_2+Na_2CO_3$
- **d)** $CaCO_3+NaOH$

Question 30:

Water content of soda lime is ________.

a) 0%

b) 5%

c) 10%

d) 15%

Question 31:

Laminar flow mainly depends on:

a) Viscosity

b) Density

c) Solubility

d) Molecular weight

Answer Key

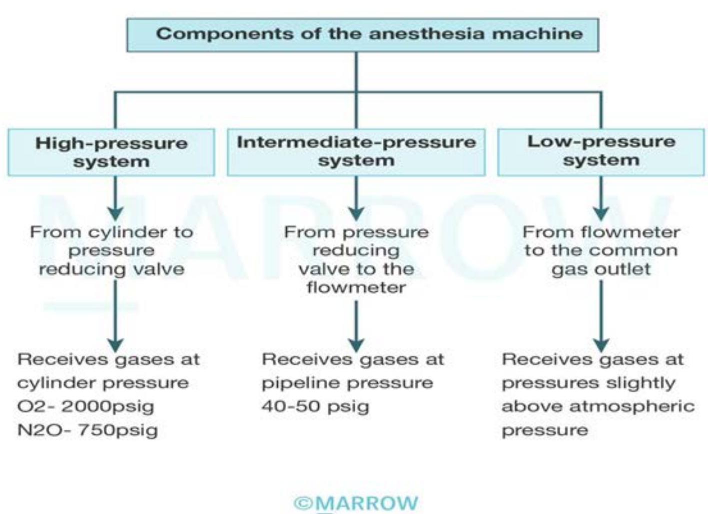
Question No.	Correct Option
1	a
2	c
3	c
4	b
5	d
6	b
7	d
8	c
9	a
10	c
11	a
12	d
13	c
14	a
15	c

16	a
17	a
18	d
19	b
20	b
21	c
22	b
23	c
24	a
25	a
26	c
27	b
28	d
29	d
30	d
31	a

Detailed Explanations

Solution to Question 1:

Flowmeter is not a part of the high-pressure system. It is a part of the low-pressure system.



Solution to Question 2:

Soda lime is the most commonly used carbon dioxide absorbent in circle breathing systems.

Solution to Question 3:

100 gm of Soda lime absorbs 23 L of carbon dioxide.

Soda lime is the most commonly used carbon dioxide absorbent in circle breathing systems.

Solution to Question 4:

Statement 1: 100 g of sodalime can absorb 23 liters of CO_2

Statement 2: The end product of the reaction of soda lime with CO_2 is $CaCO_3$+NaOH. Reaction end products include heat (the heat of neutralization), water, calcium carbonate, and sodium hydroxide.

Its reactions are as follows:

- $CO_2 + H_2O \rightarrow H_2CO_3$
- $H_2CO_3 + 2NaOH \rightarrow Na_2CO_3 + 2H_2O$ + Heat (a fast reaction)
- $Na_2CO_3 + Ca(OH)_2 \rightarrow CaCO_3 + 2NaOH$ + Heat (a slow reaction)

Note that the water and sodium hydroxide initially required are regenerated.

Statement 3: The major constituent of soda lime is $Ca(OH)_2$ - 80%

Statement 4: Water content of sodalime is 15%

Statement 5: KOH is one of the components of sodalime - 2%

Solution to Question 5:

When carbon dioxide absorbing capacity of soda lime using ethyl violet indicator is exhausted, the color changes from white to purple.

Soda lime indicator dye

Indicator	Color when Fresh	Color when Exhausted
Ethyl violet	White	Purple
Phenolphthalein	Colorless	Pink
Clayton yellow	Red	Yellow

Indicator	Color when Fresh	Color when Exhausted
Ethyl orange	Orange	Yellow
Mimosa 2	Red	White

Solution to Question 6:

Silica in the soda lime acts as a hardening agent.

In Amsorb, polyvinylpyrrolidone is used as a hardening agent.

NaOH and KOH serve as catalysts or activators to speed up the reaction between calcium hydroxide and carbon dioxide.

Ethyl violet is the most commonly used indicator dye in soda lime.

Solution to Question 7:

The ideal granule size of the carbon dioxide absorbent is between 4 and 8 mesh (1.5-5 mm).

Smaller granule size favors greater area for absorption of carbon dioxide. But, it offers greater airflow resistance (caking).

Converse is true with larger granule size - the absorptive area is less but airflow resistance is minimal (channeling).

So, the ideal size is to be between 4 and 8 mesh as absorptive surface area and resistance to flow are optimized.

Solution to Question 8:

The true statement concerning Compound A is that its formation is less common with Amsorb absorbent.

Compound A is fluoro-methyl-2,2-difluoro-1-(trifluoromethyl) vinyl ether which is the degradation product of Sevoflurane, not desflurane.

The strong bases like NaOH and KOH present in absorbents (soda lime) lead to its formation. Lack of strong alkali in Amsorb makes its formation less common.

Compound A is nephrotoxic, not neurotoxic.

It is seen predominantly with low flow anesthesia techniques and high absorbent temperatures.

Solution to Question 9:

The true statement is baralyme is less efficient than soda-lime.

Baralyme is less efficient than soda-lime as its absorptive capacity is 9-18L of CO2/100 g while of soda lime is 23L of CO2/100 g.

Baralyme with the composition of calcium hydroxide and barium hydroxide (activator) is less caustic than soda lime.

It gives more reliable performance in a dry environment.

As compared to soda lime, baralyme has a greater tendency to produce carbon monoxide.

Solution to Question 10:

MRI compatible medical gas cylinders are made of aluminium, while most medical gas cylinders are constructed of molybdenum steel.

The cylinders are produced in various sizes designated by a capital letter code.

• Size A is the smallest.

• Size H is the largest.

• Size E is the cylinder most commonly used in anesthesia machines, for patient transport, and resuscitation, followed by Size D.

• Size J is commonly used for cylinder manifold systems for central supply.

Solution to Question 11:

Colour of the shoulder of oxygen cylinder in India is white, and the body is black.

Maximum pressure in the oxygen cylinder is around 2000 psig.

Solution to Question 12:

Blue cylinders are used to store nitrous oxide.

Maximum pressure in the nitrous oxide cylinder is around 745 psig.

Critical temperature of nitrous oxide is 36.5oC, hence it is present in liquid form at room temperature.

Solution to Question 13:

Maximum pressure in oxygen cylinder is 2000 psig (pounds per square inch gauge)

Maximum pressure in the E-cylinders:

• 750 psig for nitrous oxide (liquid)

• 2000 psig for air (gaseous)

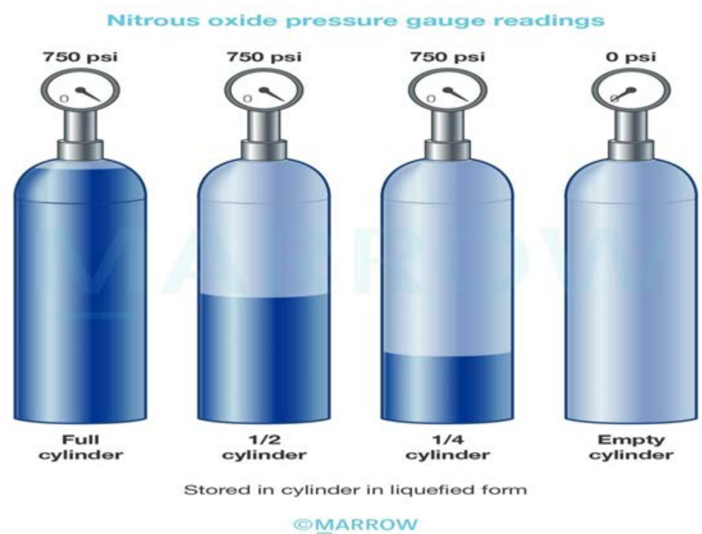
• 2000 psig for oxygen (gaseous)

Each cylinder is passed through a high-pressure regulator, which reduces the high pressures inside the cylinder to a lower, nearly constant pressure of 45 psig, which is suitable for use in the anesthesia machine.

Solution to Question 14:

Nitrous oxide cylinder at 100%, 50%, and 25% volume would show 750, 750, 750 PSI (pounds per square inch) respectively.

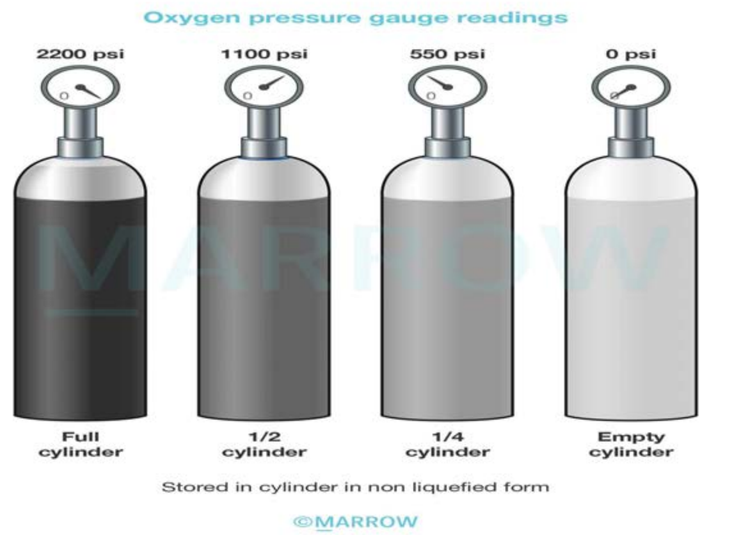
This is because N_2O (and CO_2) are stored in the cylinder as a liquid under the pressure of 750 psi at room temperature. Hence, N_2O gauge will read full as long as there is liquid in the tank. After which the pressure falls until the cylinder is exhausted.



N_2O pressure gauge reading at full, half, one-fourth, and empty cylinder.

The contents of N_2O cylinders can be accurately measured by weighing the cylinders rather than by pressure gauge.

To measure the content, the weight of an empty cylinder, known as Tare weight is subtracted from the actual weight of the cylinder.



O2 pressure gauge reading at full, half, one-fourth and empty cylinder.

In a cylinder containing a non-liquefied gas such as Oxygen, the pressure in the cylinder decreases as the contents are used. Therefore the pressure gauge can be used to measure the cylinder content.

Oxygen pressure gauge would read 2200, 1100, and 550 PSI at 100%, 50%, and 25% content respectively.

Solution to Question 15:

The given image shows the Pin index system (3,5) of Nitrous oxide.

Pin index system (PISS) is a safety measure to prevent incorrect cylinder attachment.

• Each gas cylinder has two holes (except entonox) in its cylinder valve that fits the corresponding pins in the yoke of the anesthesia machine. The relative positioning of the pins and holes is unique for each gas which constitutes the pin index system.

• The PISS should only be considered as partial protection because pin index failures have been reported due to bent or broken pins.

Solution to Question 16:

Pin index system for oxygen gas is 2,5.

Pin index system (PISS) is a safety measure to prevent incorrect cylinder attachment.

Solution to Question 17:

The normal hospital pipeline supply pressure of all gases in India is 60 psig.

The hospital pipeline supply is the primary source of all gases. 2000 psig of oxygen cylinder, which is a part of the high pressure system, is regulated to 45 psig after it enters the anaesthesia workstation.

The regulated cylinder pressure is 45 psig which is less than that of pipeline pressure.

Solution to Question 18:

The Diameter Index Safety System (DISS) prevents incorrect pipeline attachment.

DISS is a safety feature in the modern anesthesia workstation. DISS connectors have unique diameters for each type of gas to prevent wrong pipeline attachment to the wrong inlet.

Diameter Index Safety system

Incorrect cylinder attachment(not pipeline) is prevented by Pin Index Safety System.

Contamination of the anesthetic environment by waste gases is prevented by Scavenging system.

Delivery of hypoxic gases is prevented by Oxygen failure safety device (shut-off or proportionating device).

Solution to Question 19:

The blue pipeline in operation theatre is for nitrous oxide.

Other options:

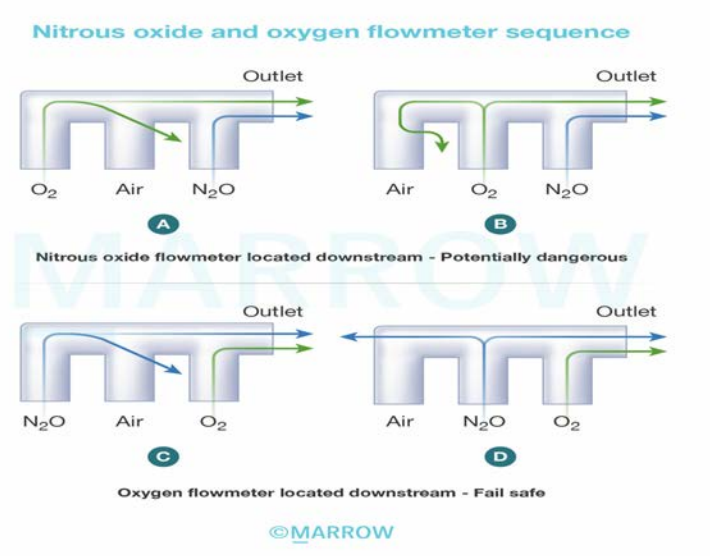
Oxygen: White

Air: Black

Vacuum/Central suction: Yellow

Solution to Question 20:

The oxygen flowmeter is located downstream of the other flowmeters. This is to avoid the generation of a hypoxic mixture in the event of any air leak.



In the first two images, A and B, the nitrous oxide flowmeter is located downstream and there is a leak in the airflow tube. Through this leak, most of the oxygen passes out and mainly nitrous oxide is provided at the outlet leading to the production of a hypoxic mixture.

But in the other two images, C and D, the oxygen flowmeter is located downstream. Through the leak in the airflow tube, some of the nitrous oxide passes out and the remaining passes out through the outlet with the oxygen. Thus the production of a hypoxic mixture is less likely if oxygen flowmeter is placed downstream.

Solution to Question 21:

The flow tubes used in rotameters are also called Thorpe tubes.

Key points on Flowmeter:

• Flowmeters are part of the low-pressure anesthetic gas supply system.

• The knobs are part of the intermediate pressure system and are textured for easy identification.

• Rotameters are variable orifice (area) constant pressure flowmeter.

• Thorpe tubes are made of tapered glass tube, the bottom has a smaller diameter than the top.

• The indicator is known as bobbin or float. Rotating float indicates the flow of gas.

• The Interior of the tube is coated with a conductive substance (gold or tin oxide) in order to reduce the effect of static electricity.

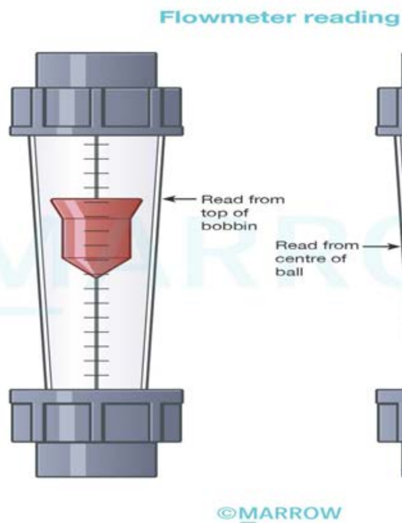
Solution to Question 22:

The flow rate of oxygen in the given image is 3 L.

The indicator present in the Rotameter (Flow meter) is known as Bobbin or Float.

The flows are read from the top end of the bobbin.

Some rotameters have ball indicator. Here, the reading is taken from the center of the ball.



Solution to Question 23:

The Heidbrink meter in boyle's machine indicates the flow of gases.

Heidbrink is a type of flow meter, which was used in the past.

Solution to Question 24:

Enflurane vaporizers are orange in color, not green.

Solution to Question 25:

The image shows a specialized vapouriser Tec 6. Because of high vapor pressure (669 mmHg at 20°C) and low boiling point (22.8°C ~ room temperature), Desflurane requires this specialized vaporizer for its delivery.

Anesthetic gas with the highest vapor pressure is Desflurane.

Other salient features of Desflurane:

• High saturated vapor pressure which is 3-4 times the other agents

• Low boiling point

• Low blood-gas solubility (0.42) resulting in rapid uptake and recovery

• High MAC value of 6, indicating low potency

• Requires specialized vapouriser such as Tec 6

• Color coding of Desflurane - Blue

- Undergoes minimal metabolism
- Degraded into CO by the desiccated CO_2 absorbent

Solution to Question 26:

The maximum pressure allowed in an anesthesia reservoir bag is 60 cm H_2O.

The reservoir bag serves as a reservoir for inhaled excess fresh gas and helps to generate positive pressure ventilation.

It is most commonly placed between the expiratory unidirectional valve and the CO_2 absorber.

The minimum allowed pressure is 30 cm H_2O.

Anesthesia workstation

Solution to Question 27:

Heat and moisture exchanger (HME) is a passive humidifier, not active.

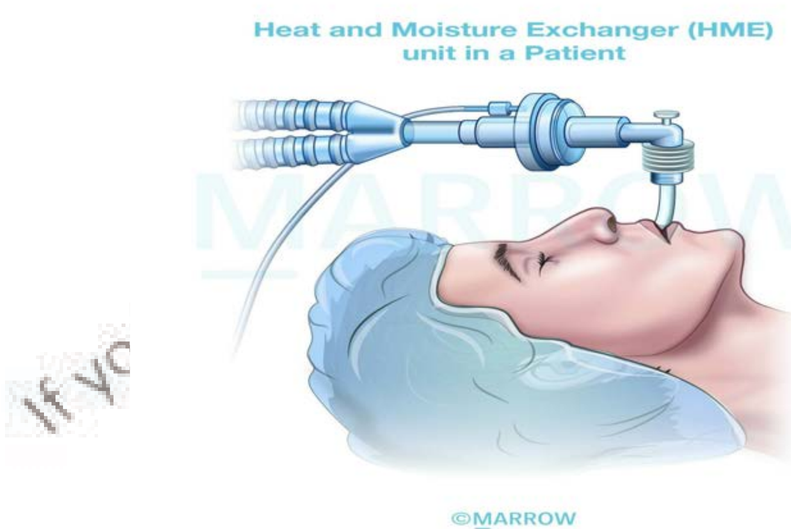
The natural humidification and conservation of heat by the upper respiratory tract is lost or bypassed after tracheal intubation or tracheostomy. HME acts as an artificial nose, which traps the exhaled water vapor and heat passively by its hygroscopic material, and thus conserves heat and adds moisture to the inhaled gases.

Active humidifiers act by allowing air passage inside a heated water reservoir. These devices are placed in the inspiratory limb of the ventilator circuit, proximal to the ventilator. After the air is loaded with water vapor in the reservoir, it travels along the inspiratory limb to the patient's airway.

Some humidifiers also serve as filters to trap bacteria/viruses and thus prevent the transmission of microbes from the patient to the machine and hence to other patients.

The disadvantage with the humidifier is that excess saturation can lead to blockage of the circuit.

Shown above is an HME filter impregnated with a hygroscopic material.



Shown above is the placement of HME filter in the breathing circuit.

Solution to Question 28:

Ability to scavenge exhaled gases is maximum with Circle system (Circle>Mapleson>Open).

Scavenging is the process of removal of waste anesthetic gases from both the anesthesia machine and the anesthetizing location (operation theatre), thus minimizing operating room pollution.

Solution to Question 29:

The end product of the reaction of soda lime with CO_2 is $CaCO_3$+NaOH.

CO_2 absorbents contain hydroxide salts that are capable of neutralizing the carbonic acid.

Reaction end products include heat (the heat of neutralization), water, calcium carbonate, and sodium hydroxide.

Its reactions are as follows:

• $CO_2 + H_2O \rightarrow H_2CO_3$

• $H_2CO_3 + 2NaOH \rightarrow Na_2CO_3 + 2H_2O$ + Heat (a fast reaction)

• $Na_2CO_3 + Ca(OH)_2 \rightarrow CaCO_3 + 2NaOH$ + Heat (a slow reaction)

Note that the water and sodium hydroxide initially required are regenerated.

Solution to Question 30:

The water content of soda lime is 15%.

Dry CO_2 absorbent (Baralyme > Sodalime) can produce carbon monoxide.

The magnitude of CO production from greatest to least: Desflurane >= Enflurane > Isoflurane >> Halothane =Sevoflurane

Solution to Question 31:

Laminar flow mainly depends on the viscosity of gas while turbulent flow is more dependent on density.

The transition between laminar and turbulent flow is given by Reynold's number.

Re = pvD/n

(v- velocity of the fluid, p- density of the fluid, D- diameter of the tube, n- viscosity.)

A Reynold's number <2000 ~ laminar flow; >4000 ~ turbulent flow.

BLS and PALS

Question 1:

Which of the following is the correct sequence?

a) Assess the patient's response, Activate ERS, check carotid pulse, Start CPR

b) Check carotid pulse, Start CPR, Call for help and activate ERS, Defibrillate

c) Defibrillate, Assess response, Check carotid pulse, Maintain airway

d) Start CPR, Activate ERS, Defibrillate, Check pulse

Question 2:

On your morning walk in the park, you notice an unconscious man lying on the ground. Which of the following options would be the next best step?

a) Check carotid pulse, start CPR, and call for help; Defibrillate if no pulse.

b) Call for help, check pulse, do CPR, defibrillate if no pulse

c) Observe

d) Ignore and continue to walk

Question 3:

On witnessing a cardiac arrest, what is the first thing you would do?

a) Check for victim's responsiveness

b) Check for a pulse

c) Check for breathing

d) Check for scene safety

Question 4:

What does the cardiopulmonary resuscitation sequence start with?

a) Airway

b) Breathing

c) Circulation

d) Drugs

Question 5:

A 50-year-old man presented to the ER with complaints of chest pain. He suddenly collapsed and became unresponsive. His pulse was not recordable so you started chest compressions. Which of the following steps would you not perform according to the BLS algorithm?

a) Defibrillation using Automated external defibrillator

b) Intubation using Laryngeal mask airway

c) Performing Head tilt – chin lift

d) Bag and mask ventilation

Question 6:

You witness a 40-year-old man suddenly collapse near the ER. He is unresponsive and you start chest compressions as his pulse is also not recordable. For maximum effectiveness, what should be the depth of your compressions?

a) 1 cm

b) 2 cm

c) 3 cm

d) 5 cm

Question 7:

In order to provide high-quality CPR, what should the rate of chest compressions per minute be?

a) 60-80

b) 80-100

c) 100-120

d) 120-140

Question 8:

When providing CPR to an adult, what ratio of chest compressions to rescue breaths would you provide if there were 2 rescuers?

a) 15:1

b) 15:2

c) 30:1

d) 30:2

Question 9:

For effective chest compression during CPR, where should the hands of the healthcare provider ideally be placed?

a) Upper half of sternum

b) Middle third of sternum

c) Lower half of sternum

d) Upper third of sternum

Question 10:

Which of the following can be considered as effective CPR?

a) 1, 2, 3, and 4

b) 1, 2, and 4

c) 2, 3, and 4

d) 1 and 2 only

Question 11:

Which of the following is not included in high-quality CPR?

a) Compression depth of at least 5 cm

b) Rotate chest compressor every 3 mins

c) Avoid excessive ventilation

d) Compression – ventilation ratio of 30:2

Question 12:

A 3-year-old child is brought to the casualty with a history of choking over a peanut. The child suddenly becomes unresponsive. What would you do as the next step of management?

a) Give 5 back slaps

b) Give abdominal thrusts

c) Endotracheal intubation

d) Chest compressions

Question 13:

Identify the device shown in the image below.

a) Automated External Desynchonizer

b) Automated External Defibrillator

c) Automated Electronic Defibrillator

d) Automated External decompressor

Question 14:

In a cardiac arrest patient, if intravenous access cannot be obtained, what is the next best way to administer epinephrine?

a) Endotracheal route

b) Intramuscular

c) Intraosseus

d) Wait till intravenous access is made

Question 15:

An unconscious 4-year-old child is brought to the ER. On examination, she is gasping but her pulse is not recordable. You start chest compressions and rescue breaths. As the child is not responding you want to start IV epinephrine, but you cannot obtain IV access. Which of the following sites is preferred for intraosseous access in this situation?

a) Proximal Tibia

b) Sternum

c) Iliac crest

d) Proximal femur

Question 16:

According to the AHA 2020 guidelines for the Pediatric Basic and Advanced Life Support, which of the following statements is incorrect?

a) Administer the initial dose of epinephrine within 5 minutes from the start of chest compressions

b) Cuffed endotracheal tubes are preferred for intubating infants and children

c) Routine use of cricoid pressure is recommended during endotracheal intubation

d) In infants the respiratory rate should be 20-30 breaths/minute

Question 17:

A 6-year-old girl is admitted to the pediatric ward for severe pneumonia. She suddenly becomes unresponsive. On examination, her pulse is not detectable. You immediately start cardiopulmonary resuscitation. What is the ratio of chest compressions to ventilation to be provided if there are 2 rescuers?

a) 15:1

b) 15:2

c) 30:1

d) 30:2

Question 18:

An unresponsive child is brought to the ER. His BP is not recordable, pulse rate is 40 per minute. CPR is initiated but his SpO_2 is 70% despite proper oxygenation and ventilation, and pulse rate is not improving. What is the next best step of management?

a) IV atropine

b) IV epinephrine

c) IV dopamine

d) IV adenosine

Question 19:

A 5-year-old child is brought to the casualty after having suddenly collapsed while playing. Pulse is not recordable and CPR is started. After 2 minutes of CPR, the monitor shows ventricular fibrillation rhythm. What is the energy to be set for defibrillation?

a) 1 J/kg

b) 2 J/kg

c) 4 J/kg

d) 6J /kg

Question 20:

You are providing basic resuscitative care to a newborn. After the initial management of airway, oxygenation, and IV access, you perform a 12 lead ECG as the heart rate is 190/minute. What is the cut-off value to determine increased QRS duration according to the AHA 2020 Guidelines for Pediatric Management of tachycardia with a pulse?

a) >0.11 sec

b) >0.10 sec

c) >0.09 sec

d) >0.12 sec

Answer Key

Question No.	Correct Option
1	a
2	b
3	d
4	c
5	b
6	d
7	c
8	d
9	c
10	c
11	b
12	d
13	b
14	c
15	a
16	c
17	b
18	b
19	b
20	c

Detailed Explanations

Solution to Question 1:

BLS sequence:

First step – Assess safety of the surroundings.

Second step - Assess for responsiveness

Third step – Proceed if the patient is unresponsive. Shout for help.

If the patient is unresponsive assess for breathing and carotid pulse simultaneously for no more than 10 seconds.

Solution to Question 2:

The next best step is to Call for help, check pulse, do CPR, defibrillate If no pulse.

Steps in basic life support:

First step – Assess safety of the surroundings.

Second step - Assess for responsiveness

Third step – Proceed if the patient is unresponsive. Shout for help.

If the patient is unresponsive, assess for breathing and carotid pulse simultaneously for no more than 10 seconds.

In the given scenario, it is already mentioned that you are in a park (scene safety has been assessed), and that the person is unconscious (responsiveness has been assessed). So, the immediate next step is to call for help, and start CPR.

Solution to Question 3:

The first thing that needs to be done on witnessing a cardiac arrest is to verify the scene safety.

On ensuring that the scene is safe, the victim is checked for responsiveness. If unresponsive, call for help and then check for breathing and pulse simultaneously taking not more than 10 seconds.

If there is no breathing and no pulse, immediate chest compression and rescue breaths are started at a ratio of 30:2.

If there is a pulse, but no breathing, give one rescue breath every 5-6 seconds or about 10-12 breaths/min.

When an automated external defibrillator arrives, the rhythm is checked; if shockable, one shock is administered and CPR is resumed immediately.

If not shockable, then CPR is resumed immediately.

Solution to Question 4:

The sequence of cardiopulmonary resuscitation starts with circulation, airway and then breathing.

Maintaining circulation involves chest compressions which lead to ejection of blood from the heart as a result of actual compression of the heart between the sternum and vertebral column.

Solution to Question 5:

Laryngeal mask airway and other supraglottic airway devices are part of advanced airway management, which is included in advanced cardiac life support (ACLS).

Basic life support refers to the emergency management of sudden cardiac arrest, heart attack, stroke, and foreign body airway obstruction, usually without the use of equipment other than automated external defibrillators.

The CPR sequence is as follows - circulation (chest compression), airway, and then breathing:

• Circulation:

• Chest compressions lead to ejection of blood from the heart, as a result of actual compression of the heart between the sternum and vertebral column.

• Airway:

• Head tilt, chin lift, and jaw thrust maneuvers are used to open the airway.

• Breathing:

• If there is no adequate breathing even after opening the airway, the rescuer should initiate assisted ventilation by giving rescue breaths to the patient using mouth-to-mouth, mouth-to-nose, mouth-to-stoma, mouth-to-barrier device, mouth-to-face shield, or mouth-to-mask rescue breathing or by using a bag-mask device.

• Defibrillation:

• Using automated external defibrillators (AED)

Solution to Question 6:

High-quality cardiopulmonary resuscitation involves adequate chest compressions to a depth of at least 5 cm in adults.

If a feedback device is used, then the compression depth can be increased to 6 cm.

Solution to Question 7:

Chest compressions should be performed at a rate of 100-120/ minute.

Solution to Question 8:

During cardiopulmonary resuscitation of adults, the ratio of chest compression to rescue breaths is 30:2 irrespective of the number of rescuers.

In infants and children, the ratio is 30:2 for a single-rescuer and 15:2 if 2 or more rescuers are present.

Solution to Question 9:

In children and adults, chest compressions are performed by locating the xiphoid process and placing the heel of the hand over the lower half of the sternum. The other hand is placed over the hand on the sternum with the fingers either interlaced or extended and the elbow extended so that the weight of the upper body is used for compression.

In infants, if there is a single rescuer, compressions are effected by placing 2 fingers in the center of the chest, just below the nipple line. If there are 2 or more rescuers, then 2 thumb technique is used.

In infants and children, the depth of compression should be at least one-third of the anteroposterior diameter of the chest, which is about 5 cm in children and 4 cm in infants.

For pediatric patients, the ratio of chest compression to rescue breaths is 30:2 for a single rescuer and 15:2 if 2 or more rescuers are present. In adults, the ratio is 30:2 irrespective of the number of rescuers.

Solution to Question 10:

The ideal rescue breath rate for adults is 10 breaths/min, while in infants and children up to puberty it is 20-30 breaths/min. As the person's age group is not specified in the question, assuming an adult, statement 1 is incorrect, while 2, 3, and 4 are correct.

Effective chest compression in adults:

• Provide 100-120 compressions per minute (30 compressions for every 15-18 sec).

• Place your arms, one over the other in the midline, on the lower 1/3rd of the patient's sternum, and lock your arms.

• Use both arms to press the chest to a depth of 5-6 cm (2 - 2.4 inches) or more.

• Press hard and fast

• Allow for full chest recoil after every compression.

Effective chest compressions in a child older than 1 year and up to puberty:

• The compression rate is 100 - 120/min (30 compressions for every 15-18 sec).

• One or both palms are placed in the midline.

• The depth of compression is 2 inches.

• Press hard and fast

• Allow for full chest recoil after every compression.

Effective chest compressions in infants (<1 year):

• 100 to 120 compressions per minute (30 compressions for every 15-18 sec).

• One provider: Place two fingers, one between the nipple line and the other 1 cm below.

• Two providers: Encircle the infant's torso with both hands with both thumbs pointing cephalic positioned 1cm below the nipples over the sternum.

• Depth of compressions should be at least 1.5 inches or 1/3 the depth of the infant’s chest.

• Press hard and fast

• Allow for full chest recoil after every compression.

Solution to Question 11:

Rotation of chest compressor is done every 2 minutes or earlier if the compressor is fatigued.

Solution to Question 12:

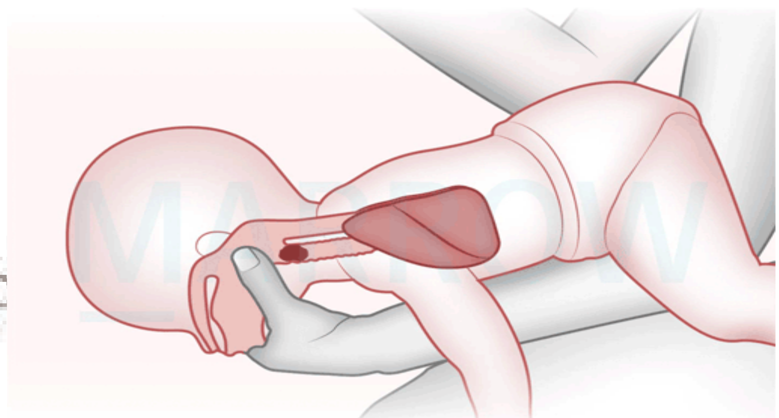
If a choking victim becomes unresponsive, call for help and immediately start CPR, beginning with chest compressions.

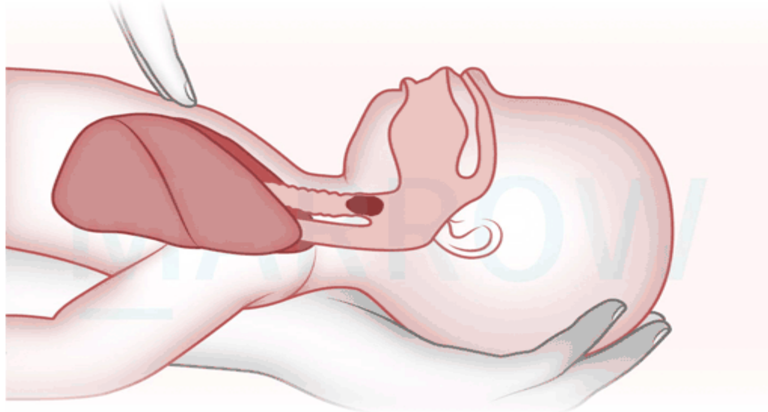
For pediatric CPR, if a single rescuer is present, then chest compression to ventilation is performed in a ratio of 30:2. If there are 2 or more rescuers, then the ratio is 15:2.

While giving rescue breaths, the airway is checked for a foreign body. If it is accessible, then the object can be removed. If not, then CPR is continued. Blind finger sweeping may be hazardous as it can push the object further down the airway.

If the child is responsive, then abdominal thrusts are performed to help relieve airway obstruction.

In a choking infant who is responsive, 5 back slaps between the shoulder blades and 5 downward thrusts on the chest are given in order to dislodge the foreign body.





©MARROW

Solution to Question 13:

The device is an Automated External Defibrillator (AED).

This is a special medical device that is commonly used for recognizing the absence/presence of rapid ventricular tachycardia or ventricular fibrillation. With no need for intervention by an operator, it determines whether an electrical shock right to the heart must be performed (defibrillation).

An automated external defibrillator can be used on those victims, who are unconscious and aren't breathing in a normal way. As a rule, it is used together with CPR in cases of sudden cardiac arrest. It is forbidden to use it on patients who are less than eight years old or those weighing less than 25 kgs.

Solution to Question 14:

American Heart Association recommends the intraosseous (IO) route as an alternative to an intravenous route in order to deliver drugs and fluids, especially in children.

This is because intraosseous access can easily be made in 30-60 seconds and thus provide emergency vascular access. It involves placing a catheter into the marrow venous plexus and administering, crystalloids, colloids, drugs, and blood which leads to rapid and reliable absorption into the systemic circulation.

Sites of choice: proximal tibia, distal femur, the distal end of radius, or ulna.

The fluids are administered under pressure because of the resistance to fluid flow from the IO catheter into the IO space. The disadvantage with this route is the risk of osteomyelitis, compartment syndrome, bone marrow or fat embolism.

IO access is superior to the endotracheal route. The American Heart Association does not recommend an intramuscular route for cardiac resuscitation.

Solution to Question 15:

The site preferred for intraosseous access among the given options is proximal tibia.

Other sites of choice are distal femur, distal end of radius, or ulna.

Intraosseous access involves placing a catheter into the marrow venous plexus and administering, crystalloids, colloids, drugs, and blood which leads to rapid and reliable absorption into the systemic circulation.

The fluids are administered under pressure because of the resistance to fluid flow from the IO catheter into the IO space. The disadvantage with this route is the risk of osteomyelitis, compartment syndrome, bone marrow or fat embolism.

American Heart Association recommends the intraosseous route as an alternative to an intravenous route in order to deliver drugs and fluids, especially in children. This is because intraosseous access can easily be made in 30-60 seconds and thus provide emergency vascular access.

Solution to Question 16:

According to the AHA 2020 guidelines, routine use of cricoid pressure is not recommended during the endotracheal intubation of pediatric patients.

Option A: For pediatric patients in any setting, it is reasonable to administer the initial dose of epinephrine within 5 minutes from the start of chest compressions.

Option B: It is reasonable to prefer cuffed ETTs over uncuffed ETTs for intubating infants and children to reduce air leak.

Option D: For infants and children with a pulse but an absent or inadequate respiratory effort, 1 breath can be given every 2 to 3 seconds (20-30 breaths/min).

Solution to Question 17:

During cardiopulmonary resuscitation of infants and children, the ratio of chest compression to rescue breaths is 30:2 for a single rescuer and 15:2 if 2 or more rescuers are present.

In adults, the ratio is 30:2 irrespective of the number of rescuers.

In infants and children, the depth of compression should be at least one-third of the anteroposterior diameter of the chest which is about 5 cm in children and 4 cm in infants.

The compression rate should be 100-120/minute.

Allow complete chest recoil after each compression and minimize interruptions in compressions (10 seconds or less). Rotate between compressors every 2 minutes or earlier if fatigued.

Excessive ventilation is to be avoided.

Solution to Question 18:

Epinephrine is the drug of choice for treating bradycardia in infants and children. The recommended dose is 0.01 mg/ kg of a 1:10,000 solution. It can be given intravenously or via the intraosseous route. It can be repeated every 3-5 minutes.

If intravenous or intraosseous access cannot be obtained, then it can be administered via the endotracheal route at a dose of 0.1 mg/kg of a 1:1,000 solution.

If epinephrine is not effective in increasing the heart rate, then atropine can be used with a dose of 0.02 mg/kg and repeated.

For adults, treatment is initiated with 1 mg atropine iv which may be repeated at 3-5 minute intervals to a maximum dose of 3 mg. Along with atropine, transcutaneous pacing is to be done.

Solution to Question 19:

In a pediatric cardiac arrest, the initial energy for defibrillation is set at 2 J/kg for both monophasic and biphasic waveforms. It is increased to 4 J/kg if a second shock is required.

If a pediatric defibrillator is not available, then an adult defibrillator can be used.

In children the most common cause of cardiac arrest is asphyxia. However, a sudden witnessed collapse in a child is usually due to ventricular fibrillation.

For adult defibrillation, the energy that must be applied is

• Monophasic defibrillator– 360 J

• Biphasic defibrillator- 120-200 J (manufacturer recommended)

Solution to Question 20:

The cut off value for increased QRS duration according to the AHA 2020 guidelines for pediatric management of tachycardia with a pulse is >0.09 second. Wide QRS duration of >0.09 second is suggestive of possible ventricular tachycardia.

When a pediatric patient is in tachycardia, a 12-lead ECG is done to evaluate the rhythm and QRS complex duration. In addition, cardiopulmonary compromise is also assessed by checking for acutely altered mental status, signs of shock, and hypotension.

Based on the QRS complex duration on the ECG, it can be:

• Narrow (≤0.09 seconds) indicating a probable supraventricular tachycardia

• Wide (>0.09 seconds) indicating a possible ventricular tachycardia

Treatment of patient with probable supraventricular tachycardia:

• Presence of cardiopulmonary compromise - adenosine

• Absence of cardiopulmonary compromise - vagal maneuvers

Treatment of patient with possible ventricular tachycardia:

• Presence of cardiopulmonary compromise - synchronized cardioversion

• Absence of cardiopulmonary compromise - adenosine, if the the rhythm is regular and QRS is monomorphic

ACLS

Question 1:

A 45-year-old woman presented to the ER with dizziness. Her blood pressure is 80/60 mmHg, pulse rate is 45/minute. Her ECG is shown below. What is the next best step of management?

a) IV Epinephrine

b) IV Atropine

c) IV Amiodarone

d) IV Adenosine

Question 2:

A middle-aged woman with an acute altered mental state was brought to the ER. She had a history of hypothyroidism but was not on regular medication. On examination, her pulse rate was 40 beats per minute, BP was 80/60 mmHg. Which of the following cannot be used in the treatment of this patient?

a) Atropine

b) Dopamine

c) Transcutaneous pacing

d) Adenosine

Question 3:

What is the maximum dose of IV atropine that can be given to treat a patient with symptomatic bradycardia?

a) 0.5 mg

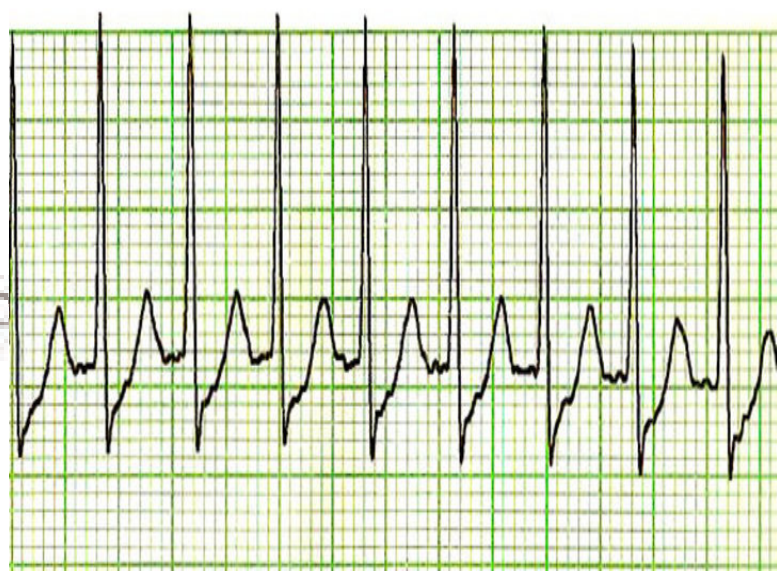
b) 0.6 mg

c) 3 mg

d) 6 mg

Question 4:

A 22-year-old man was brought to the casualty with palpitations and dizziness. His heart rate was 160/min and blood pressure was 110/80 mm Hg. His ECG is given below. What is the first line of management?



a) Adenosine 6 mg

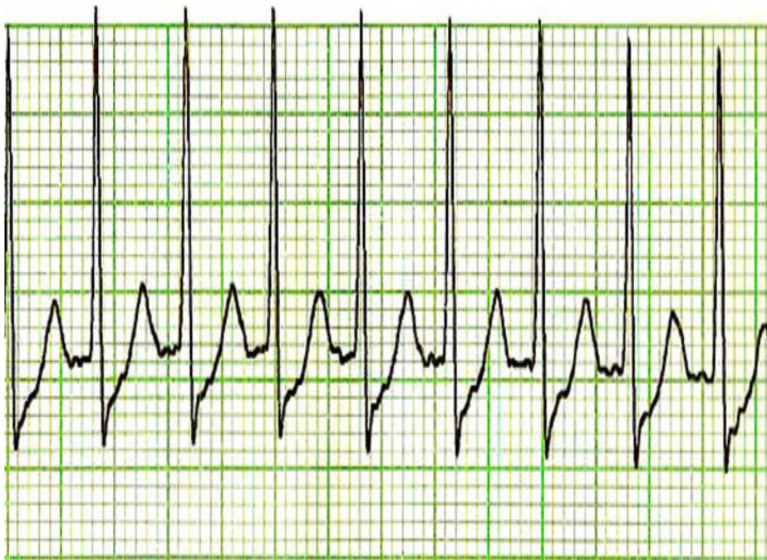
b) Adenosine 12 mg

c) Vagal manoeuvre

d) Amiodarone 300 mg

Question 5:

A 22-year-old man was brought to the casualty with palpitations and dizziness. His heart rate was 160/min and blood pressure was 110/80 mmHg. His ECG is given below. Vagal maneuver was found to be ineffective. What would your next line of management be?



a) Adenosine 0.6 mg

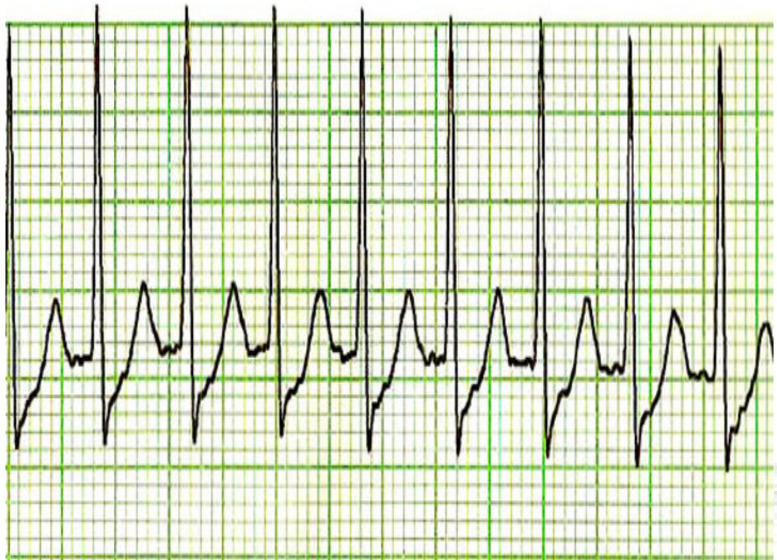
b) Adenosine 1.2 mg

c) Adenosine 6 mg

d) Adenosine 12 mg

Question 6:

A 22-year-old male was brought to the casualty with palpitations and dizziness. His heart rate is 170/min and his blood pressure was 70/40 mm Hg. His ECG is given below. What is the first line of management?



a) Vagal manoeuvre

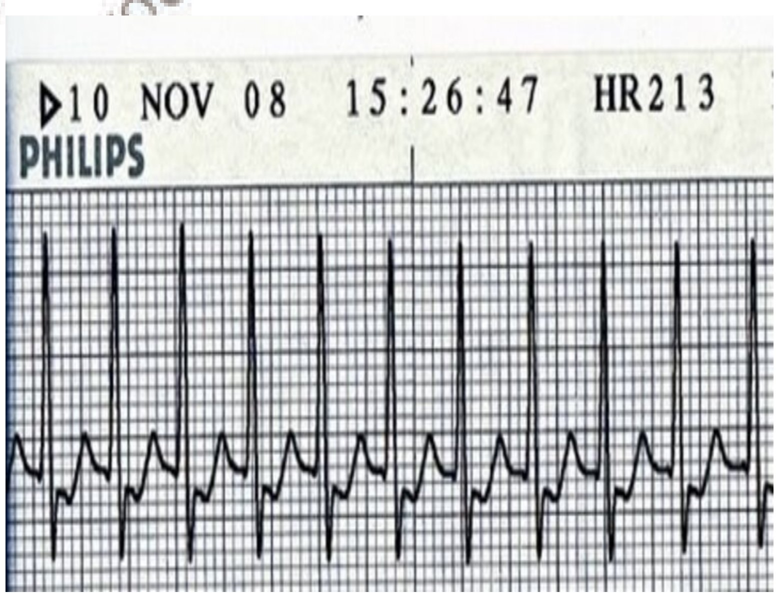
b) Adenosine 6 mg IV

c) Adenosine 12 mg IV

d) Cardioversion

Question 7:

A 50-year-old patient with a history of hypertension and diabetes mellitus developed the following rhythm. His blood pressure was 90/40 mm Hg and he had a feeble pulse. What is the next step of management?



a) IV adenosine

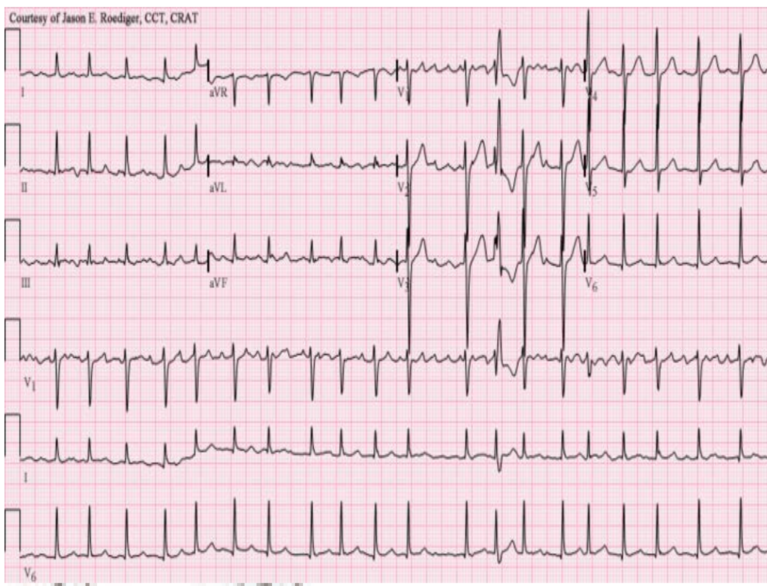
b) IV diltiazem

c) DC cardioversion

d) Ibutilide

Question 8:

