Chapter 1

Instruments and Bedside Procedures

"The greater the ignorance, the greater the dogmatism."

— **Sir William Osler** (1849-1919), Baronet, Canadian physician and professor of medicine, an author, medical philosopher, historian and teacher—could well be considered the most influential figure in the history of medicine—*'Father of modern medicine'*

RYLE'S TUBE (NASOGASTRIC TUBE)

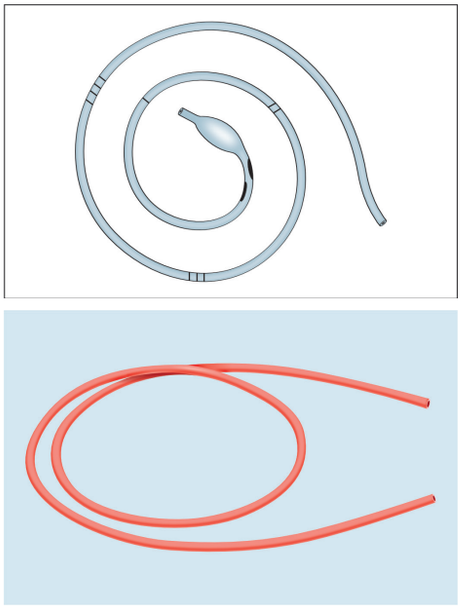


Fig. 1.1: Ryle's tube (polythene and rubber) showing markings

Q. Description (Fig. 1.1):

It is a fine bore flexible red rubber or polythene (transparent) tube with external circumference of 8 mm and length 105 cm. The blind bulbous tip contains a lead shot inside the tube to facilitate passage of the tube into the oesophagus (it is heavy and thus easier for the patient to swallow the tip). The lower end of the tube is perforated by a number of side holes at different levels to allow easy suction of gastro-duodenal contents. There are four black circular markings in the body of the tube as mentioned below:

a. ***First mark (single circular mark):*** Placed at a distance of 40 cm from the tip and indicates the distance from upper central incisor teeth to cardiac orifice of stomach.
b. ***Second mark (two circular marks):*** Indicates the distance between upper central incisor teeth and body of stomach (50 cm).
c. ***Third mark (three circular marks):*** Indicates the distance between upper central incisor teeth and pylorus (57 cm).
d. ***Fourth mark (four circular marks):*** Indicates the distance between upper central incisor teeth and first part of duodenum (65 cm). It means the tube has reached duodenum when the fourth mark is seen at the teeth.

The base (open end) is usually plugged by a conical plastic cap, and is used to fit with the nozzle of a syringe to push or to draw materials from the stomach. Ryle's tube is usually sterilised by keeping in boiling water for 30 minutes or by gamma ray irradiation.

The tip is made blunt to avoid trauma during introduction. If the perforations near the lower end are placed at same level, the tube may be easily torn during manipulation and if blocked (with openings at same level) by food debris or sticking to the mucosal surface of stomach, it would hamper suction of gastro-duodenal contents. Ryle's tube is available in different sizes like 4–18 French (tube with smaller diameter is used in children; adult size is 16–18 French). Instead of lead shot, polythene tube usually contains 3 radio-opaque metal balls.

Q. How to be sure that the tip has reached the stomach?

It is confirmed by the following methods:

1. Apply a 50 mL syringe at the open end of Ryle's tube. Inject air into the tube by pushing the piston with a single rapid thrust and simultaneously auscultate over the epigastrium. A gurgling sound confirms the position of the tube in the stomach.
2. Aspirate the gastric contents; the contents come out freely if the tube is in the stomach. Acidic nature of the

gastric contents may be confirmed by litmus paper test.

3. Fluoroscopy or straight X-ray of the abdomen shows the exact position of the tip of the tube as the tip contains lead shot or radio-opaque material.
4. Colorimetric capnography done to assure the postion in a mechanically ventilated patient.

- If the tube is passed falsely into the respiratory tract (trachea),

a. The patient complains of a choking sensation.

b. Violent cough appears and persists for a long time.

c. Air comes from the open end with breathing.

d. Yield of aspiration becomes nil.

In this situation, take out the tube immediately and try to reintroduce it cautiously.

Q. Why this nasogastric tube is named after 'Ryle'?

So far too many varieties of nasogastric tubes have been discovered but the tube designed by the physician, John Alfred Ryle (1889–1950) of Guy's Hospital Medical School is the most acceptable and commonly used type.

Another nasogastric tube: **Levine's tube** is longer, made of Portex and without the lead shot at the tip.

Q. How the Ryle's tube is introduced?

The patient is first explained about the procedure in order to obtain maximum cooperation. Ask the patient to lie flat in bed with extended neck. Remove the dentures, if present. In the nose, a more patent nostril is selected and properly cleansed, and lubricated with lignocaine jelly (2%). At first, check patency of the tube. Lubricate the tip of the sterilised tube with liquid paraffin or glycerine, and introduce the tip gently through one nostril (manually, mould the lower end of the tube a bit curved for easy passage through nasopharynx). As the tube reaches the oropharynx, the patient may start coughing once or twice and may even try to throw the tube by pulling it with his hands. Reassure the patient and ask him to swallow the tube, and to facilitate swallowing, one or two teaspoonfull of water may be poured into the mouth. With patience, the tube will gradually pass into the stomach by gentle push. Be sure that the tube is in the stomach and not within the trachea (see above). Take care in case of a comatosed patient, where the protective cough reflex is lost and the tube may be falsely introduced within the trachea without any alarming sign.

Lastly, the base (open end) of the tube is kept adhered to the forehead by a leucoplast and the open end is usually plugged (except in intestinal obstruction where the open end is kept open to allow continuous drainage). In a restless patient, hands should be tied.

Conventionally, the tube should not be kept for more than 48 hours. After 48 hours, the tube should be smeared daily with some antiseptic solution by withdrawing it only for 2 inches (the part lying within the nose), and then reintroducing it.

- Do not force the passage of Ryle's tube, if persistent resistance is felt.
- In repeated failure, try a smaller gauge tube.

Q. Different uses of Ryle's tube?

A. Diagnostic

1. To confirm and evaluate upper GI haemorrhage (i.e. in haematemesis or melaena).
2. Fractional test meal (gastric analysis)—virtually obsolete nowadays.
3. To isolate AFB from gastric juice in a child who is suffering from pulmonary tuberculosis (children usually swallow their sputum), or the patient who cannot expectorate sputum; searching for malignant cells in gastric carcinoma.
4. For forensic purpose—detection of cause of death in a suspected case of poisoning by subsequent chemical analysis of gastric aspiration (e.g. barbiturate, organophosphorus, copper sulphate, alcohol, etc.).
5. To aspirate duodenal secretions for analysis of:
   a. Pancreatic functions,
   b. Detection of typhoid carriers, and
   c. Detection of *Giardia lamblia* infestation.
6. To diagnose gastric outlet obstruction (gastic aspirate will exceed 200 mL after overnight fasting).

B. Therapeutic

1. Nasogastric feeding (*see* the next question).
2. Nasogastric suction in:
   a. Acute intestinal obstruction to relieve abdominal distension,
   b. Bowel rest in acute pancreatitis, Crohn's disease and intestinal fistula,
   c. Acute dilatation of stomach (i.e. gastric decompression),
   d. Acute abdomen,
   e. Postoperative, and
   f. GI tract haemorrhage or perforation (paralytic ileus).
3. Gastric wash or lavage done in:
   a. Pyloric stenosis,
   b. Non-corrosive poisoning, drug overdose, and
   c. Severe hiccough (i.e. bowel irrigation by ice-cold water or sodi-bicarbonate solution).
4. Medication in comatose patient or critically ill patient.
5. It can be used as a tourniquet (tourniquet is a device, made of latex tube, which is commonly used to stop the flow of blood through a vein or artery).

- **Gastric lavage is contraindicated** in a) Corrosive poisoning (Ryle's tube may perforate the oesophagus in acid or alkali poisoning), and b) Kerosine oil, paraffin or petrolium poisoning (gastric lavage increases the chance of development of lipoid pneumonia). Ryle's tube should not be used in severe fracture of base of the skull as there is a rare chance of intracranial introduction. Nasogastric feeding is unsuitable in stricture of

upper GI tract and patients with high risk of aspiration (e.g. kerosine oil).

- The **two main indications for use of Ryle's tube** are: a) aspiration of gastric contents, and b) nutritional supplementation of the patient.
- Left lateral position of the patient facilitates the recovery of gastric juices through Ryle's tube.
- Insert a cuffed endotracheal tube before performing gastric lavage in unconscious patients.

Q. Indications for Ryle's tube feeding:

1. Unconscious patients (e.g. CVA, hepatic encephalopathy, diabetic ketoacidosis, cerebral malaria, encephalitis, meningitis, head injury) or critically ill patients.
2. Inability to swallow, e.g. after facio-maxillary injury or surgery, bulbar palsy.
3. Patients who are reluctant to take food orally, e.g. severe anorexia, anorexia nervosa, etc.
4. Neurogenic dysphagia, nasal regurgitation in polymyositis or dermatomyositis.
5. In patients with burns.

Clinical Wisdom

Previously used intragastric milk drip in acute exacerbation of chronic duodenal ulcer is not practised now as milk may increase gastric acid secretion and release of gastrin, stimulated by direct effect of milk protein and calcium.

Q. Complications of nasogastric intubation:

1. Rhinitis and pharyngitis; ulceration in oesophagus may develop.
2. Epistaxis (from nasal injury during introduction).
3. If the tube enters into trachea, aspiration pneumonia and even death may result.
4. Blockage of the tube.
5. If the tube is kept *in situ* for a prolonged period (e.g. in bulbar palsy), it is often difficult to take out the tube (the Ryle's tube may be coiled spontaneously inside the lumen of stomach).
6. Perforation of pharynx or oesophagus (chance increased in presence of oesophageal disease).
7. Chance of respiratory tract infections in prolonged intubation (thus, chest physiotherapy is necessary).

Q. Stomach wash (gastric lavage) tube: What is it (Fig. 1.2)?

It is a special wide-bore tube of 75 cm in length, and with an attached funnel (may have a plastic or wooden mouth gag, which prevents biting of the tube by teeth) at the proximal end to wash (gastric lavage) poison, alcohol or overdose of drug. It has a black ring at 45 cm from the tip which indicates the distance between upper central incisor teeth and cardiac end of stomach. This tube is used for stomach wash and is kept in emergency room of every hospital (adult size: 36–40 French). The complications encountered are aspiration, laryngospasm and bradycardia.

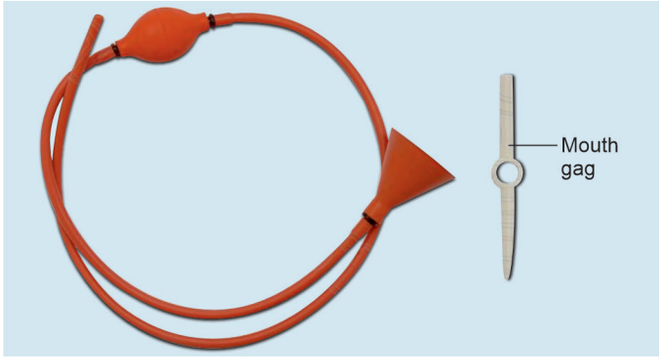


Fig. 1.2: Stomach wash tube (Ewald's)

Q. Hypochlorhydria and hyperchlorhydria:

A. Hypochlorhydria or achlorhydria:

1. Aged persons >60 years.
2. Pernicious anaemia.
3. Gastric malignancy.
4. After proton-pump inhibitor therapy.

B. Hyperchlorhydria:

1. Zollinger-Ellison syndrome.
2. Systemic mastocytosis.
3. Hyperparathyroidism.
4. G-cell hyperplasia.

Note

Read corrosive poisoning, drug overdose, haematemesis in details.

TRACHEOSTOMY TUBE (Fig. 1.3)

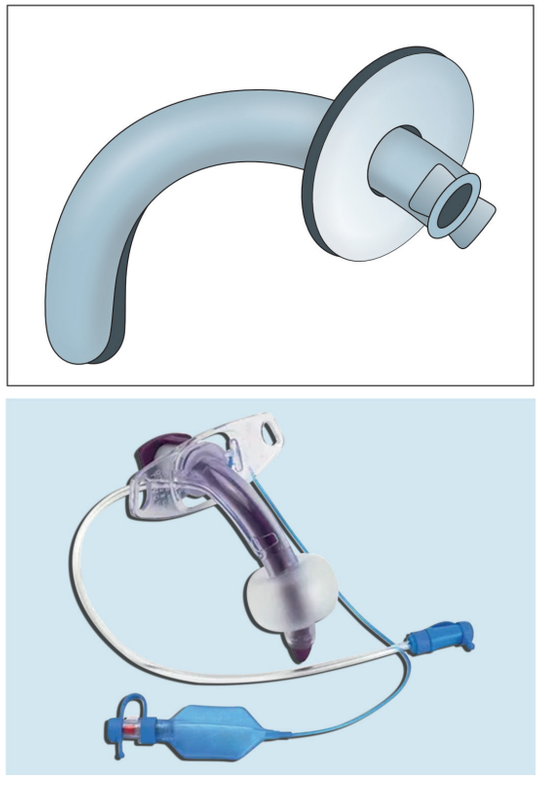


Fig. 1.3: Fuller's bivalved tracheostomy tube

Q. Available varieties:

A. Metallic variety:

a. Fuller's bivalved tube **(Fig. 1.3)**.
b. Parker's angled tube.
c. Durham's Lobster tail tube.

B. Rubber (synthetic) variety:

a. Ordinary rubber tube.
b. Portex tube.
c. Morrant Baker cuffed rubber tube.

Clinical Wisdom

Plastic or silicone tubes are increasingly popular because they are softer, less irritant and there is less crusting of secretions.

Q. Types of tracheostomy tube:

A. Metallic, or portex or rubber.
B. Cuffed (i.e. a balloon at the distal end of the tube, which can provide a seal between the tube and tracheal wall, if inflated) or uncuffed.

- Cuffed tracheostomy tube prevents aspiration, keeps the tube in position and prevents gaseous leak while on positive-pressure ventilation.
- Metallic tube is used in permanent tracheostomy, e.g. following laryngectomy.

Q. Description of Fuller's tracheostomy tube:

It is the commonly used type. It consists of one outer and one inner tube.

Outer tube: The curved tube is split distally into two thin blades which can be easily approximated. As the blades have spring-like action, it acts as a tracheal dilator. Proximally, the outer tube contains a rounded shield bearing an opening on each side through which threads can pass and is fastened to the back of the neck of the patient to fix the tube.

Inner tube: It is a tube with an opening and made for air passage. At its proximal end, there are two rings for easy handling. An obturator is the third part of the tube.

Q. What is tracheostomy?

'Tracheostomy' is an operation for temporary relief of a patient who is suffering from acute upper airway obstruction. It is aimed at making an opening into the trachea in order to by-pass the upper airway obstruction and introducing a tube into that opening through the incision given in the neck.

'Tracheotomy' is a simple incision given temporarily on trachea in an attempt to expose the tracheal lumen for the treatment of tumour or stenosis.

