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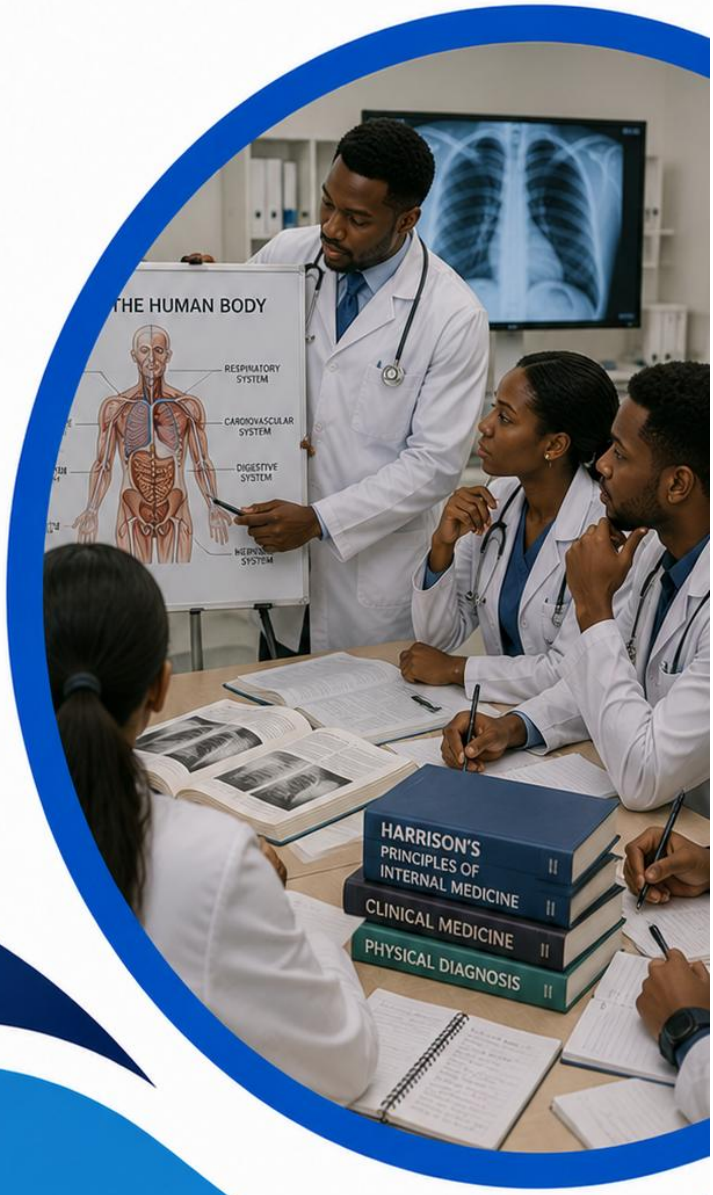
MED 401

INTRODUCTION TO CLINICAL MEDICINE I



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Course code: MED 401

Course title: Introduction to Clinical Medicine I

Course credit load: 2 Units

Series 1: The Clinical Interview and Communication with Patients

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Introduction

Clinical medicine begins not with stethoscopes or investigations but with conversation. The clinical interview is the most powerful diagnostic tool available to any physician: it provides the majority of the information needed for diagnosis in most medical encounters, guides the subsequent examination, and determines the therapeutic relationship that will influence whether the patient follows advice and returns for follow-up. A physician who cannot conduct an effective clinical interview is handicapped regardless of their technical skills.

The aim of this Series is to define the clinical interview and describe its components, examine the structure and content of the medical history, develop the communication skills essential for effective clinical encounters, and establish the ethical and professional framework within which clinical interviews are conducted.

We shall commence by defining the clinical interview and examining its components and types. Next, we will examine the detailed structure of the medical history. Moving on, we will address the communication skills that make clinical encounters effective. Finally, we will close by examining the ethical and professional dimensions of the clinical interview.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 1.1** define the clinical interview and describe its purpose and components,
- **SLO 1.2** take a structured and comprehensive medical history,
- **SLO 1.3** apply effective verbal and non-verbal communication skills in a clinical encounter,

- **SLO 1.4** describe the approach to breaking bad news and managing sensitive communication, and
- **SLO 1.5** explain the ethical principles of informed consent, confidentiality, and professional conduct in the clinical interview.

1.1 The Clinical Interview

1.1.1 Definition and purpose of the clinical interview

The **clinical interview** is a structured, purposeful conversation between a clinician and a patient (and sometimes a third party such as a relative or carer) aimed at gathering the information necessary to understand the patient health problem, establish a diagnosis, and formulate a management plan. It is the first and most fundamental clinical skill, because without accurate and comprehensive information from the patient, no examination finding or investigation result can be correctly interpreted.

The purposes of the clinical interview extend beyond data collection. It **establishes the therapeutic relationship** between doctor and patient, creating the trust that underpins the patient willingness to disclose sensitive information and adhere to treatment. It **identifies the patient agenda** (the concerns, expectations, and ideas that the patient brings to the consultation, which may differ substantially from the presenting complaint). It also serves an **educational function**, providing the patient with information and explanation, and a **therapeutic function**, since the experience of being heard and understood has direct psychological benefit.

Fill in the blank: The clinical interview serves multiple purposes including data collection, establishing the therapeutic _____ , identifying the patient agenda, providing education, and offering therapeutic benefit through being heard.

1.1.2 Components of the clinical interview

The clinical interview has two broad components: the **history-taking component** (the systematic collection of medical information through structured questioning, examined in detail in Part 1.2) and the **communication component** (the interpersonal process through which this information is exchanged, examined in Part 1.3). These two components are inseparable in practice: even the most thorough history-taking framework produces incomplete or inaccurate information if the communication process fails to put the patient at ease, fails to ask questions in a manner the patient understands, or fails to probe appropriately when initial answers are vague.

The structural components of the clinical interview include: **opening** (establishing rapport, clarifying the reason for the visit, and setting the agenda for the consultation); **information gathering** (systematic history-taking using open and closed questioning techniques); **physical examination** (which follows and is guided by the history); **explanation and planning** (sharing the clinician assessment and negotiating a management plan with the patient); and **closure** (summarising, checking understanding, and arranging follow-up). This structure is often described as the **Calgary-Cambridge framework** for the medical consultation.

Fill in the blank: The Calgary-Cambridge framework for the medical consultation describes five structural components: opening, information gathering, physical examination, explanation and planning, and _____ .

1.1.3 Types of clinical interview

Clinical interviews vary in purpose and structure. The **new patient or initial consultation** is the most comprehensive, involving a full history, examination, and plan for a patient presenting for the first time. The **follow-up consultation** reviews progress, assesses response to treatment, and adjusts the management plan. The **focused or problem-specific consultation** addresses a single defined issue, typically in a patient known to the clinician, and does not require a full history from the beginning. The **emergency consultation** is abbreviated and directed, prioritising immediate life threats over comprehensive history.

Special types include the **third-party interview** (conducted with a relative, carer, or interpreter when the patient cannot provide history due to altered consciousness, cognitive impairment, age, or language barrier), the **paediatric consultation** (which adapts questioning and communication

to the developmental stage of the child while also engaging the parent or guardian), and the **psychiatric interview** (which explores mental state, thoughts, perceptions, and feelings in addition to the standard medical history). Recognising which type of interview is appropriate for the specific clinical context is itself an important clinical skill.

Fill in the blank: The _____ consultation is abbreviated and directed, prioritising immediate life threats over comprehensive history-taking when a patient presents in an acute or emergency situation.

Figure 1.1: Components and types of the clinical interview

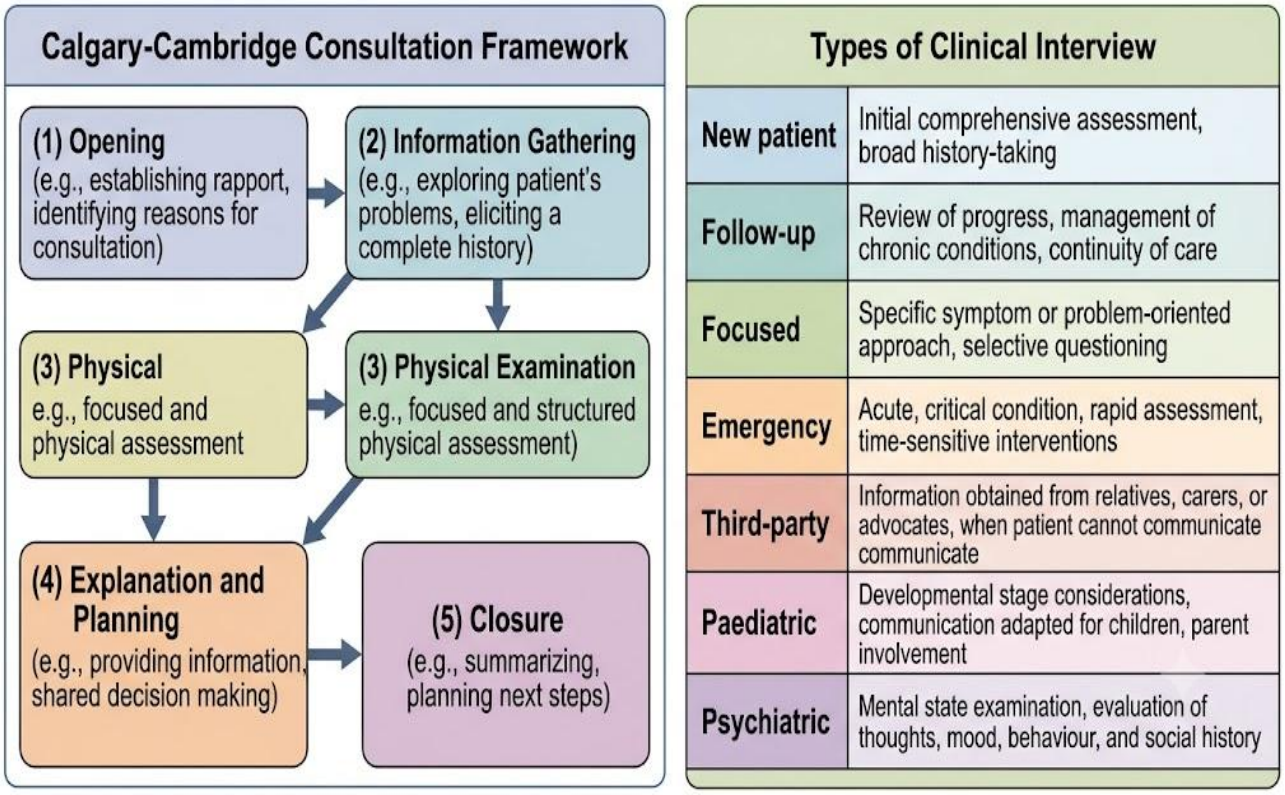

Figure 1.1: Components and types of the clinical interview

Pilot questions 1.1

1. Define the clinical interview.
2. Name five purposes of the clinical interview beyond data collection.
3. Name the five structural components of the Calgary-Cambridge consultation framework.

4. Distinguish between a new patient consultation and a follow-up consultation.
5. When would a third-party interview be required?

1.2 The Medical History

1.2.1 Chief complaint and history of presenting illness

The **chief complaint (CC)** is the primary symptom or problem that brings the patient to seek medical attention, recorded in the patient own words and as brief as possible (for example, "chest pain for two hours" or "difficulty breathing since yesterday evening"). The chief complaint anchors the consultation and directs the remainder of the history. It should be identified at the outset and confirmed with the patient, since the presenting complaint as documented in a referral letter or appointment record may differ from what the patient most wants to discuss.

The **history of presenting illness (HPI)** is the detailed chronological account of the development of the chief complaint from its onset to the present. The HPI should address: **onset** (when and how suddenly the symptom began), **duration** (how long it has been present), **character** (quality and nature of the symptom), **severity** (intensity on a scale, functional impact), **location** and **radiation** (for pain), **associated symptoms** (other symptoms occurring concurrently), **modifying factors** (what makes it better or worse), and **previous similar episodes**. The mnemonic **SOCRATES** (Site, Onset, Character, Radiation, Associations, Time course, Exacerbating and relieving factors, Severity) is a commonly used framework for characterising pain.

Fill in the blank: The mnemonic _____ (Site, Onset, Character, Radiation, Associations, Time course, Exacerbating/relieving factors, Severity) is used to systematically characterise a patient pain in the history of presenting illness.

1.2.2 Past medical, family, and social history

The **past medical history (PMH)** documents all previous significant illnesses, hospitalisations, surgical procedures, and medical conditions, including childhood illnesses, chronic diseases (diabetes, hypertension, asthma, HIV), and any known complications or sequelae. It provides the clinical context within which the presenting illness must be understood: a patient with known ischaemic heart disease presenting with chest pain carries a very different prior probability than a 20-year-old with no cardiac history. Past obstetric history is recorded separately for female patients of reproductive age.

The **family history (FH)** documents significant illnesses in first-degree relatives (parents, siblings, children), particularly conditions with known hereditary components such as ischaemic heart disease, diabetes, hypertension, cancers, and inherited disorders. The **social history (SH)** documents the patient occupation, living situation, marital and family status, smoking and alcohol use, recreational drug use, dietary habits, exercise, recent travel, and any relevant social stressors. The social history is often the most neglected component of the history despite its critical importance for understanding disease causation, health behaviours, and the feasibility of management plans.

Fill in the blank: The _____ history documents the patient occupation, living situation, smoking and alcohol use, recreational drug use, dietary habits, and relevant social stressors, providing essential context for understanding disease causation.

1.2.3 Drug history and review of systems

The **drug history (DH)** documents all current medications (prescribed, over-the-counter, herbal, and traditional preparations) with their doses, frequencies, and routes of administration; all known drug allergies and the nature of the allergic reaction; and any recently discontinued medications relevant to the presenting problem. The drug history is clinically critical because medications are a common cause of symptoms (drug side effects, interactions, and toxicities) and because polypharmacy in older patients creates complex management challenges.

The **review of systems (ROS)** is a systematic screen of all body systems beyond those already addressed in the HPI, designed to identify additional symptoms the patient may not have spontaneously reported. It proceeds organ system by organ system: cardiovascular, respiratory,

gastrointestinal, genitourinary, musculoskeletal, neurological, dermatological, endocrine, and psychiatric. A positive finding in the ROS may reveal an associated condition or a complication of the presenting illness that significantly changes the diagnosis or management plan. The ROS is typically conducted after the focused history is complete and before the examination.

Fill in the blank: The review of _____ is a systematic screen of all body systems beyond those addressed in the history of presenting illness, designed to identify additional symptoms the patient may not have spontaneously reported.

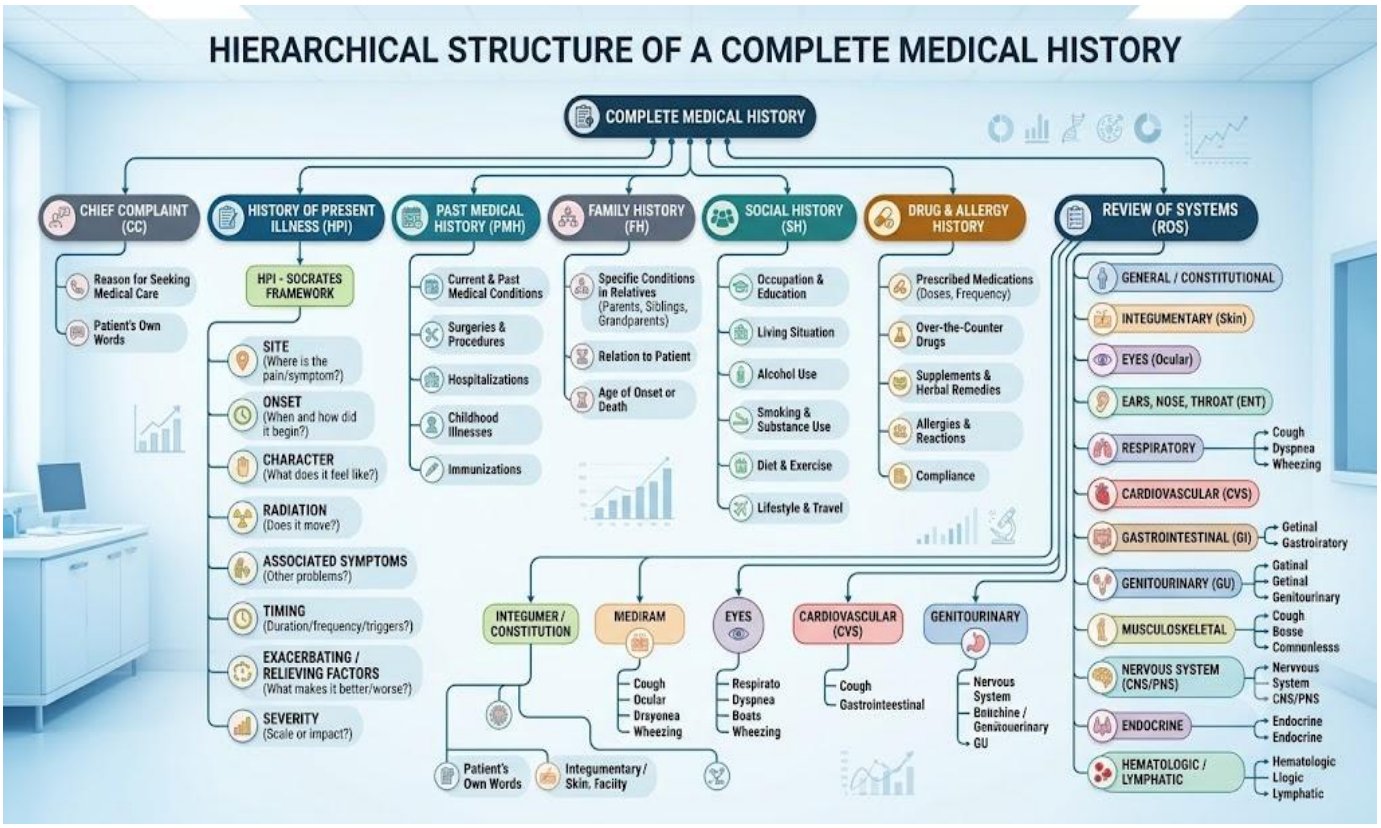

Figure 1.2: Structure of the medical history

Pilot questions 1.2

1. Define the chief complaint and explain how it should be recorded.
2. What does the mnemonic SOCRATES stand for?
3. Why is the social history often the most neglected component of the medical history?
4. What does the drug history include beyond current prescribed medications?

5. What is the purpose of the review of systems?

1.3 Communication Skills in Clinical Medicine

1.3.1 Principles of effective doctor-patient communication

Effective doctor-patient communication is grounded in several principles. **Active listening** (giving the patient full, focused attention; using verbal and non-verbal cues to signal engagement; resisting the urge to interrupt or redirect prematurely) enables the patient to tell their story completely, producing more accurate and complete information than a clinician-driven interrogation. **Empathy** (the ability to understand and acknowledge the patient emotional experience without necessarily sharing it) is associated with greater patient satisfaction, better adherence, and improved clinical outcomes.

Patient-centred communication balances two agendas: the **disease framework** (the clinician biomedical model of what is causing the symptoms) and the **illness framework** (the patient subjective experience, concerns, beliefs, and expectations). Effective communication explores both and integrates them in the explanation and management plan. **Avoiding jargon**, using language matched to the patient educational level and health literacy, **checking understanding** at regular intervals (not simply asking "do you understand?" but asking the patient to explain back what they have understood), and **allowing silence** (giving the patient space to think and respond without premature closure) are practical principles of high-quality clinical communication.

Fill in the blank: Patient-centred communication balances the disease framework (the clinician biomedical model) and the _____ framework (the patient subjective experience, concerns, beliefs, and expectations about their illness).

1.3.2 Verbal and non-verbal communication

Verbal communication in the clinical interview uses a sequence from **open questions** (inviting the patient to describe their experience in their own words: "Tell me what has been troubling you") through **facilitation** (encouraging the patient to continue: "Please go on", "I see") to **focused questions** (directing attention to specific aspects: "Where exactly is the pain?") and **closed questions** (requiring a yes/no or factual answer: "Have you ever had this before?"). Starting with open questions and progressively narrowing produces the most complete and accurate history.

Non-verbal communication encompasses **body language** (posture, orientation, and movement), **eye contact** (appropriate and culturally sensitive), **facial expression** (neutral and engaged rather than judgemental), **physical distance** (proxemics: maintaining appropriate interpersonal space), **touch** (used appropriately and with sensitivity, particularly important in Nigerian cultural contexts where touching may carry significance), and **para-language** (tone, pace, and volume of speech). Non-verbal cues account for a substantial proportion of the emotional content of communication and must be congruent with verbal messages; a reassuring statement delivered with a tense expression or averted gaze undermines the intended communication.

Fill in the blank: A clinical interview begins with _____ questions that invite the patient to describe their experience in their own words, before progressively narrowing to focused and closed questions.

1.3.3 Breaking bad news and sensitive communication

Breaking bad news requires a structured approach. The **SPIKES protocol** (Setting up; assessing the patient Perception; obtaining the patient Invitation to receive information; giving Knowledge and information; addressing Emotions with Empathy; and Strategy and Summary) provides a widely used framework. **Setting** involves ensuring privacy, having a support person present if the patient wishes, and avoiding interruptions. **Perception** involves asking what the patient already knows or suspects about their condition before delivering new information, preventing either unnecessary distress from repeating what is known or the shock of information delivered without context.

Sensitive communication is also required in other contexts: discussing sexual history, substance use, domestic violence, mental health symptoms, and stigmatised conditions (HIV, tuberculosis, epilepsy in the Nigerian cultural context). These conversations require **explicit normalisation** ("These are questions I ask all patients"), **non-judgemental framing** (asking about behaviour without implying moral condemnation), **assurance of confidentiality** (explaining who will have access to the information), and **cultural sensitivity** (awareness that disclosure norms, shame, and stigma vary significantly across Nigeria diverse communities and must be respected in the manner of inquiry).

Fill in the blank: The _____ protocol (Setting, Perception, Invitation, Knowledge, Empathy, Strategy) provides a structured framework for breaking bad news to patients in clinical settings.

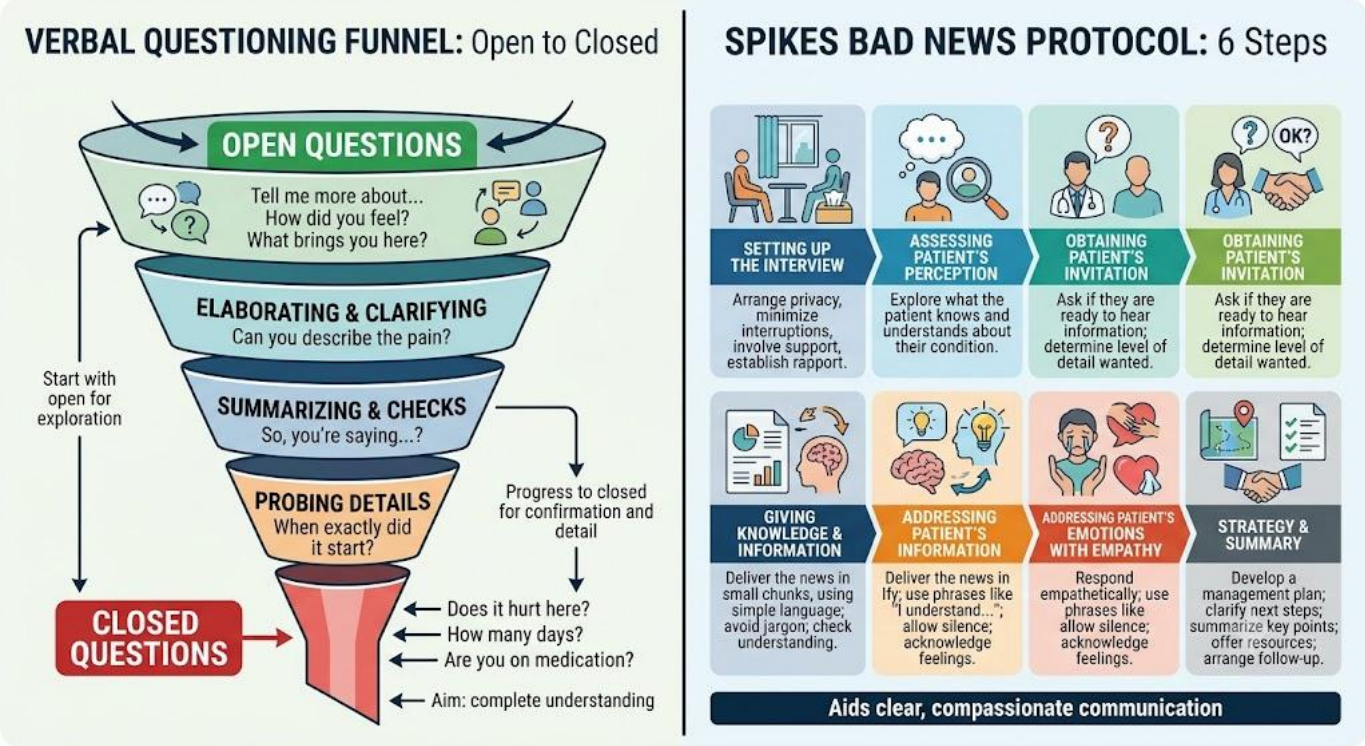

Figure 1.3: Communication skills framework and SPIKES protocol

Pilot questions 1.3

1. Name four principles of effective doctor-patient communication.
2. Distinguish between open and closed questions in the clinical interview.

3. Name four components of non-verbal communication in clinical practice.
4. What does the SPIKES acronym stand for?
5. Name two sensitive communication contexts requiring special care in Nigerian clinical practice.

1.4 Ethics and Professionalism in the Clinical Interview

1.4.1 Informed consent and patient autonomy

Informed consent is the process by which a patient voluntarily authorises a medical intervention after receiving adequate information about the nature, purpose, benefits, risks, alternatives, and consequences of refusing. Valid informed consent requires three elements: **disclosure** (the clinician must provide sufficient information), **competence** (the patient must have the mental capacity to understand and reason), and **voluntariness** (the decision must be made freely without coercion or undue influence). Consent is not a signature on a form; it is an ongoing process of communication and shared decision-making.

Patient autonomy, the right of patients to make their own healthcare decisions, is a foundational ethical principle that clinicians must respect even when they disagree with the patient choice. A competent adult patient has the right to refuse any treatment, including life-saving treatment, after receiving appropriate information. When patients lack decision-making capacity (due to unconsciousness, severe mental illness, or cognitive impairment), decisions are made in their **best interests** by the clinician in consultation with family members, guided by any known previously expressed wishes (advance directives). Special considerations apply to **paediatric patients**, where consent is obtained from parents or guardians, but the child assent should be sought when appropriate.

Fill in the blank: Valid informed consent requires three elements: disclosure (adequate information provided), competence (decision-making _____), and voluntariness (decision made freely without coercion).

1.4.2 Confidentiality and its limits

Medical confidentiality is the obligation of clinicians to protect patient health information from disclosure to third parties without the patient consent. It is both an ethical obligation (grounded in the duty of non-maleficence, the Hippocratic tradition, and the requirements of professional regulatory bodies) and a practical necessity: patients are more likely to disclose sensitive information if they trust it will not be shared without their agreement, and this disclosure is essential for accurate diagnosis and effective treatment.

Confidentiality is not absolute. Recognised **limits** include: disclosure required to **protect third parties** from serious identifiable harm (for example, a patient with poorly controlled epilepsy who continues to drive, or a patient with a communicable disease who is endangering others); disclosure to **statutory authorities** as required by law (notifiable diseases, certain forensic contexts); disclosure in the **patient best interests** when they lack capacity; and disclosure within the **clinical team** providing care (information shared with treating colleagues on a need-to-know basis). In all cases, the minimum necessary information should be disclosed, and where possible the patient should be informed and their cooperation sought.

Fill in the blank: Medical confidentiality may be breached to protect _____ parties from serious identifiable harm, to comply with statutory notification requirements, or to act in the patient best interests when they lack capacity.

1.4.3 Professional conduct and ethical issues in clinical practice

Good clinical practice requires adherence to professional standards that extend beyond technical competence. **Honesty and integrity** (including acknowledging uncertainty and error, rather than concealing mistakes from patients) are foundational. **Respect for persons** requires treating every patient with dignity regardless of social status, diagnosis, behaviour, or personal characteristics. **Non-discrimination** requires delivering care without prejudice based on race, ethnicity, religion, gender, sexual orientation, disability, or socioeconomic status. **Maintaining professional boundaries** prohibits exploiting the power asymmetry inherent in the doctor-patient relationship for personal, financial, or sexual benefit.

The **Medical and Dental Council of Nigeria (MDCN)** is the professional regulatory body responsible for setting and enforcing standards of medical practice in Nigeria, including registration requirements, continuing professional development obligations, and disciplinary procedures for professional misconduct. Key ethical frameworks relevant to clinical practice include the **four principles approach** (autonomy, beneficence, non-maleficence, and justice), the **duties-based** approach (focusing on obligations and rules), and the **virtue ethics** approach (focusing on the character and values of the practitioner). All three frameworks find expression in the ethical issues encountered in the clinical interview.

Fill in the blank: The _____ and Dental Council of Nigeria (MDCN) is the professional regulatory body responsible for setting and enforcing standards of medical practice, registration, and professional conduct in Nigeria.