A 58-year-old man presented to the casualty with complaints of increasing shortness of breath, lightheadedness, and palpitations. He had an irregularly irregular pulse and blood pressure was 120/70mm Hg. His ECG is given below. What is the treatment of choice?



a) Immediate defibrillation

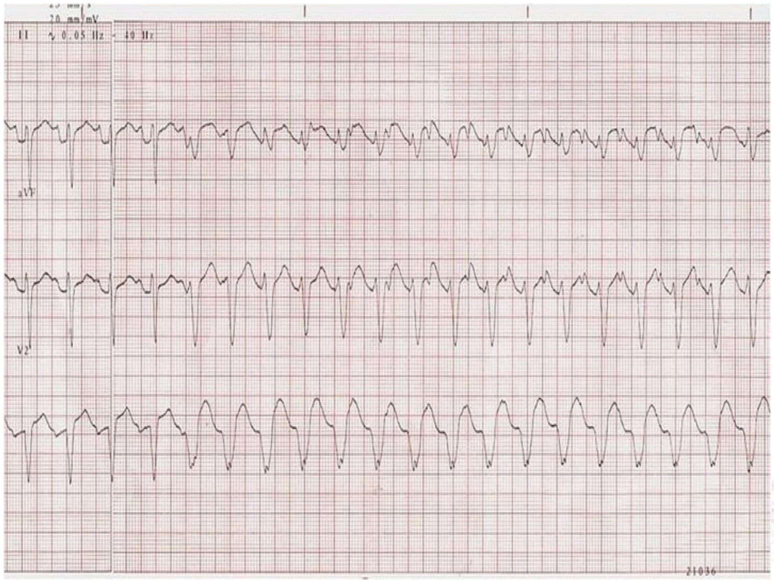
b) Synchronized cardioversion

c) IV adenosine

d) IV ibutilide

Question 9:

A young man was brought to the casualty with complaints of palpitations and dizziness. His pulse rate was 150/min and blood pressure 120/70 mm Hg. His ECG is shown below. What is the line of management?



a) IV procainamide

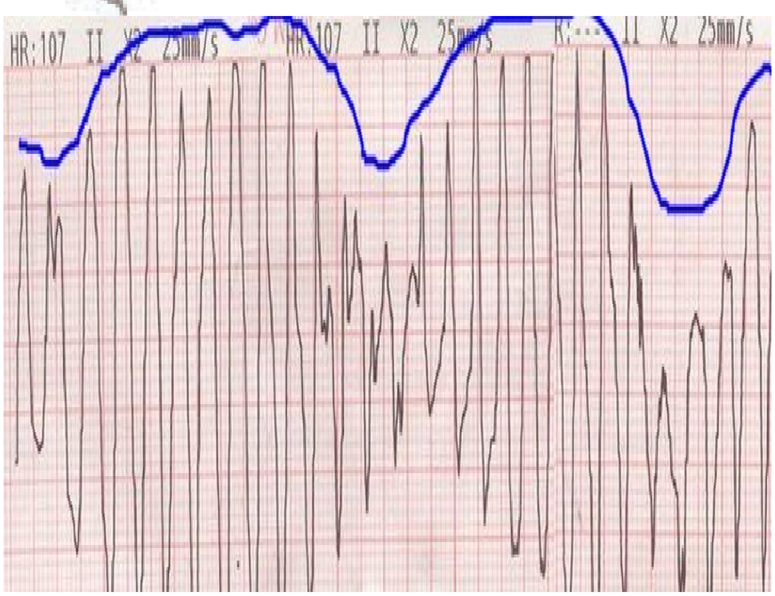
b) IV adenosine

c) IV lidocaine

d) Defibrillation

Question 10:

A 70-year-old woman with chronic kidney disease on chronic therapy with a loop diuretic was brought to the ER. Her daughter says that she complained of palpitation, dizziness, and then suddenly collapsed. Her ECG is given below. Which electrolyte abnormality has to be considered in this patient?



a) Hypermagnesemia

b) Hypomagnesemia

c) Hypernatremia

d) Hyponatremia

Question 11:

Which among the following is the most common cause of pulseless electrical activity?

a) Cardiac tamponade

b) Pulmonary embolism

c) Tension pneumothorax

d) Hypovolemia

Question 12:

Which of the following is an incorrect statement concerning pulseless electrical activity (PEA)?

a) A pulselessness in the presence of organized electrical activity

b) Cardiac tamponade can lead to PEA

c) Immediate defibrillation is required

d) 1mg of epinephrine is given immediately

Question 13:

Which is the most common cardiac rhythm seen in adults experiencing sudden cardiac arrest?

a) Ventricular fibrillation

b) Asystole

c) Atrial fibrillation

d) Paroxysmal supraventricular tachycardia

Question 14:

What is the most common cause of cardiac arrest in children?

a) Ventricular fibrillation

b) Myocardial infarction

c) Asphyxia

d) Congenital heart disease

Question 15:

A 30-year-old man was brought to the ER in an unconscious state after having collapsed in a railway station. As there was no pulse, cardiopulmonary resuscitation was started, and the monitor showed asystole. What is the next step in the management?

a) Defibrillation

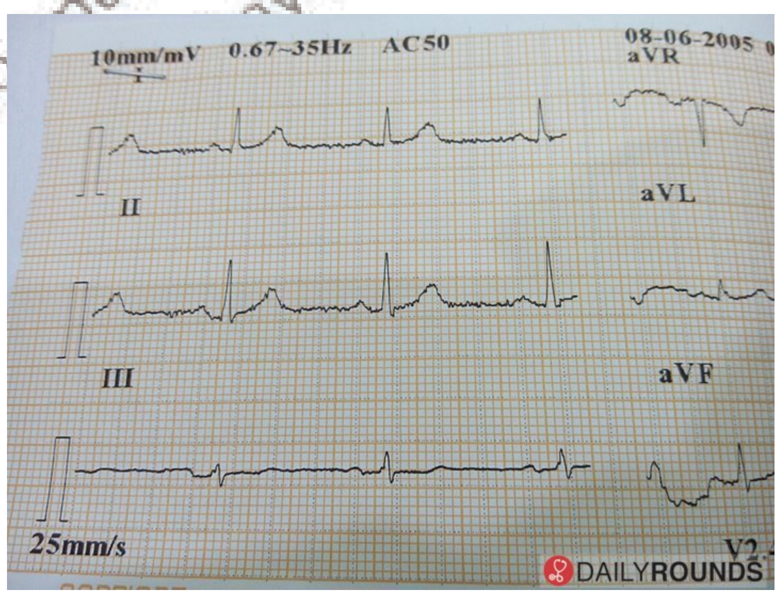
b) Synchronized cardioversion

c) 0.5 mg atropine IV

d) 1 mg epinephrine IV

Question 16:

A 47-year-old woman was brought to the casualty in an unconscious state after having suddenly collapsed. As there was no pulse, cardiopulmonary resuscitation was started and the monitor showed the following rhythm. What is the next step?



a) Defibrillation

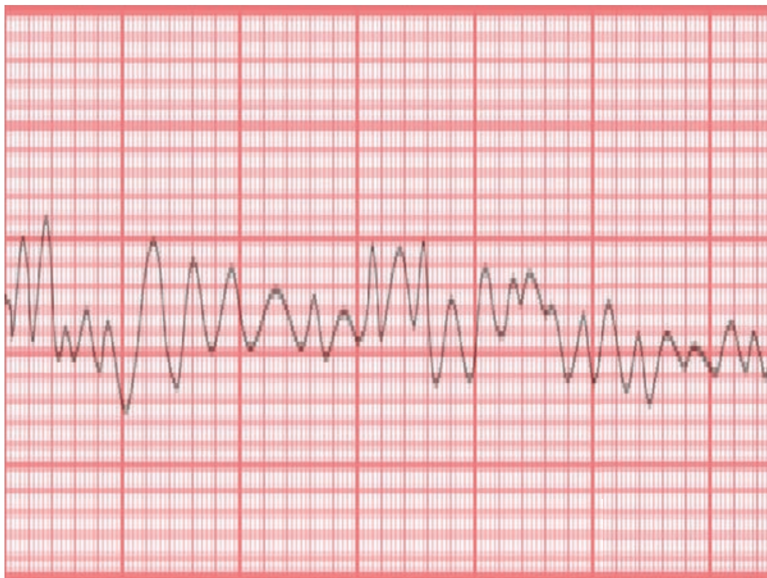
b) Synchronized cardioversion

c) 1 mg epinephrine IV

d) 0.5 mg atropine IV

Question 17:

You are performing cardiopulmonary resuscitation on a patient who had gone into cardiac arrest, and the monitor shows the following rhythm. What is the next step in management?



a) Defibrillation

b) Synchronized cardioversion

c) 0.5 mg atropine IV

d) 1 mg epinephrine IV

Question 18:

You have just performed defibrillation in a patient with ventricular fibrillation. According to the ACLS guidelines, what should be your next step?

a) Check for a pulse

b) Resume chest compression

c) Epinephrine 1 mg IV

d) Amiodarone 300 mg IV bolus

Question 19:

Which of the following drugs are not approved for resuscitation in a cardiac arrest victim?

a) Vasopressin

b) Epinephrine

c) Amiodarone

d) B and C

Question 20:

Which of the following is true about adrenaline in CPR?

a) Can be given intratracheally

b) Intracardiac route is better than IV

c) Converts coarse fibrillation into fine ones

d) The dose used is 2 ml containing 1 in 1000 concentration

Question 21:

In cardiac arrest patients, what is the dose of epinephrine you would prefer to use?

a) 10 mL of 1:1000

b) 10 mL of 1:10,000

c) 10 mL of 1:1,00,000

d) 1 mL of 1:1,00,000

Question 22:

Which of the following drugs cannot be administered via the endotracheal route?

a) Adrenaline

b) Vasopressin

c) Lignocaine

d) Sodium bicarbonate

Question 23:

What alternative drug would you use for cardiac arrest if epinephrine is not effective?

a) Vasopressin

b) Atropine

c) Amiodarone

d) Adenosine

Question 24:

A comatose patient is being shifted to the cardiac ICU after achieving return of spontaneous circulation (ROSC). What is the body temperature to be maintained in this patient?

a) 12-16°

b) 20-24 °C

c) 32-36°C

d) 42- 45° C

Question 25:

You are performing CPR on a woman who is 38-weeks pregnant. She was admitted to the ER after a massive pulmonary embolism had lead to cardio-pulmonary arrest. Despite adequate resuscitative measures, there is no improvement. What is the cut-off time for perimortem cesarean delivery in this scenario?

a) 1 minute

b) 2 minutes

c) 5 minutes

d) 3 minutes

Answer Key

Question No.	Correct Option
1	b
2	d
3	c
4	c
5	c

6	d
7	c
8	d
9	a
10	b
11	d
12	c
13	b
14	c
15	d
16	c
17	a
18	b
19	a
20	a
21	b
22	d
23	c
24	c
25	c

Detailed Explanations

Solution to Question 1:

The ECG shown above is the second-degree atrioventricular block type 1 - Wenckebach phenomenon.

Treatment is indicated when bradycardia is accompanied by any one of the following:

• Hypotension

• Acutely altered mental status

• Signs of shock

• Ischemic chest discomfort

• Acute heart failure

Treatment is initiated with 1 mg atropine iv which may be repeated at 3-5 minute intervals to a maximum dose of 3 mg.

Along with atropine, transcutaneous pacing is to be done.

If the bradycardia is refractory to both atropine and transcutaneous pacing, then IV infusions of dopamine (5 to 20 µg/kg/min) or epinephrine (2 to 10 µg/min) should be considered.

If the patient still isn't responding, then transvenous pacing should be tried. If the patient is under spinal anesthesia, low-dose (0.2 mg) IV epinephrine can be given.

Epinephrine is the drug of choice for treating bradyarrhythmias in infants and children.

Solution to Question 2:

Adenosine cannot be used in the treatment of this patient. It is used to treat supraventricular tachyarrhythmias, not bradyarrhythmias.

The scenario depicts a patient with symptomatic bradycardia, marked by acute altered mental status and hypotension with hypothyroidism as the risk factor.

Treatment is indicated when bradycardia is accompanied by any one of the following:

- Hypotension
- Acutely altered mental status
- Signs of shock
- Ischemic chest discomfort
- Acute heart failure

Treatment is initiated with 1 mg atropine iv which may be repeated at 3-5 minute intervals to a maximum dose of 3 mg.

Along with atropine, transcutaneous pacing is to be done.

If the bradycardia is refractory to both atropine and transcutaneous pacing, then IV infusions of dopamine (5 to 20 µg/kg/min) or epinephrine (2 to 10 µg/min) should be considered.

If the bradycardia is still not responding, then transvenous pacing should be tried. If the patient is under spinal anesthesia, low-dose (0.2 mg) IV epinephrine can be given.

Epinephrine is the drug of choice for treating bradyarrhythmias in infants and children.

Solution to Question 3:

IV atropine is used in the treatment of symptomatic bradyarrhythmia starting at a dose of 1 mg, which can be repeated every 3-5 minutes to a maximum dose of 3 mg.

Along with atropine, transcutaneous pacing is to be done.

If the bradycardia is refractory to both atropine and transcutaneous pacing, then IV infusions of dopamine (5 to 20 µg/kg/min) or epinephrine (2 to 10 µg/min) should be considered.

If the bradycardia is still not responding, then transvenous pacing should be tried. If the patient is under spinal anesthesia, low-dose (0.2 mg) IV epinephrine can be given.

Epinephrine is the drug of choice for treating bradyarrhythmias in infants and children.

Solution to Question 4:

The patient has paroxysmal supraventricular tachycardia. As the patient's blood pressure is normal and there is no evidence of hemodynamic deterioration, initial treatment consists of vagal maneuvers (Valsalva maneuver) in awake patients. This is because vagal maneuvers alone can terminate approximately 20% to 25% of reentry supraventricular tachycardias (SVTs).

If this is unsuccessful, then IV adenosine 6 mg is given. If necessary another dose of adenosine 12 mg may be administered after 1-2 minutes.

If the drug is administered via a central venous catheter, then these doses are reduced to 3 mg and 6 mg, respectively.

If there is hemodynamic deterioration, then cardioversion is the treatment of choice.

Solution to Question 5:

The patient has paroxysmal supraventricular tachycardia.

As vagal maneuver has been found ineffective, then the next best step is to administer adenosine 6 mg IV.

For treating supraventricular tachycardia, the hemodynamic status of the patient has to be assessed. In this patient, as his blood pressure is normal and there is no evidence of hemodynamic deterioration, initial treatment consists of vagal maneuvers (Valsalva maneuver) in awake patients.

In this scenario, as this was unsuccessful, IV adenosine 6 mg had to be given. If necessary another dose of adenosine 12 mg may be administered after 1-2 minutes.

If the drug is administered via a central venous catheter, then these doses are reduced to 3 mg and 6 mg, respectively.

If there is hemodynamic deterioration, then cardioversion is the treatment of choice.

Solution to Question 6:

This patient has supraventricular tachycardia with evidence of hemodynamic deterioration. Immediate treatment would be cardioversion (50-100J).

If the patient were hemodyamically stable, initial treatment would be vagal maneuvers (Valsalva maneuver) in awake patients. This is because vagal maneuvers alone can terminate approximately 20% to 25% of reentry supraventricular tachycardias (SVTs).

If this is unsuccessful, then iv adenosine 6 mg is given. If necessary another dose of adenosine 12 mg may be administered after 1-2 minutes.

If the drug is administered via a central venous catheter, then these doses are reduced to 3 mg and 6 mg respectively.

Solution to Question 7:

The clinical scenario suggests supraventricular tachycardia with hemodynamic instability and the next step of management is DC cardioversion (50-100J).

If the patient was hemodyamically stable, initial treatment would be vagal maneuvers (Valsalva maneuver) in awake patients. This is because vagal maneuvers alone can terminate approximately 20% to 25% of reentry supraventricular tachycardias (SVTs).

If this is unsuccessful, then iv adenosine 6 mg is given. If necessary another dose of adenosine 12 mg may be administered after 1-2 minutes.

If the drug is administered via a central venous catheter, then these doses are reduced to 3 mg and 6 mg respectively.

Solution to Question 8:

The patient is in atrial fibrillation but his hemodynamic status is normal. So the treatment of choice is IV Ibutilide.

Ibutilide is a class III antiarrhythmic drug that has a rapid onset of action. It restores sinus rhythm by prolonging the action potential duration and effective refractory period.

It is administered at a dose of 1 mg over 10 minutes. If necessary, a second dose can be administered 10 minutes after the first.

If there is evidence of hemodynamic deterioration, immediate cardioversion is the treatment of choice.

Cardioversion is a synchronized administration of shock as the timing is typically synchronized with the R waves or QRS complex of a cardiac cycle. On the other hand, random administration of shock anywhere in between a cardiac cycle is termed as Defibrillation which is non-synchronized.

However, the mechanism for both processes is quite similar. The electric current is made to travel from the negative to the positive electrode in such a way that it traverses the entire myocardium at once to conduct a simultaneous contraction of each cell of the heart muscle. It is made to interrupt any ongoing abnormal electrical activity by terminating it so that the sinus node can take back the charge and resume its normal pacemaker activity.

Cardioversion is typically performed under induction or sedation using a short-acting agent such as midazolam, unless the patient is hemodynamically unstable or if cardiovascular collapse is imminent. Defibrillation is more of an emergent maneuver and, when necessary, should be preferably performed in conjunction with or prior to the administration of induction or sedative agents.

Energy may be delivered through mainly two waveforms in defibrillators that are monophasic or biphasic.

Monophasic defibrillation delivers a charge in only one direction as opposed to biphasic defibrillation delivering a charge in one direction for half of the shock and in the electrically opposite direction for the second half.

Biphasic waveforms are adopted in newer defibrillators as they deliver a more consistent magnitude of the current which successfully terminates arrhythmias at lower energies than monophasic waveform defibrillators.

Energy selection for defibrillation or cardioversion. Following are the guidelines for initial energy requirements issued by the American Heart Association in 2010.

Atrial fibrillation energy requirements are as follows:

• 200 Joules for monophasic devices

• 120-200 Joules for biphasic devices

Atrial flutter energy requirements are as follows:

• 100 Joules for monophasic devices

• 50-100 Joules for biphasic devices

Ventricular tachycardia with pulse energy requirements are as follows:

• 200 Joules for monophasic devices

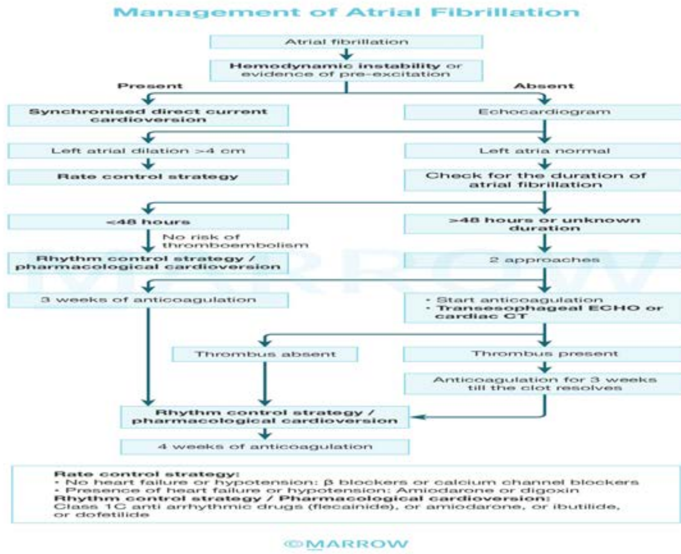
• 100 Joules for biphasic devices

Ventricular fibrillation or pulseless ventricular tachycardia energy requirements are as follows:

• 360 Joules for monomorphic devices

• 120-200 Joules for biphasic devices

Indications for electrical cardioversion	Indications for defibrillation
Supraventricular tachycardia(atrioventricular nodal reentrant tachycardia [AVNRT] and atrioventricular reentrant tachycardia [AVRT])Atrial fibrillationAtrial flutter(types I and II)Ventricular tachycardia(with a pulse)Any patient with re-entranttachycardia withnarrow or wide QRScomplex (ventricular rate >150 bpm) who isunstable(eg, ischemic chest pain, acute pulmonary edema, hypotension, acute altered mental status, signs of shock)	Pulseless ventricular tachycardia (VT)Ventricular fibrillation (VF)Cardiac arrestdue to or resulting in VF



Solution to Question 9:

The patient is in ventricular tachycardia with hemodynamic stability. The next line of management is to administer procainamide, class IA antiarrhythmic drug.

Antiarrhythmic therapy for stable wide QRS tachycardia include procainamide, amiodarone, or sotalol. Synchronized cardioversion is considered when the patient is unstable.

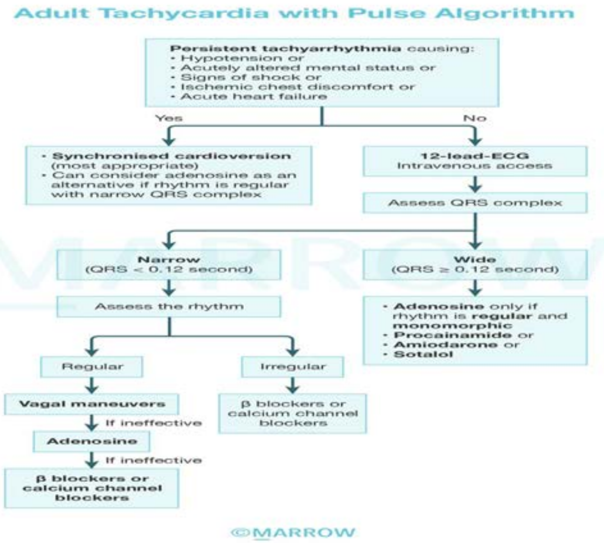
When a patient is in tachyarrhythmia typically with a heart rate of ≥150 per minute, the initial intervention consists of identifying and treating the underlying cause. This includes:

• Maintaining a patent airway and assisting breathing as necessary

• Administering oxygen if hypoxemic

• Attaching cardiac monitor to identify rhythm; monitor blood pressure and oximetry

When there is persistent tachyarrhythmia, the management is as depicted by the flowchart (based on the AHA guidelines) below:



Option B: Adenosine is used in regular narrow complex tachycardia.

Option C: Lidocaine has limiting side effects and, increase the overall mortality risk.

Option D: It is the treatment for immediately life-threatening arrhythmias with which the patient does not have a pulse, ie ventricular fibrillation (VF) or pulseless ventricular tachycardia (VT).

Solution to Question 10:

Chronic use of loop diuretics such as furosemide can predispose to hypomagnesemia. The given ECG classically depicts polymorphic ventricular tachycardia—torsades de pointes. Torsade rhythm is most commonly is seen in association with hypomagnesemia and hypokalemia.

Torsades de pointes is a polymorphic ventricular tachycardia meaning “twisting of the points,” characterized by twisting of the QRS axis around the baseline and a polymorphic appearance.

There is QT interval prolongation in the ECG due to a non-uniform delay in repolarization.

The other cause of torsades de pointes include:

• Drugs like quinidine, procainamide, disopyramide, and phenothiazine (amiodarone is rarely associated with torsades de pointes because the delay in repolarization induced by it is uniform).

• Bradycardia

• Acute ischemia or infarction

Management:

• Discontinue the offending drug

• Correct electrolyte abnormalities, pH and hypoxia

• Magnesium sulphate infusion

• Increase the heart rate - electrical pacing, isoproterenol infusion, or intravenous atropine

Solution to Question 11:

Hypovolemia and hypoxia are the two most common causes of pulseless electrical activity (PEA).

Most likely causes of Pulseless electrical activity:

- In a trauma patient: hypovolemia, cardiac tamponade, and tension pneumothorax
- In the intraoperative or postoperative period: acute massive pulmonary thromboembolism or air embolism
- In pregnant women: uterine compression of the inferior vena cava, amniotic fluid embolism, or uterine rupture.

Solution to Question 12:

A pulseless electrical activity (PEA) is a non-shockable rhythm. Defibrillation is of no benefit.

PEA involves a heterogeneous group of cardiac rhythms all without a pulse.

The immediate treatment for this is giving chest compressions and 1 mg epinephrine at the earliest until more definitive therapy to the cause can be instituted.

It is essential to rule out the reversible causes of cardiac arrest because the treatment for each of them is different and PEA is likely to persist until the cause is treated.

Solution to Question 13:

The most common cardiac rhythm seen in adults experiencing sudden cardiac arrest is asystole, as recorded at initial contact in 45–50% of cases.

Previously VF was thought to be the common rhythm, but its incidence has now been decreasing.

Solution to Question 14:

In children, the more common cause of cardiac arrest is asphyxia rather than ventricular fibrillation.

Even though asphyxia is the more common cause, pediatric resuscitation starts with chest compressions rather than rescue breaths as in adults for simplicity in training. This is because the cycle of 30 chest compressions before rescue breathing delays ventilation for only 15 to 20 seconds.

During cardiopulmonary resuscitation of infants and children, the ratio of chest compression to rescue breaths is 30:2 for a single rescuer and 15:2 if 2 or more rescuers are present. In adults, the ratio is 30:2 irrespective of the number of rescuers.

In infants and children, the depth of compression should be at least one-third of the anteroposterior diameter of the chest which is about 5 cm in children and 4 cm in infants.

Solution to Question 15:

Asystole is a non-shockable rhythm. Treatment for both involves starting CPR immediately and administering 1 mg epinephrine IV.

Asystole is the complete and sustained absence of electrical activity. It is usually seen as a terminal rhythm in a resuscitation attempt that started with another rhythm, or in a patient with unwitnessed or prolonged cardiac arrest. The prognosis for persistent asystole is poor.

Another example of a non-shockable rhythm is Pulseless electrical activity. It involves a heterogeneous group of cardiac rhythms, all without a pulse.

It is essential to rule out the reversible causes of cardiac arrest because the treatment for each of them is different and PEA is likely to persist until the cause is treated.

Solution to Question 16:

The patient has an organized, apparently normal ECG without a pulse - i.e the patient has pulseless electrical activity (PEA). A pulseless electrical activity involves a heterogeneous group of cardiac rhythms, all without a pulse.

The immediate treatment for this is giving chest compressions and 1 mg epinephrine at the earliest until definitive therapy to the cause can be instituted.

It is essential to rule out the reversible causes of cardiac arrest because the treatment for each of them is different and PEA is likely to persist until the cause is treated.

Solution to Question 17:

The ECG rhythm shown is ventricular fibrillation which is treated by immediate defibrillation.

The management of ventricular fibrillation and pulseless ventricular tachycardia (shockable rhythms) is the same. Immediate chest compression is to be started.

It is of utmost necessity to defibrillate at the earliest because the chances of survival decrease by 7-10% every minute without defibrillation.

Defibrillation involves delivering an electrical current between two pads placed on the chest so as to interrupt the disorganized cardiac activity and restore an organized cardiac rhythm or asystole for at least 5 seconds.

The energy that must be applied is

• Monophasic defibrillator– 360 J

• Biphasic defibrillator- 120 J

Solution to Question 18:

Chest compressions should be resumed immediately following shock delivery.

Pulse check and reanalysis of the cardiac rhythm is performed only after 2 minutes of chest compression and rescue breaths. This is because the heart is temporarily stunned by a defibrillator shock and so chest compressions would benefit the patient by providing coronary blood flow during this period.

Defibrillation involves delivering an electrical current between two pads placed on the chest so as to interrupt disorganized cardiac activity and restore an organized cardiac rhythm or asystole for at least 5 seconds. It is of utmost necessity to defibrillate immediately because the chances of survival decrease by 7-10% every minute without defibrillation.

If after 2 minutes, the rhythm remains the same, then another shock is delivered. Chest compression and rescue breaths are resumed and 1 mg epinephrine is administered. Consideration is given for an advanced airway placement.

If after 2 minutes the rhythm still remains the same, the first dose of amiodarone 300mg bolus is given.

With the next cycle of CPR, a shock is delivered and 1 mg of epinephrine is given. And with the cycle of CPR after that, shock is delivered and the second dose of amiodarone- 150mg is given

Solution to Question 19:

Vasopressin was a part of the resuscitation protocol in the 2010 American Heart Association (AHA) cardiac arrest algorithm but it has been removed from the 2015 guidelines.

Vasopressin causes intense peripheral vasoconstriction due to stimulation of V1 receptors in the endothelium but it causes a limited increase in myocardial contractility, myocardial and cerebral oxygen consumption, and metabolic demands. Thus it doesn't have much of a survival benefit.

Epinephrine and amiodarone are the two main drugs approved by the AHA for resuscitation of a patient in cardiac arrest.

The first dose of epinephrine,1 mg IV, is administered after the 2nd defibrillator shock is delivered and it is continued every 3-5 minutes.

If this is not effective, 300 mg IV bolus dose of amiodarone can be given and another dose of 150 mg given if necessary

Solution to Question 20:

Intravenous Adrenaline is the drug of choice for CPR. However, adrenaline can be given intratracheally also. The concentration required for intratracheal administration is 2-2.5 times more than required for the IV route.

Option B: Intracardiac injection is not recommended as it can cause myocardial damage. Recommended routes for adrenaline are intravenous, intraosseous (children), and intra-tracheal.

Option C: Adrenaline converts fine fibrillation to coarse fibrillation which then responds well to defibrillation.

Option D: Adrenaline is available as a 1 mL injection containing 1 mg of adrenaline in 1:1000 concentration. The dose used in cardiac arrest is 1mg of adrenaline every 3-5 minutes, usually given as 1ml in 1:1000 concentration or 10ml in 1:10,000 concentration (more preferred since in cardiac arrest peripheral circulation is absent; hence larger volume is required for the drug to reach the central circulation).

Solution to Question 21:

Epinephrine is used in cardiac arrest patients at a dose of 10 mL of 1: 10,000 solution (1 mg epinephrine).

Epinephrine is an adrenergic agonist: ° -Adrenergic effects increase myocardial blood flow. β-Adrenergic effects increases myocardial contractility.

Indication: VF/VT, electromechanical dissociation, ventricular asystole, severe bradycardia unresponsive to atropine or pacing, severe hypotension.

Dose: 1 mg IV. Repeat doses every 3–5 min as necessary. Administration down a tracheal tube requires higher doses (2–2.5 mg in adults).

Solution to Question 22:

Sodium bicarbonate cannot be administered via the endotracheal route.

The dosage for intratracheal route is 2-2.5 times higher than the intravenous dose. The drugs should be diluted in 10 ml of normal saline or distilled water for adults and 5 ml for children.

When there is no intravenous access, the intraosseous route is preferred over the endotracheal route because the optimal dose via the endotracheal route is not known. Also, CPR needs to be stopped momentarily as the drug may be regurgitated up the endotracheal tube during chest compression.

Solution to Question 23:

Epinephrine and amiodarone are the two main drugs approved by the AHA for the resuscitation of a cardiac arrest patient.

The first dose of epinephrine 1 mg IV is administered after the 2nd defibrillator shock is delivered and it is continued every 3-5 minutes.

If this is not effective, 300 mg IV bolus dose of amiodarone can be given and another dose of 150 mg given if necessary

Solution to Question 24:

According to the post-cardiac arrest care algorithm, targeted temperature management is the maintenance of a constant target temperature between 32-36oC for at least 24 hours.

This is done in post-cardiac resuscitation patients who have achieved return of spontaneous circulation (ROSC), but are still comatose.

The entire body is to be cooled using a combination of methods like fluid-filled cooling blankets, ice packs, forced air blankets, cold IV fluids, and/or invasive devices or catheters.

It has been found to be the only intervention that can improve neurological recovery after cardiac arrest. It is most beneficial in ventricular fibrillation and pulseless ventricular tachycardia patients.

Solution to Question 25:

Perimortem cesarean delivery should be considered if there is no return of spontaneous circulation in 5 minutes, according to the AHA 2020 Guidelines.

When a pregnant woman is in cardiac arrest, high-quality CPR and defibrillation are performed and epinephrine is administered. The maternal cardiac arrest team is assembled to look for the etiology and perform the following interventions:

• Maternal interventions:

• Airway management

• Administration of of 100% O_2

• Placing the IV above the diaphragm

• If the patient is on IV magnesium - stopping it and administering calcium chloride or gluconate

• Obstetric interventions:

• Continuous lateral uterine displacement

After performing the above-mentioned interventions, if there is no return of spontaneous circulation (ROSC) in 5 minutes, a perimortem cesarean section is considered.

Ventilation and O2 Delivery Systems

Question 1:

Which of the following is not a low-flow variable performance device?

a) Nasal cannula
b) Non-rebreathing mask
c) Nasal mask
d) Anaesthetic bag

Question 2:

What is the maximum percentage of oxygen that can be delivered via nasal cannula?

a) 100 %
b) 90%
c) 40%
d) 10%

Question 3:

In which of the following situations should nasal cannula be avoided?

a) Requiring inspiratory oxygen flow rate of 45 L/min
b) Minute ventilation of 8 L/min
c) Respiratory rate at 15 breaths/min
d) Tidal volume less than 0.8 L

Question 4:

What is the maximum oxygen concentration delivered by a venturi mask?

a) 20%
b) 40%
c) 60%

d) 100%

Question 5:

An 18-year-old boy is rushed to the emergency department after having choked on a bone while eating. He is responsive but unable to speak. What is to be done next?

a) Bag and mask ventilation

b) Endoscopic removal

c) Deliver 5 backslaps and 5 chest compressions

d) Perform Heimlich maneuver

Question 6:

In an intubated patient, after what duration of endotracheal intubation will you need to perform a tracheostomy?

a) 2 hours

b) 2 days

c) 2 weeks

d) 2 months

Question 7:

Which of the following is not an indication for mechanical ventilation?

a) Arterial oxygen tension < 50 mm Hg

b) Arterial CO2 tension < 50 mm Hg

c) Tidal volume < 5 ml/kg

d) Vital capacity < 15 ml/kg

Question 8:

Which of the following is associated with respiratory alkalosis?

a) Assisted control mode ventilation

b) Controlled mandatory

c) Pressure controlled

d) SIMV

Question 9:

You are planning to wean a patient off mechanical ventilation. Which of the following is not a criterion to do so?

a) Tidal volume of 5 ml/kg

b) Vital capacity of 5 ml/kg

c) Minute ventilation of 10L/min

d) Inspiratory pressure of –25 cm H_2O

Question 10:

Following a road traffic accident, an unresponsive young man was brought to the emergency room. In order to declare him as brain dead, which of the following criteria can be used?

a) 2, 3 and 5

b) 1, 2 and 4

c) 1, 3 and 5

d) 2, 3 and 4

Answer Key

Question No.	Correct Option
1	d
2	c
3	a
4	c
5	d
6	c
7	b
8	a
9	b

10	a

Detailed Explanations

Solution to Question 1:

Anaesthetic bag or the bag-mask-valve system is a high flow fixed performance system - the delivered FiO2 is not affected by changes in ventilatory level or breathing pattern of the patient and thus deliver accurate oxygen concentration. It is of two types: the self-inflating bags with a reservoir of 1.5 L and the non-self-inflating bags with a reservoir of 1, 2 or 3 L.

The disadvantage is high cost and poor patient tolerability due to high flow. The other fixed performance devices include venturi mask, air-entraining nebulizers, and high flow air oxygen systems.

The nasal cannula, non–rebreathing mask, and nasal mask are low flow variable performance systems. Oxygen is delivered at a low, fixed flow which is only a portion of the inspired gas mixture. They are cheap with better patient tolerability. The disadvantage is that the FiO2 delivered cannot be accurately predicted, so they are suitable for patients with stable breathing patterns.

High flow systems	Low flow systems
Fixed performance systems	Variable performance system s
Examples:venturi maskair-en training nebulizershigh flow air oxygen systemsanaestheti c bag	Examples:nasal cannulanon–rebreathing masknasal mask

Solution to Question 2:

The nasal cannula is a low flow variable performance oxygen delivery system that can achieve a maximum inspired oxygen concentration of 40-50 % if flow rates are greater than 10L/ min for short periods.

Flow rates greater than 5 L/min are not tolerated because of the discomfort associated with this high flow entering the nasal cavity and also due to drying and crusting of the nasal mucosa.

At flow rates of 3-4 L, it can provide an inspired oxygen concentration of 30-35%.

In mouth-to-mouth resuscitation, the percentage of oxygen delivered is 16%.

Solution to Question 3:

A nasal cannula is a low flow variable performance oxygen delivery system. It is not suited for patients requiring high FiO_2 or inspiratory oxygen flow rates greater than 40 L/min for which devices like venturi mask, anaesthetic bag, air-entraining nebulizers, or high flow air oxygen systems are preferred.

Indications of a nasal cannula and other low-flow oxygen delivery systems include

• Minute ventilation < 8–10 L/min

• Breathing frequencies < 20 breaths/min

• Tidal volumes (V T) < 0.8 L

• Normal inspiratory flow (10–30 L/min).

Solution to Question 4:

Venturi mask is a high-flow, fixed-performance oxygen delivery system and the highest oxygen concentration (FiO_2) delivered is 60% at a flow rate of 15 L/min.

It is available in different colors, with the green valve venturi mask providing 60% FiO_2.

This is useful with patients who require greater FiO_2 such as COPD patients, where it is important to provide controlled oxygenation.

Colour of Venturi valve	FiO_2 (%)	Flow rate(L/min)
Blue	24	2
White	28	4
Orange	31	6
Yellow	35	8
Red	40	10

Colour of Venturi valve	FiO2 (%)	Flow rate(L/min)
Green	60	15

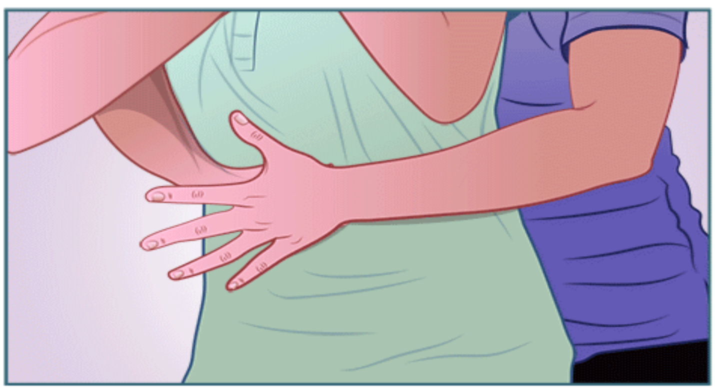
Solution to Question 5:

In a choking child (more than 1 year old) or an adult, the first step to be done is to perform Heimlich maneuver which involves delivering abdominal thrusts.

The rescuer should stand or kneel behind the patient and wrap his arms around the patient's waist. A fist is made with one hand and using the other hand, the fist is driven into the patient's abdomen with a rapid, forceful upward thrust so as to dislodge the foreign body. This is continued until the foreign body is expelled or if the patient becomes unresponsive.

If the patient becomes unresponsive, immediately start CPR.

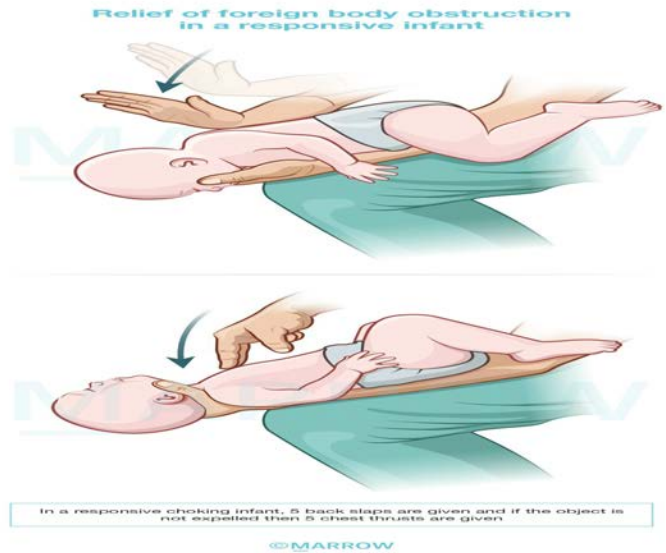
Heimlich maneuver



©MARROW

In a choking infant who is responsive, 5 back slaps between the shoulder blades and 5 downward thrusts on the chest are given in order to dislodge the foreign body.

If the patient becomes unresponsive, immediately start CPR.



Solution to Question 6:

Tracheostomy is performed in an intubated patient after 2-3 weeks.

This is because if an orotracheal or nasotracheal tube is left in situ for more than 2-3 weeks, it results in subglottic stenosis.

Hence it is ideal to replace the endotracheal tube with a cuffed tracheostomy tube.

If on intubation, it is perceived that the patient may require intubation for a period longer than 2 weeks, then tracheostomy can be performed soon after intubation.

Tracheostomy has been found to reduce the incidence of pneumonia, the duration of mechanical ventilation, and the length of stay in hospitals for patients with major head injuries.

Solution to Question 7:

Arterial CO2 tension < 50 mm Hg is not an indication for mechanical ventilation.

Indications of mechanical ventilation:

Directly measured indices

• Arterial oxygen tension <50 mmHg on room air

• Arterial CO2 tension >50 mmHg in the absence of metabolic alkalosis

Derived indices

• PaO2 /FiO2 ratio <300 mm Hg

• PA–a O2 gradient >350 mm Hg

• Vd /Vt >0.6

Clinical indices

• Respiratory rate >35 breaths/min

Mechanical indices

• Tidal volume <5 mL/kg

• Vital capacity <15 mL/kg

• Maximum Inspiratory Force > –25 cm H 2 O

Solution to Question 8:

Respiratory alkalosis can occur in Assist Control Mode Ventilation

Ventilatory Mode	ACMV(Assist Control Mode Ventilation)	IMV(Intermittent Mandatory Ventilation)	PSV(Pressure Support Ventilation)	NIV(Noninvasive Ventilation)
Variables set by User (Independent)	Tidal volumeVentilator rateFio2PEEP levelPressure limit	Tidal volumeMandatory ventilator rateFio2PEEP levelPressure limitSpontaneous breaths between assisted breaths	Inspiratory pressure levelFio2PEEPPressure limit	Inspiratory and expiratory pressure levelFio2
Variables Monitored by the user (Dependent)	Peak, mean, and plateau airway pressuresVEABGI/E ratio	Peak, mean, and plateau airway pressuresVEABGI/E ratio	Tidal volumeRespiratory rateVEABG	Tidal volumeRespiratory rateVEABG
Trigger cycle limit	Patient effortTimer Pressure limit	Patient effortTimer Pressure limit	Pressure limitInspiratory flow	Pressure limitInspiratory flow
Advantages	Patient controlGuaranteed ventilation	Patient controlComfort from spontaneous breathsGuaranteed ventilation	Patient controlComfortAssures synchrony	Patient control
Disadvantages	Potential hyperventilation(Leading to respiratory alkalosis) Barotrauma and volutraumaEvery effective breath generates a ventilator volume	Potential dysynchronyPotential hypoventilation	No timer backupPotential hypoventilation	Mask interface may cause discomfort and facial bruisingLeaks are commonHypoventilation

Solution to Question 9:

Weaning off mechanical ventilation is indicated when vital capacity is >10 mL/kg.

Solution to Question 10:

Absent spinal cord reflex and decorticate posturing are not criteria for brain death. The statements 2, 3 and 5 are correct.

Brain death is defined as the irreversible cessation of all brain function. Spinal cord function below C1 may still be present.

Brain death criteria can be applied only in the absence of:

• Hypothermia

• Hypotension

• Uncorrected metabolic or endocrine abnormalities

• Neuromuscular blockers

• Drugs known to depress brain function.

Generally accepted clinical criteria for brain death include the following:

• Coma

• Absent motor activity, including no decerebrate or decorticate posturing

• Spinal cord reflexes may be preserved

• Absent brainstem reflexes, including no pupillary, corneal, vestibulocochlear (caloric), or gag (or cough) reflexes

• Absence of ventilatory effort, with the arterial CO_2 tension >60 mm Hg or 20 mm Hg above the pretest level (positive apnea test)

Confirmatory test findings (not mandatory but may assist in diagnosis)

• Isoelectric electroencephalogram

• Absence of brainstem auditory evoked potentials

• Absence of cerebral perfusion as documented by angiographic, transcranial Doppler, or radioisotopic studies

Depolarising Muscle Relaxants

Question 1:

Which of the following statements is false regarding succinylcholine?

a) It produces both phase I and phase II block

b) It raises intracranial pressure

c) Precurarization reduces fasciculations and myalgia associated with Sch

d) It is a non–depolarizing muscle relaxant

Question 2:

Which is the shortest acting muscle relaxant?

a) Vecuronium

b) Pancuronium

c) Suxamethonium

d) Pipecuronium

Question 3:

In a road traffic accident victim with a GCS of 8/15, rapid sequence intubation is planned. Which of the following muscle relaxants is used here?

a) Atracurium

b) Mivacurium

c) Rocuronium

d) Succinylcholine

Question 4:

Which drug produces phase II block?

a) Atracurium

b) Pancuronium

c) D-tubocurarine

d) Suxamethonium

Question 5:

Which of the following statements regarding depolarising muscle relaxants is false?

a) Causes muscle fasciculations

b) Phase I block cannot be reversed by neostigmine

c) Depolarised muscle fibres are unresponsive to other stimuli

d) Fade is seen in phase I block

Question 6:

A 70 kg athlete was posted for surgery on her injured rotator cuff. She was administered a total of 640mg of succinylcholine by intermittent dosing. During recovery, she was unable to respire spontaneously and move her limbs. What is the most likely reason for this?

a) Muscular weakness due to fasciculation produced by succinylcholine

b) Undiagnosed muscular dystrophy and muscular weakness

c) Phase II blockade produced by succinyl choline

d) Pseudocholinesterase deficiency increasing action of succinylcholine

Question 7:

The anesthetist asks you to administer succinylcholine to a patient in the OT and warns you to monitor the dose carefully to prevent the development of a phase II block. Which of the following is incorrect regarding this phase of the block?

a) Presence of fade phenomenon

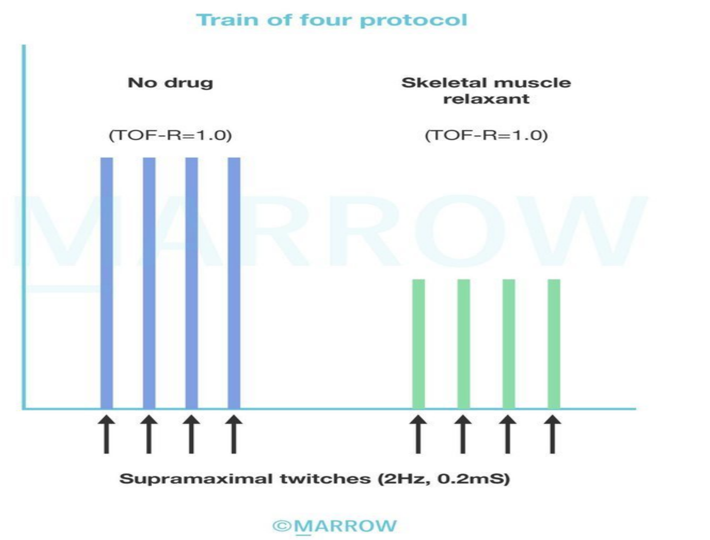
b) Presence of post tetanic facilitation

c) Preceded by muscle fasciculation

d) Can be reversed by cholinesterase inhibitor

Question 8:

Which of the following skeletal muscle relaxants exhibit the following response to the 'train of four protocol' used in the clinical assessment of neuromuscular blockade?



a) d-Tubocurarine

b) Mivacurium

c) Succinylcholine

d) Atracurium

Question 9:

Which drug stimulates the autonomic ganglia?

a) D-tubocurarine

b) Succinylcholine

c) Pancuronium

d) Vecuronium

Question 10:

Which of the following muscle relaxants does not require the administration of a block reversal agent following surgery?

a) Succinylcholine

b) Pancuronium

c) Rocuronium

d) Vecuronium

Question 11:

Which of the following adverse effects are not attributed to succinylcholine?

a) Hypokalemia

b) Masseter spasm

c) Increased intracranial pressure

d) Arrhythmias

Question 12:

While inducing anesthesia, you noticed the patient's eyelids were twitching. A few hours post-op, she complains of generalized body ache. Which muscle relaxant was likely administered to her?

a) Atracurium

b) Mivacurium

c) Suxamethonium

d) Pancuronium

Question 13:

You are about to administer succinylcholine to a patient before intubating him when your senior asks you to administer a non-depolarizing muscle relaxant before doing so. He says this will prevent muscle fasciculations. Which drug do you choose for this?

a) Pancuronium

b) Atracurium

c) Rocuronium

d) Vecuronium

Question 14:

Which of the following patients are not at risk of hyperkalemia from succinylcholine?

a) Patient of muscle dystrophy

b) Patient with 45% burns

c) Patient of spinal cord injury

d) Patient of myasthenia gravis

Question 15:

Which of the following adverse effects would you not expect while using succinylcholine as a muscle relaxant for a surgery being done under general anesthesia?

a) Increased intra ocular pressure

b) Increased intra cranial pressure

c) Hyperkalemia

d) Decreased intragastric pressure

Question 16:

Which of the following conditions does not reduce the activity of butyrylcholinesterase?

a) Liver disease

b) Pregnancy

c) Malnutrition

d) Renal disease

Question 17:

Which of the following drugs potentiate the action of succinylcholine?

a) 2, 3, 4, 5

b) 1, 3, 5

c) 1, 2, 4

d) 1, 2, 3, 4

Question 18:

What is the next line of management in a patient diagnosed with succinylcholine apnoea?

a) Increase the dose of succinylcholine

b) Administer neostigmine

c) Fresh frozen plasma transfusion

d) Continue mechanical ventilation

Question 19:

A 5-year-old child was given intravenous succinylcholine for rapid sequence intubation at a dose of 0.5 mg/kg. During intubation, a masseteric spasm was noted. Temperature and BP were normal. What would be your first line of management?

a) IV dantrolene

b) Cool the child by using cooling blanket

c) Stop intubation

d) Increase the dose of succinylcholine

Question 20:

During a pre-op evaluation, a patient tells you he had been kept on a ventilator for 2 days following his previous surgery. There are similar instances in his family history. The reports from his previous surgery reveal his dibucaine number to be 20. What is this number used to assess?

a) Concentration of butyrylcholinesterase

b) Concentration of acetyl cholinesterase

c) Genetic make up of an individual with respect to butyryl cholinesterase

d) Concentration of ACh receptors

Question 21:

In a patient with a Dibucaine number of 20, which of the following drug/s are to be avoided?

a) Only 1

b) 1, 2 & 5

c) 1 & 4

d) 1, 2 & 3

Question 22:

Which selective GABA-B receptor agonist is used as a muscle relaxant?

a) Diazepam

b) Clonazepam

c) Flumazenil

d) Baclofen

Question 23:

Which of the following muscle relaxants decreases calcium release from sarcoplasmic reticulum?

a) Succinylcholine

b) Dantrolene

c) Vecuronium

d) Decamethonium

Question 24:

You are planning to administer a non-depolarising muscle relaxant to a patient. Which of the following will you not choose?

a) Pancuronium

b) Rocuronium

c) Suxamethonium

d) Vecuronium

Question 25:

A 72-year-old man with a history of a stroke 8 years prior presents with a displaced humerus fracture. He is planned for open reduction and fixation. Which muscle relaxant is to be avoided in him?

a) Succinylcholine

b) Atracurium

c) Mivacurium

d) Cisatracurium

Answer Key

Question No.	Correct Option
1	d
2	c
3	d
4	d
5	d
6	c
7	c
8	c
9	b
10	a
11	a
12	c
13	c
14	d
15	d
16	d
17	d
18	d
19	d
20	c
21	c
22	d
23	b
24	c
25	a

Detailed Explanations

Solution to Question 1:

Succinylcholine is a depolarizing muscle relaxant.