Q. Function of tracheostomy:

The tracheostomy serves the following purposes:

1. It by-passes the upper respiratory obstruction.
2. It reduces the physiological dead space and thus improves efficiency of respiration.
3. It diminishes airway resistance, i.e. strain of respiration is reduced.
4. It helps in removing the excess bronchial secretions.
5. Insertion of a cuffed tracheostomy tube helps in application of positive-pressure ventilation.

Q. Common indications for 'emergency' tracheostomy:

The principal indication is upper airway obstruction like:

1. Laryngeal diphtheria (pseudomembrane obstructs the larynx).
2. Impacted foreign body in the larynx.
3. Acute laryngeal oedema (oedema glottis resulting from anaphylaxis or inhalation of irritant gases) with cyanosis.
4. Tetany (in case of laryngysmus stridulus) or tetanus (laryngeal spasm).
5. Acute bulbar palsy (e.g. poliomyelitis, GB syndrome, rabies, myasthenic crisis).
6. Ludwig's angina.
7. Spasm of vocal cord (tabetic laryngeal crisis) in tabes dorsalis (not seen nowadays).

Q. Common indications for 'planned' or 'elective' tracheostomy:

1. As a preliminary step in different operations in larynx.
2. To relieve obstruction in a case of laryngeal carcinoma.
3. In respiratory failure (paralysis of intercostal muscles), i.e. for long-term ventilation, this is aimed to reduce the dead space. Apart from this, intermittent positive-pressure ventilation may be applied through a cuffed endotracheal tube inserted via a tracheostomy, in patients suffering from respiratory paralysis with or without bulbar palsy (particularly when the respiratory paralysis is likely to last for more than 2–3 days)—facilitation of ventilation support.
4. Bronchial lavage.
5. Incompetent larynx with aspiration.

Q. Different types of tracheostomy:

It depends on the position of isthmus of the thyroid gland.

a. *High tracheostomy:* Opening done above the isthmus (it has the risk of injuring cricoid cartilage, followed by stenosis).
b. *Median tracheostomy:* Opening done at the level of the isthmus (choice in acute emergencies).
c. *Low tracheostomy:* Opening done below the isthmus (some physicians prefer this method).

Q. Common bedside features of laryngeal (or upper airway) obstruction:

The patient presents with:

1. Restlessness with hyperactive accessory muscles of respiration.
2. Dyspnoea and even orthopnoea.

3. Cough (croupy cough is seen in diphtheria).
4. Stridor.
5. Central cyanosis.
6. Intercostal suction.
7. Signs of exhaustion.

Q. How the tube is introduced?

The two tubes are separated. Press the two cusps (blades) of the outer tube and try to appose them, and now introduce it with its concavity directed downwards. The blades will open up and will act as a tracheal dilator. Tie the outer tube round the neck with a thread. Then introduce the inner tube through the outer one and place a piece of wet sterile gauze over the opening of the tube. The advantages of double tubing are:

a. When the inner tube is taken out for cleaning, the outer tube serves the purpose.
b. Bivalved outer tube helps to avoid the use of an additional tracheal dilator.

Q. Precautions taken during the period of intubation:

1. The metallic tube is kept for a short period, usually not more than 24 hours to avoid necrosis of trachea which may lately give rise to tracheal stenosis. This should be replaced by rubber tracheostomy tube.
2. The rubber tube may be kept up to a desired period.
3. Precautions are taken so that the tube remains patent. Intermittent suction may serve the purpose.
4. Strict asepsis is maintained. A sterile gauze piece soaked in 1:1000 acriflavine solution or povidone-iodine solution is commonly used over the opening of the tube.
5. Systemic broad-spectrum antibiotic is used to prevent respiratory tract infections, as and when necessary. Good nursing care with strict asepsis is maintained.

- The inner tube should be removed every four hours for cleaning purpose. The excess of secretions should be removed (by suction) with a soft rubber catheter. Mucolytic aerosols or humidifiers are often used to liquefy the viscid secretions. The rubber tracheostomy tube can be kept usually for 2–3 weeks.
- Once the patient can sleep for a night with the tube plugged, it is then possible to remove the tracheostomy tube.
- The tracheostomy tube is sterilised by immersing in concentrated lysol solution.

Clinical Wisdom

Explain the procedure (if possible) and obtain **written informed consent** from the patient or relatives in all invasive procedures like tracheostomy, lumbar puncture, bone marrow aspiration, liver biopsy, etc.

Q. Postoperative complications:

1. Bronchopneumonia.
2. Mediastinal emphysema.
3. Mediastinitis (i.e. mediastinal infection).
4. Pneumothorax.
5. Pressure necrosis of anterior tracheal wall by inflated cuff.
6. Blockage of the tracheostomy tube (in improper toileting).
7. Tracheal stenosis or collapse of the tracheal rings; collapse of the lung.
8. Tracheo-oesophageal fistula.
9. Erosion of innominate artery.
10. Difficulty in decannulation ('decannulation' is the method of removal of tracheostomy tube by which tubes of progressively smaller diameter are introduced in order to adapt the patient to breathe through the normal airway, as the patient often forgets to breathe normally when tracheostomy tube remains for a longer period).

Note

Read steps of tracheostomy operation from standard ENT text-book. Read diphtheria and bulbar palsy in details.

SIMPLE RUBBER CATHETER

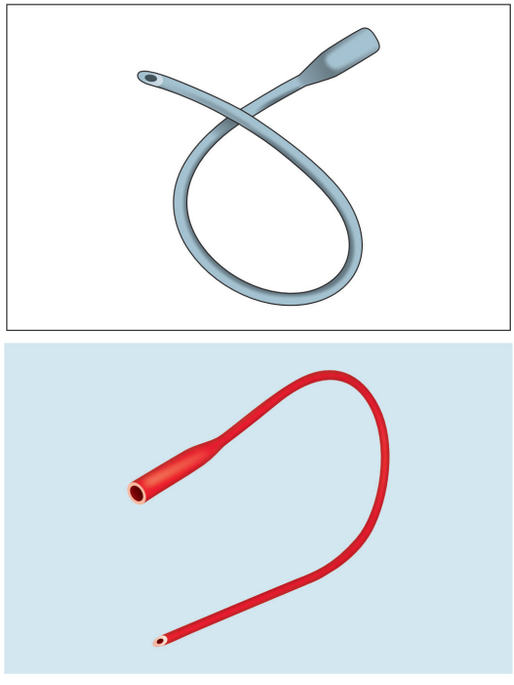


Fig. 1.4: Simple rubber catheter

Q. Description (Fig. 1.4):

1. Simple tube made of India-rubber or latex-rubber, and is also known as Robinson or Nelaton catheter.
2. There is a channel throughout the whole length of the tube.
3. Blunt and rounded tip with perforation (eye); the other end is open.
4. Number of size (available in different sizes) is printed on the catheter.

- The catheter is sterilised by keeping in boiling water for 30 minutes or by gamma ray irradiation.
- Catheters made of 'latex' make it biologically inert as far as possible. 'Silicone' catheters are preferred when required to be kept for a longer time or patient is allergic to latex.

Q. Different uses:

1. To relieve acute retention of urine.
2. To differentiate retention of urine from anuria.
3. To obtain urine specimen for examination in an unconscious or comatose patient.
4. To differentiate pelvic lump from bladder swelling.
5. Before or during delivery (child birth).
6. To monitor the urine output or to measure the residual volume of urine.
7. To prevent urinary incontinence in neurogenic bladder.
8. Used prior to cystography (to introduce dye in the urinary bladder).
9. For bladder wash or irrigation (by acriflavine or silver nitrate solution).
10. As a drainage tube.
11. As a tourniquet (to produce haemostasis or to make the veins prominent).
12. As an oxygen tube, i.e. used as a nasal catheter.
13. In infants, it may be used as a feeding tube.

- Simple rubber cathater is used for catheterisation 'just once' only.

Q. Mention common 'medical causes' of catheterisation:

Urinary catheters are of three types:

1. Simple rubber cetheter (intermittent self-catheter)
2. Self-retaining catheter (indwelling catheter):
   a. Gibbons catheter
   b. Foley's catheter
   c. Malecot's catheter
3. Condom catheter (*see* later)

Temporary catheterisation is done as an emergency measure to relieve pain induced by acute retention of urine. This is usually achieved by using simple rubber catheter or **Gibbons catheter**.

A self-retaining catheter (e.g. **Foley's catheter**) is used with intention to retain the catheter for a few days **(Fig. 1.5A)**. They are basically used in patients with benign hypertrophy of prostate (BHP) who are unfit for prostatectomy, neurogenic bladder and in patients who are mostly bed-bound (e.g. hemiplegia or paraplegia). **Malecot's catheter** is not used as an urethral catheter; the wings of the catheter provide increased drainage and as such it is used for drainage urine after renal or bladder surgery, pus from empyema thoracis or to relieve a patient of pneumothorax **(Fig. 1.5B)**. A 'haematuria catheter' is a three-way catheter (used in haematuria) with an extra channel for irrigation. The 'medical causes' are:

1. Coma or unconsciousness due to any cause, e.g. CVA (*hemiplegia*), diabetic ketoacidosis, encephalitis, hepatic coma, cerebral malaria.
2. Meningitis (tuberculous commonly).
3. Compressive myelopathy (caries spine), acute transverse myelitis, spinal injury, anterior spinal artery thrombosis, i.e. in *paraplegia*.

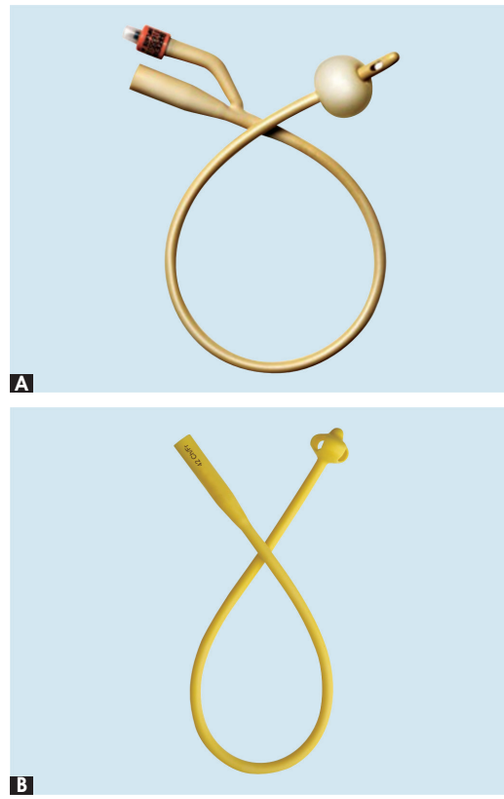


Fig. 1.5: (A) Foley's catheter; (B) Malecot's catheter

4. Poisoning: Opium, dhatura, organophosphorus or drug overdose (sedatives).
5. Snake bite (especially Viperidae group).
6. Sometimes, catheterisation is done in acute nephritis, nephrotic syndrome, renal failure and patients in intensive therapeutic unit (ITU) to measure the actual urinary output.

- Common surgical indications are BHP, vesical calculus, bladder injury and carcinoma of prostate.
- **Suprapubic cystostomy** (in hypogastrium) is done when urethral passage is narrow or blocked (e.g. severe prostatic enlargement), post-bladder and urethral surgeries, or for long term bladder drainage.
- Recurrent UTI is a relative contraindication for catheterisation.

Clinical Wisdom

Foley's catheter is named after American urologist Frederic Foley, who designed it in 1929. The balloon inside should be inflated by sterile water, and not by saline or air.

Q. Contraindications of catheterisation:

1. Recurrent urinary tract infection (UTI).
2. Meatal stenosis.
3. Rupture (suspected) of the urethra.
4. Stricture of the urethra.

Q. How to catheterise the urinary bladder?

Maintenance of strict asepsis is very important.

1. The procedure should be explained to the patient. The catheter is sterilised properly (or already done by manufacturers). The physician should follow strict

antiseptic and aseptic measures—hand washing by soap and spirit, and wearing sterile mask, gown and gloves. The local part (urethral meatus) of the patient is cleansed meticulously by any antiseptic solution.

2. The tip of the catheter is lubricated by liquid paraffin and introduced per urethra while the left hand is holding the shaft of the penis erect, in case of males; 2% lignocaine jelly may be used to reduce pain during introduction.
3. Oulflow of urine confirms proper introduction while evacuation of the bladder is done gradually.
4. The free end of the catheter should not touch the urine contained in the kidney-tray as contaminated urine from the container may be sucked into the bladder by negative intravesical pressure after evacuation.
5. The catheter is taken out after evacuation is over or may be kept for some time by proper adhesion on the thigh by leucoplast; if repeated or prolonged catheterisation is necessary, a self-retaining catheter (e.g. Foley's catheter) should replace simple rubber catheter.

- For self-retaining catheters in adults, it is better to choose the 'medium size' (neither too large nor too fine). A 14 Charriere catheter is a good first choice in an adult (catheters are sized using the system invented by Joseph FB Charriere). A Charriere's French scale was used to describe the external diameter of a catether. Adult sizes of catheter: 14–24, Children 8–12.
- *Large size catheter:* Used in postoperative bladder irrigation, haemorrhage in bladder and pyuria.
- *Small size catheter:* Used in urethral strictures and bladder neck obstruction.

Q. Risk of rapid evacuation of the bladder:

Rapid evacuation may be dangerous due to development of:

1. Reflex shock.
2. Haematuria as a result of rupture of engorged and dilated submucous veins of the bladder.
3. Reflex anuria (rare).

Q. Initial steps to relieve acute retention of urine:

1. Reassurance.
2. Alternate application of hot and cold over the hypogastrium.
3. Produce the hissing sound of a running tap (to initiate childhood reflex).
4. Apply hot hip bath.
5. Inj. carbachol—2 mL, IM may be given to initiate the reflex; parasympathetic stimulation enhances evacuation of urine.
6. Lastly, try catheterisation.

Q. Differentiation between retention of urine and anuria:

A. Clinically: On inspection, hypogastrium looks distended in retention of urine. Now percussion of the hypogastrium is done from above downwards where retention will produce a dull note and in anuria, normal tympanitic note of abdomen is elicited. Moreover, application of pressure over hypogastric swelling produces desire for micturition in retention of urine.

B. By catheterisation: In anuria, no urine comes out after introduction of a simple rubber catheter; urine comes out after catheterisation in a case of retention of urine.

Q. Complications of catheterisation:

1. Urinary tract infection or UTI—urethritis, cystitis (the most common); catheter fever.
2. Catheter trauma to urethra and bladder, and bleeding.
3. Haematuria after sudden and rapid evacuation.
4. Shock (reflex)—rare.
5. False passage (rare).
6. Blockage of the lumen of catheter leading to retention of urine.
7. Long-term catheterisation may be associated with urethral ulceration, stricture formation, formation of vesical calculus or calculus formation at tip of the catheter.
8. Perforation of urinary bladder.

- An indwelling catheter invariably leads to urinary tract infection (UTI) within days or weeks. This can be minimised by regular bladder wash done by saline or dilute chlorhexidine solution, and changing the catheter once in 2–3 weeks. The patient is strictly advised not to pull the catheter by his hands
- In urine leakage around Foley's catheter, think of smaller catheter size, smaller balloon size, spasm of urinary bladder or UTI.