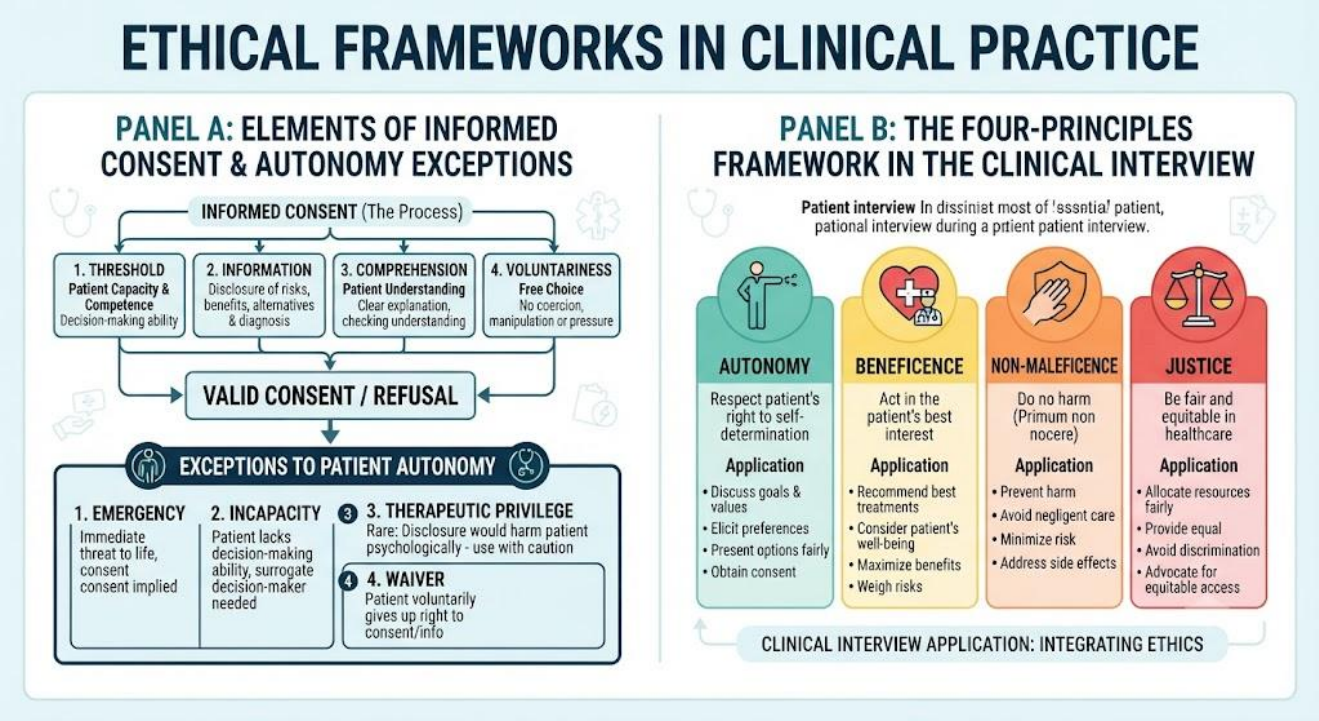

Figure 1.4: Ethics in the clinical interview

Pilot questions 1.4

1. State the three elements required for valid informed consent.
2. What is patient autonomy and what is its limit in clinical practice?

3. Define medical confidentiality and name three circumstances in which it may be breached.
4. Name four principles of professional conduct required in good clinical practice.
5. Name the four principles of the standard bioethical framework and give one example of each in the clinical interview context.

Series Summary

This Series established the foundational knowledge and skills for conducting effective clinical interviews. The clinical interview was defined as a structured, purposeful conversation serving data collection, therapeutic, educational, and relational purposes, structured within the Calgary-Cambridge framework of opening, information gathering, examination, explanation and planning, and closure. The types of interview were described, from new patient through emergency and paediatric consultations, recognising that each requires adaptation of approach and content.

The comprehensive medical history was structured into its components: chief complaint and HPI (using SOCRATES), past medical, family, and social history, drug history and review of systems. Communication skills were examined through patient-centred principles, the verbal questioning sequence from open to closed, non-verbal communication, and the SPIKES framework for breaking bad news. The Series concluded by examining informed consent (disclosure, competence, voluntariness), the limits of confidentiality, and the professional and ethical standards governing clinical practice in Nigeria, including the roles of the MDCN and the four-principles bioethical framework (SLOs 1.1 to 1.5).

Glossary of Terms

- **Active listening:** giving the patient full, focused attention and using verbal and non-verbal cues to signal engagement, enabling the patient to tell their story completely.
- **Calgary-Cambridge framework:** a structured model of the medical consultation comprising opening, information gathering, physical examination, explanation and planning, and closure.
- **Chief complaint:** the primary symptom or problem that brings the patient to seek medical attention, recorded in the patient own words.

- **Confidentiality:** the ethical and legal obligation to protect patient health information from disclosure to third parties without the patient consent.
- **History of presenting illness (HPI):** the detailed chronological account of the development of the chief complaint from onset to presentation.
- **Informed consent:** the process by which a patient voluntarily authorises a medical intervention after receiving adequate information about its nature, benefits, risks, and alternatives.
- **MDCN:** Medical and Dental Council of Nigeria; the professional regulatory body responsible for setting and enforcing standards of medical practice in Nigeria.
- **Patient autonomy:** the right of competent patients to make their own healthcare decisions, including the right to refuse treatment.
- **Review of systems (ROS):** a systematic screen of all body systems to identify additional symptoms not reported spontaneously.
- **SOCRATES:** a mnemonic (Site, Onset, Character, Radiation, Associations, Time course, Exacerbating/relieving factors, Severity) for systematically characterising pain symptoms.
- **SPIKES:** a protocol for breaking bad news (Setting, Perception, Invitation, Knowledge, Empathy, Strategy) providing a structured framework for difficult clinical conversations.

Concept Check Questions [Series 1]

Objective questions

1. The clinical interview establishes the therapeutic _____ between doctor and patient, creating the trust that underpins patient disclosure and treatment adherence. (Linked to SLO 1.1)
2. The Calgary-Cambridge framework concludes with _____ , which involves summarising, checking understanding, and arranging follow-up. (Linked to SLO 1.1)
3. The mnemonic _____ (Site, Onset, Character, Radiation, Associations, Time course, Exacerbating/relieving factors, Severity) is used to characterise pain in the HPI. (Linked to SLO 1.2)
4. Patient-centred communication balances the disease framework and the _____ framework, which represents the patient subjective experience and concerns. (Linked to SLO 1.3)
5. The _____ protocol (Setting, Perception, Invitation, Knowledge, Empathy, Strategy) provides a structured approach to breaking bad news. (Linked to SLO 1.4)
6. Valid informed consent requires disclosure, competence (decision-making _____), and voluntariness. (Linked to SLO 1.5)

Short-answer questions

7. Describe the structure of the medical history, naming all major components in sequence. (Linked to SLO 1.2)
8. Explain the limits of medical confidentiality, giving three circumstances in which it may be breached. (Linked to SLO 1.5)

Long-answer questions

9. Discuss the principles and skills of effective doctor-patient communication, covering verbal questioning techniques, non-verbal communication, and the approach to sensitive conversations. (Linked to SLOs 1.3–1.4)

10. Evaluate the ethical framework governing clinical interviews in Nigeria, covering informed consent, confidentiality, professional conduct, and the four principles of bioethics. (Linked to SLO 1.5)

Answers to Concept Check Questions [Series 1]

Objective questions

1. Relationship.
2. Closure.
3. SOCRATES.
4. Illness.
5. SPIKES.
6. Capacity.

Short-answer questions

7. Chief complaint (primary symptom in patient own words); history of presenting illness (chronological account using SOCRATES: onset, character, severity, location, radiation, associations, modifying factors, previous episodes); past medical history (previous illnesses, hospitalisations, operations, chronic conditions); family history (significant illness in first-degree relatives); social history (occupation, living situation, smoking, alcohol, drugs, diet, travel); drug history (current medications with doses, drug allergies, recently stopped medications); review of systems (systematic screen of all body systems).
8. Confidentiality may be breached: (1) to protect third parties from serious identifiable harm (e.g. patient with uncontrolled epilepsy driving, or patient endangering others with a communicable disease); (2) as required by statute (notifiable diseases, forensic contexts); (3) in the patient best interests when they lack decision-making capacity. In all cases, minimum necessary information should be disclosed and the patient informed where possible.

Long-answer questions

9. **Basic response:** Principles: active listening (full attention, not interrupting), empathy (acknowledging emotional experience), patient-centred (balancing disease and illness frameworks), avoiding jargon, checking understanding, allowing silence. Verbal: open questions first (Tell me what has been troubling you), facilitation (Please go on), focused (Where exactly?), closed (Yes/no). Non-verbal: body language, eye contact, facial expression, proxemics, appropriate touch, para-language (tone, pace, volume); must be congruent with verbal messages. Sensitive conversations: normalising (I ask all patients), non-judgemental framing, assuring confidentiality, cultural sensitivity. SPIKES for bad news: Setting, Perception, Invitation, Knowledge, Empathy, Strategy.

   Value-added response: The most common communication failure in clinical practice is not asking the wrong questions but failing to listen to the answers: clinicians interrupt patients on average within 18 to 23 seconds of the opening narrative, truncating information that would have been volunteered spontaneously and clinically relevant. In the Nigerian clinical context, the hierarchical doctor-patient dynamic and time pressures in busy PHC facilities make active listening particularly challenging to sustain, but its yield in diagnostic accuracy and therapeutic relationship quality consistently justifies the investment of those extra few minutes of uninterrupted patient narrative.

10. **Basic response:** Informed consent: three elements (disclosure, competence, voluntariness); ongoing process not one-off signature; right of competent adults to refuse even life-saving treatment; incapacity managed by best interests decision with family; paediatric consent from parents with child assent where appropriate. Confidentiality: ethical and legal obligation; limits include third-party harm, statutory notification, clinical team (need to know basis), patient incapacity; minimum disclosure principle. Professional conduct: honesty, respect, non-discrimination, maintaining boundaries; MDCN as regulatory body with registration, CPD, and disciplinary functions. Four principles: autonomy (patient decision-making rights), beneficence (acting in patient interest), non-maleficence (avoiding harm), justice (fair distribution of care).

Value-added response: The four-principles framework is particularly valuable in clinical interview ethics because it makes the ethical tensions explicit rather than obscuring them: when a patient refuses a beneficial treatment (tension between autonomy and beneficence), when withholding information might prevent harm but violates honesty (tension between non-maleficence and truthfulness), or when limited resources require prioritisation decisions (justice). Recognising which principle is in tension with which, rather than applying a single principle absolutistically, produces more nuanced and defensible ethical reasoning in the complex situations that arise in clinical practice.

Answers to Pilot Questions [Series 1]

Part 1.1

1. The clinical interview is a structured, purposeful conversation between a clinician and a patient aimed at gathering information necessary to understand the health problem, establish a diagnosis, and formulate a management plan.
2. Any five of: establishing the therapeutic relationship; identifying the patient agenda (concerns, expectations, ideas); providing patient education; offering therapeutic benefit through being heard; guiding subsequent examination; determining whether the patient will adhere to treatment.
3. Opening, information gathering, physical examination, explanation and planning, and closure.
4. A new patient consultation is comprehensive, involving a full history, examination, and management plan for a patient presenting for the first time. A follow-up consultation reviews progress, assesses treatment response, and adjusts the management plan for a patient known to the clinician.
5. A third-party interview is required when the patient cannot provide history due to altered consciousness, cognitive impairment (dementia), severe mental illness, age (infants and young children), or language barrier requiring an interpreter.

Part 1.2

1. The chief complaint is the primary symptom or problem that brings the patient to seek medical attention. It should be recorded briefly in the patient own words, anchoring the consultation and directing the remainder of the history.
2. Site, Onset, Character, Radiation, Associations, Time course, Exacerbating and relieving factors, Severity.
3. Because it addresses lifestyle, behavioural, and social determinants of health that clinicians may feel uncomfortable asking about or may consider less immediately relevant than the biomedical complaint, yet these factors often explain disease causation, risk, and the feasibility of management plans.
4. Current medications (prescribed, over-the-counter, herbal, and traditional preparations) with doses, frequencies, and routes; known drug allergies and the nature of the reaction; recently discontinued medications relevant to the presenting problem.
5. To systematically screen all body systems beyond those addressed in the HPI, identifying additional symptoms the patient may not have spontaneously reported, which may reveal associated conditions or complications significantly affecting diagnosis or management.

Part 1.3

1. Any four of: active listening; empathy; patient-centred communication (balancing disease and illness frameworks); avoiding jargon; checking understanding; allowing silence.
2. Open questions invite the patient to describe their experience in their own words (Tell me what has been troubling you) and produce broader narrative responses. Closed questions require a yes/no or specific factual answer (Have you had this before?) and are used to confirm specific details after the open narrative is complete.
3. Any four of: body language (posture, orientation); eye contact; facial expression; proxemics (physical distance/interpersonal space); appropriate touch; para-language (tone, pace, volume of speech).
4. Setting, Perception, Invitation, Knowledge, Empathy, Strategy and Summary.

5. Any two of: discussing sexual history; discussing substance (alcohol, drug) use; domestic violence; mental health symptoms; stigmatised conditions such as HIV, tuberculosis, or epilepsy.

Part 1.4

1. Disclosure (the clinician provides sufficient information), competence (the patient has decision-making capacity to understand and reason), and voluntariness (the decision is made freely without coercion or undue influence).
2. Patient autonomy is the right of competent patients to make their own healthcare decisions, including the right to refuse any treatment. Its limit is reached when the patient lacks decision-making capacity, in which case decisions are made in their best interests, guided by any known previously expressed wishes.
3. Medical confidentiality is the obligation to protect patient health information from disclosure without consent. It may be breached: (1) to protect identified third parties from serious harm; (2) as required by statute (notifiable diseases, forensic contexts); (3) when sharing within the treating clinical team on a need-to-know basis.
4. Any four of: honesty and integrity; respect for persons; non-discrimination; maintaining professional boundaries; acknowledging uncertainty and error.
5. Autonomy (respecting patient right to refuse investigation, e.g. patient refusing a needed biopsy); beneficence (recommending the best available treatment); non-maleficence (avoiding unnecessary investigations or treatments that cause harm); justice (seeing patients without discrimination based on social status or diagnosis).

References and Attributions [Series 1]

Textual references

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- National Open University of Nigeria (NOUN). (2023). Introduction to clinical medicine I course material. NOUN Press.

Figures, Plates, Tables, and Boxes

- Figure 1.1: Components and types of the clinical interview Attribution: AI generated using prompt "Generate a two-panel diagram showing the Calgary-Cambridge consultation framework and types of clinical interview with distinguishing features." Suggested OER search string: "clinical interview Calgary-Cambridge consultation framework types of medical consultation history-taking OER"
- Figure 1.2: Structure of the medical history Attribution: AI generated using prompt "Generate a hierarchical diagram of the complete medical history structure with chief complaint, HPI (SOCRATES), PMH, FH, SH, drug history, and review of systems." Suggested OER search string: "medical history taking structure chief complaint SOCRATES HPI past medical family social drug history review of systems OER"
- Figure 1.3: Communication skills framework and SPIKES protocol Attribution: AI generated using prompt "Generate a two-panel diagram showing the verbal questioning funnel from open to closed questions, and the SPIKES bad news protocol with six labelled steps." Suggested OER search string: "doctor patient communication open closed questions SPIKES breaking bad news clinical interview OER"

- Figure 1.4: Ethics in the clinical interview Attribution: AI generated using prompt "Generate a two-panel diagram showing the elements of informed consent with patient autonomy exceptions, and the four-principles ethical framework applied to the clinical interview." Suggested OER search string: "informed consent patient autonomy confidentiality medical ethics four principles clinical interview OER"

Series 2: Basic Clinical Skills and General Examination

- **Part 2.1: Approach to the Clinical Examination**
    - Sub Part 2.1.1: Principles and sequence of clinical examination
    - Sub Part 2.1.2: Preparation of the patient and the examination environment
    - Sub Part 2.1.3: General survey and first impressions
- **Part 2.2: Vital Signs**
    - Sub Part 2.2.1: Temperature
    - Sub Part 2.2.2: Pulse and blood pressure
    - Sub Part 2.2.3: Respiratory rate and oxygen saturation
- **Part 2.3: General Physical Signs**
    - Sub Part 2.3.1: Pallor, jaundice, and cyanosis
    - Sub Part 2.3.2: Oedema, clubbing, and lymphadenopathy
    - Sub Part 2.3.3: Other general physical signs
- **Part 2.4: Techniques of Clinical Examination**
    - Sub Part 2.4.1: Inspection
    - Sub Part 2.4.2: Palpation and percussion
    - Sub Part 2.4.3: Auscultation

Introduction

The physical examination is the second major component of clinical assessment, following and guided by the history. A well-conducted examination confirms or refutes hypotheses generated from the history, reveals signs the patient has not reported or does not perceive, and provides objective data that cannot be obtained by history alone. In clinical medicine, the ability to conduct a systematic, thorough, and technically competent examination is an essential professional skill that improves through deliberate practice and disciplined attention to technique.

The aim of this Series is to describe the principles and sequence of clinical examination, establish the approach to patient preparation and the general survey, examine the measurement and interpretation of vital signs, describe the major general physical signs and their clinical significance, and develop competence in the four fundamental examination techniques of inspection, palpation, percussion, and auscultation.

We shall commence by examining the approach to clinical examination and the general survey. Next, we will examine vital signs in detail. Moving on, we will address the major general physical signs. Finally, we will close by examining the four examination techniques and their correct application.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 2.1** describe the principles, sequence, and preparation for clinical examination,
- **SLO 2.2** conduct and interpret a general survey of the patient,
- **SLO 2.3** measure and interpret vital signs including temperature, pulse, blood pressure, and respiratory rate,
- **SLO 2.4** identify and describe the clinical significance of major general physical signs, and

- **SLO 2.5** demonstrate the correct techniques of inspection, palpation, percussion, and auscultation.

2.1 Approach to the Clinical Examination

2.1.1 Principles and sequence of clinical examination

Clinical examination follows four organising principles. **Systematisation**: examination proceeds in a defined, consistent sequence from head to toe and from general to specific, ensuring that no region or system is overlooked. **Technique**: each examination manoeuvre must be performed correctly to elicit valid signs; an incorrectly performed test produces unreliable findings and may lead to diagnostic error. **Contextualisation**: findings are interpreted in light of the history, so that a sign confirmed by examination is understood in the context of the clinical picture rather than in isolation. **Documentation**: findings are recorded accurately and in conventional clinical notation immediately after examination, before memory degrades.

The standard sequence of clinical examination is: **general survey** (overall impression of the patient state); **vital signs** (temperature, pulse, blood pressure, respiratory rate, oxygen saturation); **general physical examination** (hands, nails, face, eyes, mouth, neck, lymph nodes, peripheral signs); followed by **systemic examination** of each organ system (cardiovascular, respiratory, gastrointestinal, neurological, musculoskeletal, genitourinary, dermatological) as directed by the clinical problem. Not every system requires full examination in every encounter; the history guides which systems receive priority attention.

Fill in the blank: Clinical examination follows four organising principles: systematisation, technique, _____ (interpreting findings in the light of the history), and documentation.

2.1.2 Preparation of the patient and the examination environment

Before examination begins, the clinician must ensure **adequate privacy** (examination behind a closed door or curtain, with minimum necessary exposure maintained throughout), **patient**

comfort (a clean, appropriately positioned examination couch or bed, with the patient lying flat or at 45 degrees as the examination requires), **adequate lighting** (natural or bright artificial light, particularly important for inspection of skin colour changes and subtle signs), and **necessary equipment** (stethoscope, sphygmomanometer, thermometer, pen torch, tendon hammer, and other required tools present and functional before the examination begins, not sought mid-examination).

Patient preparation includes: **explaining the examination** (what will be done and why, maintaining informed consent throughout the clinical encounter), **appropriate undressing** (exposing the region being examined while maintaining dignity by covering areas not under immediate examination), **positioning** (supine for abdominal and cardiovascular examination; sitting forward for cardiac auscultation of the back; standing for musculoskeletal assessment), and **hand hygiene** (the clinician must wash or sanitise hands before and after patient contact, both for infection control and as a signal of professional respect for the patient).

Fill in the blank: Before clinical examination begins, the clinician must wash or sanitise hands for infection control and as a signal of professional _____ for the patient, and must ensure adequate privacy, lighting, and necessary equipment.

2.1.3 General survey and first impressions

The **general survey** is the clinician overall impression formed in the first moments of the clinical encounter, before any formal examination manoeuvre begins. It encompasses the patient **appearance** (well or unwell, comfortable or distressed, alert or drowsy), **body habitus** (build, nutritional status, obesity, cachexia), **posture and gait** (as the patient enters or moves), **dress and grooming** (which may reflect cognitive function, self-care capacity, or socioeconomic circumstances), **mood and affect** (anxious, depressed, flat, or appropriate), and any **immediately visible abnormalities** (jaundice, pallor, respiratory distress, obvious deformity).

The general survey also includes **nutritional assessment**: classifying the patient as underweight, normal weight, overweight, or obese using body mass index (BMI = weight in kg divided by height in metres squared), with BMI below 18.5 indicating underweight, 18.5 to 24.9 normal, 25 to 29.9 overweight, and 30 or above obese. **Hydration status** is assessed by skin turgor, mucous

membrane moisture, and the presence of sunken eyes or dry lips. An **apparently well or unwell** overall impression must be explicitly documented, as it influences the urgency of subsequent assessment and the threshold for investigation.

Fill in the blank: Body mass index (BMI) is calculated as weight in kilograms divided by height in _____ squared, with values below 18.5 indicating underweight and 30 or above indicating obesity.

Figure 2.1: Approach to clinical examination and general survey

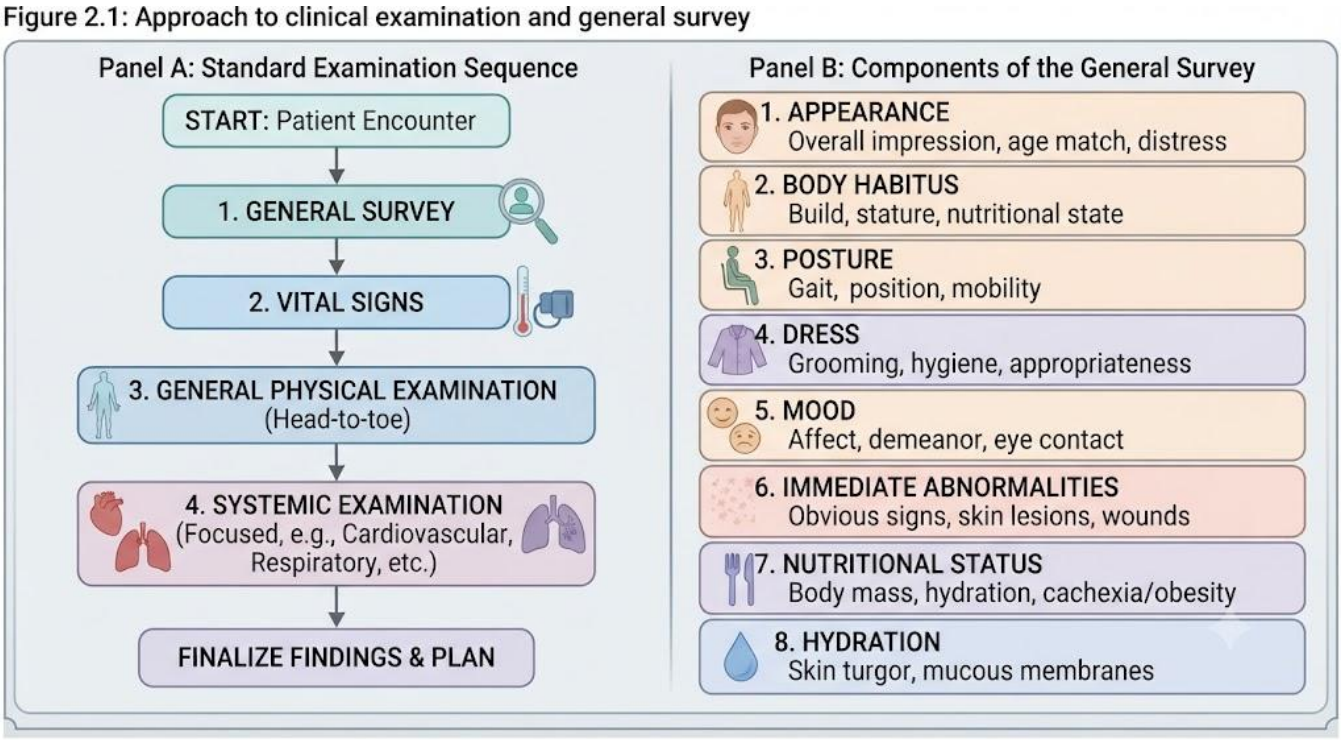


Figure 2.1: Approach to clinical examination and general survey

Pilot questions 2.1

1. Name the four organising principles of clinical examination.
2. Describe the standard sequence of clinical examination.
3. Name four preparation steps required before beginning clinical examination.
4. What is the general survey and what does it encompass?
5. Define BMI and state the classification thresholds.

2.2 Vital Signs

2.2.1 Temperature

Body temperature reflects the balance between heat production (from metabolic activity) and heat loss (through radiation, conduction, convection, and evaporation). **Normal core body temperature** is 36.5 to 37.5 degrees Celsius (97.7 to 99.5°F). Temperature is measured at several sites: **oral** (common in adults, normal range 36.3 to 37.4°C), **axillary** (most common in Nigerian clinical practice, typically 0.5°C below oral), **rectal** (most accurate for core temperature, 0.5°C above oral, preferred in infants and unconscious patients), and **tympanic** (infrared, rapid, useful in children).

Pyrexia (fever) is defined as a temperature above 37.5°C and may be **low-grade** (37.5 to 38.0°C), **moderate** (38.0 to 39.0°C), or **high** (above 39.0°C). **Hyperpyrexia** (above 41.5°C) is a medical emergency. **Hypothermia** is a core temperature below 35°C, seen in exposure, metabolic disorders, and severe sepsis. The **pattern of fever** is clinically informative: **intermittent fever** (temperature returning to normal between spikes, as in malaria), **remittent fever** (fluctuating but never returning to normal, as in typhoid), and **continuous fever** (sustained elevation with less than 1°C variation).

Fill in the blank: Pyrexia is defined as a temperature above 37.5°C and may be low-grade, moderate, or high; _____ (above 41.5°C) is a medical emergency requiring immediate management.

2.2.2 Pulse and blood pressure

The **pulse** is assessed at the radial artery (most common) or other accessible arteries (brachial, carotid, femoral, popliteal, posterior tibial, dorsalis pedis). Pulse assessment includes: **rate** (normal 60 to 100 beats per minute in adults; bradycardia below 60, tachycardia above 100), **rhythm** (regular or irregular; if irregular, whether regularly irregular as in ectopic beats or irregularly irregular as in atrial fibrillation), **character** (volume and waveform: full/bounding in high output states, small/thready in shock, collapsing/water-hammer in aortic regurgitation), and

symmetry (comparing both radial pulses simultaneously for radiofemoral delay in coarctation of the aorta).

Blood pressure is measured using a **sphygmomanometer** (aneroid or electronic), with a cuff of appropriate size (the bladder should encircle at least 80% of the arm circumference; too small a cuff falsely elevates, too large falsely lowers readings). Standard technique: patient seated with arm at heart level, cuff around upper arm, auscultation over the brachial artery. **Systolic pressure** is the pressure at which Korotkoff sounds appear (phase I), **diastolic** at which they disappear (phase V). Normal blood pressure is below 120/80 mmHg; **hypertension** is defined as persistently 130/80 mmHg or above (ACC/AHA 2017) or 140/90 mmHg or above (older WHO/ESH definitions).

Fill in the blank: Blood pressure is measured with a cuff whose bladder should encircle at least _____ % of the arm circumference; a cuff that is too small falsely elevates and one that is too large falsely lowers the reading.

2.2.3 Respiratory rate and oxygen saturation

Respiratory rate is the most frequently neglected vital sign despite its high clinical importance as an early indicator of deterioration. It is measured by counting chest movements over a full 60 seconds (or 30 seconds multiplied by two). Normal adult rate is 12 to 20 breaths per minute. **Tachypnoea** (above 20/min) indicates increased ventilatory demand from hypoxia, hypercapnia, metabolic acidosis, pain, anxiety, or primary lung pathology. **Bradypnoea** (below 12/min) suggests respiratory centre depression from opioids, severe metabolic alkalosis, or raised intracranial pressure.

Oxygen saturation (SpO_2) is measured by **pulse oximetry**, a non-invasive device that detects the differential light absorption of oxyhaemoglobin and deoxyhaemoglobin in pulsatile arterial blood. Normal SpO_2 is 95 to 100%. Below 94% requires investigation; below 90% indicates significant hypoxaemia requiring oxygen therapy. Pulse oximetry is unreliable in **peripheral vasoconstriction** (shock, cold), **severe anaemia** (inadequate signal), **methaemoglobinaemia**, and **carboxyhaemoglobinaemia** (carbon monoxide poisoning, where readings are falsely normal). Nail polish on the probe finger can also impair readings.

Fill in the blank: Pulse oximetry measures _____ saturation (SpO_2) and is unreliable in peripheral vasoconstriction, severe anaemia, methaemoglobinaemia, and carbon monoxide poisoning.

VITAL SIGNS: REFERENCE GUIDE FOR CLINICAL PRACTICE

VITAL SIGN & UNIT:	NORMAL RANGE (Adults):	ABNORMALITY TERMINOLOGY	CLINICAL SIGNIFICANCE & CAUSES
TEMPERATURE (°F / °C)	97.8°F - 99.1°F (36.5°C - 37.3°C) - Oral	Hyperthermia (Fever), Hypothermia	**Hyperthermia:** Infection, inflammation, heatstroke. **Hypothermia:** Exposure to cold, sepsis, metabolic disorders.
PULSE (Beats/min - bpm)	60 - 100 bpm	Tachycardia (Fast), Bradycardia (Slow)	**Tachycardia:** Exercise, fever, pain, anxiety, dehydration. **Bradycardia:** Fitness, heart block, medication (e.g., beta-blockers), hypothyroidism.
BLOOD PRESSURE (mmHg)	Systolic: <120 AND Diastolic: <80	Hypertension (High), Hypotension (Low)	**Hypertension:** Essential (primary), secondary (renal, endocrine), stress, obesity. **Hypotension:** Dehydration, hemorrhage, shock, heart failure, autonomic dysfunction.
RESPIRATORY RATE (Breaths/min - brpm)	12 - 20 brpm	Tachypnea (Fast), Bradypnea (Slow), Apnea (None)	**Tachypnea:** Anxiety, pain, respiratory distress, fever, exertion. **Bradypnea:** Drug overdose (e.g., opioids), head injury, deep sleep. **Apnea:** Sleep apnea, cardiac arrest, neurological damage.

