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ANE 601

ANAESTHESIA LECTURES

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Course code: ANE 601

Course title: Anaesthesia Lectures

Course credit load: 3 Unit

Series 1: Applied Basic Sciences and Pharmacology for Anaesthesia

- **Part 1.1: Applied Anatomy for Anaesthesia**
  - Sub Part 1.1.1: Anatomy of the upper airway
  - Sub Part 1.1.2: Anatomy of the lower airway and lungs
  - Sub Part 1.1.3: Anatomy of the peripheral nervous system relevant to anaesthesia
- **Part 1.2: Common Diseases and Emergencies Including Trauma**
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Introduction

Every safe anaesthetic ultimately rests on a genuinely thorough working knowledge of the patient's own underlying anatomy and physiology, since the anaesthetist deliberately manipulates consciousness, airway reflexes, respiratory drive, and cardiovascular stability all at once, and doing so safely requires knowing precisely what normal looks like before attempting to control it. This opening Series of **ANE 601: Anaesthesia Lectures** builds that essential foundation, working through applied airway and peripheral nervous system anatomy, the common diseases and emergencies, including trauma, that anaesthetists routinely encounter, the applied physiology of respiration, the cardiovascular system, and the nervous and neuromuscular systems, and, finally, the basic biochemistry and pharmacological principles underlying safe, informed drug administration.

The aim of this Series is to equip you with a thorough understanding of the basic anatomy of the airway and peripheral nervous system, common diseases and emergencies including trauma, basic physiology of respiration, the cardiovascular, nervous, and neuromuscular systems, and basic biochemistry of electrolytes, acid-base disorders, drug ionisation, and nutrition.

This Series begins with **applied anatomy for anaesthesia**, before turning to **common diseases and emergencies including trauma**, **applied physiology of respiration and the cardiovascular system**, and **applied physiology of the nervous and neuromuscular systems**. It concludes with **applied biochemistry and pharmacological principles**.

Series Learning Outcomes

At the end of this Series, you should be able to:

- **SLO 1.1:** describe the applied anatomy of the airway and peripheral nervous system relevant to anaesthesia
- **SLO 1.2:** describe common diseases, airway and respiratory emergencies, and trauma relevant to anaesthetic practice
- **SLO 1.3:** describe the applied physiology of respiration
- **SLO 1.4:** describe applied cardiovascular physiology and its interaction with respiratory physiology under anaesthesia
- **SLO 1.5:** describe the applied physiology of the autonomic nervous system and neuromuscular junction
- **SLO 1.6:** describe central nervous system considerations relevant to anaesthesia
- **SLO 1.7:** describe applied electrolyte and acid-base physiology
- **SLO 1.8:** explain the ionisation of drugs and its clinical relevance
- **SLO 1.9:** describe nutrition as it relates to anaesthetic practice, and
- **SLO 1.10:** describe basic pharmacological principles underlying drug use in anaesthesia.

1.1 Applied Anatomy for Anaesthesia

1.1.1 anatomy of the upper airway

Structures directly relevant to airway management

The **upper airway**, extending from the nares and lips through the pharynx to the larynx, comprises structures of direct, immediate relevance to every anaesthetic encounter, since the anaesthetist must repeatedly assess, manipulate, and, where necessary, instrument this specific anatomical region to establish and maintain a patent airway throughout the perioperative period.

The **larynx**, discussed in relation to its cartilaginous framework, marks the transition between the upper and lower airway, with the **vocal cords** and **glottic opening** representing the narrowest point an endotracheal tube must successfully pass through during intubation, meaning detailed familiarity with laryngeal anatomy directly underpins safe, confident airway instrumentation technique.

Fill in the blank: The upper airway extends from the nares and lips through the pharynx to the larynx, comprising structures of direct, immediate relevance to every anaesthetic _____.

1.1.2 anatomy of the lower airway and lungs

The tracheobronchial tree and respiratory unit

The **trachea**, continuing from the larynx, bifurcates at the carina into the **right and left main bronchi**, with the right main bronchus following a characteristically more vertical, direct course, a detail of genuine practical relevance since it explains why an inadvertently advanced endotracheal tube preferentially enters the right main bronchus, producing recognisable, asymmetric ventilation.

Beyond the major airways, discussed earlier in this sub-Part, the lungs themselves comprise progressively branching bronchioles terminating in **alveoli**, the functional gas exchange unit, with pleural anatomy and the lungs' segmental organisation carrying further practical relevance to positioning, one-lung ventilation, and recognition of complications such as pneumothorax during anaesthetic care.

Fill in the blank: The trachea bifurcates at the carina into the right and left main bronchi, with the right main bronchus following a characteristically more vertical, direct _____.

1.1.3 anatomy of the peripheral nervous system relevant to anaesthesia

Nerve pathways underlying regional technique and monitoring

The **peripheral nervous system**, comprising the spinal and cranial nerves and their branches, provides the essential anatomical basis for every regional anaesthetic technique, discussed further in a later Series of this course, since accurate, confident nerve blockade depends directly on detailed knowledge of individual nerve course, relations, and the specific dermatomal or myotomal territory each nerve supplies.

This peripheral anatomy, discussed earlier in this sub-Part, additionally underpins neuromuscular monitoring during anaesthesia, discussed further later in this course, since peripheral nerve stimulation, generally applied to the ulnar or facial nerve, provides the essential clinical means of assessing neuromuscular blockade depth throughout a general anaesthetic.

Fill in the blank: Accurate, confident regional nerve blockade depends directly on detailed knowledge of individual nerve course, relations, and the specific dermatomal or myotomal territory each nerve _____.

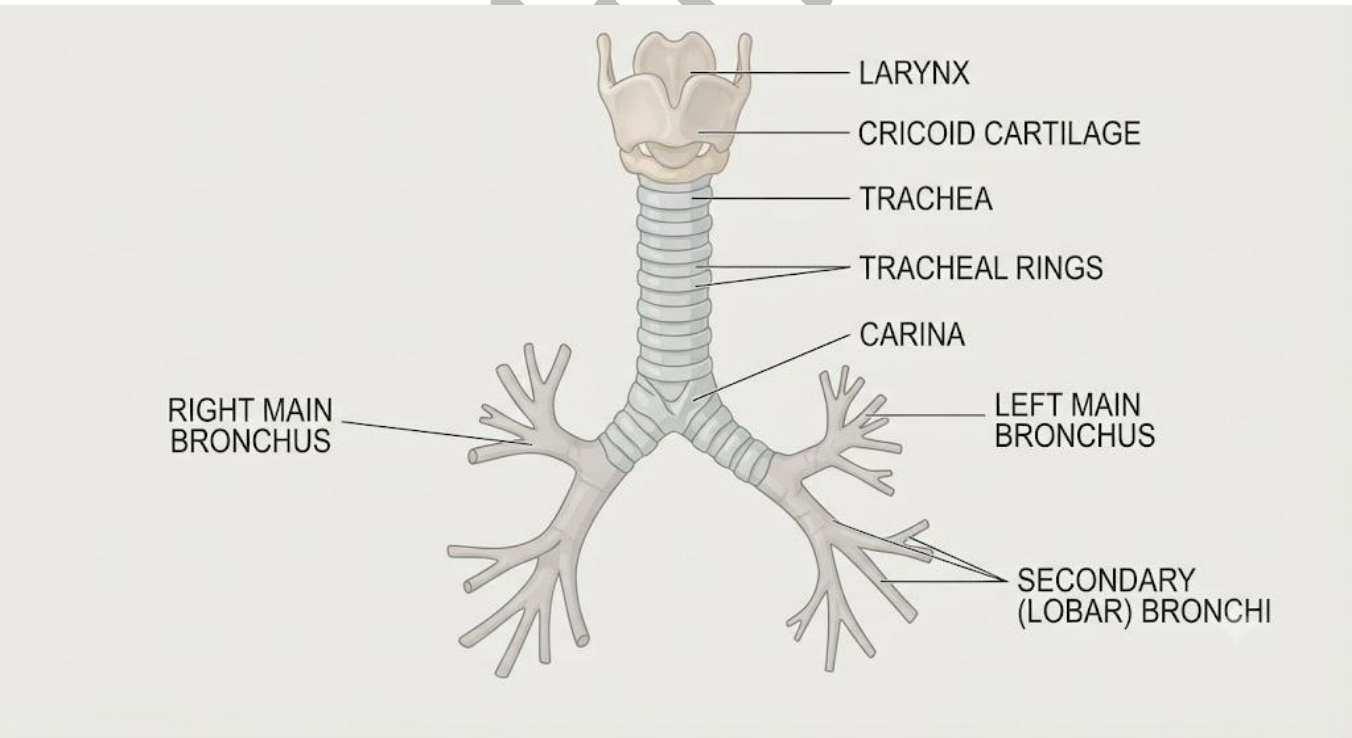

Figure 1.1: A diagram illustrating the upper and lower airway anatomy relevant to airway management, from the larynx through the tracheobronchial tree.

Pilot questions 1.1

1. Describe the structures comprising the upper airway. (Linked to SLO 1.1)
2. Explain the clinical relevance of laryngeal anatomy to intubation. (Linked to SLO 1.1)
3. Describe the anatomy of the tracheobronchial tree at the carina. (Linked to SLO 1.1)
4. Explain why an inadvertently advanced endotracheal tube preferentially enters the right main bronchus. (Linked to SLO 1.1)
5. Explain the relevance of peripheral nervous system anatomy to regional anaesthesia and neuromuscular monitoring. (Linked to SLO 1.1)

1.2 Common Diseases and Emergencies Including Trauma

1.2.1 common diseases relevant to anaesthetic practice

Comorbidity shaping anaesthetic risk and planning

Anaesthetists routinely encounter patients with significant coexisting disease, including hypertension, diabetes mellitus, sickle cell disease, and chronic respiratory or cardiac conditions, discussed further in relation to specific disease-modified anaesthetic technique in a later Series of this course, each carrying genuine implications for perioperative risk assessment and anaesthetic planning.

Recognising these common comorbidities, discussed earlier in this sub-Part, before proceeding with anaesthesia allows appropriate, individualised modification of anaesthetic technique, monitoring intensity, and perioperative management plan, meaning a genuinely thorough preoperative assessment, discussed further later in this course, remains foundational to safe anaesthetic practice regardless of the specific procedure planned.

Fill in the blank: Anaesthetists routinely encounter patients with significant coexisting disease, each carrying genuine implications for perioperative risk assessment and anaesthetic _____.

1.2.2 airway and respiratory emergencies

Time-critical events demanding immediate recognition

Airway emergencies, including complete or partial airway obstruction, laryngospasm, and bronchospasm, represent genuinely time-critical events requiring immediate recognition and skilled intervention, since even brief delay in restoring adequate airway patency or ventilation risks rapid, potentially catastrophic patient deterioration.

Further recognised respiratory emergencies, discussed earlier in this sub-Part, include aspiration of gastric contents, particularly relevant to the full-stomach patient discussed further in a later

Series of this course, and acute hypoxaemia from a range of underlying causes, each demanding a systematic, well rehearsed emergency response from the anaesthetic team.

Fill in the blank: Airway emergencies represent genuinely time-critical events requiring immediate recognition and skilled intervention, since even brief delay risks rapid, potentially catastrophic patient _____.

1.2.3 trauma and its anaesthetic implications

A population demanding specific additional caution

The **trauma patient**, discussed throughout this Part, presents genuinely specific additional anaesthetic considerations, including the presumption of a full stomach regardless of reported fasting status, discussed further in relation to full-stomach technique in a later Series of this course, potential cervical spine injury complicating standard airway manoeuvres, and haemodynamic instability from occult or overt haemorrhage.

These specific factors, discussed earlier in this sub-Part, together mean trauma anaesthesia genuinely demands a modified, more cautious approach to airway management, induction technique, and fluid resuscitation compared with elective anaesthetic practice, reflecting the trauma patient's substantially elevated overall physiological risk.

Fill in the blank: Trauma anaesthesia genuinely demands a modified, more cautious approach to airway management, induction technique, and fluid resuscitation, reflecting the trauma patient's substantially elevated overall physiological _____.

Table 1.2: Key anaesthetic considerations in the trauma patient.

Consideration	Implication	Modified approach
Full stomach presumption	Aspiration risk regardless of reported fasting	Rapid sequence induction technique
Possible cervical spine injury	Standard airway manoeuvres may be unsafe	In-line stabilisation during airway management
Haemodynamic instability	Occult or overt haemorrhage	Cautious induction and early fluid resuscitation

Pilot questions 1.2

1. List common diseases relevant to anaesthetic practice. (Linked to SLO 1.2)
2. Explain why recognising comorbidity before anaesthesia is important. (Linked to SLO 1.2)
3. List recognised airway and respiratory emergencies. (Linked to SLO 1.2)

4. Describe why aspiration risk is particularly relevant in the trauma patient. (Linked to SLO 1.2)
5. List key anaesthetic considerations specific to the trauma patient. (Linked to SLO 1.2)

1.3 Applied Physiology of Respiration and the Cardiovascular System

1.3.1 physiology of respiration

Ventilation, gas exchange, and their anaesthetic modification

Normal respiratory physiology, discussed in relation to airway anatomy earlier in this Series, depends on coordinated **ventilation**, movement of air into and out of the lungs, and **gas exchange**, diffusion of oxygen and carbon dioxide across the alveolar-capillary membrane, both of which are directly and substantially altered by anaesthetic agents and positioning.

General anaesthesia, discussed further in a later Series of this course, characteristically reduces functional residual capacity and alters normal ventilation-perfusion matching, meaning the anaesthetist must actively understand and compensate for these predictable physiological changes to maintain adequate oxygenation and ventilation throughout the anaesthetic period.

Fill in the blank: General anaesthesia characteristically reduces functional residual capacity and alters normal ventilation-perfusion matching, meaning the anaesthetist must actively compensate for these predictable physiological _____.

1.3.2 cardiovascular physiology relevant to anaesthesia

Cardiac output, blood pressure, and anaesthetic effects

Cardiac output, the product of heart rate and stroke volume, and systemic vascular resistance together determine arterial blood pressure, with essentially every anaesthetic agent producing some degree of predictable cardiovascular effect, whether through direct myocardial depression, vasodilation, or altered autonomic tone.

Understanding these specific, drug-dependent cardiovascular effects, discussed earlier in this sub-Part, allows the anaesthetist to anticipate, monitor for, and appropriately manage the haemodynamic changes that accompany induction and maintenance of anaesthesia, meaning cardiovascular physiology knowledge directly underpins safe anaesthetic drug selection and dosing.

Fill in the blank: Understanding drug-dependent cardiovascular effects allows the anaesthetist to anticipate, monitor for, and appropriately manage the haemodynamic changes that accompany induction and maintenance of _____.

1.3.3 interaction between respiratory and cardiovascular physiology under anaesthesia

Two systems that cannot be considered in isolation

Respiratory and cardiovascular physiology, discussed throughout this Part, interact continuously and substantially under anaesthesia, since hypoxaemia and hypercapnia each directly influence cardiovascular tone and rhythm, while cardiovascular instability itself can secondarily compromise adequate pulmonary perfusion and gas exchange.

This genuine interdependence, discussed earlier in this sub-Part, means effective anaesthetic monitoring and management must always consider both systems together rather than in isolation, reflecting the fundamentally integrated nature of cardiorespiratory physiology that the anaesthetist continuously assesses and supports throughout every anaesthetic.

Fill in the blank: Effective anaesthetic monitoring and management must always consider the respiratory and cardiovascular systems together rather than in isolation, reflecting their fundamentally integrated _____.

Table 1.3: Key physiological effects of general anaesthesia.

System	Typical effect	Clinical relevance
Respiratory	Reduced functional residual capacity, altered V/Q matching	Risk of hypoxaemia; requires active monitoring
Cardiovascular	Myocardial depression, vasodilation, altered autonomic tone	Predictable haemodynamic change requiring anticipation
Combined interaction	Hypoxaemia and hypercapnia affect cardiovascular tone	Systems must be monitored and managed together

Pilot questions 1.3

1. Describe the components of normal respiratory physiology relevant to anaesthesia. (Linked to SLO 1.3)
2. Explain how general anaesthesia typically alters respiratory physiology. (Linked to SLO 1.3)
3. Describe the determinants of arterial blood pressure. (Linked to SLO 1.4)

4. Explain why understanding cardiovascular physiology is important for anaesthetic drug selection. (Linked to SLO 1.4)
5. Explain the interaction between respiratory and cardiovascular physiology under anaesthesia. (Linked to SLO 1.4)

1.4 Applied Physiology of the Nervous and Neuromuscular Systems

1.4.1 autonomic nervous system physiology

Sympathetic and parasympathetic balance under anaesthesia

The **autonomic nervous system**, comprising the **sympathetic** and **parasympathetic** divisions, maintains ongoing physiological homeostasis through opposing, balanced regulation of heart rate, vascular tone, and numerous other organ systems, with anaesthetic agents and surgical stimulation each capable of substantially disrupting this normal autonomic balance.

Recognising the specific, characteristic signs of sympathetic or parasympathetic predominance, discussed earlier in this sub-Part, such as tachycardia and hypertension reflecting sympathetic activation, or bradycardia reflecting parasympathetic, generally vagal, activation, allows the anaesthetist to interpret intraoperative haemodynamic changes and respond with appropriately targeted pharmacological intervention.

Fill in the blank: Recognising the specific, characteristic signs of sympathetic or parasympathetic predominance allows the anaesthetist to interpret intraoperative haemodynamic changes and respond with appropriately targeted pharmacological _____.

1.4.2 neuromuscular junction physiology

The site targeted by muscle relaxant drugs

The **neuromuscular junction**, discussed in relation to acetylcholine receptor physiology, is the specific synaptic site where motor nerve impulses are transmitted to skeletal muscle through acetylcholine release and subsequent receptor binding, representing the precise pharmacological target of the muscle relaxant drugs discussed further in a later Series of this course.

Understanding this junction's normal physiology, discussed earlier in this sub-Part, including the distinction between **depolarising** and **non-depolarising** blockade mechanisms, allows the anaesthetist to select appropriate muscle relaxants, interpret neuromuscular monitoring,

discussed earlier in this Series, and safely reverse residual blockade at the conclusion of anaesthesia.

Fill in the blank: The neuromuscular junction is the specific synaptic site where motor nerve impulses are transmitted to skeletal muscle through acetylcholine release and subsequent receptor _____.

1.4.3 central nervous system considerations relevant to anaesthesia

The site of consciousness and general anaesthetic action

The **central nervous system**, discussed throughout this Part, represents the ultimate site of action for general anaesthetic agents, which produce reversible loss of consciousness, amnesia, and analgesia through complex, still incompletely understood effects on multiple neurotransmitter systems and neural networks throughout the brain.

Further central nervous system considerations, discussed earlier in this sub-Part, include the effects of anaesthetic agents on cerebral blood flow and intracranial pressure, discussed further in relation to neuroanaesthesia in related coursework, and the genuine importance of maintaining adequate cerebral perfusion throughout anaesthesia to avoid secondary neurological injury.

Fill in the blank: Further central nervous system considerations include the effects of anaesthetic agents on cerebral blood flow and intracranial _____.

Pilot questions 1.4

1. Describe the autonomic nervous system's role in physiological homeostasis. (Linked to SLO 1.5)
2. Explain how sympathetic and parasympathetic predominance can be clinically recognised under anaesthesia. (Linked to SLO 1.5)
3. Describe the neuromuscular junction and its relevance to muscle relaxant drugs. (Linked to SLO 1.5)
4. Distinguish depolarising from non-depolarising neuromuscular blockade. (Linked to SLO 1.5)
5. Describe central nervous system considerations relevant to general anaesthesia. (Linked to SLO 1.6)

1.5 Applied Biochemistry and Pharmacological Principles

1.5.1 electrolyte and acid-base physiology

Homeostatic balance directly relevant to perioperative safety

Normal **electrolyte** balance, particularly of sodium, potassium, and calcium, and normal **acid-base** status, generally assessed through arterial blood gas analysis, discussed further in a later Series of this course, together represent essential physiological parameters the anaesthetist must monitor and, where necessary, correct throughout the perioperative period.

Significant derangement of either electrolyte balance or acid-base status, discussed earlier in this sub-Part, can produce genuinely serious consequences, including cardiac arrhythmia from potassium disturbance or impaired drug metabolism from significant acidosis, meaning careful perioperative biochemical monitoring represents an essential component of safe anaesthetic practice.

Fill in the blank: Significant derangement of electrolyte balance or acid-base status can produce genuinely serious consequences, including cardiac arrhythmia from potassium _____.

1.5.2 ionisation of drugs and its clinical relevance

A property directly shaping drug distribution and effect

The degree to which a given drug exists in its **ionised** versus **non-ionised** form, determined by the drug's own specific pKa relative to the surrounding physiological pH, directly influences that drug's ability to cross lipid membranes, since only the non-ionised, lipid-soluble fraction can readily traverse the blood-brain barrier or placental barrier.

This principle, discussed earlier in this sub-Part, carries direct clinical relevance to local anaesthetic onset time, discussed further in a later Series of this course, and to drug transfer across the placenta in the pregnant patient, discussed further in the next Series of this course, meaning understanding drug ionisation genuinely underpins rational, informed anaesthetic pharmacology.