Q. What is a urosac bag (Fig. 1.5C)?

This is a calibrated bag, usually of 2-litre capacity, which collects urine drained by a self-retaining catheter. The bag is disposable and sterile. It has two tubes: one is connected with the urinary catheter and the other is used to empty the urosac. The urosac is usually tied with the iron rod of the bed.

Fig. 1.5C: Urosac

Q. Common causes of anuria:

A. Pre-renal:

1. Shock, sepsis (septicaemia), haemorrhage (massive).
2. Dehydration due to any cause (e.g. acute gastroenteritis) or severe vomiting.
3. Crush syndrome.
4. Burn (extensive).
5. Intravascular haemolysis, mismatched blood transfusion.
6. Congestive cardiac failure.
7. Acute pancreatitis.

B. Renal:

1. Acute glomerulonephritis, rapidly progressive glomerulonephritis (RPGN).
2. Acute renal failure (ARF) or acute kidney injury (AKI).
3. Acute papillary necrosis (diabetes, phenacetin-induced, sickle cell disease).
4. Diffuse cortical necrosis.
5. Complete renal arterial and venous obstruction.
6. Chronic renal failure (produces anuria terminally)

C. Post-renal:

1. Reflex anuria (calculus in one ureter may produce reflex obstruction of the other ureter).
2. Ligation of the ureters (accidental) or bilateral ureteric obstruction by clots, stones or crystals.
3. Ureteric obstruction due to retroperitoneal fibrosis or malignant infiltrations around the ureters.

- Clinically distended bladder, enlarged prostate and hydronephrosis point towards post-renal cause of ARF.

Q. No urine comes out after catheterisation—reasons behind:

In this situation, one should think of:

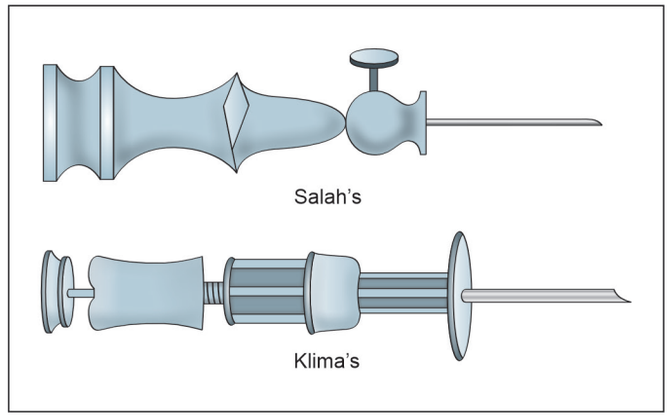
1. False passage.
2. Eye of the catheter remaining above the urine level in the bladder—a little adjustment of the catheter brings out urine.
3. Catheter is blocked.
4. Dealing with anuria instead of retention of urine.

- An oxygen tube may be used as a rubber catheter though it is very thin. Don't confuse a simple rubber catheter with the Ryle's tube (Ryle's tube is longer, and has lead shot or metal balls at the tip).
- A **suction catheter** (extracts secretion of body like mucus and is connected with a suction machine) looks like a simple rubber catheter.
- Self-retaining catheters (Foley's, Malecot's) are usually encountered in surgery practical examination.

Clinical Wisdom

Keep the urosac bag lower than the bladder so that urine does not flow back up into the urinary bladder.

BONE MARROW ASPIRATION NEEDLE



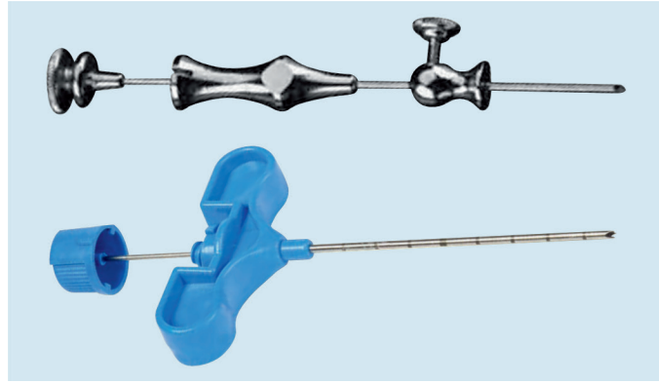


Fig. 1.6A: Sternal puncture needle (Salah's and Klima's variety)

Q. Use:

It is used for bone marrow aspiration. Often it is loosely termed as sternal puncture (SP) needle.

Q. Description:

The needle consists of three parts:

1. *The needle proper:* It is a stout wide bore needle (length is 5 cm); the needle is shortly bevelled at one end, and the base of the stylet or the nozzle of a syringe fits in the other broad end.
2. *The stylet:* It keeps the needle patent during introduction. When kept inside the needle proper, it helps to know whether the tip of the needle has entered into the marrow cavity or not. The base of the stylet contains a small projection for better fixation with the needle proper.
3. *The adjustable guard:* The adjustable screw guard prevents over-penetration of the needle. The plane or flat surface of the guard should look down to the chest wall of the patient.

   The SP needle is made of steel. There are two types: 1. Salah (commonly used) and 2. Klima.

   The two varieties differ in the design, especially in the type of the guard. Klima's variety contains an adjustable guard on the stem of the needle proper; it has a central screw (not projected from the side like Salah's variety). The neede is sterilised by immersing in concentrated lysol solution.

Clinical Wisdom

Bone marrow biopsy is of two types:

a. Aspiration biopsy (by Salah's or Klima's needle) **(Fig. 1.6A)**, and

b. Trephine biopsy (by Jamshidi's needle).

Q. Sites of puncture:

1. *Body of the sternum:* 2nd or 3rd piece of body on either side of midline (manubrium sterni is less cellular). According to haematologists, this site is not recommended at present for safety purpose.
2. Posterior iliac crest (an ideal and safe site for all) **(Fig. 1.6B)**.
3. Upper part of the medial surface of tibia, just below the tibial tuberosity.
4. Spinous process of lumbar vertebrae (rarely used).
5. Ribs (rarely used).
6. Any site of bone infiltration or tumour (in disease).

No. 2 (above two years of age) and No. 3 (below two years of age) are the ideal sites of puncture in children because these sites contain sufficient marrow material and are without any risk of injuring great vessels. In adults, all the sites may be used for puncture.

Marrow aspiration from posterior iliac crest is less painful and less hazardous. It is also preferred in elderly (especially osteoporotic individuals), patients receiving sternal irradiation (sternum may not yield marrow) and in repeated marrow aspiration. In obese persons, sternum is the preferred site.

Q. Indications of bone marrow aspiration:

1. *Anaemia:* Hypoplastic anaemia (hypocellularity of bone marrow), megaloblastic anaemia (megaloblasts), sideroblastic anaemia (ringed sideroblasts) and other unexplained anaemia.
2. *Leukaemia:* Confirmation of different leukaemias, especially subleukaemic and aleukaemic leukaemias.
3. Pancytopenia, or thrombocytopenia, or abnormal cell morphology in peripheral smear.

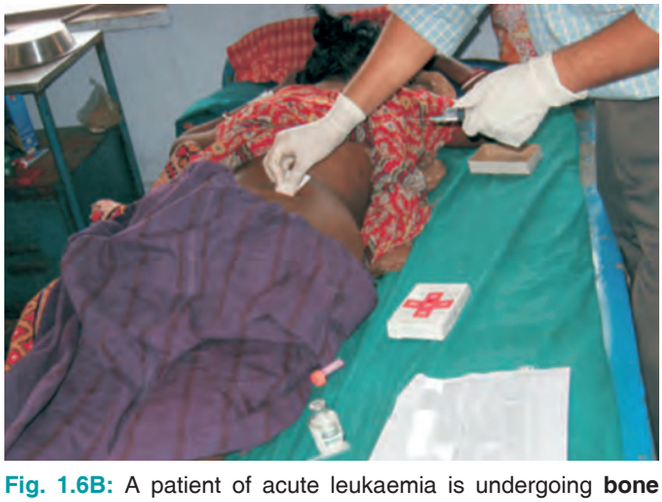


Fig. 1.6B: A patient of acute leukaemia is undergoing **bone marrow aspiration** from posterior iliac crest

4. *Kala-azar:* Demonstration of LD bodies confirms the diagnosis (chronic or acute).
5. Multiple myeloma
6. Hypersplenism.
7. Bone marrow transplant (therapeutic use)
8. Miscellaneous—secondary carcinoma of bone (bony metastasis), myelofibrosis, polycythemia, immune thrombocytopenic purpura (ITP), lymphoma (mainly for staging purpose), agranulocytosis, AIDS, lipid storage disease (Gaucher's disease), carcinomatosis and other myeloproliferative disorders.

In clinical practice, bone marrow aspiration is usually carried out in unexplained anaemia, unexplained hepatosplenomegaly, unexplained lymphadenopathy and in cases with pyrexia of unknown origin (PUO).

Q. Contraindications of bone marrow aspiration:

1. Local sepsis or infection; osteomyelitis
2. Coagulation disorders like haemophilia or severe thrombocytopenia (platelet count <20000/mm^3); or hepatic disorders (relative contraindications).
3. Very poor general condition/restless patient.

- Always measure the platelet count, BT, CT and prothrombin time before aspiration. Usually thrombocytopenia (i.e. platelet count <100000/mm^3) is not a contraindication.

Q. How the sternal puncture tray is prepared?

1. Spirit, iodine, sterile gown, mask and gloves for antiseptic purpose.
2. 2% lignocaine solution as local anaesthetic.
3. 2 mL glass syringe with needle for local anaesthesia,
4. Sterile SP needle with stylet.
5. 2 mL metal syringe or record syringe (the piston and nozzle are made of metal) for aspirating marrow material.
6. Cotton, sterile gauze, gauze-holding forcep.
7. 6 pairs of glass slides.
8. Blotting paper or pipette.
9. Benzoin solution and leucoplast.

Q. Procedure of bone marrow aspiration:

A. Sternal puncture:

1. Local antiseptic and aseptic preparations are taken (spirit-iodine-spirit). Skin is shaved over sternum in hairy chest. The physician should wash his hands, and wear sterile mask, gown and gloves, and should stand on the right side of the patient.
2. The patient is sedated by inj. diazepam 10 mg or inj. pentazocine 30 mg, IM given 30 minutes before the procedure.
3. The patient lies supine. Reassure the patient and explain him what you are going to perform. Keep the prepared SP tray by the side of the patient.
4. The skin and the subcutaneous tissue down to the periosteum (periosteum is very sensitive to pain)

are anaesthetised by 2% lignocaine injection and during the procedure, the depth from the skin to the periosteum is assessed.

5. The guard is adjusted at a distance which is equal to the depth of the skin and the subcutaneous tissue (varies with the build of the patient) plus 0.5 cm extra length (this is the thickness of cortex of the sternum). The stylet is now put within the needle, and by boring or drilling movement the needle is pushed through the skin vertically down (the needle is held at right angles to the bone) till the medulla is reached.
6. As soon as the bone marrow as reached, the stylet is removed and a metal syringe is attached to the needle. Now as the marrow is aspirated, the patient complains of excruciating suction pain; 0.2 mL of bone marrow is sucked out gently. The needle with the metal syringe is then removed as a whole. The aspirated marrow is dropped immediately over the properly cleaned slides to prepare films.
7. Sufficient pressure is given over the puncture site for 2–5 minutes to assure haemostasis. The puncture site is now sealed with tincture benzoin and the patient is advised to take rest for at least 30 minutes. Pulse and BP are monitored half hourly for 4 hours, and analgesics may be advised to relieve pain; nothing per mouth (NPM) is given for 4 hours.
8. Usually 6 pairs of glass slides are given in the tray. Remove the blood or fluid part from the slide by tilting the slide, or by means of blotting paper or pipette. Marrow films (marrow is granular) are now prepared like blood films (or two slides containing marrow material are apposed and slided over). After drying, the slides are stained (usually with Leishman's stain).

- Aspiration of more than 0.2 mL of material will unnecessarily dilute the marrow (as blood comes) and reduce the concentration of marrow cells. If no marrow is obtainable from a site, a different site may be chosen.

B. Iliac crest puncture **(Fig. 1.6B)*:*** Safest, the patient lies in prone position on a pillow placed beneath the pelvis.

C. Lumbar spinous process puncture: Easy procedure. Patient sits or adopts lateral decubitus position. The needle is introduced perpendicularly and a bit lateral to the midline.

Q. How to recognise that marrow material is present on the slide?

As the marrow is granular, the surface of the film will appear uneven.

Q. How to be sure that marrow cavity has reached?

This is diagnosed by:

1. Sudden loss of resistance.
2. The needle remains in vertical position without any support.
3. The tip of the stylet is smeared with red granular marrow material when removed from the needle.
4. Reintroduction of the stylet will produce pain.
5. Suction by the syringe produces severe and intense pain (most reliable proof), and is due to irritation of pain carrying nerve fibres surrounding the marrow cells.

Q. Complications of bone marrow aspiration:

1. Over-penetration (if posterior table of sternum is penetrated, aorta and its branches and other vital mediastinal structures may be damaged)—cardiac tamponade and pneumothorax may develop. It may happen with very soft bones.
2. Haemorrhage (haematoma) and bone pain.
3. Shock.
4. Infection (osteomyelitis).
5. Sudden death due to accidental injury to vital organs.

Q. Causes of dry tap:

Failure to obtain marrow may be due to:

1. Faulty technique.
2. Myelosclerosis or myelofibrosis (marrow replaced by fibrous tissue).
3. Marrow aplasia or hypoplasia (marrow replaced by fat).
4. Gross marrow hyperplasia—may be seen in leukaemia.
5. Carcinomatous infiltration of the bone marrow (tightly packed with infiltrates).
6. In marble bone disease (osteopetrosis), bone marrow may not be penetrated.

- These cases actually demand trephine biopsy.
- 'Bloody tap' is the bone marrow which is greatly diluted with blood.

Q. Examination of the bone marrow film:

Following are examined under the microscope:

a. The cellularity of the marrow.
b. Type and activity of erythropoiesis.
c. The number and type of:
   1. Developing WBC.
   2. Megakaryocytes.
   3. Plasma cell.
d. Myeloid-erythroid ratio (M:E).
e. Presence of:
   1. Parasites (LD bodies) or any organism.
   2. Foreign body; tumour cells or any abnormal cell.
   3. Fatty and fibrous tissue.
   4. Iron (content).

- Normal M:E = 3:1 or 4:1

Q. Composition of normal bone marrow:

The normal bone marrow is composed of haemopoietic cells (nucleated cells 20000–1 lac/mm^3), blood vessels, reticulum, fatty tissue and nerves.

Q. Criteria for ideal site in bone marrow puncture:

1. Superficial bone (i.e. easy accessibility).
2. Not close to any vital structure.
3. Thin cortex with more cancellous tissue.

❍ **Trephine biopsy** needle is used where aspiration of bone marrow is unsuccessful (myelofibrosis, myelosclerosis) or unhelpful (malignant infiltration) or in diagnosis and assessment of osteomalacia/ hyperparathyroid bone disease. Jamshidi-Swain (marrow) biopsy needle has a distal cutting edge. The posterior iliac crest is preferred for performing trephine biopsy.

LIVER BIOPSY NEEDLE

Q. Types:

There are three types of needle used for biopsy of liver:

1. Vim-Silverman's biopsy needle (commonly used; it is a cutting needle) **(Fig. 1.7A)**.
2. Menghini's aspiration biopsy needle (fragmentation of liver tissue is better, low cost, quicker).
3. Sheathed 'Trucut' needle (modified Vim-Silverman's needle).