***NOTE:** *Ranges are general for a healthy adult; individual factors (age, activity) apply.*

COMPREHENSIVE VITAL SIGNS REFERENCE TABLE

VITAL SIGN	MEASUREMENT UNIT	NORMAL RANGE (ADULT)	ABNORMALITY TERMINOLOGY (HIGH)	CLINICAL SIGNIFICANCE (HIGH)	CLINICAL SIGNIFICANCE (LOW)	ICON
TEMPERATURE		97°F - 99°F (36.1°C - 37.2°C) orally	Hyperthermia / Fever	Infection, inflammation, heatstroke, dehydration, malignancy	Exposure to cold, shock, metabolic disorders, sepsis	
			Hypothermia	Hypothermia	Exposure to cold, shock, metabolic disorders, sepsis	
PULSE (Heart Rate)		60 - 100 beats per minute (bpm)	Tachycardia (>100 bpm)	Anxiety, fever, pain, dehydration, exercise, heart conditions, hyperthyroidism	Physical conditioning, heart block, medications (e.g., beta-blockers), hypothyroidism, vagal stimulation.	
			(>100 bpm)	Bradycardia (<60 bpm)		
BLOOD PRESSURE		<120 mmHg (Systolic) <80 mmHg (Diastolic)	Hypertension (>130/80 mmHg)	Essential hypertension, kidney disease, stress, obesity, cardiovascular disease risk, preeclampsia		
				Hypotension (<90/60 mmHg)	Shock, dehydration, hemorrhage, heart failure, Addison n's disease, severe infection	
RESPIRATORY RATE		12 - 20 breaths per minute	Tachypnea (>20 breaths/min)	Anxiety, fever, pain, respiratory distress, asthma, pneumonia, COPD, pulmonary embolism		
				Bradypnea (<12 breaths/min)	Sedation, opioid overdose, brain injury, metabolic disorders, deep sleep	

Figure 2.2: Vital signs: normal values, abnormalities, and clinical significance

Pilot questions 2.2

1. State the normal range of body temperature and define pyrexia, hyperpyrexia, and hypothermia.
2. Name four characteristics of the pulse that should be assessed.
3. Describe the correct technique for measuring blood pressure.
4. Why is respiratory rate described as the most neglected vital sign?
5. Name four conditions that cause unreliable pulse oximetry readings.

2.3 General Physical Signs

2.3.1 Pallor, jaundice, and cyanosis

Pallor is a reduction in the pink colour of skin and mucous membranes, most reliably detected at the **conjunctival mucosae**, **palmar creases**, and **nail beds** rather than from overall skin colour

alone (which varies with racial pigmentation). Pallor indicates reduced haemoglobin or reduced blood flow to the skin. The commonest cause in Nigeria is **anaemia** (from iron deficiency, malaria, haemoglobinopathy, or chronic disease). Shock also produces pallor through cutaneous vasoconstriction. Pallor does not reliably estimate haemoglobin level; definitive assessment requires full blood count.

Jaundice (icterus) is yellow discolouration of the skin, sclerae, and mucous membranes due to elevated bilirubin (above approximately 35 μmol/L). It is most reliably detected in the **sclerae** (the white of the eyes), particularly in natural light. It is classified as **pre-hepatic** (haemolysis, causing unconjugated hyperbilirubinaemia; common causes: malaria, sickle cell crisis), **hepatic** (hepatocyte dysfunction: viral hepatitis, cirrhosis), or **post-hepatic** (biliary obstruction: gallstones, pancreatic cancer). **Cyanosis** is blue-grey discolouration from deoxyhaemoglobin: **central** (lips and tongue, indicating arterial hypoxaemia) or **peripheral** (fingers and toes, from reduced peripheral perfusion).

Fill in the blank: Jaundice is most reliably detected in the _____ (the white of the eyes), particularly in natural light, and indicates elevated bilirubin above approximately 35 μmol/L.

2.3.2 Oedema, clubbing, and lymphadenopathy

Oedema is the abnormal accumulation of fluid in the interstitial space, detected clinically by **pitting** (sustained finger pressure over the pretibial area or sacrum produces an indent that persists after pressure is released) in dependent oedema. **Pitting oedema** is caused by raised venous pressure (heart failure, venous obstruction), reduced plasma oncotic pressure (hypoalbuminaemia from nephrotic syndrome, liver disease, or malnutrition), or increased capillary permeability (sepsis, anaphylaxis). **Non-pitting oedema** (lymphoedema, myxoedema in hypothyroidism) does not indent on pressure.

Clubbing is loss of the normal angle between the nail and the nail fold (Lovibond angle, normally less than 180 degrees), with soft tissue hypertrophy of the finger pulp. **Schamroth window test**: when the dorsal surfaces of corresponding fingers are placed together, a diamond-shaped window is normally visible; in clubbing, this window is lost. Causes include chronic pulmonary suppuration (bronchiectasis, empyema, lung abscess), cyanotic congenital heart

disease, infective endocarditis, hepatic cirrhosis, and inflammatory bowel disease. **Lymphadenopathy** (enlarged lymph nodes) is assessed for site, size, consistency (hard: malignancy; soft: infection), tenderness, and fixity.

Fill in the blank: The _____ window test detects clubbing by placing the dorsal surfaces of corresponding fingers together; in clubbing, the normal diamond-shaped window is lost.

2.3.3 Other general physical signs

Koilonychia (spoon-shaped nails) suggests iron deficiency anaemia. **Leukonychia** (white discolouration of the nails) is associated with hypoalbuminaemia. **Palmar erythema** (reddening of the palmar eminences) suggests chronic liver disease, pregnancy, or thyrotoxicosis. **Dupuytren contracture** (palmar fibrosis causing fixed flexion of the fingers) is associated with alcohol excess, epilepsy medication, and hereditary predisposition. **Spider naevi** (vascular lesions with a central arteriole and radiating vessels, blanching on pressure) are significant when more than five are found above the umbilicus, suggesting chronic liver disease.

Xanthomata (lipid deposits in skin and tendons) indicate hyperlipidaemia. **Xanthelasma** (periorbital xanthomata) may occur with or without elevated serum lipids. **Tar staining** of the fingers indicates heavy tobacco smoking. **Gynaecomastia** (breast tissue enlargement in males) may be physiological (puberty, old age) or pathological (hepatic cirrhosis, drugs including spironolactone, digoxin, and cimetidine, or hypogonadism). **Scratch marks** on the skin suggest pruritus from cholestasis, renal failure, lymphoma, or iron deficiency. Each of these general signs, taken in context with the history and other findings, contributes to the overall clinical picture.

Fill in the blank: _____ naevi (vascular lesions with a central arteriole and radiating vessels) are significant when more than five are found above the umbilicus, suggesting underlying chronic liver disease.

Figure 2.3: Major general physical signs and their clinical significance

Physical Sign	Clinical Description	Where Best Detected	Common Causes
Pallor	Pale skin and mucous membranes due to reduced blood flow or hemoglobin.	Conjunctivae, nail beds, palmar creases.	Anemia, shock, hypotension, vasoconstriction.
Jaundice	Yellow discoloration of skin, sclerae, and mucous membranes due to elevated bilirubin.	Sclerae (best), skin, under tongue.	Liver disease (e.g., cirrhosis, hepatitis), biliary obstruction, hemolysis.
Cyanosis	Bluish discoloration of skin and mucous membranes due to deoxygenated hemoglobin.	Lips, tongue, earlobes, fingers, toes.	Hypoxemia (e.g., respiratory failure, heart failure), cold exposure.
Oedema	Swelling caused by excess fluid accumulation in body tissues.	Ankles (pedal), sacrum (if bedridden), periorbital (eyes).	Heart failure, kidney disease, liver failure, venous insufficiency, lymphatic obstruction.
Clubbing	Bulbous enlargement of the ends of fingers or toes with loss of the nail bed angle.	Fingers and toes (Disto-phalangeal joints).	Chronic lung disease (e.g., bronchiectasis, lung cancer), cyanotic heart disease, inflammatory bowel disease.
Lymphadenopathy	Enlargement of lymph nodes (>1 cm).	Cervical, axillary, inguinal, supraclavicular regions.	Infection (local/systemic), lymphoma, metastatic cancer, autoimmune diseases.
Koilonychia	Spoon-shaped, concave nails.	Fingernails.	Iron deficiency anemia (most common), malnutrition.
Palmar Erythema	Redness of the palms, particularly the thenar and hypothenar eminences.	Palms of hands.	Chronic liver disease (e.g., cirrhosis), pregnancy, thyrotoxicosis, rheumatoid arthritis.
Spider Naevi	Small, dilated blood vessels (arterioles) with a central red dot and radiating branches.	Upper trunk, face, arms.	Chronic liver disease (e.g., cirrhosis), pregnancy, high estrogen levels.

Note: This list is not exhaustive and represents common clinical signs.

Figure 2.3: Major general physical signs and their clinical significance

Pilot questions 2.3

1. Where is pallor most reliably detected and what does it indicate?
2. Classify jaundice into its three types and give one cause of each.
3. Distinguish between central and peripheral cyanosis.
4. Distinguish between pitting and non-pitting oedema and give two causes of each.
5. Describe the Schamroth window test and name three causes of clubbing.

2.4 Techniques of Clinical Examination

2.4.1 Inspection

Inspection is the deliberate, systematic visual examination of the patient, and it is the first and most important technique in every examination. It requires **adequate lighting**, **appropriate exposure** (the region to be examined must be fully visible), and **unhurried attention** before proceeding to other techniques. During inspection, the clinician observes **surface characteristics** (colour, texture, symmetry, swelling, rash, scar, skin changes), **movement** (respiratory excursion, pulsations, tremor, involuntary movements), and **shape and contour** (normal or abnormal contours, asymmetry, visible masses).

Inspection is often undervalued because it is the least technological of the four techniques, but experienced clinicians derive the majority of their diagnostic information from careful inspection before touching the patient. **Facial inspection** alone may reveal anaemia (conjunctival pallor), jaundice (scleral icterus), Cushingoid features, thyroid disease (exophthalmos, lid lag), or signs of specific syndromes (Down syndrome, acromegaly, Parkinson disease). **Inspection of the hands** yields signs of anaemia (koilonychia, pallor), liver disease (leuconychia, palmar erythema, Dupuytren), pulmonary disease (clubbing, cyanosis), and cardiovascular disease (splinter haemorrhages in infective endocarditis).

Fill in the blank: Inspection requires adequate _____ , appropriate exposure of the region to be examined, and unhurried attention before proceeding to palpation, percussion, or auscultation.

2.4.2 Palpation and percussion

Palpation uses the hands to assess **texture**, **temperature**, **tenderness**, **consistency**, **size**, and **movement** of structures. **Light palpation** uses the fingertips with gentle pressure (approximately 1 cm depth) to detect superficial tenderness, muscle guarding, and skin temperature, and must always precede deep palpation. **Deep palpation** (4 to 5 cm depth) is used to assess abdominal organs (liver, spleen, kidneys, and abnormal masses). Always palpate away from the area of greatest reported tenderness to avoid causing early guarding that prevents complete examination.

Percussion involves tapping a finger (the **plexor**) against a finger placed flat on the surface (the **pleximeter**) to generate sounds that reflect the density of the underlying tissue. **Resonant** sounds indicate air-containing structures (normal lung). **Hyperresonant** sounds indicate increased air (pneumothorax, emphysema). **Dull** sounds indicate solid or fluid-filled tissue (liver, consolidated lung, pleural effusion). **Stony dull** sounds indicate fluid above the level expected for dullness, as in massive pleural effusion. Percussion is used to define organ borders (liver, spleen, cardiac), detect pleural effusion and pneumothorax, and assess abdominal ascites.

Fill in the blank: In percussion, _____ sounds indicate air-containing structures (normal lung), while dull sounds indicate solid or fluid-filled tissue such as consolidated lung or pleural effusion.

2.4.3 Auscultation

Auscultation uses the stethoscope to listen to body sounds. The **diaphragm** of the stethoscope (the flat side) transmits **high-frequency sounds** (normal breath sounds, normal heart sounds S1 and S2, bowel sounds) and should be applied with firm pressure. The **bell** (the concave cup side) transmits **low-frequency sounds** (third and fourth heart sounds S3 and S4, mitral stenosis murmur) and should be applied with light pressure only (heavy pressure converts it to a diaphragm). **Warming the stethoscope** before application is a simple act of patient comfort.

In **cardiac auscultation**, the four standard areas are **aortic** (right second intercostal space, right sternal border), **pulmonary** (left second intercostal space, left sternal border), **tricuspid** (left lower sternal border), and **mitral** (apex, fifth intercostal space, mid-clavicular line). In **respiratory auscultation**, breath sounds are assessed for quality (vesicular versus bronchial), adventitious sounds (crackles/crepitations from fluid or fibrosis; wheeze from bronchospasm or obstruction; pleural rub from pleuritis), and areas of absent breath sounds (consolidation, pleural effusion, pneumothorax). **Bowel sounds** in abdominal auscultation are assessed for presence, pitch, and frequency.

Fill in the blank: The _____ of the stethoscope transmits high-frequency sounds with firm pressure, while the bell transmits low-frequency sounds and must be applied with light pressure to remain effective.

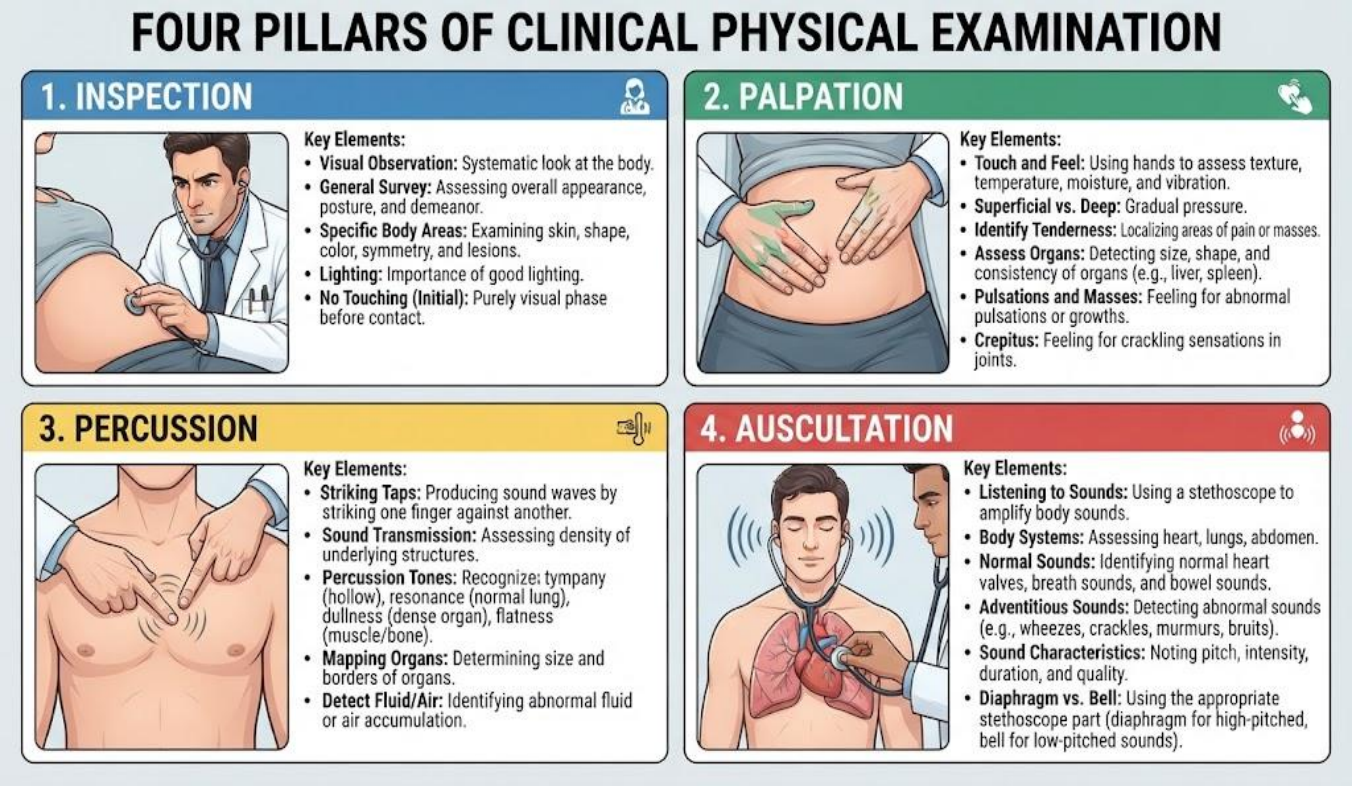


Figure 2.4: The four examination techniques

Pilot questions 2.4

1. What does inspection assess and why is it considered the most important examination technique?
2. Distinguish between light and deep palpation in terms of technique and purpose.
3. Name the four percussion notes and the clinical condition producing each.
4. Distinguish between the diaphragm and bell of the stethoscope in terms of frequency and correct application.
5. Name the four cardiac auscultation areas and their anatomical locations.

Series Summary

This Series established the principles and techniques of basic clinical examination. The four organising principles of examination (systematisation, technique, contextualisation, and documentation) and the standard examination sequence were described, alongside the preparation requirements for patient, environment, and equipment. The general survey was characterised as the overall clinical impression covering appearance, body habitus, nutritional status, hydration, and immediately visible abnormalities. Vital signs were examined in detail: temperature (normal range, patterns, and abnormalities), pulse (rate, rhythm, character, symmetry), blood pressure (technique, cuff sizing, Korotkoff sounds), respiratory rate (significance as early deterioration marker), and oxygen saturation (normal values and causes of unreliable readings).

The major general physical signs were described systematically: pallor (conjunctival, palmar, nail bed detection; anaemia aetiology), jaundice (pre-hepatic, hepatic, post-hepatic classification; scleral detection), cyanosis (central versus peripheral), oedema (pitting versus non-pitting), clubbing (Schamroth window test; pulmonary, cardiac, and hepatic causes), lymphadenopathy, and a range of additional signs including koilonychia, spider naevi, palmar erythema, and gynaecomastia. The four examination techniques were examined: inspection (deliberate visual assessment, critical importance), palpation (light then deep), percussion (four notes and their significance), and auscultation (diaphragm versus bell, cardiac areas, respiratory and bowel sounds) (SLOs 2.1 to 2.5).

Glossary of Terms

- **Auscultation:** the use of a stethoscope to listen to body sounds, using the diaphragm for high-frequency and the bell for low-frequency sounds.
- **Bradycardia:** a pulse rate below 60 beats per minute.
- **Cyanosis:** blue-grey discolouration of the skin and mucosae from deoxyhaemoglobin; central (arterial hypoxaemia) or peripheral (reduced peripheral perfusion).

- **Clubbing:** loss of the normal nail-fold angle with soft tissue hypertrophy of the finger pulp, detected by the Schamroth window test.
- **Hyperpyrexia:** core temperature above 41.5°C; a medical emergency.
- **Jaundice:** yellow discolouration of the skin, sclerae, and mucosae due to elevated bilirubin; classified as pre-hepatic, hepatic, or post-hepatic.
- **Korotkoff sounds:** the sounds heard over the brachial artery during blood pressure measurement; systolic pressure is recorded at their appearance (phase I) and diastolic at their disappearance (phase V).
- **Pallor:** reduction in the pink colour of skin and mucous membranes, most reliably detected at the conjunctival mucosae, palmar creases, and nail beds.
- **Palpation:** the use of the hands to assess texture, temperature, tenderness, consistency, size, and movement of structures.
- **Percussion:** the technique of tapping a pleximeter finger to generate sounds reflecting the density of underlying tissue (resonant, hyperresonant, dull, stony dull).
- **Pitting oedema:** oedema in which sustained finger pressure produces a persistent indent, indicating fluid accumulation from raised venous pressure or hypoalbuminaemia.
- **Tachycardia:** a pulse rate above 100 beats per minute.

Concept Check Questions [Series 2]

Objective questions

1. Clinical examination follows four organising principles: systematisation, technique, _____ , and documentation. (Linked to SLO 2.1)
2. Pyrexia is defined as temperature above 37.5°C; _____ (above 41.5°C) is a medical emergency. (Linked to SLO 2.3)
3. Blood pressure cuff bladder should encircle at least _____ % of the arm circumference. (Linked to SLO 2.3)
4. Jaundice is most reliably detected in the _____ , particularly in natural light. (Linked to SLO 2.4)
5. The _____ window test detects clubbing by observing loss of the diamond-shaped window when dorsal finger surfaces are apposed. (Linked to SLO 2.4)
6. The _____ of the stethoscope transmits high-frequency sounds with firm pressure. (Linked to SLO 2.5)

Short-answer questions

7. Describe the assessment of the pulse, naming the four characteristics that must be evaluated and giving one abnormality of each. (Linked to SLO 2.3)
8. Describe the four percussion notes, state what tissue each reflects, and give a clinical example. (Linked to SLO 2.5)

Long-answer questions

9. Discuss the major general physical signs a clinician should assess, covering pallor, jaundice, cyanosis, oedema, and clubbing, and explain the clinical significance of each. (Linked to SLO 2.4)
10. Evaluate the four techniques of clinical examination (inspection, palpation, percussion, auscultation) describing the purpose, method, and clinical yield of each. (Linked to SLO 2.5)

Answers to Concept Check Questions [Series 2]

Objective questions

1. Contextualisation.
2. Hyperpyrexia.
3. 80.
4. Sclerae.
5. Schamroth.
6. Diaphragm.

Short-answer questions

7. Rate: normal 60 to 100 bpm; tachycardia above 100 (e.g. in fever, anaemia); bradycardia below 60 (e.g. in heart block). Rhythm: regular or irregular; irregularly irregular rhythm in atrial fibrillation. Character: full/bounding (high output states, aortic regurgitation); small/thready (shock, severe aortic stenosis); collapsing/water-hammer (aortic regurgitation). Symmetry: both radial pulses compared; radiofemoral delay in coarctation of the aorta.
8. Resonant: air-containing tissue (normal lung). Hyperresonant: excess air in closed space (pneumothorax, emphysema). Dull: solid or fluid-filled tissue (normal liver dullness; consolidated lung in pneumonia; pleural effusion above the fluid level). Stony dull: large fluid collection such as massive pleural effusion or ascites.

Long-answer questions

9. **Basic response:** Pallor: reduced haemoglobin or cutaneous blood flow; detected at conjunctivae, palmar creases, nail beds; commonest cause in Nigeria is anaemia (iron deficiency, malaria, haemoglobinopathy). Jaundice: elevated bilirubin above 35 μmol/L; detected in sclerae in natural light; classified pre-hepatic (haemolysis: malaria, sickle cell), hepatic (hepatocyte damage: viral hepatitis, cirrhosis), post-hepatic (biliary obstruction: gallstones, pancreatic cancer). Cyanosis: central (arterial hypoxaemia, lips and tongue) vs peripheral (reduced peripheral perfusion, fingers and toes). Oedema:

pitting (heart failure, hypoalbuminaemia) vs non-pitting (lymphoedema, myxoedema). Clubbing: loss of Lovibond angle; Schamroth window test; causes include chronic pulmonary suppuration, cyanotic congenital heart disease, cirrhosis.

Value-added response: General physical signs are valuable precisely because they provide systemic information without requiring invasive investigation: a patient with pallor, jaundice, and splenomegaly presents a diagnostic triad pointing toward haemolytic anaemia that can be identified by inspection and palpation before a single investigation is ordered. In resource-limited Nigerian clinical settings, where laboratory results may be delayed or unavailable, the ability to derive maximum diagnostic information from clinical signs alone is not merely a traditional skill but a practical necessity that directly affects patient care.

10. **Basic response:** Inspection: deliberate visual examination of surface colour, texture, symmetry, movement, and contour; must precede touching; diagnostic yield from face (anaemia, jaundice, endocrine signs) and hands (liver, lung, cardiac signs). Palpation: light (superficial tenderness, temperature, guarding, 1 cm depth) then deep (organ assessment, masses, 4 to 5 cm depth); always start from area of least tenderness. Percussion: plexor on pleximeter finger; four notes (resonant: air; hyperresonant: excess air; dull: solid or fluid; stony dull: large effusion); used for organ borders, pneumothorax, pleural effusion, ascites. Auscultation: diaphragm (high-frequency sounds, firm pressure: breath sounds, S1, S2, bowel sounds); bell (low-frequency sounds, light pressure: S3, S4, mitral stenosis); four cardiac areas; respiratory sounds (vesicular, bronchial, crackles, wheeze, pleural rub).

Value-added response: The sequence of inspection before palpation before percussion before auscultation is not arbitrary but reflects the clinical logic of proceeding from observational to manipulative techniques: inspection cannot be performed after disturbing the patient by palpation, and auscultation of bowel sounds should precede abdominal palpation to avoid artificially increasing intestinal activity. Importantly, the same sequence is not universally applied: in abdominal examination, auscultation precedes palpation and percussion to preserve authentic bowel sounds, demonstrating that technique guidelines encode physiological logic rather than mere convention.

Answers to Pilot Questions [Series 2]

Part 2.1

1. Systematisation, technique, contextualisation, and documentation.
2. General survey, vital signs, general physical examination (hands, nails, face, eyes, mouth, neck, lymph nodes, peripheral signs), then systemic examination of each relevant organ system.
3. Any four of: ensure adequate privacy; provide a clean, appropriate examination couch; ensure adequate lighting; gather necessary equipment before starting; explain the examination to the patient; maintain patient dignity by appropriate draping.
4. The general survey is the overall clinical impression formed before formal examination begins, encompassing appearance (well or unwell, distressed or comfortable), body habitus, posture and gait, dress and grooming, mood and affect, and immediately visible abnormalities.
5. BMI = weight (kg) divided by height (m) squared. Below 18.5: underweight; 18.5 to 24.9: normal weight; 25 to 29.9: overweight; 30 or above: obese.

Part 2.2

1. Normal temperature is 36.5 to 37.5°C. Pyrexia: temperature above 37.5°C. Hyperpyrexia: above 41.5°C (medical emergency). Hypothermia: core temperature below 35°C.
2. Rate (normal 60 to 100 bpm), rhythm (regular or irregular), character (volume and waveform), and symmetry (comparing both radial pulses).
3. Patient seated with arm at heart level; appropriately sized cuff (bladder encircling at least 80% of arm circumference) applied around upper arm; auscultation over the brachial artery; systolic pressure recorded at appearance of Korotkoff sounds (phase I); diastolic at their disappearance (phase V).
4. Because it is often not counted at all or counted inaccurately, yet it is one of the earliest and most sensitive indicators of patient deterioration, with tachypnoea frequently preceding other signs of respiratory or systemic compromise.

5. Peripheral vasoconstriction (shock, cold), severe anaemia (insufficient signal), methaemoglobinaemia, and carboxyhaemoglobinaemia (carbon monoxide poisoning). Also acceptable: nail polish on the probe finger.

Part 2.3

1. Pallor is most reliably detected at the conjunctival mucosae, palmar creases, and nail beds. It indicates reduced haemoglobin (anaemia) or reduced cutaneous blood flow (shock, peripheral vasoconstriction).
2. Pre-hepatic (haemolytic): malaria or sickle cell crisis. Hepatic: viral hepatitis or cirrhosis. Post-hepatic (obstructive): gallstones or pancreatic carcinoma.
3. Central cyanosis affects the lips and tongue and indicates arterial hypoxaemia (reduced oxygen content of arterial blood). Peripheral cyanosis affects the fingers and toes and indicates reduced peripheral perfusion without necessarily impaired arterial oxygenation.
4. Pitting oedema: causes include heart failure and hypoalbuminaemia (nephrotic syndrome, cirrhosis, malnutrition). Non-pitting oedema: causes include lymphoedema and myxoedema (hypothyroidism).
5. Schamroth window test: dorsal surfaces of corresponding fingers are placed together; in health a diamond-shaped window is visible at the nail bases; in clubbing this window is lost. Three causes: bronchiectasis (chronic pulmonary suppuration); cyanotic congenital heart disease; hepatic cirrhosis.

Part 2.4

1. Inspection assesses surface characteristics (colour, texture, symmetry, rash, swelling, scar), movement (respiratory excursion, pulsations, tremor), and shape and contour. It is considered most important because experienced clinicians derive the majority of diagnostic information from careful inspection before touching the patient.

2. Light palpation: fingertips applied with approximately 1 cm depth; used for superficial tenderness, guarding, skin temperature, and surface abnormalities; must always precede deep palpation. Deep palpation: 4 to 5 cm depth; used to assess abdominal organs (liver, spleen, kidneys) and detect deep masses.
3. Resonant: air-containing (normal lung). Hyperresonant: excess air (pneumothorax, emphysema). Dull: solid or fluid-filled tissue (liver, consolidated lung, pleural effusion). Stony dull: large fluid collection (massive pleural effusion, ascites).
4. The diaphragm (flat side) transmits high-frequency sounds (normal breath sounds, S1, S2, bowel sounds) and is applied with firm pressure. The bell (concave cup side) transmits low-frequency sounds (S3, S4, mitral stenosis murmur) and must be applied with light pressure only, as heavy pressure converts it to a diaphragm.
5. Aortic area: right second intercostal space, right sternal border. Pulmonary area: left second intercostal space, left sternal border. Tricuspid area: left lower sternal border. Mitral area (apex): fifth intercostal space, mid-clavicular line.

References and Attributions [Series 2]

Textual references

- Talley, N. J., & O'Connor, S. (2018). Clinical examination: A systematic guide to physical diagnosis (8th ed.). Elsevier.
- Bickley, L. S., & Szilagyi, P. G. (2017). Bates' guide to physical examination and history taking (12th ed.). Wolters Kluwer.
- Douglas, G., Nicol, F., & Robertson, C. (Eds.). (2013). Macleod's clinical examination (13th ed.). Churchill Livingstone.
- National Open University of Nigeria (NOUN). (2023). Introduction to clinical medicine I course material. NOUN Press.