Option A: It produces both phase I and phase II block (at a higher dose).

Option B: Succinylcholine can produce a rise in intracranial pressure as a result of increased cerebral blood flow due to muscle fasciculations.

Option C: Precurarization is the administration of a small dose of a non-depolarizing neuromuscular blocking agent, a few minutes before Sch to minimize complications like fasciculations, post-operative myalgia, rise in intragastric pressure, and rise in ICP.

Solution to Question 2:

Suxamethonium (succinylcholine) is the shortest-acting muscle relaxant.

It has a rapid-onset (30–60secs) and short duration of action (typically less than 10 min) due to rapid hydrolysis by butyrylcholinesterase (plasma cholinesterase or pseudocholinesterase).

Solution to Question 3:

Succinylcholine is the muscle relaxant of choice for rapid sequence intubation. Although succinylcholine causes increase in ICP, it is used in rapid sequence intubation.

Succinylcholine has a rapid onset of action and is the shortest acting muscle relaxant. It provides muscle relaxation within 30-60 seconds.

If succinylcholine is contraindicated, then the non-depolarizing muscle relaxant, rocuronium can be used.

Solution to Question 4:

Suxamethonium (also known as succinylcholine) produces both phases I and II blocks.

Suxamethonium is a depolarizing muscle relaxant.

Mechanism of depolarizing blockade:

• Phase I block - continuous endplate depolarization and subsequent muscle relaxation.

• Phase II block - seen with a single, large dose, repeated doses, or a continuous infusion which can lead to desensitization of the receptors resulting in the prolonged neuromuscular blockade.

Phase II block has features of a non-depolarizing blockade. But 'phase II' is specifically used for depolarizing blockade by succinylcholine.

Solution to Question 5:

Fade is seen in the non-depolarising phase II block caused by depolarizing muscle relaxants.

Depolarising neuromuscular blockers result in prolonged depolarization with a brief period of fasciculations (repetitive excitation) followed by blocking of neuromuscular transmission and flaccid paralysis. This is termed as phase I block and cannot be reversed by neostigmine as the membrane is in a depolarised state.

The depolarised nerves are unresponsive to other stimuli during this period.

As the concentration of the drug and time increases, the block may convert slowly to a non-depolarising phase II block. Fade can be seen in this phase. The phase II block is reversible by neostigmine but is difficult to predict and usually avoided in clinical conditions.

Solution to Question 6:

The most likely reason which led to this scenario is phase II blockade produced by succinylcholine.

Phase II block is clinically seen with the dose >5 mg/kg. It is seen with a single large dose, repeated doses, or a continuous infusion of Sch which can lead to desensitization of the receptors resulting in a prolonged neuromuscular blockade.

Causes of prolonged apnea include:

• Atypical/pseudocholinesterase deficiency - can result in apnea even with a normal dose of succinylcholine

• Altered response of endplate to depolarizing relaxant (myasthenia gravis)

• Accumulation of succinylcholine leading to phase II blockade

Note: Although options A, B, and D can lead to prolonged apnea, in the above case scenario, the patient has received ~9 mg/kg of succinylcholine. Hence, the most probable diagnosis is phase II blockade leading to prolonged apnea.

Solution to Question 7:

Phase I depolarizing block is preceded by muscle fasciculation.

Note: Cholinesterase inhibitors are not routinely used to reverse phase II blockade as certain individuals have abnormal cholinesterase activity (due to genotypic variations). Their response to cholinesterase activity is unpredictable. Thus a wait and watch policy is implemented where the patient is put on a ventilator (100% O2) and observed for 24-48 hours until spontaneous reversal.

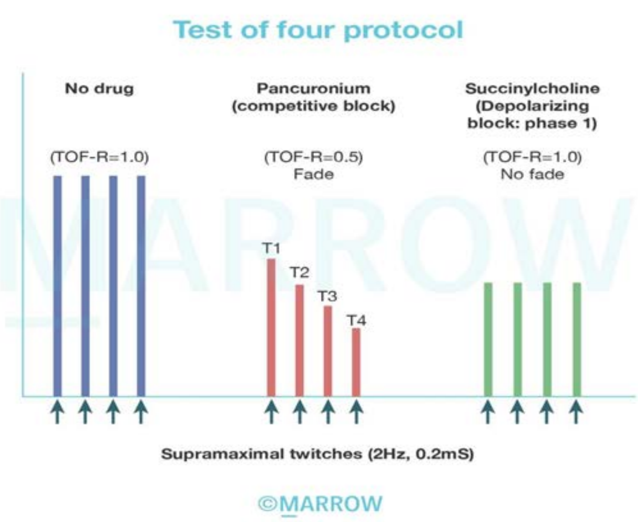
Phase I	Phase II
Depolarizing block	Non-depolarizing block
No fade during repetitive sti mulation	Fadeduring repetitive stimula tion (tetanic or Train Of Four)
No post-tetanic facilitation	Post tetanic facilitation(poten tiation)

Phase I	Phase II
Block antagonized by rapidhy drolysisdue tobutyrylcholines terase/plasma cholinesterase	Block can be antagonized by administering acholinesteras e inhibitorlike neostigmine.

Solution to Question 8:

Succinylcholine exhibits the above-given response to the 'train of four protocol' used in the clinical assessment of neuromuscular blockade.

Train of four protocol is one of the methods used in the clinical assessment of neuromuscular blockade. It is done by stimulating the ulnar nerve with a stimulus and watching the contractile responses in the adductor pollicis muscle. Four successive stimuli of 2Hz strength are given at fixed time intervals and the response achieved is plotted as a graph.



	Non-depolarizing blockers	Depolarizing blockers
Fade phenom enon	Present	Phase 1: AbsentPhase 2: Pres ent
Mechanism	Initial stimulus: Amount of A ch released is large enough to compete with the drug at the motor endplate causing max imal contraction of the muscl e.Successive stimuli: Amount of Ach released is insufficien t to compete with the drug an d results in sequentially dimi nished contractions	Phase 1: No competition betw een Sch and Ach. Sch acts lik e Ach at its receptors, but is not as easily metabolized by acetylcholinesterases resultin g in persistent depolarisation. Phase 2: When the dose of Sc h is increased maximally, it a lso exhibits a fade phenomen on.

Solution to Question 9:

Succinylcholine stimulates the autonomic ganglia.

• Parasympathetic ganglion (vagal ganglion) - bradycardia

• Sympathetic ganglion - hypertension and tachycardia.

Pancuronium causes tachycardia by blocking the cardiac muscarinic receptor and not by stimulation of autonomic ganglia.

D-tubocurarine blocks the autonomic ganglia. Whereas vercuronium does not act on autonomic ganglia.

Solution to Question 10:

Reversal of neuromuscular blockade is usually not needed in cases where succinylcholine is used, as it is rapidly metabolized by pseudocholinesterase resulting in a short duration of action.

Cholinesterase inhibitors can prolong neuromuscular blockade produced by succinylcholine by increasing neuromuscular junction ACh concentration and inhibiting the pseudocholinesterase-induced metabolism of succinylcholine.

Solution to Question 11:

Succinyl choline produces hyperkalemia not hypokalemia.

Use of succinylcholine increases the plasma K+ levels by 0.5 mEq/L. This increase in K+ is well tolerated by healthy individuals but could be deliterious in patients with severe metabolic acidosis and hypovolemia.

Solution to Question 12:

The muscle relaxant administered was likely suxamethonium (succinylcholine). It is associated with muscle fasciculations and myalgia.

Administration of a non-depolarizing muscle relaxant like rocuronium prior to succinylcholine (precurarization) is effective in preventing fasciculations and reducing postoperative myalgias.

Solution to Question 13:

Rocuronium is the agent of choice for precurarization.

Precurarization is the administration of a small dose (10% of ED95) of a non-depolarizing neuromuscular blocking agent, a few minutes before succinylcholine to minimize complications like fasciculations, postoperative myalgia, and rise in intragastric, intraocular, and intracranial pressure.

Rocuronium is ideal because it has a rapid onset of action (90 seconds), which is comparable with succinylcholine and is very effective in decreasing fasciculations and postoperative myalgias.

Solution to Question 14:

All the given conditions except myasthenia gravis are associated with the risk of hyperkalemia from succinylcholine (SCh)

In patients with myasthenia gravis:

• Depolarizing muscle relaxants (SCh) - resistant

• Non-depolarizing muscle relaxants - hypersensitive

All the other options include conditions that can have preexisting hyperkalemia. Thus, the succinylcholine-induced release of potassium from skeletal muscles may lead to catastrophic hyperkalemia in these patients.

Solution to Question 15:

Succinylcholine increases intragastric pressure. This is likely due to fasciculations of the abdominal skeletal muscle.

Solution to Question 16:

The renal disease does not affect the activity of butyrylcholinesterase.

Butyrylcholinesterase is the enzyme that degrades succinylcholine. It is synthesized in the liver and found in the plasma.

Reduced butyrylcholinesterase activity is seen in:

• Liver disease

• Pregnancy

• Malnutrition

• Old age

• Drugs like - oral contraceptives, monoamine oxidase inhibitors, echothiophate, cytotoxic drugs, anticholinesterase drugs, and metoclopramide.

Decreased butyrylcholinesterase is not a major concern in clinical practice because even a large decrease in the enzyme activity will produce only a slight increase in the duration of neuromuscular blockade.

Solution to Question 17:

Calcium causes resistance to neuromuscular blockade caused by succinylcholine.

Neostigmine being an anticholinesterase leads to inhibition of acetylcholinesterase. This results in a higher ACh concentration at the nerve terminal, which intensifies depolarization.

Neostigmine, oral contraceptive pills (OCPs), metoclopramide, and aminoglycosides (streptomycin) can potentiate the paralysis produced by succinylcholine.

Solution to Question 18:

The mainstay in the treatment of succinylcholine apnea due to atypical pseudocholinesterase is to continue mechanical ventilation until muscle function returns to normal by clinical signs.

Option B: Administration of neostigmine is controversial as the effects may be transient, possibly followed by an intensified neuromuscular blockade.

Option C: Fresh frozen plasma can augment the patient's endogenous plasma pseudocholinesterase activity but is not recommended because of the risk of iatrogenic viral infections.

Note: If human plasma cholinesterase is available, it can be given to reverse neuromuscular blockade.

Solution to Question 19:

The first line of management in this child would be to increase the dose of succinylcholine.

The incidence of muscle spasms without any symptoms and signs of malignant hyperthermia frequently results from an inadequate dosage of succinylcholine. Succinylcholine dosage for intubation is 1-2mg/kg

Conditions to be ruled out in isolated masseteric spasm:

- Inadequate dose of succinylcholine (less than the recommended dose of 1 mg/kg)
- Inadequate time for the onset of succinylcholine action
- Duchenne muscular dystrophy, myotonia congenita, and other muscle disorders
- Temporomandibular joint dislocation

Confusion-buster: Although an increase in the tone of the masseter is considered to be an early indicator of malignant hyperthermia, this finding is not consistently associated with it.

Solution to Question 20:

Dibucaine number indicates the genetic makeup of an individual with respect to butyrylcholinesterase. It is a qualitative measure that measures pseudocholinesterase function but not the amount of enzyme.

A patient with normal pseudocholinesterase has a dibucaine number of 80; whereas a homozygote for an atypical enzyme will have a dibucaine number of 20.

Therefore, the adequacy of pseudocholinesterase can be determined quantitatively in units per liter - in the laboratory

Solution to Question 21:

Succinylcholine and mivacurium are eliminated through hydrolysis by plasma cholinesterases. Thus, in a patient with a low Dibucaine number, both of these drugs should be avoided. Both drugs can cause prolonged apnea in patients with atypical plasma cholinesterase.

Dibucaine number refers to the percentage of inhibition of pseudocholinesterase activity.

Solution to Question 22:

Baclofen is a centrally acting selective GABA-B receptor agonist used as a muscle relaxant. It hyperpolarizes neurons by increasing potassium conductance and altering calcium influx.

Centrally acting muscle relaxants reduce skeletal muscle tone by a selective action in the cerebrospinal axis without altering consciousness.

Classification of centrally acting muscle relaxants:

• Mephenesin congeners - mephenesin, carisoprodol, chlorzoxazone, chlormezanone, methocarbamol.

• Benzodiazepines - diazepam and others.

• GABA mimetic - baclofen, thiocolchicoside.

• Central ° 2 receptor agonist - tizanidine.

Solution to Question 23:

Calcium release from the sarcoplasmic reticulum is decreased by dantrolene.

It is a direct-acting skeletal muscle relaxant that acts on the RyR1 (ryanodine receptor) calcium channels in the sarcoplasmic reticulum of skeletal muscles and inhibits calcium-induced calcium release. It results in the uncoupling of membrane depolarization and muscle contraction.

IV dantrolene is the drug of choice for malignant hyperthermia which is due to the persistent release of calcium from the sarcoplasmic reticulum.

Solution to Question 24:

Suxamethonium or succinyl choline is a depolarizing muscle relaxant. All the other options are non-depolarising muscle relaxants and so can be chosen here.

Solution to Question 25:

Succinylcholine is avoided in patients with a history of stroke, due to the risk of hyperkalemia.

Non-Depolarising Muscle Relaxants

Question 1:

What is the mechanism of action of the curare group of muscle relaxants?

a) Persistently depolarizing at neuromuscular junction

b) Competitively blocking the binding of ACh to its receptors

c) Repetitive stimulation of ACh receptors on muscle endplate

d) Inhibiting the calcium channels on presynaptic membrane

Question 2:

Following administration of which of the following neuromuscular blockers, is a patient is likely to recover fastest?

a) Atracurium

b) Cis-atracurium

c) Mivacurium

d) Rocuronium

Question 3:

Which of the following non-depolarising neuromuscular blockers has the fastest onset of action?

a) Succinylcholine

b) Mivacurium

c) Rocuronium

d) Vecuronium

Question 4:

Which of the following is not a property of gantacurium?

a) Mixed-onium fumarate compound

b) Undergoes enzymatic degradation

c) Adduction products formed with L-cysteine

d) Available as lyophilized powder

Question 5:

A 33-year-old lady with infertility is taken up for laparoscopic ovarian drilling in outpatient surgery. Mivacurium is administered under daycare anesthesia. Why is this drug preferred in this scenario?

a) Rapid absorption

b) Rapid hydrolysis

c) Rapid excretion

d) Rapid conjugation

Question 6:

Which of the following is an incorrect statement regarding mivacurium?

a) Can be used in a case of raised ICP

b) Metabolized by pseudocholinesterase

c) Causes histamine release

d) Elimination is kidney function dependent

Question 7:

Which of the following drugs is least suitable for muscle relaxation in long procedures?

a) Doxacurium

b) Cis-atracurium

c) Pancuronium

d) Pipecuronium

Question 8:

Which of the following muscle relaxants can cause seizures?

a) Atracurium

b) Mivacurium

c) Pancuronium

d) Rocuronium

Question 9:

Which of the following is incorrect regarding atracurium?

a) Mixture of 10 optical isomers

b) Safe in asthmatics

c) Undergoes spontaneous non-enzymatic degradation

d) Chemically incompatible with thiopental

Question 10:

Which of the following drugs does not have a steroid ring in its structure?

a) Vecuronium

b) Pancuronium

c) Atracurium

d) Rocuronium

Question 11:

Which of the following is a true statement regarding cis-atracurium?

a) No laudanosine production

b) Less potent than atracurium

c) Contraindicated in renal failure

d) No histamine production

Question 12:

A 7-year-old child is posted for an elective tonsillectomy. Which drug will you use to facilitate his intubation?

a) Vecuronium

b) Rocuronium

c) Suxamethonium

d) Pancuronium

Question 13:

Which is the ideal muscle relaxant for a 2-day old neonate planned for surgery?

a) Succinylcholine

b) Pancuronium

c) Rocuronium

d) Atracurium

Question 14:

Which of the following muscle relaxants is vagolytic?

a) Pancuronium

b) Atracurium

c) Mivacurium

d) d-tubocurarine

Question 15:

A 50-year-old man with a history of myocardial infarction 1 year back presented with acute abdominal pain. He is found to have a perforated peptic ulcer and is planned for an emergency laparotomy. Which muscle relaxant would you choose to use in him?

a) Succinyl choline

b) d-tubocurarine

c) Pancuronium

d) Vecuronium

Question 16:

While conducting a pre-anesthetic check, you note the patient's creatinine to be 2.3 mg/dl. Which muscle relaxant is to be avoided in her?

a) Pancuronium

b) Atracurium

c) Mivacurium

d) Cis atracurium

Question 17:

Which of the following is an incorrect statement concerning rapacuronium?

a) Rapid onset and short duration of action

b) Minimal cardiovascular side effects

c) Safe in asthmatics

d) Non-depolarising muscle relaxant

Question 18:

Which of the following drugs produces maximum ganglion blockade?

a) Succinylcholine

b) Pancuronium

c) Vecuronium

d) d-Tubocurarine

Question 19:

A 65-year-old woman suspected to have ovarian cancer is set to undergo a diagnostic laparotomy under general anesthesia. During the pre-op evaluation, you note that the patient has a 5-year history of diabetic nephropathy. Which of the following drugs will you prefer to use in her case?

a) Pancuronium

b) Pipecuronium

c) Cis-atracurium

d) Doxacurium

Question 20:

A patient with chronic hepatitis B is posted for an appendectomy. His pre-op investigations show a deranged LFT. Which muscle relaxant will you choose to use in him?

a) Vecuronium

b) Pancuronium

c) Atracurium

d) Pipecuronium

Question 21:

Following the administration of a muscle relaxant, a patient developed erythema and flushing of the face, neck, and upper body, with a drop in blood pressure. Which drug was most likely administered?

a) Pancuronium

b) Atracurium

c) Vecuronium

d) Rocuronium

Question 22:

During recovery from anesthesia, which of the following drugs cannot be used for reversal of neuromuscular blockade?

a) Neostigmine

b) Sugammadex

c) Glycopyrrolate

d) Pyridostigmine

Question 23:

Which of the following muscles is the last to recover from the effects of neuromuscular blockade?

a) Orbicularis oculi

b) Laryngeal adductors

c) Diaphragm

d) Adductor pollicis

Question 24:

Which of the following is the best sign to assess adequate reversal of neuromuscular blockade in a patient recovering from GA?

a) Sustained head lift > 3 seconds

b) Protrusion of the tongue

c) Sustained leg lift > 3 seconds

d) Train of four ratio > 0.9

Question 25:

Neostigmine is administered following a laparoscopic procedure to reverse the neuromuscular blockade. This would result in all of the following effects in the patient except:

a) Decreasing the breakdown of acetylcholine at the motor end plate

b) Preventing the potassium efflux from the cell

c) Increasing the release of acetylcholine at the motor end plate

d) Depolarization at the motor end plate

Question 26:

Before shifting a patient to the PACU, the anesthetist administers atropine along with neostigmine. What is the purpose of doing this?

a) Prevent metabolism of neostigmine

b) Block muscarinic side effects

c) Enhance excretion

d) Enhance potency

Question 27:

As you enter the OT, the senior resident asks you to administer Sugammadex to a patient being shifted to the post-op ward. Which muscle relaxant was likely to have been administered?

a) Succinylcholine

b) Mivacurium

c) Atracurium

d) Rocuronium

Question 28:

A patient is given a nicotinic receptor antagonist as a muscle relaxant. Which drug is given postoperatively to recover from muscle weakness?

a) Physostigmine

b) Neostigmine

c) Carbachol

d) Succinylcholine

Answer Key

Question No.	Correct Option
1	b
2	c
3	c
4	b
5	b
6	d
7	b
8	a
9	b
10	c
11	d
12	b
13	d
14	a
15	d
16	a
17	c
18	d

19	c
20	c
21	b
22	c
23	d
24	d
25	b
26	b
27	d
28	b

Detailed Explanations

Solution to Question 1:

The curare group of drugs includes non-depolarizing neuromuscular blocking agents that act by competitively blocking the binding of acetylcholine to its receptors.

This leads to a decrease in the effect of acetylcholine and thus, neuronal transmission to the muscle does not occur.

Solution to Question 2:

Mivacurium is the shortest acting non-depolarizing muscle relaxant among the given options. Thus, the fastest recovery will occur on the administration of mivacurium.

Gantacurium is the shortest acting non-depolarizing muscle relaxant.

Solution to Question 3:

Rocuronium has the fastest onset of action among non-depolarising blockers.

Succinylcholine's onset is comparable with rocuronium, but succinylcholine is a depolarising blocker.

The onset of action:

- Rocuronium- 0.5-2 minutes
- Succinylcholine- 0.8-1.4 minutes
- Mivacurium- 2-3 minutes
- Vecuronium- 2-3 minutes

Solution to Question 4:

Gantacurium is an ultra-short acting, rapid-onset, non-depolarizing muscle relaxant that undergoes non-enzymatic degradation.

It belongs to the mixed-onium fumarate group.

L-cysteine adduction results in the formation of a heterocyclic ring that cannot interact with the Ach receptor in the post-junctional space. The administration of L-cysteine can thus rapidly inactivate fumarate compounds and reverse neuromuscular blockade.

It is available as a lyophilized powder which must be reconstituted before use. It is unstable as an aqueous solution.

Note: Atracurium, cis-atracurium and gantacurium undergo non-enzymatic degradation.

Solution to Question 5:

Mivacurium is preferred as it undergoes rapid hydrolysis by butyrylcholinesterase (plasma cholinesterase/ pseudocholinesterase).

Mivacurium is a short-acting muscle relaxant preferred in day-care anesthesia. It has an onset of action within 2-3 minutes and a duration of action of 10-20 minutes.

Patients with atypical pseudocholinesterase will have a prolonged duration of the block similar to succinylcholine administration.

Solution to Question 6:

Elimination of mivacurium is independent of kidney function.

Mivacurium is a short-acting, non-depolarizing muscle relaxant. It is the only non-depolarizing agent that is metabolized by pseudocholinesterase (butyrylcholinesterase).

It is safe to use in a patient with or at risk of intracranial hypertension.

It can cause histamine release but in lesser quantities as compared to tubocurarine.

Solution to Question 7:

Cis–atracurium is an intermediate-acting muscle relaxant, and would be unsuitable for long procedures.

Solution to Question 8:

Atracurium can cause seizures due to the accumulation of its metabolite, laudanosine.

Laudanosine, a tertiary amine, is a breakdown product of atracurium's Hofmann elimination. It has CNS-stimulating properties and can result in precipitation of seizures but this is significant only with large doses and hepatic failure.

Cisatracurium is a stereoisomer of atracurium, which results in lesser laudanosine production than atracurium.

Solution to Question 9:

Atracurium is avoided in asthmatic patients because it is associated with histamine release and bronchospasm.

It is metabolized by Hofmann elimination and non-specific ester hydrolysis. Hofmann elimination is a spontaneous non-enzymatic degradation of atracurium into laudanosine and mono-quaternary acrylate. Laudanosine has CNS stimulating properties and can result in precipitation of seizures.

Atracurium precipitates as a free acid if it is introduced into an intravenous line containing an alkaline solution such as thiopental. Thus, the 2 drugs are chemically incompatible.

Solution to Question 10:

Atracurium is a benzylisoquinoline derivative.

Classification of non-depolarizing muscle relaxants according to structure:

- Steroidal compounds:
- Pancuronium
- Pipecuronium
- Vecuronium
- Rocuronium
- Benzylisoquinoline compounds:
- d - Tubocurarine
- Metacurine
- Doxacurium
- Atracurium
- Cisatracurium
- Mivacurium
- Onium chlorofumarate compounds - Gantacurium

- Phenolic ethers - Gallamine
- Diallyl derivative of toxiferine - Alcuronium

Solution to Question 11:

Cisatracurium does not cause histamine release, atracurium does.

Option A: Cisatracurium produces laudanosine, but it is about five times lesser than that of atracurium.

Option B: Cisatracurium is a stereoisomer of atracurium that is four times more potent.

Option C: Cisatracurium undergoes Hofmann elimination which is a spontaneous non-enzymatic organ-independent degradation (independent of renal function). Hence it is the drug of choice in renal failure patients.

Solution to Question 12:

Rocuronium is the drug of choice during routine intubation in pediatric patients due to its faster onset of action and its availability as an intramuscular injection.

Succinylcholine is avoided for routine, elective intubation in children due to its side effects. The only indication for intravenous succinylcholine in children is rapid sequence induction with a "full" stomach and laryngospasm.

The durations of action of vecuronium and pancuronium are prolonged in children due to immature hepatic function.

Solution to Question 13:

Atracurium (or cisatracurium) is the ideal muscle relaxant for neonates.

Neonates have immature hepatic and renal functions. Atracurium and cisatracurium undergo Hofmann elimination, which is spontaneous non-organ dependent non-enzymatic degradation. These drugs are independent of hepatic or renal excretion.

Solution to Question 14:

Pancuronium is vagolytic (resulting from blockade of M_2 receptors) leading to increased heart rate and hence increased blood pressure and cardiac output.

The vagolytic action of pancuronium may be used to counteract opioid-induced bradycardia.

Note: Gallamine has the most potent vagolytic properties of any relaxant but is not in use.

Effect	Stimulation	Blockade
Autonomic ganglia	Succinylcholine	d-Tubocurarine
Cardiacmuscarinic receptor	Succinylcholine	Rocuronium (weak)Pancuronium (moderate)
Histamine release	Succinylcholine, mivacurium, atracurium (weak)d-tubocurarine (significant)	

Solution to Question 15:

Vecuronium is devoid of significant cardiovascular effects and is the most cardiostable muscle relaxant, making it the muscle relaxant of choice in cardiac patients.

Effect	Stimulation	Blockade
Autonomic ganglia	Succinylcholine	d-Tubocurarine
Cardiacmuscarinic receptor	Succinylcholine	Rocuronium (weak)Pancuronium (moderate)
Histamine release	Succinylcholine, mivacurium, atracurium (weak)d-tubocurarine (significant)	

Solution to Question 16:

Pancuronium is avoided as it is predominantly eliminated by the kidney and hence, can accumulate in renal failure or imapirment.

Atracurium and cisatracurium undergo Hofmann elimination, i.e., spontaneous non-enzymatic degradation which is non-organ dependant.

Metabolism of mivacurium is independent of the kidney function as it is hydrolyzed by butyrylcholinesterase.

Solution to Question 17:

Rapacuronium is a non-depolarizing muscle relaxant that has a very high incidence of bronchospasm (>9%) and so it is contraindicated in asthmatics.

It has been withdrawn from the market due to this effect.

Rapacuronium has a rapid onset and short duration of action and minimal cardiovascular side effects.

Solution to Question 18:

d-Tubocurarine produces maximum ganglionic blockade leading to hypotension.

d-Tubocurarine is the most potent histamine releaser among muscle relaxants leading to bronchospasm, hypotension, and wheals. The effects of the ganglionic blockade and histamine release can lead to severe hypotension. Hence, d-tubocurarine had been withdrawn from the market.

Succinylcholine stimulates the vagal ganglion, leading to bradycardia, and stimulates the sympathetic ganglion, causing hypertension and tachycardia.

Pancuronium is vagolytic and produces sympathetic stimulation leading to tachycardia.

Effect	Stimulation	Blockade
Autonomic ganglia	Succinylcholine	d-Tubocurarine
Cardiacmuscarinic receptor	Succinylcholine	Rocuronium (weak)Pancuronium (moderate)
Histamine release	Succinylcholine, mivacurium, atracurium (weak)d-tubocurarine (significant)	

Solution to Question 19:

Cis-atracurium is preferred in patients with renal impairment as it does not depend on the kidney for excretion.

Both atracurium and cis-atracurium undergo Hofmann elimination and are thus safe in renal disease.

Steroidal muscle relaxants are predominantly eliminated by ultrafiltration by the glomeruli before urinary excretion. Doxacurium, pancuronium, and pipecuronium are partially excreted by the kidneys, so the neuromuscular block is prolonged in patients with renal failure.

Solution to Question 20:

Atracurium and cisatracurium are the muscle relaxants of choice in liver disease because of non-hepatic metabolism.

Atracurium and cisatracurium undergo Hofmann elimination. The clearance of both drugs is independent of liver function. Hence, they are the agents of choice in liver failure patients.

Pancuronium, rocuronium, and vecuronium are dependent on the liver for excretion.

Solution to Question 21:

The given scenario is suggestive of histamine release. Atracurium is the most potent histamine releaser among the given options and was likely administered.

Erythema, flushing, and hypotension are manifestations of histamine release.

Solution to Question 22:

Anticholinergic drugs like glycopyrrolate and atropine are not used for the reversal of neuromuscular blockade. They only attenuate the undesirable muscarinic effects of anticholinesterase reversal agents.

Reversal agents commonly used in clinical practice:

• Cholinesterase inhibitors - Neostigmine (most common), edrophonium, and pyridostigmine.

• Sugammadex, a cyclodextrin, is the first selective relaxant binding agent for rocuronium and vecuronium.

• L-cysteine causes the inactivation of gantacurium.

Solution to Question 23:

Adductor pollicis is the last to recover from neuromuscular blockade among the given choices.

Most sensitive to neuromuscular blockade:

• Diaphragm and abdominal muscles

• Peripheral muscles of the limbs

• Orbicularis oculi muscle

• Geniohyoid

• Masseter

• Upper airway muscles.

Note: Sensitivity and recovery are not exactly the same. Even though the laryngeal adductors recover sooner than adductor pollicis, recovery of adductor pollicis function does not exactly parallel the complete recovery of muscles required to maintain an airway. This may lead to dynamic obstruction postoperatively.

Solution to Question 24:

The best sign of recovery from neuromuscular blockade is a train of four ratio >0.9

The TOF ratio must exceed 0.90 to exclude clinically important residual neuromuscular block.

Clinical signs consistent with recovery are:

• Sustained head lift for 5 seconds

- Sustained leg lift for 5 seconds
- Sustained handgrip for 5 seconds
- Sustained “tongue depressor test”
- Maximum inspiratory pressure 40 to 50 cm H_2O or greater

Solution to Question 25:

Neostigmine has no effect on potassium efflux.

Neostigmine is an acetylcholine esterase inhibitor. Its primary mechanism of action is decreased breakdown of acetylcholine at the motor endplate.

Minor actions:

- Increases the release of acetylcholine from motor endplates.
- Direct depolarization of the postjunctional motor endplate.

It is used for the reversal of neuromuscular blockade produced by non-depolarizing muscle relaxants used during anesthesia.

Note: Cobra venom consists of a neurotoxin that is responsible for respiratory paralysis which similar to that produced by a non-depolarizing muscle relaxant. A combination of artificial respiration and neostigmine is useful in resuscitation.

Solution to Question 26:

Anticholinergic drugs like atropine, glycopyrrolate are routinely administered with anticholinesterases in order to attenuate the undesirable muscarinic effects.

Solution to Question 27:

Sugammadex is used for the reversal of rocuronium.

Sugammadex is a cyclodextrin. It is the first selective relaxant binding agent. It exerts its reversal effect by forming tight complexes in a 1:1 ratio with steroidal non-depolarizing agents (rocuronium > vecuronium >> pancuronium).

It is eliminated unchanged via the kidneys.

Solution to Question 28:

Neostigmine is given postoperatively to recover from muscle weakness.

Non-depolarizing muscle relaxants (NDMRs) act mainly by the competitive antagonism of nicotinic (Nm) receptors. Neostigmine inhibits acetylcholinesterase and inhibits the degradation of acetylcholine. The increased accumulation of undegraded acetylcholine can effectively compete with NDMRs, and thereby displace them from the site and antagonize their effects.

Inhaled Anaesthetics - Properties, N2O and Halothane

Question 1:

Which among the following is the most potent inhaled anesthetic?

a) Halothane

b) Isoflurane

c) Desflurane

d) Sevoflurane

Question 2:

At what concentration does the administration of an inhaled general anesthetic prevent movement in response to noxious stimuli in 50% of the population?

a) Maximum anesthetic concentration

b) Minimum anesthetic concentration

c) Maximum alveolar concentration

d) Minimum alveolar concentration

Question 3:

What does the blood-gas partition coefficient of an inhaled anesthetic indicate?

a) Duration of action

b) Potency

c) Solubility in blood

d) Solubility in lipid

Question 4:

Which anesthetic agent has the least solubility in blood?

a) Nitrous oxide

b) Desflurane

c) Xenon

d) Methoxyflurane

Question 5:

What is the rationale for choosing an inhaled anesthetic with the lowest MAC value?

a) Fastest induction and recovery

b) Highest potency

c) Slowest inducton and recovery

d) Lowest potency

Question 6:

According to Meyer Overton rule, which of the following is related to the potency of an anesthetic?

a) Solubility in blood

b) Solubility in lipid

c) Blood- gas partition coefficient

d) Minimum Alveolar Concentration

Question 7:

At what concentration does the administration of an inhaled general anesthetic prevent movement in response to noxious stimuli in 50% of the population?

a) 3 % decrease per decade

b) 3% increase per decade

c) 6% decrease per decade

d) 6% increase per decade

Question 8:

In which of the following patients would a lower amount of inhalational anesthetic be administered?

a) 1 & 3 only

b) 2, 3 & 5 only

c) 3 & 5 only

d) 3, 4 & 5 only

Question 9:

Your senior asks you to administer oxygen to a patient in order to avoid diffusion hypoxia. When is this phenomenon observed during anesthesia?

a) Induction with halothane

b) Induction with nitrous oxide

c) Recovery from halothane

d) Recovery from nitrous oxide

Question 10:

While setting up the anesthesia cart in the morning, you note the technician shifting a blue-colored cylinder to the operation theatre. Which of the following is a false statement about the gas present in the cylinder?

a) It is least potent

b) It shows second gas effect

c) It decreases cerebral metabolic rate

d) It is an NMDA receptor antagonist

Question 11:

A polytrauma patient with the given x-ray finding is being taken up for damage control surgery. Which of the following inhalational agents should be avoided in her?

- **a)** Halothane
- **b)** Sevoflurane
- **c)** Desflurane
- **d)** Nitrous oxide

Question 12:

In which of the following patients can you safely administer nitrous oxide?

- **a)** A 40-year-old man with sigmoid volvulus
- **b)** A 32-year-old man undergoing tympanic membrane grafting
- **c)** A 56-year-old woman posted for vitreoretinal surgery
- **d)** A 16-year-old girl undergoing tooth extraction

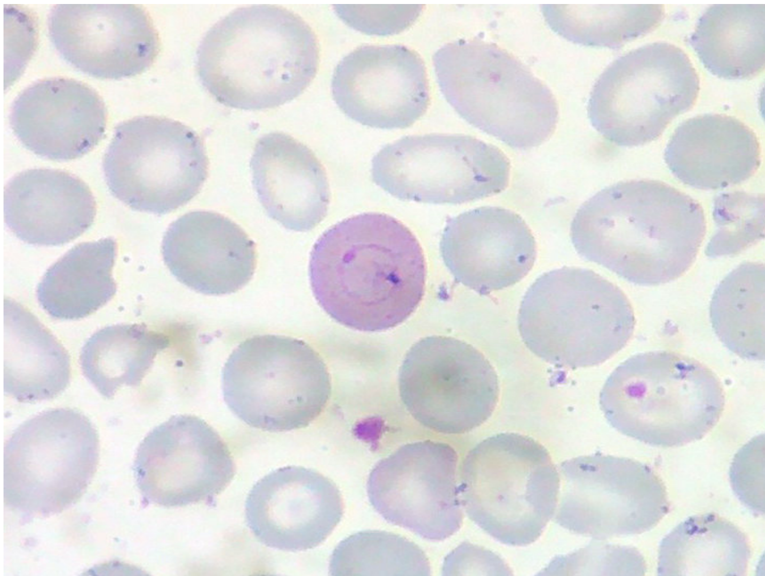
Question 13:

Which anesthetic agent does not undergo metabolism in our body?

- **a)** Halothane
- **b)** Sevoflurane
- **c)** Methoxyflurane
- **d)** Nitrous oxide

Question 14:

During the pre-anesthetic evaluation of a young woman planned for surgery, the following findings are described in the peripheral smear. Which inhalational anesthetic agent should be avoided to prevent neurological symptoms of this disease from developing?



a) Nitrous oxide

b) Halothane

c) Isoflurane

d) Desflurane

Question 15:

A 42-year-old obese woman is posted for a revision laparotomy surgery. She gives a history of jaundice following the previous surgery. Which drug should be avoided in her?

a) Nitrous oxide

b) Xenon

c) Halothane

d) Sevoflurane

Question 16:

A patient with a prior history of halothane hepatitis is now scheduled for a surgery. Which would be the inhalational agent of choice in this patient?

a) Halothane

b) Isoflurane

c) Desflurane

d) Sevoflurane

Question 17:

Which of the following statements is false regarding halothane?

a) Maximum decrease in cardiac output

b) Contraindicated in pheochromocytoma

c) Can trigger malignant hyperthermia

d) Contraindicated in asthmatics

Question 18:

Which of the following agents does not liberate fluoride?

a) Methoxyflurane

b) Halothane

c) Sevoflurane

d) Isoflurane

Question 19:

A 32-year-old man presents with recurrent episodes of headache, palpitation, and sweating. His BP is 160/100 mm Hg and heart rate is 130/min. 24-hour urinary metanephrines are elevated and CT abdomen shows a right suprarenal mass. He is scheduled for surgery. Which inhalational anesthetic is contraindicated in him?

a) Nitrous oxide

b) Halothane

c) Desflurane

d) Sevoflurane

Question 20:

A patient was taken up for surgery and was administered an inhalational agent for anesthesia. Suddenly his heart rate dropped from 94/min to 58/min. Which anesthetic agent was most likely administered?

a) Halothane

b) Desflurane

c) Enflurane

d) Isoflurane

Question 21:

Which inhalational anesthetic agent causes the maximum decline in hepatic blood flow?

a) Isoflurane

b) Desflurane

c) Sevoflurane

d) Halothane

Question 22:

A primigravida developed postpartum hemorrhage 45 minutes after delivery. She has a history of a myomectomy done 2 years prior. The obstetrician suspects placenta succenturiata and requests the anesthetist to administer an inhaled drug for uterine relaxation. Which of the following agents can be used in this scenario?

a) Ether

b) Chloroform

c) Nitrous oxide

d) Halothane

Question 23:

The second gas effect is seen with which anesthetic?

a) Cyclopropane

b) Nitrous oxide

c) Ether

d) Methoxyflurane

Question 24:

What is the incidence of halothane hepatitis?

a) 1 in 200

b) 1 in 350

c) 1 in 20, 000

d) 1 in 35,000

Question 25:

On administration of which of the following inhaled anesthetics can megaloblastic anemia occur as an adverse effect?

a) Halothane

b) Nitrous oxide

c) Sevoflurane

d) Desflurane

Answer Key

Question No.	Correct Option
1	a
2	d
3	c
4	c
5	b
6	b
7	c
8	c
9	d
10	c
11	d
12	d

13	d
14	a
15	c
16	d
17	d
18	b
19	b
20	a
21	d
22	d
23	b
24	d
25	b

Detailed Explanations

Solution to Question 1:

The most potent inhaled anesthetic among the given options is halothane, with a minimum alveolar concentration (MAC) value of 0.75%.

The least potent inhaled anesthetic is nitrous oxide with a MAC value of 104%.

Note: Methoxyflurane has a MAC of 0.16%, making it more potent than halothane. However, it is obsolete now. The most potent agent overall is methoxyflurane and the most potent agent in clinical use is halothane.

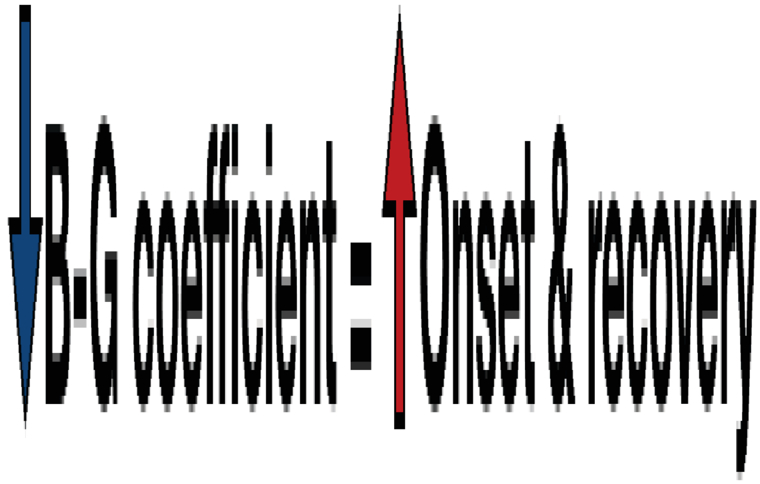
Solution to Question 2:

Minimum alveolar concentration (MAC) is the inhaled anesthetic concentration required to prevent movement in response to noxious stimuli in 50% of patients.

Solution to Question 3:

The blood gas (B:G) partition coefficient of an inhaled anesthetic is an indicator of solubility in blood which determines the speed of induction and recovery.

An inhalational anesthetic with a lower blood gas partition (B:G) coefficient would have lower solubility in blood. This would mean a higher alveolar concentration which will lead to faster induction and recovery.



Xenon with a blood-gas partition coefficient of 0.115 has the fastest induction and emergence from anesthesia.

Methoxyflurane with a blood gas partition coefficient of 12 has the slowest induction and emergence from anesthesia.

The speed of induction and emergence:

Xenon > Desflurane > Sevoflurane> Isoflurane > Enflurane > Halothane > Methoxyflurane

Solution to Question 4:

The anesthetic agent, least soluble in the blood is xenon with a blood:gas partition coefficient of 0.115

The speed of induction and emergence:

Xenon > Desflurane > Sevoflurane > Isoflurane > Enflurane > Halothane > Methoxyflurane

Solution to Question 5:

A drug with the lowest MAC would have the highest potency.

The minimum alveolar concentration (MAC) value of an inhaled anesthetic is a measure of the potency of the anesthetic agent.

Least potent: nitrous oxide (MAC-104%). 1 MAC with nitrous oxide is practically impossible and thus it is always combined with other agents.

Most potent: methoxyflurane (MAC-0.16%) > trilene (MAC-0.2%), both of which are obsolete now.

Among the inhaled agents in clinical use, halothane is the most potent.

Solution to Question 6:

Meyer Overton rule relates potency of an anesthetic to the solubility in lipid.

This rule suggests that anesthesia occurs when a sufficient number of inhalational anesthetic molecules dissolve in the lipid cell membrane.

Solution to Question 7:

The minimum alveolar concentration (MAC) decreases by 6% per decade for inhalational anesthetics. This is due to altered sensitivity in the ion channels and receptors (nicotinic, acetylcholine, glutamate, and GABA).

Recovery with a volatile anesthetic in geriatric patients may be prolonged because of an increased volume of distribution(increased body fat) and decreased pulmonary gas exchange.

Dosage requirements for local and general (MAC) anesthetics are reduced in elderly patients. Administration of a given volume of epidural or spinal anesthetic results in a more extensive spread and longer duration in elderly patients.

Solution to Question 8:

Minimum alveolar concentration (MAC) decreases in pregnancy and hypercalcemia. Thus, these patients require a lower dose of inhalational anesthetic agents.

Chronic alcoholics, infants, and people with a history of cocaine abuse would require higher doses of anesthetic agents.

Solution to Question 9:

Diffusion hypoxia is observed in anesthesia during recovery from nitrous oxide anesthesia.

Due to low solubility (low blood gas partition coefficient), N_2O diffuses from the blood to the alveoli and replaces the oxygen. This reduces alveolar O_2 concentration, resulting in relative hypoxemia.

Diffusion hypoxia can be avoided by using 100% oxygen for 10 minutes during recovery from anesthesia.

Solution to Question 10:

The given color code of a blue cylinder indicates that the gas present inside the cylinder is nitrous oxide. Nitrous oxide increases cerebral metabolic rate.

Nitrous oxide increases cerebral metabolic rate, cerebral oxygen consumption, and cerebral blood flow. Hence it is not preferred in neuro anesthesia as it increases intracranial pressure.

Option A: N_2O has a MAC value of 104%, which makes it the least potent inhaled anesthetic. Hence it is always used in combination with the more potent volatile agents.

Option B: N_2O has low blood-gas solubility resulting in phenomena such as second gas effect, concentration–effect, and diffusion hypoxia.

Option D: N_2O acts as an antagonist at N-methyl-D-aspartate (NMDA) receptors, which are excitatory receptors in the brain.

Solution to Question 11:

The image shows a pneumothorax. The inhalational agent to be avoided is nitrous oxide.

Nitrous oxide has the potential to expand air-containing cavities, as it can diffuse into and accumulate in them. Hence it should be avoided in patients with pneumothorax.

Solution to Question 12:

As the sole agent, nitrous oxide can be used with oxygen for dental analgesia. It can also be used for obstetric analgesia.