Fill in the blank: Only the non-ionised, lipid-soluble fraction of a drug can readily traverse the blood-brain barrier or _____ barrier.

1.5.3 nutrition and basic pharmacological principles in anaesthesia

Nutritional status and the essentials of drug handling

Nutritional status, discussed in relation to preoperative assessment, carries genuine relevance to anaesthetic risk, since malnutrition can impair wound healing, immune function, and drug metabolism, while obesity, conversely, carries its own distinct set of airway and pharmacokinetic considerations relevant to safe anaesthetic drug dosing.

Basic pharmacological principles, discussed throughout this Series, including **pharmacokinetics**, what the body does to a drug, and **pharmacodynamics**, what a drug does to the body, together provide the essential conceptual framework underlying every specific drug class discussed throughout the remainder of this course, from premedicants through anaesthetic agents to muscle relaxants and local anaesthetics.

Fill in the blank: Basic pharmacological principles include pharmacokinetics, what the body does to a drug, and pharmacodynamics, what a drug does to the _____.

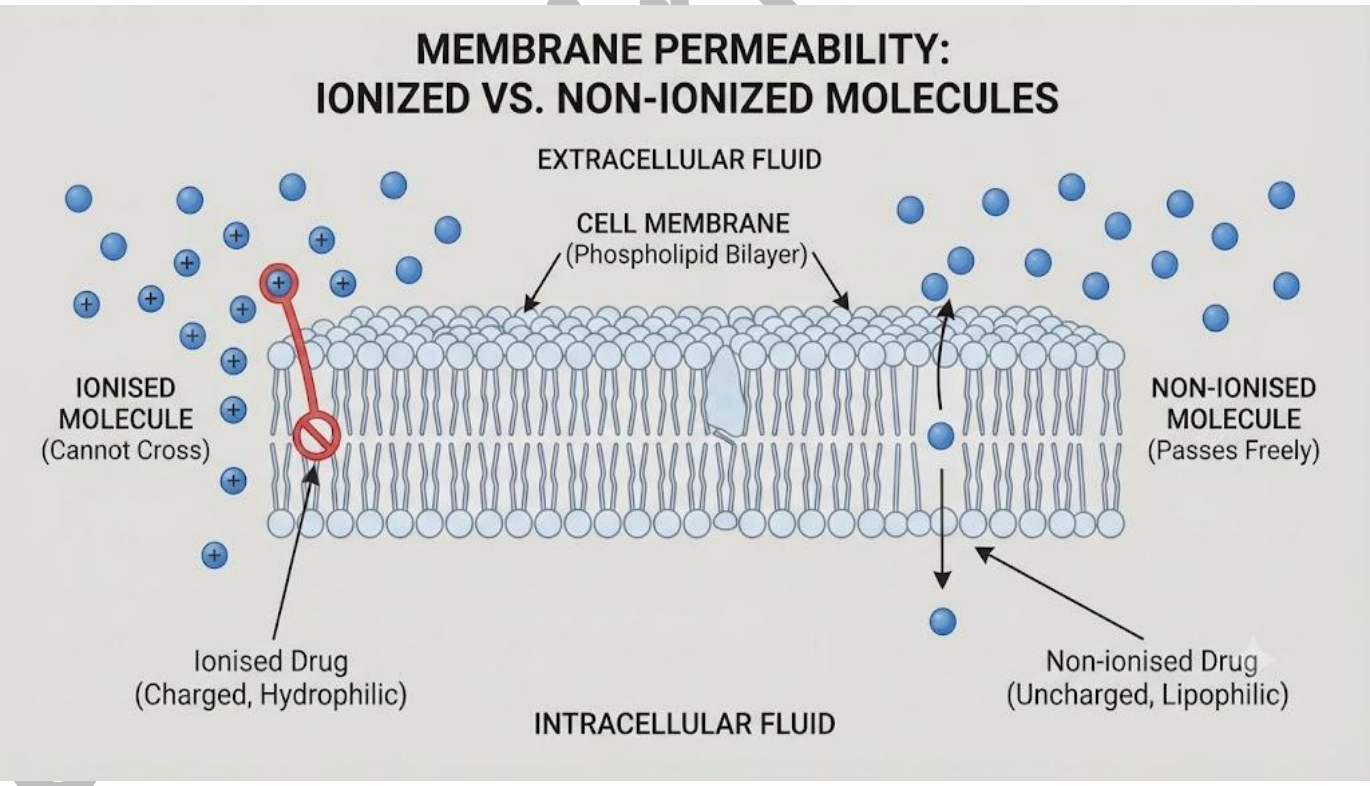

Figure 1.5: A diagram illustrating how drug ionisation state, determined by pKa relative to physiological pH, influences membrane crossing.

Pilot questions 1.5

- Describe the electrolytes and acid-base parameters most relevant to perioperative monitoring. (Linked to SLO 1.7)
- Explain the clinical consequences of significant electrolyte or acid-base derangement. (Linked to SLO 1.7)
- Explain how drug ionisation state relates to membrane crossing. (Linked to SLO 1.8)
- Describe the clinical relevance of drug ionisation to local anaesthetics and placental drug transfer. (Linked to SLO 1.8)
- Distinguish pharmacokinetics from pharmacodynamics. (Linked to SLO 1.9, SLO 1.10)

Series Summary

This opening Series worked through applied anatomy for anaesthesia, upper and lower airway structures and peripheral nervous system anatomy, common diseases and emergencies including trauma, applied respiratory and cardiovascular physiology and their genuine interaction under anaesthesia, applied nervous and neuromuscular system physiology, and, finally, applied biochemistry and pharmacological principles, electrolytes, acid-base balance, drug ionisation, nutrition, and the essential concepts of pharmacokinetics and pharmacodynamics.

This basic science and pharmacological foundation carries directly into obstetric anaesthesia and analgesia in labour, examined in the next Series of this course.

Glossary of Terms

- **Larynx:** the structure marking the transition between the upper and lower airway, containing the vocal cords.
- **Carina:** the point at which the trachea bifurcates into the right and left main bronchi.
- **Functional residual capacity:** the volume of air remaining in the lungs after normal exhalation, reduced under general anaesthesia.
- **Cardiac output:** the product of heart rate and stroke volume, a key determinant of blood pressure.
- **Autonomic nervous system:** the sympathetic and parasympathetic system regulating involuntary physiological function.
- **Neuromuscular junction:** the synaptic site where motor nerve impulses are transmitted to skeletal muscle.

- **Depolarising blockade:** a mechanism of neuromuscular blockade produced by agents such as suxamethonium.
- **pKa:** the pH at which a drug exists equally in ionised and non-ionised form.
- **Non-ionised fraction:** the lipid-soluble portion of a drug capable of crossing biological membranes.
- **Pharmacokinetics:** the study of what the body does to a drug, including absorption, distribution, metabolism, and excretion.
- **Pharmacodynamics:** the study of what a drug does to the body.
- **Rapid sequence induction:** an induction technique used to minimise aspiration risk in patients presumed to have a full stomach.

Concept Check Questions [Series 1]

Objective questions

1. The upper airway extends from the nares and lips through the pharynx to the larynx, comprising structures of direct, immediate relevance to every anaesthetic _____.
2. The trachea bifurcates at the carina into the right and left main bronchi, with the right main bronchus following a characteristically more vertical, direct _____.
3. General anaesthesia characteristically reduces functional residual capacity and alters normal ventilation-perfusion matching, meaning the anaesthetist must actively compensate for these predictable physiological _____.
4. The neuromuscular junction is the specific synaptic site where motor nerve impulses are transmitted to skeletal muscle through acetylcholine release and subsequent receptor _____.
5. Basic pharmacological principles include pharmacokinetics, what the body does to a drug, and pharmacodynamics, what a drug does to the _____.

Short-answer questions

6. Explain the clinical relevance of laryngeal anatomy to intubation.
7. List key anaesthetic considerations specific to the trauma patient.
8. Explain how general anaesthesia typically alters respiratory physiology.
9. Distinguish depolarising from non-depolarising neuromuscular blockade.
10. Explain how drug ionisation state relates to membrane crossing.

Long-answer questions

11. Discuss the applied anatomy of the upper and lower airway and the peripheral nervous system relevant to anaesthesia. (Linked to SLO 1.1)

12. Discuss common diseases, emergencies, and trauma relevant to anaesthetic practice. (Linked to SLO 1.2)
13. Discuss the applied physiology of respiration and the cardiovascular system, and their interaction under anaesthesia. (Linked to SLO 1.3, SLO 1.4)
14. Discuss the applied physiology of the autonomic nervous system, neuromuscular junction, and central nervous system considerations. (Linked to SLO 1.5, SLO 1.6)
15. Discuss applied biochemistry and basic pharmacological principles relevant to anaesthesia. (Linked to SLO 1.7, SLO 1.8, SLO 1.9, SLO 1.10)

Answers to Concept Check Questions [Series 1]

Objective questions

1. Encounter.
2. Course.
3. Changes.
4. Binding.
5. Body.

Short-answer questions

6. The vocal cords and glottic opening represent the narrowest point an endotracheal tube must pass through during intubation.
7. Full stomach presumption, possible cervical spine injury, and haemodynamic instability from occult or overt haemorrhage.
8. It reduces functional residual capacity and alters normal ventilation-perfusion matching.
9. Depolarising blockade, produced by agents such as suxamethonium, initially stimulates then blocks the receptor; non-depolarising blockade competitively blocks the receptor without initial stimulation.
10. Only the non-ionised, lipid-soluble fraction of a drug can readily cross biological membranes such as the blood-brain barrier.

Long-answer questions

11. **Basic response:** The upper airway and tracheobronchial tree provide the essential anatomical basis for airway management, while peripheral nerve anatomy underpins regional technique and neuromuscular monitoring.

Value-added response: Detailed familiarity with these structures directly supports safe, confident airway instrumentation and monitoring throughout anaesthetic care.

12. **Basic response:** Anaesthetists routinely manage patients with significant comorbidity and must recognise airway, respiratory, and trauma-related emergencies.

Value-added response: The trauma patient specifically requires modified technique given full stomach presumption, possible cervical spine injury, and haemodynamic instability.

13. **Basic response:** General anaesthesia predictably alters both respiratory and cardiovascular physiology, reducing functional residual capacity and producing haemodynamic change.

Value-added response: These two systems interact continuously under anaesthesia, meaning effective monitoring must consider them together rather than in isolation.

14. **Basic response:** The autonomic nervous system, neuromuscular junction, and central nervous system are each directly targeted or affected by anaesthetic agents.

Value-added response: Understanding their normal physiology allows the anaesthetist to interpret intraoperative changes and select and dose drugs appropriately.

15. **Basic response:** Electrolyte and acid-base balance, drug ionisation, and nutritional status each carry direct relevance to perioperative safety.

Value-added response: Pharmacokinetic and pharmacodynamic principles provide the essential conceptual framework underlying every specific drug class discussed throughout this course.

Answers to Pilot Questions [Series 1]

Part 1.1

1. The nares, lips, pharynx, and larynx.
2. The vocal cords and glottic opening represent the narrowest point an endotracheal tube must pass through.
3. The trachea bifurcates at the carina into the right and left main bronchi.
4. Because the right main bronchus follows a more vertical, direct course than the left.
5. It underpins accurate nerve blockade technique and provides the basis for peripheral nerve stimulation used in neuromuscular monitoring.

Part 1.2

1. Hypertension, diabetes mellitus, sickle cell disease, and chronic respiratory or cardiac conditions.
2. Because it allows appropriate, individualised modification of anaesthetic technique and monitoring.
3. Complete or partial airway obstruction, laryngospasm, bronchospasm, aspiration, and acute hypoxaemia.
4. Because trauma patients are presumed to have a full stomach regardless of reported fasting status.
5. Full stomach presumption, possible cervical spine injury, and haemodynamic instability.

Part 1.3

1. Ventilation, movement of air into and out of the lungs, and gas exchange across the alveolar-capillary membrane.
2. It reduces functional residual capacity and alters normal ventilation-perfusion matching.
3. Cardiac output, the product of heart rate and stroke volume, and systemic vascular resistance.
4. Because essentially every anaesthetic agent produces predictable cardiovascular effects that must be anticipated.
5. Hypoxaemia and hypercapnia affect cardiovascular tone, while cardiovascular instability can compromise pulmonary perfusion and gas exchange.

Part 1.4

1. It maintains ongoing physiological homeostasis through balanced sympathetic and parasympathetic regulation.
2. Tachycardia and hypertension suggest sympathetic activation; bradycardia suggests parasympathetic, generally vagal, activation.
3. The synaptic site where motor nerve impulses are transmitted to skeletal muscle, the target of muscle relaxant drugs.
4. Depolarising blockade initially stimulates then blocks the receptor; non-depolarising blockade competitively blocks without initial stimulation.
5. Effects on cerebral blood flow, intracranial pressure, and the need to maintain adequate cerebral perfusion.

Part 1.5

- Sodium, potassium, and calcium, together with acid-base status generally assessed through arterial blood gas analysis.
- Cardiac arrhythmia from potassium disturbance, and impaired drug metabolism from significant acidosis.

- Only the non-ionised, lipid-soluble fraction of a drug can readily cross biological membranes.
- It influences local anaesthetic onset time and drug transfer across the placenta.
- Pharmacokinetics describes what the body does to a drug; pharmacodynamics describes what a drug does to the body.

References and Attributions [Series 1]

- Aitkenhead, A. R., Moppett, I. K., & Thompson, J. P. (2013). Smith and Aitkenhead's Textbook of Anaesthesia (6th ed.). Churchill Livingstone.
- Butterworth, J. F., Mackey, D. C., & Wasnick, J. D. (2018). Morgan and Mikhail's Clinical Anesthesiology (6th ed.). McGraw-Hill.
- Miller, R. D., et al. (2019). Miller's Anesthesia (9th ed.). Elsevier.
- Barash, P. G., et al. (2017). Clinical Anesthesia (8th ed.). Wolters Kluwer.

Figures, Plates, Tables, and Boxes

- Figure 1.1: A diagram illustrating the upper and lower airway anatomy relevant to airway management, from the larynx through the tracheobronchial tree. AI-generated using the prompt: "A single clean, accurate anatomical diagram of the airway from the larynx through the trachea, showing the carina and the more vertical right main bronchus branching from the more angled left main bronchus, textbook anatomical diagram style, neutral background, no photographic realism, no other panels."
- Table 1.2: Key anaesthetic considerations in the trauma patient. AI-generated using the prompt: "Create a clean clinical reference table titled Key Anaesthetic Considerations in the Trauma Patient, listing consideration, implication, and modified approach. Medical reference table style with outside border, no photographic elements."
- Table 1.3: Key physiological effects of general anaesthesia. AI-generated using the prompt: "Create a clean physiology reference table titled Key Physiological Effects of General Anaesthesia, listing system, typical effect, and clinical relevance. Medical reference table style with outside border, no photographic elements."
- Figure 1.5: A diagram illustrating how drug ionisation state, determined by pKa relative to physiological pH, influences membrane crossing. AI-generated using the prompt: "A single clean, accurate schematic diagram of a cell membrane with molecules labelled ionised on one side unable to cross, and molecules labelled non-ionised shown passing

through the membrane, textbook pharmacology diagram style, neutral background, no photographic realism, no other

Series 2: Obstetric Anaesthesia and Analgesia in Labour

- **Part 2.1: Physiological Changes in Pregnancy**
    - Sub Part 2.1.1: Cardiovascular changes in pregnancy
    - Sub Part 2.1.2: Respiratory and airway changes in pregnancy
    - Sub Part 2.1.3: Gastrointestinal and other changes relevant to anaesthesia
- **Part 2.2: Regional Anaesthesia in Obstetrics: Subarachnoid Block**
    - Sub Part 2.2.1: Principles of subarachnoid (spinal) block in obstetrics
    - Sub Part 2.2.2: Technique of spinal anaesthesia for caesarean section
    - Sub Part 2.2.3: Complications of spinal anaesthesia in obstetrics
- **Part 2.3: Regional Anaesthesia in Obstetrics: Epidural**
    - Sub Part 2.3.1: Principles of epidural anaesthesia and analgesia
    - Sub Part 2.3.2: Technique of epidural placement in obstetrics
    - Sub Part 2.3.3: Complications of epidural anaesthesia in obstetrics
- **Part 2.4: General Anaesthesia in the Full-Stomach Pregnant Patient**
    - Sub Part 2.4.1: Rationale for rapid sequence induction in pregnancy
    - Sub Part 2.4.2: Technique of general anaesthesia in the pregnant patient
    - Sub Part 2.4.3: Specific risks of general anaesthesia in pregnancy
- **Part 2.5: Modalities of Analgesia in Labour**
    - Sub Part 2.5.1: Non-pharmacological analgesia in labour
    - Sub Part 2.5.2: Systemic pharmacological analgesia in labour
    - Sub Part 2.5.3: Regional analgesia in labour

Introduction

Pregnancy quietly rewrites nearly every physiological system relevant to anaesthetic practice, the airway, the cardiovascular system, gastric physiology, all shift in specific, predictable directions well before a single anaesthetic agent has even been administered, and every technique discussed throughout this Series builds directly on that shifted baseline. This Series works through the

specific physiological changes of pregnancy, the two principal regional techniques used in obstetric anaesthesia, **subarachnoid block** and **epidural**, the modified technique required for general anaesthesia in the full-stomach pregnant patient, and, finally, the full range of modalities available for providing analgesia during labour itself.

The aim of this Series is to equip you with a thorough understanding of the physiological changes of pregnancy as they relate to anaesthesia, regional anaesthesia and analgesia in obstetrics, subarachnoid block and epidural, the technique of general anaesthesia in the full-stomach pregnant patient, and various modalities of providing analgesia in labour.

This Series begins with **physiological changes in pregnancy**, before turning to **regional anaesthesia in obstetrics**, subarachnoid block and epidural, and **general anaesthesia in the full-stomach pregnant patient**. It concludes with **modalities of analgesia in labour**.

Series Learning Outcomes

At the end of this Series, you should be able to:

- **SLO 2.1:** describe cardiovascular and respiratory changes of pregnancy relevant to anaesthesia
- **SLO 2.2:** describe gastrointestinal and other physiological changes of pregnancy relevant to anaesthesia
- **SLO 2.3:** describe the principles and technique of subarachnoid (spinal) block for caesarean section
- **SLO 2.4:** describe complications of spinal anaesthesia in obstetrics
- **SLO 2.5:** describe the principles and technique of epidural anaesthesia and analgesia in obstetrics
- **SLO 2.6:** describe complications of epidural anaesthesia in obstetrics
- **SLO 2.7:** explain the rationale for rapid sequence induction in the pregnant patient
- **SLO 2.8:** describe the technique and specific risks of general anaesthesia in pregnancy
- **SLO 2.9:** describe non-pharmacological and systemic pharmacological modalities of analgesia in labour, and
- **SLO 2.10:** describe regional modalities of analgesia in labour.

2.1 Physiological Changes in Pregnancy

2.1.1 cardiovascular changes in pregnancy

A high-output, volume-expanded state with genuine anaesthetic implications

Pregnancy produces substantial **cardiovascular** change, including a genuinely significant increase in cardiac output, generally beginning early in the first trimester and continuing to rise throughout gestation, together with expanded circulating blood volume and reduced systemic vascular resistance, reflecting the body's adaptation to the growing metabolic demands of the fetoplacental unit.

Of particular anaesthetic relevance, the gravid uterus, discussed further later in this Series, can produce **aortocaval compression** when the mother lies supine, substantially reducing venous return and cardiac output, meaning left uterine displacement or a lateral tilt position represents an essential, routine precaution during essentially any anaesthetic or analgesic procedure performed in the third-trimester pregnant patient.

Fill in the blank: The gravid uterus can produce aortocaval compression when the mother lies supine, substantially reducing venous return and cardiac _____.

2.1.2 respiratory and airway changes in pregnancy

Reduced reserve and a genuinely more difficult airway

Pregnancy produces increased minute ventilation and oxygen consumption alongside reduced functional residual capacity, discussed in relation to respiratory physiology in the previous Series of this course, meaning the pregnant patient desaturates considerably more rapidly during any period of apnoea, such as during induction of general anaesthesia, than a non-pregnant patient would.

The pregnant airway, discussed earlier in this sub-Part, additionally becomes genuinely more difficult to manage given mucosal oedema, capillary engorgement, and weight gain affecting airway visualisation, meaning airway management in pregnancy demands both meticulous preparation for potential difficulty and genuine urgency given the substantially reduced apnoea tolerance this population carries.

Fill in the blank: The pregnant patient desaturates considerably more rapidly during any period of apnoea than a non-pregnant patient, given increased oxygen consumption and reduced functional residual _____.

2.1.3 gastrointestinal and other changes relevant to anaesthesia

Delayed gastric emptying and the full-stomach principle

Pregnancy, discussed throughout this Part, produces reduced lower oesophageal sphincter tone and, particularly once labour has begun, genuinely delayed gastric emptying, together substantially increasing the risk of regurgitation and pulmonary aspiration of gastric contents, the principle underlying the full-stomach precautions discussed further later in this Series.