Figures, Plates, Tables, and Boxes

- Figure 2.1: Approach to clinical examination and general survey Attribution: AI generated using prompt "Generate a two-panel diagram showing the clinical examination sequence and the components of the general survey." Suggested OER search string: "clinical examination approach sequence general survey vital signs systemic examination body habitus BMI OER"
- Figure 2.2: Vital signs: normal values, abnormalities, and clinical significance Attribution: AI generated using prompt "Generate a table of vital signs showing normal ranges, abnormality terminology, and clinical significance for temperature, pulse, blood pressure, and respiratory rate." Suggested OER search string: "vital signs temperature pulse blood pressure respiratory rate normal range abnormalities clinical significance OER"
- Figure 2.3: Major general physical signs and their clinical significance Attribution: AI generated using prompt "Generate a table of major general physical signs with description, detection site, and common causes." Suggested OER search string: "pallor jaundice cyanosis oedema clubbing lymphadenopathy general physical signs clinical examination OER"

- Figure 2.4: The four examination techniques Attribution: AI generated using prompt "Generate a four-panel diagram showing inspection, palpation, percussion, and auscultation with key elements of each technique." Suggested OER search string: "clinical examination techniques inspection palpation percussion auscultation stethoscope resonance OER"

Series 3: Systemic Examination and Eliciting Physical Signs

- **Part 3.1: Cardiovascular Examination**
  - Sub Part 3.1.1: Inspection and palpation of the precordium
  - Sub Part 3.1.2: Cardiac auscultation: heart sounds and murmurs
  - Sub Part 3.1.3: Peripheral cardiovascular signs
- **Part 3.2: Respiratory Examination**
  - Sub Part 3.2.1: Inspection and chest wall assessment
  - Sub Part 3.2.2: Percussion and palpation of the chest
  - Sub Part 3.2.3: Auscultation of breath sounds
- **Part 3.3: Abdominal Examination**
  - Sub Part 3.3.1: Inspection and auscultation of the abdomen
  - Sub Part 3.3.2: Palpation of the abdomen and abdominal organs
  - Sub Part 3.3.3: Percussion of the abdomen and special signs
- **Part 3.4: Neurological Examination**
  - Sub Part 3.4.1: Assessment of consciousness and higher cortical functions
  - Sub Part 3.4.2: Cranial nerve examination
  - Sub Part 3.4.3: Motor, sensory, and cerebellar examination

Introduction

The systemic examination translates the general examination skills of Series 2 into focused assessment of each organ system. Where the general examination provides a broad clinical picture, systemic examination identifies the specific signs that localise pathology, characterise disease severity, and guide investigation and management. Each system has its own sequence, technique adaptations, and repertoire of signs that the student must learn and practise to develop reliable clinical competence.

The aim of this Series is to describe the examination of four major organ systems: the cardiovascular system, the respiratory system, the abdomen, and the neurological system. For each system, the correct sequence, the key physical signs, and their clinical interpretation are addressed, with emphasis on eliciting signs correctly and documenting findings in conventional clinical notation.

We shall commence with cardiovascular examination, covering the precordium and peripheral signs. Next, we will examine the respiratory system in detail. Moving on, we will address abdominal examination including organ palpation and special signs. Finally, we will close with neurological examination, from consciousness and higher function through cranial nerves to the motor, sensory, and cerebellar systems.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 3.1** conduct a systematic cardiovascular examination and interpret key findings,
- **SLO 3.2** conduct a systematic respiratory examination and interpret key findings,
- **SLO 3.3** conduct a systematic abdominal examination including organ palpation and special signs, and
- **SLO 3.4** conduct a systematic neurological examination including assessment of consciousness, cranial nerves, and the motor, sensory, and cerebellar systems.

3.1 Cardiovascular Examination

3.1.1 Inspection and palpation of the precordium

Cardiovascular examination begins with inspection of the **precordium** (the anterior chest overlying the heart). The patient lies supine at 45 degrees. Inspection may reveal **visible pulsations** (the apex beat is normally visible in thin individuals at the fifth left intercostal space, mid-clavicular line; a displaced or hyperdynamic visible pulsation suggests cardiomegaly or high output state), **chest wall deformity** (pectus excavatum, pectus carinatum, or kyphoscoliosis, all of which affect cardiac position and examination findings), and **surgical scars** (median sternotomy scar indicating previous cardiac surgery; left lateral thoracotomy for mitral valvotomy).

Palpation of the precordium assesses the **apex beat**: the most lateral and inferior point at which the cardiac impulse is palpable. Normal position is the fifth left intercostal space, mid-clavicular line. **Displacement** laterally and inferiorly suggests **left ventricular enlargement** (cardiomegaly, volume overload). A **heaving apex** (sustained, forceful impulse lifting the palm) indicates left ventricular pressure overload (hypertension, aortic stenosis). A **tapping apex** (a palpable first heart sound, like a tap) suggests mitral stenosis. **Thrills** (palpable murmurs, indicating turbulent flow) and **heaves** (right ventricular impulse at the left sternal border, indicating right ventricular hypertrophy) are also assessed by palpation.

Fill in the blank: The normal apex beat is located at the fifth left intercostal space, _____ line; lateral and inferior displacement suggests left ventricular enlargement from cardiomegaly or volume overload.

3.1.2 Cardiac auscultation: heart sounds and murmurs

The **first heart sound (S1)** is produced by closure of the mitral and tricuspid valves at the onset of systole; it is best heard at the apex and left lower sternal border. The **second heart sound (S2)** is produced by closure of the aortic and pulmonary valves at the end of systole; it is loudest at the base of the heart (aortic and pulmonary areas). **Physiological splitting of S2** (widening during inspiration, narrowing during expiration) is normal. **Fixed splitting** occurs in atrial septal

defect. **Paradoxical splitting** (wider in expiration) occurs in left bundle branch block and severe aortic stenosis.

Added heart sounds: S3 (a low-pitched sound in early diastole, best heard with the bell at the apex in the left lateral position; pathological in adults, indicating ventricular dysfunction and fluid overload, as in heart failure) and S4 (a low-pitched sound in late diastole immediately before S1; indicates stiff ventricle with impaired compliance, as in hypertension or hypertrophic cardiomyopathy). **Murmurs** are assessed for: **timing** (systolic, diastolic, or continuous), **grade** (Levine I to VI scale: I barely audible to VI audible without stethoscope), **character** (harsh, blowing, rumbling), **location and radiation**, and **response to manoeuvres** (standing, squatting, Valsalva).

Fill in the blank: The third heart sound (S3) is a low-pitched sound in early _____ , heard with the bell at the apex in the left lateral position, and is pathological in adults, indicating ventricular dysfunction and fluid overload.

3.1.3 Peripheral cardiovascular signs

Peripheral cardiovascular examination extends beyond the precordium to assess **jugular venous pressure (JVP)**: the height of the venous blood column in the internal jugular vein, measured with the patient at 45 degrees as the vertical height above the sternal angle (normally less than 3 to 4 cm). **Elevated JVP** indicates raised right atrial pressure (right heart failure, fluid overload, cardiac tamponade, superior vena cava obstruction). The **JVP waveform** provides additional information: the **a wave** represents atrial contraction; the **v wave** represents venous filling against a closed tricuspid valve. A cannon a wave (giant a wave) occurs in complete heart block and nodal rhythm.

Peripheral pulses are assessed in all accessible sites to detect peripheral vascular disease or coarctation. **Peripheral oedema** (pitting oedema of the ankles and legs) is assessed for extent (ankle, calf, thigh, sacral) as a measure of fluid overload. **Ankle-brachial pressure index (ABPI)** compares ankle to brachial systolic pressure and is reduced (below 0.9) in peripheral arterial disease. **Capillary refill time** (the time for colour to return to a fingertip after 5 seconds

of pressure, normally less than 2 seconds) assesses peripheral perfusion; prolonged refill indicates poor perfusion from shock or peripheral arterial disease.

Fill in the blank: Jugular venous pressure is measured at 45 degrees as the vertical height above the sternal angle; elevated JVP (above 3 to 4 cm) indicates raised right _____ pressure from right heart failure, fluid overload, or cardiac tamponade.

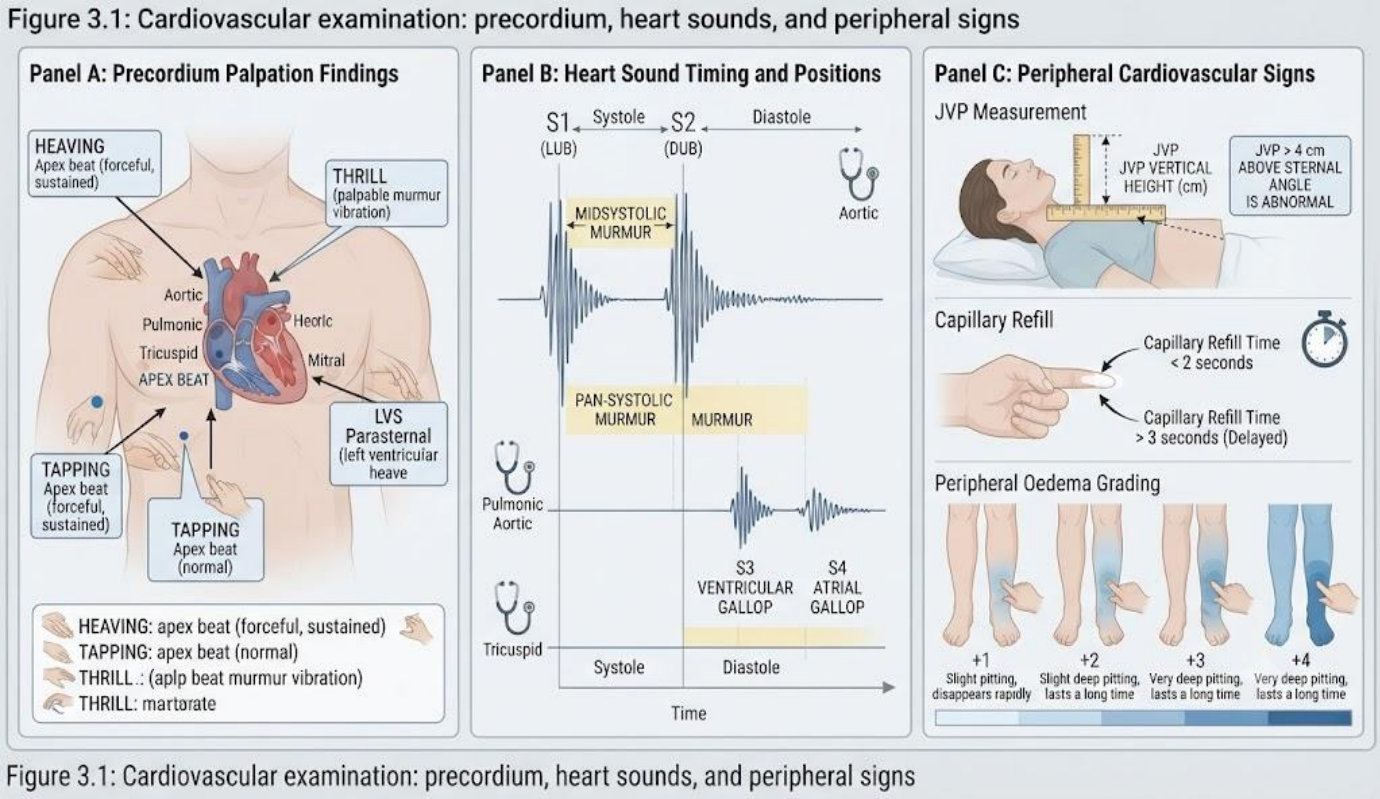


Figure 3.1: Cardiovascular examination: precordium, heart sounds, and peripheral signs

Figure 3.1: Cardiovascular examination: precordium, heart sounds, and peripheral signs

Pilot questions 3.1

1. Where is the normal apex beat located and what does lateral displacement indicate?
2. Distinguish between a heaving and a tapping apex beat.
3. Name the four characteristics of a murmur that should be described.
4. What is S3 and what does it indicate in an adult?
5. How is jugular venous pressure measured and what does elevation indicate?

3.2 Respiratory Examination

3.2.1 Inspection and chest wall assessment

Respiratory examination begins with inspection of the patient and chest wall. The clinician notes **respiratory rate and pattern**: **Cheyne-Stokes breathing** (cyclical waxing and waning of depth, with periods of apnoea; occurs in heart failure, uraemia, and raised intracranial pressure), **Kussmaul breathing** (deep, regular, rapid breathing of metabolic acidosis, especially diabetic ketoacidosis), and **Biot breathing** (irregular with variable periods of apnoea; indicates medullary damage). **Use of accessory muscles** (sternocleidomastoid, scalene) indicates increased respiratory effort. **Tracheal deviation** is assessed by palpating the trachea in the suprasternal notch: deviation toward the affected side suggests collapse or fibrosis; away suggests tension pneumothorax or large pleural effusion.

Inspection of the **chest wall shape** identifies: **barrel chest** (increased anteroposterior diameter, seen in emphysema and chronic hyperinflation), **pectus excavatum** (funnel chest, depressed sternum), **pectus carinatum** (pigeon chest, prominent sternum), **Harrison sulcus** (bilateral groove at the costal margin from chronic childhood respiratory obstruction), and **kyphoscoliosis** (which may restrict respiratory mechanics and cause respiratory failure). **Chest expansion** is assessed by placing the hands symmetrically on the lower chest with thumbs meeting at the midline: equal expansion of 3 to 5 cm in all directions is normal; reduced or asymmetric expansion indicates the pathological side.

Fill in the blank: Tracheal deviation toward the affected side suggests pulmonary collapse or _____ ; deviation away from the affected side suggests tension pneumothorax or a large pleural effusion.

3.2.2 Percussion and palpation of the chest

Tactile vocal fremitus (TVF) is assessed by placing the ulnar border of the hand on symmetric chest wall areas and asking the patient to say "ninety-nine": **increased TVF** occurs where lung tissue is consolidated (sound transmits better through solid lung than through air), as in pneumonia. **Decreased TVF** occurs where there is a barrier between the bronchus and the chest

wall, as in pleural effusion (fluid barrier) and pneumothorax (air barrier). Vocal resonance (auscultatory equivalent of TVF, asking patient to say "ninety-nine" while auscultating) is assessed alongside TVF, with **bronchophony** (increased) and **aegophony** (a nasal "ee" to "ay" change, heard just above an effusion) as notable variants.

Percussion of the chest follows the sequence of comparing symmetric sites bilaterally from apex to base (both front and back). **Dullness** to percussion occurs in consolidation, pleural effusion (stony dull), pleural thickening, atelectasis, and haemothorax. **Hyperresonance** occurs in pneumothorax and emphysema. **Stony dullness** (dullest possible percussion note) is characteristic of **pleural effusion**. The **upper level of dullness in pleural effusion** is typically flat (horizontal), while in consolidation it follows the anatomy of the lobe. **Shifting dullness** assessed by percussing with position change is used to detect abdominal ascites but not typically for pleural effusion.

Fill in the blank: Increased tactile vocal fremitus occurs where lung tissue is _____ (as in pneumonia), because sound transmits better through solid tissue than through air or fluid.

3.2.3 Auscultation of breath sounds

Normal **vesicular breath sounds** are soft, low-pitched sounds heard over most of the lung fields, with inspiration louder and longer than expiration (inspiration:expiration ratio approximately 3:1). **Bronchial breathing** is harsher, higher-pitched, with a distinct gap between inspiration and expiration and an equal or louder expiratory phase; it is normally heard over the trachea but is pathological when heard over the lung fields, indicating underlying **consolidation** (the air-filled bronchi transmit bronchial sounds to the stethoscope through consolidated, airless lung). **Absent breath sounds** indicate a barrier between the bronchus and the chest wall (pleural effusion, pneumothorax, severe emphysema, or complete collapse).

Adventitious sounds: **fine crackles** (fine, short, high-pitched inspiratory sounds, like rubbing hairs together by the ear; indicate alveolar fluid or fibrosis, as in pulmonary oedema or pulmonary fibrosis), **coarse crackles** (lower-pitched, longer, bubbling sounds; indicate secretions in larger airways, as in bronchiectasis or pneumonia), **wheeze** (musical, high-pitched, polyphonic expiratory sounds from diffuse airway narrowing as in asthma; monophonic wheeze

suggests fixed localised obstruction, as by a tumour), and **pleural rub** (a creaking, leathery sound from inflamed pleural surfaces rubbing together, heard in pleuritis, with a sound often compared to walking on fresh snow).

Fill in the blank: Bronchial breathing is pathological when heard over the lung fields and indicates underlying _____ , because solid lung transmits the bronchial sound pattern to the stethoscope.

Figure 3.2: Respiratory examination: key findings and their clinical significance

Physical Sign	Normal	Consolidation	Pleural Effusion	Pneumothorax
Tracheal Deviation	Midline	Midline	Shifted AWAY from affected side	Shifted AWAY from affected side (if large)
Chest Expansion	Symmetrical	Reduced on affected side	Reduced on affected side	Reduced on affected side
Tactile Vocal Fremitus (TVF)	Normal	Increased	Decreased or absent	Decreased or absent
Percussion Note	Resonant	Dull	Stony Dull	Hyperresonant
Breath Sounds	Vesicular	Bronchial	Decreased or absent	Decreased or absent
Adventitious Sounds	None	Late inspiratory crackles	None (may have pleural rub)	None (may have decreased breath sounds)

Note: *Findings may vary depending on the size and stage of the condition.*

Figure 3.2: Respiratory examination: key findings and their clinical significance

Pilot questions 3.2

1. What does tracheal deviation toward versus away from the affected side indicate?
2. Describe the assessment of chest expansion.
3. What is tactile vocal fremitus and when is it increased?
4. Distinguish between vesicular and bronchial breath sounds.
5. Name four types of adventitious breath sounds and give a clinical cause of each.

3.3 Abdominal Examination

3.3.1 Inspection and auscultation of the abdomen

The patient lies flat with arms at their sides. **Inspection** of the abdomen assesses: **shape** (flat, scaphoid, distended, or asymmetric), **surface** (skin: scars, striae, caput medusae, spider naevi, dilated veins), **movement** (respiratory movement of the abdominal wall is reduced in peritonitis; pulsatile aortic pulsation is visible in thin individuals and may suggest abdominal aortic aneurysm), and **visible peristalsis** (seen in intestinal obstruction or pyloric stenosis). **Caput medusae** (dilated para-umbilical veins radiating outward from the umbilicus) indicates portal hypertension with collateral venous drainage.

Auscultation precedes palpation in abdominal examination to avoid artificially stimulating bowel sounds. **Normal bowel sounds** are intermittent, low-pitched gurgling sounds (typically four to five per minute). **High-pitched, tinkling, or rushing bowel sounds** suggest intestinal obstruction (increased sounds above the obstruction). **Absent bowel sounds** (confirmed after listening for at least two minutes) indicate **paralytic ileus** (from peritonitis, post-operative state, or severe metabolic disturbance). A **bruit** over the renal arteries (heard in the flanks) or the aorta suggests arterial stenosis or aneurysm and should be sought routinely during auscultation.

Fill in the blank: _____ medusae (dilated para-umbilical veins radiating from the umbilicus) indicates portal hypertension with collateral venous drainage through the abdominal wall.

3.3.2 Palpation of the abdomen and abdominal organs

Palpation begins with **superficial palpation** of all nine abdominal regions (right hypochondrium, epigastrium, left hypochondrium, right lumbar, umbilical, left lumbar, right iliac fossa, hypogastrium, left iliac fossa) to detect tenderness, guarding, and surface abnormalities, starting from the region farthest from reported pain. **Deep palpation** then assesses each region for masses, organ enlargement, and deep tenderness. **Guarding** (involuntary muscle contraction in response to palpation) and **rigidity** (board-like muscle contraction present even before palpation, indicating peritonitis) are critical signs requiring urgent evaluation.

Liver palpation: start in the right iliac fossa and move superiorly with each expiration, as the liver descends on inspiration; the normal liver edge is soft, smooth, and not tender; hepatomegaly is measured in finger-breadths below the right costal margin. **Spleen palpation**: start in the right iliac fossa and move toward the left upper quadrant; the spleen must be at least three times normal size to be palpable and may reach the right iliac fossa in massive splenomegaly. **Kidney palpation** (bimanual technique): the posterior hand lifts the kidney from behind while the anterior hand palpates; the right kidney may be palpable normally in thin individuals.

Fill in the blank: Liver palpation begins in the right _____ fossa and moves superiorly with each expiration; hepatomegaly is measured in finger-breadths below the right costal margin.

3.3.3 Percussion of the abdomen and special signs

Percussion of the abdomen assesses the extent of liver dullness (the span of hepatic dullness is normally 6 to 12 cm in the mid-clavicular line; this span is reduced in cirrhosis and hepatic atrophy, and increased in hepatomegaly), splenic dullness (the Traube space, a tympanitic area over the left ninth to eleventh ribs in the anterior axillary line; loss of Traube space tympanism suggests splenomegaly), and the presence of **ascites**. Ascites (free fluid in the peritoneal cavity) is detected by **shifting dullness**: percussion reveals flank dullness that shifts to the uppermost flank when the patient rolls, as fluid gravitates to the dependent position.

Special abdominal signs: **Rebound tenderness** (Murphy sign of parietal peritoneal irritation: pain on rapid release of deep pressure, suggesting peritoneal inflammation) is assessed gently. **Murphy's sign** (inspiratory arrest during deep palpation in the right hypochondrium, caused by an inflamed gallbladder descending onto the palpating hand) indicates acute cholecystitis. **Rovsing sign** (pressure in the left iliac fossa producing pain in the right iliac fossa) suggests acute appendicitis. **Psoas sign** (pain on extending the right hip) and **obturator sign** (pain on internal rotation of the flexed right hip) also indicate retrocaecal appendicitis.

Fill in the blank: _____ dullness (flank dullness that shifts to the uppermost flank when the patient rolls to the side) is the clinical sign used to detect free fluid (ascites) in the peritoneal cavity.

Figure 3.3: Abdominal examination: organ palpation and special signs

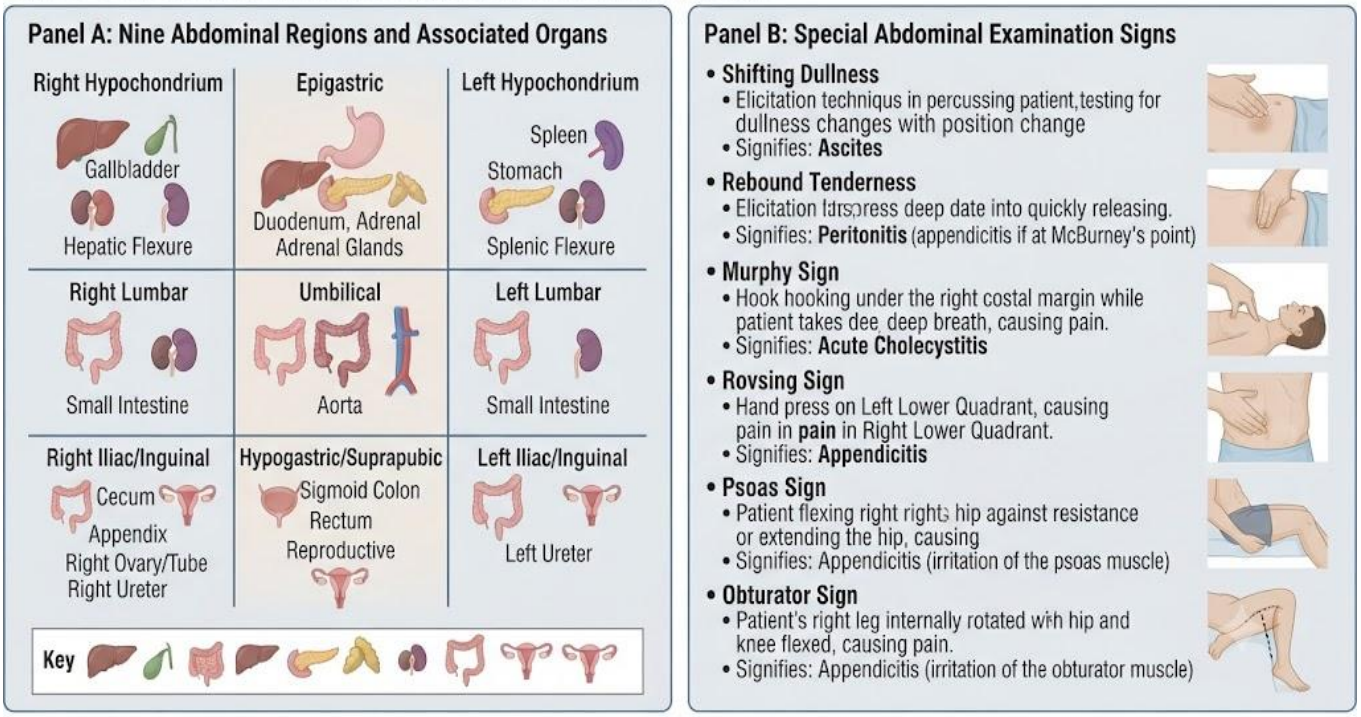


Figure 3.3: Abdominal examination: organ palpation and special signs

Figure 3.3: Abdominal examination: organ palpation and special signs

Pilot questions 3.3

1. What does caput medusae indicate and why does it occur?
2. Why does auscultation precede palpation in abdominal examination?
3. Distinguish between guarding and rigidity.
4. Describe the technique for palpating the liver.
5. What is shifting dullness and what does it detect?

3.4 Neurological Examination

3.4.1 Assessment of consciousness and higher cortical functions

Level of consciousness is assessed using the **Glasgow Coma Scale (GCS)**, which scores three domains: **eye opening** (E: 1 to 4: 4 = spontaneous; 3 = to voice; 2 = to pain; 1 = none), **verbal**

response (V: 1 to 5: 5 = oriented; 4 = confused; 3 = words; 2 = sounds; 1 = none), and **motor response** (M: 1 to 6: 6 = obeys commands; 5 = localises pain; 4 = withdraws; 3 = flexion; 2 = extension; 1 = none). Maximum score is 15 (fully conscious); 8 or below indicates coma and the need for airway protection. GCS is widely used in trauma, stroke, and ICU assessment.

Higher cortical functions include: **orientation** (person, place, time), **memory** (immediate recall: repeat three words; short-term: recall at five minutes; long-term: historical events), **language** (fluency, comprehension, repetition, naming; assessed for dysphasia in suspected stroke or dominant hemisphere lesion), **attention and concentration** (serial subtraction of 7 from 100, or spelling WORLD backwards), **praxis** (ability to perform skilled motor acts on command, impaired in apraxia), and **visuospatial function** (copying a drawing, identifying objects in space, impaired in non-dominant parietal lesions). The **Mini-Mental State Examination (MMSE)** is a standardised 30-point tool for assessing these functions in dementia and delirium.

Fill in the blank: The Glasgow Coma Scale scores eye opening, verbal response, and _____ response, with a maximum of 15 (fully conscious) and 8 or below indicating coma requiring airway protection.

3.4.2 Cranial nerve examination

The **twelve cranial nerves** are assessed systematically. **CN I (Olfactory)**: test each nostril separately with a familiar odour (coffee, peppermint); anosmia may follow head injury or be the first sign of a frontal lobe tumour. **CN II (Optic)**: visual acuity (Snellen chart), visual fields by confrontation, pupillary light reflex (direct and consensual), and fundoscopy (optic disc, retina, vessels). **CN III, IV, VI (Oculomotor, Trochlear, Abducens)**: eye movements in the H pattern, pupil size and reactivity, ptosis. **CN V (Trigeminal)**: facial sensation in three divisions (ophthalmic, maxillary, mandibular), corneal reflex, jaw movements and masseter strength.

CN VII (Facial): facial symmetry at rest and during movement (raise eyebrows, close eyes tightly, show teeth, puff cheeks); upper motor neurone lesion spares the forehead (bilateral cortical representation) while lower motor neurone lesion (Bell palsy) involves the forehead. **CN VIII (Vestibulocochlear)**: hearing (whispered voice, Rinne, and Weber tests to distinguish

sensorineural from conductive hearing loss). **CN IX and X (Glossopharyngeal and Vagus)**: gag reflex, palate elevation ("say ah"; unilateral palatal palsy deviates uvula away from the lesion). **CN XI (Accessory)**: sternocleidomastoid (turning head) and trapezius (shoulder shrug) strength. **CN XII (Hypoglossal)**: tongue protrusion (deviates toward the lesion in unilateral lower motor neurone hypoglossal palsy).

Fill in the blank: In a lower motor neurone (Bell palsy) facial nerve lesion, the _____ is involved, while in an upper motor neurone lesion the forehead is spared due to bilateral cortical representation.