Q. Description:

Vim-Silverman needle has three parts **(Fig. 1.7A and B)**:

1. Outer hollow needle: It guides the inner split needle.
2. Inner split needle: It brings out the liver tissue.
3. Solid stylet: It keeps the needle patent during introduction.

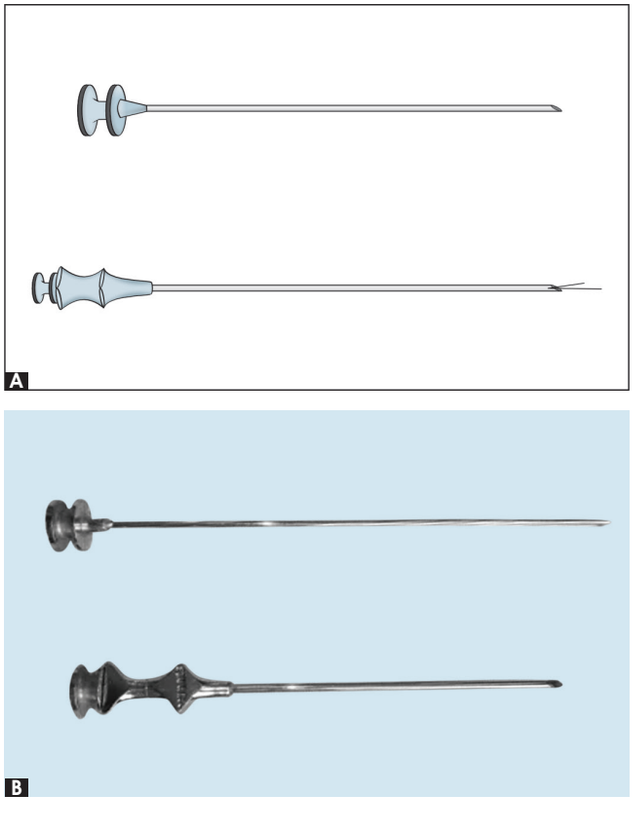


Fig. 1.7: (A) Liver biopsy needle (the solid stylet; and outer hollow needle with inner split needle within); (B) Actual photograph

Q. Indications of liver biopsy:

Liver biopsy (i.e. percutaneous removal of liver tissue for histological diagnosis) is done to diagnose the suspected cases of:

1. Cirrhosis of liver (the most common).
2. Carcinoma of liver (primary or secondary).
3. Chronic hepatitis (to diagnose, and to determine the grade and stage).
4. Portal hypertension of any aetiology.
5. Alcoholic liver disease, drug-induced hepatitis or cholestasis of uncertain origin.
6. Storage and metabolic disorders, e.g. glycogen storage disease, haemochromatosis, Wilson's disease, amyloidosis.
7. Infective or granulomatous diseases, e.g. tuberculosis, brucelosis, leptospirosis, amoebiasis, sarcoidosis.
8. Lymphoma (operative liver biopsy for staging), myeloid metaplasia.
9. Unexplained hepatomegaly or jaundice, or elevation of liver enzymes; pyrexia of unknown origin.
10. Post-hepatic transplantation (to assess for rejection and intensity of recurrence of disease).

Q. Contraindications of liver biopsy:

A. Absolute contraindications are:

1. Hepatic encephalopathy (i.e. severe hepato-cellular failure).
2. Bleeding diathesis: Abnormal blood clotting mechanism (thrombocytopenia, haemophilia).
3. Suspected hydatid cyst of liver (may precipitate anaphylactic reaction after puncture of the cyst).
4. Passive venous congestion of liver (i.e. in the presence of congestive cardiac failure).
5. Subphrenic abscess (right).
6. Right-sided empyema thoracis or pleural effusion, septic cholangitis or peritonitis.
7. Haemangioma of liver.
8. Dilated biliary channels (may lead to biliary peritonitis).

B. Relative contraindications are:

1. Massive ascites.
2. Severe and protracted jaundice.
3. Severe obstructive airway disease.
4. Non-cooperative patient (i.e. inability to hold breath).

Clinical Wisdom

Liver biopsy should not be performed if the platelet count goes below 80000/mm^3 and bilirubin above 20 mg/dL. In massive and tense ascites, specimen of liver tissue may not be obtained (as liver is displaced medially, it impedes penetration by the biopsy needle, or the biopsy material may be lost in ascitic fluid) or may lead to continuous oozing of fluid.

Q. Prerequisites for liver biopsy:

1. **Prothrombin time** should not be more than 3 seconds prolonged over control values (if control prothrombin

time is 16 seconds, then patient's value should not be >19 seconds to have a safe liver biopsy). BT (bleeding time) and CT (clotting time) should also be measured.
2. Try to rule out hydatid cyst of liver, subphrenic abscess, empyema thoracis or haemangioma of liver by prior ultrasonography. Take the H/o any bleeding tendency (e.g. from thrombocytopenia) before attempting liver biopsy.
3. Rule out protracted deep jaundice.
4. Ascites, if present, should be drained before liver biopsy is done.
5. Patient's blood group should be known; arrange for blood transfusion to combat any post-biopsy bleeding. If prothrombin time is high, try to normalise it by giving 10 mg of inj. vitamin K daily by IM route for consecutive 3 days before performing liver biopsy; correct thrombocytopenia with platelet transfusions or coagulopathy with fresh frozen plasma. Sedation before biopsy is not routinely advocated because it may interfere with patient's cooperation.

Q. How the liver biopsy tray is prepared?

1. Spirit, iodine, sterile gown, mask and gloves for antiseptic purpose.
2. 2% lignocaine solution as local anaesthetic.
3. Sterile liver biopsy needle.
4. 2 mL glass syringe with needle for local anaesthesia.
5. Sterile gauze and cotton.
6. Specimen containers (empty vials) with preservative solution (formol-saline).
7. Benzoin solution.
8. Leucoplast.

Q. Procedure of performing liver biopsy:

A. Vim-Silverman's needle:

1. Patient lies flat near the edge of the bed as far as possible. One pillow under the head and one under the patient's lower part of thorax may be placed for the purpose of expansion of thoracic cage.
2. The physician should wear the sterile gown. Standing on the right side of the patient, the physician cleans the local part by antiseptic solution.
3. Idealy, the biopsy site is 2–3 ICS below the upper border of liver dullness, which should be assessed beforehand. Local anaesthetic solution is usually infiltrated at the 8th or 9th ICS in the midaxillary line (skin, subcutaneous tissue and parietal pleura are infiltrated).
4. The outer hollow needle with the solid stylet is introduced through the 8th or 9th ICS in the midaxillary line at the end of expiration or with the patient breathing quietly (it is not always possible for the patient to hold the respiration) till is felt to enter the liver. The direction of the needle is slightly posterior and cranial to avoid the injury of gall-bladder.
5. Now ask the patient to hold breath for few seconds (ask the patient to practice holding of breath before the procedure is started). Remove the stylet quickly and introduce the inner split needle through the outer needle. The outer hollow needle is advanced completely, and the outer needle plus the inner split needle is rotated as a whole through 360° (as Vim-Silverman's needle is a cutting needle).
6. The whole needle is now withdrawn. The puncture site is sealed with tincture benzoin.
7. The biopsy tissue captured by the inner split needle is kept in the preservative solution of biopsy container for histological examination.
8. After-care—rest in bed for 24 hours is essential. Observe the pulse, BP and respiratory rate every one hour for next 24 hours. The patient is advised to lie on right lateral position for first 4 hours and no food is given per mouth for that period. Give analgesics, sedatives, antibiotics whenever indicated.

B. Menghini's needle: This needle is attached with a syringe, which is filled-up with 3 mL of sterile saline solution. Insert the needle through 8th or 9th ICS, and flush it with 2 mL of saline to clear the needle of any skin fragment. Now aspiration by the needle starts. Asking the patient to hold breath in expiration, the needle is quickly pushed to liver substance and then withdrawn quickly applying negative pressure to the syringe. Following steps are as per Vim-Silverman method.

- The hepatic biopsy tissue is usually sent for histopathology, cytology, frozen section or culture examination. In selective cases of Wilson's disease or haemochromatosis, copper and iron contents are measured, respectively.

Q. How to be sure that needle has gone within the liver?

After introduction of the outer needle with the stylet, take off your hand from the needle, and ask the patient to breathe in and out very slowly. If the needle is within the liver, it starts moving with respiration.

Q. 'Dry' (tap) liver biopsy or biopsy failure:

1. Faulty technique.
2. Very tough hepatic tissue (e.g. cirrhosis of liver).
3. Tense ascites.
4. Emphysema.

Q. Complications of liver biopsy:

1. Haemorrhage—intraperitoneal or intrathoracic (haemothorax). Bleeding is due to perforation of distented portal or hepatic veins, or aberrant intercostal arteries.
2. Biliary peritonitis (due to trauma in gallbladder).
3. Shock or precipitation of hepatic coma (encephalopathy).
4. Perihepatitis and/or pleurisy (patient may complain of severe pain in the right hypochondrium and right shoulder, and hepatic/pleural rub may appear).

5. Haemobilia—bleeding from damaged hepatic vessel into bile duct.
6. Intrahepatic arteriovenous fistula formation.
7. Intrahepatic haematoma or laceration of liver.
8. Transient bacteraemia, septicaemia.
9. Anaphylaxis (if hydatid cyst is punctured).
10. Small pneumothorax (right), puncture of intra-abdominal viscera.

- Nowadays, USG or CT-guided biopsy reduces the rate of complications. Actually, if the performer is skillful and the patient is carefully selected, the rate of complications is less.

Q. Criteria for ideal biopsy tissue:

It is surprising that a small biopsy tissue is the representative of changes in the whole liver. The biopsy tissue should be 2–4 cm long and should weigh 20–40 mg. Naked eye appearance of the biopsy tissue often gives clue to diagnosis, e.g. chocolate-coloured in Dubin-Johnson syndrome or green-coloured in biliary cirrhosis.

Q. What is trans-jugular liver biopsy?

When the patient suffers from massive ascites, coagulation disorder, small liver (from cirrhosis commonly) or is really uncooperative, a special Trucut needle is inserted to perform the biopsy through a catheter which is already placed in the hepatic vein, via the jugular vein. The extra advantage of this method is the measurement of the wedged hepatic venous pressure.

- Liver biopsy is done by 4 methods: 1. Percutaneous (by Vim-Silverman's needle), 2. Trans-jugular, 3. Laparoscopy, 4. Laparotomy (if done for some other reason).
- The modern 'biopty gun' (Biopter) is a modified Trucut needle.
- The **'Trucut' needle** is less injurious to Vim-Silverman's needle, and is disposable. The 'Trucut' needle (may be called as **tissue biopsy needle**) may be used for taking biopsy from liver, kidney, pleura. It has a trocar and canula, and the trocar is longer than the canula. It is also a cutting needle; the cutting needle comprises a 11.5 cm long pointed needle with a 2 cm notch close to the tip, enclosed by a cutting sleeve of 2 mm diameter. Trucut needle is less traumatic and yields a better specimen. Menghini's needle is less injurious than others, so far the complications are concerned; and the success rate is approximately 75%. The success rate of Vim-Silverman's needle is high (approximately 95%).
- Liver biopsy needle may be used in pleural biopsy in the absence of Abram's or Cope's pleural biopsy needle. The needle is sterilised by immersing the separated parts in concentrated lysol solution.

Clinical Wisdom

Fine needle aspiration cytology (FNAC) is less reliable than excisional biopsy of any tissue. The technique usually obtains only a suspension of cells from within a mass. Cytology from unexplained mass of lymph nodes, thyroid, breast, bone, or pleura/liver/abdomen (USG or CT-guided) is examined by a skilled histopathologist. Though not full-proof, FNAC is very often the investigation of choice in early malignancy where the primary investigations do not yield any result.

LUMBAR PUNCTURE NEEDLE

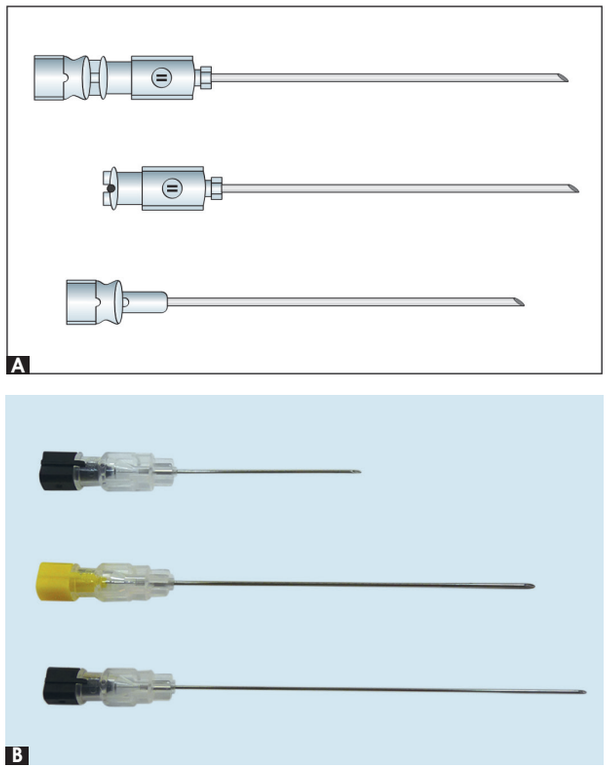


Fig. 1.8: (A) Lumbar puncture needle (the complete set, the needle proper and the stylet presented sequentially); (B) Actual photograph

Q. Description (Fig. 1.8A and B):

This is a sharp, slender, malleable narrow-bore needle and consists of two parts like:

1. *The needle proper:* It is made of platinum-irridium or German alloy, and gives the needle its malleability (nowadays, malleable steel is being used). The needle is round, slender, cannulated with a shortly bevelled tip and the usual length is 10–12 cm. The base of the needle fits with the knob (or projection) of the stylet and thus locks the stylet with the needle proper. The hole in the base allows the nozzle of a syringe for intrathecal injection.
2. *The stylet:* It maintains the patency of the needle, i.e. prevents blockage of the needle proper. The knob (or projection) present at its base fits well with the groove present at the base of the needle proper. The length of the stylet should be such that if should not protrude through the bevelled cutting edge of the needle proper.

- The needle is sterilised by immersing the separated parts in concentrated lysol solution or by gamma ray irradiation. The needle is made malleable for finer adjustment during manipulation.

Q. What is lumbar puncture (LP)?

It is a manoeuvre by which a temporary artificial communication is made with the CSF pathway and

the exterior (at lumbar region). It is a simple method to collect CSF sample.

Q. Indications of lumbar puncture:

A. Diagnostic purpose:

a. Meningitis (bacterial, tuberculous, viral, fungal or carcinomatous).
b. Subarachnoid haemorrhage (SAH)—especially if CT scan of brain is normal.
c. Encephalitis or meningoencephalitis.
d. Meningism.
e. Unexplained coma—where the diagnosis cannot be reached by other investigations.
f. GB syndrome (albumino-cytological dissociation) or multiple sclerosis (isolated rise in gammaglobulin).
g. Staging of lymphomas.
h. *Miscellaneous:* PUO, unexplained dementia, neurosyphilis, neurosarcoidosis, Behcet's syndrome, or neoplastic involvement of the central nervous system.
i. Queckenstedt's test for diagnosis of spinal sub-arachnoid block.
j. CT myelography (done in a suspected case of compressive myelopathy to diagnose the level of spinal block), cisternography or pneumoencephalography (done to demonstrate cerebral atrophy; obsolete in the era of CT or MRI scan).