Further relevant changes, discussed earlier in this sub-Part, include a generally increased, physiologically dilutional degree of anaemia, and hormonally mediated ligamentous laxity affecting spinal positioning during regional anaesthetic technique, discussed further later in this Series, together meaning essentially every organ system relevant to anaesthetic practice is genuinely, meaningfully altered by pregnancy.

Fill in the blank: Pregnancy produces reduced lower oesophageal sphincter tone and genuinely delayed gastric emptying, substantially increasing the risk of regurgitation and pulmonary _____ of gastric contents.

Table 2.1: Key physiological changes of pregnancy relevant to anaesthesia.

System	Change	Anaesthetic implication
Cardiovascular	Increased cardiac output, aortocaval compression risk	Requires left lateral tilt in the supine position
Respiratory	Increased oxygen consumption, reduced functional residual capacity	Rapid desaturation during apnoea
Gastrointestinal	Delayed gastric emptying, reduced sphincter tone	Full-stomach precautions required

Pilot questions 2.1

- Describe cardiovascular changes of pregnancy relevant to anaesthesia. (Linked to SLO 2.1)
- Explain aortocaval compression and how it is prevented. (Linked to SLO 2.1)
- Describe respiratory changes of pregnancy and their anaesthetic implications. (Linked to SLO 2.1)
- Explain why airway management is more difficult in pregnancy. (Linked to SLO 2.1)
- Describe gastrointestinal changes of pregnancy and their relevance to aspiration risk. (Linked to SLO 2.2)

2.2 Regional Anaesthesia in Obstetrics: Subarachnoid Block

2.2.1 principles of subarachnoid (spinal) block in obstetrics

A single injection producing rapid, dense blockade

Subarachnoid, or spinal, block involves injecting local anaesthetic directly into the cerebrospinal fluid within the subarachnoid space, producing rapid onset, dense sensory and motor blockade well suited to the specific requirements of caesarean section, where surgical anaesthesia is generally needed within minutes rather than the more gradual onset characteristic of epidural technique discussed further later in this Series.

This technique, discussed earlier in this sub-Part, avoids many of the risks associated with general anaesthesia in pregnancy, discussed further later in this Series, including airway management difficulty and aspiration risk, meaning spinal anaesthesia represents the generally preferred technique for elective and many urgent caesarean sections where no specific contraindication exists.

Fill in the blank: Subarachnoid block involves injecting local anaesthetic directly into the cerebrospinal fluid within the subarachnoid space, producing rapid onset, dense sensory and motor _____.

2.2.2 technique of spinal anaesthesia for caesarean section

Careful positioning and precise anatomical landmark identification

Spinal anaesthesia for caesarean section, discussed earlier in this Part, is generally performed with the patient in the sitting or lateral position, identifying the appropriate lumbar interspace, generally L3/4 or L4/5, using surface anatomical landmarks such as the iliac crests, before advancing a fine spinal needle through the intervertebral space into the subarachnoid space.

Confirmation of correct needle placement, discussed earlier in this sub-Part, generally relies on free flow of clear cerebrospinal fluid, before injecting a carefully calculated dose of local anaesthetic, often combined with an intrathecal opioid, discussed further later in this Series, to enhance block quality and provide early postoperative analgesia.

Fill in the blank: Confirmation of correct spinal needle placement generally relies on free flow of clear cerebrospinal _____.

2.2.3 complications of spinal anaesthesia in obstetrics

Recognised risks requiring prompt recognition and management

Hypotension, discussed in relation to the sympathetic blockade produced by spinal anaesthesia, represents the most common recognised complication, generally managed with intravenous fluid administration and vasopressor therapy, while **high spinal block**, extending unexpectedly cephalad, can produce respiratory compromise and requires prompt recognition and supportive management.

Further recognised complications, discussed earlier in this sub-Part, include **post-dural puncture headache**, resulting from cerebrospinal fluid leak through the puncture site, and, rarely, more serious complications including epidural haematoma or infection, meaning ongoing postoperative monitoring and prompt recognition of any complication remains essential following spinal anaesthesia.

Fill in the blank: Post-dural puncture headache results from cerebrospinal fluid leak through the puncture _____.

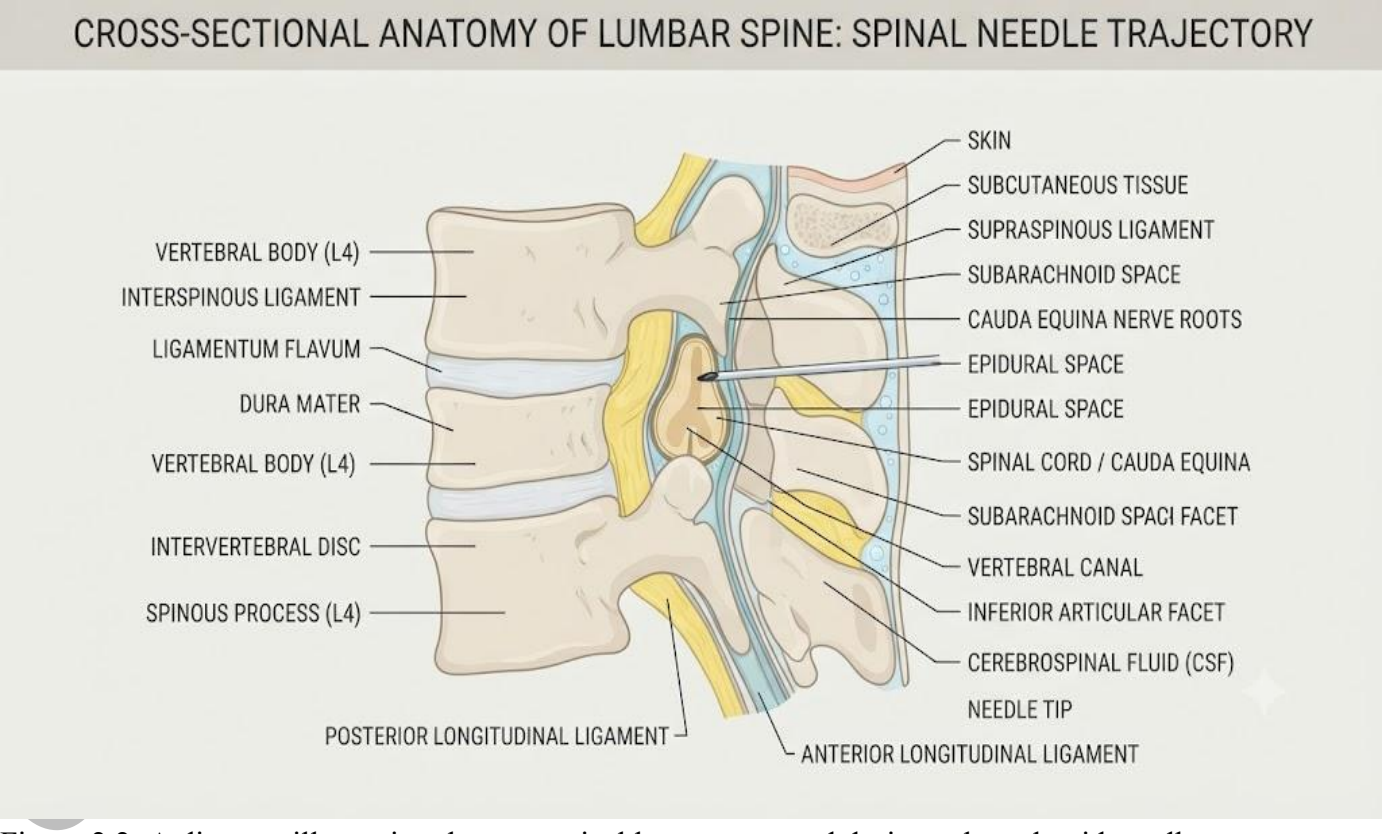

Figure 2.2: A diagram illustrating the anatomical layers traversed during subarachnoid needle placement, from skin to the subarachnoid space.

Pilot questions 2.2

1. Describe the principle of subarachnoid block. (Linked to SLO 2.3)
2. Explain why spinal anaesthesia is generally preferred for caesarean section. (Linked to SLO 2.3)
3. Describe the technique of spinal anaesthesia for caesarean section. (Linked to SLO 2.3)
4. List complications of spinal anaesthesia in obstetrics. (Linked to SLO 2.4)
5. Describe the management of hypotension following spinal anaesthesia. (Linked to SLO 2.4)

2.3 Regional Anaesthesia in Obstetrics: Epidural

2.3.1 principles of epidural anaesthesia and analgesia

A titratable technique suited to labour and surgery alike

Epidural technique involves injecting local anaesthetic, generally combined with an opioid, into the epidural space surrounding the dura, producing a somewhat slower onset but genuinely more titratable, adjustable block than the single-injection spinal technique discussed earlier in this Series, given the option of placing an indwelling catheter for continued top-up dosing.

This titratability, discussed earlier in this sub-Part, makes epidural technique particularly well suited to labour analgesia, discussed further later in this Series, where analgesia is genuinely required over a prolonged, unpredictable duration, and can additionally be extended to provide surgical anaesthesia should caesarean delivery subsequently become necessary.

Fill in the blank: Epidural technique produces a somewhat slower onset but genuinely more titratable, adjustable block than the single-injection spinal technique, given the option of placing an indwelling _____.

2.3.2 technique of epidural placement in obstetrics

Loss of resistance and catheter placement technique

Epidural placement, discussed earlier in this Part, generally uses the **loss of resistance** technique, advancing a specialised epidural needle through the ligamentum flavum while applying continuous gentle pressure to an attached syringe, with the sudden loss of resistance signalling entry into the epidural space itself, just short of the dura.

Following confirmation of correct space identification, discussed earlier in this sub-Part, a fine catheter is threaded through the needle and secured in place, allowing intermittent bolus dosing

or continuous infusion of local anaesthetic and opioid throughout labour or the surgical procedure, discussed further later in this Series.

Fill in the blank: Epidural placement generally uses the loss of resistance technique, with the sudden loss of resistance signalling entry into the epidural space, just short of the _____.

2.3.3 complications of epidural anaesthesia in obstetrics

Recognised risks distinct from those of spinal technique

Inadvertent dural puncture, discussed in relation to needle technique earlier in this Part, can produce post-dural puncture headache, discussed earlier in this Series, or, if unrecognised, an unexpectedly extensive "total spinal" block should the intended epidural dose be delivered directly into the subarachnoid space, representing a genuine anaesthetic emergency.

Further recognised complications, discussed earlier in this sub-Part, include hypotension, generally milder than with spinal anaesthesia given the more gradual onset, local anaesthetic systemic toxicity should inadvertent intravascular injection occur, and, rarely, epidural haematoma or abscess, meaning careful technique and vigilant monitoring remain essential throughout epidural use.

Fill in the blank: Should the intended epidural dose be delivered directly into the subarachnoid space following unrecognised dural puncture, an unexpectedly extensive total spinal block can result, representing a genuine anaesthetic _____.

Table 2.3: Comparing spinal and epidural anaesthesia in obstetrics.

Feature	Spinal	Epidural
Onset	Rapid	Slower
Duration/titratability	Single injection, fixed duration	Catheter allows continued titration
Typical use	Caesarean section requiring rapid surgical anaesthesia	Labour analgesia, extendable to surgery

Pilot questions 2.3

1. Describe the principle of epidural anaesthesia and analgesia. (Linked to SLO 2.5)
2. Explain why epidural technique suits labour analgesia particularly well. (Linked to SLO 2.5)
3. Describe the loss of resistance technique for epidural placement. (Linked to SLO 2.5)
4. Describe the risk and consequence of inadvertent dural puncture during epidural placement. (Linked to SLO 2.6)

5. List complications of epidural anaesthesia in obstetrics. (Linked to SLO 2.6)

2.4 General Anaesthesia in the Full-Stomach Pregnant Patient

2.4.1 rationale for rapid sequence induction in pregnancy

Minimising the window of aspiration vulnerability

Rapid sequence induction, discussed in relation to the pregnant patient's genuinely elevated aspiration risk earlier in this Series, aims to minimise the time between loss of protective airway reflexes and secure endotracheal tube placement, given the delayed gastric emptying and reduced sphincter tone discussed earlier in this Series that place essentially every pregnant patient at genuine risk of regurgitation.

This technique, discussed earlier in this sub-Part, involves careful preoxygenation, administration of a rapidly acting induction agent immediately followed by a rapidly acting muscle relaxant, and application of cricoid pressure, discussed further in the next sub-Part, together aiming to secure the airway before any meaningful opportunity for aspiration can occur.

Fill in the blank: Rapid sequence induction aims to minimise the time between loss of protective airway reflexes and secure endotracheal tube placement, given the pregnant patient's genuinely elevated aspiration _____.

2.4.2 technique of general anaesthesia in the pregnant patient

A modified sequence reflecting pregnancy's specific risks

General anaesthesia in the pregnant patient, discussed throughout this Part, generally follows the rapid sequence induction principle discussed earlier in this Part, together with **cricoid pressure**, firm posterior pressure applied to the cricoid cartilage aiming to occlude the oesophagus and reduce passive regurgitation risk during the vulnerable period before the airway is secured.

Left lateral tilt or manual uterine displacement, discussed earlier in this Series in relation to aortocaval compression, should be maintained throughout induction and the procedure itself, together with careful attention to the potentially more difficult airway discussed earlier in this Series, meaning general anaesthesia in pregnancy demands genuinely meticulous, well rehearsed preparation before proceeding.

Fill in the blank: Cricoid pressure applies firm posterior pressure to the cricoid cartilage aiming to occlude the oesophagus and reduce passive regurgitation risk during the vulnerable period before the airway is _____.

2.4.3 specific risks of general anaesthesia in pregnancy

Risks concentrated at induction and emergence

The specific risks of general anaesthesia in pregnancy, discussed throughout this Part, are genuinely concentrated at induction, given aspiration risk and the possibility of failed intubation in a potentially difficult airway, and at emergence, when protective airway reflexes must be fully recovered before extubation to avoid the same aspiration risk present at induction.

Further recognised risks, discussed earlier in this sub-Part, include **awareness under anaesthesia**, given the historically more cautious use of volatile anaesthetic agents in obstetric practice, and uterine relaxation from higher concentrations of volatile agent, potentially contributing to increased intraoperative blood loss, meaning general anaesthesia in pregnancy carries a genuinely distinct risk profile from general anaesthesia in the non-pregnant adult.

Fill in the blank: Specific risks of general anaesthesia in pregnancy include awareness under anaesthesia, given the historically more cautious use of volatile anaesthetic _____.

Pilot questions 2.4

1. Explain the rationale for rapid sequence induction in the pregnant patient. (Linked to SLO 2.7)
2. Describe the technique of rapid sequence induction. (Linked to SLO 2.7)
3. Define cricoid pressure and explain its purpose. (Linked to SLO 2.8)
4. Explain why the risks of general anaesthesia in pregnancy are concentrated at induction and emergence. (Linked to SLO 2.8)
5. List specific risks of general anaesthesia in pregnancy beyond aspiration. (Linked to SLO 2.8)

2.5 Modalities of Analgesia in Labour

2.5.1 non-pharmacological analgesia in labour

Techniques avoiding pharmacological agents entirely

Non-pharmacological analgesic modalities in labour, discussed in relation to the full spectrum of available techniques, include continuous labour support, breathing and relaxation techniques, hydrotherapy, and transcutaneous electrical nerve stimulation, each offering genuine, though generally more modest, analgesic benefit without any of the pharmacological side effects associated with the medication-based approaches discussed further later in this Series.

These techniques, discussed earlier in this sub-Part, are frequently used as a genuinely valuable complement to, rather than strict replacement for, pharmacological analgesia, and remain appropriate options for women specifically wishing to minimise medication exposure during labour, or as an initial approach before progressing to more potent analgesic techniques should labour pain intensify.

Fill in the blank: Non-pharmacological analgesic modalities in labour offer genuine, though generally more modest, analgesic benefit without any of the pharmacological side effects associated with medication-based _____.

2.5.2 systemic pharmacological analgesia in labour

Opioid and inhalational agents with genuine limitations

Systemic opioids, generally administered intramuscularly or intravenously, provide moderate labour analgesia but carry genuine recognised limitations, including maternal sedation and nausea, and, particularly relevant given placental transfer discussed in relation to drug ionisation in the previous Series of this course, neonatal respiratory depression if administered close to the time of delivery.

Inhalational analgesia, generally using nitrous oxide in combination with oxygen, discussed earlier in this sub-Part, offers a further systemic option, providing intermittent, self-administered analgesia during contractions with a genuinely favourable safety profile, though generally producing less complete analgesia than the regional techniques discussed in the final sub-Part of this Series.

Fill in the blank: Systemic opioids carry genuine recognised limitations, including maternal sedation and nausea, and neonatal respiratory _____ if administered close to the time of delivery.

2.5.3 regional analgesia in labour

The most effective available modality, epidural technique

Epidural analgesia, discussed in detail earlier in this Series, generally provides the most effective available labour analgesia, titrated throughout labour via an indwelling catheter, discussed earlier in this Series, and readily extended to provide surgical anaesthesia should operative delivery subsequently become necessary.

Combined spinal-epidural technique, discussed earlier in this sub-Part, offers a further recognised option, combining the rapid onset of a small initial spinal dose with the ongoing titratability of an epidural catheter, meaning regional techniques together represent the genuinely most effective, most flexible category of labour analgesia currently available.

Fill in the blank: Combined spinal-epidural technique combines the rapid onset of a small initial spinal dose with the ongoing titratability of an epidural _____.

Table 2.5: Comparing modalities of analgesia in labour.

Modality	Example	Key Characteristic
Non-pharmacological	Breathing techniques, water immersion, massage	Enhances coping and relaxation; minimal side effects; supportive adjunct
Systemic pharmacological	Intravenous opioids (e.g., pethidine, fentanyl)	Provides moderate pain relief; may cause maternal sedation and neonatal respiratory depression
Regional modalities	Epidural analgesia, spinal block	Most effective pain relief; requires skilled provider; potential for motor block and hypotension

Pilot questions 2.5

1. List non-pharmacological modalities of analgesia in labour. (Linked to SLO 2.9)
2. Describe the limitations of systemic opioid analgesia in labour. (Linked to SLO 2.9)
3. Describe inhalational analgesia in labour. (Linked to SLO 2.9)
4. Explain why epidural analgesia is generally considered the most effective labour analgesic modality. (Linked to SLO 2.10)
5. Describe combined spinal-epidural technique. (Linked to SLO 2.10)

Series Summary

This Series worked through the physiological changes of pregnancy, cardiovascular, respiratory, and gastrointestinal, before examining regional anaesthesia in obstetrics, subarachnoid block and epidural technique, general anaesthesia in the full-stomach pregnant patient, rapid sequence induction and its specific risks, and concluded with the full range of modalities of analgesia in labour, from non-pharmacological techniques through systemic agents to regional analgesia.

This obstetric foundation carries directly into preanaesthetic evaluation, airway management, and general anaesthesia, examined in the next Series of this course.

Glossary of Terms

6. **Aortocaval compression:** reduced venous return from gravid uterus compression of the aorta and vena cava in the supine position.
7. **Subarachnoid (spinal) block:** injection of local anaesthetic into the cerebrospinal fluid, producing rapid, dense blockade.
8. **Post-dural puncture headache:** headache resulting from cerebrospinal fluid leak through a dural puncture site.
9. **Epidural anaesthesia:** injection of local anaesthetic into the epidural space, producing titratable blockade.
10. **Loss of resistance technique:** the method used to identify correct epidural needle placement.
11. **Total spinal block:** an unexpectedly extensive block from epidural dose delivered into the subarachnoid space.
12. **Rapid sequence induction:** an induction technique minimising the time between loss of airway reflexes and secure intubation.
13. **Cricoid pressure:** posterior pressure on the cricoid cartilage aiming to reduce passive regurgitation risk.
14. **Combined spinal-epidural:** a technique combining an initial spinal dose with an ongoing epidural catheter.
15. **Non-pharmacological analgesia:** labour pain relief methods not involving medication.
16. **Neonatal respiratory depression:** a risk of systemic opioid analgesia administered close to delivery.
17. **Uterine displacement:** manual or positional technique used to relieve aortocaval compression.

Concept Check Questions [Series 2]

Objective questions

- The gravid uterus can produce aortocaval compression when the mother lies supine, substantially reducing venous return and cardiac _____.
- Subarachnoid block involves injecting local anaesthetic directly into the cerebrospinal fluid, producing rapid onset, dense sensory and motor _____.
- Epidural placement generally uses the loss of resistance technique, with the sudden loss of resistance signalling entry into the epidural space, just short of the _____.
- Rapid sequence induction aims to minimise the time between loss of protective airway reflexes and secure endotracheal tube placement, given the pregnant patient's genuinely elevated aspiration _____.
- Combined spinal-epidural technique combines the rapid onset of a small initial spinal dose with the ongoing titratability of an epidural _____.

Short-answer questions

1. Explain aortocaval compression and how it is prevented.
2. List complications of spinal anaesthesia in obstetrics.
3. Describe the loss of resistance technique for epidural placement.
4. Define cricoid pressure and explain its purpose.
5. Describe the limitations of systemic opioid analgesia in labour.