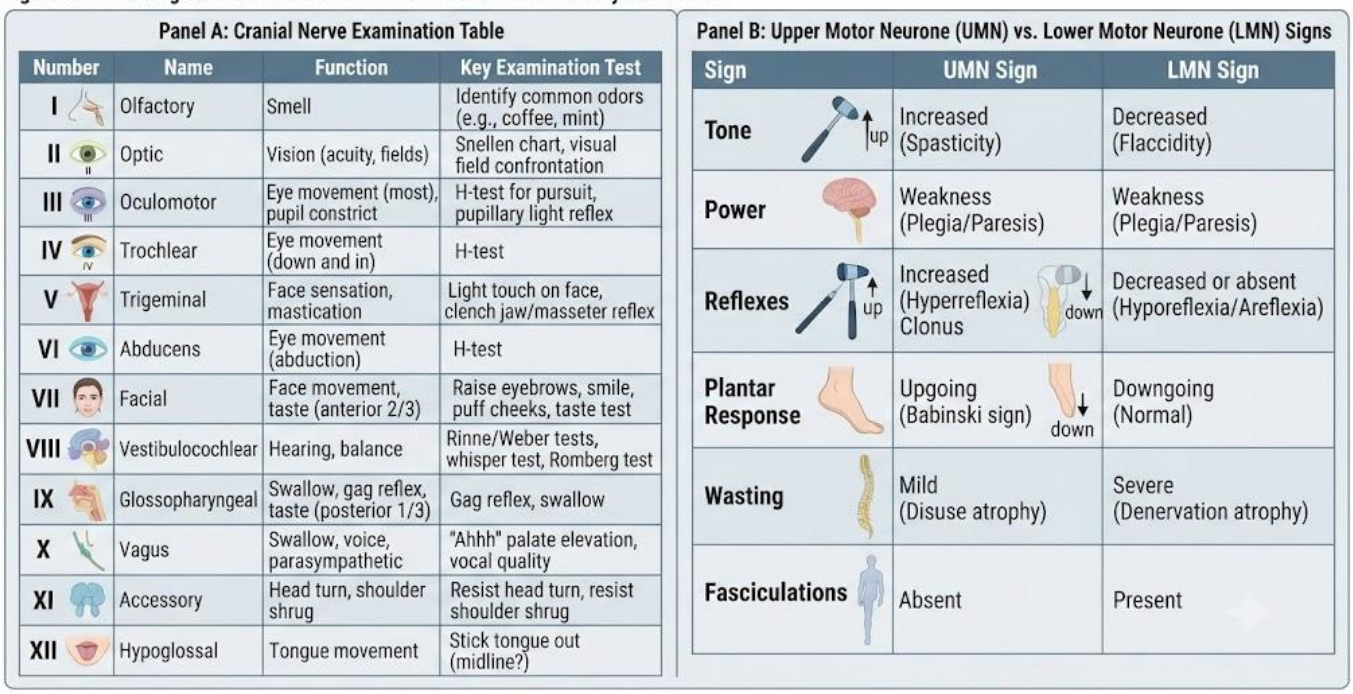
3.4.3 Motor, sensory, and cerebellar examination

Motor examination assesses: **inspection** (wasting, fasciculations, involuntary movements), **tone** (spasticity: increased, velocity-dependent resistance in upper motor neurone lesions; rigidity: increased throughout range in extrapyramidal disease; hypotonia: reduced in lower motor neurone and cerebellar lesions), **power** (Medical Research Council scale 0 to 5: 0 = no movement; 3 = movement against gravity; 5 = normal power), and **reflexes** (deep tendon reflexes graded 0 to 4+: 0 = absent; 2+ = normal; 4+ = clonus; Babinski sign: extensor plantar response indicates upper motor neurone lesion above the sacral cord).

Sensory examination tests: **light touch** (cotton wool), **pain** (pin), **temperature** (warm and cold tubes), **vibration** (128 Hz tuning fork at bony prominences), and **proprioception** (joint position sense). **Cerebellar examination** assesses: **gait** (broad-based, ataxic, inability to tandem walk), **dysmetria** (past-pointing on finger-nose and heel-shin tests), **dysdiadochokinesis** (impaired rapid alternating movements), **nystagmus** (involuntary oscillating eye movements, typically horizontal and toward the side of the lesion in peripheral vestibular disease), and **speech** (dysarthria: slurred, scanning, or staccato speech from cerebellar involvement).

Fill in the blank: The Medical Research Council (MRC) motor power scale grades power from 0 (no movement) to 5 (normal); grade _____ indicates movement against gravity but not against resistance.

Figure 3.4: Neurological examination: cranial nerves and motor-sensory assessment



Panel A: Cranial Nerve Examination Table

Number	Name	Function	Key Examination Test
I	Olfactory	Smell	Identify common odors (e.g., coffee, mint)
II	Optic	Vision (acuity, fields)	Snellen chart, visual field confrontation
III	Oculomotor	Eye movement (most), pupil constrict	H-test for pursuit, pupillary light reflex
IV	Trochlear	Eye movement (down and in)	H-test
V	Trigeminal	Face sensation, mastication	Light touch on face, clench jaw/masseter reflex
VI	Abducens	Eye movement (abduction)	H-test
VII	Facial	Face movement, taste (anterior 2/3)	Raise eyebrows, smile, puff cheeks, taste test
VIII	Vestibulocochlear	Hearing, balance	Rinne/Weber tests, whisper test, Romberg test
IX	Glossopharyngeal	Swallow, gag reflex, taste (posterior 1/3)	Gag reflex, swallow
X	Vagus	Swallow, voice, parasympathetic	"Ahhh" palate elevation, vocal quality
XI	Accessory	Head turn, shoulder shrug	Resist head turn, resist shoulder shrug
XII	Hypoglossal	Tongue movement	Stick tongue out (midline?)

Panel B: Upper Motor Neurone (UMN) vs. Lower Motor Neurone (LMN) Signs

Sign	UMN Sign	LMN Sign
Tone	Increased (Spasticity)	Decreased (Flaccidity)
Power	Weakness (Plegia/Paresis)	Weakness (Plegia/Paresis)
Reflexes	Increased (Hyperreflexia) Clonus	Decreased or absent (Hyporeflexia/Areflexia)
Plantar Response	Upgoing (Babinski sign)	Downgoing (Normal)
Wasting	Mild (Disuse atrophy)	Severe (Denervation atrophy)
Fasciculations	Absent	Present

Figure 3.4: Neurological examination: cranial nerves and motor-sensory assessment

Figure 3.4: Neurological examination: cranial nerves and motor-sensory assessment

Pilot questions 3.4

1. What are the three domains of the Glasgow Coma Scale and what is the total maximum score?
2. Name four higher cortical functions and state one test for each.
3. How does an upper motor neurone facial nerve lesion differ from a lower motor neurone lesion (Bell palsy)?
4. Name the five components of motor examination.
5. Name four signs of cerebellar disease.

Series Summary

This Series examined the systemic examination of four major organ systems. Cardiovascular examination covered precordial inspection and palpation (apex beat location, character, thrills, and heaves), cardiac auscultation (S1, S2, physiological splitting, S3, S4, and murmur characteristics on the Levine scale), and peripheral signs (JVP measurement, peripheral oedema, capillary refill). Respiratory examination covered inspection (breathing patterns, tracheal deviation, chest deformity, expansion), percussion and palpation (TVF, percussion notes, and their differential diagnosis), and auscultation (vesicular versus bronchial breath sounds, fine and coarse crackles, wheeze, and pleural rub).

Abdominal examination covered inspection (shape, surface, caput medusae, visible peristalsis), auscultation (bowel sounds, bruits), palpation (nine regions, superficial and deep, guarding, rigidity, liver, spleen, and kidney techniques), percussion (liver span, Traube space, shifting dullness for ascites), and special signs (rebound tenderness, Murphy sign, Rovsing sign, psoas sign, and obturator sign). Neurological examination covered the Glasgow Coma Scale, higher cortical functions, a systematic cranial nerve examination, motor assessment (inspection, tone, power, reflexes, plantar response), sensory testing (light touch, pain, temperature, vibration, proprioception), and cerebellar signs (ataxia, dysmetria, dysdiadochokinesis, nystagmus) (SLOs 3.1 to 3.4).

Glossary of Terms

- **Apex beat:** the most lateral and inferior point at which the cardiac impulse is palpable; normally at the fifth left intercostal space, mid-clavicular line.
- **Bronchial breathing:** harsh, high-pitched breath sounds with an equal or louder expiratory phase, normally heard over the trachea; pathological over lung fields, indicating consolidation.
- **Caput medusae:** dilated para-umbilical veins radiating from the umbilicus, indicating portal hypertension.

- **Dysdiadochokinesis:** impaired ability to perform rapid alternating movements, a sign of cerebellar disease.
- **Glasgow Coma Scale (GCS):** a 15-point scale scoring eye opening, verbal response, and motor response to assess level of consciousness.
- **Hepatomegaly:** enlargement of the liver, measured as finger-breadths below the right costal margin.
- **Murphy's sign:** inspiratory arrest during deep palpation in the right hypochondrium, indicating acute cholecystitis.
- **Shifting dullness:** flank dullness that moves to the uppermost side when the patient rolls, indicating free fluid (ascites) in the peritoneal cavity.
- **Splenomegaly:** enlargement of the spleen; the spleen must be at least three times normal size to be palpable.
- **Tactile vocal fremitus:** vibration felt on the chest wall when the patient speaks, increased in consolidation and decreased in effusion or pneumothorax.
- **Vesicular breath sounds:** normal breath sounds, soft and low-pitched, with inspiration louder and longer than expiration.

Concept Check Questions [Series 3]

Objective questions

1. The normal apex beat is at the fifth left intercostal space, _____ line; lateral displacement indicates left ventricular enlargement. (Linked to SLO 3.1)
2. S3, heard in early diastole with the bell at the apex, is pathological in adults and indicates ventricular _____ and fluid overload. (Linked to SLO 3.1)
3. Tracheal deviation _____ from the affected side suggests tension pneumothorax or large pleural effusion. (Linked to SLO 3.2)
4. Bronchial breathing heard over lung fields indicates underlying _____ because solid lung transmits bronchial sounds to the stethoscope. (Linked to SLO 3.2)
5. _____ dullness (flank dullness shifting when the patient rolls) detects free peritoneal fluid. (Linked to SLO 3.3)
6. The Glasgow Coma Scale has a maximum of 15; a score of 8 or below indicates _____ and the need for airway protection. (Linked to SLO 3.4)

Short-answer questions

7. Describe the auscultatory findings that distinguish consolidation from pleural effusion on respiratory examination. (Linked to SLO 3.2)
8. Describe the special signs used in abdominal examination and the clinical condition each suggests. (Linked to SLO 3.3)

Long-answer questions

9. Discuss the cardiovascular examination, covering precordial inspection, palpation, cardiac auscultation, and peripheral cardiovascular signs. (Linked to SLO 3.1)
10. Describe the neurological examination, covering assessment of consciousness, higher cortical function, cranial nerves, and the motor, sensory, and cerebellar systems. (Linked to SLO 3.4)

Answers to Concept Check Questions [Series 3]

Objective questions

1. Mid-clavicular.
2. Dysfunction.
3. Away.
4. Consolidation.
5. Shifting.
6. Coma.

Short-answer questions

7. Consolidation: bronchial breathing (harsh, equal inspiration and expiration); increased TVF and vocal resonance; dull percussion note; fine crackles may be present. Pleural effusion: absent breath sounds; decreased TVF and vocal resonance; stony dull percussion note; bronchial breathing and aegophony just above the upper level of the effusion.
8. Rebound tenderness: pain on rapid release of deep pressure, indicating peritoneal inflammation. Murphy sign: inspiratory arrest on deep palpation in right hypochondrium, indicating acute cholecystitis. Rovsing sign: left iliac fossa pressure producing right iliac fossa pain, suggesting appendicitis. Psoas sign: pain on right hip extension, indicating retrocaecal appendicitis. Obturator sign: pain on internal rotation of flexed right hip, also indicating appendicitis. Shifting dullness: flank dullness moving with position change, detecting ascites.

Long-answer questions

9. **Basic response:** Inspection: visible pulsations, chest deformity, surgical scars. Palpation: apex beat location (normal: fifth LICS MCL); character (heaving = LV pressure overload; tapping = mitral stenosis); thrills (palpable murmurs); parasternal heave (RV hypertrophy). Auscultation: S1 (mitral and tricuspid closure); S2 (aortic and pulmonary closure; physiological splitting, fixed splitting in ASD, paradoxical in LBBB); S3

(ventricular dysfunction, early diastole, bell); S4 (stiff ventricle, late diastole, pre-S1); murmurs assessed for timing, grade (Levine I-VI), character, location, radiation, response to manoeuvres. Peripheral: JVP (normal below 3-4 cm above sternal angle; elevated in right heart failure, tamponade); peripheral oedema; capillary refill.

Value-added response: Cardiac murmur assessment illustrates the principle that clinical sign interpretation requires integration of multiple characteristics, not any single feature: a systolic murmur at the apex that is grade III, blowing, radiating to the axilla, and louder in the left lateral position is almost certainly mitral regurgitation, while a systolic murmur at the right second intercostal space that is harsh, grade IV, and radiates to the carotids is almost certainly aortic stenosis. Systematic characterisation of all murmur features is therefore not merely academic but determines whether the clinician can generate a specific differential diagnosis and appropriate investigation plan from auscultation alone.

10. **Basic response:** Consciousness: GCS (E1-4, V1-5, M1-6; total 15; coma if 8 or below). Higher cortical: orientation (person, place, time); memory (immediate, short-term, long-term); language (fluency, comprehension, repetition, naming; dysphasia in dominant hemisphere lesion); attention (serial 7s); praxis; visuospatial; MMSE 30-point screen. Cranial nerves: CN I (smell); CN II (acuity, fields, pupil, fundoscopy); CN III/IV/VI (eye movements, ptosis); CN V (facial sensation, corneal reflex, jaw); CN VII (forehead spared in UMN, involved in LMN); CN VIII (Rinne, Weber); CN IX/X (palate, uvula deviation away from lesion); CN XI (SCM, trapezius); CN XII (tongue deviates toward lesion). Motor: wasting, fasciculations, tone (spastic/rigid/hypotonic), power (MRC 0-5), reflexes (0-4+), Babinski. Sensory: light touch, pain, temperature, vibration, proprioception. Cerebellar: ataxic gait, dysmetria (finger-nose), dysdiadochokinesis, nystagmus, dysarthria.

Value-added response: The neurological examination produces the most precise anatomical localisation of any clinical examination: a combination of right-sided hemiparesis with a right upper motor neurone facial palsy (forehead spared), right-sided sensory loss, and expressive aphasia (dominant hemisphere), with no cerebellar signs, localises pathology to the left internal capsule or left middle cerebral artery territory before any imaging is

obtained. This localising precision makes the neurological examination disproportionately important in stroke, head injury, and spinal cord disease, where the examination guides both the imaging requested and the emergency management decisions made while awaiting results.

Answers to Pilot Questions [Series 3]

Part 3.1

1. Normal apex beat: fifth left intercostal space, mid-clavicular line. Lateral displacement indicates left ventricular enlargement from cardiomegaly or volume overload (e.g. mitral regurgitation, aortic regurgitation).
2. Heaving apex: sustained, forceful impulse lifting the palm, indicating left ventricular pressure overload (hypertension, aortic stenosis). Tapping apex: a palpable first heart sound, like a tap, felt rather than heard, characteristic of mitral stenosis.
3. Any four of: timing (systolic, diastolic, or continuous); grade (Levine I to VI); character (harsh, blowing, rumbling); location and radiation; response to manoeuvres (standing, squatting, Valsalva).
4. S3 is a low-pitched added sound heard in early diastole, best detected with the bell of the stethoscope at the apex with the patient in the left lateral position. In adults it is pathological, indicating left ventricular dysfunction and fluid overload as seen in congestive heart failure.
5. JVP is measured with the patient at 45 degrees as the vertical height of the visible venous column in the internal jugular above the sternal angle (normal below 3 to 4 cm). Elevation indicates raised right atrial pressure from right heart failure, fluid overload, cardiac tamponade, or superior vena cava obstruction.

Part 3.2

1. Tracheal deviation toward the affected side: pulmonary collapse or pulmonary fibrosis (the affected side shrinks, pulling the trachea toward it). Tracheal deviation away from the affected side: tension pneumothorax (requires urgent needle decompression) or large pleural effusion (fluid pushes trachea away).
2. Both hands are placed symmetrically on the lower chest with thumbs meeting at the midline; the patient is asked to take a deep breath; equal expansion of 3 to 5 cm in all directions is normal; reduced or asymmetric expansion indicates pathology on the side with reduced movement.
3. TVF is the vibration felt by placing the hand on the chest while the patient says "ninety-nine"; it is increased in consolidation because solid lung tissue transmits sound better than air-filled or fluid-containing structures.
4. Vesicular: soft, low-pitched sounds over normal lung; inspiration louder and longer than expiration (3:1 ratio). Bronchial: harsher, higher-pitched, with a distinct gap and equal or louder expiration; pathological over lung fields, indicating consolidation.
5. Fine crackles: alveolar fluid or fibrosis (pulmonary oedema, pulmonary fibrosis). Coarse crackles: secretions in large airways (bronchiectasis, pneumonia). Wheeze: airway narrowing, diffuse polyphonic (asthma) or monophonic fixed (tumour). Pleural rub: inflamed pleural surfaces (pleuritis).

Part 3.3

1. Caput medusae indicates portal hypertension; it occurs because raised portal pressure opens collateral venous channels through para-umbilical veins, causing visible dilated veins radiating outward from the umbilicus.
2. Because palpation may artificially stimulate bowel sounds, and authentic bowel sound assessment is important for detecting intestinal obstruction (high-pitched sounds) or paralytic ileus (absent sounds); auscultating before palpation preserves the validity of bowel sound findings.
3. Guarding: involuntary muscle contraction in response to palpation, a protective reflex indicating underlying peritoneal irritation. Rigidity: board-like muscle contraction present

even without palpation, indicating established peritonitis; guarding is dynamic and reactive while rigidity is constant.

4. Start in the right iliac fossa; move superiorly toward the right costal margin one finger-breadth at a time, timed to coincide with expiration (when the liver descends on inspiration and moves toward the palpating hand); continue until the liver edge is felt or the costal margin is reached; measure enlargement in finger-breadths below the right costal margin.
5. Shifting dullness is flank dullness detected on percussion that moves to the uppermost side when the patient rolls to that side, as free peritoneal fluid (ascites) gravitates to the dependent position. It detects ascites in the peritoneal cavity.

Part 3.4

1. Eye opening (E: 1 to 4), verbal response (V: 1 to 5), and motor response (M: 1 to 6). Maximum total score: 15.
2. Orientation: ask person, place, time. Memory: immediate recall (repeat three words), short-term recall (recall at five minutes). Language: ask patient to name objects, repeat a phrase, follow commands. Attention: serial 7 subtraction from 100.
3. Upper motor neurone (cortical) facial palsy: forehead muscles are spared because of bilateral cortical representation; only lower face is affected. Lower motor neurone lesion (Bell palsy or CN VII nucleus/nerve damage): entire face is affected on the side of the lesion including the forehead (wrinkle forehead command fails).
4. Inspection (wasting, fasciculations, involuntary movements), tone (spasticity, rigidity, hypotonia), power (MRC scale 0 to 5), reflexes (deep tendon reflexes graded 0 to 4+), and plantar response (Babinski sign).
5. Any four of: ataxic broad-based gait; dysmetria (past-pointing on finger-nose or heel-shin test); dysdiadochokinesis (impaired rapid alternating movements); nystagmus; dysarthria (slurred, scanning, or staccato speech).

References and Attributions [Series 3]

Textual references

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- National Open University of Nigeria (NOUN). (2023). Introduction to clinical medicine I course material. NOUN Press.

Figures, Plates, Tables, and Boxes

- Figure 3.1: Cardiovascular examination: precordium, heart sounds, and peripheral signs Attribution: AI generated using prompt "Generate a three-panel diagram of cardiovascular examination showing precordium palpation findings, heart sound timing, and peripheral cardiovascular signs." Suggested OER search string: "cardiovascular examination apex beat heart sounds murmurs JVP peripheral signs clinical OER"
- Figure 3.2: Respiratory examination: key findings and their clinical significance Attribution: AI generated using prompt "Generate a table comparing respiratory examination findings in normal, consolidation, pleural effusion, and pneumothorax." Suggested OER search string: "respiratory examination consolidation pleural effusion pneumothorax breath sounds percussion TVF comparison table OER"
- Figure 3.3: Abdominal examination: organ palpation and special signs Attribution: AI generated using prompt "Generate a two-panel diagram showing the nine abdominal regions with organs and special abdominal examination signs with their clinical significance." Suggested OER search string: "abdominal examination nine regions organ palpation special signs Murphy Rovsing shifting dullness OER"
- Figure 3.4: Neurological examination: cranial nerves and motor-sensory assessment Attribution: AI generated using prompt "Generate a two-panel diagram showing cranial

nerve examination table and UMN versus LMN sign comparison." Suggested OER search string: "cranial nerve examination table neurological signs UMN LMN upper lower motor neurone comparison OER"

Series 4: Immunological and Genetic Basis of Diseases

- **Part 4.1: The Immune System and Immunological Disease**
  - Sub Part 4.1.1: Overview of the immune system
  - Sub Part 4.1.2: Hypersensitivity reactions
  - Sub Part 4.1.3: Autoimmune diseases
- **Part 4.2: Immunodeficiency and Infection**
  - Sub Part 4.2.1: Primary immunodeficiencies
  - Sub Part 4.2.2: Secondary immunodeficiency: HIV/AIDS
  - Sub Part 4.2.3: Clinical approach to the immunocompromised patient
- **Part 4.3: Genetic Basis of Disease**
  - Sub Part 4.3.1: Principles of genetics relevant to clinical medicine
  - Sub Part 4.3.2: Patterns of inheritance
  - Sub Part 4.3.3: Common genetic diseases in clinical practice
- **Part 4.4: Clinical Application of Immunology and Genetics**
  - Sub Part 4.4.1: Genetic counselling and risk assessment
  - Sub Part 4.4.2: Diagnostic investigation in immunological and genetic disease
  - Sub Part 4.4.3: Principles of management and prevention

Introduction

Disease is not merely the failure of an organ or the invasion of a pathogen. Two of the most fundamental mechanisms underlying a wide range of clinical conditions are immunological dysfunction (the immune system attacking self, failing to defend against infection, or mounting inappropriately intense responses) and genetic abnormality (heritable or acquired alterations in DNA that predispose to or cause disease). Understanding these mechanisms transforms the clinician from someone who recognises patterns of illness to someone who understands why those patterns occur.

The aim of this Series is to examine the immune system and the clinical consequences of its dysfunction through hypersensitivity reactions, autoimmune diseases, and immunodeficiency; to describe the genetic basis of disease including patterns of inheritance and common genetic diseases; and to address the clinical application of immunological and genetic knowledge through counselling, investigation, and management.

We shall commence with an overview of the immune system and immunological disease. Next, we will examine immunodeficiency, with emphasis on HIV/AIDS. Moving on, we will address the genetic basis of disease and patterns of inheritance. Finally, we will close with the clinical application of immunology and genetics in investigation, counselling, and management.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 4.1** describe the major components and functions of the immune system,
- **SLO 4.2** classify hypersensitivity reactions and describe autoimmune diseases,
- **SLO 4.3** describe primary and secondary immunodeficiency with emphasis on HIV/AIDS,
- **SLO 4.4** explain the genetic basis of disease including chromosomal, single gene, and multifactorial disorders, and

- **SLO 4.5** apply immunological and genetic knowledge to clinical counselling, investigation, and management.

4.1 The Immune System and Immunological Disease

4.1.1 Overview of the immune system

The immune system protects the host against infection and malignancy through two interconnected arms. The **innate immune system** provides immediate, non-specific defence: physical barriers (skin, mucosae), cellular components (neutrophils, macrophages, natural killer cells, dendritic cells), soluble mediators (complement, acute phase proteins, interferons), and the inflammatory response. It acts within minutes to hours but has no immunological memory. The **adaptive immune system** provides specific, delayed, but long-lasting defence: **B lymphocytes** produce antigen-specific antibodies (humoral immunity) and **T lymphocytes** mediate cellular immunity and regulate the overall response.

Key **T lymphocyte subsets** include **CD4+ T helper cells** (which orchestrate immune responses by activating B cells and cytotoxic T cells; depleted by HIV), **CD8+ cytotoxic T cells** (which kill virus-infected and malignant cells), and **regulatory T cells** (which suppress immune responses to prevent autoimmunity). The **major histocompatibility complex (MHC)**, known in humans as **HLA (Human Leucocyte Antigen)**, presents peptide antigens to T cells; **MHC class I** presents intracellular antigens to CD8+ cells and **MHC class II** presents extracellular antigens to CD4+ cells. HLA typing is important in organ transplantation, disease associations (HLA-B27 in ankylosing spondylitis), and pharmacogenomics.

Fill in the blank: CD4+ T _____ cells orchestrate immune responses by activating B cells and cytotoxic T cells; they are the principal target of HIV, and their progressive depletion causes AIDS.

4.1.2 Hypersensitivity reactions

Hypersensitivity reactions are immunological responses that cause tissue damage. The **Gell and Coombs classification** describes four types. **Type I (immediate/IgE-mediated)**: antigen cross-links IgE bound to mast cells, triggering degranulation and release of histamine, leukotrienes, and prostaglandins within minutes; clinical manifestations include anaphylaxis, urticaria, allergic rhinitis, atopic asthma, and food allergy. **Type II (cytotoxic/antibody-mediated)**: IgG or IgM antibodies bind cell surface antigens, causing complement activation and cell destruction; examples include haemolytic transfusion reactions, autoimmune haemolytic anaemia, and Goodpasture syndrome.

Type III (immune complex-mediated): antigen-antibody complexes deposit in tissues (especially vessel walls, glomeruli, and synovium), activating complement and causing inflammation; examples include serum sickness, post-streptococcal glomerulonephritis, systemic lupus erythematosus (SLE), and rheumatoid arthritis. **Type IV (delayed/cell-mediated/T cell-mediated)**: sensitised T cells release cytokines causing inflammation 24 to 72 hours after antigen exposure; no antibody is involved; examples include contact dermatitis, tuberculin skin test reaction, graft rejection, and granulomatous inflammation (tuberculosis, sarcoidosis). **Anaphylaxis** (type I, systemic) is the most immediately life-threatening hypersensitivity reaction: treated with intramuscular adrenaline, antihistamine, corticosteroid, oxygen, and IV fluids.

Fill in the blank: Type _____ hypersensitivity (delayed, cell-mediated) involves sensitised T cells releasing cytokines 24 to 72 hours after antigen exposure and does not involve antibodies; examples include contact dermatitis and tuberculin skin test reaction.

4.1.3 Autoimmune diseases

Autoimmune diseases arise when the immune system fails to maintain **self-tolerance** and mounts responses against the body own tissues. They are classified as **organ-specific** (where the response targets a single organ or tissue: Hashimoto thyroiditis, Graves disease, type 1 diabetes mellitus, myasthenia gravis, pernicious anaemia) or **systemic** (where multiple organs are affected: systemic lupus erythematosus (SLE), rheumatoid arthritis, Sjogren syndrome, systemic sclerosis, inflammatory myositis). The mechanisms include molecular mimicry (pathogen

antigens resembling self antigens triggering cross-reactive immunity), breakdown of regulatory T cell suppression, and polyclonal B cell activation.

Systemic lupus erythematosus (SLE) is the paradigmatic systemic autoimmune disease, predominantly affecting women of reproductive age (female-to-male ratio 9:1). Clinical manifestations include: **malar (butterfly) rash** (erythema across the cheeks and nose bridge, sparing the nasolabial folds), **photosensitivity**, discoid rash, oral ulcers, arthritis, serositis (pleuritis, pericarditis), **nephritis** (lupus nephritis is a major cause of renal failure), haematological abnormalities (haemolytic anaemia, thrombocytopaenia, lymphopaenia), and neurological involvement. The diagnostic hallmark is **anti-double-stranded DNA antibody (anti-dsDNA)** and **antinuclear antibody (ANA)** positivity.

Fill in the blank: Systemic lupus erythematosus predominantly affects women of reproductive age and has a female-to-male ratio of _____ :1; its diagnostic hallmark includes anti-double-stranded DNA antibody and antinuclear antibody positivity.

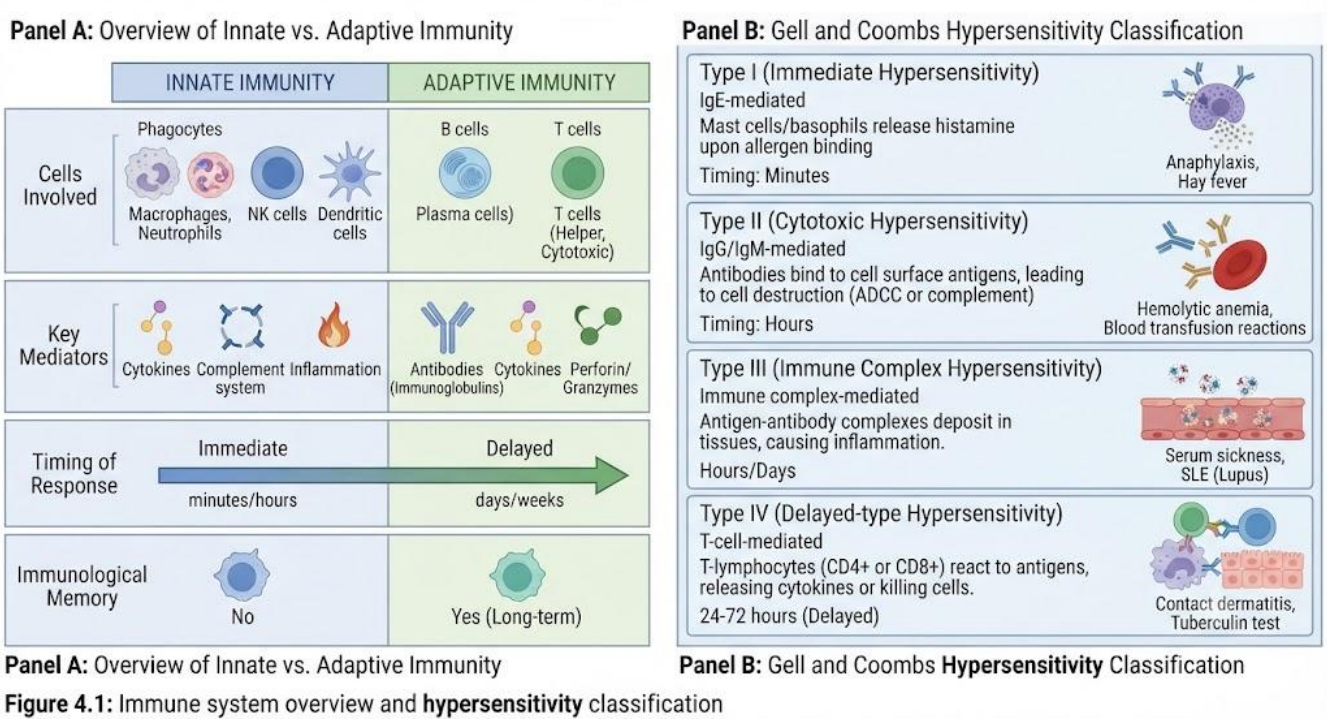


Figure 4.1: Immune system overview and hypersensitivity classification

Pilot questions 4.1

1. Name the two arms of the immune system and describe the key difference between them.
2. What is the role of CD4+ T helper cells and why is their depletion by HIV so devastating?
3. Name the four Gell and Coombs hypersensitivity types and give one example of each.
4. Distinguish between organ-specific and systemic autoimmune diseases with two examples of each.
5. Name four clinical features of systemic lupus erythematosus.