All the other conditions are contraindications to nitrous oxide because it has the potential to expand air-containing cavities, as it can diffuse into and accumulate in them. This increases the pressure within the cavity which can lead to deleterious effects.

Solution to Question 13:

Nitrous oxide does not undergo any metabolism in our body.

Methoxyflurane undergoes maximum metabolism while desflurane undergoes minimal metabolism.

Solution to Question 14:

The peripheral smear shows macro-ovalocytes and Cabot cells, suggesting megaloblastic anemia. Nitrous oxide should not be used in a patient with megaloblastic anemia.

N■O can cause a subclinical B12 deficiency to become overt, leading to subacute combined degeneration of the cord (SACD).

N■O inhibits vitamin B12 dependent enzymes like methionine synthetase which is essential for the formation of myelin. It also inhibits vitamin B12 dependent enzymes like thymidylate synthetase, which are necessary for DNA synthesis. This leads to the megaloblastic bone marrow changes.

Side effects of N■O:

• Bone marrow depression

• Megaloblastic anemia – may be seen following nitrous oxide exposure for 2- 6 hours

• Teratogenicity

• Peripheral neuropathy

Solution to Question 15:

Halothane must not be given to patients with unexplained liver dysfunction following previous anesthetic exposure due to the risk of halothane-induced hepatitis.

Halothane-induced hepatitis is immune-mediated due to antibodies against highly reactive trifluoroacetyl chloride which is a metabolite of halothane.

It is rare with an incidence of 1 per 35,000 cases but very fatal, with a mortality of 50-75%.

Risk factors for halothane hepatitis:

• Multiple exposures to halothane at short intervals

• Middle-aged obese women- halothane undergoes extensive metabolism in obese patients

• Familial predisposition to halothane hepatitis

The liver in halothane hepatitis shows centrilobular necrosis.

Solution to Question 16:

Sevoflurane is the inhalational agent of choice in a patient with a prior history of halothane hepatitis.

Unlike the other volatile anesthetics, sevoflurane is oxidized to form a stable metabolite that does not covalently bind to proteins and cause hepatic injury.

Halothane hepatitis is immune-mediated due to antibodies against highly reactive trifluoroacetyl chloride which is a metabolite of halothane.

Like halothane, other agents like isoflurane, desflurane, and enflurane also undergo metabolism to produce highly reactive intermediates that can covalently modify hepatic proteins and cause severe hepatitis.

Solution to Question 17:

Halothane is not contraindicated in asthmatics. In fact, it is suitable for induction in asthmatic patients due to its ability to cause bronchodilation.

However, the agent of choice in asthmatics would be sevoflurane due to the low safety profile of halothane. Halothane sensitizes the heart to the effects of adrenaline and causes bradycardia and arrhythmias. An overall cardiovascular and respiratory depression is seen with Halothane which are less likely with sevoflurane.

Option A: Halothane produces the maximum decrease in cardiac output among the inhalational anesthetics by a combination of decreased heart rate and depressed myocardial contractility.

Option B: Halothane sensitizes the heart to the arrhythmogenic effects of epinephrine and hence is contraindicated in pheochromocytoma.

Option C: Inhaled anesthetics like halothane, methoxyflurane, enflurane, isoflurane, desflurane, and sevoflurane are known to trigger malignant hyperthermia.

Solution to Question 18:

Halothane is not metabolized to fluoride under normal circumstances.

The renal toxicity of volatile anesthetics is due to their metabolic breakdown to free fluoride ions.

Methoxyflurane, sevoflurane, and isoflurane liberate fluoride compounds.

The amount of fluoride ions produced (in micromoles):

Methoxyflurane > Sevoflurane > Enflurane > Isoflurane = Desflurane

Methoxyflurane is the most nephrotoxic among inhalational anesthetics. It causes polyuric renal failure due to a large amount of inorganic fluoride released, and it is no longer used in clinical practice.

Solution to Question 19:

The given findings are suggestive of pheochromocytoma. Halothane is contraindicated in patients with pheochromocytoma.

Pheochromocytoma is a catecholamine secreting tumor of chromaffin origin. Halothane sensitizes the heart to the arrhythmogenic effects of epinephrine.

Other anesthetic drugs to be avoided in a patient with pheochromocytoma are:

• Succinylcholine - causes fasciculations which lead to raised intraabdominal pressure and catecholamine release from the tumor

• Ketamine - sympathomimetic

• Pancuronium - vagal blockade leading to tachycardia

• Atracurium, tubocurarine - histamine release which may provoke catecholamine release

Solution to Question 20:

Halothane induces bradycardia and causes the maximum reduction in cardiac output, as it blunts the baroreceptor reflex and depresses myocardial contractility.

Normally, hypotension inhibits baroreceptors in the aortic arch and carotid sinus, causing a decrease in vagal stimulation and a compensatory rise in heart rate.

Halothane and enflurane produce a greater decrease in myocardial contractility than isoflurane, desflurane, and sevoflurane which preserve the baroreceptor reflexes and produce tachycardia in response to a fall in arterial pressure.

Cardiac output is best preserved with isoflurane. Though it produces some myocardial depression, reflex tachycardia maintains cardiac output, isoflurane is the agent of choice in cardiac patients.

Solution to Question 21:

Maximum decline in hepatic blood flow is caused by halothane.

All volatile anesthetics decrease hepatic blood flow but halothane causes the maximum decrease. Hepatic artery vasoconstriction and increase in hepatic arterial resistance are seen with halothane.

Halothane also reduces hepatic oxygen delivery and hepatic venous oxygen saturation. This is because of the greater reduction in cardiac output caused by halothane than the other volatile agents.

Hepatic arterial buffer response(HABF) is an autoregulatory mechanism in the liver. When portal blood flow decreases due to decreased cardiac output or hypovolemia, the hepatic arterial blood flow increases in order to maintain total hepatic blood flow. Halothane disrupts this regulatory mechanism, which is best preserved with sevoflurane or isoflurane.

Desflurane and sevoflurane have the least significant effects on total hepatic blood flow and oxygen delivery. Sevoflurane is considered equal to or better than isoflurane in preserving hepatic arterial blood flow and hepatic oxygen delivery.

Solution to Question 22:

Uterine relaxation is maximum with halothane.

Although halothane is not used in cases of PPH, it is the only anesthetic agent that can inhibit uterine contraction.

Hence among the given inhaled drugs, Halothane is the appropriate answer for the given clinical scenario.

Halogenated anesthetics like halothane have potent relaxant effects on the uterus. It is utilized for facilitating intrauterine fetal manipulation.

However, its use during labor can prolong delivery and increase uterine bleeding.

Options A and B: Ether and chloroform do not have any significant uterine relaxant action.

Option C: Nitrous oxide also has uterine relaxant properties but is less than that of halogenated inhalational anesthetics.

Solution to Question 23:

The second gas effect is seen with nitrous oxide, during induction.

Second gas refers to oxygen and other volatile anesthetic agents.

Solution to Question 24:

The incidence of halothane hepatitis is 1 in 35,000, but it is very fatal with a mortality of 50-75%.

It is an immune-mediated reaction due to antibodies against highly reactive trifluoroacetyl chloride which is a metabolite of halothane.

Risk factors for halothane hepatitis:

• Multiple exposures to halothane at short intervals

• Middle-aged obese women

• Familial predisposition to halothane

The liver in halothane hepatitis shows centrilobular necrosis.

Solution to Question 25:

Nitrous oxide inhibits vitamin B12 dependent enzymes like thymidylate synthetase, which is necessary for DNA synthesis – this is responsible for the megaloblastic bone marrow changes.

Megaloblastic anemia is seen with nitrous oxide especially when exposure is greater than 2-6 hours (in healthy patients prolonged periods of exposure > 12 hours is required whereas, in critically ill patients, much shorter periods of exposure can lead to megaloblastic changes in the bone marrow).

Side effects of nitrous oxide:

• Bone marrow depression

• Subacute combined degeneration of the cord

• Teratogenicity

• Peripheral neuropathy

Contraindications of nitrous oxide:

- Venous or arterial air embolism
- Pneumothorax
- Acute intestinal obstruction with bowel distention
- Intracranial air (pneumocephalus following dural closure or pneumoencephalography)
- Pulmonary air cysts
- Intraocular air bubbles
- Tympanic membrane grafting

Inhaled Anaesthetics - Fluorinated Agents, Inert Agents and Therapeutic Gases

Question 1:

Which of the following inhaled anesthetics is the induction agent of choice in a patient planned for surgery under GA?

a) Halothane

b) Sevoflurane

c) Desflurane

d) Nitrous oxide

Question 2:

A 7-year-old boy is posted for laparoscopic appendectomy. Which of the following inhalational agents is preferred for induction?

a) Halothane

b) Isoflurane

c) Sevoflurane

d) Desflurane

Question 3:

Which inhaled anesthetic has the maximum global warming potential?

a) Nitrous oxide

b) Sevoflurane

c) Isoflurane

d) Desflurane

Question 4:

A 39-year-old woman is posted for resection of an intracranial tumor. Which inhalational anesthetic is most suitable in this case?

a) Halothane

b) Sevoflurane

c) Isoflurane

d) Desflurane

Question 5:

Which anesthetic agent is to be avoided in patients diagnosed with epilepsy?

a) Halothane

b) Enflurane

c) Nitrous oxide

d) Sevoflurane

Question 6:

An elderly male patient is scheduled to undergo an elective procedure. What is the choice of inhalational anesthetic you will consider for him?

a) Halothane

b) Desflurane

c) Isoflurane

d) Sevoflurane

Question 7:

Which of the following is the inhalational agent of choice for general anesthesia in asthmatic patients?

a) Desflurane

b) Sevoflurane

c) Halothane

d) Isoflurane

Question 8:

A middle-aged man with liver cirrhosis is posted for surgery. Which would be the inhalational anesthetic agent of choice?

a) Methoxyflurane

b) Nitrous oxide

c) Sevoflurane

d) Halothane

Question 9:

A 7-year-old kid recovering from anesthesia started developing seizures. Which of the following inhalational agents would have been used?

a) Desflurane

b) Isoflurane

c) Sevoflurane

d) Halothane

Question 10:

A first-year anaesthesia resident was managing a patient undergoing coronary artery bypass grafting (CABG). They noticed that the coronary perfusion pressure was not adequate. During the procedure, the patient exhibited signs of myocardial ischemia, including hypotension, ST-segment changes, and decreased cardiac output. The resident was evaluating potential causes and considering the role of anaesthetic agents. Which of the following anaesthetic agents is most likely to exacerbate these symptoms?

a) Nitrous oxide

b) Isoflurane

c) Desflurane

d) Halothane

Question 11:

A patient with impaired renal function was administered desflurane for general anesthesia. Which of the following statements is true regarding this drug?

a) Commonly used for induction in children

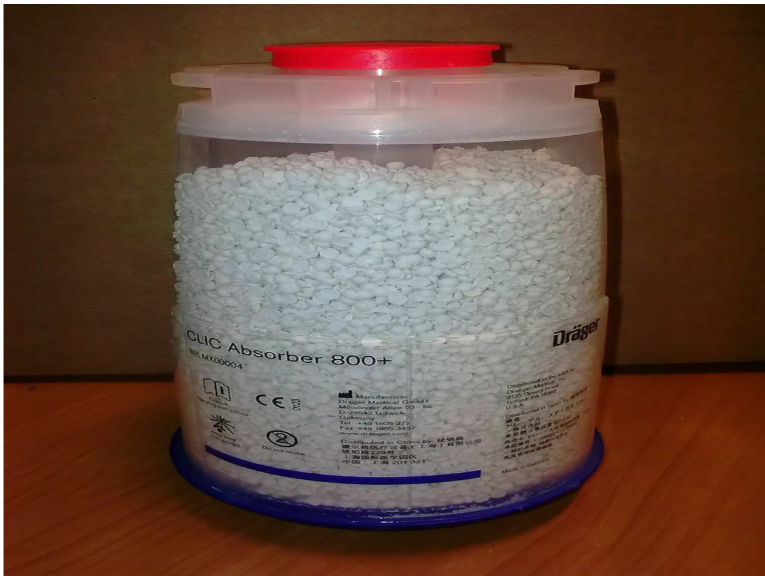
b) Rapid induction and recovery

c) Environmentally safe anesthetic

d) Less potent than nitrous oxide

Question 12:

An intern notices the following canister attached to the anesthesia circuit. Which gas produces carbon monoxide when passed through it?



a) Halothane

b) Methoxyflurane

c) Sevoflurane

d) Desflurane

Question 13:

Which of the following inhalational agents produces a nephrotoxic substance called compound A?

a) Halothane

b) Methoxyflurane

c) Sevoflurane

d) Desflurane

Question 14:

Which of the following is an incorrect statement regarding xenon?

a) Increases airflow resistance and work of breathing

b) Safe in cardiac patients

c) Teratogenic

d) Does not trigger malignant hyperthermia

Question 15:

Which inhalational anesthetic has a negligible greenhouse effect?

a) Nitrous oxide

b) Desflurane

c) Xenon

d) Halothane

Question 16:

A middle-aged man presented to the ER with stridor due to partial upper airway obstruction. You are asked to administer heliox for symptomatic relief. What is the composition of this breathing mixture?

a) Helium 30% and oxygen 70%

b) Helium 70% and oxygen 30%

c) Helium 50% and oxygen 50%

d) Helium 40% and oxygen 60%

Question 17:

Which of the following is an incorrect statement regarding oxygen as a therapeutic agent?

a) Hyperbaric oxygen increases the availability of dissolved O2 in blood

b) Primarily used in hypoxia

c) Inhalation of higher oxygen concentration increases the partial pressure of nitrogen inside the body

d) Can be administered at pressures greater than atmospheric oxygen pressure

Question 18:

During a coronary artery bypass graft surgery, the surgeon uses a therapeutic gas to flood the surgical field. Which of the following would he use?

a) Oxygen

b) Nitric oxide

c) Nitrous oxide

d) Carbon dioxide

Question 19:

In which of the following patients is inhaled nitric oxide approved for management?

a) 52-year-old man with hypertensive emergency

b) 44-year-old woman with gastric varices

c) 3-day-old neonate with persistent pulmonary hypertension

d) 80-year-old man with malignant hypertension

Question 20:

Which of the following inhalational anesthetics does not preserve cardiac output?

a) Isoflurane

b) Desflurane

c) Halothane

d) Sevoflurane

Question 21:

Ozone depletion is least with which inhaled anesthetic ?

a) Xenon

b) Nitrous oxide

c) Isoflurane

d) Halothane

Question 22:

Which of the following statements is true regarding xenon?

a) Decreases airflow resistance and work of breathing

b) Contraindicated in cardiac patients

c) Contributes to green house effect

d) Rapid induction and recovery

Question 23:

Which of the following inhalational agents is suitable for neurosurgery?

a) Halothane

b) Isoflurane

c) Nitrous oxide

d) Ether

Answer Key

Question No.	Correct Option
1	b
2	c
3	d
4	b
5	b
6	b
7	b
8	c
9	c
10	b
11	b
12	d
13	c
14	c
15	c

16	b
17	c
18	d
19	c
20	c
21	a
22	d
23	b

Detailed Explanations

Solution to Question 1:

Sevoflurane is the induction agent of choice among inhalational anesthetics.

It is non-pungent and has low blood-gas solubility (0.65), allowing for smooth induction of anesthesia.

Option A: Halothane has high blood gas solubility, leading to a slower induction of anesthesia.

Option C: Desflurane and isoflurane are airway irritants, of which desflurane is the most pungent inhalational agent. Hence, they are not used for the induction of anesthesia as they can precipitate laryngospasm. These agents are used only during the maintenance of anesthesia.

Option D: N2O has a MAC value of 104%, which makes it the least potent inhaled anesthetic. It is always used in combination with more potent volatile agents.

Solution to Question 2:

Sevoflurane is preferred for induction as it is the agent of choice in pediatric anesthesia.

Option A: Although both halothane and sevoflurane provide a smooth induction, sevoflurane appears to have a greater therapeutic index than halothane and hence is the preferred agent for inhaled induction in pediatric anesthesia.

Options B and D: Isoflurane and desflurane are airway irritants. Hence they are not used for induction of anesthesia as they can precipitate laryngospasm. These agents are used only during the maintenance of anesthesia.

Solution to Question 3:

Desflurane has the maximum global warming potential (GWP) among inhaled anesthetics.

Global warming potential of Anesthetic Gases: Nitrous oxide < Isoflurane < Sevoflurane < Desflurane (maximum)

Xenon produces no greenhouse effect or ozone depletion as it is entirely unreactive in the biosphere.

Although the GWP factor of desflurane is much higher than that of nitrous oxide, the latter contributes the most to increased climate impact (99.97%) as the consumption volumes of N_2O far exceed those of other anesthetic gases.

Solution to Question 4:

The inhalational agent of choice for neurosurgery in patients with elevated intracranial pressure (intracranial tumor) is sevoflurane.

Sevoflurane best preserves the autoregulation of cerebral blood flow and produces limited vasodilatation. Hence, it is the preferred volatile agent in patients with elevated ICP.

The order of vasodilating potency is approximately : halothane > enflurane > desflurane > isoflurane > sevoflurane.

Solution to Question 5:

Enflurane is contraindicated in patients with a known history of seizures, cerebrovascular disease, and head injuries.

Enflurane is the most epileptogenic inhalational anesthetic. It increases seizure activity, especially in the presence of cerebral injury and hypocapnia, and results in increasing the cerebral metabolism manifold.

Besides, enflurane increases cerebrospinal fluid secretion and decreases its absorption which is deleterious in those with poor intracranial compliance.

Seizures have also been associated with the use of sevoflurane in high concentrations, especially in the pediatric population.

Epileptogenic potential: enflurane >>> sevoflurane

Solution to Question 6:

Desflurane is the inhalational agent of choice in the elderly as it is rapidly eliminated and undergoes minimal metabolism.

The amount of fluoride ion produced is only about 5 µm which is much lower than the other fluorinated agents and hence safe in elderly as they may have a compromised renal function.

Desflurane is also the inhalational agent of choice in renal disease.

Solution to Question 7:

Sevoflurane is the inhalational agent of choice for asthmatics because of its bronchodilatory effect.

Although halothane produces greater bronchodilation, sevoflurane appears to have a greater therapeutic index. Halothane sensitizes the heart to adrenaline and causes cardiovascular depression, bradycardia, arrhythmias, and respiratory depression which are less likely with sevoflurane.

Solution to Question 8:

Sevoflurane is the inhalational anesthetic agent of choice in liver cirrhosis.

A cirrhotic liver has a compromised portal venous blood flow and hence it is essential to preserve the hepatic arterial blood flow.

Sevoflurane decreases portal vein blood flow but increases hepatic artery blood flow. Thus the total hepatic blood flow and oxygen delivery are better maintained.

An alternative is isoflurane which may reduce hepatic arterial blood flow but maintains hepatic oxygen supply.

Solution to Question 9:

Seizures have been associated with the use of sevoflurane in high concentrations, especially in the pediatric population.

Emergence from sevoflurane is associated with tonic-clonic movements suggestive of the seizure. Hence sevoflurane must be used cautiously in patients with a known history of seizure.

Though isoflurane can cause myoclonus and EEG spiking, frank seizure activity is not seen.

Note: Enflurane has the most epileptogenic potential among the inhaled anesthetics.

Solution to Question 10:

The given clinical scenario of myocardial ischemia, hypotension, ST-segment changes, and decreased cardiac output point towards a diagnosis of coronary steal syndrome.

Isoflurane has been associated with myocardial ischemic symptoms, particularly in scenarios where coronary perfusion pressure is compromised.

It dilates normal coronary arteries, which can redirect blood flow away from areas supplied by stenotic or diseased vessels, worsening ischemia in those regions. This redistribution of blood flow may contribute to hypotension, ST-segment changes, and reduced cardiac output. However, these effects are typically seen when hypotension occurs and can be mitigated by maintaining adequate coronary perfusion pressure.

Solution to Question 11:

Desflurane has rapid induction and recovery from anesthesia due to its low blood gas solubility.

Option A: Desflurane is not used for induction as it is very pungent and may result in cough, laryngospasm, and bronchospasm.

Option C: Desflurane is not environmentally safe as it has the maximum global warming potential among inhalational anesthetics. However, N_2O contributes the most to increased climate impact (99.97%) as the consumption volumes of N_2O far exceed those of other anesthetic gases.

Option D: Desflurane is 17 times more potent than nitrous oxide.

Solution to Question 12:

The canister contains desiccated soda lime. Desflurane undergoes degradation to produce carbon monoxide, in the presence of strong bases in dry CO_2 absorbents (like desiccated soda lime).

CO production is predominantly seen with absorbents that contain sodium or potassium hydroxide. It is seen less with barium hydroxide. The propensity for CO production correlates with the anesthetic concentration in the breathing circuit (desflurane > enflurane > isoflurane).

Amsorb is a CO_2 absorbent that is more inert than soda-lime and baralyme and so associated with lesser degradation of anesthetics and so less carbon monoxide production.

Sevoflurane, methoxyflurane, and halothane also undergo degradation in the presence of strong bases, but they do not produce CO.

Solution to Question 13:

Sevoflurane reacts with strong bases like sodium hydroxide and potassium hydroxide present in soda-lime and baralyme leading to the formation of a haloalkene (fluoromethyl-2,2-difluoro-1-[trifluoromethyl] vinyl ether) known as compound A.

Compound A has the potential to cause proximal tubular necrosis.

Risk factors for increased compound A production:

• Prolonged duration of anesthesia

• High concentration of sevoflurane

• Low flow techniques

• Dry baralyme

A fresh gas flow of at least 2L/ min can prevent the generation of compound A

Amsorb is a CO_2 absorbent that is more inert than soda-lime and baralyme and so associated with lesser degradation of sevoflurane and less compound A production.

Solution to Question 14:

Xenon is non-teratogenic.

Option A: Xenon is its high density (5.9 g/L) gas, (much higher than oxygen and nitrous oxide) which leads to increased flow resistance and work of breathing. Thus it is unsuitable for patients with compromised respiratory function.

Option B: It has minimal cardiovascular effects. It produces minimal cardiovascular depression and is not arrhythmogenic, hence safe in cardiac patients.

Option D: Does not trigger malignant hyperthermia

Advantages of xenon	Disadvantages of xenon
Inert, Non-explosive	High cost
Safe in cardiac disease	Low potency
Has analgesic activity- reduces intraoperative opioid requirements	High-density gas- higher flow resistance, poor choice for patients with respiratory compromise

Solution to Question 15:

Xenon produces no greenhouse effect or ozone depletion as it is inert in the biosphere.

All the other inhaled anesthetics are greenhouse gases.

Option A: The global warming potential of nitrous oxide is about 300 times greater than carbon dioxide.

Option B: Desflurane has the maximum global warming potential among inhaled anesthetics. Isoflurane, sevoflurane, and desflurane undergo minimal metabolism in the body and are predominantly eliminated on expiration. If these are let out into the atmosphere without scavenging, they contribute significantly to the greenhouse effect and global warming.

Option D: Halothane has the potential to destroy stratospheric ozone due to its bromine-bearing molecules.

Solution to Question 16:

Heliox is a mixture of 70% helium and 30% oxygen.

It is supplied in E-size cylinders and delivered through a non-rebreathing face mask starting at a flow rate of 10L/min.

Heliox is used in cases of partial airway obstruction as in stridor to relieve the increased work of breathing. The flow of heliox through obstruction when compared to oxygen is higher due to its density being 40% of pure oxygen. Thus it provides symptomatic relief from acute distress before definite treatment can be instituted.

The use of heliox in relieving lower airway obstruction as in acute asthma or COPD is unsatisfactory.

Solution to Question 17:

Inhalation of higher oxygen concentrations can reduce the partial pressure of nitrogen inside the body.

Reduction in total body partial pressure of nitrogen provides a substantial gradient for the removal of nitrogen from gas spaces. This is beneficial in conditions such as bowel distension from obstruction of ileus, intravascular air embolism, or pneumothorax.

Oxygen is administered at greater than atmospheric pressure in hyperbaric chambers (hyperbaric oxygen).

Solution to Question 18:

Carbon dioxide (CO_2) is commonly used to flood the surgical field during cardiac surgery.

A common cause of myocardial ischemia during open-heart surgery is air embolism to the coronary arteries.

Carbon dioxide because of its higher density, displaces the air surrounding the open heart so that any gas bubbles trapped in the heart are of carbon dioxide (soluble) and not nitrogen (insoluble).

Solution to Question 19:

Inhaled nitric oxide (NO) is approved (USFDA) for use in persistent pulmonary hypertension of the newborn.

Inhaled NO selectively dilates the pulmonary vasculature and has the potential to treat many conditions that result in increased pulmonary hypertension.

Solution to Question 20:

Halothane produces the maximum decrease in cardiac output by a combination of decreased heart rate and depressed myocardial contractility

Halothane and enflurane produce a greater decrease in myocardial contractility than isoflurane, desflurane, and sevoflurane which best maintain cardiac output.

Of these, cardiac output is best preserved with isoflurane – though it does produce some myocardial depression, reflex tachycardia maintains cardiac output. Isoflurane is the agent of choice in cardiac patients.

Solution to Question 21:

Xenon is a noble gas which is used for its anesthetic properties and it has no effect on the ozone.

Other options :

• Halothane and isoflurane have the potential to destroy stratospheric ozone due to their bromine (halothane only) and chlorine-bearing molecules.

• The contribution to stratospheric ozone loss by the anesthetic N_2O is likely more significant, compared to halothane and isoflurane.

Solution to Question 22:

Xenon has a very low blood-gas solubility coefficient (0.115) and so produces rapid induction and emergence from anesthesia.

Option A: the disadvantage with xenon gas is its high density (5.9 g/L), which is much higher than oxygen and nitrous oxide which leads to increased flow resistance and work of breathing. Thus it is not suitable for patients with compromised respiratory function.

Option B: It has minimal cardiovascular effects- it produces minimal cardiovascular depression, and it is not arrhythmogenic- so safe in cardiac patients.

Option C: Xenon produces no greenhouse effect or ozone depletion and is environmentally safe, unlike the other inhaled anesthetics.

• Other advantages of xenon:

• Does not trigger malignant hyperthermia

• Nonexplosive

• Has analgesic activity - reduces intraoperative opioid requirements

Solution to Question 23:

Among the given options, isoflurane is best suited for neurosurgery.

All of the inhalational anesthetics are cerebral vasodilators. The order of vasodilating potency is:

halothane > enflurane > desflurane > isoflurane > sevoflurane.

Note: Due to its lesser vasodilating property, sevoflurane is preferred to isoflurane for neurosurgery.

Intravenous Anesthesia - Barbiturates, Benzodiazepines & Propofol

Question 1:

What concentration of intravenous thiopentone is used to induce anesthesia in a patient?

a) 0.25%

b) 1%

c) 2%

d) 2.5%

Question 2:

In patients administered thiopentone, which property of the drug allows for the rapid recovery from anesthesia?

a) Rapid elimination

b) Rapid reabsorption

c) Rapid metabolism

d) Rapid redistribution

Question 3:

You are asked to reconstitute thiopentone a few minutes before the 1st OT case is scheduled to start. Which of the following would you not use?

a) Normal saline

b) Glucose

c) Ringer's lactate

d) Water

Question 4:

In which of the following patients can thiopentone be administered safely?

a) A 44-year-old man with brain tumor

b) A 24-year-old woman with history of acute intermittent porphyria

c) A 60-year-old woman in hypovolemic shock

d) A 52-year-old man with chronic obstructive pulmonary disease

Question 5:

On administration of intravenous thiopentone for induction, a patient loses consciousness in less than thirty seconds. Which of the following is the reason for its rapid onset of action?

a) Low lipid solubility

b) Rapid redistribution

c) High amount of ionized fraction

d) High amount of unionized fraction

Question 6:

Which of the statement regarding the drug given below is incorrect?

a) Rapid onset and ultrashort duration of action

b) Produces adequate analgesia

c) Contraindicated in status asthmaticus

d) Cerebroprotective

Question 7:

A middle-aged woman diagnosed with major depressive disorder associated with suicidal thoughts is scheduled to receive electroconvulsive therapy. What is the anesthetic agent of choice for her procedure?

- **a)** Thiopentone
- **b)** Methohexitone
- **c)** Pentobarbitone
- **d)** Lorazepam

Question 8:

Which of the following barbiturates is not completely eliminated by the liver?

- **a)** Thiopentone
- **b)** Phenobarbitone
- **c)** Thiamylal
- **d)** Methohexital

Question 9:

A school student is brought to the casualty unresponsive following trauma to the head. The NCCT image is shown below. Which drug would you prefer for induction of anesthesia in him?

a) Ketamine

b) Halothane

c) Nitrous oxide

d) Thiopentone

Question 10:

You administer intravenous thiopentone for induction in a patient. As soon as you inject the drug, the patient complains of excruciating pain in his fingers with burning sensation. Fingers turned pale initially and soon became cyanosed. What will be your next step in the management of this situation?

a) Administer saline

b) Administer heparin

c) Administer lidocaine

d) Remove the needle immediately

Question 11:

What is the main goal of pre-medication prior to surgery?

a) Decrease secretions

b) Reduce postoperative nausea and vomiting

c) Diminish anxiety

d) Prevent aspiration

Question 12:

Which of the following drugs should be avoided in patients with bronchial asthma?

a) Propofol

b) Ketamine

c) Etomidate

d) Thiopental

Question 13:

A 4-year-old child planned for an MRI requires to be sedated. Which short-acting benzodiazepine is to be ideally administered for this purpose?

a) Diazepam

b) Lorazepam

c) Midazolam

d) Temazepam

Question 14:

Benzodiazepines are administered to a patient as pre-medication, per the anesthesia orders. These drugs have all the following effects except:

a) Allay anxiety

b) Analgesia

c) Muscle relaxation

d) Perioperative amnesia

Question 15:

Remimazolam is administered to a 44-year-old man prior to an esophagogastroduodenoscopy. Which of the following statements is incorrect regarding the drug?

a) Can be used for procedures thirty minutes or less

b) Faster acting than midazolam

c) Metabolized by nonspecific esterases

d) New GABA-B receptor agonist

Question 16:

Which of the following can be used as an intravenous induction agent?

a) Lorazepam

b) Bupivacaine

c) Dexmedetomidine

d) Neostigmine

Question 17:

Overdose with which of the following drugs can be reversed with flumazenil?

a) Barbiturates

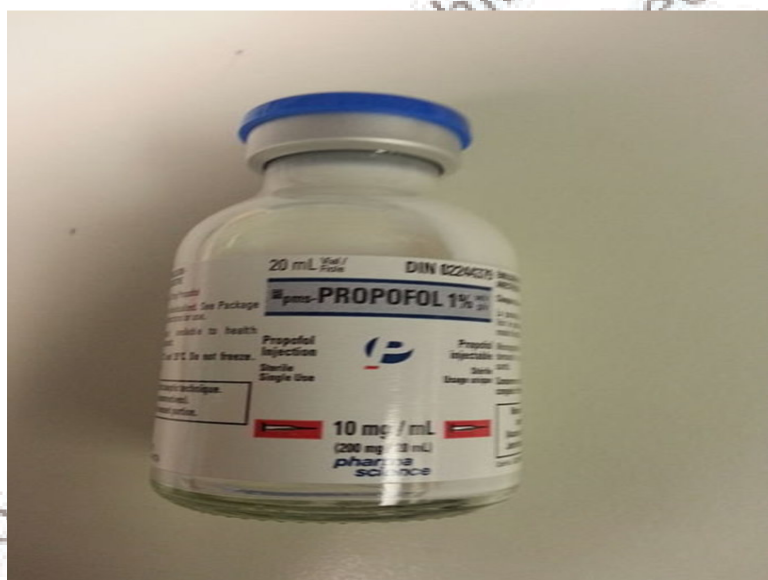
b) Benzodiazepines

c) Opioids

d) Amphetamines

Question 18:

Which of the following statements is incorrect concerning the drug in the image below?



a) Predisposes to systemic infections

b) Associated with pancreatitis

c) Reduces postoperative nausea and vomiting

d) Contraindicated in egg allergic patients

Question 19:

Bacterial contamination of drug vials is a risk with ___________.

a) Thiopentone

b) Etomidate

c) Propofol

d) Ketamine

Question 20:

Which of the following statements is incorrect regarding propofol?

a) Hypotension following induction

b) Severe pruritis following injection

c) Pain on injection

d) Depresses airway reflexes

Question 21:

You decide to use a prodrug of propofol for a bronchoscopy under conscious sedation. Which of the following is an incorrect statement regarding this drug?

a) Water soluble

b) Faster acting than propofol

c) No pain on injection

d) Less incidence of hypotension and apnea

Question 22:

Which of the following anesthetics have high abuse potential?

a) Etomidate

b) Thiopentone

c) Methohexital

d) Propofol

Question 23:

A critically ill patient was given an infusion of an intravenous anesthetic at a dose of 4mg/kg/hour. 48 hours later, the patient developed refractory bradycardia, and there was evidence of rhabdomyolysis on investigations. Which agent is most likely implicated?

a) Thiopentone

b) Propofol

c) Etomidate

d) Ketamine

Question 24:

Two days after he underwent a gastrectomy, a patient complained of severe abdominal pain, nausea, and vomiting. Labs showed elevated serum amylase and lipase levels. CECT showed diffuse parenchymal enlargement of the pancreas. Administration of which of the following anesthetics is implicated here?

a) Propofol

b) Etomidate

c) Thiopentone

d) Ketamine

Question 25:

Which of the following findings would not be seen in a patient with propofol infusion syndrome?

a) Bradycardia

b) Cardiac failure

c) Hyperlipidemia

d) Hypokalemia

Question 26:

Which one of the following anesthetic agents shows the Robin Hood phenomenon?

a) Propofol

b) Etomidate

c) Ketamine

d) Thiopentone

Question 27:

Which of the following is true about total intravenous anesthesia?

a) Reduces cerebral metabolism and cerebral blood flow

b) Smooth induction with high incidence of post operative nausea and vomiting

c) Propofol inhibits pulmonary vasoconstriction d/t hypoxia

d) Higher chances of nephrotoxicity and pulmonary toxicity

Question 28:

Which of the following is not an intravenous induction agent?

a) Propofol

b) Thiopentone

c) Etomidate

d) Halothane

Answer Key

Question No.	Correct Option
1	d
2	d
3	c
4	a
5	d
6	b
7	b
8	b
9	d
10	a
11	c
12	d
13	c
14	b
15	d
16	a
17	b
18	d

19	c
20	b
21	b
22	d
23	b
24	a
25	d
26	d
27	a
28	d

Detailed Explanations

Solution to Question 1:

Thiopentone is used as a 2.5% solution.

Thiopentone is prepared as a sodium salt (mixed with 6% by weight anhydrous sodium carbonate) and can be reconstituted with water, glucose 5%, or normal saline to produce a 2.5% solution of thiopental.

Other reconstituted solutions:

• 2% solution of thiamylal

• 1% solution of methohexital

Solution to Question 2:

Rapid recovery from thiopentone anesthesia is due to its rapid redistribution.

It is redistributed from the brain to tissues that are less perfused, like muscles, resulting in rapid recovery (within 20 minutes).

Solution to Question 3:

Thiopentone is an alkaline solution and should not be reconstituted with Ringer's lactate which has an acidic pH. Ringer's lactate decreases the alkalinity of the solution and the calcium present in it can result in the precipitation of thiopentone.

Thiopentone and other barbiturates are prepared as sodium salts (mixed with 6% by weight anhydrous sodium carbonate) and can be reconstituted with water, 5% glucose, or normal saline to produce a 2.5% solution of thiopental.

After reconstitution:

• Thiobarbiturates (thiopentone, thiamylal) – stable if refrigerated for 1 week

• Methohexital – stable if refrigerated for 6 weeks

Solution to Question 4:

Thiopentone can be safely administered in a patient with raised intracranial tension, i.e., brain tumor.

Thiopentone is cerebroprotective as it reduces CSF volume by facilitating its absorption. It also decreases cerebral blood flow, cerebral blood volume and helps in lowering intracranial pressure.

The other options are contraindications to the use of thiopentone.

Option B: Thiopentone induces aminolevulinic acid synthetase, which increases the formation of porphyrins. This precipitate porphyria attacks, especially acute intermittent porphyria or variegate porphyria in susceptible individuals.

Option C: Thiopentone should be avoided in hypovolemic or shock patients because of the significant reduction in cardiac output (69%) and arterial blood pressure due to vasodilation and venous pooling.

Option D: Thiopentone produces dose-related central respiratory depression, producing a characteristic ventilatory pattern called 'double apnea'.

Solution to Question 5:

Thiopentone has a rapid onset of action due to the high unionized fraction and high lipid solubility.

Only the unionized form can cross the blood-brain barrier and exert its action (within 30 s).

Rapid redistribution is responsible for the termination of action of thiopentone. i.e., it governs the duration of the action, not the onset.

Solution to Question 6:

Thiopentone does not produce analgesia and may even produce anti-analgesia by reducing the pain threshold.

Option A: Thiopentone has a rapid onset of action (within 30 s) due to high lipid solubility and a high unionized fraction (60%). It has an ultra-short duration of action (within 20 mins) due to rapid redistribution.

Option C: Thiopentone does not completely suppress airway responses to laryngoscopy and intubation and may lead to bronchospasm in asthmatics.

Option D: Thiopentone is cerebroprotective as it reduces CSF volume by facilitating its absorption. It decreases cerebral blood flow and cerebral blood volume, thus lowering intracranial pressure. It also has an anticonvulsant property which is advantageous in neurosurgical patients who are at increased risk of seizures.

Solution to Question 7:

Intravenous methohexital is the agent of choice for providing anesthesia during electroconvulsive therapy (ECT).

Methohexital can induce seizures and has a rapid recovery. It is also useful in identifying epileptic foci during surgery for resistant seizures.

Note: According to Mental Health Care Act (MHCA) 2017, ECT should be performed only after administering a short-acting general anesthetic along with muscle relaxants. This method is known as modified ECT.

Solution to Question 8:

Phenobarbitone is not completely eliminated by the liver. 25% to 50% of the drug is excreted by the kidneys in an unchanged form.

All barbiturates (thiopentone, thiamylal, methohexital) other than phenobarbitone are completely eliminated by the liver.

Solution to Question 9:

The imaging suggests an extradural hemorrhage (EDH). Thiopentone is preferred for induction of anesthesia in head injury.

Thiopentone is cerebroprotective, as it decreases cerebral blood flow (CBF), thus lowering intracranial pressure (ICP). It reduces cerebral oxygen consumption (decreased CMRO2). It also has an anticonvulsant property which is advantageous in neurosurgical patients who are at increased risk of seizures.

	CBF	ICP	CMRO2	Seizure
Thiopentone	↓↓↓	↓↓↓	↓↓↓	↓↓↓
Ketamine	↑↑	↑↑	↑	↑
Halothane	↑↑	↑↑	↓	↓
Nitrous oxide	↑	↑	↑	↓

Solution to Question 10:

The given clinical features of severe pain with burning sensation and cyanosis of fingers point to accidental intra-arterial administration of thiopentone. Saline administration via the same needle to dilute the drug should be the first step in managing this case.

Intra-arterial injection of thiopentone can form crystals in the arterioles and capillaries, causing severe vasoconstriction, thrombosis and even gangrene. The degree of gangrene corresponds to the concentration of the drug.

Treatment:

- The needle should not be removed as it can aggravate vasospasm
- Saline administered via the same needle to dilute the drug
- Heparin to prevent thrombosis
- Papaverine and lidocaine
- Brachial plexus block or stellate ganglion block to relieve vasospasm

Solution to Question 11:

The main goal of premedication is to diminish anxiety.

Preoperative medication may also provide relief of preoperative pain or perioperative amnesia.

Indications for preoperative medication:

- Prophylaxis against postoperative nausea and vomiting (5-HT3s)
- Prophylaxis against aspiration pneumonia (eg, antacids)
- Prevention of allergic reactions (eg, antihistamines)
- Decreasing upper airway secretions (eg, anticholinergics)

Some medications that are given preoperatively (e.g., opioids) decrease anaesthetic requirements and can cause smooth induction.

Solution to Question 12:

Histamine release is more commonly seen with barbiturates like thiopental and methohexital. Hence thiopental should be avoided in patients with bronchial asthma to prevent wheezing.

Barbiturates increase histamine release from mast cells and produce a higher incidence of wheezing when compared to propofol.

Note: Thiopental and methohexital are ultra-short acting barbiturates indicated for the induction of anesthesia.

Solution to Question 13:

The shortest-acting benzodiazepine among the given options is midazolam. It is administered as a pre-medication in children having separation anxiety before procedures or in short procedures requiring sedation.

The benzodiazepines used in anesthesia are classified according to their metabolism and plasma clearance as follows:

• Ultra-short acting - Remimazolam (FDA-approved for procedural sedation≤ 30 mins in adults)

• Short-acting agent - Midazolam

• Intermediate-acting agents - Lorazepam, temazepam

• Long-acting agent - Diazepam

Midazolam is the benzodiazepine of choice for induction of anesthesia. The onset of anesthesia is within 30 to 60 seconds.

Solution to Question 14:

Benzodiazepines do not produce analgesia, and so, they must be used with other anesthetic drugs to provide sufficient analgesia.

Benzodiazepines are the most commonly administered drugs for premedication. They act through GABA A receptors:

• ° 1 subunit - sedation, anterograde amnesia (retrograde memory unaffected) and anticonvulsant action

• ° 2 subunit - anxiolysis and muscle relaxation

Solution to Question 15:

Remimazolam is a new GABA-A receptor agonist.

It combines the properties of two unique drugs - midazolam and remifentanil. It acts on GABA-A receptors like midazolam and has organ independent metabolism like remifentanil.

It is an ultra-short-acting intravenous benzodiazepine, which is rapidly degraded in plasma by nonspecific esterases to its carboxylic acid metabolite CNS 7054.

It has a rapid onset of action, greater depth of sedation, and more rapid recovery than with midazolam.

Solution to Question 16:

Lorazepam is a benzodiazepine that can be used for induction of anesthesia at a dose of 0.1mg/kg, although midazolam is preferred among benzodiazepines.

Benzodiazepines are mainly used for sedation and less commonly for induction of anesthesia due to the availability of better induction agents (propofol, etomidate, ketamine, and thiopentone).

Dexmedetomidine is a selective alpha-2 agonist and is used primarily as an adjuvant. So, a better option would be lorazepam.

Solution to Question 17:

Flumazenil is the first benzodiazepine antagonist approved for clinical use to reverse the effects of benzodiazepines.

It is a competitive reversible antagonist at the benzodiazepine receptor with high affinity and specificity.

Flumazenil is used for both diagnostic and therapeutic reversal of benzodiazepine receptor agonists.

Solution to Question 18:

Propofol is not contraindicated in egg allergy patients.

Propofol is formulated as an oil-in-water emulsion, which contains soybean oil, glycerol, and egg lecithin. Usually, egg allergies are a reaction to egg white (egg albumin). But, propofol contains egg lecithin, which is extracted from egg yolk, and so, propofol is not necessarily contraindicated in patients with a history of egg allergy.

Propofol has been associated with life-threatening systemic infections because it decreases polymorphonuclear leukocyte chemotaxis, but not adherence phagocytosis and killing. It inhibits phagocytosis and killing of Staphylococcus aureus and Escherichia coli.

Propofol is associated with hypertriglyceridemia which can predispose to pancreatitis.

It has antiemetic properties which help in reducing the incidence of post operative nausea and vomiting.

Solution to Question 19:

Bacterial contamination of vials is a risk with propofol.

Propofol formulations contain egg lecithin and soyabean oil. The egg is a good medium for bacterial growth and the lack of preservatives supports the growth of bacteria which can lead to sepsis or even death.

Hence, propofol must be used within 6 hours of opening the ampule.

Nowadays, certain additives like 0.005% disodium edetate or 0.025% sodium metabisulfite have been added to propofol formulations so as to retard the rate of growth of microorganisms.

Solution to Question 20:

Propofol has antipruritic properties. It can also relieve cholestatic pruritus and may be as effective as naloxone in treating pruritus induced by spinal opiates.

Option A: Propofol produces a 25% to 40% reduction in systolic blood pressure following injection.

Option C: Propofol is formulated as a lipid emulsion that causes pain during injection. This can be decreased by using a large vein, avoiding veins in the dorsum of the hand, prior injection of lidocaine or by mixing lidocaine with propofol prior to injection (2 mL of 1% lidocaine in 18 mL propofol).

Option D: Propofol produces maximum inhibition of airway reflexes and can facilitate intubation, endoscopy, or laryngeal mask placement without neuromuscular blockade.

Solution to Question 21:

Fospropofol is a water-soluble prodrug of propofol that has a slower onset and slower recovery than propofol. It is hydrolyzed to propofol, phosphate, and formaldehyde.

Fospropofol is advantageous since it is not associated with pain on injection.

Fospropofol is approved for sedation during local and regional anesthesia e.g., conscious sedation and monitored anesthesia care. Due to its slower onset of sedation, it is associated with a lower incidence of hypotension, respiratory depression, apnea, and loss of airway patency.

Solution to Question 22:

Propofol is an intravenous induction agent that can be addictive because of its hypnotic property and development of tolerance on prolonged use.

The abuse potential is common among health care workers with reports of self-administration. There is only a narrow therapeutic window between the hypnotic, euphoric effect of propofol and its lethal dose. When exceeded, it can cause airway obstruction, respiratory depression, hypoxia or an unstable hemodynamic response leading to death.

Note: Ketamine also has the potential for abuse and addiction.

Solution to Question 23:

The given features point towards a diagnosis of propofol infusion syndrome. It is a rare but lethal syndrome seen when the dose of propofol infusion is > 4 mg/kg/hour for 48 hours or longer.

This syndrome is common in children and critically ill adults.

Clinical features:

• Acute refractory bradycardia leading to asystole in the presence of one or more of the following:

• Metabolic acidosis (base deficit >10 mmol/L)

• Rhabdomyolysis

• Hyperlipidemia

• Enlarged or fatty liver

• Other features - cardiomyopathy with acute cardiac failure, skeletal myopathy, hyperkalemia, hepatomegaly, and lipemia.

The symptoms and signs are the results of muscle injury and the release of intracellular toxic contents. It is due to defect in mitochondrial metabolism and electron transport chain function.

Solution to Question 24:

The given clinical scenario is suggestive of acute pancreatitis, which can be predisposed by the administration of propofol.

Propofol has been associated with hypertriglyceridemia, which may predispose the patient to pancreatitis.

Risk factors for propofol-induced hypertriglyceridemia:

• Old age

• Longer ICU stay

• Received propofol for a longer duration.

It is essential to monitor serum triglyceride levels when propofol is used for a prolonged duration or at higher infusion rates (especially in older patients).

Solution to Question 25:

Propofol infusion syndrome is associated with rhabdomyolysis which leads to hyperkalemia.

Propofol infusion syndrome is a rare but lethal syndrome due to a defect in mitochondrial metabolism and electron transport chain function. It is seen when the dose of propofol infusion is greater than 4mg/kg/hour for 48 hours or longer.

Clinical features:

• Acute refractory bradycardia leading to asystole in the presence of one or more of the following:

• Metabolic acidosis (base deficit >10 mmol/L)

• Rhabdomyolysis

• Hyperlipidemia

• Enlarged or fatty liver

• Other features - cardiomyopathy with acute cardiac failure, skeletal myopathy, hyperkalemia, hepatomegaly, and lipemia.

Solution to Question 26:

Robin Hood or reverse steal phenomenon is seen with thiopentone.

Thiopentone constricts the cerebral vasculature, causing a decrease in cerebral blood flow, cerebral blood volume, and intracranial pressure. However, this vasoconstriction occurs only in normal areas. The blood vessels in the ischemic area remain dilated due to ischemia-induced vasomotor paralysis and are unaffected by thiopentone. This leads to redistribution of blood flow from normal to ischemic areas in the brain. This is called the Robin Hood phenomenon.

Solution to Question 27:

Total intravenous anesthesia results in reduced cerebral metabolism and cerebral blood flow. The most commonly used agent is propofol.

Advantages of TIVA over inhaled anesthetics:

• Smooth induction and rapid recovery with a minimal hangover

• Low incidence of nausea and vomiting

• Safe in patients susceptible to malignant hyperpyrexia

• Reduced greenhouse effect of inhalational anesthesia

• Paralysis is not always required, reversal agents can be avoided and emergence is rapid (especially in propofol TIVA with remifentanil).

Solution to Question 28:

Halothane is an inhalational agent which is a halogenated alkane. Induction with halothane is relatively slow due to its high blood: gas partition coefficient (2.5).