Clinical Wisdom

LP is done cautiously in a suspected case of spinal subarachnoid block (Froin's syndrome) as it may aggravate the neurodeficit.

B. Therapeutic purpose:

a. Intrathecal administration of drugs, e.g. methotrexate in acute lymphoblastic leukaemia (previously streptomycin was administered in tuberculous meningitis); in lymphoma.
b. Spinal and epidural anaesthesia, especially in operation of lower adbomen, lower limbs or in perineal surgery **(Fig. 1.8C)**.
c. To relieve intracranial tension in normal pressure hydrocephalus (risky and not used commonly) or benign intracranial hypertension.

Clinical Wisdom

While using a drug intrathecally, at first withdraw equal amount of CSF by LP needle and then push the drug slowly with strict asepsis.

- LP is not done routinely in CVA (cerebrovascular accidents) patients except in case of subarachnoid haemorrhage; LP should be avoided in infants, if possible.

Fig. 1.8C: Spinal needle for spinal anaesthesia and spinal analgesia

Q. Contraindications of lumbar puncture:

1. **Papilloedema** or any other feature of **raised intracranial tension** (may precipitate cerebellar pressure cone syndrome—so, ophthalmoscopy is a must before performing lumbar puncture).
2. Local sepsis, skin infection or bed sore (may lead to meningitis, arachnoiditis).
3. Gross bony deformity in lumbar region or any congenital lesion like meningocele.
4. Restless patient/non-cooperative patient/very low general condition/bleeding diathesis/suspected spinal cord compression or spinal canal stenosis, or suspected posterior fossa tumour.

Q. What is 'cerebellar pressure cone syndrome' or 'cerebellar coning'?

It is the tentorial herniation or tonsillar herniation through foramen magnum leading to sudden death due to compression of medullary vital centres (i.e. as a result of descent of cerebellar tonsil). The syndrome develops if lumbar puncture is done in the presence of raised intracranial tension (e.g. brain tumour). The patient suddenly becomes drowsy, with positive neck stiffness and dilaled pupil; Cheyne-Stokes respiration/irregular slow respiration → decorticate posturing → bilateral Babinski's sign → apnoea → bradycardia → coma and death may supervene.

Q. How the lumbar puncture tray is prepared ?

1. Spirit, iodine, sterile gown, mask and gloves for antiseptic purpose.
2. 2% lignocaine solution as local anaesthetic.
3. Sterile LP needle with stylet.
4. Sterile plain glass test tubes (three).
5. 2 mL glass syringe with needle for local anaesthesia.
6. Sterile gauze and gauze-holding forcep.
7. Benzoin solution with cotton.
8. Leucoplast.

Q. How the lumbar puncture is performed ?

1. The patient is first explained the procedure to obtain full cooperation. Lumbar puncture is best done when the patient is kept in one lateral position (right or left) at the edge of the bed with the knees drawn-up against the abdomen and head flexed (actually an assistant helps in approximating the chin of the patient with his knees). The flexion posture helps in increasing the interspinous space on which the success of LP depends; LP may be done in sitting posture of the patient (e.g. in lumbar spondylosis).
2. The puncture is usually done between L_3 and L_4 interspace, 1/2" on either side of the midline (**puncture site**—join the highest points of iliac crests by a line and it will pass through L_4 spine; puncture the space just above this line). The spinal cord ends at the lower border of L_1 vertebra and thus there is

no risk of injuring the cord. A space above or below may also be used in a desperate situation.

3. The physician washes his/her hands and wears gloves. Then the puncture site is properly cleansed with spirit-iodine-spirit from centre-outwards and above-downwards. The site is now infiltrated with 2% lignocaine solution upto ligamentum flavum.
4. Reconfirm the puncture site. Keeping the bevelled end upwards, the LP needle with the stylet in position, it is introduced a bit obliquely in upwards and forwards direction towards patients umbilicus, keeping it parallel to bed (oblique introduction will not cause any injury to the theca), by cork-screw movement. The ligamentum flavum is pierced and the destination of spinal subarachnoid space is indicated by sudden loss of resistance (penetration of the dura matter), and is actually confirmed by CSF coming out drop by drop when the stylet is withdrawn (the needle passes through the skin, interspinous ligament, ligamentum flavum, the dura and the arachnoid matter). If CSF does not come out, slightly rotate the needle or introduce it inwards slightly. If the CSF still fails to come, withdraw the needle and introduce it again.
5. The rate of flow of CSF is noted and is collected in three sterile test tubes each containing minimally 10 drops to maximally 2 mL.
6. The stylet is reinserted and the LP needle is withdrawn. The site is now sealed with tincture benzoin solution and leucoplast.

- Manometric study may be done prior to collection of CSF. The CSF pressure rises and falls with respiration and heart beat, and rises on coughing.

Q. Management of post-lumbar puncture period:

1. The patient is kept in bed for next 8–24 hours under observation.
2. Plenty of water to drink (to prevent post-lumbar puncture headache).
3. *Foot end of the bed is raised* with no pillow below the head (to prevent post-lumbar puncture headache).
4. Analgesics are given, if headache appears.

Q. Complications of lumbar puncture:

1. Traumatic puncture (trauma to vessel, nerve, inter-vertebral disc).
2. Post-lumbar puncture headache or low-tension headache.
3. 'Coning' or cerebellar pressure cone syndrome.
4. Breaking of the needle.
5. Introduction of infection (meningitis, arachnoiditis).
6. Bleeding (due to puncture of para-vertebral venous plexus).
7. Low backache.
8. Aggravation of root pain and signs of cord compression (in the presence of spinal cord tumour).

Q. What is post-lumbar puncture headache?

This usually occurs in patients where LP is done with normal intracranial tension. Headache (bifrontal and/or occipital) appears within 4 hours, stays for a few hours to days, and is enhanced on assuming sitting or standing posture. It is due to low intracranial tension produced as a result of:

a. Withdrawal of CSF, and
b. Continuous leakage of CSF through the puncture site in the theca.

Low tension exerts traction on the meningeal blood vessels (pain-sensitive) and results in headache.

The headache (usually a dull ache) may be avoided by adopting these preventive measures:

1. Using a narrow-bore LP needle (i.e. guarded lumbar puncture).
2. Not withdrawing over 10 mL CSF.
3. Oblique introduction of the needle (transverse introduction 'divides' or 'tears' the fibres of dura and ligamentum flavum but oblique introduction 'separates' the fibres, and thus chance of CSF leakage is less if the needle is introduced obliquely).
4. Slow withdrawal of CSF.
5. The patient is kept lying flat in bed for 8–24 hours with foot end of the bed raised. Putting the patient in prone position may relieve headache.
6. Treatment of headache is done by drinking large amount of water, consuming caffeine and application of NSAID.

- Prolonged headache is recently being treated by 'autologous intrathecal blood patch', i.e. by injecting 20 mL of the patient's venous blood into the CSF.

Q. How much CSF should be withdrawn at a time?

1. For diagnostic purpose—usually 5–8 mL.
2. For therapeutic purpose—usually 10–20 mL (the amount of drug in volume should be measured first and then the same amount of CSF is withdrawn; now the drug is pushed into the subarachnoid space after fitting a syringe with the LP needle).

Q. Thick-bore needle — advantage and disadvantage:

a. *Advantage:* Helps in drawing thick purulent material in pyogenic meningitis.
b. *Disadvantage:* Post-LP headache and cerebellar pressure cone syndrome may develop as large amount of CSF is withdrawn in a short time.

Q. What is a dry tap?

CSF does not come out through the LP needle in:

1. It is due to faulty technique (needle not in subarachnoid space), incorrect position of the patient or needle blockage. If the needle is blocked, insert the stylet again to dislodge any dural flap, if present.
2. Spinal subarachnoid block.

3. Presence of very thick pus.
4. Lumbar subarachnoid space filled up with neoplastic tissue or obliterated by adhesive arachnoiditis.
5. Obstruction near foramen magnum as a result of basal meningitis.
6. Lipoma or dermoid (may be present in a case of spina bifida)

Q. What is bloody tap?

It is due to injury of meningeal vessels resulting in 'CSF mixed with blood', which may be easily confused with subarachnoid haemorrhage (SAH). Read **Table 1.1** for differentiation.

Q. What is Queckenstedt's test?

This test detects the patency of CSF pathway. It is done along with the lumbar puncture. Rise of CSF pressure is noted which is normally >40 mm of CSF or H_2O, after the compression of internal jugular vein (negative test). If the rate of flow of CSF is not increased after either internal jugular venous compression, the test is declared positive (CSF pressure is usually detected by a spinal manometer). A positive test is obtained after complete spinal block (partial block gives negative result). **Spinal block** may result from arachnoiditis, meningioma or neurofibroma, or vertebral disease with compression.

If CSF pressure rises after compression of one internal jugular vein but not with the other, it is known as positive Tobey-Ayer test and is found in lateral sinus thrombosis.

Compression of internal jugular vein results in congestion of cerebral veins and the rise in venous pressure leads to increased pressure in CSF.

Q. Other uses of LP needle:

1. Cisternal puncture (used during myelography to delineate the upper limit of spinal subarachnoid block)—not practised nowadays.
2. Splenoportal venography (to diagnose portal hypertension).
3. Paracentesis thoracis or paracentesis abdominis.

Q. CSF dynamics and other details:

CSF is formed by the choroid plexus of lateral (major source), 3rd and 4th ventricles. CSF circulation: Choroid plexus of lateral ventricles—Foramen of Monro—Third ventricle—Aqueduct of Sylvius—Fourth ventricle in the medulla—Foramen of Magendie and Luschka—Cisterna magna and cisterna pontis—Cerebral and spinal subarachnoid space—Circulation over brain and spinal cord. CSF is absorbed into venous sinuses by arachnoid villi.

Function of CSF

CSF acts as a buffer or cushion between CNS and bones. It also supplies nutrition to nervous tissue and removes the end-products of neuronal metabolism. CSF regulates the intracranial tension too.

Normal CSF Values

a. *Amount or volume:* 100–150 mL (approximately 130 mL in adults). Daily formation of CSF is 1500 mL
b. *Pressure:*
   i. 60–150 mm of CSF (lying position), and
   ii. 150–250 mm of CSF (sitting position)

- Roughly, the normal CSF flow (pressure) is equivalent to 1 drop per second on lumbar puncture.

c. *Colour:* Crystal clear or colourless
d. *pH and specific gravity:* 7.31–7.34 and 1007 respectively, osmolality: 292–297 mOsmol/kg of water
e. Biochemical:
   i. Protein: 20–40 mg%
   ii. Sugar: 40–80 mg% (usually 1/2 to 2/3rd of the random blood sugar concentration)
   iii. *Chloride:* 720–750 mg%
f. *Cells:* 0–5 cells/mm^3 and all are mononuclear cells (70% lymphocytes and 30% monocytes)
g. *Bacteriological:* Sterile
h. *Oligocional bands:* Negative

- The CSF IgG index (normal value is <0.65) is the ratio of IgG to albumin in the CSF divided by the same ratio in the serum; though the total CSF protein is usually normal or slightly elevated, the CSF IgG index is increased in multiple sclerosis, where the abnormal CSF IgG may be oligoclonal.
- CSF ammonia (normal: 25–80 µg/dL) may be increased in hepatic encephalopathy.

Q. How the examination of CSF is done?

a. *Physical:* Pressure, colour, fibrin clot.
b. *Biochemical:* Protein, sugar, chloride concentration.
c. *Cytological:* Number and types of cells are analysed (whether polymorphonuclear or lymphocytic pleocytosis present, or not).

Table 1.1: Differentiation between traumatic and non-traumatic haemorrhage

Tests	Traumatic (bloody tap)	Non-traumatic (SAH)
1. CSF collected serially in 3 test tubes	1. First tube is bright red and the next two tubes are faintly red	1. Uniformly red
2. Supernatent fluid after centrifugation or on prolonged standing	2. Clear	2. Yellowish or xanthochromic
3. Shape of the RBC	3. Normal	3. Crenated
4. Coagulation of blood	4. Occurs	4. Does not occur

d. Bacteriological including staining and culture.

e. *Serological:* VDRL, Kahn test, Wassermann reaction may be helpful in neurosyphilis.

f. *Special:* Lange's colloidal gold curve reaction (positive reaction indicates high globulin content of CSF) is positive in tabes dorsalis (tabetic curve), GPI (paretic curve) and meningitis (meningitic curve). Polymerase chain reaction (PCR) for detection of DNA sequence of different bacteria or *M. tuberculosis* is done. Adenosine deaminase activity (ADA) is determined to rule out tuberculous meningitis.

Q. Can an IV needle serve the purpose of lumbar puncture?

Yes (in dire emergency, in the absence of LP needle). Nowadays very slender, highly malleable disposable LP needle is available which are used by anaesthetists in spinal anaesthesia **(Fig. 1.8C)**.

Q. While performing LP, how do you identify or suspect different diseases?

1. Difficulty in flexing the neck of the patient at the beginning (i.e. presence of neck stiffness): Meningitis, meningism, subarachnoid haemorrhage, cerebral malaria or meningoencephalitis.
2. Unconscious patient: Meningoencephalitis, cerebral malaria, meningitis, meningism, subarachnoid haemorrhage.
3. CSF coming out at a flow rate of >1 drop/second (opening pressure): See the causes of increased intracranial tension in the section on 'Charts on CSF'. Low CSF pressure is found in bad needle placement, partial spinal block, severe dehydration and after repeated lumbar puncture.
4. Appearance or colour of CSF:
   a. *Clear:* Normal, tuberculous and viral meningitis, meningism.
   b. *Turbid:* Pyogenic meningitis (due to high leucocyte count), rarely in carcinomatous meningitis and subarachnoid haemorrhage.
   c. *Straw-coloured:* Tuberculous meningitis.
   d. *Haemorrhagic (red):* Subarachnoid haemorrhage, trauma, extensive cerebral haemorrhage, haemorrhagic encephalitis (rare), bleeding diathesis.
   e. *Xanthochromia (yellow):* See the section dealing with 'charts' on 'Xanthochromia'.
5. Coagulum on standing:
   a. Cobweb coagulum (forms after few hours): Tuberculous meningitis (most important cause). acute anterior poliomyelitis and neurosyphilis.
   b. Big coagulum (forms immediately or shortly after withdrawal): Spinal subarachnoid block, GB syndrome.
6. Manometry: Queckenstedt's test is positive in complete spinal subarachnoid block.