4.2 Immunodeficiency and Infection

4.2.1 Primary immunodeficiencies

Primary immunodeficiencies (PIDs) are inherited disorders of immune system development or function, typically presenting in infancy or early childhood with recurrent, severe, or unusual infections. They are classified by the immune component affected. **B cell deficiencies** (antibody deficiencies) present with recurrent bacterial infections, particularly with encapsulated organisms (Streptococcus pneumoniae, Haemophilus influenzae); the most common is **X-linked agammaglobulinaemia (XLA)**, affecting males, with virtual absence of circulating B cells and immunoglobulins, treated with regular intravenous immunoglobulin (IVIG) replacement.

T cell deficiencies predispose to viral, fungal, and intracellular bacterial infections; **DiGeorge syndrome** (22q11 deletion causing thymic aplasia) is a classic example presenting with hypocalcaemia, conotruncal heart defects, and immune deficiency. **Combined immunodeficiencies** affecting both T and B cells, including **severe combined immunodeficiency (SCID)**, present with life-threatening infections from birth and require haematopoietic stem cell transplantation. **Phagocyte deficiencies** (chronic granulomatous disease, in which phagocytes cannot kill certain bacteria and fungi despite engulfing them) and **complement deficiencies** (predisposing to encapsulated bacterial infections and SLE-like syndrome) complete the major categories.

Fill in the blank: X-linked agammaglobulinaemia (XLA) is a primary B cell immunodeficiency causing virtual absence of circulating B cells and immunoglobulins, treated with regular intravenous _____ replacement.

4.2.2 Secondary immunodeficiency: HIV/AIDS

HIV (Human Immunodeficiency Virus) is a retrovirus that selectively infects and destroys **CD4+ T helper cells**, progressively dismantling the adaptive immune response. Transmission occurs through unprotected sexual intercourse (predominant route), contaminated blood and blood products, and mother-to-child transmission during pregnancy, labour, or breastfeeding. After initial infection, a period of **clinical latency** lasting years may occur, during which HIV replicates but the patient remains relatively well. **AIDS (Acquired Immunodeficiency Syndrome)** is defined by a CD4 count below 200 cells/μL or the occurrence of an AIDS-defining illness, regardless of CD4 count.

Common **AIDS-defining illnesses** include: **Pneumocystis jirovecii pneumonia (PCP)** (non-productive cough, progressive dyspnoea, bilateral interstitial infiltrates on chest X-ray; treated with high-dose co-trimoxazole), **cerebral toxoplasmosis** (ring-enhancing lesions on CT; headache, focal neurological signs, fever), **cryptococcal meningitis** (subacute meningitis with elevated opening pressure; diagnosed by India ink stain and cryptococcal antigen test), **cytomegalovirus (CMV) retinitis**, **oesophageal candidiasis**, **Kaposi sarcoma** (violaceous skin and mucosal lesions caused by HHV-8), and disseminated **Mycobacterium avium complex (MAC)** infection. **Antiretroviral therapy (ART)** is the cornerstone of HIV management, suppressing viral replication, restoring CD4 counts, and dramatically reducing morbidity and mortality.

Fill in the blank: AIDS is defined by a CD4 count below _____ cells/μL or the occurrence of an AIDS-defining illness such as Pneumocystis jirovecii pneumonia or cryptococcal meningitis.

4.2.3 Clinical approach to the immunocompromised patient

Immunocompromised patients (from HIV, chemotherapy, transplant immunosuppression, or primary immunodeficiency) require a modified clinical approach. The clinician must maintain a **broad differential diagnosis** because infections in immunocompromised hosts may be caused by organisms that rarely cause disease in immunocompetent individuals (**opportunistic infections**), including Pneumocystis, Cryptococcus, CMV, Toxoplasma, atypical mycobacteria, and certain fungi. **The degree of immunosuppression** (particularly the CD4 count in HIV) determines which opportunistic infections are most likely at any given time, guiding empirical treatment.

Fever in the immunocompromised patient is a medical emergency and must be evaluated rapidly and comprehensively. A **septic screen** (blood cultures, urine culture, chest X-ray, full blood count, inflammatory markers) should be performed immediately. **Empirical broad-spectrum antibiotics** are started without waiting for culture results in febrile neutropaenia (absolute neutrophil count below 0.5×10^9/L). The pattern of clinical findings, the degree and type of immunosuppression, exposure history, and travel history guide the targeted investigation and treatment approach. **Infection prevention** through prophylactic antimicrobials (co-trimoxazole prophylaxis against PCP; fluconazole against cryptococcal disease; isoniazid preventive therapy against tuberculosis) is an integral part of management.

Fill in the blank: Fever in a neutropaenic patient (absolute neutrophil count below 0.5×10^9/L) is a medical emergency requiring immediate blood cultures and empirical broad-spectrum _____ without waiting for culture results.

Figure 4.2: Immunodeficiency: primary causes and HIV/AIDS

Panel A: Primary Immunodeficiency Classification

Component Affected	Primary Immunodeficiency	Example	Clinical Presentation
B cell	B-cell (Humoral) Immunodeficiency	X-linked agammaglobulin-emia (XLA)	Recurrent bacterial infections (e.g., otitis media, pneumonia)
T cell	T-cell Immunodeficiency	DiGeorge Syndrome	Recurrent viral, fungal, and opportunistic infections; thymic hypoplasia
Combined	Combined B- B- and T-cell Immunodeficiency	Severe Combined Immunodeficiency (SCID)	Severe, life-threatening infections in infancy; failure to thrive
Phagocyte	Phagocyte Immunodeficiency	Chronic Granulomatous Disease (CGD)	Recurrent catalase-positive bacterial and fungal infections (e.g., *S. aureus, Aspergillus*)
Complement	Complement Immunodeficiency	C3 deficiency	Recurrent pyogenic infections, autoimmune-like conditions

Panel B: Natural History of HIV Infection

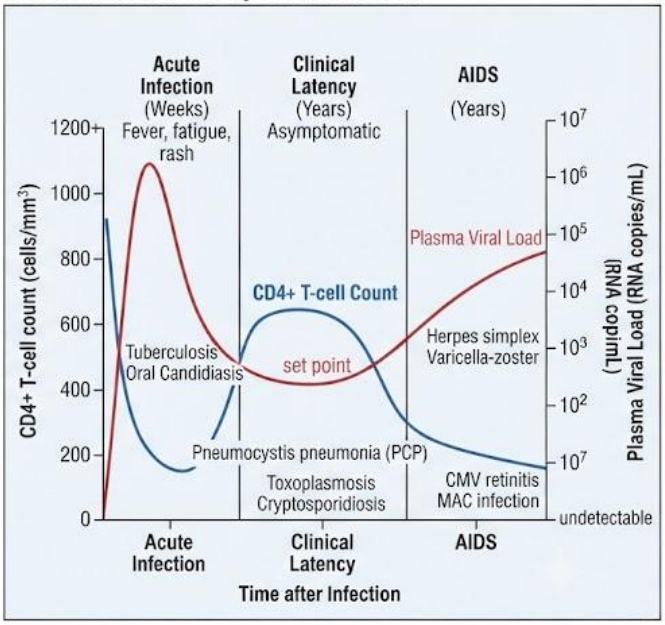


Figure 4.2: Immunodeficiency: primary causes and HIV/AIDS

Pilot questions 4.2

1. Name the five categories of primary immunodeficiency with one example of each.
2. How does HIV cause immunodeficiency?
3. Define AIDS and name four AIDS-defining illnesses.
4. Why is fever in a neutropaenic patient a medical emergency?
5. Name three prophylactic antimicrobials used to prevent opportunistic infections in HIV-positive patients.

4.3 Genetic Basis of Disease

4.3.1 Principles of genetics relevant to clinical medicine

The human genome contains approximately 3.2 billion base pairs organised into **23 pairs of chromosomes** (22 pairs of autosomes and one pair of sex chromosomes: XX in females, XY in

males). Each chromosome carries thousands of **genes**: segments of DNA that encode proteins or functional RNA molecules. **Mutations** (changes in DNA sequence) may be **point mutations** (single nucleotide substitutions, insertions, or deletions), **frameshift mutations** (insertions or deletions shifting the reading frame, often causing loss of function), or **chromosomal abnormalities** (changes in chromosome number or structure).

Gene expression is regulated at multiple levels; mutations affecting regulatory sequences can alter gene expression without changing the protein sequence. **Penetrance** describes the proportion of individuals with a disease genotype who manifest the disease phenotype; **expressivity** describes the range of phenotypic severity among those who do manifest disease. **Epigenetics** refers to heritable changes in gene expression without changes in DNA sequence, mediated by DNA methylation and histone modification, increasingly recognised as important in cancer, developmental disorders, and chronic disease. **Genomic imprinting** is parent-of-origin-specific gene expression; loss of imprinting causes disorders such as Prader-Willi and Angelman syndromes depending on which parental allele is affected.

Fill in the blank: _____ describes the proportion of individuals with a disease genotype who actually manifest the disease phenotype, which may be less than 100% even for dominant conditions.

4.3.2 Patterns of inheritance

Autosomal dominant (AD) inheritance: a single mutant allele is sufficient to cause disease; the condition appears in every generation; each affected individual has a 50% chance of passing the allele to each offspring; males and females equally affected; examples include Huntington disease, familial hypercholesterolaemia, Marfan syndrome, neurofibromatosis type 1, and adult polycystic kidney disease. **Autosomal recessive (AR)** inheritance: two mutant alleles (one from each parent) are required; parents are typically unaffected carriers; 25% of offspring of two carriers are affected; increased risk with consanguinity; examples include sickle cell disease, cystic fibrosis, phenylketonuria, and thalassaemia.

X-linked recessive inheritance: the gene is on the X chromosome; males (XY) are affected when they carry one mutant allele; females are carriers with one normal and one mutant allele; males

cannot pass the condition to sons but pass the carrier state to all daughters; examples include haemophilia A and B, Duchenne muscular dystrophy, G6PD deficiency, and XLA. **X-linked dominant**: rare; affected females may be less severely affected than affected males; example: X-linked hypophosphataemia. **Mitochondrial inheritance**: mitochondrial DNA is inherited exclusively from the mother; all offspring of an affected mother are affected; no paternal transmission; examples include Leber hereditary optic neuropathy and mitochondrial myopathies.

Fill in the blank: In autosomal _____ inheritance, two mutant alleles are required for disease expression; parents are typically unaffected carriers, and 25% of offspring of two carriers will be affected.

4.3.3 Common genetic diseases in clinical practice

Chromosomal disorders arise from abnormal chromosome number (aneuploidy) or structure. **Down syndrome (trisomy 21)** is the most common autosomal trisomy, caused by non-disjunction (increasing in frequency with maternal age), characterised by intellectual disability, hypotonia, upward-slanting palpebral fissures, single palmar crease, congenital heart disease (typically AVSD), duodenal atresia, Hirschsprung disease, and increased risk of leukaemia and early-onset Alzheimer disease. **Turner syndrome (45,X)** affects females: short stature, webbed neck, shield chest, primary amenorrhoea, bicuspid aortic valve, coarctation of the aorta, horseshoe kidney.

Sickle cell disease (HbSS), the most clinically significant inherited haemoglobinopathy in Nigeria and West Africa, results from a point mutation in the beta-globin gene causing substitution of valine for glutamic acid at position 6, producing haemoglobin S that polymerises under low oxygen tension, deforming red cells into the sickle shape and causing vaso-occlusion and haemolysis. Clinical features include: **vaso-occlusive crises** (painful crises from tissue ischaemia), **acute chest syndrome**, **stroke**, **avascular necrosis**, **splenic sequestration**, aplastic crisis (triggered by parvovirus B19), and chronic organ damage. Newborn screening and prophylactic penicillin, hydroxyurea, and folic acid are cornerstones of management.

Fill in the blank: Sickle cell disease results from a point mutation causing substitution of _____ for glutamic acid at position 6 of the beta-globin chain, producing haemoglobin S that polymerises under low oxygen tension.

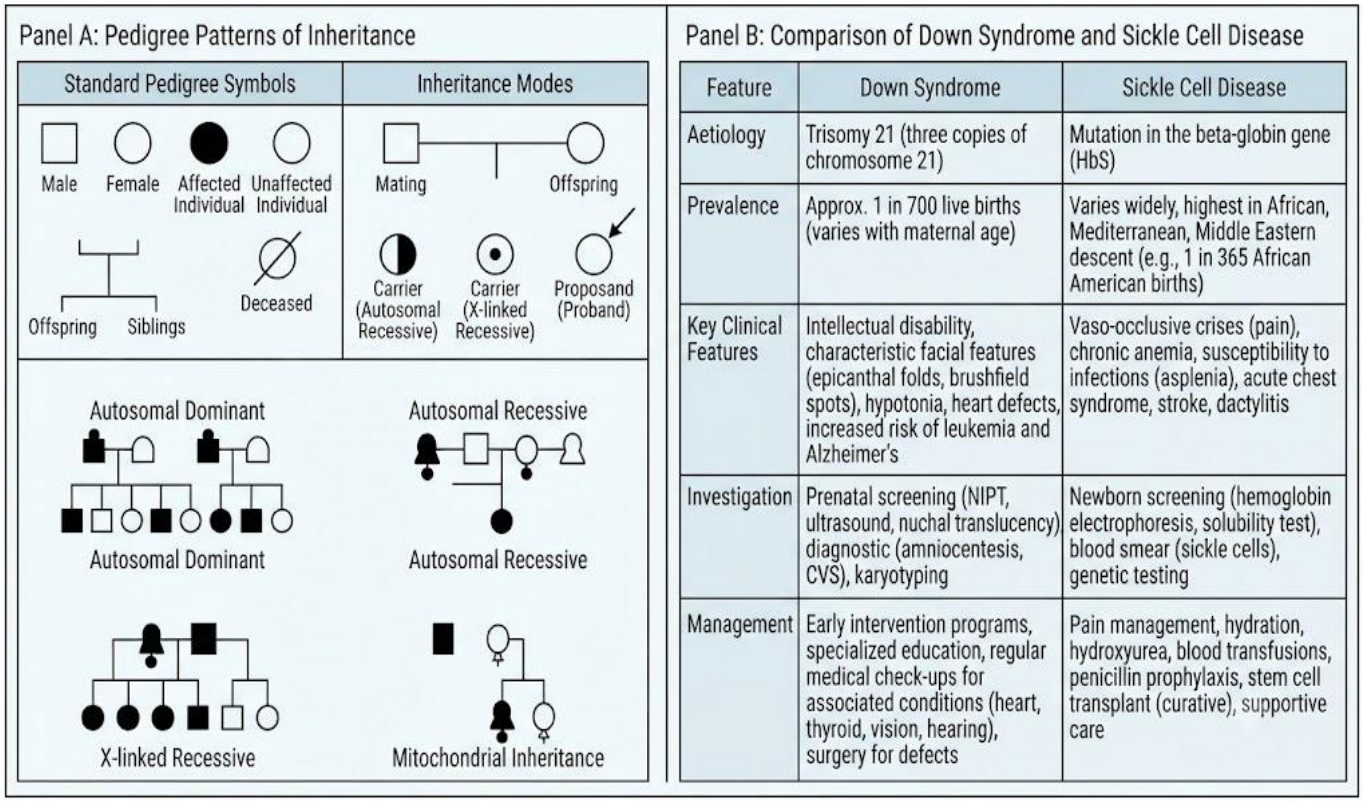


Figure 4.3: Patterns of inheritance and common genetic diseases

Figure 4.3: Patterns of inheritance and common genetic diseases

Pilot questions 4.3

1. Define penetrance and expressivity.
2. Name four conditions inherited in an autosomal dominant pattern.
3. Why are males more severely affected than females in X-linked recessive disorders?
4. Name the karyotype and four clinical features of Down syndrome.
5. Describe the molecular basis of sickle cell disease and name four clinical complications.

4.4 Clinical Application of Immunology and Genetics

4.4.1 Genetic counselling and risk assessment

Genetic counselling is the process of helping individuals and families understand and adapt to the medical, psychological, and familial implications of genetic disease. It is non-directive: the counsellor provides information and risk estimates but does not tell the patient what decision to make, respecting the ethical principle of autonomy. Key components include: **establishing the diagnosis** (accurate diagnosis is essential before genetic counselling, as risk estimates depend entirely on the correct diagnosis), **constructing a family pedigree** (at least three generations, recording affected and unaffected individuals, ages, causes of death, consanguinity, and ethnic background), and **calculating recurrence risk** (the probability that future offspring will be affected, based on the inheritance pattern).

Carrier testing identifies individuals who carry one copy of a recessive allele and are at risk of having affected offspring if their partner is also a carrier; particularly important in populations with high carrier frequencies (sickle cell trait in Nigeria, thalassaemia trait in Mediterranean populations). **Prenatal diagnosis** using chorionic villus sampling (CVS, 10 to 13 weeks gestation) or amniocentesis (15 to 20 weeks) allows chromosomal and genetic testing of the foetus; it is offered when there is a known high risk of a serious genetic condition. **Preimplantation genetic diagnosis (PGD)** in conjunction with in vitro fertilisation allows selection of unaffected embryos before implantation.

Fill in the blank: Genetic counselling is _____ -directive: the counsellor provides information and risk estimates without telling the patient what decision to make, respecting the ethical principle of autonomy.

4.4.2 Diagnostic investigation in immunological and genetic disease

Investigation of **immunological disease** includes: **full blood count** (lymphopenia in cellular immunodeficiency, neutropaenia); **serum immunoglobulins** (IgG, IgA, IgM; reduced in antibody deficiencies); **serum protein electrophoresis** (paraprotein band in multiple myeloma; reduced normal immunoglobulins); **lymphocyte subsets** by flow cytometry (CD4 and CD8

counts, essential in HIV monitoring); **complement levels** (C3, C4, CH50; reduced in complement deficiency and consumption); **autoantibody screen** (ANA, anti-dsDNA for SLE; anti-CCP for rheumatoid arthritis; anti-thyroid antibodies for autoimmune thyroid disease).

Investigation of **genetic disease** includes: **karyotyping** (chromosomal analysis by microscopy; detects trisomies, monosomies, structural rearrangements); **fluorescence in situ hybridisation (FISH)** (detects specific chromosomal microdeletions, e.g. DiGeorge 22q11 deletion); **PCR-based mutation analysis** (detects specific known mutations, e.g. sickle cell HbSS, cystic fibrosis CFTR mutations); **DNA sequencing** (next-generation sequencing panels and whole exome/genome sequencing for complex or undiagnosed genetic disease); and **newborn screening** (heel-prick blood spot test in Nigeria for sickle cell disease, congenital hypothyroidism, and other treatable conditions).

Fill in the blank: Lymphocyte subset analysis by _____ cytometry measures CD4 and CD8 counts, essential for monitoring disease progression and treatment response in HIV-infected patients.

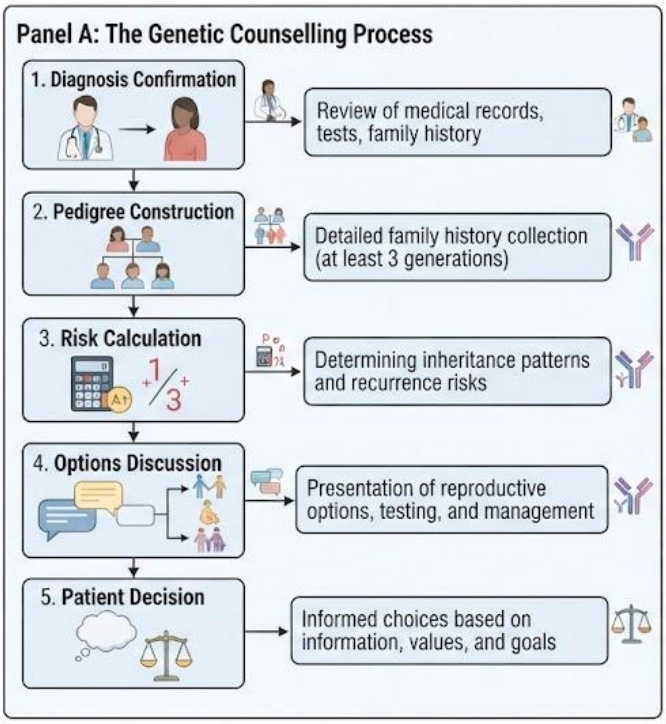
4.4.3 Principles of management and prevention

Management of **immunological disease** is tailored to the specific condition: **immunodeficiency** requires protection from infection (prophylactic antimicrobials, vaccination with non-live vaccines where appropriate, immunoglobulin replacement for antibody deficiency, ART for HIV, stem cell transplantation for SCID); **hypersensitivity** requires avoidance of triggers, symptomatic treatment (antihistamines for urticaria, bronchodilators for asthma, adrenaline for anaphylaxis), and desensitisation immunotherapy where applicable; **autoimmune disease** requires immunosuppression with corticosteroids, disease-modifying antirheumatic drugs (DMARDs), and increasingly targeted biological agents (anti-TNF, anti-IL-6, anti-CD20 antibodies).

Management of **genetic disease** employs several strategies. **Replacement therapy**: providing the missing gene product (clotting factors in haemophilia, enzyme replacement in lysosomal storage disorders, thyroid hormone in congenital hypothyroidism). **Dietary manipulation**: removing the substrate that accumulates in metabolic disorders (phenylalanine restriction in

PKU; low copper diet in Wilson disease). **Gene therapy**: delivering functional gene copies to affected cells (advancing rapidly; early successes in haemophilia, retinal dystrophy). **Prevention**: newborn screening for early identification and treatment before irreversible damage; carrier testing and prenatal diagnosis for high-risk couples; public health approaches including haemoglobin electrophoresis screening before marriage in sickle cell disease endemic regions of Nigeria.

Fill in the blank: Management of autoimmune disease requires immunosuppression with corticosteroids, disease-modifying antirheumatic drugs (DMARDs), and increasingly targeted _____ agents such as anti-TNF, anti-IL-6, and anti-CD20 antibodies.



Panel B: Summary of Immunological and Genetic Investigations

Investigation	What it Detects
Section 1: Immunological Disease Investigations	
Immunoglobulins (IgA, IgG, IgM)	Levels of major antibody classes; deficiency or excess
Lymphocyte Subsets (CD4, CD8, B cells)	Counts of T-cell, B-cell, and NK-cell populations; immunodeficiency
Complement System (CH50)	Overall function and levels of complement proteins; deficiencies
Autoantibodies (e.g., ANA, RF)	Antibodies against self-antigens; autoimmune disease
2: Genetic Disease Investigations	
Karyotype	Number and structure of chromosomes; large deletions/duplications, translocations (e.g., Down syndrome)
FISH (Fluorescence In Situ Hybridization)	Specific chromosomal regions; microdeletions, gene amplifications
PCR (Polymerase Chain Reaction)	Presence or absence of specific DNA sequences; mutations, gene insertions/
Sequencing (Sanger/NGS)	Detailed DNA sequence; single nucleotide variants, small insertions/deletions
Newborn Screening	Multiple metabolic, endocrine, and genetic disorders in infants (e.g., PKU, SCID)

Figure 4.4: Clinical application of immunology and genetics

Figure 4.4: Clinical application of immunology and genetics

Pilot questions 4.4

1. What is genetic counselling and what does non-directiveness mean?
2. Name three methods of prenatal diagnosis and state at what gestation each is performed.
3. Name four autoantibodies and the disease each is associated with.

4. Name three investigation types used in genetic disease and what each detects.
5. Name the four management strategies for genetic diseases with an example of each.

Series Summary

This Series examined the immunological and genetic basis of disease. The immune system was described through its innate and adaptive arms, with emphasis on T lymphocyte subsets and MHC/HLA function. Hypersensitivity was classified using the Gell and Coombs system: Type I (IgE-mediated; anaphylaxis, atopy), Type II (antibody-cytotoxic; haemolysis), Type III (immune complex; SLE, glomerulonephritis), and Type IV (T cell-mediated; contact dermatitis, tuberculin reaction). Autoimmune disease was described through organ-specific and systemic categories, with SLE examined as the paradigmatic systemic autoimmune condition. Primary immunodeficiency was classified by immune component (B cell, T cell, combined, phagocyte, complement), and HIV/AIDS was examined in detail including AIDS-defining illnesses and ART.

Genetic disease was approached through fundamental principles (mutations, penetrance, expressivity, epigenetics), the four major inheritance patterns (autosomal dominant, autosomal recessive, X-linked recessive, mitochondrial), and two paradigmatic clinical conditions: Down syndrome (chromosomal) and sickle cell disease (single gene). The Series concluded with clinical application: non-directive genetic counselling, carrier testing and prenatal diagnosis, immunological and genetic investigations (immunoglobulins, lymphocyte subsets, autoantibodies, karyotype, FISH, PCR, sequencing), and the management principles of replacement, dietary manipulation, gene therapy, and prevention through newborn screening (SLOs 4.1 to 4.5).

Glossary of Terms

- **Anaphylaxis:** a systemic, life-threatening type I hypersensitivity reaction requiring immediate intramuscular adrenaline.
- **Autoimmune disease:** disease arising from failure of self-tolerance, with immune responses directed against the body own tissues.

- **CD4+ T helper cell:** a T lymphocyte subset that orchestrates adaptive immune responses and is the primary target of HIV.
- **Genetic counselling:** the non-directive process of helping individuals and families understand the medical, psychological, and familial implications of genetic disease.
- **HLA (Human Leucocyte Antigen):** the human MHC molecules that present peptide antigens to T cells; important in transplantation, disease associations, and pharmacogenomics.
- **Karyotyping:** chromosomal analysis by microscopy detecting trisomies, monosomies, and structural chromosomal rearrangements.
- **Penetrance:** the proportion of individuals with a disease genotype who manifest the disease phenotype.
- **Primary immunodeficiency:** an inherited disorder of immune system development or function presenting with recurrent, severe, or unusual infections.
- **SCID (Severe Combined Immunodeficiency):** a primary immunodeficiency affecting both T and B cells, causing life-threatening infections from birth; treated by haematopoietic stem cell transplantation.
- **Sickle cell disease:** an autosomal recessive haemoglobinopathy caused by a beta-globin point mutation producing HbS that polymerises under low oxygen tension.
- **SLE (Systemic Lupus Erythematosus):** a systemic autoimmune disease predominantly affecting women of reproductive age, characterised by multi-organ involvement and anti-dsDNA and ANA positivity.

Concept Check Questions [Series 4]

Objective questions

1. CD4+ T _____ cells orchestrate adaptive immune responses and are the primary target of HIV, whose depletion causes AIDS. (Linked to SLO 4.1)
2. Type _____ hypersensitivity (T cell-mediated, delayed 24 to 72 hours) examples include contact dermatitis and tuberculin skin test reaction. (Linked to SLO 4.2)
3. AIDS is defined by a CD4 count below _____ cells/μL or the occurrence of an AIDS-defining illness. (Linked to SLO 4.3)
4. In autosomal _____ inheritance, two mutant alleles are required; parents are typically carriers; 25% of offspring of two carriers are affected. (Linked to SLO 4.4)
5. Sickle cell disease results from substitution of _____ for glutamic acid at position 6 of the beta-globin chain, producing HbS. (Linked to SLO 4.4)
6. Genetic counselling is _____ -directive: the counsellor provides information without prescribing decisions, respecting patient autonomy. (Linked to SLO 4.5)

Short-answer questions

7. Classify the four types of hypersensitivity reactions, giving the mechanism and one clinical example of each. (Linked to SLO 4.2)
8. Describe the patterns of autosomal dominant and X-linked recessive inheritance and give two clinical examples of each. (Linked to SLO 4.4)

Long-answer questions

9. Discuss HIV/AIDS, covering its pathogenesis, definition of AIDS, common AIDS-defining illnesses, and principles of management. (Linked to SLO 4.3)
10. Evaluate the clinical application of genetics in medicine, covering genetic counselling, prenatal diagnosis, investigation, and management principles including gene therapy and prevention. (Linked to SLO 4.5)

Answers to Concept Check Questions [Series 4]

Objective questions

1. Helper.
2. IV.
3. 200.
4. Recessive.
5. Valine.
6. Non.

Short-answer questions

7. Type I (IgE-mediated, immediate): IgE cross-linking on mast cells causes degranulation within minutes; example: anaphylaxis, urticaria, atopic asthma. Type II (antibody-cytotoxic): IgG/IgM bind cell surface antigens activating complement; example: haemolytic transfusion reaction, Goodpasture syndrome. Type III (immune complex-mediated): antigen-antibody complexes deposit in tissues; example: SLE, post-streptococcal glomerulonephritis. Type IV (T cell-mediated, delayed 24 to 72 hours): sensitised T cells release cytokines; no antibody involved; example: contact dermatitis, tuberculin reaction.
8. Autosomal dominant: single mutant allele sufficient; condition in every generation; 50% offspring risk; males and females equally affected; examples: Huntington disease, Marfan syndrome, familial hypercholesterolaemia, neurofibromatosis. X-linked recessive: gene on X chromosome; males affected (carry one mutant X); females carriers (one mutant, one normal X); no male-to-male transmission; affected males pass carrier status to all daughters; examples: haemophilia A and B, Duchenne muscular dystrophy, G6PD deficiency.