Intravenous induction agents:

• Propofol is the most commonly used intravenous anesthetic.

• Thiopentone is the intravenous agent of choice to provide cerebral protection.

• Etomidate is the intravenous agent of choice to maintain cardiovascular stability in patients with coronary artery disease, cardiomyopathy and cerebral vascular disease.

• Ketamine is the intravenous agent of choice in asthmatics.

Intravenous Anesthesia - Etomidate, Ketamine and Daycare Surgery

Question 1:

Which of the following agents does not elicit pain on injection?

a) Ketamine

b) Propofol

c) Etomidate

d) Thiopentone

Question 2:

Which is the most epileptogenic intravenous induction agent?

a) Thiopentone

b) Etomidate

c) Ketamine

d) Propofol

Question 3:

Which intravenous anesthetic has the maximum incidence of postoperative nausea and vomiting?

a) Thiopentone

b) Ketamine

c) Etomidate

d) Propofol

Question 4:

Which of the following is true regarding etomidate?

a) Reduces postoperative nausea and vomiting

b) Has been used to treat hypercortisolemia

c) Contraindicated in coronary artery disease

d) Avoided in neurosurgical procedures due to risk of raised ICP

Question 5:

Which of the following drugs is the intravenous induction agent of choice in a patient with a history of myocardial infarction?

a) Etomidate

b) Thiopentone

c) Propofol

d) Ketamine

Question 6:

Which intravenous anesthetic is associated with adreno-cortical suppression?

a) Thiopentone

b) Propofol

c) Etomidate

d) Ketamine

Question 7:

In the immediate post-operative period, a patient has persistent hiccups and myoclonus. Which of the following intravenous anesthetic agents was most likely administered?

a) Ketamine

b) Propofol

c) Thiopentone

d) Etomidate

Question 8:

The CT brain of an old man following a fall shows a massive subdural hemorrhage with midline shift. He is taken up for emergency surgery. Which one of these intravenous agents should not be administered for induction in him?

a) Ketamine

b) Etomidate

c) Propofol

d) Thiopentone

Question 9:

What is the main site of action of ketamine?

a) Spinal cord

b) Hippocampus

c) Cerebellum

d) Thalamoneocortical projection

Question 10:

A child was administered an anesthetic for fracture reduction in the ER. He could open his eyes, was blabbering and breathing spontaneously but did not feel any pain. Which anesthetic agent was administered?

a) Ketamine

b) Propofol

c) Etomidate

d) Thiopentone

Question 11:

How does ketamine cause dissociative anesthesia?

a) Antagonistic action at NMDA receptor

b) Agonistic action at NMDA receptor

c) Antagonistic action at GABA A receptor

d) Agonistic action at the GABA B receptor

Question 12:

A young man sustained multiple fractures following an RTA. He is being taken up for damage control surgery. His pulse is 120/min, BP 80/50mmHg, and also has cold extremities. What is the intravenous agent of choice for induction in him?

a) Propofol

b) Thiopentone

c) Ketamine

d) Etomidate

Question 13:

A patient in hemorrhagic shock was shifted for emergency surgery and given ketamine for induction. Why is this drug preferred for use in this situation?

a) Direct sympathomimetic action

b) Indirect sympathomimetic action

c) Negative inotropic action

d) Positive inotropic action

Question 14:

Which of the following is a true statement about ketamine?

a) Produces pain on injection

b) Contraindicated in asthmatic patients

c) Safe in hyperthyroidism

d) Produces salivation and lacrimation

Question 15:

An adolescent boy with bronchial asthma is about to undergo an emergency appendectomy. Which is the intravenous induction agent of choice for him if he has an active wheeze?

a) Thiopentone

b) Propofol

c) Ketamine

d) Etomidate

Question 16:

Administration of which anesthetic agent is associated with a rise in the intraocular pressure?

a) Thiopentone

b) Ketamine

c) Propofol

d) Desflurane

Question 17:

Which intravenous anesthetic preserves airway reflexes the best?

a) Etomidate

b) Ketamine

c) Propofol

d) Thiopentone

Question 18:

During recovery from anesthesia, a patient started experiencing hallucinations and vivid dreams. Which inducing agent is most likely responsible?

a) Ketamine

b) Propofol

c) Thiopentone

d) Etomidate

Question 19:

What drug can be used to prevent hallucinations and vivid dreams that can occur as an emergence reaction during the anesthesia recovery period?

a) Ketamine

b) Atropine

c) Propofol

d) Midazolam

Question 20:

In which of the following patients can you safely administer ketamine?

- **a)** 1 & 5 only
- **b)** 2, 3 & 5 only
- **c)** 2 & 3 only
- **d)** 2 & 5 only

Question 21:

A 36-year-old housewife is scheduled for an excision biopsy of a breast lump under general anaesthesia. The procedure is planned on an outpatient basis. Which is the intravenous induction agent of choice for her?

- **a)** Ketamine
- **b)** Thiopentone
- **c)** Propofol
- **d)** Etomidate

Question 22:

Which is the muscle relaxant of choice in patients posted for daycare surgery?

- **a)** Succinylcholine
- **b)** Rocuronium
- **c)** Vecuronium
- **d)** Pancuronium

Question 23:

A 45-year-old man is posted for inguinal hernia surgery. Which is the anesthetic technique of choice in order to perform fast-track surgery on him?

- **a)** General anesthesia
- **b)** Spinal anesthesia
- **c)** Epidural anesthesia
- **d)** Infiltration anesthesia

Question 24:

Which effect of ambulatory anesthesia most commonly persists after the patient is discharged?

- **a)** Myalgia
- **b)** Drowsiness
- **c)** Sore throat
- **d)** Headache

Question 25:

Which of the following intravenous anesthetics can be used to reduce postoperative pain?

- **a)** Thiopentone
- **b)** Propofol
- **c)** Ketamine
- **d)** Etomidate

Question 26:

Which of the following intravenous anesthetics is hypertensive?

- **a)** Thiopentone
- **b)** Ketamine
- **c)** Etomidate
- **d)** Propofol

Question 27:

Which class of compounds does ketamine belong to?

- **a)** Amphetamine
- **b)** Barbiturates
- **c)** Phencyclidines
- **d)** Butyrophenones

Answer Key

Question No.	Correct Option
1	a
2	b
3	c
4	b
5	a
6	c
7	d
8	a
9	d
10	a
11	a
12	c
13	b
14	d
15	c
16	b
17	b
18	a
19	d
20	d
21	c
22	b
23	d
24	b
25	c
26	b
27	c

Detailed Explanations

Solution to Question 1:

Ketamine does not elicit pain on injection, instead produces profound analgesia.

Propofol is formulated as a lipid emulsion, which causes pain on injection. A new aqueous prodrug, fospropofol is associated with less pain on injection.

Etomidate, although it causes pain on injection, the lipid formulation of etomidate is associated with a much less frequent incidence of pain.

Thiopentone at a concentration greater than 2.5% can produce pain on injection and venous thrombosis.

Solution to Question 2:

The most epileptogenic intravenous induction agent is etomidate.

Etomidate has been associated with grand mal seizures and produces increased EEG activity in epileptogenic foci. This feature has proven useful for intraoperative mapping of seizure foci before surgical ablation.

Thiopentone and propofol have anticonvulsant properties which are advantageous in neurosurgical patients who are at increased risk of seizures.

Ketamine has a mixed effect on seizure activity, with either strong pro-convulsant or strong anticonvulsant action.

Solution to Question 3:

Etomidate has the highest incidence of postoperative nausea and vomiting (PONV) among intravenous anesthetics.

Propofol has antiemetic properties thereby reducing PONV.

Other potential adverse effects of etomidate:

- Adrenocortical suppression
- Myoclonus
- Seizure precipitation
- Pain on injection

Solution to Question 4:

Etomidate can be used in the treatment of endogenous hypercortisolemia. This is due to its ability to inhibit the enzyme 11β-hydroxylase, which results in decreased biosynthesis of cortisol.

Etomidate has the highest incidence of postoperative nausea and vomiting.

Etomidate is the most cardiac stable induction agent and is the agent of choice in coronary artery disease, cardiomyopathy and cerebral vascular disease.

Etomidate can be safely used in neurosurgical procedures. It is also the anaesthetic induction agent of choice to reduce increased ICP when maintenance of cerebral or coronary perfusion pressure is important.

Solution to Question 5:

As the patient has a history of coronary artery disease, the agent of choice is etomidate.

Etomidate is the most cardiac stable intravenous agent due to its lack of effect on the sympathetic nervous system and baroreceptor function.

The myocardial oxygen supply-to-demand ratio is well maintained. It is the IV induction agent of choice in patients with coronary artery disease, cardiomyopathy, and cerebral vascular disease.

Adverse effects of etomidate:

• Postoperative nausea and vomiting (PONV)

• Myoclonus

• Adrenocortical suppression

• Epileptogenic potential

Option B: Thiopentone decreases the cardiac output, systemic arterial pressure, and peripheral vascular resistance.

Option C: Propofol produces cardiovascular depression by direct myocardial depressant effects and decreases systemic vascular resistance.

Option D: Ketamine produces an increase in arterial pressure, heart rate and thus increases myocardial oxygen demand.

Solution to Question 6:

Etomidate has been associated with adrenocortical suppression which can last for 72 hours.

Etomidate inhibits the enzyme 11β-hydroxylase, resulting in decreased biosynthesis of cortisol and mineralocorticoids and increases the formation of intermediaries like 11-deoxycorticosterone.

It is a more potent inhibitor of steroid synthesis than as a sedative-hypnotic as the concentration which produces adrenocortical suppression (10 ng/mL)is much lower than that needed for hypnosis (>200 ng/mL).

Solution to Question 7:

Etomidate has a very high incidence of myoclonus and hiccups.

The possible cause of myoclonus is thought to be subcortical disinhibition, and not due to epileptogenic foci.

This myoclonus can be minimized by premedication with benzodiazepines (midazolam) or opiates or a small dose of magnesium 60 to 90 seconds before administering etomidate.

Potential adverse effects of etomidate:

- Adrenocortical suppression
- Postoperative nausea and vomiting
- Seizure precipitation
- Myoclonus, hiccups
- Pain on injection

Solution to Question 8:

Ketamine is avoided in head injury patients as it increases cerebral oxygen consumption ($CMRO_2$), cerebral blood flow (CBF), and intracranial pressure (ICP).

Etomidate, propofol and thiopentone decrease $CMRO_2$, CBF and ICP.

Solution to Question 9:

The main site of action of ketamine is the thalamoneocortical projection system.

It inhibits certain parts of the cortex (especially association areas) and thalamus but stimulates parts of the limbic system, including the hippocampus.

Ketamine is an antagonist at the excitatory glutamatergic NMDA receptor. The NMDA receptor is highly expressed in the temporal cortex, hippocampus, basal ganglia, cerebellum, and brainstem.

Solution to Question 10:

The given features suggest dissociative anaesthesia, which is a characteristic feature of ketamine.

Ketamine produces dissociative anesthesia which is characterized by a state wherein the patient is conscious (eg., eye opening, swallowing, muscle contracture) but unable to process or respond to sensory input.

Ketamine functionally “dissociates” the thalamus (which relays sensory impulses from the reticular activating system to the cerebral cortex) from the limbic cortex (which is involved with the awareness of sensation). It acts as an antagonist at the phencyclidine site of the NMDA receptor.

Solution to Question 11:

Ketamine produces dissociative anesthesia through antagonistic action at the phencyclidine site of the NMDA receptor.

Dissociative anesthesia is a state where the patient appears conscious (eye-opening, swallowing, muscle contracture) but unable to process or respond to sensory input.

Ketamine functionally "dissociates" the thalamus, which relays sensory impulses from the reticular activating system to the cerebral cortex from the limbic cortex involved with the perception of sensation.

Solution to Question 12:

The clinical features suggest circulatory failure. The IV induction agent of choice in hypotensive patients is ketamine > etomidate.

Ketamine helps to maintain arterial pressure, heart rate, and cardiac output by central stimulation of the sympathetic nervous system and inhibition of the reuptake of norepinephrine. It also increases peripheral arteriolar resistance and reduces redistribution of hypothermia in hypovolemic patients.

Ketamine is avoided in patients with hypertension as it raises the blood pressure.

Option A: Propofol produces cardiovascular depression by direct myocardial depressant effects and decreases systemic vascular resistance, which is more profound than thiopentone.

Option B: Thiopentone decreases cardiac output, systemic arterial pressure, and peripheral vascular resistance.

Option D: Etomidate is primarily used in Neurosurgery as it decreases Intracranial pressure but despite its favorable hemodynamic profile, it causes arterial hypotension in the volume-depleted patient.

Solution to Question 13:

Ketamine is preferred due to its indirect sympathomimetic action. It is the intravenous anesthetic of choice for hemorrhagic shock.

It inhibits the reuptake of both central and peripheral catecholamines and causes increased blood pressure, heart rate, and cardiac output.

Ketamine has direct negative inotropic and vasodilating activity, but these effects are overwhelmed by the indirect sympathomimetic action.

Solution to Question 14:

Ketamine administration may be associated with salivation and lacrimation which can be attenuated by premedication with an anticholinergic agent such as glycopyrrolate.

Option A: Ketamine does not elicit pain on injection.

Option B: Ketamine is the induction agent of choice in asthmatic patients as it is a bronchial smooth muscle relaxant.

Option C: Ketamine stimulates the sympathetic nervous system and so is best avoided in patients with hyperthyroidism because of the possibility of exaggerated elevations in blood pressure and heart rate.

Solution to Question 15:

In an actively wheezing asthmatic patient, ketamine is the induction agent of choice, as it is a bronchial smooth muscle relaxant.

It is also the drug of choice in hemodynamically unstable patients.

Propofol is the intravenous induction agent of choice for the hemodynamically stable asthmatic patient, who is not actively wheezing. Both drugs possess good bronchodilatory action.

Solution to Question 16:

A rise in intraocular pressure is seen with ketamine.

Hence, ketamine may be contraindicated in patients with an open eye injury or other ophthalmologic disorder, in which an increase in intraocular pressure would be detrimental.

Solution to Question 17:

Airway reflexes are best preserved with ketamine.

Corneal, cough and swallow reflexes all may be present, but they may not be protective. So, patients at increased risk for aspiration pneumonia ("full stomachs") should be intubated during ketamine general anesthesia.

Propofol is associated with maximum inhibition of airway reflexes.

Solution to Question 18:

Hallucinations and vivid dreams during recovery from anesthesia are a manifestation of an emergence reaction following the administration of ketamine.

The incidence of psychic emergence reactions ranges from 3% to 100% and is usually associated with excitement, confusion, euphoria, and fear. The symptoms usually appear in the first hour of emergence and subside within several hours.

Solution to Question 19:

Hallucinations and vivid dreams during recovery from anesthesia are a manifestation of emergence reaction following ketamine administration.

Benzodiazepines like midazolam are the most effective group of drugs in the prevention of emergence reactions.

Solution to Question 20:

Ketamine is the intravenous induction agent of choice in bronchial asthma and shock.

Ketamine causes bronchial smooth muscle relaxation and preserves upper airway reflexes.

Ketamine increases heart rate, arterial pressure, and cardiac output by stimulation of the sympathetic nervous system and inhibition of the reuptake of norepinephrine. It is the only anesthetic that increases peripheral arteriolar resistance and thus reduces redistribution of hypothermia in hypovolemic patients.

Contraindications of ketamine:

- Raised intracranial pressure
- Open globe injury (raises intraocular pressure)
- Vascular aneurysm surgery (possible sudden change in arterial blood pressure)
- Psychiatric diseases - schizophrenia
- Hyperthyroidism (exaggerated elevations in blood pressure, heart rate)
- Ischemic heart disease (increase in myocardial oxygen consumption)

Solution to Question 21:

The intravenous induction agent of choice for ambulatory anesthesia is propofol.

Propofol has a rapid onset of action and a faster recovery. This makes it an ideal induction agent for outpatient/ambulatory/day care anesthesia.

Besides, propofol has antiemetic properties which help reduce post-operative nausea and vomiting.

Solution to Question 22:

Rocuronium is the muscle relaxant of choice for daycare surgery.

Rocuronium is an intermediate-acting muscle relaxant with a rapid onset (90 secs).

Its actions can be terminated by the reversal agent sugammadex, which produces a rapid and complete reversal of neuromuscular blockade.

Note: Succinylcholine is the shortest acting muscle relaxant, but it has a high incidence of postoperative myalgia. So, its use in day care anesthesia is discouraged.

Solution to Question 23:

Infiltration anesthesia is given for fast-track surgery.

Ambulatory/outpatient anesthesia employs the use of fast-track surgical techniques to provide adequate surgical anesthesia and minimize postoperative complications in order to reduce the duration of hospital stay.

Infiltration anesthesia (inguinal field block) is ideal to perform inguinal hernia repair because it has a lesser incidence of complications than regional or general anesthesia.

The disadvantage of infiltration anesthesia is its short duration of anesthesia even when long-acting local anesthetics like bupivacaine are used.

Solution to Question 24:

Drowsiness is the most common adverse effect that persists after discharge following an ambulatory or daycare anesthesia.

Adverse effects after ambulatory anesthesia in their decreasing order of incidence:

- Drowsiness
- Sore-throat
- Myalgia
- Headache, dizziness
- Nausea, vomiting
- Cardiovascular - hypotension, hypertension, arrhythmias, cardiac arrest (rare)
- Respiratory - hypoxemia, laryngospasm, bronchospasm, aspiration, pulmonary edema, pneumothorax (rare)

Solution to Question 25:

Ketamine can be used to reduce postoperative pain as it produces profound analgesia.

It inhibits nociceptive central hypersensitization.

Besides, ketamine may be effective in the treatment of:

- cancer pain, visceral pain
- migraine, chronic neuropathic pain
- phantom limb pain
- fibromyalgia, complex regional pain syndrome

Solution to Question 26:

Ketamine causes hypertension due to central stimulation of the sympathetic nervous system and inhibition of the reuptake of norepinephrine. Hence, it is useful in patients in shock.

Thiopentone, propofol, and etomidate produce a fall in arterial blood pressure.

Solution to Question 27:

Ketamine is an arylcyclohexylamine, a congener of phencyclidine.

Ketamine produces dissociative anaesthesia through antagonistic action at the phencyclidine site of the NMDA receptor.

Ketamine, like other phencyclidines, produces emergence reactions which are undesirable psychological reactions, which occur during awakening from anesthesia.

Local Anaesthetics - General Properties

Question 1:

The main mechanism of action of lignocaine is through inhibition of __________.

a) Resting, voltage-gated Na channel

b) Inactivated, voltage-gated Na channel

c) Resting, ligand-gated Na channel

d) Inactivated, ligand-gated Na channel

Question 2:

By what mechanism do local anesthetics block nerve conduction?

a) Inhibiting the release of neurotransmitters

b) Decreasing the influx of sodium into the cells

c) Increasing the release of inhibitory neurotransmitters

d) Inhibiting the efflux of sodium from neurons

Question 3:

A patient has presented to your OPD with a sebaceous cyst on the scalp. You plan to excise it. Before making the first incision, you inject lidocaine around it. Which of the following effects does this drug have?

a) Only 1

b) 1, 3 & 5

c) 1, 2 & 4

d) 1, 3, 4 & 5

Question 4:

Which of the following is not an amino ester?

a) Cocaine

b) Procaine

c) Lidocaine

d) Chloroprocaine

Question 5:

Which of the following local anaesthetics is not metabolised by plasma esterase?

a) Tetracaine

b) Procaine

c) Cocaine

d) Articaine

Question 6:

In a patient undergoing surgical fixation of a distal radius fracture, an axillary approach brachial block is administered for the added benefit of prolonged pain relief. Which of the following drugs is least suited for this purpose?

a) Bupivacaine

b) Ropivacaine

c) Tetracaine

d) Lidocaine

Question 7:

Arrange the following local anaesthetics in order of potency from most potent to least.

a) 2 > 1 > 3

b) 2 > 3 > 1

c) 1 > 3 > 2

d) 3 > 1 > 2

Question 8:

The local anesthetic with maximum amount of unionized drug at physiological pH is

____

a) Bupivacaine

b) Chloroprocaine

c) Prilocaine

d) Lidocaine

Question 9:

Which of the following patients should you observe most closely for signs of local anesthesia toxicity?

a) A patient who underwent hip replacement under epidural anesthesia

b) A patient who underwent hand surgery under brachial plexus block

c) A patient who underwent hernioplasty under local anesthesia

d) A patient who underwent ICD insertion under intercostal nerve block

Question 10:

When asked to administer a combination of lignocaine and epinephrine for a minor procedure under local anesthesia, what concentration of epinephrine will you use?

a) 1 : 10,000

b) 1 :20,000

c) 1 : 1,00, 000

d) 1 : 2,00,000

Question 11:

You are administering lidocaine to a patient before wound suturing. If you add adrenaline to it, what would be the duration of action of the anaesthetic?

a) 1 hour

b) 2 hours

c) 3 hours

d) 4 hours

Question 12:

While administering which of the following blocks will you never use a vasoconstrictor-local anesthetic combination?

a) Digital block

b) Spinal block

c) Epidural block

d) Intercostal nerve block

Question 13:

While administering lidocaine to a patient in the ER, the anesthesia resident adds sodium bicarbonate to it before injecting. All of the following benefits are achieved by this except:

a) Faster onset of action

b) Reduced pain on injection

c) Improved quality of block

d) Reduced local anesthetic toxicity

Question 14:

Which local anaesthetic solution causes maximum neurotoxicity on neuro-axial placement?

a) Bupivacaine

b) Lidocaine

c) Ropivacaine

d) Prilocaine

Question 15:

Upon intramuscular injection of which of the following local anesthetics, is maximum myotoxicity induced?

a) Lidocaine

b) Prilocaine

c) Procaine

d) Bupivacaine

Question 16:

A young male is brought to the ER with uncoordinated movements and difficulty speaking. His friends tell you that these symptoms started he ate a shellfish dish. He complained of nausea and vomited also. Shellfish poisoning is suspected. Where does this toxin act on?

- **a)** Inner pore of voltage gated sodium channel
- **b)** Outer pore of voltage gated sodium channel
- **c)** Inner pore of ligand gated sodium channel
- **d)** Outer pore of ligand gated sodium channel

Question 17:

A patient was being given spinal anesthesia with bupivacaine when there was an inadvertent intravascular injection. Following this, the patient developed an arrhythmia and went into cardiac arrest. What should you treat this with?

- **a)** Esmolol
- **b)** Epinephrine
- **c)** Lignocaine
- **d)** Calcium channel blockers

Question 18:

Which nerve fibre is most susceptible to local anesthetic?

- **a)** Type C
- **b)** A gamma
- **c)** Type B
- **d)** A delta

Question 19:

Which nerve fibers are most resistant to local anesthetics?

- **a)** Type A°
- **b)** Type B
- **c)** Type Aβ

d) Type Aγ

Question 20:

What is the order of susceptibility of nerve fibers to local anesthetics?

a) A° > Aβ > B > C

b) Aβ > B > A° > C

c) C > B > Aβ > A°

d) B > Aγ > Aδ > Aβ

Answer Key

Question No.	Correct Option
1	b
2	b
3	d
4	c
5	c
6	d
7	b
8	d
9	d
10	d
11	b
12	a
13	d
14	b
15	d
16	b
17	b
18	c
19	a
20	d

Detailed Explanations

Solution to Question 1:

The main mechanism of action of local anesthetics is through inhibition of inactivated, voltage-gated Na channel.

Local anesthesia involves the abolition of local sensation through blockade of nerve impulses.

Na channels exist in 3 states:

• Resting (non-conducting)

• Open (conducting)

• Inactivated (non conducting)

Local anesthetics have a greater affinity for the channel in the open or inactivated state than in the resting state. They bind to the Na channel from the inner aspect in cationic form.

They bind to the ° subunit of Na channel and inhibit the conformational changes associated with channel opening, thereby preventing Na influx. When a considerable number of Na channels are inactivated, the action potential cannot be generated and impulse cannot be propagated.

Solution to Question 2:

Local anesthetics block nerve conduction by decreasing the influx of sodium ions into the cells. Normally, sodium influx is followed by slight depolarization of the membrane.

Local anesthetics in unionized form cross the cell membrane and are converted to ionized forms inside the cytoplasm the sodium channel blockade occurs. Resting/closed conformation of the sodium channels have relatively low affinity for local anesthetics.

Solution to Question 3:

Local anesthetics inhibit potassium channels.

The effects of local anesthetics include:

• Inhibition of voltage-gated Na channels

• Blockade of potassium and calcium channels

• Transient receptor potential vanilloid 1 (TRPV1)

• Interaction with cholinergic or N-methyl-D-aspartate (NMDA) receptors

• Interference with cellular metabolic processes (eg, oxidative phosphorylation, free fatty acid utilization)

However, the main action of local anesthetics is mediated by inhibition of voltage-gated Na channels.

Solution to Question 4:

Lidocaine (lignocaine, xylocaine) is an amino-amide.

Solution to Question 5:

Cocaine is the only amino ester that is not metabolized by plasma cholinesterases. It is partially metabolized by hepatic carboxylesterase and partially excreted unchanged in the urine.

Articaine is the only amino amide which is inactivated by plasma esterases.

Note: Cocaine is a vasoconstrictor due to its property of norepinephrine reuptake inhibition. All the other local anaesthetics are vasodilators except cocaine.

Solution to Question 6:

Lidocaine is an intermediate-acting local anesthetic. It is not preferred in procedures for prolonged pain relief.

Long-acting local anesthetics are preferred for prolonged pain relief.

Bupivacaine, ropivacaine, and tetracaine are all long-acting and thus can be used to administer the brachial plexus block in this case.

Solution to Question 7:

The most potent local anaesthetic among the following is bupivacaine followed by mepivacaine and then procaine.

Potency depends on hydrophobicity. Hydrophobicity can be increased by the addition of alkyl groups to the molecule.

Note: Dibucaine is the most potent, most toxic and longest acting local anaesthetic agent.

Solution to Question 8:

Among the given options, lidocaine has the lowest pKa value. Thus, it has the maximum amount of unionized drug at physiological pH.

It is the unionized form of local anesthetics that penetrate the membrane. Hence, pKa correlates with the onset of action.

pKa of a drug is the pH at which the drug is 50% ionized and 50% nonionized.

pKa values of Local Anesthetics

- Chloroprocaine - 9.1
- Procaine - 8.9
- Tetracaine - 8.4
- Bupivacaine - 8.1
- Prilocaine - 8.0
- Etidocaine - 7.9
- Lidocaine - 7.8
- Mepivacaine - 7.7

Solution to Question 9:

Solution to Question 10:

Epinephrine is used along with local anesthetics at a concentration of 5 µg/mL or 1:200,000. At this dose, epinephrine provides adequate vasoconstriction.

Advantages of vasoconstrictors:

- Increased duration of action
- Improved depth of anesthesia
- Decreased local anesthetic toxicity
- As a marker for inadvertent intravascular injection

Solution to Question 11:

By adding adrenaline to lidocaine, the duration of action can be increased to 2 hours.

Drug	Maximum dose	Duration of action	
Lignocaine	Plain	4.5mg/kg	30-60 min
With Adrenaline	7mg/kg	120 min	
Bupivacaine	Plain	3mg/kg	120-140 min
With Adrenaline	3mg/kg	180-240 min	

Solution to Question 12:

The use of a vasoconstrictors-local anesthetic combination is contraindicated in digital block (ring block). This is an area supplied by end arteries and there is a risk of ischemia and necrosis.

The combination of local anesthetic with a vasoconstrictor is contraindicated in:

• Digital nerve block (ring block)

• Toe block

• Surgery of the tip of the nose and pinna

• Surgery of the penis (circumcision)

Solution to Question 13:

The addition of sodium bicarbonate to local anesthetics does not reduce local anesthetic toxicity.

All local anesthetics are weak bases, but commercially available solutions have an acidic pH in order to maximize the stability and shelf life. In acidic solutions, most of the drug will be in ionized form. It is only the uncharged (non-ionized) form that diffuses across the lipid barrier to the site of action.

A basic solution (sodium bicarbonate) can be added to a local anesthetic solution immediately before injection to raise the pH. This is termed 'alkalinization' or 'buffering'. Alkalinization increases the proportion of non-ionized drug resulting in more rapid drug diffusion.

Advantages of alkalinization:

• Faster onset of action

• Reduced pain/stinging on subcutaneous injection

• Improved quality of the block

1mL 8.4% sodium bicarbonate is added to 10 mL of local anesthetic solution.

Excessive sodium bicarbonate raises the pH too far and precipitates non-charged basic form in the solution.

Solution to Question 14:

Neurotoxicity from neuro-axial (epidural or spinal) placement of local anesthetic solution is maximum with lidocaine.

Order of neurotoxicity: Lidocaine = Tetracaine > Bupivacaine > Ropivacaine.

Neurotoxicity may manifest as transient neurological symptoms or cauda equine syndrome.

Solution to Question 15:

Local anesthetic-induced myotoxicity following intramuscular injection is maximum with bupivacaine.

The mechanism of muscle damage is due to mitochondrial damage.

Toxicity is reversible as it resolves within 2 weeks.

Solution to Question 16:

The manifestations of shellfish poisoning are due to the action of the poison on the outer pore of the voltage-gated sodium channel.

Shellfish poisoning is due to the neurotoxin saxitoxin and puffer fish poisoning is due to tetrodotoxin. Although these toxins are chemically distinct, they are exceedingly potent and have similar mechanisms of action.

While local anesthetics inhibit sodium channel activity by binding to the inner pore (from intracellular side), these toxins bind to the outer pore of the channel. As a result, the action potential is blocked.

Unlike local anesthetics, these neurotoxins are very specific to neuronal Na channels, hence cardiac and neurological side effects are low.

Treatment includes gastric lavage, vasopressors. Mechanical ventilation may be required if respiratory paralysis sets in.

Prognosis is good when the patient survives after 24 hours.

Solution to Question 17:

Bupivacaine toxicity resulting in cardiac arrest is treated with epinephrine.

If cardiac arrest occurs, the American Society of Regional Anesthesia (ASRA) recommends standard Advanced Cardiac Life Support (ACLS) with the following modifications:

- If epinephrine is used, small initial doses (10-100 µg boluses in adults) are preferable
- Vasopressin is not recommended
- Avoid calcium channel blockers and beta-blockers
-

If ventricular arrhythmias develop, amiodarone is preferable

20% Lipid emulsion therapy at 1.5ml/kg : Consider administering at the first signs of local anesthesia systemic toxicity (LAST), after airway management. (~100ml in adults)

In bupivacaine toxicity unresponsive to lipid emulsion and vasopressor therapy, cardiopulmonary bypass may be considered.

Note: Among anti-arrhythmic drugs, current data emphasizes amiodarone as the mainstay drug. The use of bretylium is no longer endorsed.

Solution to Question 18:

Nerve fibre most susceptible to local anaesthetic is type B. The order of susceptibility of nerve fibres to local anaesthetics is B >A-γ > A-δ > A-β > A-° > C i.e

• B fibres are the most susceptible/least resistant

• C fibres are the least susceptible/most resistant

Factors that increase the sensitivity of nerve fibres are :

• Smaller diameter

• Unmyelinated nerves

• Anatomical and physiological factors

*Note: Although theoretically, C fibres are supposed to be the most susceptible to local anaesthetics, practically it was found to be the least susceptible.

Solution to Question 19:

Type A° fibres are most resistant to local anaesthetics, among the given options. The order of susceptibility of nerve fibres to local anaesthetics is B >A-γ > A-δ > A-β > A-° > C.

Solution to Question 20:

The order of susceptibility of nerve fibres to local anaesthetics is B >A-γ > A-δ > A-β > A-° > C i.e

• B fibres are the most susceptible/least resistant

• C fibres are the least susceptible/most resistant

Factors that increase the sensitivity of nerve fibres are :

• Smaller diameter

• Unmyelinated nerves

• Anatomical and physiological factors

*Note: Although theoretically, C fibres are supposed to be the most susceptible to local anaesthetics, practically it was found to be the least susceptible.

Local Anesthetics - Specific Drugs

Question 1:

Before performing a bronchoscopy, the pulmonologist sprays a topical anesthetic solution in the patient's oral cavity and pharynx. Which of the following drugs is this spray unlikely to contain?

a) Lidocaine
b) Tetracaine
c) Benzocaine
d) Bupivacaine

Question 2:

The anesthesia PG applies a cream with an occlusive dressing on the forearm of a baby brought for IV cannulation. 1 hour later, the baby allows him to place the cannula without crying. What is the composition of the cream that was applied?

a) 2.5 % lidocaine and 2.5 % procaine
b) 2.5% lidocaine and 2.5 % prilocaine
c) 5% lidocaine and 2.5% procaine
d) 5% lidocaine and 2.5 % prilocaine

Question 3:

A patient presents with a foreign body in the right cornea. Which would be the topical anesthetic of choice to remove it?

a) Tetracaine
b) Cocaine
c) Bupivacaine
d) Prilocaine

Question 4:

The drug most frequently used for intravenous regional anesthesia is __________.

a) Lidocaine

b) Bupivacaine

c) Mepivacaine

d) Procaine

Question 5:

A patient presents with the following finding, and excision is planned under Bier's block. Which of the following drugs will you not use for this procedure?

a) Prilocaine

b) Lidocaine

c) Etidocaine

d) Bupivacaine

Question 6:

Which of the following statements about lignocaine is false?

a) It blocks active sodium channels with more affinity than resting sodium channels

b) It can cause cardiotoxicity

c) It can be given orally for cardiac arrhythmias

d) It's duration of action is increased by adrenaline

Question 7:

A 24-year-old primigravida in labor requests for epidural analgesia. What is the maximum dose of lidocaine that can be given to her when epinephrine is not used?

a) 3 mg/ kg

b) 4.5 mg/kg

c) 7mg/kg

d) 12mg/kg

Question 8:

For epidural anesthesia, what is the maximum dose of lidocaine with adrenaline that can be given to a 70kg patient?

a) 175 mg

b) 200 mg

c) 350 mg

d) 500 mg

Question 9:

What is the concentration of bupivacaine you use while administering spinal anesthesia to a patient?

a) 0.2%

b) 0.5%

c) 0.75%

d) 5%

Question 10:

A patient with a tibial shaft fracture is planned for tibia nailing under epidural anesthesia. What concentration of bupivacaine should be used for this purpose?

a) 1%

b) 0.1%

c) 5%

d) 0.5%

Question 11:

A patient with a history of PSVT and type I diabetes has been posted for a femoral nailing procedure. The senior resident asks you to load ropivacaine instead of the standard bupivacaine for the spinal block. What advantage of the preferred drug?

a) More potent

b) Less nephrotoxic

c) Less cardiotoxic

d) More profound motor blockade

Question 12:

What is the ratio of the dose required to produce cardiovascular collapse to that required to induce seizures (CC/CNS dose ratio) for Bupivacaine?

a) 7

b) 5

c) 3

d) 1

Question 13:

A patient in ER is administered a local anesthetic for pain relief. 10 minutes later, he turned blue and the oximeter showed an SpO_2 of 82%. Methylene blue is administered for treatment immediately. Which local anesthetic was most likely administered to him?

a) Lidocaine

b) Procaine

c) Prilocaine

d) Bupivacaine

Question 14:

A patient undergoing a dental extraction develops breathing difficulty, swelling of lips, and a diffuse rash following local anesthetic administration. Which of the following agents is commonly implicated?

- **a)** Lidocaine
- **b)** Procaine
- **c)** Prilocaine
- **d)** Bupivacaine

Question 15:

A patient with HIV is on cotrimoxazole prophylaxis. He presents with a 4 cm laceration that requires suturing under local anesthesia. Which of the following local anesthetic agents would not be preferred in this case?

- **a)** Prilocaine
- **b)** Procaine
- **c)** Lidocaine
- **d)** Bupivacaine

Question 16:

Which of the following is not a vasodilator?

- **a)** Procaine
- **b)** Lidocaine
- **c)** Cocaine
- **d)** Chlorprocaine

Question 17:

A middle-aged destitute is brought by the police and ambulance services to the ER. He is screaming about bugs crawling on his body but no such bugs are noted. A white powder is found in his pocket, found to be a drug. Which of the following statements is not true about this drug?

- **a)** Produces miosis
- **b)** Strong vasoconstrictor

c) Has abuse potential

d) Metabolised mainly in liver

Question 18:

Which of the following drugs is an aminoester local anesthetic?

a) Procaine

b) Prilocaine

c) Lidocaine

d) Bupivacaine

Question 19:

All of the following local anesthetics are metabolized by plasma esterase except ________.

a) Procaine

b) Lidocaine

c) Articaine

d) Tetracaine

Question 20:

The least potent local anesthetic is__________

a) Bupivacaine

b) Chloroprocaine

c) Procaine

d) Prilocaine

Question 21:

The maximum systemic absorption of a local anesthetic is seen with ________.

a) Tracheal injection

b) Intercostal nerve block

c) Brachial plexus block

d) Epidural block

Question 22:

The concentration of bupivacaine used for intravenous regional anesthesia is _____.

a) 0.1%

b) 0.25%

c) 0.5%

d) None of the above

Question 23:

Which of the following statements regarding Ropivacaine is incorrect?

a) R (+) enantiomer of bupivacaine

b) Higher safety profile than bupivacaine

c) More motor sparing than bupivacaine

d) Used in both spinal and epidural anesthesia

Question 24:

O-toluidine is a metabolic by product of _______.

a) Procaine

b) Lidocaine

c) Bupivacaine

d) Prilocaine

Answer Key

Question No.	Correct Option
1	d
2	b
3	a

4	a
5	d
6	c
7	b
8	d
9	b
10	d
11	c
12	c
13	c
14	b
15	b
16	c
17	a
18	a
19	b
20	c
21	b
22	d
23	a
24	d

Detailed Explanations

Solution to Question 1:

The spray used by the pulmonologist is most likely a topical anesthetic. Bupivacaine is not used for topical anesthesia.

Lidocaine, tetracaine, benzocaine, and dibucaine are used for topical anesthesia.

Lidocaine and tetracaine topical sprays:

• Endotracheal intubation - blunt the cardiovascular responses

• Esophagoscopy, bronchoscopy - mucosal analgesia.

Lidocaine patch: postherpetic neuralgia.

Benzocaine and cetacaine (a topical application spray containing benzocaine, tetracaine, and butamben) had been used but a greater incidence of methemoglobinemia due to benzocaine has discouraged their use.

Solution to Question 2:

The substance applied by the anesthesia resident is EMLA cream (Eutectic Mixture of Local Anesthetic) which consists of a 1:1 mixture of 2.5% lidocaine and 2.5% prilocaine.

A eutectic mixture has a melting point lesser than the individual drugs and hence the mixture is in the oil form at room temperature.

EMLA can provide adequate dermal analgesia for procedures like:

• Split skin graft harvesting and laser skin treatments

• Venipuncture and intravenous cannulation in children

• Lithotripsy

• Circumcision

EMLA is applied 45-60 minutes before the procedure with an occlusive dressing as shown in the image. It provides analgesia up to a depth of 5mm which lasts for 1-2 hours.

Solution to Question 3:

Tetracaine is the topical anesthesia of choice for the removal of foreign bodies from the cornea.

Topical anesthetics used in ophthalmology include:

• Tetracaine

• Proparacaine eye drops

• Lidocaine gel

• Intranasal cocaine

Solution to Question 4:

Lidocaine has been the drug used most frequently for intravenous regional anesthesia (IVRA).

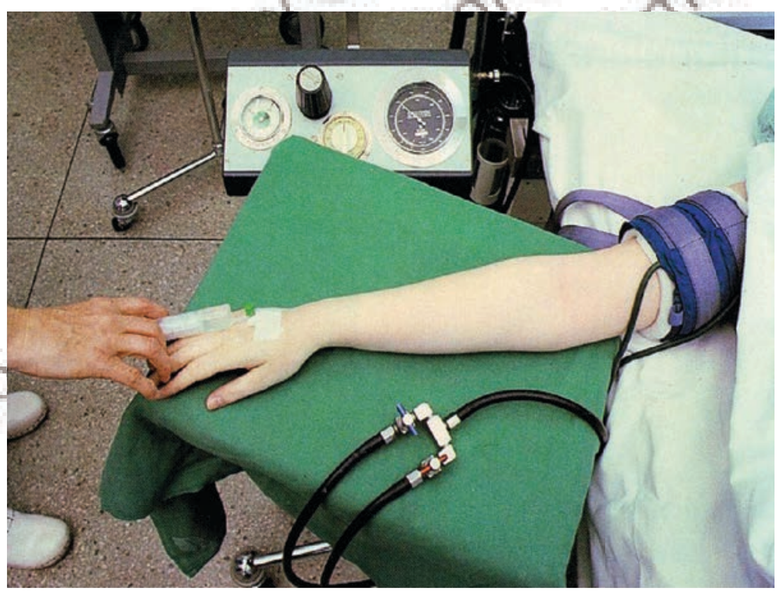
Other drugs used are:

- Prilocaine
- Mepivacaine
- Chloroprocaine
- Procaine
- Etidocaine

IVRA or Bier's block involves the intravenous administration of a local anesthetic into a tourniquet-occluded limb.

It is used to provide anesthesia for short surgical procedures (<90 minutes) on the limbs.

The image below shows Bier's block/ IVRA.



Note: Bupivacaine is not used for Biers block. It is the most cardiotoxic local anesthetic. Accidental early deflation of the tourniquet can lead to massive systemic doses of bupivacaine resulting in cardiac arrhythmias and cardiovascular collapse.

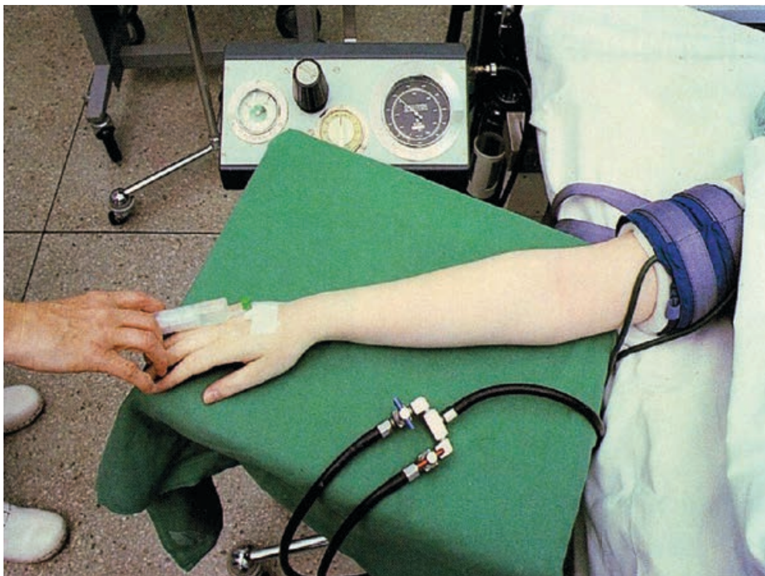
Solution to Question 5:

The image shows a ganglion cyst planned for excision under Bier's block. Bupivacaine is no longer used for Biers block.

Bupivacaine is the most cardiotoxic local anaesthetic (LA). Accidental early deflation of the tourniquet can lead to massive systemic doses of bupivacaine resulting in cardiac arrhythmias and cardiovascular collapse.

IVRA or Bier’s block involves the intravenous administration of LA into a tourniquet-occluded limb for short surgical procedures (<45-60 minutes) on the limbs. Drugs used are lidocaine (most common), prilocaine, mepivacaine, chloroprocaine, procaine, and etidocaine.

The image below shows Bier's block of the upper limb. A double pneumatic tourniquet is inflated to 50-100mmHg above systolic BP after exsanguination of the limb with Esmarch bandage. 30-40ml of 0.5% Lidocaine is injected which provides anesthesia for 30-45 minutes. Even for a very short duration procedure, the tourniquet must be left inflated for at least 15–20 min to avoid a rapid systemic absorption of LA resulting in toxicity. Slow deflation is recommended to avoid LA toxicity.



Solution to Question 6:

Lignocaine is used for cardiac arrhythmias but is not effective orally because of high first-pass metabolism.

Option A: Local anaesthetics have more affinity for active sodium channels over resting channels.

Option B: Lignocaine use can result in cardiac toxicity especially at higher doses where it interferes with impulse conduction.

Option D: Vasoconstrictor like adrenaline increases the duration of action of lignocaine when used for infiltration anaesthesia.

Solution to Question 7:

The maximum dose of lidocaine without epinephrine is 4.5 mg/kg.

Solution to Question 8:

The maximum dose of lidocaine with adrenaline is 7mg/kg up to 500mg.

Solution to Question 9:

0.5% hyperbaric preservative-free bupivacaine is most commonly used for spinal anesthesia.

1 ml of 0.5% Bupivacaine = 5 mg of Bupivacaine.

It is made hyperbaric (density heavier than CSF) by adding 8.25% dextrose to the local anesthetic solution.

Addition of vasoconstrictors (epinephrine and phenylephrine) and opioids improve the quality and the duration of local anesthetic action.

Dosages and action of spinal anesthesia drugs				
Drug	Concentration	Volume	Total Dose	Duration
Bupivacaine (levobupivacaine, Ropivacaine)	0.5% (rarely 0.75%)	3-4 ml	15-20 mg	90-200 min
Lidocaine	2% plain, 5% in 7.5% glucose	1-2 ml	30-100 mg	30-90 min
Tetracaine	1%	1-2 ml	5-20 mg	90-200 min

Solution to Question 10:

The concentration of bupivacaine used in epidural anesthesia for surgical purposes is 0.5%.

The dosage of local anesthetic in epidural anesthesia depends on the desired clinical effect. It can be used as:

• Primary anesthetic for surgical anesthesia (sensory + motor block)

• Combined with general anesthesia to supplement analgesia (sensory block)

• Postoperative analgesia or labor analgesia (sensory block)

Various concentrations of Bupivacaine and its uses			
Concentration	Sensory block	Motor block	Clinical use
0.0625- 0.1%	Analgesic	None	Labor analgesia (walking epidural)

Various concentrations of Bupivacaine and its uses			
0.1-0.25%	Analgesic	Minimal	Postoperative analgesia
0.5-0.75%	Dense	Moderate to dense	Surgical anesthesia

Solution to Question 11:

Ropivacaine is less cardiotoxic than bupivacaine.

Ropivacaine is S(-) enantiomer of bupivacaine. The R(+) isomer of bupivacaine is responsible for cardiotoxicity. Ropivacaine is less cardiotoxic and has a higher safety profile than bupivacaine.

Ropivacaine has a shorter duration of action and produces less motor block than bupivacaine (i.e. more motor sparing than bupivacaine). Ropivacaine is less potent than bupivacaine. Epidural ropivacaine is 40 % less potent than bupivacaine.

Ropivacaine can be used for infiltration anesthesia and central neuraxial blocks (both spinal and epidural).

Note: Levobupivacaine is another S(-) enantiomer of bupivacaine, with less cardiotoxicity. Ropivacaine differs from levobupivacaine in the substitution of a propyl for the butyl group on the piperidine ring.

Solution to Question 12:

The CC/CNS ratio for bupivacaine is approximately 3 whereas, for lidocaine, it is 7.

Cardiotoxicity of local anaesthetics can be compared using the CC/CNS dose ratio, that is the ratio of the dose causing cardiac collapse (CC) to the dose causing seizure/convulsions (CNS).

The lower the number, the more cardiotoxic the drug. Therefore, progression from CNS signs and symptoms to cardiovascular collapse can occur more readily with bupivacaine than with lidocaine.

Note: Patients under general anaesthesia will typically present with cardiotoxicity as the first sign of local anaesthetic toxicity.

Solution to Question 13:

The scenario describes methemoglobinemia, a side effect of prilocaine.

Prilocaine is metabolized to O-toluidine, which converts hemoglobin (Fe^{2+}) to methemoglobin (Fe^{3+}) producing methemoglobinemia. This side effect is dose-dependent.

Treatment of methemoglobinemia includes reduction of methemoglobin to hemoglobin by intravenous methylene blue (1–2 mg/kg of a 1% solution over 5 min).

Note: Benzocaine used in topical local anesthetic sprays can also cause dangerous methemoglobinemia.

Solution to Question 14:

The clinical scenario depicts the development of an allergic reaction to a local anesthetic agent. Allergic reactions are common with the use of procaine, an aminoester compound.

Solution to Question 15:

The patient is on treatment with cotrimoxazole, a sulfonamide (sulfamethoxazole). The action of sulfonamides is inhibited by procaine, and so it would not be preferred in this patient.