Q. Examination of CSF in different diseases—a synopsis:

A. Pyogenic meningitis:
- Pressure—High (++)
- Colour—Turbid (indicates increased cellularity)
- Total cells—Increased +++ (200–5000/mm^3), predominantly polymorphonuclear pleocytosis
- Protein—Increased (++)
- Sugar—Low (--)
- Chloride—A bit reduced
- Gram's stain—Gram-ve diplococci, or Gram +ve cocci in pairs

B. Tuberculous meningitis:
- Pressure—High (++)
- Colour—Clear
- On standing—Formation of cobweb coagulum
- Total cells—Increased ++ (200–500/mm^3); predominantly lymphocytic pleocytosis
- Protein—Increased (++)
- Sugar—Low (–)
- Chloride—Low (–) (may be due to prolonged vomiting)
- Ordinary culture shows no growth (sterile)

❍ Cobweb coagulum indicates presence of mild to moderate rise in protein along with fibrinogen in CSF.

C. Viral meningitis:
- Pressure—High (++)
- Colour—Clear
- Total cells—Increased + (approximately 150–200/mm^3); predominantly lymphocytic pleocytosis (may be mixed pleocytosis for first 36 hours)
- Protein—Increased (+) or normal
- Sugar—Normal
- Chloride—Normal
- Ordinary culture is sterile

D. Carcinomatous meningitis:
- Pressure—High (++)
- Colour—Clear or haemorrhagic
- Total cells—Plenty (lymphocytes ↑), malignant cells +
- Protein—Increased (+)
- Sugar—Normal
- Chloride—Normal

E. Subarachnoid haemorrhage (SAH):
- Pressure—High (++)
- Colour—Blood-stained, turbid or xanthochromia
- Total cells—Plenty; RBC+++, a few are crenated
- Protein—Raised (protein from blood is added to CSF)
- Sugar—Normal
- Chloride—Normal
- On centrifugation—Supernatent fluid is yellow
- Culture—No growth (sterile)

❍ In traumatic haemorrhage, CSF pressure remains normal and CSF protein content is not too high.

F. Meningism:

- Pressure—High (++)
- Colour—Clear
- Total cells—0-5 cells/mm^3 (all mononuclear cells)
- Protein, sugar and chloride—Within normal limit
- Gram's stain—Nothing could be detected
- Culture—Sterile

G. Xanthochromia:

- Pressure—Very low or nil
- Colour—Xanthochromic (yellowish)
- On standing—Formation of big coagulum
- Total cells—0-5 cells/mm^3 (all mononuclear cells)
- Protein—Increased (++)
- Sugar—Normal
- Chloride—Normal
- Queckenstedt's test—Positive (i.e. no rise in CSF pressure on compression of internal jugular vein)
- Culture—Sterile

- This last chart is of complete spinal subarachnoid block with albumino-cytological dissociation.
- Polymerase chain reaction (PCR) is helpful in diagnosis of some cases of meningitis. Though cryptococcal antigen test is very sensitive, the 'India ink test' is still valuable in diagnosis of meningitis caused by *Cryptococcus neoformans*.

Clinical Wisdom

Lumbar puncture is a very important bedside diagnostic tool though nowadays radiodiagnosis (e.g. CT or MRI scan) has gained importance over this age-old practice.

IV FLUID BOTTLE AND INFUSION SET

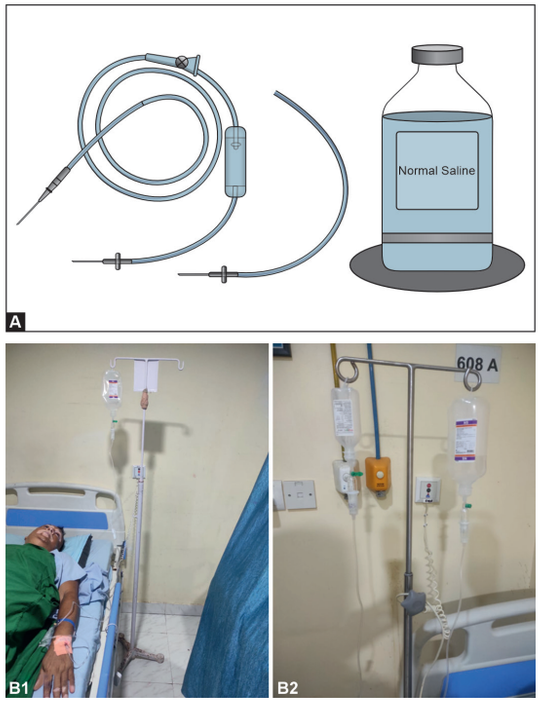


Fig. 1.9: (A) Drip tube, airway tube and the IV fluid bottle; (B_1 and B_2) Real life scenario

Q. Description (Fig. 1.9):

a. Bottle: 640 mL; made of glass or plastic. The glass bottle has a rubber stopper in the mouth with two openings (one for air entry and the other for fluid outlet). Plastic bottle has now replaced glass bottle.

B. Infusion set (i.e. IV drip set):

a. One long plastic tube (drip tube) with two needles on two sides—one enters into the bottle and the other enters into the patient's vein. A small part of the plastic tube (near the patient's vein) is replaced by a rubber tube to inject drugs by shot-push. In the middle of the tube, there is a small plastic container (Murphy's chamber) to measure the flow of the running fluid. The rate of flow of the fluid is controlled by an adjustable valve attached to the set.

b. A small plastic tube with a needle for air entry in the bottle (airway tube).

- Blood transfusion set contains a 'strainer' (to filter clots) in the Murphy's chamber. It is used for transfusion of blood and blood products (e.g. packed cells, cryoprecipitate, platelets, etc.).

Q. What is Murphy's chamber?

It is a plastic or glass chamber attached to the infusion set to regulate the flow of fluid by adjusting the number of drops coming down per minute. It has two ends: Through the inlet fluid enters into the chamber (via a glass tube), and through the outlet fluid leaves the chamber. For proper flow of fluid, a fluid level should be maintained in the chamber. If the chamber is fully occupied by fluid, it has to be reset.

Q What is a micro-drip set?

It is the same variety of IV set but contains a small calibered lumen in the Murphy's chamber. In ordinary IV set, 15 drops of fluid make 1 mL but in microdrip set 60 (micro) drops constitute 1 mL of fluid. The microdrip set is used when very small and accurate quantity (e.g. microgram dose) of a drug is delivered in IV route, e.g. dopamine, dobutamine, noradrenaline, nitroglycerine, etc.

Q. How to set-up a drip?

Indications

1. Replacement of fluids (crystalloids, blood products, different electrolyte solutions).
2. To establish an external route for administering IV medication, nutrition or blood products.

- **Crystalloids**, i.e. solutions containing solutes that can pass a semipermeable membrane → rapidly expand both intravascular and extravascular compartments; examples are dextrose, normal saline, Ringer's lactate solution, mannitol. **Colloids,** i.e. solutions containing large molecules which do not pass semipermeable membrances → expand the intravascular space more efficiently; examples are albumin, dextran, haemaccel, blood and hetastarch.

Choice of Site

Most convenient sites for peripheral cannulation are veins over the forearm, wrist or elbow. Selection of left side allows the comfortable mobility as well as different activities of right arm. If veins of the upper extremity is not available, veins of ankle or feet are used. Other sites of cannulation are subclavian or jugular vein.

Precautions

1. In patients with renal failure, there is a chance of fluid overload.
2. In patients with heart failure, problems may be alleviated by prior administration of a diuretic.
3. Proper asepsis is required to start a drip in patients who are immunocompromised or having valvular heart disease.
4. Always choose a vein with adequate calibre to maintain a smooth flow.

Procedure

1. All the clothes are removed from the site of puncture and a tourniquet is applied proximally to make the vein distended and prominent. The puncture site is cleansed with spirit properly.
2. Keeping the needle parallel to the vein chosen and with the bevelled edge facing upwards, the vein is pierced, by moving the needle, it is continued for a distance within the lumen of the vein. Now, the tourniquet is released and let the fluid from the bottle flow within the vein through the IV infusion set. The adjustable valve attached with the IV set controls the rate of flow of the fluid. The needle is fixed to the skin with adhesive tape (leucoplast) and the limb may be splinted with a wooden piece
3. Follow-up: Look for any sign of inflammation (redness, thrombophlebitis, brawny induration) at the puncture site. An IV set should not be continued for more than 2–3 days and should be replaced.

Clinical Wisdom

If no veins are visible after intensive search for intravenous infusion of fluids, a venesection or **'cut-down'** procedure may be employed in ankle, antecubital fossa or wrist in a desperate situation. Always change the puncture site (i.e. reintroduce in other site) with the appearance of first sign of inflammation (i.e. thrombophlebitis). If the drip is continued for long, pyrexia may complicate the situation. Many a time, inflammation at the venepuncture site of a drip is responsible for unexplained fever.

Q. How to change the bottle/discontinue infusion?

To change the bottle, the adjustable valve attached with the IV infusion set is locked to prevent entry of air in the tube distal do it. Now, the empty infusion bottle is replaced by a new one.

To discontinue infusion, the adjustable valve is locked; the IV needle is removed and a sterile dressing is applied over the puncture site.

Q. Different content of bottles:

1. Normal saline or isotonic saline (0.9%).
2. Glucose or dextrose solution (5%, 10%, 20%, 25%, 50%).
3. Dextrose-saline solution (DNS).
4. Sodium lactate solution.
5. Hypertonic saline (3% or 5%).
6. Ringer's lactate solution.
7. Darrow's solution.
8. Mannitol (5%, 10%, 20%).
9. Haemaccel.
10. Low molecular weight dextran (40 and 70 kDa).

Nowadays, multiple electrolyte solutions (e.g. electrolyte R, electrolyte M, etc.) are available and contains dextrose, sodium, potassium, calcium, etc. in varying combination. Some are useful in maintaining (M) daily requirements of water and electrolytes, and others for replacement (R) of fluid loss.

Q. Use of different parenteral fluids:

I. Normal Saline

Its osmotic pressure is equal to that of plasma and this is why, it is known as isotonic saline. The fluid is also isotonic with the intracellular compartment of RBC and thus, called 'normal' saline; here 0.9 g of NaCl is dissolved in 100 mL of water (0.9%). Normal saline has the same sodium content as plasma (approximately 150 mmol/L). Nowadays, it is available in 100 mL, 250 mL, 500 mL, 1000 mL and 2000 ml plastic containers.

Uses

1. To correct salt-water depletion (e.g. diarrhoea and vomiting).
2. To correct dehydration and hypovolaemia.
3. Acts as a vehicle for IV drug administration (e.g. iron-sucrose infusion).
4. To maintain the fluid balance parenterally when oral intake is not possible.
5. In treating alkalosis.

II. Glucose or Dextrose Solution

It is available in different concentration (usually 5%, 10%, 20%, 25% and 50%).

Uses

1. Acts as a vehicle for IV drug administration.
2. To provide adequate calories to the body and to correct pure H_2O deficit.
3. Hypoglycaemic coma (high concentration, i.e. 25% or 50% dextrose solution is used).
4. As fluid and nutrient replenisher.
5. As a mild osmotic diuretic (10%).
6. A 50% solution may reduce cerebral oedema.

III. Dextrose-normal saline solution (DNS)

Usually available as 5% glucose plus 0.9% (normal) saline.

Uses

1. In patients who need additional fluid with minimal sodium intake.
2. As an initial hydrating solution to establish normal renal function.
3. In the presence of metabolic alkalosis (e.g. repeated gastric suction): Fluid loss with loss of Cl^- is compensated.

IV. Sodium lactate solution

It is available in two strengths:

a. Molar sodium lactate solution, and
b. 1/6th Molar lactate solution.

Sodium ion of sodium lactate combines with HCO^-_3, (coming from lactate) and forms $NaHCO_3$, and the blood becomes alkaline.

Uses

1. Metabolic acidosis, e.g. diabetic ketoacidosis.
2. To treat hyperkalaemia (alkalosis reduces the level of serum potassium level).

V. Hypertonic saline (3% or 5%)

Prepared by dissolving 3 g or 5 g of NaCl in 100 mL of water. The osmotic pressure of hypertonic saline is higher than that of plasma.

Uses

1. Severe hyponatraemia.
2. Syndrome of inappropriate ADH secretion (SIADH).

Hyponatraemia in CCF, cirrhosis or SIADH can be treated by a competitive vasopressin receptor antagonist entitled tolvaptan.

VI. Ringer's lactate solution (Table 1.2)

Uses

1. Fluid of choice in treating cholera.
2. Burns, severe infections, peritonitis, multiple fractures.
3. Replacing deficit of extracellular fluid (ECF) due to decreased water intake or increased excretion of water.
4. Deficiency of NaCl and K^+ with acidosis.

Electrolytes concentration in Ringer's lactate is almost the same as that of plasma.

VII. Darrow's solution (contains high potassium)

Uses

1. Treatment of hypokalaemia.
2. In the management of diabetic ketoacidosis (DKA).

VIII. Mannitol (usually 20% solution is used; available in 100, 350 and 500 mL bottle)

Uses

1. To reduce increased intracranial tension due to any cause (e.g. CVA, hepatic pre-coma).
2. To expedite the urinary excretion of toxic metabolites.
3. Treatment of acute renal failure or acute kidney injury.
4. To reduce intraocular tension (when other drugs fail).
5. Acts as a vehicle for injection potassium to treat severe hypokalaemia (e.g. hypokalaemic periodic paralysis).

IX. Haemaccel (polygeline)

Uses

1. Shock or peripheral circulatory failure.
2. To raise the BP in hypotension.
3. Priming of heart-lung machine and artificial kidney.
4. As a plasma expander while performing paracentesis abdominis in cirrhosis of liver.

X. Low molecular weight (average 40000) dextran

Uses

1. As a plasma expander. As a substitute of plasma, it can be used in burn, hypovolaemic or endotoxic shock.
2. Impending shock due to haemorrhage.
3. Prevention of peritoneal adhesions.
4. Foetal distress syndrome.

Q. Different electrolytes available for therapy:

1. Sodium bicarbonate (available as 7.5% and 8.4%; 1.5% $NaHCO_3$ is isotonic solution)
   Uses: Correction of acidosis, hyperkalaemia, as a lavage (e.g. bladder, bronchial) fluid, cardiopulmonary resuscitation.
2. Potassium (2 mEq/mL)
   Uses: In treatment of hypokalaemia (e.g. severe diarrhoea, diabetic ketoacidosis), paralytic ileus, digitalis toxicity. Glucose-insulin-potassium (GIK) regimen is useful in management of DKA and acute myocardial infarction.
3. Calcium (e.g. calcium gluconate 10%)
   Uses: Severe hypocalcaemia (e.g. tetany, hypoparathyroidism, alkalosis, hypovitaminosis D), growing children, pregnancy and lactation, patients on long-continued corticosteroids, or cardiac arrest (in diastole).

Clinical Wisdom

These electrolytes are available in ampoules and are given in a drip or shot-push (i.e. IV route).

Q. Advantages and disadvantages of parenteral (IV) fluid therapy:

Advantages

1. Rapid correction of fluid deficit.
2. All types of fluid can be given.

Disadvantages (complications)

1. Thrombophlebitis.
2. Extravasation with local cellulitis (swelling and oedema); needle blockage.
3. Haematoma formation.

4. Pyrogen reaction with fever.
5. Overloading with injudicious administration, resulting in heart failure (development of pulmonary oedema) and/or renal failure.
6. Chance of transmission of infection, if proper asepsis is not maintained.
7. Air embolism.