Long-answer questions

6. Discuss the physiological changes of pregnancy relevant to anaesthesia. (Linked to SLO 2.1, SLO 2.2)
7. Discuss the principles, technique, and complications of subarachnoid block in obstetrics. (Linked to SLO 2.3, SLO 2.4)
8. Discuss the principles, technique, and complications of epidural anaesthesia in obstetrics. (Linked to SLO 2.5, SLO 2.6)
9. Discuss rapid sequence induction and general anaesthesia in the full-stomach pregnant patient. (Linked to SLO 2.7, SLO 2.8)
10. Discuss the modalities of analgesia available in labour. (Linked to SLO 2.9, SLO 2.10)

Answers to Concept Check Questions [Series 2]

Objective questions

11. Output.
12. Blockade.
13. Dura.
14. Risk.
15. Catheter.

Short-answer questions

16. Reduced venous return from gravid uterus compression of the aorta and vena cava in the supine position; prevented by left lateral tilt or uterine displacement.
17. Hypotension, high spinal block, post-dural puncture headache, and, rarely, epidural haematoma or infection.
18. Advancing the needle through the ligamentum flavum with continuous gentle syringe pressure until sudden loss of resistance signals epidural space entry.
19. Posterior pressure on the cricoid cartilage, aiming to occlude the oesophagus and reduce passive regurgitation risk.
20. Maternal sedation and nausea, and neonatal respiratory depression if administered close to delivery.

Long-answer questions

21. **Basic response:** Pregnancy produces substantial cardiovascular, respiratory, and gastrointestinal change, each carrying direct anaesthetic implications.

Value-added response: Aortocaval compression, reduced apnoea tolerance, and full-stomach precautions together shape safe obstetric anaesthetic practice.

22. **Basic response:** Subarachnoid block provides rapid, dense blockade well suited to caesarean section, performed using careful anatomical landmark identification.

Value-added response: Recognised complications include hypotension, high block, and post-dural puncture headache, requiring prompt recognition and management.

23. **Basic response:** Epidural technique offers titratable, catheter-based blockade well suited to labour analgesia and extendable to surgery.

Value-added response: Complications include inadvertent dural puncture risking total spinal block, hypotension, and, rarely, more serious infective or haematological complications.

24. **Basic response:** Rapid sequence induction minimises aspiration risk in the pregnant patient through prompt airway securing, cricoid pressure, and careful positioning.

Value-added response: Specific risks concentrate at induction and emergence, including aspiration, difficult airway, and awareness under anaesthesia.

25. **Basic response:** Labour analgesia ranges from non-pharmacological techniques through systemic opioids and inhalational agents to regional techniques.

Value-added response: Epidural and combined spinal-epidural technique generally provide the most effective, flexible analgesia currently available.

Answers to Pilot Questions [Series 2]

Part 2.1

1. Increased cardiac output, expanded circulating blood volume, and reduced systemic vascular resistance.
2. Reduced venous return from gravid uterus compression of the aorta and vena cava when supine; prevented by left lateral tilt or uterine displacement.
3. Increased minute ventilation and oxygen consumption with reduced functional residual capacity, producing rapid desaturation during apnoea.
4. Because mucosal oedema, capillary engorgement, and weight gain affect airway visualisation.
5. Reduced sphincter tone and delayed gastric emptying substantially increase regurgitation and aspiration risk.

Part 2.2

6. Injection of local anaesthetic directly into the cerebrospinal fluid within the subarachnoid space, producing rapid, dense blockade.
7. It avoids the risks of general anaesthesia in pregnancy, including airway difficulty and aspiration risk.
8. Positioning the patient, identifying the lumbar interspace, and advancing a fine spinal needle into the subarachnoid space, confirmed by cerebrospinal fluid flow.
9. Hypotension, high spinal block, post-dural puncture headache, and, rarely, epidural haematoma or infection.
10. Intravenous fluid administration and vasopressor therapy.

Part 2.3

11. Injection of local anaesthetic and opioid into the epidural space, producing titratable blockade via an indwelling catheter.
12. Because labour analgesia is needed over a prolonged, unpredictable duration that an epidural catheter can accommodate.
13. Advancing the needle through the ligamentum flavum with continuous syringe pressure until sudden loss of resistance signals epidural space entry.
14. It can produce an unexpectedly extensive total spinal block if the intended epidural dose enters the subarachnoid space.
15. Inadvertent dural puncture, hypotension, local anaesthetic systemic toxicity, and, rarely, epidural haematoma or abscess.

Part 2.4

1. It minimises the time between loss of airway reflexes and secure intubation given the pregnant patient's elevated aspiration risk.
2. Careful preoxygenation, rapidly acting induction agent immediately followed by a rapidly acting muscle relaxant, and cricoid pressure.
3. Posterior pressure on the cricoid cartilage to occlude the oesophagus and reduce passive regurgitation risk.
4. Because these are the periods of greatest aspiration and airway management vulnerability.
5. Awareness under anaesthesia and uterine relaxation from higher volatile agent concentrations, potentially increasing blood loss.

Part 2.5

1. Continuous labour support, breathing and relaxation techniques, hydrotherapy, and transcutaneous electrical nerve stimulation.
2. Maternal sedation and nausea, and risk of neonatal respiratory depression if administered close to delivery.
3. Self-administered nitrous oxide and oxygen providing intermittent analgesia during contractions with a favourable safety profile.
4. Because it is titrated throughout labour and can be extended to surgical anaesthesia if needed.
5. A technique combining a small initial spinal dose for rapid onset with an ongoing epidural catheter for continued titration.

References and Attributions [Series 2]

6. Chestnut, D. H., et al. (2020). Chestnut's Obstetric Anesthesia: Principles and Practice (6th ed.). Elsevier.
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8. Miller, R. D., et al. (2019). Miller's Anesthesia (9th ed.). Elsevier.
9. Butterworth, J. F., Mackey, D. C., & Wasnick, J. D. (2018). Morgan and Mikhail's Clinical Anesthesiology (6th ed.). McGraw-Hill.

Figures, Plates, Tables, and Boxes

1. Table 2.1: Key physiological changes of pregnancy relevant to anaesthesia. AI-generated using the prompt: "Create a clean physiology reference table titled Key Physiological Changes of Pregnancy Relevant to Anaesthesia, listing system, change, and anaesthetic implication. Medical reference table style with outside border, no photographic elements."
2. Figure 2.2: A diagram illustrating the anatomical layers traversed during subarachnoid needle placement, from skin to the subarachnoid space. AI-generated using the prompt: "A single clean, accurate cross-sectional anatomical diagram of the lumbar spine with a labelled needle trajectory passing through skin, ligamentum flavum, and dura mater into the subarachnoid space, textbook anatomical diagram style, neutral background, no photographic realism, no other panels."
3. Table 2.3: Comparing spinal and epidural anaesthesia in obstetrics. AI-generated using the prompt: "Create a clean clinical reference table titled Comparing Spinal and Epidural Anaesthesia in Obstetrics, listing feature, spinal, and epidural. Medical reference table style with outside border, no photographic elements."
4. Table 2.5: Comparing modalities of analgesia in labour. AI-generated using the prompt: "Create a clean clinical reference table titled Comparing Modalities of Analgesia in Labour, listing modality, example, and key characteristic. Medical reference table style with outside border, no photographic elements."

Series 3: Preanaesthetic Evaluation, Airway Management, and General Anaesthesia

- **Part 3.1: Preanaesthetic Evaluation and Premedication**
  - Sub Part 3.1.1: Components of preanaesthetic evaluation
  - Sub Part 3.1.2: Recognising the high-risk patient
  - Sub Part 3.1.3: Principles of premedication
- **Part 3.2: Airway Assessment and Management**
  - Sub Part 3.2.1: Airway assessment and predicting the difficult airway
  - Sub Part 3.2.2: Causes and consequences of airway obstruction
  - Sub Part 3.2.3: Non-invasive airway manoeuvres and airway devices
- **Part 3.3: Oxygen Therapy and Artificial Ventilation**
  - Sub Part 3.3.1: Hypoxia: causes, consequences, and management
  - Sub Part 3.3.2: Oxygen delivery devices
  - Sub Part 3.3.3: Introduction to artificial ventilation
- **Part 3.4: Anaesthetic Equipment and Technique of General Anaesthesia**
  - Sub Part 3.4.1: Anaesthetic machine and breathing systems
  - Sub Part 3.4.2: Induction using IV or inhalational agents
  - Sub Part 3.4.3: Muscle relaxants, maintenance, and termination of anaesthesia
- **Part 3.5: Anaesthesia in Special Disease Conditions and Day-Case Surgery**
  - Sub Part 3.5.1: Anaesthesia in hypertension and diabetes mellitus
  - Sub Part 3.5.2: Anaesthesia in sickle cell disease, shock, and renal failure
  - Sub Part 3.5.3: Day-case anaesthesia

Introduction

Genuinely safe general anaesthesia is decided long before the patient ever enters the operating theatre, in the careful preanaesthetic evaluation that identifies risk, the airway assessment that

anticipates difficulty, and the deliberate equipment and technique choices that follow from both. This Series works through that entire sequence in order, **preanaesthetic evaluation and premedication**, **airway assessment and management**, **oxygen therapy and artificial ventilation**, the **anaesthetic equipment and technique** underlying general anaesthesia itself, and, finally, the specific modifications required when anaesthetising patients with important coexisting disease or undergoing day-case surgery.

The aim of this Series is to equip you with a thorough understanding of preanaesthetic evaluation, preparation and premedication, airway assessment and management, hypoxia and oxygen delivery, artificial ventilation, anaesthetic equipment, induction, muscle relaxants, maintenance and termination of anaesthesia, anaesthesia in various disease conditions, and day-case anaesthesia.

This Series begins with **preanaesthetic evaluation and premedication**, before turning to **airway assessment and management**, **oxygen therapy and artificial ventilation**, and **anaesthetic equipment and technique of general anaesthesia**. It concludes with **anaesthesia in special disease conditions and day-case surgery**.

Series Learning Outcomes

At the end of this Series, you should be able to:

- **SLO 3.1:** describe the components of preanaesthetic evaluation and recognise the high-risk patient
- **SLO 3.2:** describe the principles of premedication
- **SLO 3.3:** describe airway assessment and prediction of the difficult airway
- **SLO 3.4:** describe causes and consequences of airway obstruction and airway management devices
- **SLO 3.5:** describe hypoxia and oxygen delivery devices
- **SLO 3.6:** describe the principles of artificial ventilation
- **SLO 3.7:** describe anaesthetic equipment and the breathing systems used in anaesthesia
- **SLO 3.8:** describe induction of anaesthesia, muscle relaxants, and maintenance and termination of anaesthesia
- **SLO 3.9:** describe anaesthesia in patients with hypertension, diabetes, sickle cell disease, shock, and renal failure, and
- **SLO 3.10:** describe the principles of day-case anaesthesia.

3.1 Preanaesthetic Evaluation and Premedication

3.1.1 components of preanaesthetic evaluation

A systematic assessment shaping the entire anaesthetic plan

Preanaesthetic evaluation, discussed in relation to common comorbidity in an earlier Series of this course, comprises a thorough history, including prior anaesthetic experience and any family history of anaesthetic complication, physical examination focused particularly on the airway and cardiorespiratory systems, and review of relevant investigations, together building a complete picture of the patient's overall fitness for the planned procedure.

This evaluation, discussed earlier in this sub-Part, directly informs **American Society of Anesthesiologists (ASA) physical status classification**, a standardised grading system communicating overall patient risk, and allows the anaesthetist to select the specific anaesthetic technique, monitoring intensity, and perioperative plan genuinely appropriate to that individual patient's own particular risk profile.

Fill in the blank: Preanaesthetic evaluation directly informs American Society of Anesthesiologists physical status classification, a standardised grading system communicating overall patient _____.

3.1.2 recognising the high-risk patient

Identifying factors that meaningfully elevate perioperative risk

The **high-risk patient**, discussed in relation to ASA classification earlier in this Part, is generally identified through a combination of factors, including significant coexisting cardiac, respiratory, or renal disease, extremes of age, emergency rather than elective surgical timing, and the specific magnitude and physiological demand of the planned surgical procedure itself.

Recognising this elevated risk, discussed earlier in this sub-Part, allows genuinely proactive planning, including additional preoperative optimisation where time permits, more intensive intraoperative monitoring, and appropriate postoperative care escalation, meaning early identification of the high-risk patient directly supports meaningfully improved perioperative safety and outcome.

Fill in the blank: Recognising the high-risk patient allows genuinely proactive planning, including additional preoperative optimisation and appropriate postoperative care _____.

3.1.3 principles of premedication

Preparing the patient pharmacologically before induction

Premedication, discussed throughout this Part, uses a range of drug classes administered before induction, including **anxiolytics**, reducing preoperative anxiety, **opioids and antagonists**, providing early analgesia, further **analgesics**, and **anticholinergics**, reducing airway secretions and vagally mediated bradycardia, each selected according to the specific patient and planned procedure.

The specific choice and combination of premedicant agents, discussed earlier in this sub-Part, should genuinely reflect the individual patient's own particular clinical circumstances, since a universal, standardised premedication approach cannot adequately address the genuinely diverse range of patient ages, comorbidities, and procedure types encountered in everyday anaesthetic practice.

Fill in the blank: Premedication uses a range of drug classes administered before induction, including anxiolytics, opioids and antagonists, further analgesics, and _____, reducing airway secretions and vagally mediated bradycardia.

Table 3.1: Key components of preanaesthetic evaluation.

Component	Focus	Purpose
History	Prior anaesthetic experience, comorbidity, family history	Identifies specific individual risk factors
Examination	Airway and cardiorespiratory systems	Predicts difficulty and guides technique
Investigations	Relevant laboratory and imaging review	Confirms fitness and informs planning

Pilot questions 3.1

- List the components of preanaesthetic evaluation. (Linked to SLO 3.1)
- Describe the ASA physical status classification and its purpose. (Linked to SLO 3.1)
- List factors identifying the high-risk patient. (Linked to SLO 3.1)
- Explain the value of proactive planning for the high-risk patient. (Linked to SLO 3.1)
- List drug classes used in premedication and their purpose. (Linked to SLO 3.2)

3.2 Airway Assessment and Management

3.2.1 airway assessment and predicting the difficult airway

Systematic bedside tests anticipating intubation difficulty

Airway assessment, discussed in relation to airway anatomy in an earlier Series of this course, uses a combination of bedside tests, including the **Mallampati classification**, assessing visible oropharyngeal structures with the mouth open, thyromental distance, and neck mobility, together helping predict the likelihood of difficult laryngoscopy or intubation before induction is attempted.

While no single assessment test achieves perfect predictive accuracy, discussed earlier in this sub-Part, combining several complementary assessment findings genuinely improves overall predictive value, meaning thorough, systematic airway assessment before every general anaesthetic represents an essential safety practice rather than an optional formality.

Fill in the blank: While no single airway assessment test achieves perfect predictive accuracy, combining several complementary assessment findings genuinely improves overall predictive _____.

3.2.2 causes and consequences of airway obstruction

Recognising obstruction before hypoxia develops

Airway obstruction, discussed in relation to airway emergencies in an earlier Series of this course, may result from soft tissue collapse in the unconscious patient, laryngospasm, foreign material, or pathological swelling, with consequences ranging from mild, audible stridor to complete obstruction and rapid, severe hypoxaemia if left unrecognised.

Recognising the specific clinical signs of obstruction, discussed earlier in this sub-Part, including paradoxical chest and abdominal movement, absent breath sounds despite respiratory effort, and characteristic added sounds such as stridor, allows prompt intervention before the genuinely serious consequences of established hypoxaemia, discussed further later in this Series, develop.

Fill in the blank: Recognising the specific clinical signs of airway obstruction allows prompt intervention before the genuinely serious consequences of established _____ develop.

3.2.3 non-invasive airway manoeuvres and airway devices

A stepwise approach from manoeuvres to instrumentation

Non-invasive manoeuvres, including **head tilt**, **jaw thrust**, and **chin lift**, discussed throughout this Part, represent the essential first-line response to airway obstruction, generally sufficient to

relieve soft tissue obstruction in the unconscious patient without requiring any additional equipment.

Where these manoeuvres alone prove insufficient, discussed earlier in this sub-Part, **airway devices**, including oropharyngeal and nasopharyngeal airways, the **laryngeal mask airway**, providing supraglottic airway support, and, where full airway protection is required, **endotracheal intubation**, or, in a genuine emergency, **cricothyrotomy**, together represent a stepwise, escalating range of airway management options.

Fill in the blank: Non-invasive manoeuvres, including head tilt, jaw thrust, and chin lift, represent the essential first-line response to airway _____.

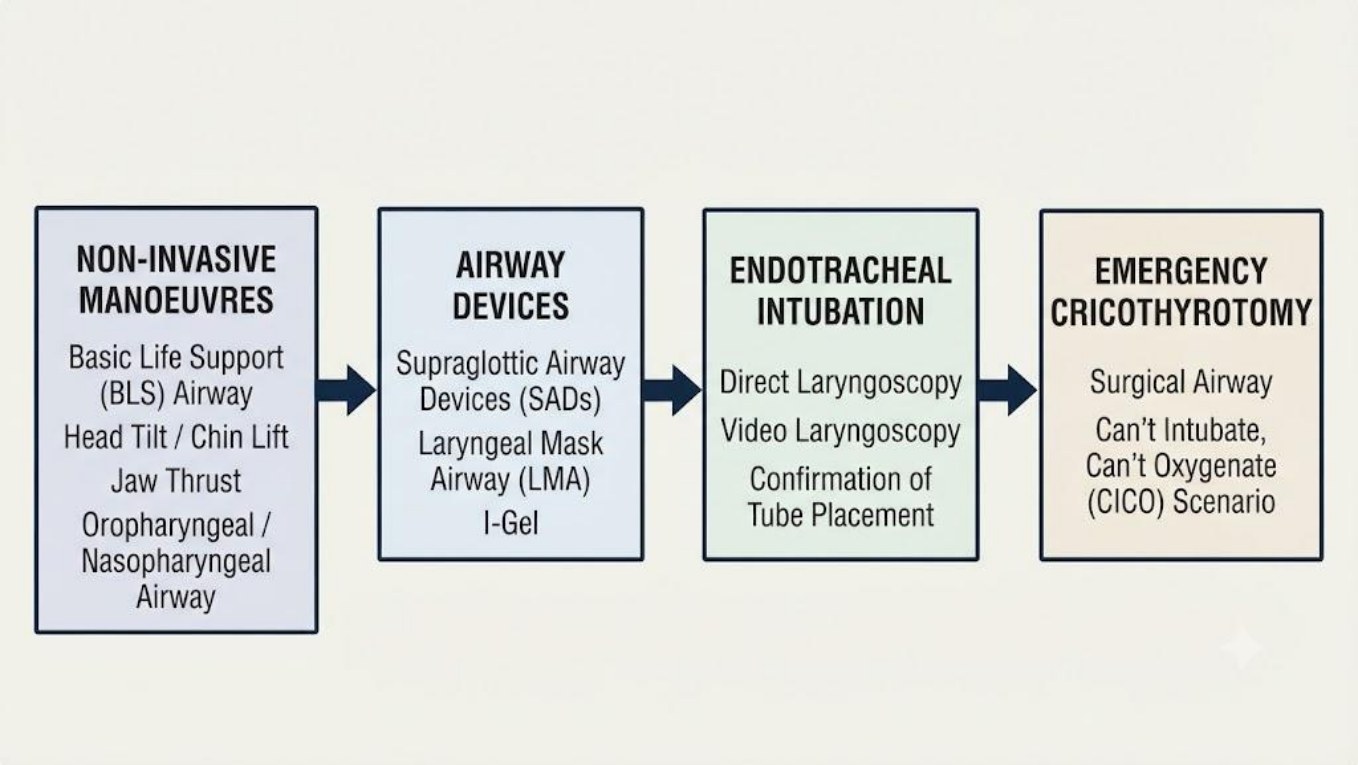

Figure 3.2: A diagram illustrating the stepwise escalation of airway management, from non-invasive manoeuvres through airway devices to definitive intubation.

Pilot questions 3.2

1. Describe the Mallampati classification and its purpose. (Linked to SLO 3.3)
2. List further bedside tests used to predict a difficult airway. (Linked to SLO 3.3)
3. List causes of airway obstruction. (Linked to SLO 3.4)
4. Describe clinical signs suggesting airway obstruction. (Linked to SLO 3.4)

5. Describe the stepwise escalation of airway management from manoeuvres to devices. (Linked to SLO 3.4)

3.3 Oxygen Therapy and Artificial Ventilation

3.3.1 hypoxia: causes, consequences, and management

Recognising and correcting inadequate tissue oxygenation

Hypoxia, discussed in relation to airway obstruction earlier in this Series, describes inadequate tissue oxygenation, resulting from a range of causes including airway obstruction, hypoventilation, ventilation-perfusion mismatch, and impaired oxygen delivery, each requiring a genuinely specific, cause-directed management approach rather than a single uniform response.