Procaine is hydrolyzed in vivo to produce para-aminobenzoic (PABA) acid that inhibits the action of sulfonamides. All ester local anesthetics produce para-aminobenzoic acid.

Prilocaine, lidocaine, and bupivacaine are amides and do not interact with sulphonamides.

Solution to Question 16:

All are vasodilators except cocaine. Cocaine is a vasoconstrictor due to its property of norepinephrine reuptake inhibition.

Other local anaesthetics do not have the property of norepinephrine reuptake inhibition.

Solution to Question 17:

The symptoms and the white powdery substance suggest the drug being abused by the man is cocaine. It produces mydriasis, not miosis.

The tactile hallucinations are a type of psychosis in cocaine addicts, known as Magnan syndrome.

Cocaine is an intrinsic vasoconstrictor with local anesthetic properties. Hence it is an ideal agent for awake nasal intubation as it reduces pain and epistaxis. It is metabolized by liver cholinesterases and excreted in urine

It has the potential for abuse as it produces euphoria by inhibiting the re-uptake of catecholamines (especially dopamine) in the CNS. Because of its abuse liability and high toxicity, cocaine use is limited to topical anesthesia of the upper respiratory tract.

Solution to Question 18:

Procaine is an aminoester.

Prilocaine, lidocaine, bupivacaine are amino amides.

Solution to Question 19:

Lidocaine is an amino amide compound that is metabolized by microsomal P-450 enzymes in the liver.

Procaine and tetracaine are amino esters that are metabolized by plasma esterases.

Articaine is the only amino amide that is metabolized by the plasma esterases.

Solution to Question 20:

The least potent local anesthetic is procaine.

The potency of local anesthetics correlates with their hydrophobicity. Hydrophobic molecules are more potent and also longer acting.

Solution to Question 21:

Maximum absorption of local anesthetics takes place with intercostal nerve block. The degree and rate of absorption depend on the vascularity of the area the local anesthetic is exposed to.

Solution to Question 22:

Bupivacaine is not used for intravenous regional anesthesia (IVRA) or Bier's block.

Bupivacaine is the most cardiotoxic of all local anesthetics. Accidental early deflation of the tourniquet in local anesthesia can lead to systemic toxicity.

Lidocaine is used for IVRA- 3mg/kg of 0.5% preservative-free lidocaine without epinephrine (25 mL for a forearm, 50 mL for an arm, and 100 mL for a thigh tourniquet).

Solution to Question 23:

Ropivacaine is S(-) enantiomer of bupivacaine, not R(+).

Option B: The R(+) isomer of bupivacaine is responsible for cardiotoxicity. Ropivacaine is less cardiotoxic and has a higher safety profile than bupivacaine.

Option C: Ropivacaine has a shorter duration of action and produces less motor block than bupivacaine (i.e. more motor sparing than bupivacaine). Ropivacaine is less potent than bupivacaine. Epidural ropivacaine is 40 % less potent than bupivacaine.

Option D: Ropivacaine can be used for infiltration anesthesia and central neuraxial blocks (both spinal and epidural).

Note: Levobupivacaine is another S(-) enantiomer of bupivacaine, with less cardiotoxicity. Ropivacaine differs from levobupivacaine in the substitution of a propyl for the butyl group on the piperidine ring.

Solution to Question 24:

O-toluidine is a metabolic by-product of prilocaine. Metabolism of the aromatic ring of prilocaine to O-toluidine produces methemoglobinemia in a dose-dependent fashion.

Regional Anesthesia: Techniques

Question 1:

In adults, at which vertebral level does the spinal cord end?

a) Upper border of L1

b) Lower border of L1

c) Upper border of L3

d) Lower border of L3

Question 2:

You are about to administer spinal anaesthesia to a 7-month-old child. At which vertebral level does his spinal cord end?

a) Lower border of S2

b) Upper border of S2

c) Lower border of L3

d) Upper border of L3

Question 3:

At which vertebral level does the dural sac end at in adults?

a) L1

b) L3

c) S1

d) S2

Question 4:

You are administering caudal anesthesia to a 9-month-old child. Which is the lowest vertebral level that should not be crossed by the tip of your needle so as to avoid accidental subarachnoid injection?

a) S3

b) S2

c) L2

d) L3

Question 5:

As an intern posted in the OT, you see the anesthesia resident mark out a line on a patient's back. She tells you that this is Tuffier's line and is used as a landmark for performing spinal anesthesia. Which vertebral level does this line correspond to?

a) L6

b) L2

c) L1

d) L4

Question 6:

Following neuraxial block, which would be the first sensation to disappear?

a) Fine touch

b) Pinprick sensation

c) Vibration

d) Sensitivity to cold

Question 7:

A patient underwent knee replacement under spinal anaesthesia. Following the procedure, you examine him in the post-op ward. Which of the following would be the first to recover?

a) Heat sensation

b) Touch sensation

c) Pinprick sensation

d) Motor function

Question 8:

You are given the opportunity to perform a neuraxial block procedure. What is the antiseptic of choice to prepare the site before this procedure?

a) Povidone iodine

b) Glutaraldehyde

c) Hydrogen peroxide

d) Chlorhexidine

Question 9:

While administering spinal anaesthesia to a patient, which of the following structures would you not be piercing?

a) Ligamentum flavum

b) Supraspinous ligament

c) Posterior longitudinal ligament

d) Duramater

Question 10:

While administering spinal anaesthesia in a patient, between which of the following structures would you be injecting the local anaesthetic?

a) Dura and ligamentum flavum

b) Dura and arachnoid

c) Pia and vertebra

d) Pia and arachnoid

Question 11:

In a normal sized adult, which of the following parameters would least affect the level of neuraxial block achieved?

a) Age

b) CSF volume

c) Height

d) Patient's position

Question 12:

Which of the following factors have the least impact on the height of neuraxial block in a patient?

a) Age

b) Gender

c) Pregnancy

d) Height

Question 13:

A patient is set to undergo cesarean section under subarachnoid block. Upto which dermatome must the anaesthetist ensure adequate anaesthesia?

a) T4

b) T8

c) T10

d) T12

Question 14:

In which procedure is the instrument shown in the image most commonly used?

a) Retrobulbar block

b) Epidural anesthesia

c) Spinal anesthesia

d) Combined spinal epidural anesthesia

Question 15:

Which of the following is not a blunt-tipped needle used in regional anaesthesia?

a) Quincke

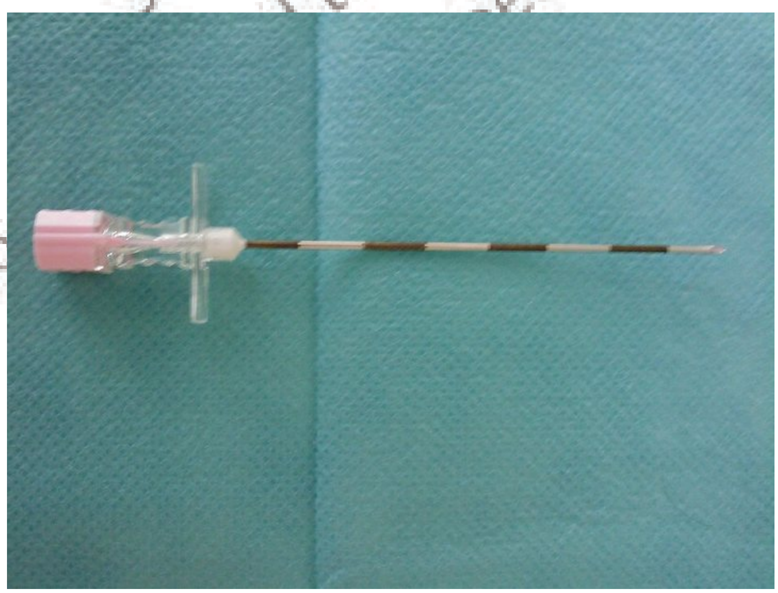
b) Whitacre

c) Sprotte

d) Tuohy

Question 16:

As an intern posted in the OT, you see the Anesthesia Senior Resident holding the needle shown in the image. What is the likely procedure that he is about to perform?



a) Spinal anesthesia

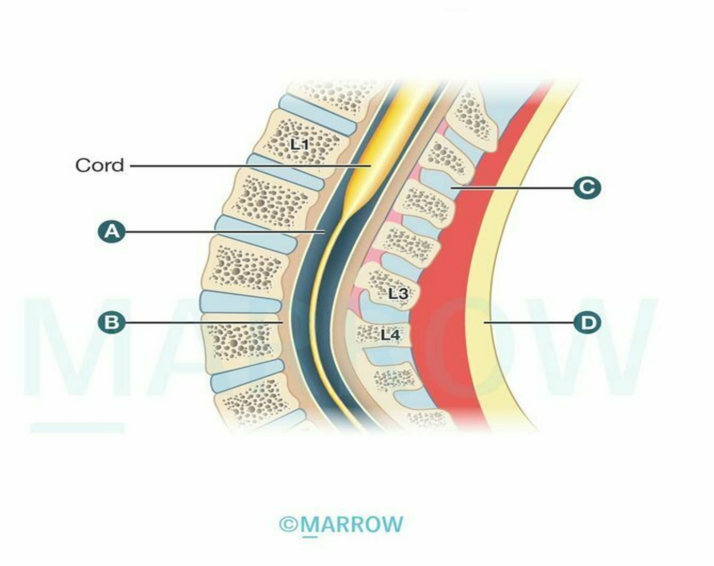
b) Epidural anesthesia

c) Combined spinal epidural anesthesia

d) IV cannulation

Question 17:

While administering epidural anesthesia to a patient, in which of the following spaces would you inject the local anesthetic?



- **a)** C
- **b)** D
- **c)** A
- **d)** B

Question 18:

A patient set to undergo an elective C section receives epidural anaesthesia before the procedure. Which structure is not pierced while performing this block?

- **a)** Skin
- **b)** Duramater
- **c)** Supraspinous ligament
- **d)** Ligamentum flavum

Question 19:

You are planning to administer combined spinal epidural anaesthesia to a pre-eclamptic patient before an elective C section. You know that the patient may have to remain seated for a while after administration of the spinal anaesthetic for insertion of the epidural catheter.Which of the following will you use for spinal anaesthesia to reduce the chances of hemodynamic disturbances in this scenario?

a) 0.5% Bupivacaine with glucose

b) 0.5% Bupivacaine with fentanyl

c) 0.5% Bupivacaine with sterile water

d) 0.5% Plain bupivacaine

Question 20:

You administer epidural anesthesia to a patient before surgery. Which of the following methods can you use to test the adequacy of motor block in him?

a) 1, 3

b) 1, 2, 3, 4

c) Only 3

d) 1, 3, 5

Question 21:

A 5-month-old child is set to undergo a herniotomy procedure for congenital inguinal hernia under caudal anesthesia. Where is the local anesthetic injected into for this procedure?

a) Spinal cord

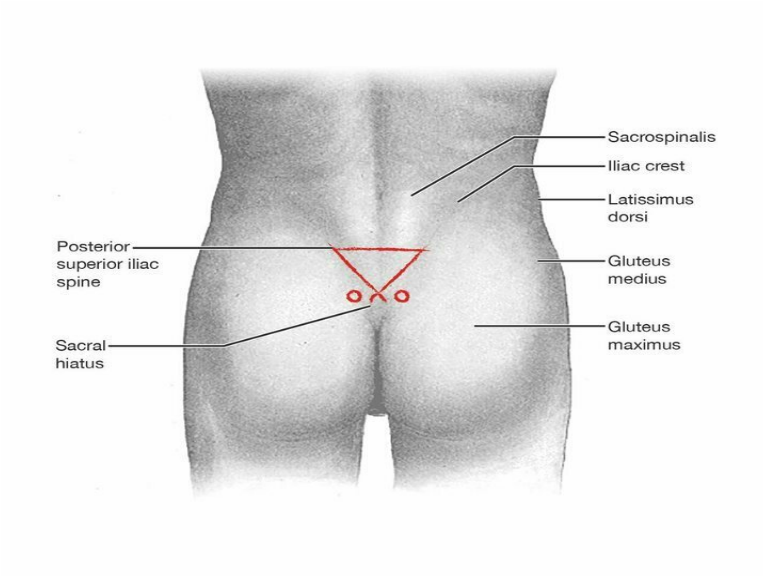
b) Subdural space

c) Subarachnoid space

d) Epidural space

Question 22:

An 18-month-old boy with CTEV is undergoing corrective treatment. He is scheduled for a posteromedial soft tissue release procedure. You see the anaesthesia resident mark out the points shown in the image on his back. In what anaesthetic procedure are these landmarks used?



a) Spinal anesthesia

b) Caudal anesthesia

c) Epidural anesthesia

d) Saddle block

Answer Key

Question No.	Correct Option
1	b
2	d
3	d
4	b
5	d
6	d
7	d
8	d
9	c
10	d
11	c
12	b
13	a
14	c

15	a
16	b
17	d
18	b
19	a
20	d
21	d
22	b

Detailed Explanations

Solution to Question 1:

In adults, the spinal cord ends at the level of lower border of L1 vertebra.

Proximally, the spinal cord is continuous with the brain stem. Distally, it terminates in the conus medullaris as the filum terminale (fibrous extension) and the cauda equina (neural extension).

The lumbar puncture during spinal anesthesia (a.k.a. sub-arachnoid block, intra-thecal block) is done below the level of L1 in adults (L2-3, L3-4, L4-5 interspace), to avoid potential needle trauma to the spinal cord.

Solution to Question 2:

The spinal cord in infants ends at the upper border of L3 vertebral level (shorter vertebral column and longer spinal cord).

Lumbar (subarachnoid) puncture into the subarachnoid space is done below L3 in children to avoids potential needle trauma to the cord.

Solution to Question 3:

The dural sac in adults ends at S2 vertebral level.

So the spinal subdural and subarachnoid spaces extend from the foramen magnum to S2 in adults.

Solution to Question 4:

The needle should be kept below the S2 vertebral level as the subarachnoid space in children extends from the foramen magnum to S2-S3.

Because of this fact, and the smaller body size, caudal anesthesia carries a greater risk of subarachnoid injection in children than in adults.

Solution to Question 5:

Tuffier's (intercristal) line is a line drawn between the highest points of both iliac crests usually crossing either the body of L4 or the L4–L5 interspace.

This is the landmark to identify the spinal level prior to performing a neuraxial block.

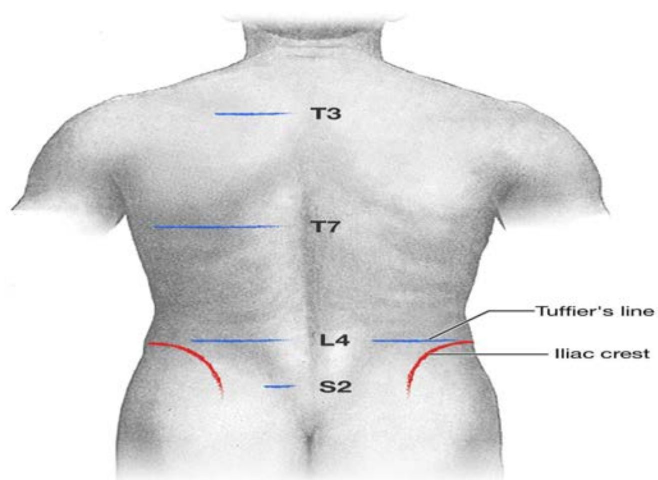
Other bony landmarks:

C7 - Vertebra prominence

T7 - Inferior angle of scapula

L1 - Lower rib margin

S2 - Posterior superior iliac spine



Solution to Question 6:

The first sensation to disappear following a neuraxial block is cold.

Pre-ganglionic sympathetic fibers (B fibers) are most sensitive to local anesthetic blockade.

The larger A-alpha motor fibers are more resistant than any of the sensory fibers.

The sensations lost at the earliest will be cold → pinprick → touch

Regression of blockade (“recovery”) follows in the reverse order: motor function > touch > pinprick > cold sensation > autonomic.

Controversial: There is an obvious discrepancy among various authors regarding the order of differential blockade. Some studies mention pin prick sensation to be lost before sensation to cold.

But our reference to this MCQ is from standard textbook of anesthesia (Miller's Anesthesia 9th edition).

Solution to Question 7:

Motor function recovers the earliest after a neuraxial block.

Motor function is carried by A alpha fibers, which are myelinated and having the largest diameter, making them resistant to local anaesthesia.

Hence, motor function is the last to get affected and the first to recover.

Solution to Question 8:

Antiseptic of choice for neuraxial block procedure is Chlorhexidine.

Solution to Question 9:

During spinal anaesthesia administration, the posterior longitudinal ligament is not pierced.

The following structures are pierced during spinal anaesthesia, in that order:

- Skin
- Subcutaneous tissue
- Supraspinous ligament
- Interspinous ligament
- Ligamentum flavum
- Dura mater
- Arachnoid

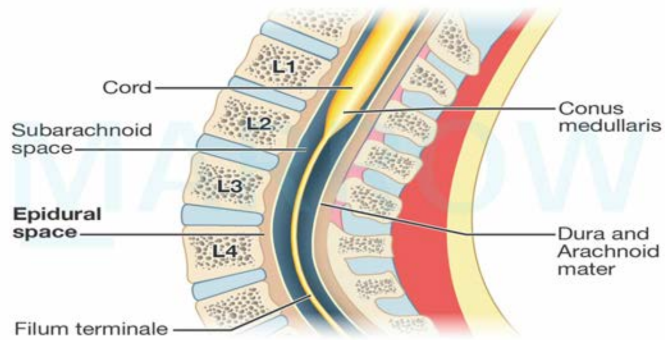
Solution to Question 10:

Spinal anesthesia (subarachnoid block, intrathecal block) involves the administration of local anesthetic between the pia and arachnoid mater.

In spinal anesthesia, the local anesthetic is injected into CSF, which bathes the nerve root. Hence, a relatively small dose and volume of local anesthetic is sufficient to achieve dense sensory and motor blockade.

Epidural anesthesia involves local anesthetic administration between the dura and ligamentum flavum. Subdural injection, seen in a failed spinal anesthesia, is between dura and arachnoid.

Epidural space



Solution to Question 11:

In a normal-sized adult, the patient's height does not seem to affect the spread of spinal anaesthesia. However, at extremes of height, consideration should be given to altering the dose accordingly.

Option A: Advanced age is associated with increased block height, due to decreased CSF volume

Option B: CSF volume is inversely related to the block level.

Option D: Patient's position affects the spread of hyperbaric and hypobaric solutions. Hyperbaric solution settles at the dependent position while hypobaric solution settles at the non-dependent position.

Solution to Question 12:

The gender of the patient is the factor that least affects the height of the neuraxial block, among the options given.

Theoretically, the density of CSF is lower in women than in men. Although this may affect relative baricity of local anaesthetics, the clinical variation in the spread is probably unimportant. Hence, this is the best answer to choose from the above options.

Option A: Higher anaesthetic levels are achieved in the elderly for a given dosage of spinal anaesthetic.

Option C: Increased intraabdominal pressure or conditions that cause engorgement of the epidural veins, decrease CSF volume and thus increase block height. This includes conditions such as pregnancy, ascites, and large abdominal tumors.

Option D: Within the range of “normal-sized” adults, patient height does not seem to affect the spread of spinal anaesthesia. But, extremes of height can affect the block height.

Solution to Question 13:

For a cesarean section, the sensory block should be achieved up to T4 dermatomal level (motor T6), as the pain-sensitive peritoneum innervation starts from T4 level.

The risk of high spinal and severe hypotension is higher because the block has to reach T4. Hence, consider prehydration with 20 ml/kg, proper positioning, and keeping phenylephrine or ephedrine on hand.

Dermatomal Level required for Various Common Surgical Procedures:

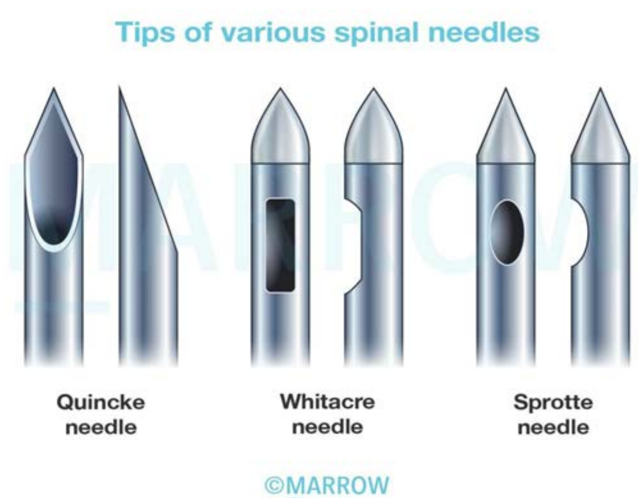
- T4 - Upper abdominal surgery
- T10 - Transurethral resection of prostate
- T10 - Hip surgery
- L2 - Foot and ankle surgery

Solution to Question 14:

The instrument shown is the Quincke Needle used in spinal anesthesia. The Quincke needle is a cutting needle with end injection.

Spinal needles are long thin needles that are classified based on their tip into:

- Cutting needles: Quincke-Babcock, Pitkin
- Pencil tip needles: Whitacre and Sprotte



This is the image of a Tuohy needle that is used to provide epidural anesthesia. It can be recognised by its curved (Huber) tip and the markings made at 1 cm interval along it's length.

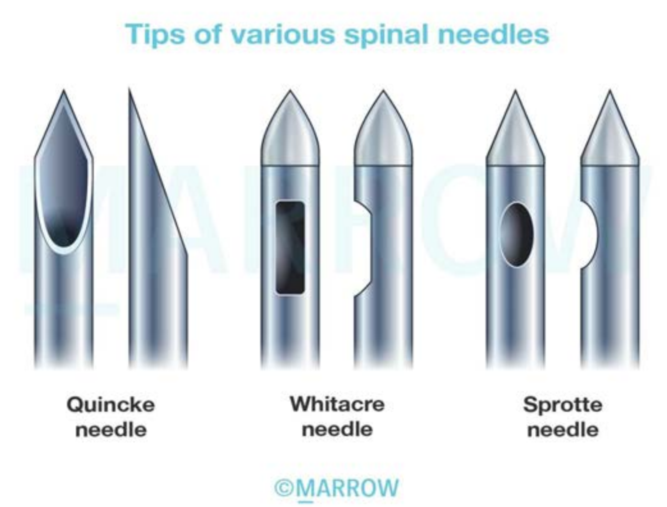
The above image shows a Combined Spinal Epidural needle. It consists of a spinal needle passed through the epidural needle.

Solution to Question 15:

All of the above are blunt-tipped needles used in regional anesthesia, except Quincke, which is a cutting type of spinal needle.

Types of spinal needles:

Cutting needle	Non-cutting (Splitting, pencil point, blunt) needle
Cut the dura	Split the dura
Hence, higher incidence of postdural puncture headache (PDPH) due to CSF leak	Hence, lower incidence of PDPH
Technically less challenging as loss of resistance is well appreciated during lumbar puncture	Technically more challenging as loss of resistance is not well appreciated
Eg: Quincke-Babcock, Pitkin	Eg: Whitacre, Sprotte



Tips of various spinal needles

Tuohy needle is the most commonly used needle for epidural anaesthesia. It has a blunt 'Huber' tip, which helps to prevent accidental penetration of the dura.

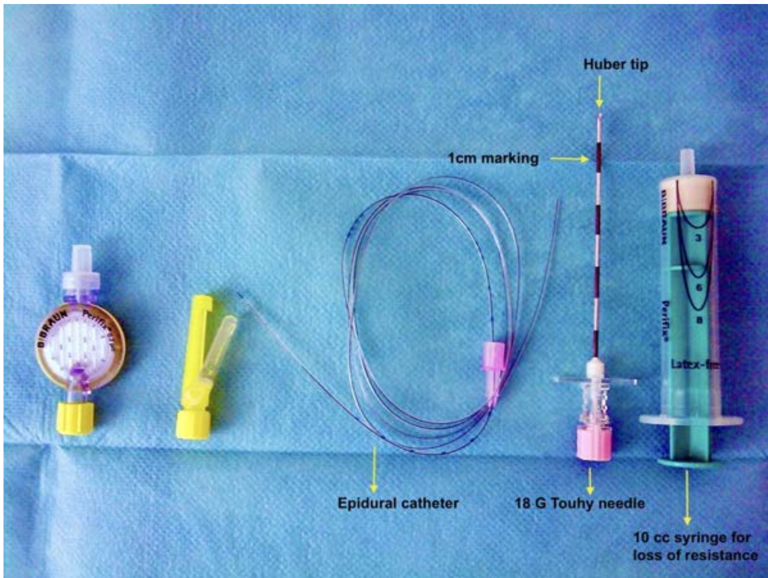
Image: Touhy epidural needle with Huber tip

Solution to Question 16:

The image shown is the 18 G Tuohy needle, which is used in epidural anesthesia.

Identification points:

- It has a blunt, curved tip (Huber tip) that helps to prevent accidental dural puncture
- The needle shaft is marked in 1-cm intervals so that the depth of insertion can be identified



Epidural anesthesia set with Touhy's needle and epidural catheter.

Other epidural needles: Crawford needle (straight needles without a curved tip): has a greater incidence of dural puncture.

Solution to Question 17:

During epidural anesthesia, the local anesthetic is injected into the epidural/extradural space. This is marked in the image as B.

The epidural space exists between the dura and the ligamentum flavum posteriorly.

The other markings are as follows:

A: Subarachnoid space

C. Interspinous ligament

D. Subcutaneous tissue

Solution to Question 18:

Dura mater is not pierced while performing an epidural block.

The structures pierced during epidural anesthesia:

- Skin
- Subcutaneous tissue
- Supraspinous ligament
- Interspinous ligament
- Ligamentum flavum

Epidural space is a potential negative pressure space. This factor is exploited in the identification of epidural space.

As the needle penetrates the ligamentum flavum, an increase in resistance is encountered. After which when the needle enters the epidural space, a sudden loss of resistance is encountered.

The techniques to identify epidural space:

- Loss of resistance (to injection of air or saline)
- Hanging drop (drop of saline is sucked in as the needle enters epidural space)

Solution to Question 19:

To prevent hemodynamic disturbances, we must prevent the migration of the spinal block to upper thoracic segments. In the sitting position, this can be achieved by using a hyperbaric solution like bupivacaine with glucose.

Baricity of local anesthetics refers to the specific gravity of the solution with respect to that of CSF.

A hyperbaric solution (addition of glucose) of local anesthetic is denser (heavier) than CSF, a hypobaric solution (addition of sterile water or fentanyl) is lighter than CSF and isobaric solution (plain or 1:1 CSF) has density same as that of CSF.

Hyperbaric solution tends to move to the dependent area of the spine. While a hypobaric solution moves to the non-dependent area. An isobaric solution remains at the level of injection.

With the patient in a head-down position, a hyperbaric solution spreads cephalad, and a hypobaric solution moves caudally.

In clinical practice, hyperbaric solutions are most commonly used during spinal anesthesia. A hypobaric solution is only used in prone jackknife position to specifically block the operative site around perineum during certain anorectal surgeries.

Solution to Question 20:

Electromyography, Modified Bromage scale, and spirometry can all be used to test the adequacy of the motor block after neuraxial anesthesia.

The Modified Bromage Scale is most commonly used, but the disadvantage is that this represents only lumbosacral motor fibers.

Modified Bromage scale

0: No motor block

1: Inability to raise extended leg; Able to move knees and feet

2: Inability to raise extended leg and move knee; Able to move feet

3: Complete block of motor limb

Electromyography and pulmonary function tests (spirometry) have been used to measure abdominal and thoracic motor function, but these are neither practical nor specific.

Train of four ratio and bispectral index are used in monitoring a patient under general anesthesia.

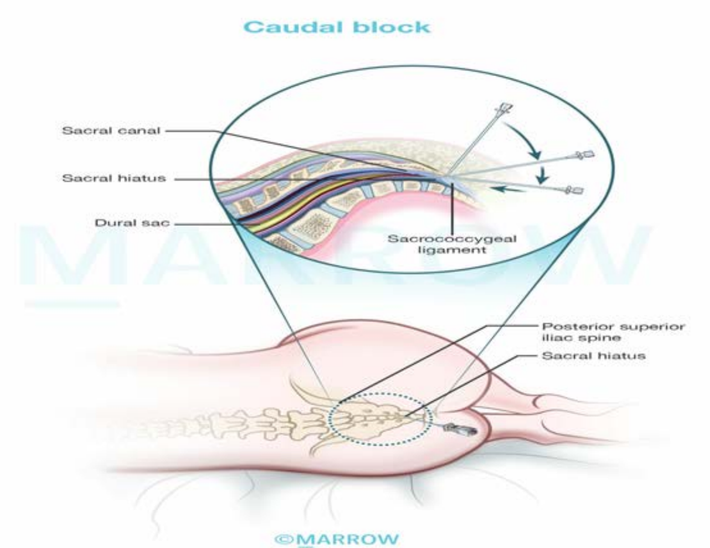
Solution to Question 21:

During caudal anaesthesia, the local anaesthetic is injected into the sacral portion of the epidural space.

Caudal anaesthesia involves a needle and/or catheter penetration of the sacrococcygeal ligament which opens into the caudal epidural space. The sacrococcygeal ligament covers the sacral hiatus that is created by the unfused S4 and S5 laminae.

Sacral hiatus is well appreciated in children. Hence, it is a common regional technique in paediatrics for procedures below the diaphragm, including urogenital, rectal, inguinal, and lower extremity surgery.

It may also be used for anorectal surgery in adults but it is technically challenging in adults.



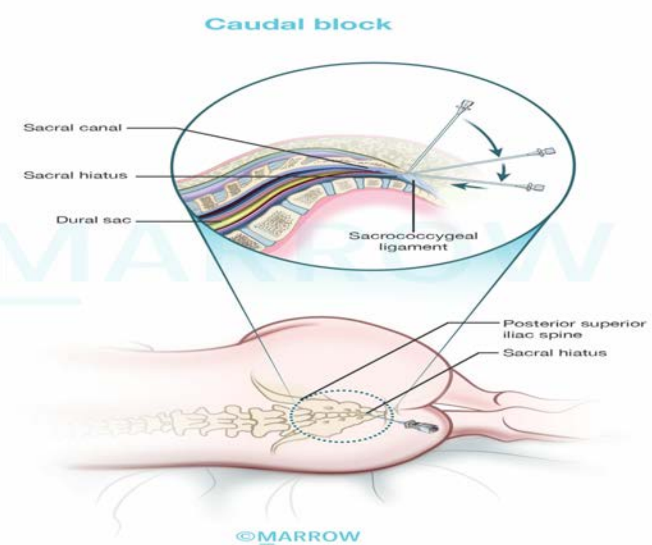
Solution to Question 22:

The landmarks depicted in the image are in reference to caudal anaesthesia. It is a common regional technique in paediatrics for procedures below the diaphragm, including urogenital, rectal, inguinal, and lower extremity surgery.

Caudal anaesthesia involves deposition of local anaesthetic in the caudal epidural space, accessed through the sacral hiatus. Sacral hiatus is formed by the unfused S4 and S5 laminae and is covered by the sacrococcygeal ligament.

The lines joining the posterior superior iliac spines and sacral hiatus make an equilateral triangle. The sacral hiatus is felt as a groove or notch above the coccyx and between two bony prominences, the sacral cornua.

It is better appreciated in children than in adults and hence it is a common regional technique among pediatric patients.



Regional Anesthesia: Complications and Contraindications

Question 1:

A 65-year-old lady with a history of motion sickness underwent a knee replacement under spinal anesthesia. After the procedure, she complains she is feeling nauseous. Which of the following is false about post-anesthetic nausea and vomiting associated?

a) History of motion sickness is a risk factor

b) Elderly age groups are at lesser risk

c) Female patients are at higher risk

d) Intrathecal morphine administration has the least incidence

Question 2:

A patient was scheduled to undergo a vaginal hysterectomy procedure under epidural anaesthesia. 5 minutes after the epidural block was given, the patient started shivering. Which of the following is false regarding post-neuraxial shivering?

a) Is not a sign of malignant hyperthermia

b) More common with spinal than epidural anesthesia

c) Epidural fentanyl can prevent shivering

d) I.V. meperidine is used for treatment

Question 3:

A patient was undergoing a surgical procedure under spinal anaesthesia. 30 mins into the procedure, his $EtCO_2$ fell and the patient became apneic. Bag and mask ventilation was given and the patient regained consciousness and began to spontaneously respire in 10 mins. What is the most common cause of the apnea seen in this patient?

a) Diaphragmatic paralysis

b) Hypotension

c) Intercostal muscle paralysis

d) Systemic toxicity of the local anesthetic

Question 4:

Which of the following statements is false about spinal-anesthesia-induced hypotension?

a) Nausea is the first symptom

b) It is common with block height above T5

c) Sustained hypotension can lead to apnea

d) It is treated with epinephrine

Question 5:

Which of the following nerve fibres are included under cardioaccelerator fibres?

a) C1-4

b) C4-7

c) T1-4

d) T5-L2

Question 6:

You are planning to administer spinal anesthesia to a young female. Which of the following needles would be the least suitable for reducing the risk of a post-dural puncture headache?

a) 22G Quincke

b) 22G Whitacre

c) 25G Quincke

d) 25G Whitacre

Question 7:

Which of the following is false regarding post-dural puncture headache?

a) Due to intracranial hypotension

b) Usually seen within first 72 hours

c) Relieved on sitting

d) Common with cutting spinal needles

Question 8:

Which of the following does the incidence of post-dural puncture headache not depend on?

a) Age

b) Timing of ambulation

c) Pregnancy

d) Gender

Question 9:

A 23-year-old primigravida underwent C- section under spinal anesthesia administered by 22G Quincke needle. 18 hours after the procedure she complained of a headache which was aggravated by sitting up and relieved on lying down. What is the definitive treatment for the condition that she is suffering from?

a) Analgesics

b) Caffeine

c) Supine posture

d) Epidural blood patch

Question 10:

Which of the following is false regarding epidural blood patch?

a) 20 mL of blood injected into epidural space

b) Effective in 90% of patients

c) A second patch performed after 24-48 hours if needed

d) Prophylactic blood patch is recommended as per the recent guidelines

Question 11:

Soon after the administration of an epidural block with 1.5 % lignocaine with epinephrine, your patient went into bradycardia, hypotension, and apnea. What is the most likely diagnosis?

a) Accidental subdural injection

b) Accidental subarachnoid injection

c) Accidental intravascular injection

d) Allergic manifestation to lignocaine

Question 12:

A patient was administered an epidural block before a lower limb surgery. After 20 minutes, the patient went into bradycardia, hypotension, and apnea. What is the most likely cause?

a) Accidental subdural injection

b) Accidental subarachnoid injection

c) Accidental intravascular injection

d) Allergic manifestation to lignocaine

Question 13:

A patient was administered an epidural block with 1.5 % lignocaine with epinephrine. Immediately after the injection, the patient became disoriented followed by an episode of seizures ending in apnea. His BP was 80/50 mm Hg. What is this most likely due to?

a) Accidental subdural injection

b) Accidental subarachnoid injection

c) Accidental intravascular injection

d) Allergic manifestation to lignocaine

Question 14:

A first-year anaesthesia resident was attempting to administer epidural anaesthesia with bupivacaine. Inadvertently he injected the local anaesthetic intravascularly. Following this, the patient's ECG showed prolonged PR intervals, widened QRS complexes and sinus bradycardia. Which of the following measures could not have prevented this?

a) Aspirating before injecting

b) Using test dose

c) Using bolus dose

d) Using incremental doses

Question 15:

A patient who was given epidural anaesthesia for a knee surgery developed fever, headache, vomiting and neck stiffness on the 4th post-operative day. Which of the following is the most likely agent causing this?

a) Streptococcus

b) Staphylococcus

c) E. coli

d) Haemophilus influenzae

Question 16:

The nurse provides you with the case list for the day. In which of the following patients can centrineuraxial (spinal and epidural) anaesthesia be safely administered to immediately?

a) 14 year old boy with h/o bleeding diathesis

b) 72 year old man on low dose aspirin

c) 48 year old woman on warfarin

d) 32 year old woman on LMWH

Question 17:

Which of the following is not an absolute contraindication for spinal anaesthesia?

a) Patient refusal

b) Myelopathy

c) Raised intracranial pressure

d) Local infection

Question 18:

As a first-year anaesthesia resident posted in the emergency OT, you are handed the list of cases posted for surgery. In which of the following patients can you plan to perform spinal anaesthesia?

a) Patient with polytrauma and massive bleeding

b) Patient having pyogenic vertebral osteomyelitis

c) Patient having a coronary stent on clopidogrel

d) Patient with hypertension on amlodipine

Question 19:

A patient on therapeutic low-molecular-weight heparin (LMWH) is to be posted for surgery. How many hours after the last dose of LMWH can a neuraxial block be safely performed?

a) Immediately

b) After 4 hours

c) After 12 hours

d) After 24 hours

Question 20:

A 65-year-old woman with a history of DVT and CKD is on heparin. She is set to undergo a hemiarthroplasty under neuraxial block. How much interval should there be between her last dose of unfractionated heparin and the surgical procedure?

a) Immediately

b) 4 hours

c) 12 hours

d) 24 hours

Question 21:

Which one of the following is the description of the term allodynia used in the context of pain management?

a) Perception of ordinarily non-noxious stimulus as severe pain

b) Absence of pain perception

c) pain in area that lacks sensation

d) Unpleasant sensation with or without a stimulus

Question 22:

You are assessing a 4-year-old child who underwent an appendicectomy for pain. You are using the Children Hospital Eastern Ontario Pain Scale (CHEOPS) for rating postoperative pain. Which of the following parameters will you not use for this?

a) Verbal expression

b) Touch position

c) Body position

d) Oxygen saturation

Question 23:

Transient neurological symptoms are mostly attributed to the use of which local anesthetic?

a) Bupivacaine

b) Lidocaine

c) Prilocaine

d) Ropivacaine

Answer Key

Question No.	Correct Option
1	d
2	b
3	b
4	d
5	c
6	a
7	c
8	b
9	d
10	d
11	b
12	a
13	c
14	c
15	a
16	b
17	b
18	d

19	d
20	b
21	a
22	d
23	b

Detailed Explanations

Solution to Question 1:

Intrathecal morphine has a higher risk and incidence of nausea and vomiting among opioids as compared to fentanyl/sufentanil.

This is because hydrophilic opioids (morphine) remain in CSF for a prolonged duration than lipophilic opioids (fentanyl) and sensitize the central chemoreceptor trigger zone.

The Apfel score is used to predict the risk of developing postoperative nausea and vomiting (PONV). According to this, risk factors are:

• Post-operative use of opioids

• Non-smoker

• Female gender

• History of postoperative nausea, vomiting, or motion sickness

Additional risk factors are the use of nitrous oxide as an inhalational anesthetic agent and the duration of anesthesia.

Ondansetron with or without dexamethasone is used in the management of this condition. The use of propofol in balanced or total IV anesthesia (TIVA) significantly reduces the incidence of PONV.

Solution to Question 2:

Post-neuraxial shivering is more common with epidural than spinal anaesthesia.

The possible reasons include the use of a large volume of cold epidural injectate as compared to a small volume of spinal drug and the inability to shiver with spinal anaesthesia because of the profound motor block as compared with epidural techniques.

Post-neuraxial shivering:

• The incidence of post-neuraxial shivering is more than 40% (~55%)

• The addition of neuraxial opioids (fentanyl, pethidine) reduces the likelihood of shivering

• Prewarming the patient with a forced-air warmer and avoiding the administration of cold epidural and intravenous fluids helps to prevent shivering

• It has no relation to malignant hyperthermia

• Intravenous meperidine and tramadol are used in the treatment

Solution to Question 3:

The most common cause of apnea following neuraxial blockade is hypotension leading to hypoperfusion of the brain stem respiratory centers.

Diaphragmatic paralysis would require the height of the block up to the cervical level (phrenic nerve), which is very rare. However, it can occur in the setting of high spinal up to the cervical level and total spinal anesthesia.

Blockade of the intercostal and abdominal muscles during neuraxial anesthesia is adequately compensated by an unaltered function of the diaphragm and other accessory respiratory muscles.

Systemic toxicity of the local anesthetic would mainly affect the central nervous system and cardiovascular system.

Solution to Question 4:

Spinal-anesthesia-induced hypotension is treated with ephedrine (most commonly), mephentermine or phenylephrine. Epinephrine is reserved only for refractory hypotension or cardiac arrest following spinal anesthesia.

Risk factors for spinal-anesthesia-induced hypotension:

• Peak block height greater than or equal to T5

• Age older than or equal to 40 years

• Baseline systolic blood pressure less than 120 mm Hg

• Combined spinal and general anesthesia

• Spinal puncture at or above the L2-L3 interspace

Clinical features:

• SBP < 90 mmHg

• Nausea precedes hypotension (first symptom to appear)

• Apnea due to medullary hypoperfusion

• Bradycardia

Treatment:

• Rapid administration of intravenous fluids

• Head-down position (only after local anesthesia is fixed (~20 minutes for bupivacaine), else, hyperbaric solution can ascend and lead to high spinal)

• Intravenous vasopressors (ephedrine, phenylephrine)

• Bradycardia is treated with atropine

Solution to Question 5:

The sympathetic cardio-accelerator fibers include T1–T4.

High spinal block above the level of T4, will block the cardio-acceleratory fibers which supply the heart. This would lead to severe bradycardia along with hypotension.

Solution to Question 6:

Post-dural puncture headache is most commonly seen with 22G Quincke needle (22G has a larger diameter than 25G). So it should be avoided in cases with a higher risk of PDPH.

Types of spinal needles:

Cutting needle	Non-cutting (Splitting, pencil point, blunt) needle
Cut the dura	Split the dura
Hence higher incidence of post dural puncture headache (PDPH) due to CSF leak	Hence, lower incidence of PDPH
Technically less challenging as loss of resistance is well appreciated during lumbar puncture	Technically more challenging as loss of resistance is not well appreciated
Eg: Quincke-Babcock, Pitkin	Eg: Whitacre, Sprotte

Solution to Question 7:

Post-dural puncture headache worsens with upright or sitting position and is relieved by supine position.

Post-dural puncture headache is believed to result from puncture of the dura (unintentional or intentional) in the setting of neuraxial anaesthesia. This causes leakage of CSF from a dural defect leading to intracranial hypotension.

The characteristic feature of a post-dural puncture headache is the frontal or an occipital headache.

Solution to Question 8:

The timing of ambulation does not seem to affect the incidence of post-dural puncture headache, i.e., early ambulation does not increase the incidence.

Solution to Question 9:

The scenario given in the question is most likely post-dural puncture headache(PDPH). The definitive treatment for post-dural puncture headache is epidural blood patch. The remaining options are conservative management approaches for PDPH.

Procedure:

• Ideally, performed 24 hours after dural puncture and development of classic PDPH symptoms.

• 15-20 mL of autologous blood is injected into the epidural space at same or one interspace below the level of the dural puncture.

It stops further leakage of CSF by either mass effect or coagulation. A second patch can be performed after 24-48 hours if needed. Approximately 90% of patients will respond to a single blood patch, and 90% of initial nonresponders will obtain relief from a second injection.

Solution to Question 10:

Prophylactic blood patch is not recommended as its efficacy is not supported by evidence.

Epidural blood patch:

• Definitive therapy for PDPH

• Performed 24–48 hours after dural puncture and the development of classic PDPH symptoms.

• 15–20 mL of autologous blood is injected into the epidural space at the same or one interspace below the level of the dural puncture.

• It stops further leakage of CSF by either mass effect or coagulation.

• A second patch can be performed after 24-48 hours, if needed.

• Approximately 90% of patients will respond to a single blood patch, and 90% of initial nonresponders will obtain relief from a second injection

Solution to Question 11:

Bradycardia, hypotension, and apnea soon after the administration of an epidural block suggests accidental subarachnoid (intrathecal) injection resulting in total spinal anaesthesia.

Salient features of total spinal anesthesia:

• Occurs following attempted epidural/caudal anesthesia if there is accidental intrathecal injection

• Rapid onset, as the anesthetic required for epidural and caudal anesthesia, is 5–10 times that required for spinal anesthesia

• High spinal anesthesia extends to involve cranial nerves

• Accompanied by hypotension, bradycardia, apnea, and loss of consciousness

Prevention:

• Careful aspiration for CSF (to rule out intrathecal placement) and blood (to rule out intravascular placement) before injecting the local anesthesia

• Use of a test dose with lidocaine and adrenaline

• Incremental injection techniques instead of a bolus dose

Treatment:

• Maintaining an adequate airway and ventilation and supporting the circulation

Option A - Accidental subdural injection manifests after 15-20 minutes with features similar to a high spinal blockade.

Option C - Accidental intravascular injection manifests as systemic toxicity with CNS and CVS symptoms.

Option D - Allergic manifestation presents with hives, angioedema, and bronchospasm.

Solution to Question 12:

Bradycardia, hypotension, and apnea presenting 20 minutes after epidural injection suggest accidental subdural injection.

The clinical presentation of subdural anaesthesia is similar to that of high spinal anaesthesia, with the exception that the onset may be delayed for 15–30 min and the block may be patchy.

Unlike the epidural space, the subdural space extends intracranially. Hence, the anaesthetic injected into the subdural space can ascend to higher levels than epidural medications.

As with high spinal anaesthesia, treatment is supportive and may require intubation, mechanical ventilation, and cardiovascular support.

Option B - Accidental subarachnoid injection manifests immediately with similar features.

Option C - Accidental intravascular injection presents with CNS and CVS symptoms.

Option D - Allergic manifestation presents with hives, angioedema and, bronchospasm.

Solution to Question 13:

The above condition is most likely due to accidental intravascular injection of local anaesthetic into the epidural vein resulting in local anaesthesia systemic toxicity (LAST).

Features of LAST:

• CNS (in the order of appearance)

• Tinnitus, blurred vision, dizziness, tongue paresthesia, and circumoral numbness

• Excitatory signs such as nervousness, agitation, restlessness, and muscle twitching leading to tonic-clonic seizures

• CNS depression with slurred speech, drowsiness, unconsciousness, and then respiratory arrest

• Patients who have received CNS depressant drugs may present with only CNS depression without any preceding excitatory signs

• CVS

• Prolonged PR intervals and widened QRS complexes, and sinus bradycardia/arrest

• Ventricular arrhythmias, including fibrillation, are more likely to occur with bupivacaine than lidocaine

Prevention:

• Careful aspiration for CSF (to rule out intrathecal placement) and blood (to rule out intravascular placement) before injecting the local anaesthesia

• Use of a test dose with lidocaine and adrenaline

• Incremental injection techniques instead of a bolus dose

• Close observation for early signs of intravascular injection

Treatment:

• Seizures: Benzodiazepine; if not available, a small dose of propofol or thiopentone. If seizures persist, a neuromuscular blockade to minimize acidosis and hypoxemia

• Cardiac arrest: standard ACLS protocol with few modifications

• Lipid emulsion therapy

• Last resort: cardio-pulmonary bypass

Solution to Question 14:

Using bolus dose does not prevent systemic toxic side effects from accidental intravascular injection of local anaesthetics.

The major systemic toxic side effects from accidental intravascular injection can be avoided by

• Initial test dose

• Aspirating prior to each injection (negative aspiration for blood)

• Using incremental dosing

• Close observation for early signs of intravascular injection (tinnitus, lingual sensations)

Solution to Question 15:

The above case scenario is suggestive of bacterial meningitis following epidural anaesthesia. The most common organism responsible for bacterial meningitis following neuraxial blockade (spinal and epidural) is Streptococcus viridians.

However, the most common organisms responsible for epidural-anaesthesia-related local infection (abscess) is Staphylococcus.

Streptococcus viridians is an oral commensal, emphasizing the purpose of wearing a mask as part of a full aseptic technique.

Solution to Question 16:

Being on low dose aspirin is not a contraindication for the use of centrineuraxial anaesthesia. So, it is safe to administer it to a patient on low dose aspirin.

This is because use of most antiplatelet agents (eg. Aspirin & NSAIDs) is not associated with an increased risk of complications from centrineuraxial anaesthesia.

LMWH administration must be stopped prophylactically (12 hours prior) and therapeutically (24 hours prior) to centrineuraxial anaesthesia. It can be done only after checking if the platelet count is normal (if LMWH has been administered for more than 4 days). This is due to reports of spinal/epidural hematomas when centrineuraxial anaesthesia is given to patients on LMWH.