Long-answer questions

9. **Basic response:** Pathogenesis: HIV (retrovirus) infects CD4+ T helper cells via gp120-CD4 interaction; reverse transcriptase converts viral RNA to DNA; integrase incorporates

viral DNA into host genome; progressive CD4 cell depletion dismantles adaptive immunity. AIDS: CD4 below 200 cells/μL or AIDS-defining illness. Common AIDS-defining illnesses: PCP (bilateral interstitial infiltrates, treated with co-trimoxazole); cerebral toxoplasmosis (ring-enhancing lesions, pyrimethamine and sulfadiazine); cryptococcal meningitis (India ink, cryptococcal antigen, amphotericin B then fluconazole); Kaposi sarcoma (HHV-8, violaceous lesions); CMV retinitis; oesophageal candidiasis; disseminated MAC. Management: ART (suppress viral replication, restore CD4); prophylaxis (co-trimoxazole, fluconazole, INH); treat opportunistic infections; monitoring (CD4 count, viral load).

Value-added response: The management of HIV has been transformed from a uniformly fatal disease to a chronic manageable condition within three decades, primarily through ART. In Nigeria, where HIV prevalence and absolute number of people living with HIV are among the highest globally, the clinical priority is not lack of effective treatment but treatment access, adherence, and retention in care. The clinical student must understand not only the pharmacology of ART but the barriers to its effective use: stigma deterring testing, treatment costs limiting access for those outside the national ART programme, supply chain interruptions causing drug stockouts, and the social and structural determinants of adherence that are as important as the drugs themselves.

10. **Basic response:** Genetic counselling: non-directive process; components: diagnosis confirmation, pedigree construction (three generations), risk calculation by inheritance pattern, presentation of options, support for decision. Prenatal diagnosis: CVS (10-13 weeks, chromosomal and genetic analysis), amniocentesis (15-20 weeks), preimplantation genetic diagnosis (with IVF). Investigation: karyotyping (chromosome number and structure, Down syndrome); FISH (microdeletions, DiGeorge 22q11); PCR mutation analysis (sickle cell, CF); next-generation sequencing (complex or undiagnosed genetic disease); newborn screening (heel-prick, sickle cell, congenital hypothyroidism). Management: replacement therapy (clotting factors in haemophilia; thyroid hormone in CH); dietary manipulation (phenylalanine restriction in PKU; low copper in Wilson disease); gene therapy (haemophilia, retinal dystrophy); prevention (newborn screening, carrier testing, prenatal diagnosis).

Value-added response: Gene therapy represents the potential to cure rather than merely manage genetic disease, and its rapid advance over the last decade (with approved therapies for haemophilia B, spinal muscular atrophy, and retinal dystrophy now available) makes it essential for the contemporary clinical student to understand its principles. However, gene therapy currently requires highly specialised infrastructure and is extremely expensive, meaning its benefits will reach Nigerian patients with genetic disease only with deliberate policy investment. The more immediately impactful genetics intervention in Nigeria is population-level sickle cell screening and newborn diagnosis, given the approximately 150,000 children born with sickle cell disease in Nigeria each year, many of whom die preventably in early childhood because they were never diagnosed.

Answers to Pilot Questions [Series 4]

Part 4.1

1. Innate immune system: immediate, non-specific, no memory; components include physical barriers, neutrophils, macrophages, complement, and inflammatory response. Adaptive immune system: delayed, antigen-specific, generates immunological memory; components include B lymphocytes (humoral immunity) and T lymphocytes (cellular immunity). The key difference is antigen specificity and immunological memory.
2. CD4+ T helper cells orchestrate immune responses by activating B cells (to produce antibodies) and CD8+ cytotoxic T cells. Their depletion by HIV progressively dismantles both humoral and cellular adaptive immunity, leaving the host vulnerable to opportunistic infections and malignancies that a competent immune system would control.
3. Type I (IgE-mediated): anaphylaxis. Type II (antibody-cytotoxic): haemolytic transfusion reaction. Type III (immune complex): post-streptococcal glomerulonephritis. Type IV (T cell-mediated, delayed): contact dermatitis.
4. Organ-specific: immune response targets a single organ; examples: Hashimoto thyroiditis (thyroid), type 1 diabetes mellitus (pancreatic beta cells). Systemic: multiple organs

affected; examples: SLE (kidneys, joints, skin, CNS), rheumatoid arthritis (joints, skin, lungs).

5. Any four of: malar (butterfly) rash; photosensitivity; discoid rash; oral ulcers; arthritis; serositis (pleuritis, pericarditis); nephritis (lupus nephritis); haematological abnormalities (haemolytic anaemia, thrombocytopaenia); neurological involvement.

Part 4.2

1. B cell deficiency (XLA); T cell deficiency (DiGeorge syndrome); combined immunodeficiency (SCID); phagocyte deficiency (chronic granulomatous disease); complement deficiency (C3 deficiency predisposing to encapsulated bacteria).
2. HIV infects CD4+ T helper cells via its envelope glycoprotein gp120 binding the CD4 receptor; reverse transcriptase converts viral RNA to DNA; viral DNA integrates into the host genome; progressive CD4 cell destruction dismantles adaptive immunity, leaving the host susceptible to opportunistic infections and malignancies.
3. AIDS is defined by a CD4 count below 200 cells/μL or the occurrence of an AIDS-defining illness. Four AIDS-defining illnesses: Pneumocystis jirovecii pneumonia; cerebral toxoplasmosis; cryptococcal meningitis; Kaposi sarcoma (also acceptable: CMV retinitis, oesophageal candidiasis, disseminated MAC).
4. Because febrile neutropaenia (ANC below 0.5×10^9/L) carries high risk of rapidly fatal bacterial sepsis; the neutropaenic patient lacks the primary cellular defence against bacterial infection and can deteriorate within hours, requiring immediate blood cultures and empirical broad-spectrum antibiotics without waiting for culture results.
5. Co-trimoxazole (against Pneumocystis jirovecii pneumonia and toxoplasmosis); fluconazole (against cryptococcal disease); isoniazid preventive therapy (against tuberculosis).

Part 4.3

1. Penetrance: the proportion of individuals with a disease genotype who manifest the disease phenotype (may be less than 100% even for dominant conditions). Expressivity: the range of phenotypic severity among those who do manifest the disease.
2. Any four of: Huntington disease, familial hypercholesterolaemia, Marfan syndrome, neurofibromatosis type 1, adult polycystic kidney disease, myotonic dystrophy, osteogenesis imperfecta.
3. Males have only one X chromosome (XY); a single copy of a mutant X-linked recessive allele is sufficient to cause disease in males because there is no second normal allele to compensate. Females have two X chromosomes and are carriers when they have one normal and one mutant allele; the normal allele compensates, preventing disease expression in most carriers.
4. Karyotype: 47,XX+21 or 47,XY+21 (trisomy 21). Features: intellectual disability; hypotonia; upward-slanting palpebral fissures; single palmar crease; congenital heart disease (AVSD most common); duodenal atresia; increased risk of leukaemia and Alzheimer disease.
5. Molecular basis: point mutation in the beta-globin gene causing substitution of valine for glutamic acid at position 6, producing haemoglobin S that polymerises under low oxygen tension and deforms red cells into the sickle shape. Complications: vaso-occlusive painful crises; acute chest syndrome; stroke; splenic sequestration; aplastic crisis; avascular necrosis; chronic organ damage.

Part 4.4

1. Genetic counselling is the process of helping individuals and families understand and adapt to the implications of genetic disease. Non-directiveness means the counsellor provides information and risk estimates without prescribing the decision, respecting the patient right to make their own autonomous choice about reproduction or management.
2. Chorionic villus sampling (CVS): 10 to 13 weeks gestation; amniocentesis: 15 to 20 weeks gestation; preimplantation genetic diagnosis (PGD): performed on embryos before implantation in IVF cycles.

3. ANA (antinuclear antibody): SLE and other connective tissue diseases. Anti-dsDNA (anti-double-stranded DNA): SLE (high specificity). Anti-CCP (anti-cyclic citrullinated peptide): rheumatoid arthritis. Anti-thyroid antibodies (anti-TPO, anti-thyroglobulin): Hashimoto thyroiditis, Graves disease.
4. Karyotyping: detects chromosomal number and structural abnormalities (e.g. Down syndrome trisomy 21). FISH: detects specific chromosomal microdeletions (e.g. DiGeorge 22q11 deletion). PCR mutation analysis: detects specific known mutations (e.g. sickle cell HbSS; cystic fibrosis CFTR mutations).
5. Replacement therapy (example: clotting factor infusion in haemophilia); dietary manipulation (example: phenylalanine restriction in phenylketonuria); gene therapy (example: functional gene delivery in haemophilia B or retinal dystrophy); prevention through newborn screening and carrier testing (example: heel-prick sickle cell screening).

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Figures, Plates, Tables, and Boxes

- Figure 4.1: Immune system overview and hypersensitivity classification Attribution: AI generated using prompt "Generate a two-panel diagram showing innate versus adaptive immunity and the four Gell and Coombs hypersensitivity types with mechanisms and examples." Suggested OER search string: "immune system innate adaptive hypersensitivity Gell Coombs type I II III IV anaphylaxis autoimmune OER"
- Figure 4.2: Immunodeficiency: primary causes and HIV/AIDS Attribution: AI generated using prompt "Generate a two-panel diagram showing primary immunodeficiency classification and HIV natural history with CD4 decline and opportunistic infections." Suggested OER search string: "primary immunodeficiency XLA SCID DiGeorge HIV AIDS CD4 opportunistic infections natural history OER"
- Figure 4.3: Patterns of inheritance and common genetic diseases Attribution: AI generated using prompt "Generate a two-panel diagram showing pedigree patterns for four inheritance modes and a comparison table of Down syndrome versus sickle cell disease." Suggested OER search string: "inheritance patterns autosomal dominant recessive X-linked pedigree Down syndrome sickle cell disease OER"
- Figure 4.4: Clinical application of immunology and genetics Attribution: AI generated using prompt "Generate a two-panel diagram showing the genetic counselling flowchart

and a comparison of immunological versus genetic disease investigations." Suggested OER search string: "genetic counselling risk assessment immunology investigations karyotype FISH PCR autoantibodies lymphocyte subsets OER"

Series 5: Applied Basic Medical Sciences and Principles of Radiology

- **Part 5.1: Applied Physiology and Pathophysiology in Clinical Medicine**
  - Sub Part 5.1.1: Homeostasis and its clinical relevance
  - Sub Part 5.1.2: Fluid and electrolyte disorders
  - Sub Part 5.1.3: Acid-base disorders
- **Part 5.2: Applied Pharmacology and Drug Therapeutics**
  - Sub Part 5.2.1: Principles of pharmacokinetics
  - Sub Part 5.2.2: Principles of pharmacodynamics and adverse drug reactions
  - Sub Part 5.2.3: Drug interactions and rational prescribing
- **Part 5.3: Basic Principles of Radiology**
  - Sub Part 5.3.1: Overview of imaging modalities
  - Sub Part 5.3.2: Principles of plain radiography
  - Sub Part 5.3.3: Computed tomography, ultrasound, and MRI
- **Part 5.4: Good Clinical Practice and Patient Safety**
  - Sub Part 5.4.1: Elements of good clinical practice
  - Sub Part 5.4.2: Medical error, patient safety, and incident reporting
  - Sub Part 5.4.3: Clinical governance and quality improvement

Introduction

Clinical medicine is anchored in the basic medical sciences. Pathophysiology explains why patients develop the symptoms and signs elicited through history and examination. Pharmacology determines how drugs are given, absorbed, distributed, and eliminated, and how they cause therapeutic effects and harm. Radiology provides the imaging tools that extend the clinician capacity to visualise internal anatomy and pathology. And good clinical practice provides the governance and safety framework within which all clinical activity must operate.

The aim of this Series is to apply basic physiological and pathophysiological knowledge to common clinical problems in fluid balance, electrolyte disorders, and acid-base disturbance; to review the principles of pharmacokinetics, pharmacodynamics, and rational prescribing; to introduce the basic principles of radiological imaging and plain film interpretation; and to describe the elements of good clinical practice and patient safety.

We shall commence with applied physiology and pathophysiology, covering homeostasis, fluid and electrolyte disorders, and acid-base balance. Next, we will examine applied pharmacology and rational prescribing. Moving on, we will address the principles of radiology and imaging. Finally, we will close with good clinical practice, patient safety, and clinical governance, completing the course.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 5.1** apply basic physiological principles to the clinical assessment and management of fluid, electrolyte, and acid-base disorders,
- **SLO 5.2** explain the principles of pharmacokinetics and pharmacodynamics and apply them to rational prescribing,
- **SLO 5.3** describe the major imaging modalities and apply basic principles of plain radiograph interpretation, and

- **SLO 5.4** describe the elements of good clinical practice, medical error recognition, patient safety, and clinical governance.

5.1 Applied Physiology and Pathophysiology in Clinical Medicine

5.1.1 Homeostasis and its clinical relevance

Homeostasis is the maintenance of a stable internal environment through dynamic regulatory processes that counteract deviations from normal. The key homeostatic variables in clinical medicine include **body temperature**, **blood pressure**, **blood glucose**, **plasma osmolality**, **arterial pH**, and **electrolyte concentrations**. Each is regulated by **negative feedback loops** involving sensors (detecting deviation), controllers (integrating information and generating a response), and effectors (implementing the corrective action). Disruption of these feedback mechanisms, whether by disease, injury, or iatrogenic intervention, produces the clinical syndromes that manifest as symptoms and signs.

Total body water (TBW) constitutes approximately 60% of body weight in adult males and 50% in adult females (lower due to higher body fat content). TBW is distributed between the **intracellular fluid (ICF)** compartment (approximately two-thirds of TBW) and the **extracellular fluid (ECF)** compartment (approximately one-third of TBW), which is further divided into **intravascular** (plasma, approximately 25% of ECF) and **interstitial** fluid (approximately 75% of ECF). **Plasma osmolality** (normally 285 to 295 mOsm/kg, determined predominantly by sodium and its anions) is the primary regulator of water distribution between compartments, sensed by hypothalamic osmoreceptors that control **ADH (antidiuretic hormone)** release.

Fill in the blank: Total body water constitutes approximately _____ % of body weight in adult males, distributed between the intracellular fluid (two-thirds) and extracellular fluid (one-third) compartments.

5.1.2 Fluid and electrolyte disorders

Hyponatraemia (serum sodium below 135 mmol/L) is the most common electrolyte disorder in hospitalised patients. It may be **hypovolaemic** (total body sodium and water both reduced, sodium more so; causes: vomiting, diarrhoea, diuretics, Addison disease), **euvolaemic** (excess water without sodium loss; cause: SIADH, hypothyroidism), or **hypervolaemic** (excess total body sodium and water, water more so; causes: cardiac failure, cirrhosis, nephrotic syndrome). **Hypernatraemia** (sodium above 145 mmol/L) indicates water deficit relative to sodium, causing cellular dehydration; causes include inadequate water intake, excessive water loss (diabetes insipidus, osmotic diuresis), or rarely excess sodium administration.

Hypokalaemia (potassium below 3.5 mmol/L) causes muscle weakness, cramps, constipation, and cardiac arrhythmias (flattened T waves, U waves, prolonged QT on ECG); causes include diuretics (especially loop diuretics), vomiting, diarrhoea, hyperaldosteronism, and renal tubular acidosis. **Hyperkalaemia** (potassium above 5.5 mmol/L) is a medical emergency at high levels; it causes peaked T waves, widened QRS, and potentially fatal ventricular arrhythmias; causes include renal failure (most common), ACE inhibitors, potassium-sparing diuretics, acidosis, and tissue destruction (rhabdomyolysis, haemolysis). Urgent treatment with IV **calcium gluconate** (membrane stabilisation), **insulin and dextrose**, and **salbutamol** drives potassium into cells.

Fill in the blank: Hyperkalaemia at dangerous levels is treated first with intravenous _____ gluconate to stabilise the cardiac membrane, followed by insulin and dextrose and salbutamol to drive potassium intracellularly.

5.1.3 Acid-base disorders

Arterial pH is normally 7.35 to 7.45, maintained by three buffer systems: **bicarbonate buffer** (the most important clinically: $CO_2 + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$), **phosphate buffer**, and **protein buffers** (including haemoglobin). The respiratory system adjusts **$PaCO_2$** rapidly (within minutes to hours) to compensate for metabolic disturbances; the kidneys adjust **HCO_3^-** slowly (over hours to days) to compensate for respiratory disturbances. **Acidaemia** (pH below 7.35) and **alkalaemia** (pH above 7.45) are the primary derangements, each with respiratory and metabolic causes.

The four primary acid-base disorders: **respiratory acidosis** (elevated $PaCO_2$, reduced pH; causes: hypoventilation, COPD, opioid overdose), **respiratory alkalosis** (reduced $PaCO_2$, elevated pH; causes: hyperventilation, pulmonary embolism, anxiety, mechanical overventilation), **metabolic acidosis** (reduced HCO_3^-, reduced pH; causes: lactic acidosis, diabetic ketoacidosis, renal failure, ingested acids; distinguished by calculating **anion gap** = $Na^+ - [Cl^- + HCO_3^-]$, normally 8 to 12 mmol/L), and **metabolic alkalosis** (elevated HCO_3^-, elevated pH; causes: vomiting, diuretics, hyperaldosteronism, alkali ingestion). **Mixed disorders** (more than one primary derangement simultaneously) are common in critically ill patients.

Fill in the blank: The _____ gap (Na^+ minus $[Cl^- + HCO_3^-]$, normally 8 to 12 mmol/L) distinguishes between high-anion-gap metabolic acidosis (lactic acidosis, DKA) and normal-anion-gap metabolic acidosis.

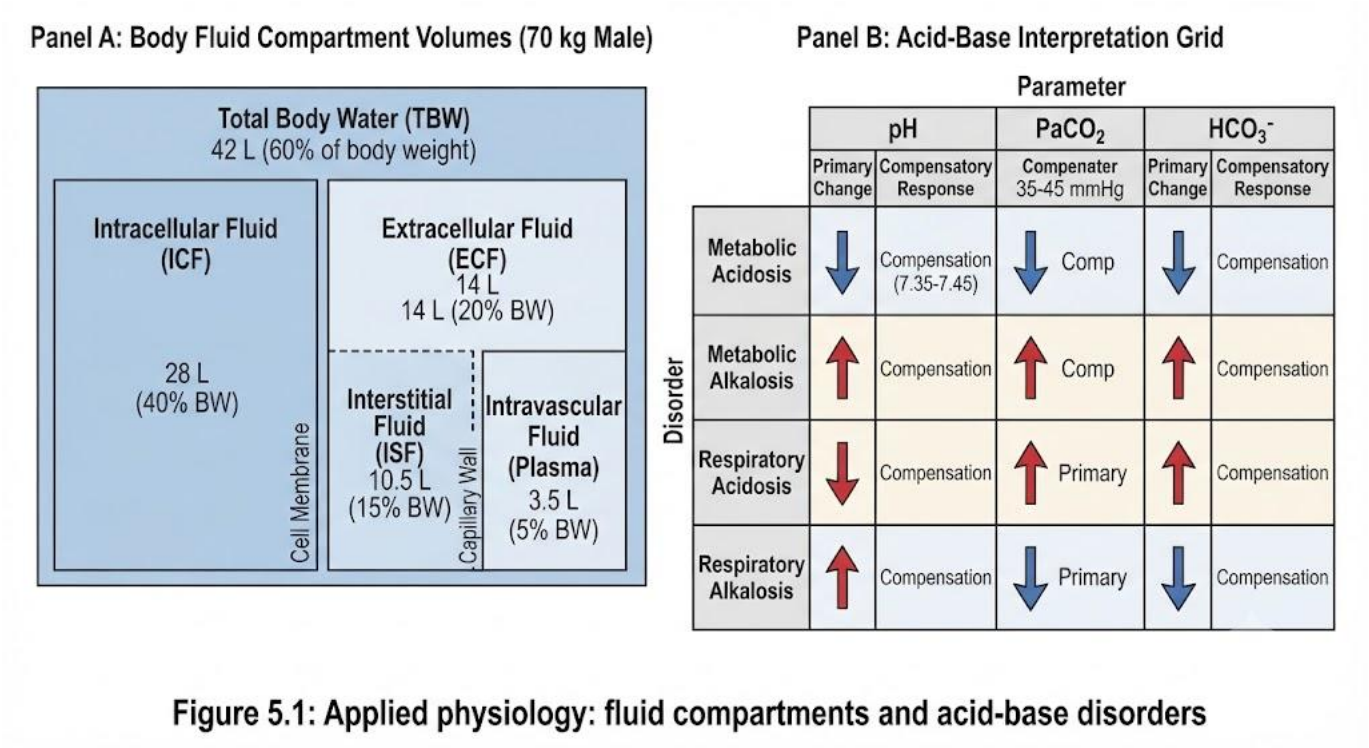


Figure 5.1: Applied physiology: fluid compartments and acid-base disorders

Figure 5.1: Applied physiology: fluid compartments and acid-base disorders

Pilot questions 5.1

1. Define homeostasis and name four key homeostatic variables regulated in the body.
2. How is total body water distributed between compartments?

3. Classify hyponatraemia by volume status and give one cause of each type.
4. Name the four primary acid-base disorders and one cause of each.
5. What is the anion gap formula and what does an elevated anion gap indicate?

5.2 Applied Pharmacology and Drug Therapeutics

5.2.1 Principles of pharmacokinetics

Pharmacokinetics describes what the body does to a drug, encompassing four processes summarised as **ADME**: **Absorption** (the movement of drug from the administration site into the systemic circulation; oral bioavailability is the fraction of an administered dose that reaches the systemic circulation after first-pass hepatic metabolism), **Distribution** (the movement of drug from the blood into tissues, determined by lipid solubility, protein binding, and tissue perfusion; the **volume of distribution** (V^d) reflects the apparent volume into which a drug distributes), **Metabolism** (biotransformation, predominantly in the liver by cytochrome P450 enzymes, to more water-soluble metabolites for excretion), and **Excretion** (elimination, predominantly renal for water-soluble drugs; biliary for some drugs entering enterohepatic circulation).

Half-life (t½) is the time required for plasma drug concentration to fall by 50%; it determines dosing interval (a drug reaches steady state after approximately five half-lives of regular dosing). **Therapeutic index** is the ratio of the toxic dose to the therapeutic dose; narrow therapeutic index drugs (digoxin, lithium, warfarin, aminoglycosides, phenytoin) require **therapeutic drug monitoring (TDM)** to maintain plasma levels within the therapeutic window. **Renal and hepatic impairment** prolong drug elimination and require dose adjustment to prevent toxic accumulation; **creatinine clearance** (estimated from the Cockcroft-Gault equation) guides renal dose adjustment.

Fill in the blank: A drug reaches _____ state after approximately five half-lives of regular dosing; drugs with a narrow therapeutic index require therapeutic drug monitoring to maintain plasma levels within safe limits.

5.2.2 Principles of pharmacodynamics and adverse drug reactions

Pharmacodynamics describes what a drug does to the body. Most drugs act by binding to specific **receptors** (proteins mediating normal physiological functions). **Agonists** bind and activate receptors, mimicking the endogenous ligand. **Antagonists** bind receptors without activating them, blocking the endogenous ligand or agonist. **Partial agonists** activate receptors to a submaximal level. **Dose-response curves** relate drug dose to effect; the **EC_{50}** is the concentration producing 50% of the maximum effect; the **maximum effect (E_{max})** is the ceiling effect regardless of dose increase.

Adverse drug reactions (ADRs) are classified as: **Type A (augmented)**: predictable, dose-dependent, related to the pharmacological action of the drug (e.g. hypoglycaemia from insulin, bradycardia from beta-blockers); most common, most predictable, dose reduction usually sufficient. **Type B (bizarre)**: unpredictable, dose-independent, not related to pharmacological action (e.g. anaphylaxis to penicillin, agranulocytosis from carbimazole); rare but often severe; drug must be stopped. **Type C (chronic)**: related to long-term use (e.g. adrenal suppression from prolonged corticosteroids; tardive dyskinesia from antipsychotics). **Type D (delayed)**: appearing long after use (e.g. carcinogenesis from chemotherapy; teratogenesis).

Fill in the blank: Type _____ adverse drug reactions are predictable, dose-dependent, and related to the pharmacological action of the drug; dose reduction is usually sufficient to manage them.

5.2.3 Drug interactions and rational prescribing

Drug interactions occur when one drug alters the effect of another through pharmacokinetic or pharmacodynamic mechanisms. **Pharmacokinetic interactions** alter ADME of the victim drug: **enzyme inducers** (rifampicin, carbamazepine, phenytoin) accelerate metabolism and reduce plasma levels of co-administered drugs; **enzyme inhibitors** (erythromycin, fluconazole, ciprofloxacin, grapefruit juice) slow metabolism and increase plasma levels, potentially causing toxicity. **Pharmacodynamic interactions** produce additive effects (two sedatives causing excessive sedation), synergistic effects (co-trimoxazole: trimethoprim and sulfamethoxazole

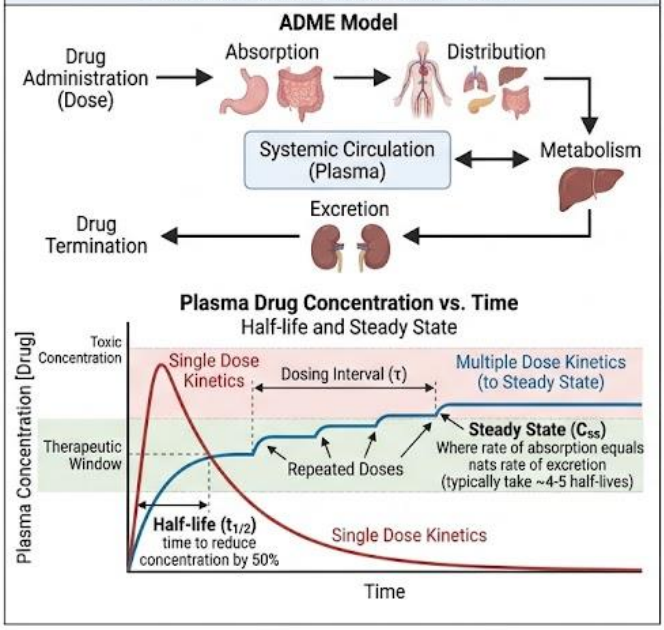
acting sequentially on the folate pathway), or antagonistic effects (beta-agonists and beta-blockers).

Rational prescribing is the selection of the right drug, in the right dose, by the right route, for the right patient, for the right duration, at the right cost. The **WHO Model of Rational Use of Medicines** requires: confirming the diagnosis; establishing the therapeutic objective; identifying effective, safe, and affordable treatment options; initiating treatment with appropriate prescription; monitoring response and adjusting as needed. **Polypharmacy** (five or more drugs concurrently) increases the risk of drug interactions, ADRs, poor adherence, and medication errors, and is a major concern in elderly patients in Nigeria where traditional remedies and prescription drugs may be used simultaneously.

Fill in the blank: Enzyme _____ (such as rifampicin, carbamazepine, and phenytoin) accelerate hepatic drug metabolism, reducing plasma levels of co-administered drugs and potentially causing therapeutic failure.

Figure 5.2: Pharmacokinetics, pharmacodynamics, and adverse drug reactions

Panel A: **The ADME Pharmacokinetic Model and Plasma Concentration over Time**



Panel B: **Types of Adverse Drug Reactions (ADRs)**

ADR Type	Mechanism	Predictability	Example	Management
Type A (Augmented)	Dose-dependent exaggerated pharmacologic effect	Yes (High)	Bleeding with anticoagulant therapy, hypoglycemia with insulin	Reduce dose or switch drug
Type B (Bizarre/ Idiosyncratic)	Dose-independent idiosyncratic reaction (e.g., immunologic)	No (Low)	Anaphylaxis with penicillin, skin rash	Stop drug immediately, avoid in future
Type C (Chronic)	Cumulative effects over long-term use	Yes (High)	Osteoporosis with chronic steroid use, nephropathy with NSAIDs	Monitor long-term, reduce dose, dose, or discontinue
Type D (Delayed)	Delayed reactions, e.g., teratogenic or carcinogenic	Yes (High)	Teratogenesis (fetal malformation with thalidomide), carcinogenesis (vaginal cancer with DES exposure)	Avoid in vulnerable populations (e.g., pregnancy)

Figure 5.2: Pharmacokinetics, pharmacodynamics, and adverse drug reactions

Pilot questions 5.2

1. Define pharmacokinetics and explain what ADME stands for.
2. What is a narrow therapeutic index drug? Give three examples.
3. Distinguish between agonists and antagonists.
4. Classify adverse drug reactions and give one example of each type.
5. Define rational prescribing and name two risks associated with polypharmacy.

5.3 Basic Principles of Radiology

5.3.1 Overview of imaging modalities

Medical imaging uses different forms of energy to visualise internal structures. **Plain radiography (X-ray)** uses ionising radiation (X-rays) that is absorbed differentially by tissues of different density: **air** appears black (most radiolucent), **fat** dark grey, **soft tissue/water** grey, **bone/calcium** white, and **metal** brightest white (most radio-opaque). It is the fastest, most widely available, and cheapest modality, used first for most clinical questions. **Fluoroscopy** is real-time X-ray imaging used for dynamic studies (barium swallow, barium enema, coronary angiography, interventional procedures).

Ultrasound uses high-frequency sound waves, produces no ionising radiation, is portable and relatively inexpensive, and is particularly valuable for soft tissue structures (gallbladder, liver, kidneys, thyroid, uterus, foetus, heart via echocardiography). **Computed tomography (CT)** uses multiple X-ray beams processed by computer to produce cross-sectional images; offers excellent spatial resolution and rapid acquisition; widely used for trauma, pulmonary embolism, stroke, and abdominal emergencies. **Magnetic resonance imaging (MRI)** uses magnetic fields and radiofrequency waves (no ionising radiation); provides superior soft tissue contrast, particularly for the brain, spinal cord, joints, and soft tissue tumours, but is slower, more expensive, and contraindicated in patients with certain metallic implants.

Fill in the blank: On a plain radiograph, _____ appears black (most radiolucent) while bone and calcium appear white (most radio-opaque) because X-rays are differentially absorbed according to tissue density.