Table 1.2: Composition of plasma and different IV fluids (mmol/L)

Different fluids	Na	K	Cl	Lactate
Plasma	136–145	3.5–5.0	98–106	–
Isotonic saline	153	–	153	–
Ringer's lactate	130	4	110	28
1/6th Molar lactate	167	–	–	167
Darrow's solution	124	36	104	56

- Normal plasma HCO_3 level is 22–26 mEq/L.
- Normal plasma osmolality is 280–300 mOsmol/kg of water.
- Approximate **composition of plasma** (mmol/litre) Na-141, K-4, Ca-2.5, Mg-2, Cl-100, HCO_3-25, PO_4/SO_4-1, and protein/acid is 25 = 300 (approx). Na and Cl are main ions in extracellular fluid, and K and PO_4 are those of the intracellular fluid.
- Approximately 60–65% of body weight is 'total body water'. pH of blood varies between 7.38 and 7.44 (average 7.40).
- IV infusion set may also be used to remove ascitic and pleural fluid. It may be used temporarily in water-seal drainage to treat a case of spontaneous pneumothorax.
- Remember, IV fluid is 'infused' while blood is 'transfused'.

Clinical Wisdom

Calculation of rate of fluid to be infused:

1 mL of fluid = 15 drops.

Infusing 540 mL (1 bottle) in 8 hours, give fluid at the rate of 1 drop/4 sec, i.e. 15 drops/min (approx).

Infusing 540 mL (1 bottle) in 6 hours, give fluid at the rate of 1 drop/3 sec, i.e. 20 drops/min (approx).

Infusing 540 mL (1 bottle) in 4 hours, give fluid at the rate of 1 drop/2 sec, i.e. 30 drops/min (approx).

Q. Causes of metabolic acidosis (Table 1.3):

1. Diabetic ketoacidosis
2. Renal failure.
3. Severe diarrhoea.
4. Starvation.
5. Lactic acidosis.
6. Poisoning by methyl alcohol, salicylates.
7. Hypoaldosteronism.
8. Renal tubular acidosis.

Q. Causes of metabolic alkalosis:

1. Severe vomiting or vigorous gastric aspiration.
2. Cushing's syndrome.
3. Primary hyperaldosteronism.
4. Severe hypokalaemia.
5. Milk-alkali syndrome.
6. Diuretics (furosemide, thiazides).

Q. Causes of respiratory acidosis:

1. Depression of respiratory centre by disease or drugs.
2. Central sleep apnoea.
3. Sudden failure of ventilation (e.g. myasthenic crisis).
4. Chronic bronchitis, emphysema.

Table 1.3: Acid-base disorders

Disorders	pH (7.40)	Primary defect	Compensatory effect
Metabolic acidosis	Low	Low HCO_3	Low $PaCO_2$
Metabolic alkalosis	High	High HCO_3	High $PaCO_2$
Respiratory acidosis	Low	High $PaCO_2$	High HCO_3
Respiratory alkalosis	High	Low $PaCO_2$	Low HCO_3

Q. Causes of respiratory alkalosis

1. Pneumonia, bronchial asthma, acute pulmonary cedema, high altitude (due to hypoxia).
2. Exercise.
3. Anxiety, fever, salicylate overdose (due to stimulation of respiratory centre).
4. Hysterical hyperventilation.

Q. What is anion gap in 'metabolic acidosis'?

It is the 'unmeasured anions' and are calculated by subtracting the sum of plasma bicarbonate and chloride concentrations (i.e. the measured anions) from plasma concentration of sodium (i.e. the measured cations).

Anion gap = $Na^+ - (HCO_3^- + Cl^-)$

The normal anion gap is 8–10 mmol/L; most of the anion gap is due to negative charges on plasma proteins (mainly albumin), and phosphate, sulphate and organic acid anions to a lesser degree. When acid anions, e.g. acetoacetic acid or lactic acid accumulate in ECF, it results in high-anion gap acidosis.

a. *Increased anion gap:*
   1. Diabetic ketoacidosis (or ketoacidosis from alcoholism and starvation).
   2. Acute and chronic renal failure.
   3. Lactic acidosis.
   4. Ingestion of toxins or drugs (salicylate, carbenicillin, ethelene glycol, methanol).

b. *Normal anion gap (hyperchloraemic acidosis):*
   1. Diarrhoea.
   2. Intestinal fistula.
   3. Ureterosigmoidostomy.
   4. Renal tubular acidosis.
   5. Hypoaldosteronism.
   6. Ingestion of toxins or drugs (ammonium chloride, cholestyramine).

Q. How to analyze arterial blood gas (ABG) results?

A rough assessment can be done by:

pH	pH <7.35 (Acidosis)	Metabolic ($\downarrow HCO_3$) (<20 mEq/L)
		Respiratory ($\uparrow PaCO_2$) (>45 mm of Hg)
	pH >7.45 (Alkalosis)	Metabolic ($\uparrow HCO_3$) (>30 mEq/L)
		Respiratory ($\downarrow PaCO_2$) (<35 mm of Hg)

Q. Causes of hyponatraemia:

1. Severe diarrhoea, vomiting, peritonitis, burns, excess of diuretics, uncontrolled diabetes mellitus, CRF (all producing 'volume depletion', i.e. loss of both Na^+ and water).
2. Congestive cardiac failure, SIADH (syndrome of inappropriate ADH secretion), cirrhosis of liver, nephrotic syndrome, acute and chronic renal failure.
3. Adrenocortical failure, hypothyroidism, hypopituitarism, psychogenic polydipsia.

Q. Causes of hypernatraemia:

1. Diabetes insipidus, diabetes mellitus (when water loss is more).
2. Cushing's syndrome.
3. Primary hyperaldosteronism.
4. Infusion of hypertonic saline.

Q. Causes of hypokalaemia:

1. Diminished dietary intake (e.g. starvation).
2. Vomiting, diarrhoea, intestinal fistula.
3. Diuretics (e.g. loop diuretics).
4. Metabolic alkalosis.
5. Aldosteronism (primary or secondary).
6. After administration of insulin.
7. Diabetic ketoacidosis.
8. Hypokalaemic periodic paralysis.

Q. Cause of hyperkalaemia:

1. Renal failure (acute or chronic).
2. Addison's disease, hypoaldosteronism.
3. Metabolic acidosis.
4. Tissue damage, e.g. internal bleeding or muscle crush.
5. Potassium-sparing diuretic, e.g. spironolactone, triamterene, amiloride, or use of ACE-Inhibitors like enalapril or lisinopril, or angiotensin-receptor blockers like losartan or telmisartan.

- Pseudohyperkalaemia: It is the artifactual increase in serum K^+ due to release of K^+ during venipuncture (fist clenching), or marked increase in cellular elements, e.g. thrombocytosis, erythrocytosis or leucocytosis.

Q. Indications of 'blood transfusion' in medical ward:

One unit of whole blood contains approximately 450 mL of blood (in India, it is usually 350 mL).

1. *Restoration of volume of circulating blood:* Acute haemorrhage, e.g. haematemesis, melaena, haemoptysis, epistaxis, haematuria or menorrhagia of severe degree.
2. *Severe anaemia due to any cause:* Aplastic anaemia, anaemia of chronic renal failure, thalassaemia, disseminated malignancy, hookworm infestation, severe iron deficiency anaemia, AIDS.
3. *Granulocyte transfusion:* Severe neutropenia, neonatal sepsis, progressive fungal infection, chronic granulomatous disease.
4. *Platelet transfusion:* Severe thrombocytopenia or platelet dysfunction.
5. *Exchange transfusion:* Haemolytic disease of newborn, thrombotic thrombocytopenic purpura, severe falciparum malaria, poisoning (e.g. methaemoglobinaemia or arsine-induced haemolysis).
6. *Fresh blood transfusion:* In coagulation disorders, e.g. haemophilia or thrombocytopenia (e.g. idiopathic or immune thrombocytopenic purpura or ITP); Viperidae group of snake bite.

Q. What are central line and TPN?

Central line placement: A central venous catheter, known as 'central line', is often used to put medicines, blood products, fluid or nutrients right into the patient's blood through larger veins like internal jugular vein, femoral vein or subclavian vein. The central line is indicated in continuous infusion of chemotherapy, giving more than one drug at a time or hypertonic solution, nutritional support, haemodialysis, or required for long-term IV treatment (volume resuscitation). Central line is also used for taking out blood sample for testing and central venous pressure monitoring.

Total parenteral nutrition (TPN) therapy (method of feeding that by-pass GI tract) through subclavian vein is required in 'specialized nutrition support' (where oral therapy may be harmful or may not be possible) delivered in extensive small bowel disease, intestinal fistula, prolonged hyperemesis gravidarum, severe intra-abdominal sepsis, acute pancreatitis, inflammatory bowel disease, severe cachexia (e.g. cancer, AIDS), in patients on ventilation or any critical illness. This is usually done in an ITU (intensive therapeutic unit) setting. For a central venous TPN regimen, a pre-mixed (contains L-amino acids, lipids, glucose with vitamins, electrolytes and trace elements) 3-litre bag is infused over 24 hours with close monitoring.

SYRINGE (5 mL/50 mL)

Q. Description:

A syringe has two parts:

a. Air-tight piston, and
b. Cylinder with a nozzle at one end for fitting tightly with the base of a needle, scalp vein set or adaptor. The cylinder possesses markings on its outer surface indicating the volume of the drug to be delivered.

The syringe is usually made of glass. Disposable plastic syringe is for single use and is available in gamma irradiated packs. This type of syringes (5 mL) are often called 'hypodermic' syringe.

Q. Sterilisation:

1. Keeping (heating) in boiling water minimally for 30 minutes, seperating the piston and cylinder (before putting in water, loosely wrap the piston and cylinder with sterile gauze): The glass syringe.
2. Autoclaving.
3. Gamma ray irradiation.
4. Ethelene oxide.

Q. Different uses (Fig. 1.10A and B):

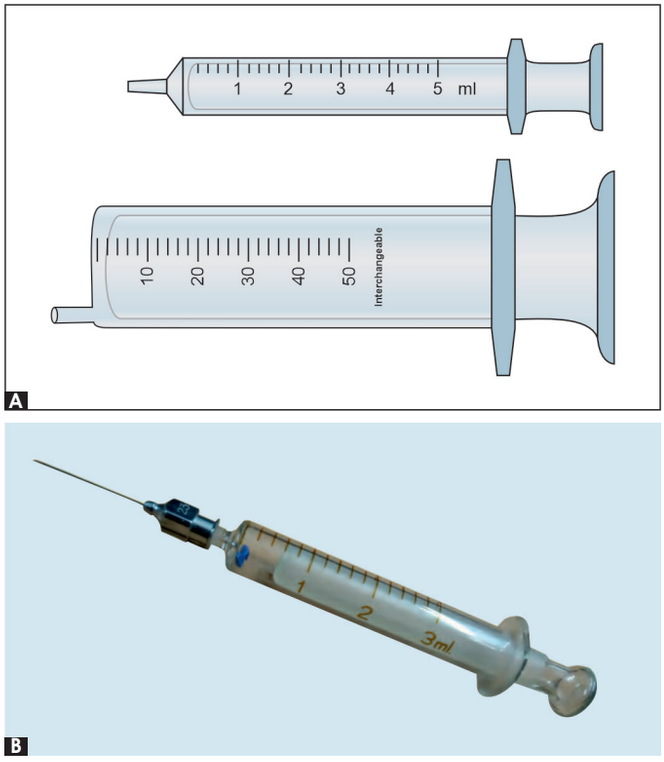


Fig. 1.10: (A) 5 and 50 mL syringes; (B) Syringe with needle

A. 5 mL Syringe

a. Collection of venous blood samples for laboratory analysis, aspiration from cyst/abscess, for myelography/IVP, etc.
b. Parenteral administration of drugs by different routes like IM (inj. tetanus toxoid), IV (antibiotics). subcutaneous (terbutaline, adrenaline, erythropoietin, adalimumab), intracutaneous (drug sensitivity, Mantoux test), intra-arterial (arteriogram), intra-articular (corticosteroid), intrathecal (methotrexate in ALL), intrapleural (for pleurodesis) and intra-peritoneal (antimetabolites).

B. 50 mL Syringe

a. Ryle's tube feeding; gastric aspiration in intestinal obstruction, pyloric stenosis, haematemesis or poisoning.
b. Aspiration of pleural and pericardial fluid, and paracentesis abdominis.
c. IV aminophylline injection.
d. Aspiration of amoebic or pyogenic liver abscess through a wide-bore needle.
e. Gastric wash by ice-cold saline in intractable hiccough.
f. Wound irrigation.

- The 'all glass' syringe is known as BD syringe (B and D stand for the manufacturer, Beckton and Dickinson). BD syringe is available as 2 mL, 5 mL, 10 mL, 20 mL, 50 mL and 100 mL syringes.
- **Venous blood collection (Fig. 1.10C)**: After adopting proper aseptic and antiseptic measures, venous blood sample is usually drawn from antecubital fossa after applying a venous tourniquet proximal to the chosen site. The operator should wear double gloves as a protection against 'high risk' cases, e.g. infection with hepatitis B or C, HIV. After drawing the blood, the venepuncture site is closed by cotton soaked in antiseptic solution and leucoplast. For femoral vein puncture (lies at the mid-inguinal point medial to femoral artery), i.e. *femoral tap*, insert the needle vertically just medial to femoral artery.

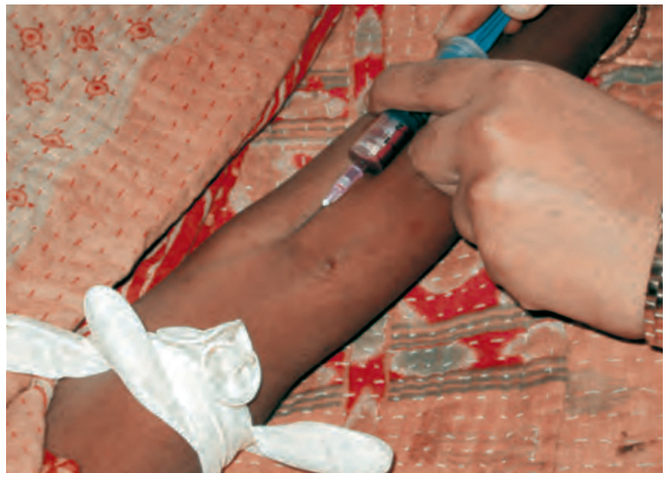


Fig. 1.10C: Blood drawn from right antecubital vein; a glove has been used here as a tourniquet

Q. Disadvantages of IM injection:

1. Painful.
2. There may be abscess formation.
3. Injury to the nerve may occur.
4. Muscle haematoma in coagulopathy (e.g. haemophilia) or prolonged bleeding (e.g. ITP).
5. Fibrous nodule formation at the injection site.
6. Anaphylaxis.
7. Transmission of some dreadful infection like hepatitis B rarely (in contamination).

Q. What is record syringe (Fig. 1.10D)?

Here, the cylinder (i.e. the body of the syringe) is made of glass while the piston and the long tapering nozzle of the cylinder are built of metal. Various sizes, e.g. 2 mL, 5 mL, 10 mL and 20 mL syringes are available. Autoclaving is not possible as it is partly glass and partly

metallic (the syringe may be damaged by autoclaving), and thus sterilisation is done by boiling. It can be used for IM injections and bone marrow aspiration (as the piston can be locked in the body satisfactorily, the suction of the bone marrow can be well maintained).