Consequences of unrecognised, uncorrected hypoxia, discussed earlier in this sub-Part, range from confusion and tachycardia in its milder stages to cardiac arrhythmia, organ dysfunction, and, ultimately, cardiac arrest if genuinely severe and prolonged, meaning prompt recognition through continuous pulse oximetry monitoring and immediate, appropriate intervention represents an essential anaesthetic safety priority.

Fill in the blank: Consequences of unrecognised, uncorrected hypoxia range from confusion and tachycardia in its milder stages to cardiac arrhythmia, organ dysfunction, and, ultimately, cardiac _____ if genuinely severe.

3.3.2 oxygen delivery devices

Matching device choice to required inspired oxygen concentration

Oxygen delivery devices, discussed throughout this Part, range from simple, low-flow nasal cannulae, providing a variable, generally modest increase in inspired oxygen concentration, through **variable performance face masks**, to **fixed performance devices**, such as Venturi masks, delivering a genuinely precise, predictable inspired oxygen concentration.

Selecting the appropriate device, discussed earlier in this sub-Part, depends on the specific clinical scenario and the degree of supplemental oxygen genuinely required, with **non-rebreathing masks** reserved for patients requiring the highest achievable inspired oxygen concentration short of formal mechanical ventilation, discussed further in the next sub-Part.

Fill in the blank: Fixed performance devices, such as Venturi masks, deliver a genuinely precise, predictable inspired oxygen _____.

3.3.3 introduction to artificial ventilation

Supporting or replacing spontaneous breathing

Artificial ventilation, discussed in relation to muscle relaxant use further later in this Series, provides mechanical support or complete replacement of spontaneous breathing, indicated in general anaesthesia with muscle relaxation, respiratory failure, and a range of critical care scenarios, discussed further in a later Series of this course.

Ventilator **modes**, discussed earlier in this sub-Part, range from fully controlled ventilation, providing complete respiratory support, to assisted modes supporting the patient's own respiratory effort, with appropriate **weaning** from ventilatory support, and recognition of recognised complications such as ventilator-associated lung injury, representing essential further components of safe mechanical ventilation practice.

Fill in the blank: Appropriate weaning from ventilatory support and recognition of recognised complications such as ventilator-associated lung injury represent essential further components of safe mechanical ventilation _____.

Table 3.3: Comparing key oxygen delivery devices.

Device	Typical FiO2 range	Key feature
Nasal cannulae	Variable, generally modest increase	Simple, well tolerated for low-flow supplementation
Venturi mask	Fixed, precise, predictable	Used where accurate FiO2 control is required
Non-rebreathing mask	High, close to maximum achievable without ventilation	Reserved for patients requiring highest supplemental oxygen

Pilot questions 3.3

1. Define hypoxia and list its causes. (Linked to SLO 3.5)
2. Describe the consequences of unrecognised hypoxia. (Linked to SLO 3.5)
3. Compare low-flow and fixed performance oxygen delivery devices. (Linked to SLO 3.5)
4. Describe the indications for artificial ventilation. (Linked to SLO 3.6)
5. Describe ventilator modes and the concept of weaning. (Linked to SLO 3.6)

3.4 Anaesthetic Equipment and Technique of General Anaesthesia

3.4.1 anaesthetic machine and breathing systems

The physical apparatus delivering gases safely to the patient

The **anaesthetic machine**, discussed throughout this Part, delivers a precisely controlled mixture of oxygen, air, and volatile anaesthetic agent to the patient, incorporating gas supply, flowmeters, vaporisers, and safety mechanisms including oxygen failure alarms, together forming the essential physical apparatus underlying safe inhalational anaesthesia.

Breathing systems, discussed earlier in this sub-Part, connect the anaesthetic machine to the patient's airway, with different circuit designs, including circle systems incorporating carbon dioxide absorption for gas recycling, offering distinct efficiency and practical advantages, meaning selecting and correctly checking the appropriate breathing system represents an essential preparatory step before every general anaesthetic.

Fill in the blank: Breathing systems connect the anaesthetic machine to the patient's airway, with circle systems incorporating carbon dioxide absorption for gas _____.

3.4.2 induction using iv or inhalational agents

Two genuinely distinct routes to unconsciousness

Intravenous induction, using agents such as propofol, generally provides rapid, smooth onset of unconsciousness well suited to most adult patients, while **inhalational induction**, using volatile agents delivered via facemask, remains particularly valuable in children or patients without ready intravenous access, discussed throughout this Part.

The choice between these two routes, discussed earlier in this sub-Part, depends on patient age, cooperation, intravenous access, and the specific clinical scenario, including the rapid sequence induction technique discussed in the previous Series of this course, meaning both induction approaches remain genuinely important, complementary tools within everyday anaesthetic practice.

Fill in the blank: The choice between intravenous and inhalational induction depends on patient age, cooperation, intravenous access, and the specific clinical _____.

3.4.3 muscle relaxants, maintenance, and termination of anaesthesia

The balanced anaesthesia concept and safe emergence

Muscle relaxants, discussed in relation to neuromuscular junction physiology in an earlier Series of this course, facilitate intubation and surgical relaxation, with **maintenance** of anaesthesia generally achieved through continued volatile agent or intravenous infusion, reflecting the **balanced anaesthesia** concept, combining several agents each contributing a specific component, hypnosis, analgesia, and muscle relaxation, rather than relying on a single drug alone.

Termination of anaesthesia, discussed earlier in this sub-Part, involves discontinuing anaesthetic agents, ensuring adequate reversal of neuromuscular blockade where used, and confirming the return of protective airway reflexes before extubation, meaning safe emergence requires the same genuine care and systematic attention as induction itself.

Fill in the blank: The balanced anaesthesia concept combines several agents each contributing a specific component, hypnosis, analgesia, and muscle relaxation, rather than relying on a single _____ alone.

Pilot questions 3.4

1. Describe the function of the anaesthetic machine. (Linked to SLO 3.7)
2. Describe breathing systems and the role of carbon dioxide absorption in circle systems. (Linked to SLO 3.7)
3. Compare intravenous and inhalational induction. (Linked to SLO 3.8)
4. Describe the balanced anaesthesia concept. (Linked to SLO 3.8)
5. Describe the components of safe termination of anaesthesia. (Linked to SLO 3.8)

3.5 Anaesthesia in Special Disease Conditions and Day-Case Surgery

3.5.1 anaesthesia in hypertension and diabetes mellitus

Modifying technique for two genuinely common comorbidities

Hypertension, discussed in relation to cardiovascular physiology in an earlier Series of this course, requires careful preoperative blood pressure optimisation and intraoperative haemodynamic monitoring, given the risk of exaggerated blood pressure swings during induction and surgical stimulation in the poorly controlled hypertensive patient.

Diabetes mellitus, discussed earlier in this sub-Part, requires careful perioperative glycaemic monitoring and management, together with specific attention to potentially difficult airway management given recognised diabetic joint stiffness affecting laryngoscopy, and awareness of diabetic autonomic neuropathy, which can blunt normal compensatory cardiovascular responses during anaesthesia.

Fill in the blank: Diabetes mellitus requires careful perioperative glycaemic monitoring and management, together with specific attention to potentially difficult airway management given recognised diabetic joint _____.

3.5.2 anaesthesia in sickle cell disease, shock, and renal failure

Conditions demanding genuinely specific anaesthetic modification

Sickle cell disease, discussed in relation to hyphaema risk in related coursework, requires meticulous avoidance of hypoxia, hypothermia, acidosis, and dehydration during anaesthesia, each capable of precipitating sickling and vaso-occlusive crisis, meaning anaesthetic management genuinely centres on maintaining optimal physiological conditions throughout the perioperative period.

Shock, discussed throughout this sub-Part, demands cautious, titrated induction technique given reduced physiological reserve, while **renal failure** requires careful drug selection avoiding agents dependent on renal excretion, and attention to fluid and electrolyte balance, discussed in relation to biochemistry in an earlier Series of this course, meaning each of these three conditions demands genuinely distinct, condition-specific anaesthetic modification.

Fill in the blank: Renal failure requires careful drug selection avoiding agents dependent on renal excretion, and attention to fluid and electrolyte _____.

3.5.3 day-case anaesthesia

A model built around rapid, safe recovery and discharge

Day-case anaesthesia, discussed throughout this Part, is used for appropriately selected patients and procedures where same-day discharge is genuinely anticipated, with **selection criteria** including patient fitness, procedure suitability, and adequate home support, each carefully assessed before the procedure is scheduled on a day-case basis.

Technique for day-case anaesthesia, discussed earlier in this sub-Part, generally favours shorter-acting agents supporting rapid recovery, with specific **discharge criteria**, including stable vital signs, adequate pain control, and ability to tolerate oral fluids, applied before discharge, and clear planning for **unplanned admission** where recovery does not proceed as genuinely anticipated.

Fill in the blank: Discharge criteria for day-case anaesthesia include stable vital signs, adequate pain control, and ability to tolerate oral _____.

Table 3.5: Anaesthetic considerations in selected disease conditions.

Condition	Key risk	Key management principle
Hypertension	Exaggerated blood pressure swings	Preoperative optimisation and careful monitoring
Sickle cell disease	Sickling and vaso-occlusive crisis	Avoid hypoxia, hypothermia, acidosis, and dehydration
Renal failure	Accumulation of renally excreted drugs	Careful drug selection and fluid/electrolyte attention

Pilot questions 3.5

1. Describe anaesthetic considerations in the hypertensive patient. (Linked to SLO 3.9)
2. Describe anaesthetic considerations in the diabetic patient. (Linked to SLO 3.9)
3. List factors requiring avoidance during anaesthesia in sickle cell disease. (Linked to SLO 3.9)
4. Describe anaesthetic considerations in shock and renal failure. (Linked to SLO 3.9)
5. Describe selection and discharge criteria for day-case anaesthesia. (Linked to SLO 3.10)

Series Summary

This Series worked through preanaesthetic evaluation and premedication, recognising the high-risk patient, airway assessment and management, from non-invasive manoeuvres through airway devices, oxygen therapy and artificial ventilation, anaesthetic equipment and the technique of general anaesthesia itself, induction, muscle relaxants, and safe termination, and concluded with anaesthesia in special disease conditions and day-case surgery.

This foundation in general anaesthetic technique carries directly into regional anaesthesia, local anaesthetics, and peripheral nerve blocks, examined in the next Series of this course.

Glossary of Terms

6. **ASA physical status classification:** a standardised grading system communicating overall perioperative patient risk.
7. **Premedication:** drugs administered before induction to reduce anxiety, provide analgesia, or reduce secretions.
8. **Mallampati classification:** a bedside test assessing visible oropharyngeal structures to predict difficult intubation.
9. **Laryngeal mask airway:** a supraglottic airway device providing airway support without tracheal intubation.
10. **Cricothyrotomy:** an emergency surgical airway technique used when other methods have failed.
11. **Hypoxia:** inadequate tissue oxygenation from a range of underlying causes.
12. **Venturi mask:** a fixed performance oxygen delivery device providing precise inspired oxygen concentration.
13. **Circle breathing system:** a breathing system incorporating carbon dioxide absorption for gas recycling.
14. **Balanced anaesthesia:** the concept of combining several agents, each contributing a specific anaesthetic component.
15. **Vaso-occlusive crisis:** sickling-related vascular occlusion, avoided through careful anaesthetic management in sickle cell disease.
16. **Day-case anaesthesia:** anaesthesia for appropriately selected patients undergoing same-day discharge procedures.
17. **Discharge criteria:** the specific standards applied before discharging a day-case patient.

Concept Check Questions [Series 3]

Objective questions

- Preanaesthetic evaluation directly informs American Society of Anesthesiologists physical status classification, a standardised grading system communicating overall patient _____.
- While no single airway assessment test achieves perfect predictive accuracy, combining several complementary assessment findings genuinely improves overall predictive _____.

- Consequences of unrecognised, uncorrected hypoxia range from confusion and tachycardia in its milder stages to cardiac arrhythmia, organ dysfunction, and, ultimately, cardiac _____.
- The balanced anaesthesia concept combines several agents each contributing a specific component, hypnosis, analgesia, and muscle relaxation, rather than relying on a single _____ alone.
- Sickled red cell-related complications during anaesthesia are avoided through meticulous avoidance of hypoxia, hypothermia, acidosis, and _____.

Short-answer questions

1. List the components of preanaesthetic evaluation.
2. List drug classes used in premedication and their purpose.
3. Describe the stepwise escalation of airway management from manoeuvres to devices.
4. Compare intravenous and inhalational induction.
5. Describe selection and discharge criteria for day-case anaesthesia.

Long-answer questions

6. Discuss preanaesthetic evaluation, recognising the high-risk patient, and the principles of premedication. (Linked to SLO 3.1, SLO 3.2)
7. Discuss airway assessment, causes and consequences of airway obstruction, and airway management devices. (Linked to SLO 3.3, SLO 3.4)
8. Discuss hypoxia, oxygen delivery devices, and the principles of artificial ventilation. (Linked to SLO 3.5, SLO 3.6)
9. Discuss anaesthetic equipment, breathing systems, induction, muscle relaxants, and termination of anaesthesia. (Linked to SLO 3.7, SLO 3.8)
10. Discuss anaesthesia in hypertension, diabetes, sickle cell disease, shock, renal failure, and day-case surgery. (Linked to SLO 3.9, SLO 3.10)

Answers to Concept Check Questions [Series 3]

Objective questions

11. Risk.
12. Value.
13. Arrest.
14. Drug.
15. Dehydration.

Short-answer questions

16. History, physical examination, and review of relevant investigations.
17. Anxiolytics for anxiety, opioids and antagonists and further analgesics for analgesia, and anticholinergics to reduce secretions and bradycardia.
18. Non-invasive manoeuvres first, followed by airway devices, then endotracheal intubation, with emergency cricothyrotomy where all else fails.
19. Intravenous induction is rapid and smooth, suited to most adults; inhalational induction is facemask-based, valuable in children or without IV access.
20. Selection based on patient fitness, procedure suitability, and home support; discharge based on stable vital signs, pain control, and oral fluid tolerance.

Long-answer questions

21. **Basic response:** Preanaesthetic evaluation identifies risk through history, examination, and investigation, informing ASA classification.

Value-added response: Recognising the high-risk patient and selecting appropriate premedication together support proactive, individualised anaesthetic planning.

22. **Basic response:** Airway assessment predicts difficulty through tests such as Mallampati classification, while obstruction is recognised through specific clinical signs.

Value-added response: Management escalates stepwise from non-invasive manoeuvres through airway devices to definitive intubation or emergency cricothyrotomy.

23. **Basic response:** Hypoxia from various causes carries serious consequences requiring prompt recognition, matched by appropriate oxygen device selection.

Value-added response: Artificial ventilation provides mechanical respiratory support where needed, with careful attention to modes, weaning, and complications.

24. **Basic response:** The anaesthetic machine and breathing systems deliver gases safely, supporting either intravenous or inhalational induction as appropriate.

Value-added response: Muscle relaxants and the balanced anaesthesia concept underpin maintenance, with careful, systematic termination ensuring safe emergence.

25. **Basic response:** Hypertension, diabetes, sickle cell disease, shock, and renal failure each demand genuinely specific anaesthetic modification.

Value-added response: Day-case anaesthesia applies careful selection and discharge criteria to support safe, appropriate same-day recovery.

Answers to Pilot Questions [Series 3]

Part 3.1

1. History, physical examination, and review of relevant investigations.
2. A standardised grading system communicating overall perioperative patient risk.
3. Significant coexisting disease, extremes of age, emergency surgery, and major surgical procedures.
4. It supports additional optimisation, more intensive monitoring, and appropriate postoperative care escalation.
5. Anxiolytics, opioids and antagonists, further analgesics, and anticholinergics, reducing anxiety, providing analgesia, and reducing secretions or bradycardia.

Part 3.2

6. A bedside test assessing visible oropharyngeal structures with the mouth open, predicting intubation difficulty.
7. Thyromental distance and neck mobility.
8. Soft tissue collapse, laryngospasm, foreign material, and pathological swelling.
9. Paradoxical chest and abdominal movement, absent breath sounds despite effort, and stridor.
10. Non-invasive manoeuvres first, then airway devices, then endotracheal intubation, with cricothyrotomy in genuine emergency.

Part 3.3

11. Inadequate tissue oxygenation; causes include airway obstruction, hypoventilation, V/Q mismatch, and impaired oxygen delivery.
12. Confusion and tachycardia initially, progressing to arrhythmia, organ dysfunction, and cardiac arrest if severe and prolonged.
13. Low-flow devices provide variable, modest oxygen increase; fixed performance devices provide precise, predictable concentration.

14. General anaesthesia with muscle relaxation, respiratory failure, and various critical care scenarios.
15. Modes range from fully controlled to assisted; weaning is the gradual, safe reduction of ventilatory support.

Part 3.4

1. It delivers a precisely controlled mixture of oxygen, air, and volatile agent, incorporating safety mechanisms.
2. They connect the machine to the patient; circle systems recycle gas using carbon dioxide absorption for efficiency.
3. Intravenous induction is rapid and smooth, suited to most adults; inhalational induction is facemask-based, valuable without IV access.
4. Combining several agents, each contributing a specific component, hypnosis, analgesia, and muscle relaxation.
5. Discontinuing agents, reversing neuromuscular blockade where used, and confirming return of protective airway reflexes before extubation.

Part 3.5

1. Careful preoperative optimisation and monitoring to avoid exaggerated blood pressure swings.
2. Glycaemic monitoring, awareness of potentially difficult airway from joint stiffness, and diabetic autonomic neuropathy.
3. Hypoxia, hypothermia, acidosis, and dehydration.
4. Cautious, titrated induction in shock; careful drug selection and fluid/electrolyte attention in renal failure.
5. Selection based on patient fitness, procedure suitability, and home support; discharge based on stable vitals, pain control, and oral tolerance.

References and Attributions [Series 3]

6. Aitkenhead, A. R., Moppett, I. K., & Thompson, J. P. (2013). Smith and Aitkenhead's Textbook of Anaesthesia (6th ed.). Churchill Livingstone.
7. Butterworth, J. F., Mackey, D. C., & Wasnick, J. D. (2018). Morgan and Mikhail's Clinical Anesthesiology (6th ed.). McGraw-Hill.
8. Miller, R. D., et al. (2019). Miller's Anesthesia (9th ed.). Elsevier.
9. American Society of Anesthesiologists (2020). Practice Guidelines for Preanesthesia Evaluation.

Figures, Plates, Tables, and Boxes

1. Table 3.1: Key components of preanaesthetic evaluation. AI-generated using the prompt: "Create a clean clinical reference table titled Key Components of Preanaesthetic Evaluation, listing component, focus, and purpose. Medical reference table style with outside border, no photographic elements."
2. Figure 3.2: A diagram illustrating the stepwise escalation of airway management, from non-invasive manoeuvres through airway devices to definitive intubation. AI-generated using the prompt: "A single clean, accurate schematic flow diagram with four labelled sequential boxes, Non-Invasive Manoeuvres, Airway Devices, Endotracheal Intubation, and Emergency Cricothyrotomy, connected by directional arrows, textbook clinical diagram style, neutral background, no photographic realism, no other panels."
3. Table 3.3: Comparing key oxygen delivery devices. AI-generated using the prompt: "Create a clean clinical reference table titled Comparing Key Oxygen Delivery Devices, listing device, typical FiO2 range, and key feature. Medical reference table style with outside border, no photographic elements."
4. Table 3.5: Anaesthetic considerations in selected disease conditions. AI-generated using the prompt: "Create a clean clinical reference table titled Anaesthetic Considerations in Selected Disease Conditions, listing condition, key risk, and key management principle. Medical reference table style with outside border, no photographic elements."

Series 4: Regional Anaesthesia, Local Anaesthetics, and Peripheral Nerve Blocks

- **Part 4.1: Local Anaesthetic Pharmacology**
    - Sub Part 4.1.1: Mechanism of action of local anaesthetics
    - Sub Part 4.1.2: Classification: esters versus amides
    - Sub Part 4.1.3: Local anaesthetic systemic toxicity
- **Part 4.2: Subarachnoid Block: Indications, Contraindications, and Technique**
    - Sub Part 4.2.1: Indications and contraindications for subarachnoid block
    - Sub Part 4.2.2: Technique and level assessment
    - Sub Part 4.2.3: Complications and management
- **Part 4.3: Epidural Analgesia/Anaesthesia: Indications, Contraindications, and Technique**
    - Sub Part 4.3.1: Indications and contraindications for epidural technique
    - Sub Part 4.3.2: Technique and dosing considerations
    - Sub Part 4.3.3: Complications and management
- **Part 4.4: Common Peripheral Nerve Blocks**
    - Sub Part 4.4.1: Brachial plexus block: approaches and indications
    - Sub Part 4.4.2: Femoral, three-in-one, and ankle block
    - Sub Part 4.4.3: Complications and management of peripheral nerve blocks
- **Part 4.5: Intravenous Regional Anaesthesia**
    - Sub Part 4.5.1: Definition and principle of intravenous regional anaesthesia (Bier's block)
    - Sub Part 4.5.2: Technique and indications
    - Sub Part 4.5.3: Contraindications and complications

Introduction

Regional technique offers a genuinely important alternative, and frequently a genuinely valuable complement, to general anaesthesia, blocking pain transmission at a specific, chosen point along

the nervous system rather than producing global unconsciousness. This Series reviews the essential pharmacology underlying every regional technique, **local anaesthetics** themselves, before working through the general indications, contraindications, and technique of **subarachnoid block** and **epidural** anaesthesia beyond the specifically obstetric context examined earlier in this course, the most **common peripheral nerve blocks** encountered in everyday practice, and, finally, **intravenous regional anaesthesia**.