5.3.2 Principles of plain radiography

Plain radiograph interpretation follows a systematic approach to avoid missing findings. The **ABCDE approach** to chest X-ray interpretation: **A (Airway)**: trachea midline, carina angle less than 70 degrees, main bronchi visible; **B (Breathing)**: lung fields (compare symmetry, look for consolidation, collapse, pneumothorax, pleural effusion, nodules); **C (Cardiac)**: cardiac size (normal cardiothoracic ratio less than 0.5 on PA film), cardiac borders, aortic knuckle; **D (Diaphragm)**: right diaphragm normally higher than left; loss of costophrenic angle indicates effusion; subphrenic gas indicates perforation; **E (Everything else)**: bones, soft tissues, lines, and tubes.

Key **radiological signs on chest X-ray**: **air bronchogram** (air-filled bronchi visible within opacified lung, indicating consolidation rather than collapse or effusion), **silhouette sign** (loss of a normally visible border between two structures of different density, e.g. loss of the right heart border indicates right middle lobe consolidation), **Kerley B lines** (horizontal lines at the lung periphery, indicating interstitial oedema from raised pulmonary capillary pressure), **pneumothorax** (visible lung edge with absent lung markings beyond, most prominent at the apex), and **blunting of costophrenic angles** (suggesting pleural effusion, present when at least 200 to 300 mL of fluid has accumulated).

Fill in the blank: The _____ sign describes loss of a normally visible anatomical border on chest X-ray; for example, loss of the right heart border indicates right middle lobe consolidation adjacent to the heart.

5.3.3 Computed tomography, ultrasound, and MRI

CT of the head is the first-line imaging for acute stroke (to distinguish haemorrhagic from ischaemic), head trauma (detecting extradural and subdural haematomas, contusions, skull fractures), and suspected intracranial mass. **CT pulmonary angiography (CTPA)** is the

investigation of choice for pulmonary embolism, demonstrating filling defects within pulmonary arteries. **CT of the abdomen and pelvis** with contrast is used for suspected appendicitis, intestinal obstruction, solid organ injury (trauma), and staging of abdominal malignancies. CT scans are presented as axial cross-sections; structures appear **hyper-dense** (white, e.g. acute blood, bone, contrast) or **hypo-dense** (dark, e.g. air, fat, ischaemic brain) relative to surrounding tissue.

Abdominal ultrasound is first-line for suspected biliary disease (gallstones appear as echogenic foci with acoustic shadow; biliary dilatation indicates obstruction), renal disease (hydronephrosis, renal cysts, mass lesions), and abdominal aortic aneurysm screening. **Echocardiography** (cardiac ultrasound) assesses ventricular function, wall motion, valvular disease, pericardial effusion, and intracardiac thrombus. **MRI of the brain** is superior to CT for detecting posterior fossa lesions (brainstem and cerebellum), early ischaemic stroke (diffusion-weighted imaging), multiple sclerosis plaques, and cerebral venous sinus thrombosis. **Radiation protection**: unnecessary imaging should be avoided; the **ALARA principle** (As Low As Reasonably Achievable) governs radiological protection.

Fill in the blank: CT pulmonary angiography (CTPA) is the investigation of choice for suspected pulmonary _____ , demonstrating filling defects within the pulmonary arteries on contrast-enhanced imaging.

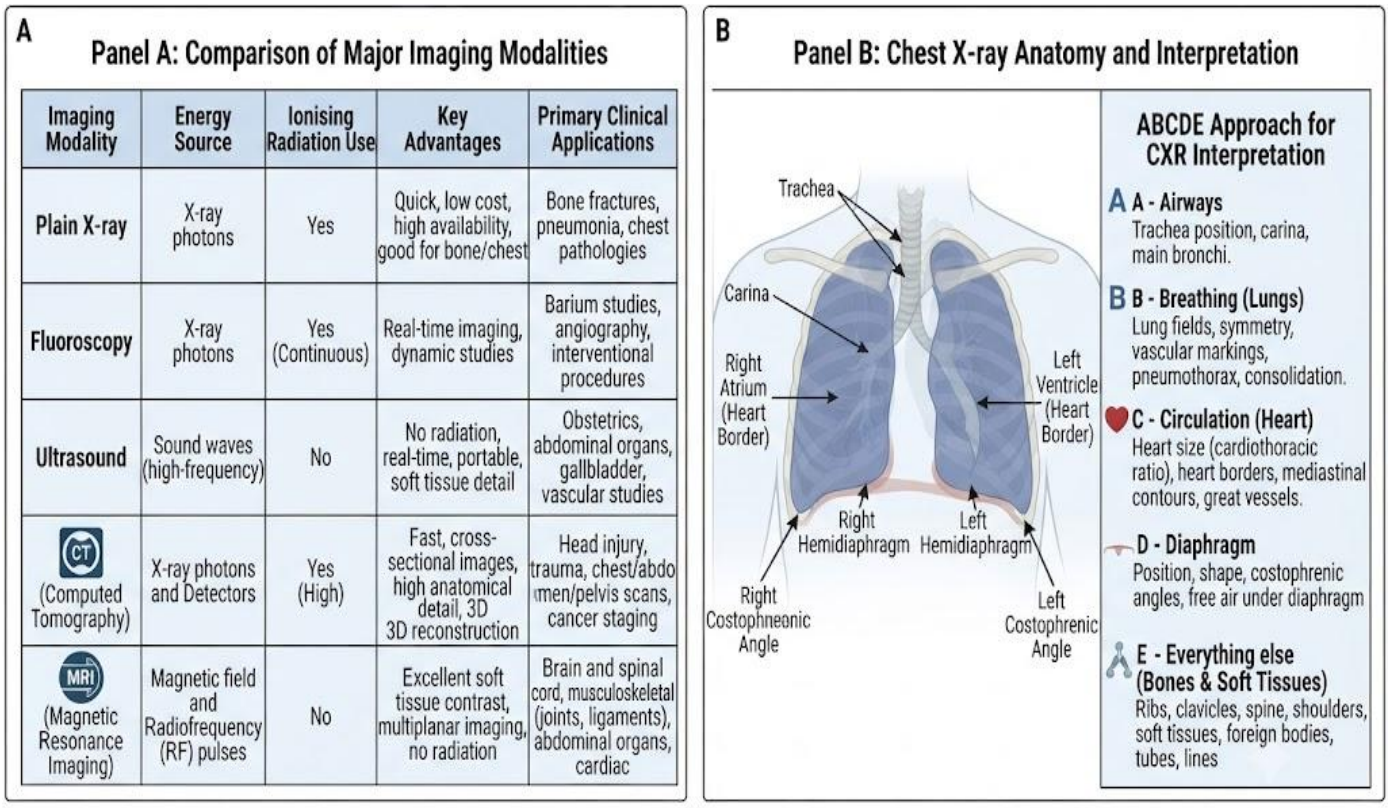


Figure 5.3: Radiology: imaging modalities and chest X-ray interpretation

Figure 5.3: Radiology: imaging modalities and chest X-ray interpretation

Pilot questions 5.3

1. Name the five imaging modalities and state one key advantage of each.
2. What does the ABCDE approach to chest X-ray interpretation stand for?
3. What is the air bronchogram sign and what does it indicate?
4. What is the investigation of choice for suspected pulmonary embolism and what does it show?
5. Name two clinical applications of abdominal ultrasound.

5.4 Good Clinical Practice and Patient Safety

5.4.1 Elements of good clinical practice

Good clinical practice (GCP) is the standard by which clinical trials and medical care are conducted to ensure that the rights, safety, and well-being of patients are protected and that results are credible. In everyday clinical medicine, GCP encompasses: **evidence-based practice** (clinical decisions informed by the best available research evidence, integrated with clinical expertise and patient values and preferences); **accurate and timely documentation** (clinical notes, investigation results, and treatment plans recorded clearly, legibly, and promptly in a standardised format, serving both clinical care and medicolegal purposes); and **clear communication** across the clinical team (structured handover using tools such as **SBAR**: Situation, Background, Assessment, Recommendation).

Continuing professional development (CPD) is the obligation of clinicians to maintain and extend their knowledge, skills, and professional standards throughout their careers, through attendance at educational activities, self-directed learning, audit, and peer review. **Clinical audit** compares current practice against defined standards to identify gaps and drive improvement; the audit cycle (standard setting, data collection, comparison with standard, change implementation, re-audit) is the primary quality improvement tool at clinical unit level. **Evidence-based clinical guidelines** (produced by organisations such as WHO, NICE, and the Federal Ministry of Health Nigeria) synthesise research evidence into practical recommendations that standardise and improve clinical care.

Fill in the blank: The _____ communication tool (Situation, Background, Assessment, Recommendation) provides a structured framework for clinical handover, reducing information loss between clinical team members.

5.4.2 Medical error, patient safety, and incident reporting

Medical error is a failure in the process of care that results in or has the potential to result in harm to the patient. Errors are classified as **active failures** (errors made by the person directly involved in patient care: wrong drug, wrong dose, wrong patient) and **latent failures**

(deficiencies in the system, organisation, or environment that create conditions in which errors are more likely: inadequate staffing, poor equipment, unclear protocols). The **Swiss cheese model** of patient safety (Reason) illustrates how multiple layers of defence each have holes (latent failures); accidents occur when these holes align, allowing a hazard to pass through all defences.

Incident reporting (the systematic reporting of adverse events, near misses, and unsafe conditions) is fundamental to patient safety improvement; near misses (events that could have caused harm but did not) are particularly valuable learning opportunities because they are more frequent than actual adverse events and reveal system weaknesses before harm occurs. **Root cause analysis (RCA)** is a structured method for investigating serious adverse events, identifying the underlying system factors (root causes) rather than blaming individual practitioners, and generating recommendations to prevent recurrence. A **non-punitive reporting culture**, in which staff can report errors without fear of disciplinary consequences, is a prerequisite for effective patient safety systems.

Fill in the blank: The _____ cheese model of patient safety illustrates how multiple defensive layers each have holes; adverse events occur when these holes align, allowing a hazard to pass through all defences simultaneously.

5.4.3 Clinical governance and quality improvement

Clinical governance is the framework through which healthcare organisations are accountable for continuously improving the quality of their services and safeguarding high standards of care. Its pillars include: **clinical audit** (measuring current practice against standards), **education and training** (ensuring staff competence), **evidence-based practice** (implementing research findings), **risk management** (identifying and mitigating potential harms), **patient and carer involvement** (incorporating patient feedback and experience into service improvement), **staffing and staff management** (maintaining adequate staffing levels and supervision), and **information management** (accurate, accessible clinical records and performance data).

Quality improvement (QI) methodologies provide structured approaches to improving clinical processes. The **Plan-Do-Study-Act (PDSA) cycle** is the most widely used: Plan (identify the

problem and plan a change), Do (implement the change on a small scale), Study (measure the effect), Act (adopt, adapt, or abandon the change based on findings, then repeat). **LEAN methodology** (derived from manufacturing) reduces waste and inefficiency in clinical processes by mapping value streams and eliminating non-value-adding steps. The **In Nigeria**, the **Standard Treatment Guidelines** and the **National Health Act 2014** provide the regulatory and clinical frameworks within which GCP and quality improvement operate, with the MDCN enforcing professional standards.

Fill in the blank: The Plan-Do-_____ -Act (PDSA) cycle is the most widely used quality improvement methodology, providing a structured approach to testing and implementing changes in clinical practice.

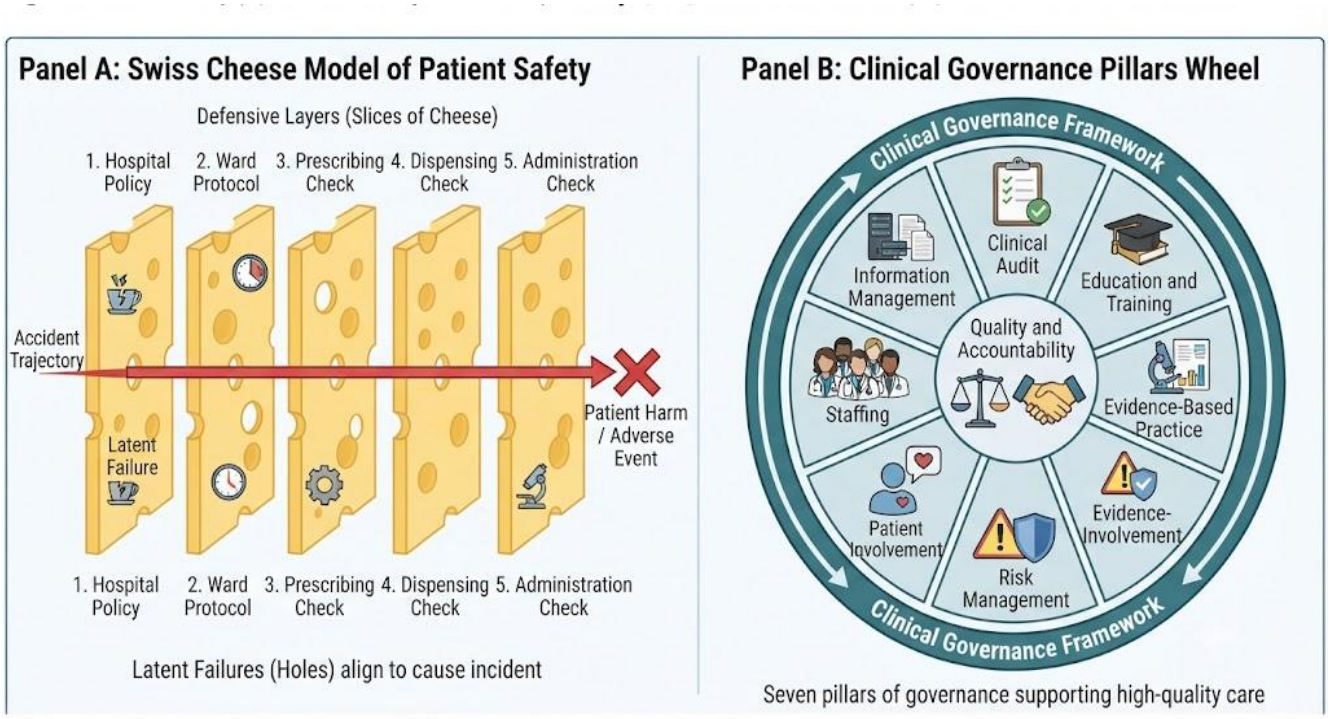


Figure 5.4: Good clinical practice, patient safety, and clinical governance

Figure 5.4: Good clinical practice, patient safety, and clinical governance

Pilot questions 5.4

1. Name four elements of good clinical practice.
2. Define medical error and distinguish between active and latent failures.
3. What is a near miss and why are near misses particularly valuable for patient safety?

4. What is root cause analysis and what is its aim?
5. Name the seven pillars of clinical governance.

Series Summary

This final Series applied basic medical science knowledge to the clinical setting across four domains. Applied physiology examined homeostasis, total body water compartment distribution, and common fluid and electrolyte disorders (hyponatraemia classified by volume status; hypokalaemia and hyperkalaemia with ECG changes and emergency management), and the four primary acid-base disorders (respiratory acidosis/alkalosis, metabolic acidosis/alkalosis), with the anion gap distinguishing high from normal gap metabolic acidosis. Applied pharmacology covered pharmacokinetics (ADME, half-life, therapeutic drug monitoring, dose adjustment in organ impairment), pharmacodynamics (receptors, agonists, antagonists, dose-response), and adverse drug reactions (Types A to D), drug interactions, and rational prescribing.

Radiology principles were described across five imaging modalities (plain X-ray, fluoroscopy, ultrasound, CT, MRI), with detailed attention to chest X-ray interpretation (ABCDE approach, air bronchogram, silhouette sign, Kerley B lines, pneumothorax, pleural effusion) and selected CT, ultrasound, and MRI applications. Good clinical practice was addressed through evidence-based practice, documentation, SBAR communication, clinical audit, and continuing professional development. Patient safety was examined through the Swiss cheese model, incident reporting, root cause analysis, and a non-punitive reporting culture. Clinical governance pillars and the PDSA quality improvement cycle completed the Series and the course (SLOs 5.1 to 5.4).

Glossary of Terms

- **ADME:** the four pharmacokinetic processes of drug disposition: Absorption, Distribution, Metabolism, and Excretion.
- **Anion gap:** calculated as Na^+ minus $[Cl^- + HCO_3^-]$; elevated above 12 mmol/L in high-anion-gap metabolic acidosis (lactic acidosis, DKA, renal failure, ingested acids).
- **Clinical audit:** a quality improvement process comparing current clinical practice against defined standards to identify gaps and drive improvement.

- **Clinical governance:** the framework through which healthcare organisations are accountable for continuously improving quality and safeguarding standards of care.
- **Half-life (t½):** the time required for plasma drug concentration to fall by 50%; a drug reaches steady state after approximately five half-lives.
- **Homeostasis:** the maintenance of a stable internal environment through dynamic negative feedback regulatory mechanisms.
- **Latent failure:** a deficiency in the system, organisation, or environment that creates conditions in which errors are more likely.
- **PDSA cycle:** Plan-Do-Study-Act; the most widely used quality improvement cycle for testing and implementing changes in clinical practice.
- **Root cause analysis (RCA):** a structured method for investigating serious adverse events to identify underlying system factors and prevent recurrence.
- **SBAR:** Situation, Background, Assessment, Recommendation; a structured communication tool for clinical handover.
- **Silhouette sign:** loss of a normally visible anatomical border on chest X-ray due to adjacent pathology of similar density.
- **Swiss cheese model:** a patient safety model illustrating how adverse events occur when holes in multiple defensive layers align simultaneously.

Concept Check Questions [Series 5]

Objective questions

1. Total body water constitutes approximately _____ % of body weight in adult males, distributed between intracellular (two-thirds) and extracellular (one-third) compartments. (Linked to SLO 5.1)
2. Hyperkalaemia at dangerous levels is treated first with intravenous calcium _____ to stabilise the cardiac membrane. (Linked to SLO 5.1)
3. A drug reaches steady _____ after approximately five half-lives of regular dosing. (Linked to SLO 5.2)
4. Type _____ adverse drug reactions are predictable, dose-dependent, and related to the pharmacological action; dose reduction is usually sufficient. (Linked to SLO 5.2)
5. On a plain radiograph, _____ appears black (most radiolucent) while calcium and bone appear white (most radio-opaque). (Linked to SLO 5.3)
6. The Swiss _____ model of patient safety illustrates how adverse events occur when holes in multiple defensive layers align. (Linked to SLO 5.4)

Short-answer questions

7. Describe the four primary acid-base disorders, giving the pH change, the primary derangement, and one cause of each. (Linked to SLO 5.1)
8. Describe the ABCDE approach to chest X-ray interpretation and name two radiological signs that indicate consolidation. (Linked to SLO 5.3)

Long-answer questions

9. Discuss the principles of pharmacokinetics and pharmacodynamics and explain how these principles guide rational prescribing and the management of adverse drug reactions. (Linked to SLO 5.2)
10. Evaluate the principles of good clinical practice, patient safety, and clinical governance, explaining how they together ensure high-quality and safe medical care. (Linked to SLO 5.4)

Answers to Concept Check Questions [Series 5]

Objective questions

1. 60.
2. Gluconate.
3. State.
4. A.
5. Air.
6. Cheese.

Short-answer questions

7. Respiratory acidosis: pH reduced, $PaCO_2$ elevated; cause: hypoventilation (COPD, opioid overdose). Respiratory alkalosis: pH elevated, $PaCO_2$ reduced; cause: hyperventilation (anxiety, pulmonary embolism). Metabolic acidosis: pH reduced, HCO_3^- reduced; cause: lactic acidosis, diabetic ketoacidosis; distinguished by anion gap. Metabolic alkalosis: pH elevated, HCO_3^- elevated; cause: vomiting, diuretics, hyperaldosteronism.
8. A (Airway): tracheal position, carina angle. B (Breathing): lung fields, symmetry, consolidation, pneumothorax, effusion. C (Cardiac): cardiothoracic ratio (normal below 0.5), cardiac borders. D (Diaphragm): level, costophrenic angles, subphrenic gas. E (Everything else): bones, soft tissues, lines, tubes. Two signs of consolidation: air bronchogram (air-filled bronchi visible within opacified lung, excluding effusion and collapse); silhouette sign (loss of a border adjacent to the consolidated lobe, e.g. right heart border lost in right middle lobe consolidation).

Long-answer questions

9. **Basic response:** Pharmacokinetics (ADME): absorption (oral bioavailability and first-pass metabolism); distribution (volume of distribution, protein binding, lipid solubility); metabolism (hepatic cytochrome P450, enzyme inducers and inhibitors); excretion (renal, guided by creatinine clearance for dose adjustment). Half-life (steady state after 5 half-lives); narrow therapeutic index drugs require TDM (digoxin, lithium, warfarin).

Pharmacodynamics: agonists (activate receptors), antagonists (block receptors), dose-response curve, EC50. ADR types: A (predictable, dose-dependent, dose reduce); B (unpredictable, stop drug); C (chronic use); D (delayed). Drug interactions: enzyme inducers (rifampicin, phenytoin) reduce co-drug levels; enzyme inhibitors (erythromycin, fluconazole) increase co-drug levels causing toxicity. Rational prescribing: right drug, dose, route, patient, duration, cost.

Value-added response: The pharmacokinetic principles of ADME are not merely academic; they explain the most common prescribing errors in Nigerian clinical practice. Failing to adjust the dose of renally cleared drugs (aminoglycosides, metformin, low-molecular-weight heparin) in patients with renal impairment, prescribing rifampicin without warning patients that it will reduce the effectiveness of oral contraceptives and antiretroviral drugs, and using narrow therapeutic index drugs without monitoring plasma levels are each directly explained by inadequate understanding of pharmacokinetics. The clinical pharmacology taught in this module therefore translates immediately into safer prescribing practices.

10. **Basic response:** Good clinical practice: evidence-based practice (best research evidence integrated with expertise and patient values); accurate documentation (medicolegal and clinical care purposes); clear communication (SBAR for handover); CPD (maintaining competence); clinical audit (current practice vs standards, audit cycle). Patient safety: medical error types (active failures: wrong drug/dose/patient; latent failures: staffing, equipment, protocols); Swiss cheese model (adverse events when defensive layer holes align); incident reporting (near misses especially valuable); root cause analysis (system factors, not blame); non-punitive culture prerequisite. Clinical governance pillars: clinical audit, education and training, evidence-based practice, risk management, patient involvement, staffing, information management. Quality improvement: PDSA cycle (Plan-Do-Study-Act); LEAN methodology.

Value-added response: The principles of patient safety and clinical governance represent a fundamental shift in how medical error is understood: from a moral failing of the individual practitioner to a systems engineering problem. This shift matters clinically because it changes what actions produce improvement: blaming and shaming individual practitioners who make

errors produces no sustainable improvement (and discourages incident reporting); systematically redesigning processes to make errors less likely and less harmful does. In Nigerian healthcare settings where staffing constraints, equipment limitations, and information system weaknesses create unusually high background latent failure rates, understanding and addressing these system factors is the highest-leverage approach to patient safety improvement.

Answers to Pilot Questions [Series 5]

Part 5.1

1. Homeostasis is the maintenance of a stable internal environment through dynamic negative feedback regulatory processes. Four key variables: body temperature, blood pressure, arterial pH, plasma osmolality (also acceptable: blood glucose, electrolyte concentrations).
2. Total body water (approximately 60% of body weight in males) is divided into intracellular fluid (approximately two-thirds of TBW) and extracellular fluid (approximately one-third of TBW); ECF is further divided into intravascular (plasma, approximately 25% of ECF) and interstitial fluid (approximately 75% of ECF).
3. Hypovolaemic hyponatraemia: reduced total body sodium and water, sodium more so; causes: vomiting, diarrhoea, diuretics. Euvolaemic hyponatraemia: excess water without sodium loss; cause: SIADH, hypothyroidism. Hypervolaemic hyponatraemia: excess total body sodium and water, water more so; causes: cardiac failure, cirrhosis, nephrotic syndrome.
4. Respiratory acidosis (elevated $PaCO_2$, reduced pH; cause: COPD). Respiratory alkalosis (reduced $PaCO_2$, elevated pH; cause: hyperventilation). Metabolic acidosis (reduced HCO_3^-, reduced pH; cause: diabetic ketoacidosis). Metabolic alkalosis (elevated HCO_3^-, elevated pH; cause: vomiting).

5. Anion gap = $Na^+ - [Cl^- + HCO_3^-]$; normal 8 to 12 mmol/L. Elevated anion gap (above 12) indicates high-anion-gap metabolic acidosis caused by addition of an unmeasured acid (lactic acidosis, diabetic ketoacidosis, renal failure, salicylate poisoning).

Part 5.2

1. Pharmacokinetics is the study of what the body does to a drug. ADME: Absorption (drug from administration site to systemic circulation), Distribution (drug from blood to tissues), Metabolism (biotransformation, primarily hepatic), Excretion (drug elimination, primarily renal).
2. A narrow therapeutic index drug is one where the toxic dose and the therapeutic dose are close together, requiring careful monitoring. Examples: digoxin, lithium, warfarin (also acceptable: phenytoin, aminoglycosides, theophylline).
3. Agonists bind receptors and activate them, mimicking the endogenous ligand to produce a pharmacological effect. Antagonists bind receptors without activating them, blocking the effect of the endogenous ligand or agonist.
4. Type A (predictable, dose-dependent, pharmacological): hypoglycaemia from insulin. Type B (unpredictable, dose-independent): anaphylaxis from penicillin. Type C (chronic use): adrenal suppression from prolonged corticosteroids. Type D (delayed): carcinogenesis from chemotherapy.
5. Rational prescribing is selecting the right drug, dose, route, patient, and duration at the right cost. Risks of polypharmacy: increased drug interactions and increased risk of adverse drug reactions (also acceptable: poor adherence, medication errors).

Part 5.3

1. Plain X-ray (fastest, cheapest, most available, first-line for most questions); ultrasound (no ionising radiation, portable, excellent for soft tissue and abdominal structures); CT (excellent spatial resolution, rapid, cross-sectional detail); MRI (superior soft tissue

contrast, no ionising radiation, best for brain and spinal cord); fluoroscopy (real-time X-ray for dynamic studies).

2. A (Airway): tracheal position and carina angle. B (Breathing): lung fields, looking for consolidation, pneumothorax, effusion, nodules. C (Cardiac): heart size (cardiothoracic ratio) and cardiac borders. D (Diaphragm): level, costophrenic angles, subphrenic gas. E (Everything else): bones, soft tissues, lines, and tubes.
3. The air bronchogram sign is the visible appearance of air-filled bronchi within an opacified (white) area of lung on chest X-ray. It indicates consolidation (as in pneumonia): the surrounding alveoli are filled with fluid or inflammatory exudate while the bronchi remain patent and air-filled.
4. CT pulmonary angiography (CTPA) is the investigation of choice for suspected pulmonary embolism. It shows filling defects (areas of absent contrast) within the pulmonary arteries where clot has occluded the vessel lumen.
5. Any two of: suspected biliary disease (gallstones, biliary dilatation); renal disease (hydronephrosis, renal cysts, mass lesions); abdominal aortic aneurysm screening; hepatic disease; obstetric assessment of the foetus.

Part 5.4

1. Any four of: evidence-based practice; accurate and timely documentation; clear communication (SBAR handover); continuing professional development (CPD); clinical audit; adherence to clinical guidelines.
2. Medical error is a failure in the process of care resulting in or having the potential to result in patient harm. Active failures are errors made by the person directly involved in patient care (wrong drug, wrong dose). Latent failures are deficiencies in the system or organisation that create conditions making errors more likely (inadequate staffing, poor equipment, unclear protocols).
3. A near miss is an event that could have caused harm but did not, through chance or timely intervention. Near misses are particularly valuable because they are more frequent than

actual adverse events and reveal system weaknesses before harm occurs, allowing corrective action without waiting for a patient to be harmed.

4. Root cause analysis is a structured method for investigating serious adverse events. Its aim is to identify the underlying system factors (root causes) rather than blame individual practitioners, and to generate actionable recommendations to prevent recurrence of similar events.
5. Clinical audit, education and training, evidence-based practice, risk management, patient and carer involvement, staffing and staff management, and information management.

References and Attributions [Series 5]

Textual references

- Rang, H. P., Ritter, J. M., Flower, R. J., & Henderson, G. (2019). Rang and Dale's pharmacology (9th ed.). Elsevier.
- Guyton, A. C., & Hall, J. E. (2020). Guyton and Hall textbook of medical physiology (14th ed.). Elsevier.
- Corne, J., Carroll, M., Brown, I., & Delany, D. (2002). Chest X-ray made easy (2nd ed.). Churchill Livingstone.
- National Open University of Nigeria (NOUN). (2023). Introduction to clinical medicine I course material. NOUN Press.

Figures, Plates, Tables, and Boxes

- Figure 5.1: Applied physiology: fluid compartments and acid-base disorders Attribution: AI generated using prompt "Generate a two-panel diagram showing body fluid compartments with volumes and an acid-base disorder interpretation grid." Suggested OER search string: "body fluid compartments intracellular extracellular TBW acid-base disorders metabolic respiratory acidosis alkalosis OER"
- Figure 5.2: Pharmacokinetics, pharmacodynamics, and adverse drug reactions Attribution: AI generated using prompt "Generate a two-panel diagram showing the ADME pharmacokinetic model and the four ADR types with mechanisms and examples." Suggested OER search string: "pharmacokinetics ADME absorption distribution metabolism excretion half-life adverse drug reactions types A B C D OER"
- Figure 5.3: Radiology: imaging modalities and chest X-ray interpretation Attribution: AI generated using prompt "Generate a two-panel diagram comparing imaging modalities in a table and a labelled chest X-ray diagram with ABCDE approach." Suggested OER search string: "radiology imaging modalities chest X-ray interpretation ABCDE CT MRI ultrasound plain radiograph OER"

- Figure 5.4: Good clinical practice, patient safety, and clinical governance Attribution: AI generated using prompt "Generate a two-panel diagram showing the Swiss cheese patient safety model and clinical governance pillars wheel." Suggested OER search string: "patient safety Swiss cheese model medical error incident reporting clinical governance PDSA quality improvement OER"