Solution to Question 17:

All of the above are absolute contraindications for spinal anaesthesia except myelopathy, which is a relative contraindication.

In the setting of neurological deficit (myelopathy), careful evaluation of neurologic status must first be undertaken and noted along with documentation of the discussion of the risks and benefits for a medico-legal purpose.

Solution to Question 18:

Patient being on antihypertensives like CCBs (amlodipine) is not a contraindication for a neuraxial block.

Patient on antiplatelets:

Antiplatelets (except aspirin and NSAIDs) should be withheld till their effects have worn off as they increase the risk of spinal hematoma.

Antiplatelets	Waiting period
Clopidogrel	7 days
Ticlopidine	14 days
Abciximab	48 hours

Solution to Question 19:

The neuraxial block can be safely performed 24 hours after the last therapeutic dose of low-molecular-weight heparin (LMWH).

In a patient who has received a prophylactic dose of LMWH, the block is delayed for 12 hours.

Postoperative LMWH thromboprophylaxis:

• Remove epidural catheter 2 hours prior to the first LMWH dose

• If thromboprophylaxis is already started, remove epidural catheter 10 hours after a dose of LMWH. Subsequent LMWH dosing is given 2 hours after the removal of the catheter.

Solution to Question 20:

An interval of atleast 4 hours must be there between her last dose of unfractionated heparin and the surgical procedure being performed under neuraxial block.

As the patient has CKD, only unfractionated heparin can be used in her. The subsequent dose can be given 1 hour after the neuraxial technique.

“Minidose” subcutaneous heparin prophylaxis, aspirin and NSAIDs are not contraindications to neuraxial anesthesia or epidural catheter removal.

Solution to Question 21:

Perception of ordinarily non-noxious stimulus as severe pain is Allodynia.

Absence of pain perception: Analgesia

Pain in an area that lacks sensation: Anaesthesia Dolorosa

Unpleasant sensation with or without a stimulus: Dysesthesia

Solution to Question 22:

The Children Hospital Eastern Ontario Pain Scale (CHEOPS) for rating postoperative pain in children does not include oxygen saturation.

It includes:

• crying

• facial expression

• body position (torso)

• verbal expression

• touch position

• leg position.

Other pain assessment scales include-

• Oucher face scale

• Visual analogue scale (VAS)

Solution to Question 23:

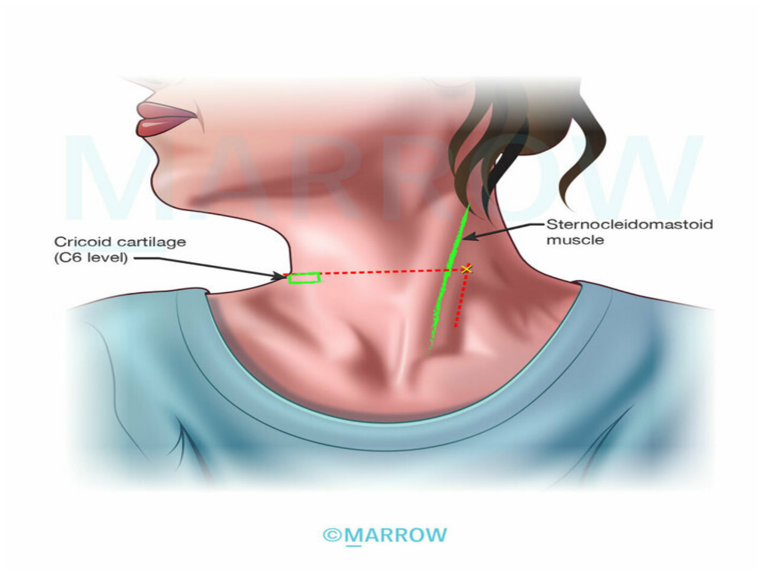
Transient neurological symptoms are mostly attributed to the use of intrathecal lidocaine.

Note: TNS was previously known as transient radicular irritation.

Peripheral Nerve Blocks

Question 1:

The anaesthesia resident has made the markings as seen in the image on a patient's neck. Which brachial plexus block is he likely planning to perform?



a) Supraclavicular block

b) Stellate ganglion block

c) Interscalene block

d) Infraclavicular block

Question 2:

You are about to administer interscalene block to a patient. What is the most common complication you should anticipate?

a) Pneumothorax

b) Diaphragmatic hemiparesis

c) Recurrent laryngeal nerve palsy

d) Horners syndrome

Question 3:

A patient presented with dislocation of the shoulder. It was not amenable to closed reduction, so you plan to perform an open reduction. Which regional anaesthetic technique will you prefer to perform this procedure under?

a) Spinal anesthesia

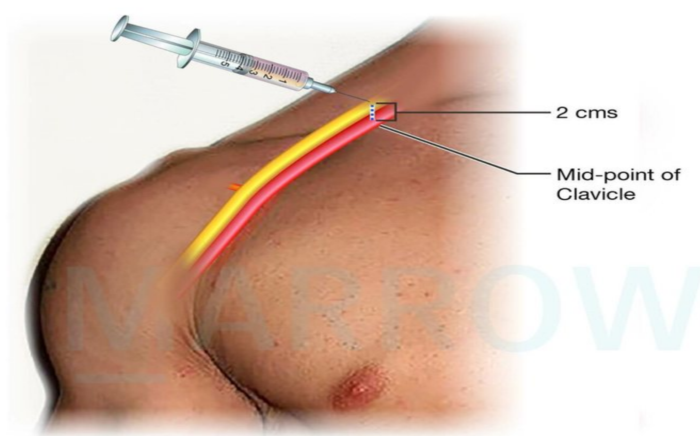
b) Epidural anesthesia

c) Interscalene block

d) Supraclavicular block

Question 4:

The anaesthesia resident is told to perform the 'spinal of the arm' before an elbow surgery. You observe him as he injects a local anaesthetic at the point shown in the image. What procedure is he performing?



©MARROW

a) Stellate ganglion block

b) Supraclavicular block

c) Infraclavicular block

d) Interscalene block

Question 5:

What is the most common complication after supraclavicular block?

a) Phrenic nerve palsy

b) Horners syndrome

c) Pneumothorax

d) Recurrent laryngeal nerve palsy

Question 6:

Which procedure has the maximum incidence of pneumothorax?

a) Supraclavicular block

b) Infraclavicular block

c) Interscalene block

d) Axillary block

Question 7:

In which of the following patients will the administration of a supraclavicular block not be of much use?

a) 30-year-old man with distal radius fracture

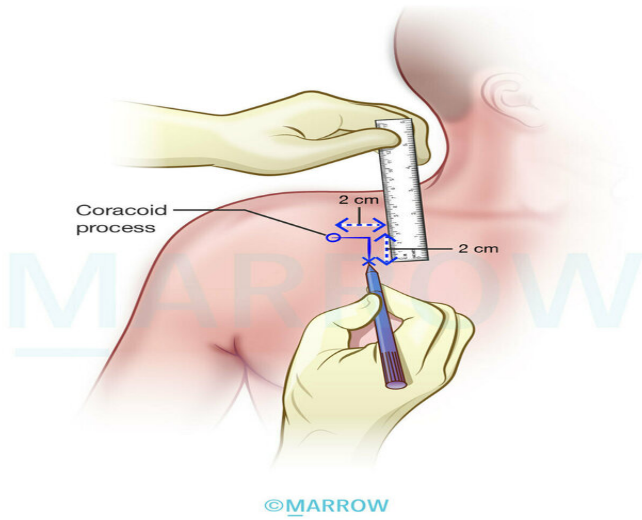
b) 16-year-old boy with elbow dislocation

c) 40-year-old man with fracture of 1st metacarpal

d) 25-year-old woman with posterior shoulder dislocation

Question 8:

Which of the following blocks is performed by injecting a local anaesthetic at the point marked in the image?



a) Stellate ganglion block

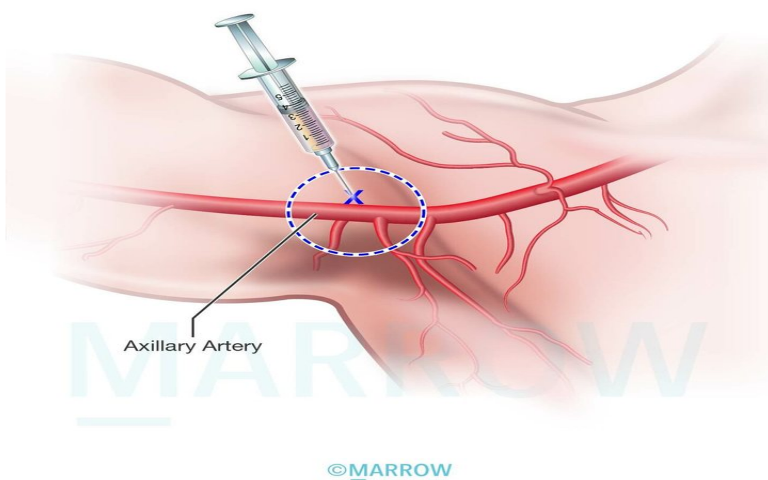
b) Supraclavicular block

c) Infraclavicular block

d) Interscalene block

Question 9:

A brachial plexus block is given by injecting a local anesthetic at the point shown in the image. Which of the following procedures cannot be performed under this block?



a) Plating of distal radius

b) Internal fixation of scaphoid fracture

c) Internal fixation of shaft humerus fracture

d) Internal fixation of ulnar fracture

Question 10:

A child presents with a dislocated fracture of the first metacarpal. What is the preferred regional anaesthesia technique for the surgery?

a) Supraclavicular block

b) Infraclavicular block

c) Interscalene block

d) Axillary block

Question 11:

A 4-year-old boy is posted for a circumcision procedure. He is given a pudendal nerve block before the surgery. Which of the following nerve roots are blocked in this technique?

a) L1L2L3

b) L2L3L4

c) S1S2S3

d) S2S3S4

Question 12:

You have administered a celiac plexus block to a patient of pancreatic cancer for pain relief. What is the most common complication of this block that you should warn him about?

a) Pneumothorax

b) Postural hypotension

c) Retroperitoneal hemorrhage

d) Intra-arterial injection

Answer Key

Question No.	Correct Option
1	c
2	b
3	c
4	b
5	a
6	a
7	d
8	c
9	c
10	d
11	d
12	b

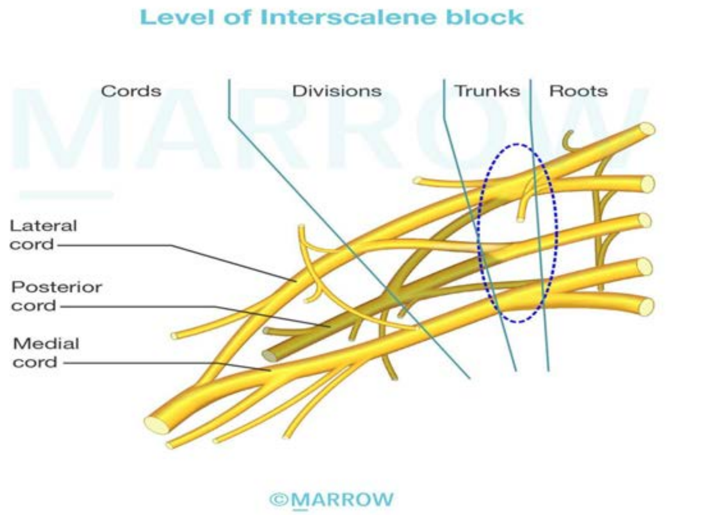
Detailed Explanations

Solution to Question 1:

The above image shows the surface marking used to perform interscalene block. The local anaesthetic is injected into the interscalene groove present behind the sternocleidomastoid at the level of cricoid cartilage (C6 vertebral level).

This is a brachial plexus block performed at the trunk level.

Level	Type of block
Superior & middle trunk (inferior trunk blockade is incomplete)	Interscalene
Distal trunk & proximal division	Supraclavicular
Cords	Infraclavicular
Terminal nerves	Axillary



It provides an adequate block of the superior and middle trunks of the brachial plexus. So, interscalene block provides surgical anesthesia for procedures of the shoulder and upper arm.

Ulnar nerve (C8, T1) from inferior trunk may be missed. Hence, this block is not used for procedures of the forearm and hand.

Solution to Question 2:

The most common complication of interscalene block, seen in 100% of patients, is diaphragmatic hemiparesis due to ipsilateral phrenic nerve blockade.

This can result in dyspnea, hypoxia, and hypercapnea, especially if the patient has compromised lung function or preexisting contralateral phrenic nerve paralysis.

Other complications of interscalene block are:

• Horner's syndrome – ptosis, miosis, anhydrosis. Due to involvement of the sympathetic nerves to the cervicothoracic ganglion.

• Recurrent laryngeal nerve palsy

• Vagus nerve involvement

• Pneumothorax

• Bezold Jarisch reflex

• Accidental vertebral artery injection (immediate seizure is seen)

• Accidental spinal or epidural injection

Solution to Question 3:

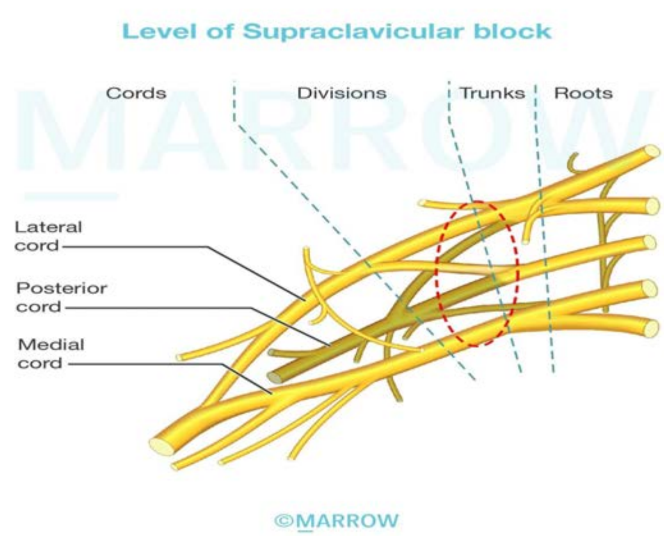
The regional anesthetic technique preferred for surgery of dislocated shoulder is interscalene brachial plexus block.

Brachial plexus block	Level	Indication	Limitation
Interscalene	Superior and middle trunk	Shoulder and upper arm	Ulnar nerve sparing
Supraclavicular	Distal trunk and proximal division	Elbow, forearm and hand	Axillary and suprascapular nerve sparing, pneumothorax, phrenic nerve palsy
Infraclavicular	Cords	Forearm and hand	Intercostobrachial nerve sparing
Axillary	Terminal nerves	Forearm and hand	Musculocutaneous, axillary, medial cutaneous nerve branches sparing;Inadvertent intravascular injection

Solution to Question 4:

The procedure being performed is the supraclavicular block. It can be identified by the point of injection 2 cm posterior to the mid-point of clavicle.

The block is given at the level distal to trunks and proximal to divisions of the brachial plexus. It is also known as the 'spinal of the arm'.



It is a type of brachial plexus block used for procedures on the elbow, forearm, and hand. The supraclavicular block does not adequately block the axillary and suprascapular nerves, and thus is not reliable for shoulder surgery.

Solution to Question 5:

The most common complication of supraclavicular block is phrenic nerve palsy with an incidence > 50 %.

This results in hemidiaphragmatic paresis which is self-limited and resolves as the block wears off.

Complications & side-effects of supraclavicular block :

• Hemidiaphragmatic paresis - due to phrenic nerve palsy

• Pneumothorax - highest when compared to other brachial plexus blocks

• Horners syndrome - from a block of the stellate ganglion

• Hoarseness - due to recurrent laryngeal nerve palsy and/or cervical sympathetic block

Note :

Pneumothorax is the most dangerous complication of the supraclavicular block but it is not the most common. It has an incidence that ranges from 0.5- 6%. The symptoms develop slowly, and may take up to 24 hours.

Solution to Question 6:

The incidence of pneumothorax is maximum with supraclavicular block (0.5- 6%) among all the approaches to brachial plexus block.

The risk can be minimised by performing ultrasound guided block.

Solution to Question 7:

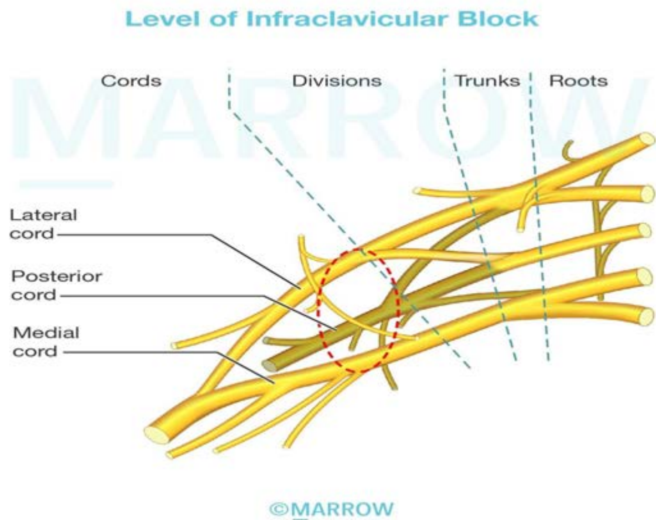
Supraclavicular block is not reliable for shoulder surgeries as axillary and suprascapular nerves are spared. So it will not be of much use in a case of posterior shoulder dislocation.

Supraclavicular block is a type of brachial plexus block used for procedures on the elbow, forearm, and hand. It provides an adequate block of the brachial plexus at the level of the distal trunk - proximal division.

Solution to Question 8:

The image shows the surface marking for performing infraclavicular block. This block is performed at a point 2 cm medial and 2 cm caudal to the coracoid process which is used as a landmark.

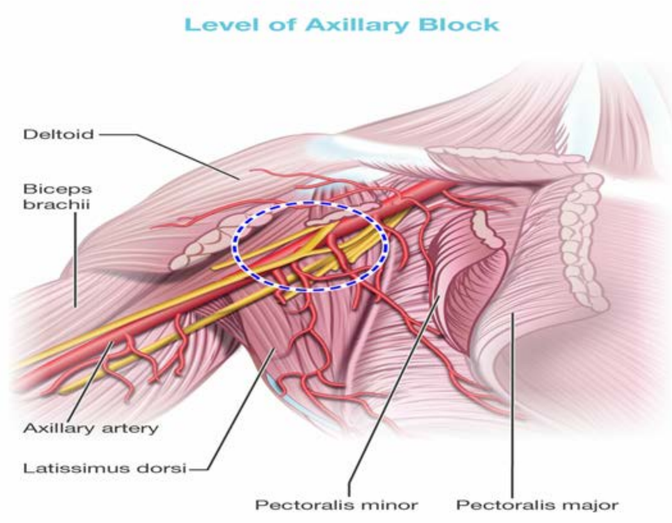
The brachial plexus is blocked at the level of cords.



The Infraclavicular block is used for procedures of the forearm and hand.

Solution to Question 9:

The image shows a local anesthetic being injected into the tip of the axilla around the axillary artery. This is the method used to perform the axillary block. It reliably produces anesthesia of the entire arm distal to the elbow, and so can be used for all of the given procedures, except fixation of the shaft of the humerus.



The terminal branches of the brachial plexus can be blocked via the axillary approach.

Solution to Question 10:

The axillary block is the most preferred approach to the brachial plexus in pediatric patients for surgeries of the elbow, forearm, and hand.

It is a relatively easy and safe procedure. Complications include systemic toxicity due to accidental intraarterial injection and permanent nerve injury from the intraneural injection.

Solution to Question 11:

Pudendal nerve block involves S2S3S4.

Solution to Question 12:

Most common complication of celiac plexus block is postural hypotension.

Celiac plexus:

• Largest plexus of the sympathetic nervous system.

• Contains preganglionic sympathetic from greater, lesser and least splanchnic nerves (T5 to T12), postganglionic sympathetic, preganglionic parasympathetic and visceral sensory afferent fibres.

• Provides sensory innervation and sympathetic outflow to stomach, liver, spleen, pancreas, kidney and GI tract up to splenic flexure.

• Located in the retroperitoneal space, anterior to aorta at the level of L1.

Indication: Pain arising from the abdominal viscera, particularly intra-abdominal cancers (Eg. pancreatic cancer).

Complications:

• Orthostatic hypotension (most common, can be minimized with fluid hydration)

• Diarrhea (secondary to blockade of sympathetic fibers)

• Paraplegia (from damage to artery of Adamkiewicz)

• Local anesthetic toxicity, spinal or epidural injection, retroperitoeneal hemorrhage, visceral organ injury, and pneumothorax.

Anaesthetic Implication of Concurrent Diseases

Question 1:

Which of the following agents is to be avoided in a hypertensive patient?

a) Thiopentone
b) Propofol
c) Ketamine
d) Etomidate

Question 2:

Which of the following muscle relaxants should be avoided in a hypertensive patient?

a) Pancuronium
b) Rocuronium
c) Vecuronium
d) Atracurium

Question 3:

A 4-year-old child is observed to have difficulty in breathing along with bluish discolouration of his lips and fingers while playing. It improves on adopting a knee-chest position. Which is the ideal induction agent of choice used for surgical correction of the condition suffered by this patient?

a) Thiopentone
b) Propofol
c) Etomidate
d) Ketamine

Question 4:

A child with a wide fixed split S2 on auscultation has been scheduled for a surgical repair for the condition. Which of the following is the inhalational agent of choice for induction in this procedure?

a) Desflurane

b) Sevoflurane

c) Isoflurane

d) Halothane

Question 5:

A patient with severe aortic stenosis is posted for surgery. Which is the preferred anaesthetic technique used for this procedure?

a) General anesthesia

b) Spinal anesthesia

c) Epidural anesthesia

d) Intercostal nerve block

Question 6:

You are conducting the pre-anesthetic checkup for a patient who is scheduled for an elective cholecystectomy. He is a known hypertensive being treated with the following drugs. Which of the following drugs should be discontinued 24 hours before the procedure?

a) Calcium channel blocker

b) Centrally acting sympathomimetics

c) Beta blocker

d) ACE inhibitor

Question 7:

During recovery from anaesthesia after a posterior cranial fossa surgery, the patient complained of a severe headache and was agitated. CT scan showed intracranial air accumulation. Which of the following agents is most likely responsible for this condition?

a) Oxygen

b) Nitrous oxide

c) Desflurane

d) Sevoflurane

Question 8:

An awake craniotomy is being performed on a patient when there is a sudden drop in his blood pressure. The surgeon is suspecting a complication of venous air embolism (VAE). Which of the following is true about the condition?

a) All VAE can be detected clinically by a decrease in end tidal carbon dioxide

b) A decrease in oxygen saturation will not always be seen, even with larger emboli

c) Patients with left to right shunt, are susceptible to paradoxical air embolism

d) The surgeon has no role in the management of VAE

Question 9:

A 40-year-old male in kidney failure with a serum creatinine of 2.1 mg/dl is scheduled for surgery. Which of the following muscle relaxants can be used?

a) 1, 2 and 4

b) 3,4 and 5

c) 2 and 4

d) 1 only

Question 10:

A patient is scheduled to undergo transurethral resection of the prostate. Which is the preferred anaesthetic technique for this procedure?

a) General anesthesia

b) Spinal anesthesia

c) Epidural anesthesia

d) Local infiltration

Question 11:

A 55-year-old female was diagnosed to have primary biliary cirrhosis and requires liver transplantation. Which of the following neuromuscular blocker of choice can be used in this patient during the transplantation procedure?

a) Cisatracurium

b) Pancuronium

c) Vecuronium

d) Rocuronium

Question 12:

Which of the following is an inhalational agent of choice for a patient posted for liver transplantation?

a) Enflurane

b) Halothane

c) Sevoflurane

d) Isoflurane

Question 13:

A 71-year-old male is posted for total hip arthroplasty. What is the preferred anaesthetic technique for this patient?

a) General anesthesia

b) Spinal anesthesia

c) Local infiltration

d) Paracervical block

Question 14:

A 71-year-old patient underwent hip replacement surgery. Postoperatively, a target control infusion (TCI) pump was set up to administer an opioid analgesic. Which is the most suitable opioid used for this patient?

a) Morphine

b) Pethidine

c) Fentanyl

d) Remifentanyl

Question 15:

A 39-year-old man had sustained major injuries in an accident as his legs were trapped under the wheel of a car. Which of the following agents can be ideally used by the EMS personnel to provide sedation and pain relief to the patient while shifting him to the hospital?

a) Propofol

b) Thiopentone

c) Midazolam

d) Ketamine

Question 16:

A 40-year-old patient is brought to the ER with hematemesis. The patient goes into haemorrhagic shock and requires emergency surgical intervention. Which of the following agents is not ideal for induction in this patient?

a) Propofol

b) Etomidate

c) Ketamine

d) None of the above

Question 17:

Shambu, a 55-year-old man met with a road traffic accident and was brought to the casualty. Radiographs revealed multiple rib fractures. Which of the following methods is used to treat this patient?

a) General anaesthesia with endotracheal intubation

b) Spinal anaesthesia

c) Epidural anaesthesia

d) Infraclavicular block

Question 18:

A 30-year-old male is scheduled for an open reduction of a fractured nose. The preferred technique of anaesthesia in this patient would be?

a) General anaesthesia

b) Local infiltration

c) Regional anaesthesia

d) Topical anaesthesia

Question 19:

A 55-year-old chronic smoker has been diagnosed with epiglottic carcinoma. The ENT surgeon has scheduled a CO_2 laser excision surgery. Which of the following anaesthetic gases needs to be avoided during the procedure?

a) Sevoflurane

b) Oxygen

c) Nitrous oxide

d) Halothane

Question 20:

A stapedectomy has been scheduled for a patient suffering from Ménière's disease. Which is the preferred intravenous induction agent for the procedure?

a) Thiopentone

b) Propofol

c) Etomidate

d) Ketamine

Question 21:

A 32-year-old male is suffering from chronic suppurative otitis media of the right ear. He is scheduled for a tympanoplasty surgery. Which of the following agents should be avoided during the procedure?

a) Propofol

b) Ketamine

c) Oxygen

d) Nitrous oxide

Question 22:

Which of the following agents should not be used during superficial parotidectomy surgery scheduled for a case of pleomorphic adenoma?

a) Inhalational anaesthetics

b) Opioids

c) Antibiotics

d) Muscle relaxants

Question 23:

A 23-year-old woman wants to undergo an aesthetic rhinoplasty. Which of the following is the safest drug that can be used during the surgery for topical vasoconstriction?

a) Lidocaine

b) Phenylephrine

c) Cocaine

d) Oxymetazoline

Question 24:

Which of the following agents cannot be used to achieve hypotensive anaesthesia during nasopharyngeal carcinoma surgery?

a) Phentolamine

b) Halothane

c) Sodium nitroprusside

d) Phenylephrine

Question 25:

During a squint surgery, the ophthalmologist hooks a muscle that causes sudden significant bradycardia in the patient. Atropine is given and the heart rhythm returns to normal. This reflex is most likely seen with traction on which muscle?

a) Superior rectus

b) Inferior rectus

c) Medial rectus

d) Lateral rectus

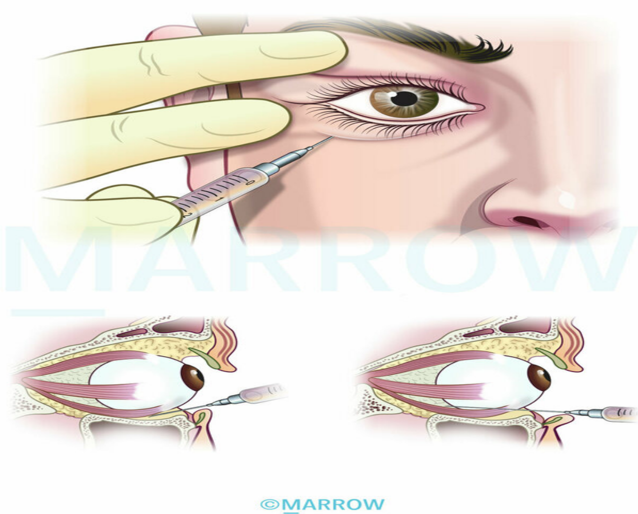
Question 26:

A child while undergoing enucleation of his right eye due to bacterial endophthalmitis, suddenly developed bradycardia. Manipulation of which of the following structures would have led to the bradycardia?

- **a)** Orbital periosteum
- **b)** Inferior oblique
- **c)** Medial rectus
- **d)** Any of the above

Question 27:

A 60-year-old female patient needs to undergo cataract surgery. Before initiating the surgery, the following procedure is performed. What is the most common complication seen in the procedure?



- **a)** Proptosis
- **b)** Subconjunctival hemorrhage
- **c)** Optic nerve damage
- **d)** Retrobulbar hemorrhage

Question 28:

In which of the following conditions is a retrobulbar block not contraindicated?

a) High myopia

b) Coagulopathy

c) Penetrating eye injury

d) Enucleation

Question 29:

A 13-year-old boy was accidentally shot in the eye by his brother while playing with a pellet gun. Examination reveals intraocular contents presenting at the wound. He is scheduled for emergency repair of the ruptured globe. What is the ideal anaesthetic technique to be used?

a) General anesthesia

b) Retrobulbar block

c) Subtenon block

d) Peribulbar block

Question 30:

A child presenting with open globe injury. Which induction agent should be avoided?

a) Propofol

b) Ketamine

c) Etomidate

d) Thiopentone

Question 31:

The best type of anesthesia for pre eclampsia is:

a) Spinal anesthesia

b) Epidural anesthesia

c) General anesthesia

d) Caudal block

Question 32:

Three combat wounded soldiers with uncontrolled blood loss are brought to the base camp. Damage control resuscitation(DCR) is initiated for the soldiers. What is the correct ratio of PRBCs, FFP, and platelets that can be used for DCR?

a) 4:2:1

b) 1:2:4

c) 2:1:2

d) 1:1:1

Answer Key

Question No.	Correct Option
1	c
2	a
3	d
4	b
5	a
6	d
7	b
8	b
9	a
10	b
11	a
12	c
13	b
14	d
15	d
16	a
17	c
18	a
19	c
20	b
21	d
22	d
23	d
24	d

25	c
26	d
27	d
28	d
29	a
30	b
31	b
32	d

Detailed Explanations

Solution to Question 1:

Ketamine is avoided in a hypertensive patient as it has intrinsic sympathomimetic properties and hence can aggravate hypertension.

Ketamine increases arterial blood pressure, heart rate, and cardiac output. This is due to central stimulation of the sympathetic nervous system and inhibition of the reuptake of norepinephrine. And hence it should be cautiously used in patients with uncontrolled hypertension, coronary artery disease, congestive heart failure and arterial aneurysms.

Its stimulatory effects may be beneficial to patients with acute shock. All other intravenous induction agents like propofol, thiopentone and etomidate produce a fall in blood pressure.

Solution to Question 2:

Pancuronium is avoided in hypertensive patients because it causes vagal blockade and sympathetic stimulation which can aggravate hypertension.

For the same reason, it is to be cautiously used in patients with-

• Coronary artery disease

• Hypertrophic cardiomyopathy

• Aortic stenosis.

Solution to Question 3:

Ketamine is the induction agent of choice in this patient who is likely suffering from tetralogy of Fallot because it maintains or increases systemic vascular resistance and increases cardiac output.

Tetralogy of Fallot is characterized by sub pulmonic stenosis, right ventricular hypertrophy, ventricular septal defect and overriding of the aorta. This results in a right to left shunt through the ventricular septal defect and consequent cyanosis.

The commonest symptoms are dyspnea on exertion and exercise intolerance and develop blue skin (cyanosis) when agitated and are known as tet spells. The patients assume a sitting posture (squatting) or knee-chest position as soon as they get dyspneic, which leads to temporary symptomatic relief.

Ketamine does not aggravate the right to left shunt seen in such cases. It also does not increase pulmonary vascular resistance in children as compared to adults and is hence safe to administer in children.

Ketamine is the agent of choice in all cyanotic congenital heart diseases.

Solution to Question 4:

Wide fixed split S2 is suggestive of atrial septal defect (ASD) and sevoflurane is the inhalational agent of choice for induction in a child undergoing cardiac surgery.

Halothane and sevoflurane are non-pungent and hence can be used for induction in pediatric patients. Sevoflurane is not associated with significant myocardial depression as is seen with halothane. Hence, sevoflurane is preferred over halothane especially in all cardiovascular surgeries in the paediatric age group.

Following induction, isoflurane and sevoflurane are the most commonly used inhalation agents for maintenance.

Solution to Question 5:

General anaesthesia is preferred in patients with severe aortic stenosis.

Spinal and epidural anaesthesia are relatively contraindicated. This is because regional anaesthesia produces profound hypotension which can lead to a fall in preload, afterload or both.

Most general anaesthetics especially the volatile agents also cause vasodilation and hypotension which can be treated with escalating doses of vasopressors like phenylephrine.

Mild to moderate aortic stenosis are not contraindications to regional anaesthesia. In such situations, epidural anaesthesia is preferred over spinal because of its slower onset of hypotension which can be adequately corrected.

Solution to Question 6:

The anti-hypertensive that is discontinued 24hours before surgery is ACE inhibitor due to the risk of hemodynamic instability.

Although the continuation of ACE inhibitors or ARBs is controversial, among the given options this is the best answer. If these drugs are continued, vasopressin is the drug of choice for refractory hypotension.

Solution to Question 7:

The given case scenario is suggestive of pneumocephalus and nitrous oxide is responsible for causing this condition.

Solution to Question 8:

The correct statement regarding venous air embolism (VAE) is, a decrease in oxygen saturation will not always be seen, even with larger emboli.

VAE can occur when the pressure within an open vein is subatmospheric. It can occur in any position or procedure, whenever the wound is above the level of the heart. The incidence of venous air embolism is greater during sitting craniotomies than in craniotomies in any other position.

Option A: Physiological monitors (heart rate, blood pressure, oxygen saturation, and end-tidal carbon dioxide) have poor sensitivity and specificity and the clinical signs are manifested late. Transesophageal echocardiogram (TEE) is the most sensitive method to monitor and can detect up to 0.02ml/kg of air embolism.

Option C: Patients with a right to left shunt are susceptible to paradoxical air emboli which can result in a stroke or coronary occlusion.

Option D: The surgeon should be notified immediately so that he or she can flood the surgical field with saline or pack it with wet gauzes and apply bone wax to the skull edges until the entry site is identified and occluded.

Solution to Question 9:

Succinylcholine, atracurium and cis-atracurium can be used in this patient who has a renal failure with elevated serum creatinine(normal value- 0.8–1.3 mg/dL in men and 0.6–1 mg/dL in women).

Succinylcholine can be safely administered to patients with diminished or absent kidney function provided serum potassium levels are normal. If the serum potassium is increased, then a non-depolarizing muscle relaxant like atracurium or cisatracurium which is non-dependent on renal excretion is to be used. Atracurium or cisatracurium undergo Hofmann elimination which is non-enzymatic spontaneous degradation.

Pancuronium is almost entirely dependent on the kidney for excretion (60–90%). Pancuronium has a prolonged elimination half-life in renal failure patients and thus should be used very cautiously.

40-60% of d-tubocurarine is excreted via the kidney and so prolonged effects are seen with renal insufficiency

Solution to Question 10:

Spinal anaesthesia is the preferred choice of anaesthetic for the TURP procedure.

Regional anaesthesia is preferred over general anaesthesia in TURP due to the following reasons:

• Less likely to mask the symptoms of TURP syndrome

• Helps assess patients mental status as an alteration in mental status is an early sign of TURP

• A lesser amount of operative blood loss and lesser risk of DVT.

• Less likely to mask symptoms of bladder perforation like nausea, abdominal pain, dyspnea, shoulder pain, and hiccups.

• Decreased need for analgesics in the immediate post-operative period.

Spinal anaesthesia is preferred over epidural anaesthesia due to:

• Easier to perform in elderly patients.

• Duration of surgery is not usually long, so an epidural is not required.

• Epidural anaesthesia may incompletely block the sacral nerve roots which can be avoided with spinal anaesthesia.

Caudal anaesthesia may be used in high-risk patients undergoing laser prostatectomy as it provides the advantage of hemodynamic stability. Local infiltration does not provide sufficient operative analgesia as spinal anaesthesia.

Solution to Question 11:

The neuromuscular blocker (NMB) of choice in a cirrhotic patient is cisatracurium.

It is used as NMB of choice because of its nonhepatic metabolism.

Solution to Question 12:

Sevoflurane is the inhalational anaesthetic agent of choice during liver transplantation because it is superior to other inhalational agents in preserving hepatic arterial blood flow and hepatic oxygen delivery.

The liver has an autoregulatory mechanism called the hepatic arterial buffer response(HABF)- when portal blood flow decreases due to decreased cardiac output or hypovolemia, the hepatic arterial blood flow increases in order to maintain total hepatic blood flow. This response is preserved in sevoflurane.

Solution to Question 13:

Spinal anaesthesia is preferred in elderly patients undergoing major vascular and orthopaedic surgeries.

They are preferred over general anaesthesia due to:

• Decreased incidence of deep vein thrombosis and pulmonary embolism

• Local anaesthetics used will inhibit platelet aggregation and stabilize endothelial cells

• Regional anaesthesia is associated with less surgical blood loss

• Lower incidence of hypoxemia as it avoids airway instrumentation

But the disadvantage with regional anaesthesia is that due to hypotension, patients with coronary artery disease will have increased oxygen demand due to reflex tachycardia and reduced coronary perfusion.

Solution to Question 14:

Remifentanil is the opioid that was most likely used in this elderly patient.

Remifentanil is hydrolysed by plasma and tissue esterases and so its metabolism is independent of hepatic and renal function- no dose adjustment is required and is safe in liver failure patients and renal failure patients.

Because of this hydrolysis, it has a high clearance and is eliminated rapidly with a quick recovery (half-life less than 10 minutes) and thus is preferred in elderly patients.

Solution to Question 15:

Ketamine is the ideal agent of choice to provide sedation and analgesia in the prehospital setting.

Drugs that can be used by nurses and paramedics in the prehospital setting like the site of RTA/Trauma should have-

• Wide safety margin, even for inexperienced providers

• Hemodynamic stability

• Minimal respiratory depression

• Ease of administration

• Early-onset of action

Ketamine provides potent analgesia and sedation for entrapped patients with trauma during extrication. It maintains hemodynamic stability in patients with hypovolemic shock, is a potent bronchodilator, and causes minimal respiratory depression. Because of its hallucinogenic properties, benzodiazepines should be co-administered. In larger doses, it can be used for induction of anaesthesia.

Option C: Benzodiazepines like diazepam and midazolam have wide safety margins and can be administered via many routes and can be used to provide sedation, but lack an analgesic action.

Option A and B: Propofol causes hemodynamic instability and respiratory depression and thiopentone produces effects similar to propofol.

Solution to Question 16:

Propofol is not an ideal agent for induction in a patient with haemorrhagic shock.

Propofol when given to a patient in hemorrhagic shock will lead to worsening of shock due to the profound hypotensive action because of its vasodilatory and negative inotropic effects.

Option B: Etomidate preserves the sympathetic tone and has cardiovascular stability. Thus it is safer to use than propofol.

Option C: Ketamine has been effectively used in trauma patients because it is a CNS stimulant. It has indirect cardiovascular effects due to central stimulation of the sympathetic nervous system and inhibition of the reuptake of norepinephrine which is beneficial in acute shock.

Solution to Question 17:

Epidural anaesthesia is used to provide adequate analgesia which is the mainstay of treatment in patients with multiple rib fractures.

The complications can be minimized by adequate pain relief with epidural anaesthesia. Rib fracture patients will have the following complications due to splinting and pain:

• Hypoventilation

• Hypoxia

Other techniques to provide analgesia following rib fractures are intercostal nerve block and intrapleural block which necessitates multiple injections, which increases the risk for complications.

The complications include vascular puncture, pneumothorax, patient discomfort due to the need for palpation of the fractured rib during local anaesthetic (LA) administration. Also, LA toxicity can occur because of the high systemic absorption.

Option A: General Anaesthesia is more invasive to manage patient with multiple rib fractures and has potentially more side effects and complications than Epidural Anaesthesia. Endotracheal intubation as treatment is reserved only for patients who cannot maintain an airway or maintain sufficient oxygen saturation.

Option B: Spinal anaesthesia involves a high level of anaesthesia which is required to cover the thoracic dermatomes which would lead to high spinal or total spinal anaesthesia.

Option D: Infraclavicular block is a brachial plexus block that is used for the upper limbs.

Solution to Question 18:

General anaesthesia is preferred in this patient because of the insufficient block and patient discomfort associated with local anaesthesia.

Local anaesthesia may be suitable for simple procedures such as-

• Cauterization

• Polypectomy

• Turbinectomy

General anaesthesia may be used for the following procedures-

• Open nasal fracture reduction

• Septoplasty

• Rhinoplasty

Note- Closed nasal fracture reduction is performed with propofol sedation as the procedure is extremely painful.

Solution to Question 19:

Nitrous oxide is avoided in laser surgeries as it supports combustion.

Oxygen concentration should be limited to the lowest, so as to maintain acceptable saturation levels to prevent the possibility of fire while using lasers.

Solution to Question 20:

Propofol is preferred for induction in patients undergoing stapedectomy or any ear surgery, especially the inner ear.

Surgeries that can be conducted with propofol as induction agent-

• Stapedectomy or stapedotomy

• Tympanoplasty

• Mastoidectomy

• Myringotomy with insertion of tympanostomy tubes

Solution to Question 21:

Nitrous oxide is avoided in middle ear surgeries.

This is because nitrous oxide can increase middle ear pressure as it can diffuse into air-containing cavities because it is more soluble in blood than nitrogen.

If nitrous oxide had been used in an overlay procedure, it would lead to pressure build-up inside the middle ear and displacement of the graft.

Solution to Question 22:

Muscle relaxants are avoided during a procedure of parotidectomy.

The most common surgery for pleomorphic adenoma is superficial parotidectomy with facial nerve dissection. It is essential to preserve the facial nerve and hence, nerve stimulators are used during the surgery to identify the facial nerve and its branches. This cannot be possible if muscle relaxation is present.

Solution to Question 23:

Oxymetazoline is the preferred topical vasoconstrictor in ENT surgeries due to the safety profile and easy availability of the drug.

0.05% solution is administered as 3 nasal sprays in each nostril before any nasal procedure. It should be avoided in patients who are on monoamine oxidase inhibitors as the interaction can result in high blood pressure.

Option B: Phenylephrine is an ° -adrenergic agonist topical vasoconstrictor. It can cause severe hypertension and blood pressure monitoring is required.

Option C: Cocaine has cardiovascular effects- it is sympathomimetic and when administered at a concentration of 4%, it inhibits the reuptake of norepinephrine at sympathetic nerve terminals thus making it unsafe in patients with coronary artery disease or those on monoamine oxidase inhibitors.

Option A: Lidocaine as such does not have vasoconstrictor properties but may be used with phenylephrine.

Solution to Question 24:

Phenylephrine cannot be used to achieve controlled hypotension during nasopharyngeal carcinoma surgeries.

Phenylephrine is a selective ° ■-adrenergic receptor agonist of the phenethylamine class and can cause an increase in blood pressure. Hence it cannot be used to achieve hypotensive anaesthesia in any procedures.

Solution to Question 25:

The medial rectus muscle is the most likely muscle to elicit bradycardia (oculocardiac reflex) when stimulated.

Traction on the extraocular muscles or pressure on the globe causes bradycardia, atrioventricular block, ventricular ectopy, or asystole and is known as oculocardiac reflex. In particular, it is seen with traction on the medial rectus muscle, but it can occur with stimulation of any of the orbital contents, including the periosteum.

Solution to Question 26:

Stimulation of any of the orbital contents can cause oculocardiac reflex.

Traction on the extraocular muscles or pressure on the globe causes bradycardia, atrioventricular block, ventricular ectopy, or asystole and is known as oculocardiac reflex. In particular, it is seen with traction on the medial rectus muscle, but it can occur with stimulation of any of the orbital contents, including the periosteum.

Solution to Question 27:

The most common complication seen in the procedure of retrobulbar block is retrobulbar haemorrhage.

The image shown above depicts the technique of retrobulbar block which is a regional anaesthesia technique used in ophthalmic surgery. It involves the injection of a local anaesthetic into the extraocular muscle cone. The needle penetrates the lower lid at the junction of the middle and lateral one-third of the orbit.

Solution to Question 28:

Retrobulbar blocks are not contraindicated in enucleation of the eyes.

The Retrobulbar block is a regional anesthesia technique used in ophthalmic surgical procedures which involves the injection of a local anesthetic into the extraocular muscle cone.

Solution to Question 29:

General anaesthesia is the ideal anaesthetic technique to be used in a person who has to undergo surgery for a penetrating eye injury.

Regional anaesthesia is relatively contraindicated in patients with penetrating eye injuries because injecting local anaesthetic behind the globe increases intraocular pressure and may lead to the expulsion of intraocular contents.

Therefore these patients require general anaesthesia—despite the increased risk of aspiration pneumonia when it is administered.

Solution to Question 30:

Ketamine should be avoided in a child presenting with open globe injury as it can increase intraocular pressure.

It usually raises arterial blood pressure and also does not relax extraocular muscles and may cause nystagmus and blepharospasm.

Solution to Question 31:

Continuous epidural anesthesia is the first choice for most patients with preeclampsia during labor, vaginal delivery, and cesarean section.

Pre-eclampsia patients have a risk of severe airway edema, which makes intubation difficult. Thus continuous epidural anesthesia is advantageous as it avoids the need for intubation. Besides, continuous epidural anesthesia can improve uteroplacental perfusion and also decrease catecholamine secretion.

But one major prerequisite for regional anesthesia in preeclamptic patients is normal platelet count and normal coagulation. Coagulopathy is a contraindication for regional anesthesia.

Minimal platelet count for regional anesthesia is 100,000/µL, but some cases can be taken up with a platelet count as low as 70,000/µL.

General anesthesia is indicated in patients with coagulopathy and in severe pre-eclampsia with complications.

Spinal anesthesia can be given in mild pre-eclampsia but hypotension associated with spinal anesthesia limits its use in moderate to severe pre-eclampsia.

Since the severity of pre-eclampsia or the type of delivery (vaginal or cesarean) is not mentioned, epidural anesthesia has an advantage over other techniques for above-mentioned reasons. Hence the best option here would be epidural anesthesia.

Solution to Question 32:

In DCR, the ratio of PRBC: fresh frozen plasma: platelets is 1:1:1.

Administering blood products in the appropriate ratios in order to facilitate resuscitation from trauma and avert trauma-induced coagulopathy is termed damage control resuscitation(DCR).

The rationale behind 1:1:1 ratio-

• The red blood cell component will improve oxygen delivery to ischemic tissues.

• Fresh frozen plasma improves clotting by providing clotting factors V and VIII and fibrinogen.

• Platelet transfusion is required if the platelet count is below 50,000 / high power field, significant blood loss or prolonged resuscitation.