The aim of this Series is to equip you with a thorough understanding of local anaesthetics, subarachnoid block, epidural analgesia and anaesthesia, common nerve blocks, and intravenous regional anaesthesia, including their indications, contraindications, technique, and complications.

This Series begins with **local anaesthetic pharmacology**, before turning to **subarachnoid block**, **epidural analgesia and anaesthesia**, and **common peripheral nerve blocks**. It concludes with **intravenous regional anaesthesia**.

Series Learning Outcomes

At the end of this Series, you should be able to:

- **SLO 4.1:** describe the mechanism of action and classification of local anaesthetics
- **SLO 4.2:** describe local anaesthetic systemic toxicity
- **SLO 4.3:** describe indications, contraindications, and technique of subarachnoid block
- **SLO 4.4:** describe complications and management of subarachnoid block
- **SLO 4.5:** describe indications, contraindications, and technique of epidural analgesia and anaesthesia
- **SLO 4.6:** describe complications and management of epidural technique
- **SLO 4.7:** describe brachial plexus block and its approaches and indications
- **SLO 4.8:** describe femoral, three-in-one, and ankle block, and complications of peripheral nerve blocks
- **SLO 4.9:** define intravenous regional anaesthesia and describe its technique and indications, and
- **SLO 4.10:** describe contraindications and complications of intravenous regional anaesthesia.

4.1 Local Anaesthetic Pharmacology

4.1.1 mechanism of action of local anaesthetics

Reversible blockade of neuronal sodium channels

Local anaesthetics, discussed in relation to drug ionisation in an earlier Series of this course, produce reversible blockade of voltage-gated **sodium channels** within neuronal cell membranes, preventing the propagation of action potentials along the affected nerve and, consequently, blocking transmission of pain and other sensory or motor signals along that nerve's specific distribution.

The **non-ionised** fraction of the local anaesthetic molecule, discussed earlier in this sub-Part, must first cross the neuronal cell membrane before the drug can access and block the sodium channel from within, meaning factors affecting drug ionisation, such as tissue pH, directly influence how rapidly and effectively a given local anaesthetic achieves clinical block.

Fill in the blank: Local anaesthetics produce reversible blockade of voltage-gated sodium channels within neuronal cell membranes, preventing the propagation of action potentials along the affected _____.

4.1.2 classification: esters versus amides

Two chemical classes with distinct metabolic pathways

Local anaesthetics are broadly classified as **esters**, including procaine and, in different clinical use, cocaine, or **amides**, including lidocaine and bupivacaine, distinguished by the specific chemical linkage connecting the aromatic and amine portions of the molecule, a distinction carrying genuine practical relevance to both metabolism and allergy risk.

Ester local anaesthetics, discussed earlier in this sub-Part, are generally metabolised by plasma cholinesterase, while **amide** local anaesthetics undergo hepatic metabolism, meaning amides generally carry a longer plasma half-life and, in patients with significant hepatic impairment, potentially prolonged clinical effect, while esters carry a somewhat higher recognised risk of true allergic reaction given their specific metabolic breakdown products.

Fill in the blank: Ester local anaesthetics are generally metabolised by plasma cholinesterase, while amide local anaesthetics undergo hepatic _____.

4.1.3 local anaesthetic systemic toxicity

A genuine emergency from excessive systemic absorption

Local anaesthetic systemic toxicity, discussed throughout this Part, results from excessive systemic drug absorption, whether from inadvertent intravascular injection or genuine dose excess, producing characteristic central nervous system effects, including perioral numbness, tinnitus, and, in more severe cases, seizures, together with genuinely dangerous cardiovascular effects, including arrhythmia and cardiovascular collapse.

Management of local anaesthetic systemic toxicity, discussed earlier in this sub-Part, requires immediate cessation of drug administration, supportive airway and cardiovascular management, and, specifically, **intravenous lipid emulsion** therapy, a specific antidote genuinely capable of reversing cardiovascular collapse from local anaesthetic toxicity, meaning every practitioner performing regional technique must have this specific treatment genuinely available and familiar.

Fill in the blank: Management of local anaesthetic systemic toxicity requires immediate cessation of drug administration and, specifically, intravenous lipid emulsion therapy, a specific _____ for local anaesthetic toxicity.

Table 4.1: Comparing ester and amide local anaesthetics.

Feature	Esters	Amides
Example agents	Procaine, cocaine	Lidocaine, bupivacaine
Metabolism	Plasma cholinesterase	Hepatic
Allergy risk	Somewhat higher	Lower

Pilot questions 4.1

- Describe the mechanism of action of local anaesthetics. (Linked to SLO 4.1)
- Explain the relevance of drug ionisation to local anaesthetic onset. (Linked to SLO 4.1)
- Distinguish ester from amide local anaesthetics. (Linked to SLO 4.1)
- Describe the clinical features of local anaesthetic systemic toxicity. (Linked to SLO 4.2)
- Describe the management of local anaesthetic systemic toxicity. (Linked to SLO 4.2)

4.2 Subarachnoid Block: Indications, Contraindications, and Technique

4.2.1 indications and contraindications for subarachnoid block

Suitable procedures and genuine contraindications

Subarachnoid block, discussed in relation to its obstetric application in an earlier Series of this course, is genuinely well suited to surgery of the lower abdomen, pelvis, and lower limbs, providing dense, reliable sensory and motor blockade without the airway management or systemic physiological demands of general anaesthesia.

Recognised **contraindications**, discussed earlier in this sub-Part, include patient refusal, coagulopathy or anticoagulant therapy given bleeding risk at the puncture site, local infection at the intended puncture site, and significant hypovolaemia, given the risk of profound hypotension from the sympathetic blockade the technique itself produces.

Fill in the blank: Recognised contraindications to subarachnoid block include coagulopathy or anticoagulant therapy given bleeding risk, local infection at the puncture site, and significant _____.

4.2.2 technique and level assessment

Confirming an adequate block before proceeding

The technique of subarachnoid block, discussed in relation to obstetric spinal anaesthesia earlier in this course, follows the same fundamental principle in non-obstetric practice, sterile preparation, identification of the appropriate lumbar interspace, and injection of local anaesthetic into the subarachnoid space, with dose and baricity, discussed further in this sub-Part, adjusted to the specific surgical requirement.

Block level assessment, discussed earlier in this sub-Part, generally uses loss of sensation to cold or light touch, or loss of pin prick sensation, tested systematically along the trunk, confirming that the block has reached a dermatomal level genuinely adequate for the specific planned surgical procedure before proceeding.

Fill in the blank: Block level assessment generally uses loss of sensation to cold or light touch, confirming that the block has reached a dermatomal level genuinely adequate for the specific planned surgical _____.

4.2.3 complications and management

Recognised risks requiring vigilant perioperative monitoring

Complications of subarachnoid block, discussed in relation to obstetric practice earlier in this course, include hypotension, managed with fluid and vasopressor therapy, high or total spinal block requiring airway and cardiovascular support, and post-dural puncture headache, each

requiring prompt recognition regardless of the specific surgical context in which the technique is used.

Further recognised complications, discussed earlier in this sub-Part, include urinary retention from blockade of sacral autonomic fibres, and, rarely, more serious neurological complications including epidural haematoma or abscess, meaning ongoing postoperative monitoring for these specific recognised risks remains essential following every subarachnoid block.

Fill in the blank: Further recognised complications of subarachnoid block include urinary retention from blockade of sacral autonomic _____.

Pilot questions 4.2

1. List indications for subarachnoid block. (Linked to SLO 4.3)
2. List contraindications for subarachnoid block. (Linked to SLO 4.3)
3. Describe how block level is assessed following subarachnoid injection. (Linked to SLO 4.3)
4. List complications of subarachnoid block. (Linked to SLO 4.4)
5. Describe the management of hypotension and high spinal block. (Linked to SLO 4.4)

4.3 Epidural Analgesia/Anaesthesia: Indications, Contraindications, and Technique

4.3.1 indications and contraindications for epidural technique

A titratable technique for surgery and prolonged analgesia

Epidural technique, discussed in relation to labour analgesia in an earlier Series of this course, extends beyond obstetric use to provide surgical anaesthesia for lower abdominal, pelvic, and lower limb procedures, and, importantly, prolonged postoperative analgesia through an indwelling catheter, particularly valuable following major abdominal or thoracic surgery.

Contraindications, discussed earlier in this sub-Part, mirror those recognised for subarachnoid block, discussed earlier in this Series, including patient refusal, coagulopathy, local infection, and significant hypovolaemia, meaning careful patient selection remains equally important for epidural as for spinal technique.

Fill in the blank: Epidural contraindications mirror those recognised for subarachnoid block, including patient refusal, coagulopathy, local infection, and significant _____.

4.3.2 technique and dosing considerations

Loss of resistance identification and titrated dosing

Epidural technique, discussed in relation to loss of resistance identification in an earlier Series of this course, follows the same fundamental approach in the non-obstetric setting, with catheter placement at a vertebral level appropriate to the planned surgical incision, since epidural analgesia is generally most effective when targeted to the specific dermatomal level of surgical stimulation.

Dosing, discussed earlier in this sub-Part, may use intermittent bolus administration or continuous infusion, generally combining local anaesthetic with an opioid to enhance analgesic quality while permitting a lower overall local anaesthetic concentration, meaning epidural dosing genuinely requires careful, individualised titration against the specific patient's clinical response.

Fill in the blank: Epidural analgesia is generally most effective when targeted to the specific dermatomal level of surgical _____.

4.3.3 complications and management

Risks distinct from, though overlapping with, spinal technique

Complications of epidural technique, discussed in relation to obstetric practice in an earlier Series of this course, include inadvertent dural puncture risking post-dural puncture headache or total spinal block, local anaesthetic systemic toxicity from inadvertent intravascular catheter placement, discussed earlier in this Series, and hypotension, generally more gradual in onset than with spinal technique.

Further recognised complications, discussed earlier in this sub-Part, include epidural catheter migration, potentially producing inadequate or excessive block, and, rarely, epidural haematoma or abscess, each requiring prompt recognition through ongoing clinical assessment of block adequacy and neurological function throughout the period of epidural use.

Fill in the blank: Further recognised complications of epidural technique include epidural catheter migration, potentially producing inadequate or excessive _____.

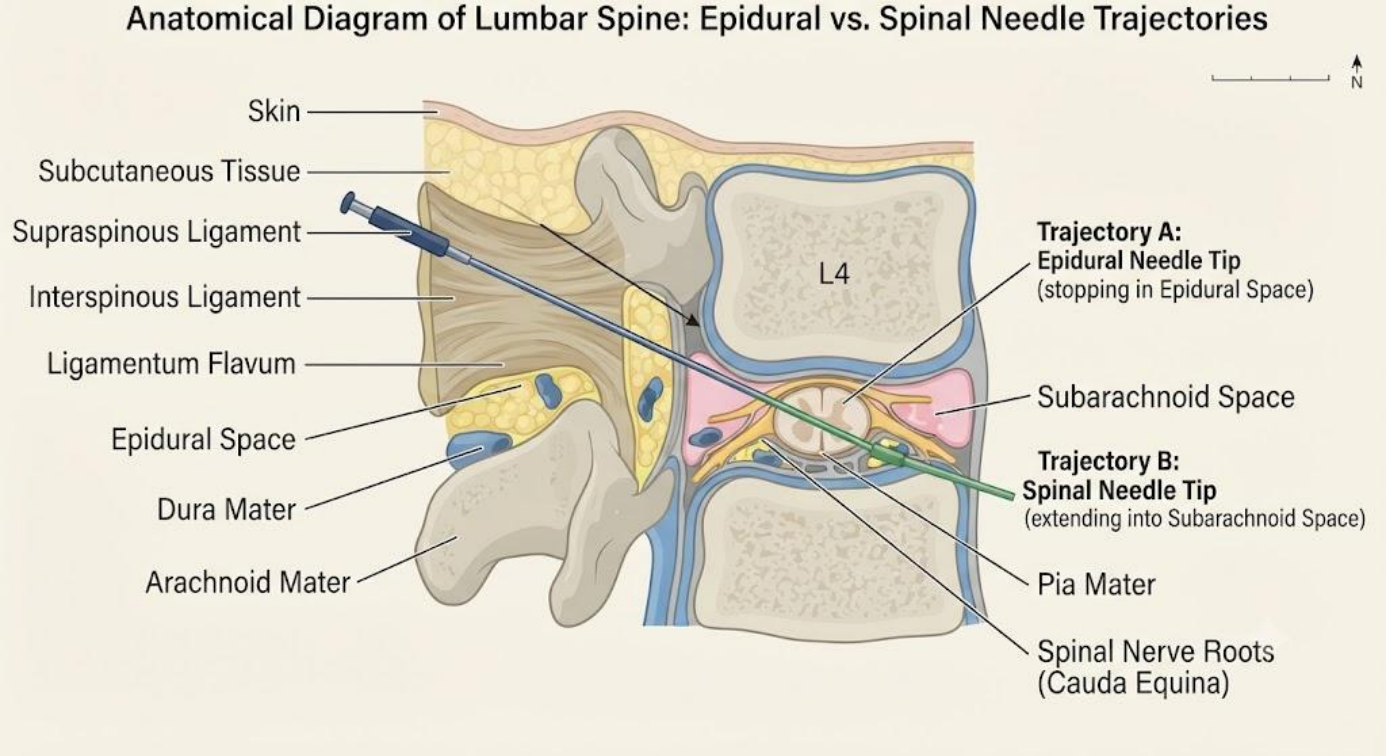

Figure 4.1: A diagram comparing the anatomical target of subarachnoid and epidural injection relative to the dura.

Pilot questions 4.3

1. List indications for epidural technique beyond labour analgesia. (Linked to SLO 4.5)
2. List contraindications for epidural technique. (Linked to SLO 4.5)
3. Explain why epidural catheter placement level is chosen according to the planned surgical incision. (Linked to SLO 4.5)
4. List complications of epidural technique. (Linked to SLO 4.6)
5. Describe epidural catheter migration and its consequence. (Linked to SLO 4.6)

4.4 Common Peripheral Nerve Blocks

4.4.1 brachial plexus block: approaches and indications

Multiple approaches to a single, richly branching plexus

Brachial plexus block, discussed in relation to peripheral nerve anatomy in an earlier Series of this course, provides anaesthesia or analgesia for upper limb surgery, with several recognised approaches, **interscalene**, **supraclavicular**, **infraclavicular**, and **axillary**, each targeting the

plexus at a genuinely different anatomical level and therefore suited to somewhat different specific surgical procedures.

The **interscalene** approach, discussed earlier in this sub-Part, provides excellent shoulder and proximal arm coverage but may spare the ulnar distribution, while the **axillary** approach provides reliable hand and forearm coverage with a lower recognised risk of pneumothorax, meaning approach selection should genuinely reflect the specific surgical site requiring anaesthesia.

Fill in the blank: The interscalene approach to brachial plexus block provides excellent shoulder and proximal arm coverage but may spare the ulnar _____.

4.4.2 femoral, three-in-one, and ankle block

Lower limb blocks for surgery and postoperative analgesia

Femoral nerve block, discussed in relation to lower limb innervation, provides anaesthesia or analgesia for anterior thigh and knee surgery, while the **three-in-one block**, a variation targeting the femoral, lateral femoral cutaneous, and obturator nerves through a single injection point, offers somewhat broader lower limb coverage.

Ankle block, discussed earlier in this sub-Part, targets the five peripheral nerves supplying the foot, providing reliable anaesthesia for foot surgery without requiring more proximal blockade, meaning these lower limb blocks together offer a genuinely flexible range of options tailored to the specific level of surgery required.

Fill in the blank: The three-in-one block targets the femoral, lateral femoral cutaneous, and obturator nerves through a single _____ point.

4.4.3 complications and management of peripheral nerve blocks

Risks shared across essentially every peripheral block

Recognised complications shared across peripheral nerve blocks, discussed throughout this Part, include local anaesthetic systemic toxicity, discussed earlier in this Series, nerve injury from direct needle trauma or intraneural injection, and, specifically for supraclavicular brachial plexus approaches, pneumothorax given the block's proximity to the lung apex.

Modern use of **ultrasound guidance**, discussed earlier in this sub-Part, allowing direct visualisation of the target nerve and surrounding structures during needle placement, has meaningfully reduced the incidence of several of these recognised complications compared with

older, landmark-based blind technique, though vigilant monitoring for complication remains essential regardless of the specific technique used.

Fill in the blank: Modern use of ultrasound guidance, allowing direct visualisation of the target nerve and surrounding structures during needle placement, has meaningfully reduced the incidence of several recognised _____.

Table 4.2: Comparing common peripheral nerve blocks.

Block	Target region	Notable feature
Interscalene	Shoulder and proximal arm	May spare ulnar distribution
Axillary	Hand and forearm	Lower pneumothorax risk than supraclavicular
Ankle block	Foot	Targets five peripheral nerves at the ankle

Pilot questions 4.4

1. List the four approaches to brachial plexus block. (Linked to SLO 4.7)
2. Compare the interscalene and axillary approaches to brachial plexus block. (Linked to SLO 4.7)
3. Describe the three-in-one block. (Linked to SLO 4.8)
4. Describe ankle block. (Linked to SLO 4.8)
5. List complications shared across peripheral nerve blocks and explain the value of ultrasound guidance. (Linked to SLO 4.8)

4.5 Intravenous Regional Anaesthesia

4.5.1 definition and principle of intravenous regional anaesthesia (bier's block)

Local anaesthetic delivered through the venous system itself

Intravenous regional anaesthesia, also termed **Bier's block**, involves injecting local anaesthetic intravenously into an exsanguinated, tourniquet-isolated limb, with the drug diffusing from the venous system into the surrounding tissue and peripheral nerves to produce reliable, genuinely rapid-onset anaesthesia throughout the isolated limb.

This technique, discussed earlier in this sub-Part, depends entirely on maintaining an effective tourniquet throughout the procedure, since premature tourniquet deflation would release a

substantial bolus of local anaesthetic directly into the systemic circulation, risking genuine local anaesthetic systemic toxicity, discussed earlier in this Series.

Fill in the blank: Intravenous regional anaesthesia depends entirely on maintaining an effective tourniquet throughout the procedure, since premature tourniquet deflation would release a substantial bolus of local anaesthetic directly into the systemic _____.

4.5.2 technique and indications

A technique well suited to short limb procedures

Technique, discussed throughout this Part, generally involves establishing intravenous access distally in the limb, exsanguinating the limb using an Esmarch bandage or elevation, inflating a dual-cuff tourniquet, and injecting local anaesthetic, generally lidocaine without adrenaline, through the previously established distal cannula.

This technique, discussed earlier in this sub-Part, is genuinely well suited to short surgical procedures on the forearm or hand, discussed further in this Series, generally those completing within approximately an hour, given the recognised limits of safe tourniquet time, meaning Bier's block represents a genuinely efficient option for appropriately selected minor limb surgery.

Fill in the blank: Intravenous regional anaesthesia is genuinely well suited to short surgical procedures on the forearm or hand, given the recognised limits of safe tourniquet _____.

4.5.3 contraindications and complications

Risks concentrated around tourniquet failure and toxicity

Recognised contraindications, discussed throughout this Series, include patient refusal, allergy to the specific local anaesthetic agent, and conditions where tourniquet application itself is genuinely unsafe, including severe peripheral vascular disease or sickle cell disease, discussed in relation to the sickling risk of prolonged limb ischaemia in an earlier Series of this course.

The single most significant recognised complication, discussed earlier in this sub-Part, remains local anaesthetic systemic toxicity from premature or inadequate tourniquet deflation, meaning careful attention to tourniquet integrity and minimum inflation time throughout the procedure represents the essential safety principle underlying this specific regional technique.

Fill in the blank: The single most significant recognised complication of intravenous regional anaesthesia remains local anaesthetic systemic toxicity from premature or inadequate tourniquet _____.

Pilot questions 4.5

1. Define intravenous regional anaesthesia (Bier's block). (Linked to SLO 4.9)
2. Explain why maintaining an effective tourniquet is essential during Bier's block. (Linked to SLO 4.9)
3. Describe the technique of intravenous regional anaesthesia. (Linked to SLO 4.9)
4. List contraindications to intravenous regional anaesthesia. (Linked to SLO 4.10)
5. Describe the single most significant complication of intravenous regional anaesthesia. (Linked to SLO 4.10)

Series Summary

This Series worked through local anaesthetic pharmacology, mechanism of action, ester versus amide classification, and systemic toxicity, before examining subarachnoid block and epidural technique beyond the obstetric context, their general indications, contraindications, technique, and complications, common peripheral nerve blocks, brachial plexus, femoral, three-in-one, and ankle block, and concluded with intravenous regional anaesthesia, its definition, technique, and recognised risks.

This regional anaesthesia foundation carries directly into perioperative care, basic life support, critical care, and pain management, examined in the final Series of this course.

Glossary of Terms

6. **Sodium channel blockade:** the mechanism by which local anaesthetics prevent nerve signal propagation.
7. **Ester local anaesthetic:** a local anaesthetic class, metabolised by plasma cholinesterase, including procaine.
8. **Amide local anaesthetic:** a local anaesthetic class, metabolised hepatically, including lidocaine and bupivacaine.
9. **Local anaesthetic systemic toxicity:** a potentially life-threatening reaction from excessive systemic local anaesthetic absorption.
10. **Intravenous lipid emulsion:** the specific antidote for local anaesthetic systemic toxicity.

11. **Baricity:** the density of a local anaesthetic solution relative to cerebrospinal fluid, affecting spinal spread.
12. **Brachial plexus block:** regional anaesthesia of the upper limb via one of several approaches to the brachial plexus.
13. **Three-in-one block:** a lower limb block targeting the femoral, lateral femoral cutaneous, and obturator nerves.
14. **Ultrasound guidance:** a technique using real-time imaging to guide needle placement during nerve blockade.
15. **Intravenous regional anaesthesia (Bier's block):** local anaesthetic delivered intravenously into a tourniquet-isolated limb.
16. **Exsanguination:** the process of emptying blood from a limb before tourniquet inflation in Bier's block.
17. **Tourniquet time:** the duration a tourniquet remains inflated, subject to recognised safety limits.

Concept Check Questions [Series 4]

Objective questions

- Local anaesthetics produce reversible blockade of voltage-gated sodium channels within neuronal cell membranes, preventing the propagation of action potentials along the affected _____.
- Ester local anaesthetics are generally metabolised by plasma cholinesterase, while amide local anaesthetics undergo hepatic _____.
- Recognised contraindications to subarachnoid block include coagulopathy, local infection at the puncture site, and significant _____.
- The interscalene approach to brachial plexus block provides excellent shoulder and proximal arm coverage but may spare the ulnar _____.
- Intravenous regional anaesthesia depends entirely on maintaining an effective tourniquet, since premature deflation would release a substantial bolus of local anaesthetic directly into the systemic _____.

Short-answer questions

1. Distinguish ester from amide local anaesthetics.
2. Describe the clinical features and management of local anaesthetic systemic toxicity.
3. List contraindications for subarachnoid block.
4. List the four approaches to brachial plexus block.

5. Define intravenous regional anaesthesia and describe why tourniquet integrity is essential.

Long-answer questions

6. Discuss the mechanism of action, classification, and systemic toxicity of local anaesthetics. (Linked to SLO 4.1, SLO 4.2)
7. Discuss the indications, contraindications, technique, and complications of subarachnoid block. (Linked to SLO 4.3, SLO 4.4)
8. Discuss the indications, contraindications, technique, and complications of epidural analgesia and anaesthesia. (Linked to SLO 4.5, SLO 4.6)
9. Discuss brachial plexus, femoral, three-in-one, and ankle block, and their complications. (Linked to SLO 4.7, SLO 4.8)
10. Discuss the definition, technique, indications, contraindications, and complications of intravenous regional anaesthesia. (Linked to SLO 4.9, SLO 4.10)

Answers to Concept Check Questions [Series 4]

Objective questions

11. Nerve.
12. Metabolism.
13. Hypovolaemia.
14. Distribution.
15. Circulation.

Short-answer questions

16. Esters are metabolised by plasma cholinesterase; amides undergo hepatic metabolism and carry lower allergy risk.
17. Perioral numbness, tinnitus, seizures, and cardiovascular collapse; managed with cessation of drug, supportive care, and intravenous lipid emulsion.
18. Patient refusal, coagulopathy or anticoagulant therapy, local infection, and significant hypovolaemia.
19. Interscalene, supraclavicular, infraclavicular, and axillary.
20. Local anaesthetic delivered intravenously into a tourniquet-isolated limb; tourniquet integrity prevents systemic release causing toxicity.

Long-answer questions

21. **Basic response:** Local anaesthetics block sodium channels to prevent nerve signal propagation, classified as esters or amides by metabolic pathway.

Value-added response: Systemic toxicity from excessive absorption produces central nervous system and cardiovascular effects, managed with lipid emulsion therapy.

22. **Basic response:** Subarachnoid block suits lower abdominal, pelvic, and lower limb surgery, with specific contraindications including coagulopathy and hypovolaemia.

Value-added response: Complications including hypotension, high block, and headache require prompt recognition and appropriate management.

23. **Basic response:** Epidural technique extends beyond obstetric use to surgical anaesthesia and prolonged postoperative analgesia, sharing similar contraindications to spinal block.

Value-added response: Complications include dural puncture, systemic toxicity, and catheter migration, requiring ongoing clinical monitoring.

24. **Basic response:** Brachial plexus block offers several approaches suited to different surgical sites, while femoral, three-in-one, and ankle blocks address lower limb surgery.

Value-added response: Shared complications include nerve injury and systemic toxicity, with ultrasound guidance reducing several recognised risks.

25. **Basic response:** Intravenous regional anaesthesia delivers local anaesthetic into a tourniquet-isolated limb, suited to short forearm or hand procedures.

Value-added response: The principal risk is systemic toxicity from tourniquet failure, meaning careful tourniquet management is the essential safety principle.

Answers to Pilot Questions [Series 4]

Part 4.1

1. Reversible blockade of voltage-gated sodium channels preventing action potential propagation.
2. Only the non-ionised fraction crosses the neuronal membrane to access and block the sodium channel.

3. Esters, metabolised by plasma cholinesterase, versus amides, metabolised hepatically.
4. Perioral numbness, tinnitus, seizures, and cardiovascular arrhythmia or collapse.
5. Cessation of drug administration, supportive airway and cardiovascular management, and intravenous lipid emulsion.

Part 4.2

6. Surgery of the lower abdomen, pelvis, and lower limbs.
7. Patient refusal, coagulopathy, local infection at the puncture site, and significant hypovolaemia.
8. By testing loss of sensation to cold or light touch, or pin prick, systematically along the trunk.
9. Hypotension, high or total spinal block, post-dural puncture headache, urinary retention, and rarely haematoma or abscess.
10. Hypotension is managed with fluid and vasopressor therapy; high spinal block requires airway and cardiovascular support.

Part 4.3

11. Surgical anaesthesia for lower abdominal, pelvic, and lower limb procedures, and prolonged postoperative analgesia.
12. Patient refusal, coagulopathy, local infection, and significant hypovolaemia.
13. Because analgesia is most effective when targeted to the dermatomal level of surgical stimulation.
14. Inadvertent dural puncture, local anaesthetic systemic toxicity, hypotension, catheter migration, and rarely haematoma or abscess.
15. Displacement of the catheter tip, potentially producing inadequate or excessive block.

Part 4.4

1. Interscalene, supraclavicular, infraclavicular, and axillary.
2. Interscalene suits shoulder and proximal arm but may spare the ulnar distribution; axillary suits hand and forearm with lower pneumothorax risk.
3. A block targeting the femoral, lateral femoral cutaneous, and obturator nerves through a single injection.
4. A block targeting the five peripheral nerves supplying the foot, providing anaesthesia for foot surgery.
5. Local anaesthetic systemic toxicity, nerve injury, and, for supraclavicular approaches, pneumothorax; ultrasound guidance has reduced these risks.

Part 4.5

1. Local anaesthetic delivered intravenously into a tourniquet-isolated, exsanguinated limb.
2. Because premature deflation releases a substantial bolus of local anaesthetic into the systemic circulation, risking toxicity.
3. Establishing distal intravenous access, exsanguinating the limb, inflating a tourniquet, and injecting local anaesthetic through the distal cannula.
4. Patient refusal, local anaesthetic allergy, and conditions making tourniquet application unsafe, such as severe peripheral vascular disease or sickle cell disease.
5. Local anaesthetic systemic toxicity from premature or inadequate tourniquet deflation.

References and Attributions [Series 4]

6. Aitkenhead, A. R., Moppett, I. K., & Thompson, J. P. (2013). Smith and Aitkenhead's Textbook of Anaesthesia (6th ed.). Churchill Livingstone.
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8. Neal, J. M., et al. (2018). ASRA Practice Advisory on Local Anesthetic Systemic Toxicity. Regional Anesthesia and Pain Medicine, 43(2), 113-123.
9. Butterworth, J. F., Mackey, D. C., & Wasnick, J. D. (2018). Morgan and Mikhail's Clinical Anesthesiology (6th ed.). McGraw-Hill.

Figures, Plates, Tables, and Boxes

1. Table 4.1: Comparing ester and amide local anaesthetics. AI-generated using the prompt: "Create a clean pharmacology reference table titled Comparing Ester and Amide Local Anaesthetics, listing feature, esters, and amides. Medical reference table style with outside border, no photographic elements."
2. Figure 4.1: A diagram comparing the anatomical target of subarachnoid and epidural injection relative to the dura. AI-generated using the prompt: "A single clean, accurate cross-sectional anatomical diagram of the spine with two labelled needle trajectories, one extending through the dura into the subarachnoid space, the other stopping in the epidural space just outside the dura, textbook anatomical diagram style, neutral background, no photographic realism, no other panels."

3. Table 4.2: Comparing common peripheral nerve blocks. AI-generated using the prompt: "Create a clean clinical reference table titled Comparing Common Peripheral Nerve Blocks, listing block, target region, and notable feature. Medical reference table style with outside border, no photographic elements."

Series 5: Perioperative Care, Basic Life Support, Critical Care, and Pain Management

- **Part 5.1: Post Anaesthesia Care and Complications of Anaesthesia**
  - Sub Part 5.1.1: The post anaesthesia care unit
  - Sub Part 5.1.2: Common complications in the PACU
  - Sub Part 5.1.3: General complications of anaesthesia and their management
- **Part 5.2: Perioperative Fluid and Blood Management**
  - Sub Part 5.2.1: Perioperative fluid management
  - Sub Part 5.2.2: Perioperative blood loss and replacement
  - Sub Part 5.2.3: Basic blood gas analysis and interpretation
- **Part 5.3: Basic Life Support and the Anaesthetist's Role in Resuscitation**
  - Sub Part 5.3.1: Recognition of cardiopulmonary arrest
  - Sub Part 5.3.2: The sequence and skills of basic life support
  - Sub Part 5.3.3: The role of the anaesthetist in resuscitation and emergency anaesthesia
- **Part 5.4: Critical Care and Palliative Care**
  - Sub Part 5.4.1: Introduction to intensive care
  - Sub Part 5.4.2: Introduction to palliative care
  - Sub Part 5.4.3: Differentiating palliative care and intensive care
- **Part 5.5: Pain Assessment and Management**
  - Sub Part 5.5.1: Pain assessment methods
  - Sub Part 5.5.2: Causes and management of acute pain
  - Sub Part 5.5.3: Causes and management of chronic pain across age groups

Introduction

An anaesthetist's genuine responsibility extends well beyond the operating theatre itself, through recovery, resuscitation, critical illness, and, for many patients, the ongoing management of pain long after any specific procedure has concluded. This final Series closes the course by working

through **post anaesthesia care and complications**, **perioperative fluid and blood management**, **basic life support** and the anaesthetist's genuinely central role in resuscitation, an **introduction to critical and palliative care**, and, finally, the **assessment and management of acute and chronic pain** across every age group.

The aim of this Series is to equip you with a thorough understanding of complications of anaesthesia and post anaesthesia care, perioperative fluid management and blood loss and replacement, basic life support and the role of the anaesthetist in resuscitation, the distinction between palliative care and intensive care, and the assessment and management of acute and chronic pain conditions in all age groups.

This Series begins with **post anaesthesia care and complications of anaesthesia**, before turning to **perioperative fluid and blood management**, **basic life support and the anaesthetist's role in resuscitation**, and **critical care and palliative care**. It concludes with **pain assessment and management**.

Series Learning Outcomes

At the end of this Series, you should be able to:

- **SLO 5.1:** describe the post anaesthesia care unit and its common complications
- **SLO 5.2:** describe general complications of anaesthesia and their management
- **SLO 5.3:** describe perioperative fluid management and blood loss and replacement
- **SLO 5.4:** describe basic blood gas analysis and interpretation
- **SLO 5.5:** describe recognition of cardiopulmonary arrest and the sequence and skills of basic life support
- **SLO 5.6:** describe the role of the anaesthetist in resuscitation and emergency anaesthesia
- **SLO 5.7:** describe an introduction to intensive care
- **SLO 5.8:** describe an introduction to palliative care and differentiate it from intensive care
- **SLO 5.9:** describe pain assessment methods and the management of acute pain, and
- **SLO 5.10:** describe the causes and management of chronic pain across age groups.

5.1 Post Anaesthesia Care and Complications of Anaesthesia

5.1.1 the post anaesthesia care unit

Structured monitoring through the vulnerable recovery period

The **post anaesthesia care unit**, or PACU, discussed in relation to safe termination of anaesthesia in an earlier Series of this course, provides structured, continuous monitoring of vital signs, level of consciousness, and surgical site during the genuinely vulnerable period immediately following anaesthesia, when the effects of anaesthetic agents and surgery itself have not yet fully resolved.

Discharge from the PACU, discussed earlier in this sub-Part, generally requires specific criteria to be met, including stable vital signs, adequate pain control, and, where applicable, return of protective airway reflexes and adequate motor function following regional technique, discussed further in an earlier Series of this course, meaning PACU discharge represents a genuinely important safety checkpoint rather than a routine formality.

Fill in the blank: Discharge from the post anaesthesia care unit generally requires specific criteria to be met, including stable vital signs and adequate pain _____.

5.1.2 common complications in the pacu

Recognised, generally manageable early recovery issues

Common PACU complications, discussed throughout this Part, include **postoperative nausea and vomiting**, genuinely common and distressing though generally manageable with appropriate antiemetic therapy, **shivering**, related to intraoperative hypothermia and residual anaesthetic effect, and **emergence delirium**, particularly recognised in paediatric patients following certain volatile agents.

Further recognised complications, discussed earlier in this sub-Part, include residual airway obstruction from incomplete recovery of protective reflexes, discussed in relation to airway management in an earlier Series of this course, and hypotension or hypertension from incomplete haemodynamic recovery, meaning continuous, vigilant PACU monitoring remains essential throughout this specific recovery period.

Fill in the blank: Common PACU complications include postoperative nausea and vomiting, shivering, and emergence delirium, particularly recognised in paediatric patients following certain volatile _____.

5.1.3 general complications of anaesthesia and their management

A broader spectrum spanning minor to genuinely life-threatening

General complications of anaesthesia, discussed throughout this Series, range from relatively minor, self-limiting issues such as sore throat following intubation, discussed in relation to airway instrumentation in an earlier Series of this course, to genuinely serious, potentially life-threatening events including anaphylaxis, malignant hyperthermia, and aspiration pneumonitis.

Malignant hyperthermia, discussed earlier in this sub-Part, a rare, genetically predisposed hypermetabolic reaction to certain triggering agents, requires immediate recognition and treatment with **dantrolene**, meaning every anaesthetic department must maintain genuine readiness to recognise and treat this specific, though uncommon, life-threatening complication.

Fill in the blank: Malignant hyperthermia, a rare, genetically predisposed hypermetabolic reaction to certain triggering agents, requires immediate recognition and treatment with _____.

Table 5.1: Common and serious complications of anaesthesia.

Category	Example	Management approach
Common, PACU-related	Postoperative nausea and vomiting, shivering	Antiemetic therapy, active warming
Airway-related	Sore throat, residual obstruction	Generally self-limiting; supportive airway management
Life-threatening	Anaphylaxis, malignant hyperthermia	Immediate recognition and specific emergency treatment

Pilot questions 5.1

- Describe the function of the post anaesthesia care unit. (Linked to SLO 5.1)
- List discharge criteria from the PACU. (Linked to SLO 5.1)
- List common complications encountered in the PACU. (Linked to SLO 5.1)
- Describe malignant hyperthermia and its treatment. (Linked to SLO 5.2)
- List general complications of anaesthesia ranging from minor to life-threatening. (Linked to SLO 5.2)

5.2 Perioperative Fluid and Blood Management

5.2.1 perioperative fluid management

Replacing deficits, maintenance needs, and ongoing losses

Perioperative fluid management, discussed in relation to electrolyte physiology in an earlier Series of this course, requires careful calculation addressing preoperative fluid deficit from fasting, ongoing maintenance requirements, and intraoperative losses from surgical trauma and evaporation, together determining the total fluid volume and composition appropriate for a given patient and procedure.

Choice of fluid type, discussed earlier in this sub-Part, whether crystalloid or, where indicated, colloid, and careful, ongoing reassessment against clinical response, urine output, and haemodynamic parameters, together ensure genuinely appropriate, individualised fluid therapy rather than a fixed, formula-based approach applied uniformly to every patient.

Fill in the blank: Choice of fluid type, whether crystalloid or colloid, and careful, ongoing reassessment against clinical response, urine output, and haemodynamic parameters, together ensure genuinely appropriate, individualised fluid _____.

5.2.2 perioperative blood loss and replacement

Recognising when transfusion becomes genuinely necessary

Perioperative blood loss, discussed throughout this Part, must be estimated and actively monitored throughout surgery, with replacement decisions generally guided by estimated total blood loss relative to the patient's own estimated blood volume, ongoing haemodynamic stability, and, where available, laboratory haemoglobin measurement.

Blood transfusion, discussed earlier in this sub-Part, carries genuine recognised risks alongside its benefits, including transfusion reaction and infection transmission, meaning the specific indication and threshold for transfusion should genuinely reflect the individual patient's own physiological reserve and ongoing clinical trajectory rather than a rigid, universally applied numerical threshold alone.

Fill in the blank: Blood transfusion carries genuine recognised risks alongside its benefits, including transfusion reaction and infection _____.

5.2.3 basic blood gas analysis and interpretation

A systematic approach to a genuinely valuable investigation

Arterial blood gas analysis, discussed in relation to acid-base physiology in an earlier Series of this course, provides essential information regarding oxygenation, ventilation, and acid-base status, with a systematic interpretation approach, examining pH, carbon dioxide tension, bicarbonate, and oxygen tension in sequence, supporting accurate, confident clinical interpretation.

This systematic approach, discussed earlier in this sub-Part, allows the clinician to distinguish respiratory from metabolic acid-base disturbance, and to assess whether any identified disturbance is genuinely compensated or uncompensated, meaning basic blood gas interpretation represents an essential, genuinely practical skill throughout perioperative and critical care practice.

Fill in the blank: A systematic blood gas interpretation approach allows the clinician to distinguish respiratory from metabolic acid-base _____.

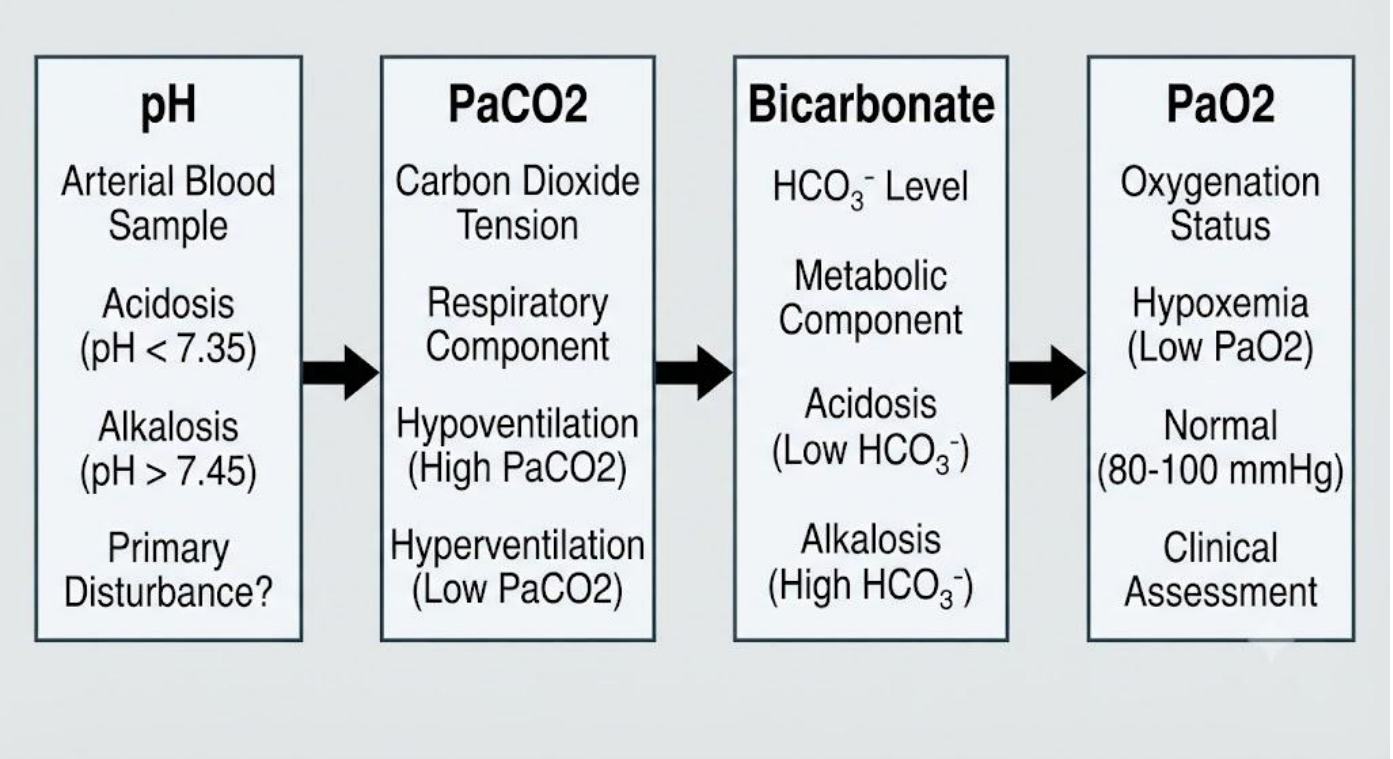

Figure 5.1: A diagram illustrating a systematic sequence for interpreting arterial blood gas results, from pH through carbon dioxide and bicarbonate to oxygenation.