Pediatric and Obstetric Anaesthesia

Question 1:

A 25-year-old woman was taken up for a cesarean section. Following the administration of spinal anaesthesia, she suddenly developed hypotension. Which of the following would be the vasopressor of choice for this patient?

a) Dopamine

b) Adrenaline

c) Ephedrine

d) Phenylephrine

Question 2:

In pregnant women who are administered general anaesthesia, which of the following is the most common cause for mortality?

a) Hypotension

b) Pulmonary aspiration

c) Arrhythmias

d) Amniotic fluid embolism

Question 3:

What is the rate of maternal mortality due to pulmonary aspiration in patients undergoing general anaesthesia?

a) 0.5%

b) 1%

c) 5%

d) 50%

Question 4:

Which of the following is the most commonly used IV induction agent in a patient requiring caesarean section?

a) Propofol

b) Thiopentone

c) Etomidate

d) Ketamine

Question 5:

A 24-year-old woman, G2P1L1, presents with features of placental abruption. If she has to be taken in for an emergency cesarean section, what will be the preferred anaesthetic technique?

a) General anesthesia

b) Spinal anesthesia

c) Epidural anesthesia

d) Caudal anesthesia

Question 6:

A 28-year-old woman, G3P2L2, with a history of LSCS, is brought to the ER with complaints of abdominal pain, hematuria, and vaginal bleeding. On examination, the patient is hypotensive along with foetal bradycardia and non-reassuring foetal heart rate tracing. Which of the following is the preferred IV induction agent?

a) Propofol

b) Thiopentone

c) Ketamine

d) Etomidate

Question 7:

Which of the following muscle relaxants will you prefer to conduct a cesarean section under general anaesthesia?

a) Vecuronium

b) Pipecuronium

c) Rocuronium

d) Succinylcholine

Question 8:

A 25-year-old primigravida is screaming in pain while being wheeled into the labour room at 2 am. On examination, her cervix is well-effaced and is 4 cm dilated. What is the preferred anaesthetic technique to ensure this patient has a painless labour?

a) Pudendal nerve block

b) Spinal anesthesia

c) Caudal anesthesia

d) Lumbar epidural

Question 9:

You observe a resident injecting a local anaesthetic to provide pain relief to a primigravida who is in labour. Which of the following is the local anaesthetic of choice in this case?

a) Lidocaine

b) Bupivacaine

c) Chloroprocaine

d) Cocaine

Question 10:

Which of the following drug combinations is preferred for providing epidural analgesia during labour?

a) Bupivacaine + epinephrine

b) Bupivacaine + fentanyl

c) Bupivacaine + neostigmine

d) Bupivacaine + clonidine

Question 11:

What is the concentration of bupivacaine you will use to provide labour analgesia, when used in combination with fentanyl?

a) 0.0625 %

b) 0.25%

c) 0.5%

d) 5%

Question 12:

To provide epidural analgesia during labour, what is the ideal concentration of epinephrine added to the local anaesthetic?

a) 1:10,000

b) 1: 1,00,000

c) 1: 2,00,000

d) 1: 4,00,000

Question 13:

In a patient scheduled for an elective caesarean section, what is the preferred anaesthetic technique used?

a) General anesthesia

b) Spinal anesthesia

c) Lumbar epidural

d) Paracervical block

Question 14:

A 20-year-old primigravida who is in her second trimester of pregnancy is scheduled for an open appendectomy. What is the preferred anaesthetic technique for this surgery?

a) General anesthesia

b) Spinal anesthesia

c) Epidural anesthesia

d) Caudal anesthesia

Question 15:

An elderly primigravida at 37 weeks of gestation develops bilateral pedal oedema. On examination, she has a BP of 148/92 mmHg and proteinuria of 400mg/day. Emergency LSCS has been scheduled for the patient. Which of the following anaesthetic techniques would be prefered in this patient?

a) General anesthesia

b) Spinal anesthesia

c) Lumbar epidural

d) Caudal anesthesia

Question 16:

A 30-year-old woman with coarctation of the aorta is admitted for elective caesarean section. Which of the following is the anaesthesia of choice?

a) Spinal anesthesia

b) Epidural anesthesia

c) General anesthesia

d) Local anesthesia with nerve blocks

Question 17:

Which of the following is false regarding neonates and their airways?

a) They are obligate nasal breathers.

b) Narrowest part of their larynx is the glottis.

c) Epiglottis is omega-shaped.

d) Their glottis lies at the level of C4 vertebrae.

Question 18:

A 4-year-old boy was rushed to the ER after he accidentally swallowed a small coin. The ENT surgeon has planned a rigid bronchoscopy to remove the coin. Which of the following drugs will you prefer for rapid sequence induction before the procedure?

a) Succinylcholine

b) Rocuronium

c) Vecuronium

d) Atracurium

Question 19:

Which of the following is not used for induction of anaesthesia in pediatric patients?

a) Halothane

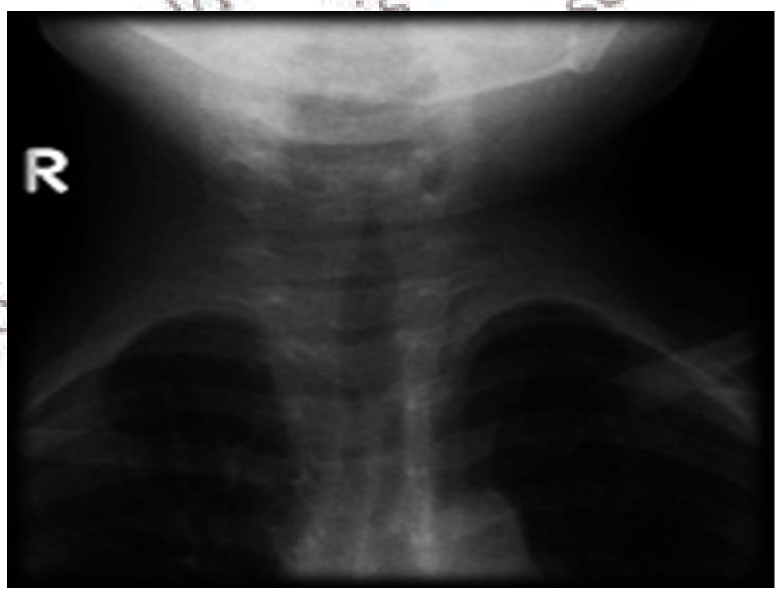
b) Sevoflurane

c) Desflurane

d) Nitrous oxide

Question 20:

A 5-year-old child was brought to the local clinic in a remote village with a high fever for the past 2 days. It was associated with a barking cough. His neck radiograph is given below. In case a laryngoscopy has to be done, what will be the preferred induction agent?



a) Nitrous oxide

b) Halothane

c) Sevoflurane

d) Desflurane

Question 21:

In a child with temporal lobe epilepsy, which of the following anaesthetic agents should be avoided?

a) Thiopentone

b) Methohexitone

c) Propofol

d) Ketamine

Question 22:

Which of the following is the most commonly used opioid in children?

a) Morphine

b) Meperidine

c) Fentanyl

d) Sufentanil

Question 23:

A 6-week-old baby was brought to the OPD with a history of projectile, non-bilious vomiting. On abdominal examination, an olive-shaped mass was noted in the RUQ. After further evaluation, he was scheduled for surgical correction. Which of the following is true regarding his anaesthetic management?

a) Aspiration of gastric contents with an NG tube is not indicated

b) Cricoid pressure needs to be applied

c) Atropine has to be administered before giving suxamethonium

d) Mask ventilation is contraindicated

Question 24:

Which of the following is the preferred agent used as sedative premedication in pediatric anaesthesia?

a) Barbiturate

b) Diazepam

c) Midazolam

d) Propofol

Question 25:

Which of the following agents is not used for induction of anaesthesia in children?

- **a)** Halothane
- **b)** Sevoflurane
- **c)** Morphine
- **d)** Nitrous oxide

Question 26:

In which of the following cases is ketamine preferred as the induction agent?

- **a)** A 25-year old man with an open eye injury
- **b)** RTA case with head injury
- **c)** An elderly woman with sinusitis
- **d)** A case of stab injury with severe hypotension

Answer Key

Question No.	Correct Option
1	d
2	b
3	c
4	a
5	a
6	c
7	d
8	d
9	b
10	b
11	a
12	d
13	b

14	b
15	c
16	c
17	b
18	b
19	c
20	b
21	b
22	c
23	c
24	c
25	c
26	d

Detailed Explanations

Solution to Question 1:

Phenylephrine is the vasopressor of choice to manage hypotension caused by spinal anaesthesia in pregnancy.

Phenylephrine produces lesser fetal acidosis and has lesser fetal transfer than ephedrine. Ephedrine was recommended in the past; however, its use has declined since it is associated with fetal acidosis and base deficit.

Solution to Question 2:

Pregnant women who undergo general anaesthesia are at increased risk of mortality from pulmonary aspiration of gastric contents.

Other risk factors include failed intubation of the trachea and inadequate ventilation. General anaesthesia has a 1.7 times greater risk of maternal morbidity and mortality than regional anaesthesia. Maternal mortality associated with aspiration is 5-15%.

Mendelson's syndrome is chemical pneumonitis or aspiration pneumonitis caused by aspiration during anaesthesia, especially during pregnancy.

Solution to Question 3:

Maternal mortality associated with aspiration in patients under general anaesthesia is 5-15%.

Mendelson's syndrome is chemical pneumonitis or aspiration pneumonitis caused by aspiration during anesthesia, especially during pregnancy. The risk factors include:

- Gastric volume >25 mL (0.4 mL/kg)
- Gastric pH < 2.5

Measures to reduce the incidence of aspiration:

- Administration of nonparticulate antacids like sodium citrate
- H2 receptor antagonists like intravenous ranitidine
- Metoclopramide

Solution to Question 4:

Propofol is the most common intravenous induction agent used in general anesthesia for cesarean delivery.

Propofol can induce unconsciousness in approximately 45 seconds. Its administration does not affect neonatal Apgar scores with typical intravenous induction doses (2-2.5 mg/kg). Repeated or larger cumulative doses (9 mg/kg) are associated with significant newborn depression.

Other options:

Option B: Thiopentone was the most commonly used agent for induction before the introduction of propofol.

Option C: Etomidate is not used as it can induce seizures in patients with reduced seizure thresholds. It is also associated with a higher incidence of nausea and vomiting.

Option D: Ketamine is the preferred agent for patients with hemodynamic compromise as it helps maintain arterial pressure, heart rate, and cardiac output due to central stimulation of the sympathetic nervous system.

Solution to Question 5:

General anaesthesia is the preferred anaesthetic technique of choice in an emergency LSCS in a patient with placental abruption considering the emergency nature of the surgery and the possibility of hemodynamic instability due to massive blood loss.

Advantages of General anaesthesia include:

- A very rapid and reliable onset
- Control over the airway and ventilation
- More comfortable for patients who have morbid fears of needles or surgery
- Less incidence of hypotension as compared to regional anaesthesia.

General anaesthesia is preferred in emergency conditions such as:

- Massive bleeding (placenta previa or accreta, abruption placentae, or uterine rupture)

• Coagulopathy

• Hemodynamic instability

• Severe fetal distress.

Disadvantages/risks of general anaesthesia:

• Pulmonary aspiration of gastric contents

• Difficult or failed intubation

• Drug exposure to the fetus.

Solution to Question 6:

The given clinical scenario is suggestive of hemodynamic compromise secondary to uterine scar dehiscence. Ketamine is the preferred induction agent in this patient.

Ketamine is the preferred induction agent for patients with hemodynamic compromise as it helps maintain arterial pressure, heart rate, and cardiac output due to sympathetic stimulation and norepinephrine reuptake inhibition.

Other properties of ketamine are:

• Dissociative anesthesia with profound analgesia

• Preserves laryngeal and pharyngeal reflex

• Does not depress respiration

• Bronchial dilatation

Options A and B: Propofol and thiopentone cause hypotension following induction.

Option D: Etomidate, although cardiostable causes a mild reduction in peripheral vascular resistance that is responsible for a slight decline in arterial blood pressure.

Solution to Question 7:

Succinylcholine will be the preferred muscle relaxant in the given scenario.

Pregnancy is considered to be a state of 'full stomach' and therefore rapid sequence induction is preferred when undergoing procedures under general anaesthesia.

Succinylcholine is the preferred muscle relaxant in rapid sequence induction due to its following properties:

• Rapid onset (30-45 seconds)

• The short duration of action (metabolized by pseudocholinesterase)

• Highly ionized and poorly lipid-soluble (lower placental transfer to foetus).

Rocuronium can be used as an alternative to succinylcholine. It is the non-depolarizing neuromuscular blocking agent of choice for rapid sequence induction. It has a rapid onset(<60 seconds) and its duration of action can be terminated by the reversal agent sugammadex. But the use of rocuronium is associated with lower Apgar scores at 1 minute when compared with succinylcholine.

Solution to Question 8:

Lumbar epidural is the most commonly used technique to produce labour analgesia because it can provide analgesia during the first stage of labour and also provide anaesthesia during vaginal delivery or cesarean section if necessary.

For adequate pain relief, the sensory block of T10-L1 is required during the first stage of labour and S2-S4 is required during the second stage. The epidural catheter placed at L3-L4 or L4-L5 interspace sufficiently provides T10–S5 neural blockade.

Option A: Pudendal nerve block is given in the second stage of labor just before delivery of the baby to provide analgesia to the vulva and anus . However, it has no effect on the pain of contractions. It is also given before repair of episiotomy or perineal lacerations.

Option B: Spinal anaesthesia for labour analgesia has the advantage of a rapid and reliable onset of the neural blockade, and it is technically easier to administer compared to epidural analgesia. However, repeated intrathecal injections may be required for a prolonged labour, thus increasing the risk of post-dural puncture headache.

Option C: Caudal epidural is largely abandoned to provide pain relief in obstetrics. It requires large volumes of a local anaesthetic to anaesthetize upper lumbar and lower thoracic dermatomes to provide adequate labour analgesia. Though rare, accidental puncture of the fetus is a possibility.

Solution to Question 9:

Bupivacaine is the preferred local anaesthetic (LA) agent for labour analgesia.

Bupivacaine is preferred over lidocaine, chloroprocaine, and cocaine for labour analgesia because of its following properties:

• Differential blockade (less motor blockade as compared to sensory blockade). This preferred motor function is useful as voluntary push down efforts by the patient may lead to better delivery outcomes.

• Long duration of action (infrequent top-ups).

Solution to Question 10:

The preferred combination used for epidural analgesia during labour is bupivacaine with fentanyl.

This is because, doses of local anaesthetics can be reduced by combining them with opioids like fentanyl or sufentanil.

The lesser concentration of local anaesthetic used leads to greater preservation of motor function and makes ambulation of the patient possible (walking or mobile epidural). Also, by reducing the concentration of the drugs, adverse effects like hypotension and drug toxicity are minimized.

Solution to Question 11:

The concentration of bupivacaine used to provide labour analgesia, when used along with fentanyl is 0.0625%.

The required doses of local anaesthetics can be reduced if it is used in combination with opioids like fentanyl or sufentanil.

Concentration of LA used in epidural:

The dose of opioid used in epidural:

• Fentanyl : 2–3 mcg/mL

• Sufentanil: 0.3–0.5 mcg/mL

Drug	Concentrations	
	Without opioid	With opioid
Bupivacaine	0.25%	0.0625-0.125%
Ropivacaine	0.2%	0.0625-0.2%

Solution to Question 12:

Very dilute concentration of epinephrine (1:400,000 to 1:800,000) is used along with local anaesthetics for labour epidural analgesia.

Epidural epinephrine can provide vasoconstriction which would delay the vascular uptake of local anaesthetic and opioid. Additionally, it can activate ° 2-adrenergic receptors and thus produce analgesia on its own.

Epinephrine, used along with local anaesthetics at a concentration of 5 µg/mL or 1:200,000 may be associated with uterine artery vasoconstriction which can adversely affect the fetus and delay the progress of labour. Hence epinephrine at this dose is used only for test dose (15 µg/mL or 3 ml of 1:200,000). A test dose is given to rule out the intravascular placement of epidural catheter following the procedure.

Solution to Question 13:

Spinal anaesthesia is preferred over other techniques for an elective cesarean section.

Advantages of spinal anaesthesia over general anaesthesia:

• Less neonatal exposure to potentially depressant drugs

• A decreased risk of maternal pulmonary aspiration

• An awake mother at the birth of her child

• Spinal opioids can be used for postoperative pain relief

Advantages of spinal anaesthesia over epidural anaesthesia:

• Rapid and predictable block

• Complete block (lesser failure rate)

• Lesser risk of systemic toxicity or high spinal due to accidental intravascular or intrathecal injection seen with epidural anesthesia

• More cost-effective

Paracervical block is used for labour analgesia, but not for elective cesarean section. Side effects include transient fetal bradycardia, maternal local anaesthetic toxicity, and accidental injection of local anaesthetic into the presenting fetal head.

Solution to Question 14:

Spinal anesthesia is preferred over other techniques for the appendectomy in the second trimester. Total anesthetic drug exposure is least with spinal anesthesia over others.

General anesthesia is associated with a greater risk of:

• Pulmonary aspiration of gastric contents

• Difficult or failed intubation

• Drug exposure to the fetus

Epidural anesthesia has the risk of:

• Accidental intravascular injection

• Accidental intrathecal injection

Although spinal anesthesia is preferred in most situations, the choice between general anesthesia and spinal anesthesia is to be individualized. In general, spinal anesthesia is appropriate for open appendectomies and general anesthesia for laparoscopic appendectomies.

Solution to Question 15:

Epidural anaesthesia is the preferred anaesthetic technique in this patient who is likely to be suffering from preeclampsia.

Epidural anaesthesia is the first choice anaesthetic technique for patients with pre-eclampsia during labour, vaginal delivery, and cesarean section. One major prerequisite for its usage is normal platelet count (minimum 100,000/µL) and normal coagulation.

It has been shown to decrease catecholamine secretion and improve uteroplacental perfusion up to 75% in these patients, provided hypotension is avoided.

Option A: General anaesthesia is indicated in patients with coagulopathy and in severe pre-eclampsia with complications.

Option B: Spinal anaesthesia can be given in mild pre-eclampsia but hypotension associated with spinal anaesthesia limits its use in moderate to severe pre-eclampsia.

Option D: Caudal anaesthesia is generally unpopular in obstetric anaesthesia because of painful needle placement, high failure rates, potential contamination at the injection site, and risks of accidental fetal injection.

Solution to Question 16:

General anaesthesia is the technique of choice for elective caesarean section in a patient with coarctation of the aorta.

In coarctation of the aorta, any decrease in cardiac output or cardiac return is deleterious to the fetus because the placental circulation is already compromised on account of coarctation.

Regional anaesthesia should be avoided in the patient with coarctation of the aorta because hypotension is the most common side effect of these anaesthesias.

Local anaesthesia with nerve blocks does not provide adequate anaesthesia for caesarean section.

Solution to Question 17:

The cricoid cartilage is the narrowest point of the airway (larynx is funnel-shaped) in children under 5 years of age.

In adults, it was earlier believed that the narrowest part of the airway is the glottis. But, now it has been discovered that the subglottic region at the level of the cricoid cartilage is the narrowest portion in about 70% of adults.

Salient features of pediatric airway:

• Neonates are obligate nasal breathers (up to 5 months).

• Nasal passages are narrower.

• Larger tongue in relation to the oropharynx (airway obstruction and difficult intubation may be a problem).

• The larynx is placed higher in the neck (the glottis is at a vertebral level of C4 versus C6 in adults), so straight laryngoscope blades are preferred.

• A short, omega-shaped epiglottis, and a shorter trachea and neck.

• Vocal cords are angulated and so if a tracheal tube is passed blindly instead of passing into the trachea it could lodge in the anterior commissure.

Solution to Question 18:

Rocuronium is considered to be the drug of choice to provide muscle relaxation during routine rapid sequence induction or intubation in pediatric patients with foreign body aspiration.

It has a faster onset and can be administered intramuscularly. Its long duration of action is a disadvantage. Sugammadex is a specific reversal agent that can terminate the action of rocuronium.

Option A: Succinylcholine is used for rapid sequence induction of anaesthesia because of its rapid onset and ultra-short duration of action. It is the shortest acting muscle relaxant but it is not used for routine intubation in children due to its many adverse effects like rhabdomyolysis, hyperkalemia, cardiac arrhythmias, and malignant hyperthermia.

Option C: Vecuronium action is prolonged in small children due to immature hepatic and renal function.

Option D: Atracurium or cisatracurium may be preferred in young infants, particularly for short procedures, because they undergo Hoffman elimination leading to a short duration of action. Besides, they do not require intact hepatic and renal functions.

Solution to Question 19:

Desflurane is a highly pungent gas and can produce laryngospasm if used for inhalational induction. Hence it is not used as an induction agent.

The incidence of laryngospasm following desflurane induction is almost 50%. It is usually used for maintenance of anaesthesia only and is of particular value in obese patients, neurosurgical and spinal fusion procedures where rapid awakening is required for neurological function assessment.

Option A: Halothane is hepatotoxic but can be used (Sevoflurane is preferred)

Option B: Sevoflurane is the preferred inhalational agent for induction in the pediatric age group. Cardiovascular depression, bradycardia, and arrhythmias are less frequent with sevoflurane than with halothane and hence the former is preferred.

Option D: Nitrous oxide has the highest minimum alveolar concentration and so it is the least potent. It is used in combination with other potent inhaled anaesthetics to reduce their dose. It can be used to hasten the induction of anaesthesia along with other induction agents.

Solution to Question 20:

The clinical features and neck radiograph (steeple sign) are suggestive of laryngotracheobronchitis (croup) in the child and halothane is the preferred agent used for induction in this condition.

Normally sevoflurane and halothane are agents used for induction in children. But in a child with airway obstruction like croup (laryngotracheobronchitis), rapid induction is contraindicated.

To perform laryngoscopy and tracheal intubation in such children, slow induction of anaesthesia is required before the child becomes sufficiently anaesthetized. Moreover, halothane has a slower excretion than sevoflurane, which provides sufficient time for airway management.

The therapeutic index of sevoflurane is higher than halothane (myocardial depression, sensitization of the myocardium to arrhythmias, halothane hepatitis) and hence is preferred for routine cases. However in certain underdeveloped countries, due to its cost-effectiveness, halothane is preferred.

Solution to Question 21:

Methohexitone has the potential to cause seizures, hence it is avoided in children with temporal lobe epilepsy.

Intravenous administration of methohexitone can cause burning, hiccups, apnea, and extrapyramidal-like movements. Due to its potential to cause seizures, it is used to therapeutically induce seizures in electroconvulsive therapy in adults.

Option D: Ketamine is contraindicated in patients with increased intracranial tension and better avoided in epileptic patients due to ketamine-induced myoclonic and seizure-like activity.

Options A and C: Propofol and thiopentone have anti-convulsant property.

Note: This is a controversial MCQ. Among the above options, methohexitone is the most specific answer.

Solution to Question 22:

Fentanyl is the most commonly used opioid in infants and children due to its rapid onset and short duration of action.

Termination of its effects is due to rapid redistribution and elimination. It has the advantage of maintaining cardiovascular stability while providing anaesthesia. But, fentanyl induced bradycardia may require treatment with atropine/glycopyrrolate since the cardiac output of neonates is determined by the heart rate.

Option A: Morphine leads to greater respiratory depression in neonates due to slower clearance of morphine.

Option B: Meperidine / Pethidine is not used in children since long term or repeated administration of the drug leads to seizures due to the accumulation of its metabolite-normeperidine.

Option D: Sufentanil is usually preferred for cardiac anaesthesia.

Solution to Question 23:

The clinical scenario is suggestive of pyloric stenosis and the child should be pretreated with atropine if suxamethonium is used during the surgery.

For surgical repair in children with pyloric stenosis, either of the following two techniques can be done:

• Rapid-sequence induction - if suxamethonium (2mg/kg) is used, atropine (0.02 mg/kg) should be given because children are more susceptible than adults to bradycardia and sinus node arrest associated with suxamethonium.

• Awake intubation - preserves airway reflexes

The classically described rapid sequence technique (preoxygenation, cricoid pressure, and avoiding mask ventilation) is not appropriate for an infant with pyloric stenosis.

Opton A: Aspiration of gastric contents is done by suctioning with a wide bore vented catheter before induction of anaesthesia to remove 98% of gastric contents.

Option B: Cricoid pressure can distort the anatomy making laryngoscopy difficult, hence avoided. If it is applied and there is no clear view of the larynx then the pressure should be relaxed.

Option D: Infants rapidly desaturate compared to adults due to greater oxygen consumption and smaller functional residual capacity. This means that gentle bag-mask ventilation is required prior to laryngoscopy to avoid hypoxemia and bradycardia.

Solution to Question 24:

The preferred sedative premedication in children is midazolam.

It is preferred as it has a shorter elimination half-life (2 hours) and has the advantage of producing anterograde amnesia. It is water-soluble and hence painless on injection. It is usually administered to children 10 to 12 months or older because of separation anxiety from parents.

Other sedative premedications that are sometimes used include dexmedetomidine, clonidine, temazepam and ketamine.

Option A: Barbiturates are not commonly used for premedication in children since the availability of short-acting benzodiazepines. A major disadvantage is hyperalgesia, which can induce agitation in children with pain.

Option B: Diazepam has a longer elimination half-life (18 hours) and immature liver function that would prolong its action in young children.

Option D: Propofol is the most useful sedative-hypnotic drug but is not approved for this use in pediatric patients.

Note- Ketamine is effective as a sedative, but it can increase oral secretion and can cause hallucinations during recovery. Hence oral ketamine is usually avoided, and when used, is administered along with antisialogogue (atropine/glycopyrrolate) and a benzodiazepine (such as midazolam).

Solution to Question 25:

Morphine is not commonly recommended for induction of anaesthesia in children, especially below the age of 6 months.

Most commonly used induction agents in children:

Inhalational agents:

- Nitrous oxide
- Halothane
- Sevoflurane

Intravenous agents:

- Propofol
- Thiopentone
- Etomidate
- Ketamine

Solution to Question 26:

Ketamine is the agent of choice for induction of anesthesia in patients with hypovolemia.

It helps to maintain arterial pressure, heart rate, and cardiac output via central stimulation of the sympathetic nervous system and inhibition of the reuptake of norepinephrine.

The following are contraindications for ketamine:

- Active upper respiratory infection (URI)
- Increased intracranial pressure
- Open-globe injury (only intravenous induction agent which raises intraocular pressure)
- Psychiatric or seizure disorder

Complications of Anaesthesia

Question 1:

Which of the following drugs would you avoid in a patient with a high risk of postoperative nausea and vomiting?

a) Dexamethasone

b) Propofol

c) Nitrous oxide

d) Ondansetron

Question 2:

Which of the following should you suspect as the most common anaphylactic agent during anesthesia?

a) Antibiotics

b) Propofol

c) Latex

d) Rocuronium

Question 3:

The use of which of the following drugs is unlikely to trigger an anaphylaxis reaction in a patient?

a) Rocuronium

b) Procaine

c) Furosemide

d) Fentanyl

Question 4:

A 67-year-old patient underwent a CABG procedure. He started shivering within 15 minutes of shifting him to the post-operative ward. His temperature was 35.5-degrees Celcius. Which of the following agents can be used to treat this patient?

- **a)** 2, 3 and 5
- **b)** 2 only
- **c)** 1, 4 and 5
- **d)** 1, 2, 4 and 5

Question 5:

The most common preventable cause of anesthetic mishaps is:

- **a)** Faulty laryngoscope
- **b)** Ventilator dysfunction
- **c)** Anesthetic machine malfunction
- **d)** Human errors

Question 6:

During the pre-op counselling of a patient set to undergo a day care procedure, which of the following would you mention as the most common adverse effect following daycare anaesthesia?

- **a)** Myalgia
- **b)** Drowsiness
- **c)** Sore throat
- **d)** Headache

Question 7:

Which of the following is not a risk factor for postoperative pulmonary complications?

- **a)** BMI > 30
- **b)** Well controlled asthma
- **c)** Upper abdominal surgery
- **d)** Age > 70 years

Question 8:

Which of the following is the most common cause of perioperative vision loss?

a) Globe perforation

b) Angle closure glaucoma

c) Retinal emboli

d) Ischemic optic neuropathy

Question 9:

You notice your surgery chief informing the anesthesia junior resident to place the forearm of the patient in a supinated position so as to avoid a common peripheral nerve injury. Which nerve injury is he most likely concerned about?

a) Radial nerve

b) Ulnar nerve

c) Posterior interosseous nerve

d) Anterior interosseous nerve

Question 10:

You have been posted as an army medical officer in a military base. Your battalion has suffered injuries from grenade attacks and sustained multiple burns. Which would be the fluid of choice for resuscitating them in the initial 24 hours?

a) Hypertonic saline

b) Ringer lactate

c) Albumin

d) Dextran

Question 11:

A young adult was injured in a steam boiler explosion at his factory. He was rushed to the burns centre with multiple injuries covering 40% of his total body surface area (TBSA). He weighs around 70kg. The volume of fluids to be administered in the first 8 hours is _____.

a) 4 L

b) 3 L

c) 7.5 L

d) 5.6 L

Question 12:

An adult with burns requires treatment with IV fluids if the percentage of burns exceeds

a) 10%

b) 20%

c) 15%

d) 25%

Question 13:

A 30-year-old sous-chef was trapped in a restaurant fire due to a gas line leak. She was rescued and brought to the casualty by EMS. On examination, 55% of her total body surface area (TBSA) was covered in full-thickness burns. What is the total volume of fluid resuscitation required in this patient according to the Parkland formula if she weighs 65kg?

a) 22.4 Litres

b) 12.5 Litres

c) 14.3 Litres

d) 15.4 Litres

Question 14:

Which of the following is not a colloid solution?

a) Plasmalyte

b) Gelatin

c) Albumin

d) Hydroxyethyl starch

Question 15:

A 23-year-old carpenter severed two of his fingers while working with a power saw. He is brought to the casualty by his friend who had preserved the severed fingers in a small box with ice. The hand surgeon takes him up for a reconstructive procedure. Which fluid does he request the nurse to arrange for the surgery?

a) Dextran 40

b) Dextran 70

c) Hydroxyethyl starch

d) Gelatin

Question 16:

Which of the following solutions is hypotonic?

a) Normal saline

b) 5% dextrose

c) Ringer lactate

d) 3% Nacl

Question 17:

A 32-year-old man involved in a road traffic accident is brought to the casualty. The patient is bleeding and is hypovolemic. Which of the following blood groups can be used for an emergency transfusion in this patient?

a) O +ve

b) O –ve

c) AB +ve

d) AB –ve

Question 18:

A patient involved in a road traffic accident is brought to the casualty. The patient is hypotensive and is transfused with multiple units of Ringer lactate followed by 10 units of PRBC's. Within a few hours, he starts bleeding from the gums. He also has petechiae and ecchymoses all over his body. What is the most likely cause for this bleeding?

a) ABO incompatibility

b) Rh incompatibility

c) Dilutional thrombocytopenia

d) Pre-existing Hemophilia

Question 19:

A patient needs to undergo a packed red blood cell (PRBC) transfusion due to severe anemia. Before administration, you must make sure the unit of PRBC is at a temperature of_______.

a) 20°C

b) 6°C

c) 24°C

d) 37°C

Question 20:

Which blood component is associated with the maximum risk of bacterial contamination?

a) Packed red blood cells

b) Platelet concentrates

c) Fresh frozen plasma

d) Whole blood

Question 21:

Post-blood transfusion syphilis is most likely related to the use of which blood product?

a) Whole blood

b) Packed red cell concentrate

c) Platelet concentrate

d) Fresh frozen plasma

Question 22:

In blood component therapy, hematocrit of packed red blood cell component is:

a) 20%

b) 40%

c) 70%

d) 100%

Question 23:

Irradiation of granulocytes before transfusion reduces all of the following except

a) Graft versus host disease

b) Febrile reactions

c) Re-perfusion injury

d) Acute hemolytic reaction

Question 24:

The incidence of anaphylactoid reactions is least with

a) Gelatin

b) Haemaccel

c) Hydroxyethyl starch

d) Dextran

Question 25:

The highest incidence of anaphylactic reactions is seen with

a) Albumin

b) Gelatin

c) Hydroxyethyl starch

d) Dextran

Question 26:

Which of the following anesthetic agent should be avoided in a patient with prior history of malignant hyperthermia ?

a) Desflurane

b) Propofol

c) Etomidate

d) Ketamine

Question 27:

Which of the following drugs can trigger malignant hyperthermia?

a) Succinyl choline
b) Halothane
c) Enflurane
d) All of the above

Question 28:

Which of the following is not an early sign of malignant hyperthermia?

a) Hyperthermia
b) Tachycardia
c) Masseter spasm
d) Elevated end tidal carbon dioxide

Question 29:

Which of the following is not included in the treatment for malignant hyperthermia?

a) Stop the triggering anesthetic
b) Administer dantrolene reconstituted with saline
c) Cold intravenous fluids
d) Administer bicarbonate

Answer Key

Question No.	Correct Option
1	c
2	a
3	d
4	d

5	d
6	b
7	b
8	d
9	b
10	b
11	b
12	b
13	c
14	a
15	a
16	b
17	b
18	c
19	d
20	b
21	c
22	c
23	d
24	c
25	b
26	a
27	d
28	a
29	b

Detailed Explanations

Solution to Question 1:

Nitrous oxide is associated with postoperative nausea and vomiting (PONV). Hence it is avoided in patients at high risk of PONV.

PONV has an incidence of 20-30% in general surgical population and 70-80% in those with predisposing risk factors.

Risk factors for PONV:

• Patient-specific: Female gender, non-smoking status, history of motion sickness/PONV

• Anesthetic-specific: Nitrous oxide, volatile anesthetics, opioids

• Surgery-specific: Increased duration of surgery, type of surgery

Drugs used in the prophylaxis and treatment of PONV:

• 5-HT 3 antagonists - ondansetron, palonosetron

• Butyrophenones- droperidol

• Dexamethasone

• Transdermal scopolamine

Note: Propofol has antiemetic property and thus reduces the risk of PONV.

Solution to Question 2:

Antibiotics are the most common anaphylactic agents during anesthesia.

The most common agents precipitating anaphylactic reactions are antibiotics> neuromuscular blocking agents. Penicillins and cephalosporins are the most common causes of anaphylaxis among antibiotics.

Solution to Question 3:

The use of fentanyl is unlikely to cause an anaphylactic reaction. True allergic reactions to opioids like fentanyl are very rare.

The most common cause of anaphylactic reactions during anesthesia is antibiotics (especially penicillin and cephalosporin), followed by neuromuscular blockers (rocuronium).

Amino ester local anesthetics (procaine) exhibit allergic reactions due to the metabolite PABA. Sulfa drugs like sulfonamide antibiotics, furosemide, hydrochlorothiazide, and captopril also exhibit allergy in surgical patients.

Solution to Question 4:

The clinical features are suggestive of postoperative hypothermia and shivering in this patient. Remifentanil is known to cause postoperative shivering when given in high doses and has no role in the treatment of this patient.

Postoperative hypothermia is defined as a core temperature < 36°C. Postoperative shivering is usually, but not always, associated with hypothermia. The primary cause of postoperative shivering is perioperative hypothermia. The most efficient way to reduce post-anaesthetic shivering is to prevent hypothermia by avoiding cold epidural and intravenous fluids.

Treatment-

• Meperidine is the most effective treatment for post-anesthetic hypothermia and shivering.

• Opioids(Tramadol), ondansetron, clonidine, physostigmine and ketamine have been shown to be effective in abolishing shivering.

• Intraoperative infusion of dexmedetomidine has been shown to be an effective prophylactic.

Solution to Question 5:

The most common preventable cause of anesthetic mishaps is human error.

Common human errors include:

• Unrecognized breathing circuit disconnection

• Mistaken drug administration

• Airway mismanagement

• Anesthesia machine misuse

• Fluid mismanagement

• Intravenous line disconnection

Equipment malfunctions that can cause preventable anesthetic accidents are:

• Breathing circuit malfunction

• Monitoring device malfunction

• Ventilator dysfunction

• Anesthesia machine malfunction

• Faulty laryngoscope

Unpreventable mishaps include sudden death syndrome and fatal idiosyncratic drug reactions.

Solution to Question 6:

The most common adverse effect persisting following day-care anaesthesia is drowsiness.

Adverse effects after day-care anesthesia-

• Drowsiness(most common)

• Sore throat

• Myalgia

• Headache

• Dizziness

• Nausea and vomiting

Cardiovascular adverse effects -

• Hypotension

• Hypertension

• Arrhythmias

• Cardiac arrest

Respiratory complications -

• Hypoxemia

• Laryngospasm

• Bronchospasm

• Aspiration

• Pulmonary edema

• Pneumothorax (rare)

Solution to Question 7:

Well-controlled asthma is not a risk factor for postoperative pulmonary complications.

Risk factors for postoperative pulmonary complications:

• Age >70 years

• COPD (uncontrolled)

• Neck, upper abdominal, Aortic, neurologic surgical procedures

• Prolonged procedure >2 hours

• General anesthesia with intubation

• BMI > 30

• Albumin concentration < 35 g/L

• Inability to walk two blocks on level land or one flight of stairs

Solution to Question 8:

Ischemic optic neuropathy is the most common cause of perioperative vision loss.

It is usually seen after spine surgeries in the prone position, radical neck dissections and following cardiopulmonary bypass.

Symptoms: Reduced visual acuity, rarely complete blindness; usually presents on awakening from anesthesia.

Preoperative risk factors:

• Diabetes, hypertension

• Smoking

• Coronary artery disease.

Intraoperative risk factors:

• Anaemia

• Hypotension

• Prone position

• Prolonged duration of surgery

Solution to Question 9:

The surgeon is concerned about injury to the ulnar nerve which can be prevented by positioning the forearm in supination compared to pronation. The ulnar nerve is the most commonly injured peripheral nerve following anesthesia.

Other commonly injured nerves include

• Peroneal nerve

• Brachial plexus

• Common peroneal nerve

• Sciatic nerves

Solution to Question 10:

The fluid of choice for resuscitation in burns patients is Ringer lactate in the first 24 hours followed by albumin and 5% dextrose.

This is in contrast to blunt and penetrating trauma patients in whom colloids (albumin, hydroxyethyl starch) hypertonic saline, and blood are preferred.

Solution to Question 11:

The patient needs to be resuscitated with 3L of fluid (ringer lactate) over the first 8 hours. According to ATLS 10th edition 2018, the resuscitation formula used in thermal burns is 2 mL/kg × % total body surface area (TBSA) over 24 hours.

Half the volume over the first 8 hours: 1 mL/kg × % TBSA

Remaining volume over the next 16 hours: 1 mL/kg × % TBSA

In the given question for a patient who weighs 70 kg, with a TBSA of 40%, 1×70×40= 2800 mL ~ 3L of fluid will be needed in the first 8 hours.

Solution to Question 12:

IV fluids are usually administered for deep partial and full-thickness burns larger than 20% TBSA in adults.

Fluid resuscitation in burns

According to ATLS 10th edition, 2018, the resuscitation formula used in thermal burns is 2 mL/kg × % TBSA.

First 8 hours: 1 mL/kg × % TBSA (lactated Ringer solution)

Next 16 hours: 1 mL/kg × %TBSA (lactated Ringer solution)

Solution to Question 13:

The patient needs to be resuscitated with 14.3 Litres of fluids. Fluid resuscitation in a burns patient is estimated using the Parkland formula.

Parkland's formula:

• Total percentage body surface area × weight (kg) × 4 = volume (mL).

• 55% x 65kg x 4ml = 14.3 Litres of fluids need to be administered in the next 24 hours

• Half of the calculated volume should be administered in the first 8 hours and the remainder over the following 16 hours.

Recent update:

According to ATLS 10th edition,2018, the resuscitation formula used in thermal burns is 2 mL/kg × % TBSA.

First 8 hours: 1 mL/kg × % TBSA (lactated Ringer solution)

Next 16 hours: 1 mL/kg × %TBSA (lactated Ringer solution)

Solution to Question 14:

Plasmalyte is a crystalloid solution that is iso-osmolar (osmolarity 294 mosm/L) with plasma. It can be used for fluid resuscitation for patients losing blood due to trauma or intraoperative procedures.

Composition of Plasmalyte:

• Na-140 meq/L

• Cl- 98 meq/L

• K- 5 meq/L

• Mg -3 meq/L

• Along with acetate and gluconate

The colloids are of two types:

• Blood-derived- human albumin and plasma protein fractions

• Semisynthetic- dextran, gelatin, hydroxyethyl starch

Solution to Question 15:

The surgeon most likely requests for Dextran 40 (colloid) which is the fluid ideally used in microvascular surgery, where its dilutional effects on blood viscosity and anticoagulant effects favour flow in the microcirculation.

Dextran is a highly branched polysaccharide produced by the bacterium Leuconostoc mesenteroides.

Solution to Question 16:

5% dextrose solution is hypotonic as its osmolarity is 252mosm/kg which is less than that of plasma (285mosm/kg).

5% dextrose (D5W solution):

• It contains 50g/L glucose

• Soon after infusion, the dextrose is taken up into the cell leaving behind free water

• Used for replacement of pure water deficits and as a maintenance fluid for patients on sodium restriction

• The predominant effect of D5W is cellular swelling and hemolysis due to hypotonicity

Normal saline:

• 0.9% NaCl is isotonic normal saline but this solution is neither chemically nor physiologically normal

• Contains 9 gram of NaCl per liter

• Due to high chloride concentration, the excessive infusion can lead to hyperchloremic metabolic acidosis

Ringer lactate:

• aka Hartman's solution.

• It is isotonic and is the most physiological solution.

• Should not be used as a diluent fluid for transfusion of PRBCs as it can precipitate and form clots

Hypertonic saline:

• 1.8%, 3% and 7.5% NaCl

• Particularly useful in the treatment of hyponatremia, volume resuscitation, and increased ICP.

	In mmo l/L	Na+	K+	HCO 3-	Cl-	Ca+	Other	osmola lity
Plasma		140	4.5	26	100	2.5	-	285-29 5
Crystalloid	0.9% sa line	154	-	-	154	-	-	310
5% dextrose	-	-	-	-	-	50g/L dextrose	250	
Ringer lactate	131	5	-	111	2	29mmol/L Lactate*	280	
4%dextrose/0.18% saline	30	-	-	30	-	40g/L dextrose	262	
Colloids	Gelofusi ne	154	0.4	-	120	0.4	40g/L gelat ine	274
Haemaccel	145	5	-	145	6.25	35 g/L Polygeline	301	
HES 6%	154	-	-	154	-	60g/LPoly(O-2-hydroxyeth yl)starch	310	
4.5% albumin	145	2	-	154	-	45g/L albumin	290	
Lactate metabolizes into bi carbonate in the liver								

Solution to Question 17:

The patient must be given an emergency blood transfusion with Type O Rh-negative blood (universal donor)

If the recipient's blood type and Rh status is not known with certainty and transfusion must be started before determination, type O Rh-negative (universal donor) red cells may be used.

Type O negative blood is preferred because it lacks the A and B and Rh antigens and thus it cannot be hemolyzed by anti-A, anti-B, or anti-D antibodies in the recipient's blood.

Solution to Question 18:

The most likely cause of bleeding in this patient who has received multiple PRBC transfusions is dilutional thrombocytopenia.

The most common cause of nonsurgical bleeding following massive blood transfusion is dilutional thrombocytopenia. Massive transfusion is most often defined as the need to transfuse one to two times the patient's blood volume. For most adult patients, that is the equivalent of 10–20 units.

Major trauma or blood loss will initiate a cascade of coagulation abnormalities, including a consumptive coagulopathy from tissue hypoperfusion as manifested by increased protein C levels. This coagulopathy is caused by a combination of factors, of which the most important are the dilution of coagulation factors by volume administration e.g., crystalloid, colloid, PRBC, and the duration of hypotension and hypoperfusion.

Concurrent transfusion of packed red cells, plasma, and platelets can be done to avoid dilutional coagulopathy.

Solution to Question 19:

PRBC transfusion is to be done after warming it to a temperature of 37°C.

Packed RBCs are stored at 1-6°C. Transfusion at this temperature will lead to profound hypothermia. If the body temperature decreases to less than 30°C, ventricular irritability and cardiac arrest may occur. Shivering from even mild hypothermia increases metabolic demands and is counterproductive to tissue perfusion, especially in settings where anemia or hypoperfusion is contributing to tissue ischemia.

Hypothermia together with low levels of 2,3-diphosphoglycerate (2,3-DPG) in stored blood can cause a marked leftward shift of the hemoglobin–oxygen dissociation curve which can lead to tissue hypoxia.

The ideal method of warming blood is to pass it through plastic coils or cassettes in a warm water bath(37°C to 38°C) or warming plates.

Solution to Question 20:

The blood component with a maximum risk of bacterial contamination is platelet concentrates as they are stored at room temperature of 20°C-24°C. Hence, they are at maximum risk of bacterial overgrowth and consequent sepsis.

With the incidence of 1 in 2000, any fever occurring within 6 hours of a platelet transfusion is likely to be sepsis from the use of stored platelets.

Solution to Question 21:

Post blood transfusion syphilis is most likely related to the use of platelet concentrate.

The causative agent of syphilis, Treponema pallidum, cannot survive in storage at 10 to 16°C. So, it does not survive in most blood components except platelet concentrates, because platelets are stored at room temperature.

Solution to Question 22:

Packed red blood cell (PRBC) component has a hematocrit of 70%.

Salient points on PRBCs:

• Obtained after centrifugation of whole blood.

• One unit of whole blood yields 250 mL of packed red cells with a hematocrit of 70%

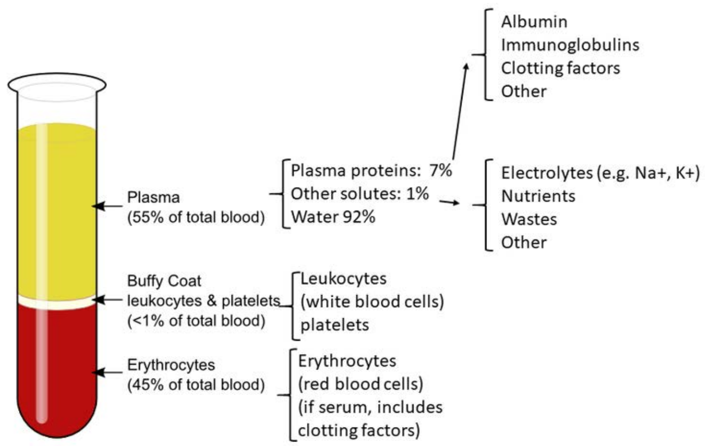
• Saline preservative is added to this bringing a total volume of 350 mL

• This is stored at 1-6°C.

• Blood with some rare phenotypes can be stored by freezing the packed cells in hypertonic glycerol solution, which makes it available for 10 years.

• Each unit of PRBC is expected to raise hemoglobin by 1 g/dL

The image given below shows the components of whole blood.



Solution to Question 23:

Irradiation of granulocytes before transfusion does not reduce acute hemolytic reaction as it is due to attack on the transfused donor RBCs by recipient's antibodies and complements.

Similarly, the risk of bacterial contamination of platelets and transfusion-related acute lung injury (TRALI) has not decreased with leukoreduction.

Irradiation of granulocytes or use of leukoreduced blood components has several advantages over the use of packed red blood cells:

• Decreased risk of graft versus host disease-which is due to engraftment of donor lymphocytes from the transfused blood products leading to an immune reaction against recipient tissues

• Reduces chances of febrile reactions

• Decreases re-perfusion injury (myocardium; after heart by-pass)

• Decreases transmission of cytomegalovirus

Solution to Question 24:

The incidence of anaphylactoid reactions is least with hydroxyethyl starch.

The colloids are of two types:

• Blood-derived- human albumin and plasma protein fractions

• Semisynthetic- dextran, gelatin, hydroxyethyl starch

Solution to Question 25:

The highest incidence of anaphylactic reactions is seen with gelatin.

Gelatin is a semisynthetic colloid obtained by hydrolysis of bovine collagen.

Hydroxyethyl Starch (Hetastarch) is non-antigenic and rarely causes anaphylactoid reactions.

Solution to Question 26:

Desflurane, being an inhalational anesthetic, is a triggering factor for malignant hyperthermia.

Solution to Question 27:

All of the above agents can trigger malignant hyperthermia.

Malignant hyperthermia is a genetic(autosomal dominant) hypermetabolic muscle disease.

Triggering agents include

• Inhaled general anesthetics

• Ether

• Halothane

• Methoxyflurane

• Enflurane

• Isoflurane

• Desflurane

• Sevoflurane

• Depolarizing muscle relaxants

• Succinylcholine

Solution to Question 28:

Hyperthermia is a late sign of malignant hyperthermia.

Clinical Manifestations of Malignant Hyperthermia:

Early Signs:

- Elevated end-tidal carbon dioxide
- Tachypnea and/or tachycardia
- Masseter spasm, if succinylcholine has been used
- Generalized muscle rigidity
- Mixed metabolic and respiratory acidosis
- Profuse sweating
- Mottling of skin
- Cardiac arrhythmias
- Unstable blood pressure

Late Signs

- Hyperkalemia
- Rapid increase of core body temperature- body temperature rises by 1°C every 5 minutes
- Elevated creatine phosphokinase levels
- Gross myoglobinemia and myoglobinuria
- Cardiac arrest
- Disseminated intravascular coagulation

Solution to Question 29:

Dantrolene sodium is the drug of choice for malignant hyperthermia, but it is to be reconstituted with sterile distilled water and not saline as it can precipitate in saline or other salt solutions.

It is given at a dose of 2.5 mg/ kg intravenously and can be repeated every 5-10 minutes (up to 10 mg/kg) until the attack subsides.

All anesthetic agents should be cut off and the patient is given 100% oxygen.

Bicarbonate at a dose of 1 to 4 mEq/kg IV can be used to treat metabolic acidosis.

If the body temperature is high, it should be brought down using cold intravenous fluids, cooling body cavities with sterile iced fluids, surface cooling with ice packs and cooling blankets.