Pilot questions 5.2

1. Describe the components of perioperative fluid calculation. (Linked to SLO 5.3)
2. Distinguish crystalloid from colloid fluid therapy. (Linked to SLO 5.3)
3. Describe how perioperative blood loss is monitored and estimated. (Linked to SLO 5.3)
4. Describe risks associated with blood transfusion. (Linked to SLO 5.3)
5. Describe a systematic approach to interpreting arterial blood gas results. (Linked to SLO 5.4)

5.3 Basic Life Support and the Anaesthetist's Role in Resuscitation

5.3.1 recognition of cardiopulmonary arrest

Prompt, confident recognition as the essential first step

Cardiopulmonary arrest, discussed throughout this Part, is recognised through unresponsiveness together with absent or abnormal breathing, generally assessed within a genuinely brief period to avoid unnecessary delay before initiating resuscitation, since prompt recognition and immediate response represent the single most important determinant of survival following cardiac arrest.

This recognition, discussed earlier in this sub-Part, should trigger immediate activation of the emergency response system and initiation of chest compressions, discussed further in the next sub-Part, without delay for further, prolonged assessment, since every minute of delay before effective resuscitation begins meaningfully reduces overall survival probability.

Fill in the blank: Prompt recognition of cardiopulmonary arrest and immediate response represent the single most important determinant of _____ following cardiac arrest.

5.3.2 the sequence and skills of basic life support

A systematic sequence delivering effective circulation and ventilation

Basic life support, discussed throughout this Part, follows a systematic sequence, beginning with high-quality chest compressions, generally at a rate of 100 to 120 per minute and adequate depth, combined with rescue breaths, and, where available, early **defibrillation** using an automated external defibrillator for shockable rhythms.

Genuine competence in these specific skills, discussed earlier in this sub-Part, including correct hand positioning, adequate compression depth and rate, and effective rescue breath technique, requires regular hands-on practice and skills demonstration rather than theoretical knowledge alone, meaning basic life support training must genuinely combine both cognitive understanding and practical skill development.

Fill in the blank: Basic life support follows a systematic sequence, beginning with high-quality chest compressions, generally at a rate of 100 to 120 per minute and adequate _____.

5.3.3 the role of the anaesthetist in resuscitation and emergency anaesthesia

A specifically valuable set of airway and drug skills

The **anaesthetist**, discussed throughout this Series, brings genuinely specific, valuable skills to the resuscitation team, including advanced airway management, discussed in relation to airway devices in an earlier Series of this course, and detailed knowledge of resuscitation drugs and their appropriate dosing, meaning anaesthetists frequently lead or substantially contribute to the airway management component of cardiac arrest response.

Emergency anaesthesia, discussed earlier in this sub-Part, carries its own genuinely specific peculiarities beyond routine elective practice, including limited time for preoperative optimisation, presumed full stomach regardless of fasting status, discussed in relation to the pregnant patient in an earlier Series of this course, and frequently unstable patient physiology, meaning emergency anaesthetic practice demands genuine additional caution and adaptability.

Fill in the blank: Emergency anaesthesia carries its own genuinely specific peculiarities, including limited time for preoperative optimisation and frequently unstable patient _____.

Table 5.2: Key components of the basic life support sequence.

Component	Description	Key parameter
Recognition	Unresponsiveness with absent or abnormal breathing	Assessed promptly, without prolonged delay
Chest compressions	High-quality compressions with rescue breaths	Rate 100-120/min, adequate depth
Defibrillation	Early shock delivery for shockable rhythms	Applied as soon as an AED is available

Pilot questions 5.3

1. Describe how cardiopulmonary arrest is recognised. (Linked to SLO 5.5)
2. Explain why prompt recognition and response are critical to survival. (Linked to SLO 5.5)
3. Describe the basic life support sequence. (Linked to SLO 5.5)
4. Describe the specific role of the anaesthetist in the resuscitation team. (Linked to SLO 5.6)
5. List the specific peculiarities of emergency anaesthesia. (Linked to SLO 5.6)

5.4 Critical Care and Palliative Care

5.4.1 introduction to intensive care

Sustained, intensive support for the critically ill

Intensive care, discussed throughout this Part, provides sustained, genuinely intensive organ support and monitoring for critically ill patients, generally including mechanical ventilation, discussed in relation to artificial ventilation in an earlier Series of this course, invasive haemodynamic monitoring, and, where required, renal replacement therapy, together supporting patients through the acute phase of genuinely severe, life-threatening physiological derangement.

The goal of intensive care, discussed earlier in this sub-Part, is genuinely restorative, aiming to support the patient through a recognised, potentially reversible critical illness toward eventual recovery, meaning intensive care admission generally presumes a reasonable, genuine prospect of meaningful physiological recovery given adequate, sustained support.

Fill in the blank: Intensive care provides sustained, genuinely intensive organ support and monitoring for critically ill patients, aiming to support recovery through a recognised, potentially reversible critical _____.

5.4.2 introduction to palliative care

A genuinely different goal, focused on comfort and quality of life

Palliative care, discussed in relation to the specific goals of intensive care earlier in this Part, focuses genuinely on symptom control, comfort, and quality of life, generally for patients with

advanced, incurable illness where restorative treatment is no longer genuinely appropriate or achievable.

This approach, discussed earlier in this sub-Part, addresses physical symptoms including pain, discussed further later in this Series, alongside psychological, social, and spiritual dimensions of suffering, reflecting palliative care's genuinely holistic, whole-person philosophy rather than a narrow, purely biomedical focus on disease management alone.

Fill in the blank: Palliative care addresses physical symptoms alongside psychological, social, and spiritual dimensions of suffering, reflecting its genuinely holistic, whole-person _____.

5.4.3 differentiating palliative care and intensive care

Contrasting goals rather than contrasting quality of care

The fundamental distinction between palliative and intensive care, discussed throughout this Part, lies in their genuinely different underlying goal, intensive care aiming toward physiological recovery through active, sustained organ support, while palliative care aims toward comfort and quality of life where cure or meaningful recovery is genuinely no longer achievable.

This distinction, discussed earlier in this sub-Part, should never be understood as reflecting differing standards of care, since both approaches demand genuinely skilled, attentive, expert practice, meaning the choice between them reflects the specific, individual patient's own clinical circumstances and realistic prognosis rather than any judgement regarding the value of the patient's own life or care.

Fill in the blank: The distinction between palliative and intensive care should never be understood as reflecting differing standards of care, since both approaches demand genuinely skilled, attentive, expert _____.

Pilot questions 5.4

1. Describe the general goal and components of intensive care. (Linked to SLO 5.7)
2. Describe the general goal and focus of palliative care. (Linked to SLO 5.8)
3. Explain the holistic dimensions addressed by palliative care beyond physical symptoms. (Linked to SLO 5.8)
4. Differentiate palliative care from intensive care. (Linked to SLO 5.8)
5. Explain why the distinction between palliative and intensive care does not reflect differing standards of care. (Linked to SLO 5.8)

5.5 Pain Assessment and Management

5.5.1 pain assessment methods

Matching the assessment tool to the patient's capacity to report

Pain assessment, discussed throughout this Series, uses a range of methods appropriate to the patient's own age and communicative capacity, including simple numerical or visual analogue scales for cooperative adults, and specific behavioural or physiological observation-based tools for infants, young children, or patients unable to reliably self-report.

Regular, structured pain reassessment, discussed earlier in this sub-Part, following any analgesic intervention, allows the clinician to confirm treatment effectiveness and adjust management appropriately, meaning pain assessment should genuinely be treated as an ongoing, iterative process rather than a single, isolated measurement taken at one point in time alone.

Fill in the blank: Regular, structured pain reassessment following any analgesic intervention allows the clinician to confirm treatment effectiveness and adjust management _____.

5.5.2 causes and management of acute pain

Time-limited pain generally tied to a specific, identifiable cause

Acute pain, discussed in relation to postoperative pain management, generally results from a specific, identifiable cause, such as surgery, trauma, or acute medical illness, and is typically expected to resolve as the underlying tissue injury heals, meaning management genuinely aims to control pain effectively while that underlying healing process proceeds.

Management, discussed earlier in this sub-Part, generally follows a **multimodal** approach, combining several complementary analgesic classes, including paracetamol, non-steroidal anti-inflammatory drugs where not contraindicated, and opioids for more severe pain, together achieving genuinely more effective analgesia with fewer side effects than reliance on any single agent alone.

Fill in the blank: Acute pain management generally follows a multimodal approach, combining several complementary analgesic classes, achieving genuinely more effective analgesia with fewer side effects than reliance on any single _____ alone.

5.5.3 causes and management of chronic pain across age groups

Pain persisting beyond expected healing, across every life stage

Chronic pain, discussed in relation to acute pain earlier in this Part, persists beyond the expected period of tissue healing, generally defined as pain continuing for three months or longer, and may reflect ongoing nociceptive input, neuropathic mechanisms, or complex, multifactorial processes affecting patients across every age group, from children with chronic disease to older adults with degenerative conditions.

Management of chronic pain, discussed earlier in this sub-Part, genuinely requires a broader, biopsychosocial approach beyond pharmacological treatment alone, including physical rehabilitation, psychological support, and, where appropriate, interventional techniques, meaning chronic pain management represents a genuinely distinct clinical discipline from the more straightforward, time-limited management of acute pain discussed earlier in this Series.

Fill in the blank: Chronic pain persists beyond the expected period of tissue healing, generally defined as pain continuing for three months or _____.

Table 5.3: Comparing acute and chronic pain.

Feature	Acute pain	Chronic pain
Typical duration	Expected to resolve with healing	Persists three months or longer
Underlying cause	Specific, identifiable cause	Nociceptive, neuropathic, or multifactorial
Management approach	Multimodal pharmacological analgesia	Biopsychosocial approach beyond medication alone

Pilot questions 5.5

1. Describe pain assessment methods appropriate to different patient populations. (Linked to SLO 5.9)
2. Explain why regular pain reassessment is important. (Linked to SLO 5.9)
3. Define acute pain and describe the multimodal management approach. (Linked to SLO 5.9)
4. Define chronic pain. (Linked to SLO 5.10)
5. Describe the biopsychosocial approach to chronic pain management. (Linked to SLO 5.10)

Series Summary

This final Series worked through post anaesthesia care and complications of anaesthesia, from the PACU through genuinely life-threatening events such as malignant hyperthermia, perioperative fluid and blood management, including basic blood gas interpretation, basic life support and the anaesthetist's genuinely central role in resuscitation and emergency anaesthesia, an introduction to critical and palliative care and the important distinction between them, and, finally, the assessment and management of acute and chronic pain across every age group.

Across this entire course, you have now worked through applied basic sciences and pharmacology, obstetric anaesthesia and analgesia in labour, preanaesthetic evaluation, airway management, and general anaesthesia, regional anaesthesia, local anaesthetics, and peripheral nerve blocks, and, finally, perioperative care, basic life support, critical care, and pain management, together forming a genuinely comprehensive introduction to anaesthesia addressed throughout ANE 601.

Glossary of Terms

6. **Post anaesthesia care unit (PACU):** the unit providing structured monitoring during the vulnerable recovery period after anaesthesia.
7. **Malignant hyperthermia:** a rare, genetically predisposed hypermetabolic reaction to certain anaesthetic triggering agents.
8. **Dantrolene:** the specific treatment for malignant hyperthermia.
9. **Crystalloid:** a fluid type used in perioperative fluid therapy, containing small dissolved molecules.
10. **Arterial blood gas analysis:** an investigation providing information on oxygenation, ventilation, and acid-base status.
11. **Cardiopulmonary arrest:** the sudden cessation of effective circulation and breathing.
12. **Basic life support:** the systematic sequence of chest compressions, rescue breaths, and defibrillation used in cardiac arrest.
13. **Automated external defibrillator (AED):** a device delivering an electrical shock to restore normal cardiac rhythm in shockable arrest.
14. **Intensive care:** sustained, intensive organ support and monitoring aimed at recovery from critical illness.
15. **Palliative care:** care focused on symptom control, comfort, and quality of life in advanced, incurable illness.

16. **Multimodal analgesia:** combining several complementary analgesic classes to improve pain control with fewer side effects.
17. **Chronic pain:** pain persisting beyond the expected period of tissue healing, generally three months or longer.

Concept Check Questions [Series 5]

Objective questions

- Discharge from the post anaesthesia care unit generally requires specific criteria to be met, including stable vital signs and adequate pain _____.
- Malignant hyperthermia, a rare, genetically predisposed hypermetabolic reaction to certain triggering agents, requires immediate recognition and treatment with _____.
- Prompt recognition of cardiopulmonary arrest and immediate response represent the single most important determinant of _____ following cardiac arrest.
- Intensive care provides sustained, genuinely intensive organ support and monitoring for critically ill patients, aiming to support recovery through a recognised, potentially reversible critical _____.
- Chronic pain persists beyond the expected period of tissue healing, generally defined as pain continuing for three months or _____.

Short-answer questions

1. List common complications encountered in the PACU.
2. Describe how perioperative blood loss is monitored and estimated.
3. Describe the basic life support sequence.
4. Differentiate palliative care from intensive care.
5. Define acute pain and describe the multimodal management approach.

Long-answer questions

6. Discuss the post anaesthesia care unit and general complications of anaesthesia. (Linked to SLO 5.1, SLO 5.2)
7. Discuss perioperative fluid management, blood loss and replacement, and basic blood gas interpretation. (Linked to SLO 5.3, SLO 5.4)
8. Discuss recognition of cardiopulmonary arrest, basic life support, and the anaesthetist's role in resuscitation. (Linked to SLO 5.5, SLO 5.6)
9. Discuss intensive care and palliative care and how they are differentiated. (Linked to SLO 5.7, SLO 5.8)

10. Discuss pain assessment methods and the management of acute and chronic pain across age groups. (Linked to SLO 5.9, SLO 5.10)

Answers to Concept Check Questions [Series 5]

Objective questions

11. Control.
12. Dantrolene.
13. Survival.
14. Illness.
15. Longer.

Short-answer questions

16. Postoperative nausea and vomiting, shivering, emergence delirium, residual airway obstruction, and haemodynamic instability.
17. Estimated relative to the patient's blood volume, ongoing haemodynamic stability, and laboratory haemoglobin measurement where available.
18. High-quality chest compressions with rescue breaths, and early defibrillation for shockable rhythms.
19. Intensive care aims toward physiological recovery through active organ support; palliative care aims toward comfort and quality of life where cure is not achievable.
20. Pain from a specific, identifiable cause expected to resolve with healing; managed with a multimodal combination of analgesic classes.

Long-answer questions

21. **Basic response:** The PACU provides structured monitoring through the vulnerable recovery period, with discharge requiring specific criteria.

Value-added response: General complications range from minor, self-limiting issues to genuinely life-threatening events such as malignant hyperthermia, requiring prompt recognition.

22. **Basic response:** Perioperative fluid management addresses deficit, maintenance, and ongoing losses, with blood replacement guided by estimated loss and clinical trajectory.

Value-added response: Systematic blood gas interpretation, examining pH, carbon dioxide, bicarbonate, and oxygen tension in sequence, supports confident clinical assessment.

23. **Basic response:** Prompt recognition of cardiopulmonary arrest triggers immediate basic life support, chest compressions, rescue breaths, and defibrillation.

Value-added response: Anaesthetists contribute genuinely valuable airway and drug expertise to resuscitation, and emergency anaesthesia demands specific additional caution.

24. **Basic response:** Intensive care aims toward recovery through sustained organ support, while palliative care aims toward comfort where recovery is not achievable.

Value-added response: This distinction reflects differing clinical goals rather than differing standards of care, both requiring genuinely skilled, expert practice.

25. **Basic response:** Pain assessment uses methods appropriate to the patient's communicative capacity, with acute pain managed through multimodal analgesia.

Value-added response: Chronic pain, persisting beyond expected healing, requires a broader biopsychosocial approach across every age group.

Answers to Pilot Questions [Series 5]

Part 5.1

1. It provides structured, continuous monitoring during the vulnerable recovery period immediately following anaesthesia.
2. Stable vital signs, adequate pain control, and, where applicable, return of protective airway reflexes and motor function.
3. Postoperative nausea and vomiting, shivering, and emergence delirium.
4. A rare, genetically predisposed hypermetabolic reaction to certain triggering agents; treated with dantrolene.
5. Sore throat, residual airway obstruction, anaphylaxis, malignant hyperthermia, and aspiration pneumonitis.

Part 5.2

6. Preoperative fluid deficit from fasting, ongoing maintenance requirements, and intraoperative losses.
7. Crystalloid contains small dissolved molecules; colloid contains larger molecules affecting oncotic pressure.

8. Estimated relative to the patient's blood volume, ongoing haemodynamic stability, and laboratory haemoglobin measurement.
9. Transfusion reaction and infection transmission.
10. Examining pH, carbon dioxide tension, bicarbonate, and oxygen tension in sequence.

Part 5.3

11. Unresponsiveness together with absent or abnormal breathing, assessed promptly.
12. Because every minute of delay before effective resuscitation begins meaningfully reduces overall survival probability.
13. High-quality chest compressions with rescue breaths, and early defibrillation for shockable rhythms.
14. Advanced airway management and detailed knowledge of resuscitation drugs and their appropriate dosing.
15. Limited time for preoperative optimisation, presumed full stomach, and frequently unstable patient physiology.

Part 5.4

1. Sustained, intensive organ support and monitoring, including mechanical ventilation and invasive monitoring, aimed at recovery.
2. Symptom control, comfort, and quality of life, generally for patients with advanced, incurable illness.
3. Psychological, social, and spiritual dimensions of suffering, alongside physical symptoms.
4. Intensive care aims toward physiological recovery through active support; palliative care aims toward comfort where cure is not achievable.
5. Because both approaches demand genuinely skilled, expert practice, reflecting differing clinical goals rather than differing quality of care.

Part 5.5

1. Numerical or visual analogue scales for cooperative adults, and behavioural or physiological observation-based tools for infants or non-communicative patients.
2. Because it confirms treatment effectiveness and allows appropriate adjustment of management.
3. Pain from a specific, identifiable cause expected to resolve with healing; managed with combined paracetamol, NSAIDs, and opioids as appropriate.
4. Pain persisting beyond the expected period of tissue healing, generally three months or longer.

5. Combining pharmacological treatment with physical rehabilitation, psychological support, and, where appropriate, interventional techniques.

References and Attributions [Series 5]

6. Aitkenhead, A. R., Moppett, I. K., & Thompson, J. P. (2013). Smith and Aitkenhead's Textbook of Anaesthesia (6th ed.). Churchill Livingstone.
7. Resuscitation Council UK (2021). Adult Basic Life Support Guidelines.
8. Miller, R. D., et al. (2019). Miller's Anesthesia (9th ed.). Elsevier.
9. World Health Organization (2018). Integrating Palliative Care and Symptom Relief into Primary Health Care.

Figures, Plates, Tables, and Boxes

1. Table 5.1: Common and serious complications of anaesthesia. AI-generated using the prompt: "Create a clean clinical reference table titled Common and Serious Complications of Anaesthesia, listing category, example, and management approach. Medical reference table style with outside border, no photographic elements."
2. Figure 5.1: A diagram illustrating a systematic sequence for interpreting arterial blood gas results, from pH through carbon dioxide and bicarbonate to oxygenation. AI-generated using the prompt: "A single clean, accurate schematic flow diagram with four labelled sequential steps, pH, PaCO2, Bicarbonate, and PaO2, connected by directional arrows, textbook clinical diagram style, neutral background, no photographic realism, no other panels."
3. Table 5.2: Key components of the basic life support sequence. AI-generated using the prompt: "Create a clean clinical reference table titled Key Components of the Basic Life Support Sequence, listing component, description, and key parameter. Medical reference table style with outside border, no photographic elements."
4. Table 5.3: Comparing acute and chronic pain. AI-generated using the prompt: "Create a clean clinical reference table titled Comparing Acute and Chronic Pain, listing feature, acute pain, and chronic pain. Medical reference table style with outside border, no photographic elements."