Fig. 1.10D: Record syringe

Q. What is anaphylaxis?

This is an example of immediate hypersensitivity reaction (IgE-mediated). It is a group of severe (type 1) reactions which occur in rapid succession if an antigen is injected, e.g. penicillin or sting of an insect, or rarely produced by ingested food in a highly sensitive individual. It is an acute life-threatening emergency and should be tackled immediately.

Features

Bronchospasm (wheezing), laryngeal oedema with severe dyspnoea, stridor and cyanosis, and feeling of impending doom; there is fall in BP (anaphylactic shock) and the patient may be unconscious. Swelling of the tongue, anorexia, nausea and vomiting, abdominal pain and diarrhoea may be present. Intense itching, urticaria and angioneurotic oedema (usually around the lips and eyes) may be seen. The diagnosis is purely clinical, and death may occur due to laryngeal spasm and hypotension.

Treatment

It is a potentially fatal condition and if not treated promptly, it possess a threat to life.

1. Patient lies down with head-down position. Prevent further contact with the allergen.
2. Ensure airway patency and start 100% O_2 inhalation at the rate of 4–6 litres/min. Maintain an IV line for normal saline to treat hypotension.
3. *Adrenaline:* It remains the cornerstone of therapy; 0.3–1.0 mL of 1:1000 adrenaline is injected subcutaneously (in lateral thigh) or IV; may be repeated at 10–30 minutes interval, if necessary.
4. *Corticosteroids:* Hydrocortisone 100–300 mg or dexamethasone 4–8 mg, IV, to be given immediately and every 4–6 hourly. Corticosteroids may not have any role in immediate management but may prevent delayed reaction.
5. *Antihistaminics:* Inj. diphenhydramine 25–50 mg, IV given for adult and 10–25 mg for children may shorten the duration of anaphylactic reaction. Inj. chlorpeniramine 10–20 mg IV may be given.
6. Inhaled beta agonist (slabutamol or terbutaline) may be used by nebulisation in bronchospasm; inj. aminophylline may be given as a second line drug.
7. *Treatment of shock:* Raise the foot end of the bed; start dopamine infusion. Use volume expanders (colloid solutions, e.g. dextran is preferable).
8. Assisted ventilation (IPPV) with emergency tracheostomy, or endotracheal intubation may be done, if laryngeal oedema is severe and signs of hypoxaemia are evident.
9. *Miscellaneous:* Intravenous isoprenaline, salbutamol or terbutaline may be given.

Q. How and where aminophylline injection is given?

Aminophylline is commonly given in acute exacerbation of bronchial asthma. It may be given in severe bronchospasm due to any cause (e.g. anaphylaxis, acute exacerbation of COPD).

It is also known as theophylline with ethylenediamine. Usually one ampoule of inj. aminophylline contains 250 mg of the drug (in 10 mL). A loading dose of 6 mg/kg is started, followed by an infusion of 1.0 mg/kg/hour for the next 12 hours and the reafter 0.8 mg/kg/hour is maintained. In non-smokers, maintenance dose is less and in patients receiving theophylline, the loading dose will be 0.5 mg/kg. Aminophylline is mixed in the bottle of normal saline or 5% dextrose for infusion. The drugs given slowly in IV route. Common side effects are nausea, vomiting, anorexia, seizures and cardiac arrhythmias.

Aminophyline also contracts diaphragmatic muscles. At present, use of nebuliser (with bronchodilators) has replaced administration of IV aminophylline in acute severe asthma and COPD.

Q. How do you diagnose amoebic liver abscess at the bedside?

Pre-disposing factors: Young adult males, consumption of alcohol, malnutrition.

Clinical Features

1. H/o amoebic dysentery is present in only 10% cases. Onset is usualy subacute, rarely acute.
2. The patient looks ill, mildly toxic and prostrated with a peculiar sallowness of the skin. There may be fever with chill, rigor and profuse sweating though temperature rarely exceeds 40°C; presence of emaciation. The absence of toxicity in the presence of fever is often recordable.
3. Dull and aching pain or sensation of heaviness over right hypochondrium is present. Pain increases with deep inspiration and coughing. Patient tends to turn on the left side. Pain may be referred to the right shoulder. Later on, abdominal pain becomes sharp and stabbing.
4. Intercostal tenderness (important bedside clue to diagnosis). Local oedema may be present.
5. Enlarged, soft, tender liver. A bulge may be seen in the epigastrium.
6. Jaundice is unusual.

7. Spleen is not palpable. The lower zone of right lung may show features of consolidation, pleurisy (pleural rub) or pleural effusion.

- The most common site of amoebic liver abscess is in the right lobe of liver, often postero-superiorly and is usually single. The patient may present with PUO.

Q. Indications of aspiration in amoebic liver abscess:

The needle aspirates the characteristic 'anchovy sauce' or 'chocolate' pus, which chiefly consists of liquefied nectrotic liver tissue. The pus is odourless, bacteriologically sterile, may contain few RBCs with occasional WBCs. The trophozoites of *E. histolytica* are usually absent in freshly aspirated pus but may appear in the escaping pus 4–5 days after initial aspiration. The indications for aspiration are:

1. Lack of response to 3–5 days of metronidazole treatment (i.e. failure to conservative therapy).
2. Very large abscess (>5 cm in diameter) with or without threat of imminent rupture.
3. Abscess in the left lobe likely to rupture into the pericardium.
4. To rule out pyogenic abscess, especially with multiple lesions.

- Aspiration is usually done under USG or CT guidance.
- Anchovy sauce: In real life it is a chocolate colour-like sauce made by small sea fish.

Q. Needle: Description and uses (Fig. 1.10E):

The BD needle has a bevelled end, body and shoulder. The base of a needle can be fitted directly to the nozzle of a syringe; previously available Leur Lock for fixing needle with syringe is not available nowadays. The needles are available in different sizes, e.g. No. 20, i.e. it is 1/20 inch in thickness. The higher the number, the thinner is the needle. Nowadays, disposable needles are available which are thrown away after single use.

Different uses: For IM injection (No. 22–24), for collection of blood and IV infusion (No. 18–20), for collection of blood from a donor (No. 16), and for aspiration of thick fluid from different body cavities (No. 12–14).

Sterilisation is done by boiling the needle for 30 minutes or by autoclaving.

Fig. 1.10E: Hypodermic needle

Q. What is venesection?

When the veins are collapsed and venipuncture is difficult, usually the saphenous vein over the ankle is exposed to the exterior for maintenance of IV infusion by making a small incision, and is known as venesection or 'cut-down' (also *see* page 19).

Q. Arterial blood gas (ABG) sampling: How it is done?

It is done to assess the acid-base status in respiratory, renal, cardiac or hepatic failure (e.g. the blood gas analysis); also done in drug overdose/intoxication (e.g. in aspirin poisoning). Radial artery of non-dominant hand, or femoral or brachial artery is chosen for puncture. Prior to sampling, the laboratory should be informed not to delay unnecessarily. Expel the air bubbles from the 'pre-heparinised' syringe. After proper asepsis, draw the arterial blood and place the 'sample' on ice during transit to the laboratory. Haematoma formation (due to inadequate pressure haemostasis) is not uncommon.

SCALP VEIN SET

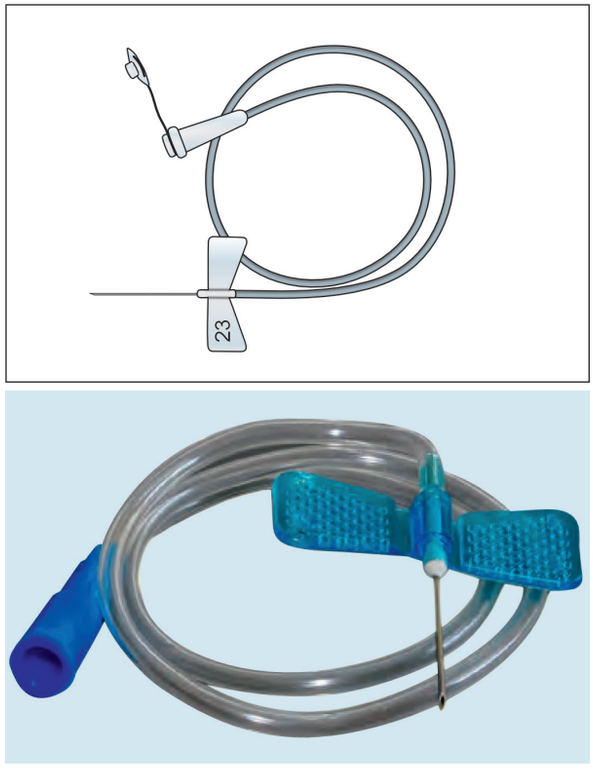


Fig. 1.11: Scalp vein set (size 23)

Description (Fig. 1.11)

1. A polythene tube: At one end, there is a fine bevelled siliconised stainless steel needle (of different size) attached and the other end is open (wider and with a cap) where the nozzle of syringe or IV set is fitted.
2. Two polythene flaps (i.e. butterfly-shaped wings) present on either side of the polythene tube near the needle: For fixation purpose by leucoplast.

The polythene tube is relatively long to be used as a heparinised channel (see below) and so much so to make the scalp vein set flexible. These are sterile and disposable needle of 18–25 G size; higher number needle possesses smaller bore.

Q. Different uses:

1. It is especially used in neonates, infants and small children where the calibre of the vein is small—can be used for parenteral fluid infusion and blood transfusion as well.
2. In adults—for the purpose of fluid infusion or blood transfusion, especially when the patient is in shock or collapsed (needle of common IV infusion set may be large in relation to a collapsed vein and thus, in that situation it may not be possible to place a big needle within the vein).
3. It may be used temporarily (making 'butterfly') for IV medication administered by shot-push (e.g. in pyogenic meningitis, SBE, septicaemia), by introducing diluted heparin (0.5 mL) within the polythene tube of the scalp vein set with the cap kept closed (i.e. acting as a 'heparinised channel'), The heparinised scalp vein set may be kept in the antecubital vein for few days for the purpose of repeated infusion. Intracath (see later) has replaced the use of heparinised scalp vein set.

Q. Why the scalp vein set is named so?

In the pediatrics ward, scalp veins may be used up to the age of 4 or 5 years for IV infusion. Usually branches of temporal vein, posterior auricular vein and veins of the forehead are commonly used as they are constant in location and large in size. The head of the child is fixed; the local skin is shaved. Putting the bevelled end upwards and maintaining the direction towards the heart, the needle is fixed at an angle of 30° (from the skin surface) with adhesive plaster. Previously, scalp veins were the preferred site for IV infusion in the paediatrics ward because it would avoid restriction of movement of limbs. Nowadays, paediatricians do not prefer to use the scalp veins as a recipient channel.

As the needle is short and sharp, there is chance of haematoma formation by counterpuncture.

Note

Read 'dehydration' with patient's assessment and fluid replacement in details.

INSULIN SYRINGE

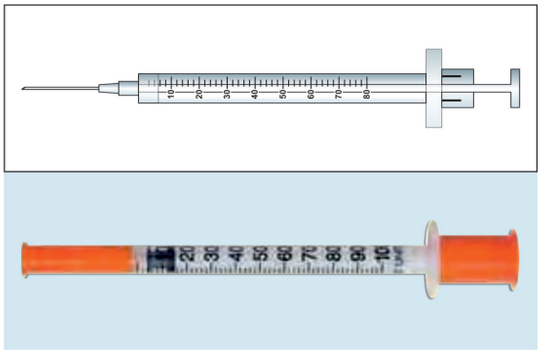


Fig. 1.12A: Insulin syringe with needle

Fig. 1.12B: Tuberculin syringe

Q. Description (Fig. 1.12A):

This is a syringe with capacity of 1 mL. The cylinder has markings on its outer surface indicating the amount of insulin in units, present distal to the piston. Insulin syringe resembles tuberculin syringe though its piston is white in colour (not blue).

Insulin is available in India as 40 units/mL or 80 units/mL commonly, or 100 units/mL as available in abroad and thus, 1 mL is graduated into 40, 80 or 100 units.

Q. Different uses:

1. To inject insulin in the subcutaneous (SC) route in diabetic patients.
2. In neonates, insulin syringe may serve the purpose of a 'hypodermic syringe' for giving injections by IM or SC route. In adults, methotrexate injection in rheumatoid arthritis or inj. adrenaline in anaphylaxis may be given by using insulin syringe (by SC route).
3. Sometimes, it is used to give an intradermal test-dose on the forearm before administering a drug (e.g. test of hypersensitivity reaction before giving injection penicillin).

- A **'tuberculin syringe'** (1 mL syringe with a **blue** pistion; used for Mantoux test or tuberculin test) **(Fig. 1.12B)** may also be used in neonates for giving injection by IM or SC route. **Mantoux test** is a type IV or delayed type of hypersensitivity reaction to tuberculoprotein. One tuberculin unit (TU) is equal to 0.00002 mg International Standard PPD (purified protein derivative). Usually 5 TU is injected (0.1 mL PPD) intradermally on volar aspect of the forearm (junction of mid and upper third). The result is read after 72 hours (3rd day). If the skin 'induration' (thickening) across the transverse axis of forearm is <10 mm, the test is negative and if ≥10 mm, it is regarded as positive. The amount of erythema (redness) present is not important. A **positive test** is presumptive evidence of current (active) or prior (old) mycobacterial infection; the larger the diameter of induration (e.g. >20 mm), the greater the support for a positive diagnosis. A negative test rules out the possibility of tuberculosis for all practical purposes. But in a child below 3 years (non-BCG-vaccinated), a positive test is commonly associated with active progressive disease. It should also be remembered that the **Mantoux test may be negative** in fulminant, miliary and meningeal tuberculosis, tuberculosis with low general condition, measles, lymphoma, sarcoidosis, leukaemia and in immunosuppression (e.g. steroid therapy, AIDS, etc); technical error (e.g. SC injection instead of intradermal) may give rise to negative result.

So, Mantoux test may be positive in recent or old *M. tuberculosis* infection, non-tuberculous mycobacterial (NTM) infection or prior BCG vaccination. This test has very low specificity and sensitivity.

The WHO advocates a PPD tuberculin known as PPD-RT-23 with Tween 80. In AIDS, an induration of 5 mm or more signifies a positive Mantoux test.

- Charles Mantoux (1877–1947) was a French physician from Cannes.
- Bacillus Calmette-Guérin (BCG) vaccine, given at birth to prevent tuberculosis, was discovered in 1921.

Q. Different uses of insulin:

1. Diabetes mellitus:
   a. All type 1 DM patients.
   b. Diabetic ketoacidosis.
   c. Diabetes with pregnancy, labour and delivery
   d. In periods of stress, e.g. acute infection, major surgery, acute myocardial infarction, any acute medical illness, stroke, acute injury, or while on glucocorticoid treatment.
   e. In type 2 DM: Secondary failure of oral hypoglycaemic agents; or inadequate control with presence of complications like painful peripheral neuropathy/retinopathy; renal failure, hepatic failure or respiratory failure.
   f. Pre-renal transplantation of diabetic patients.
2. Hyperkalaemia.
3. Insulin test or Hollander's test (not used nowadays): To know the completeness of vagotomy in a duodenal ulcer patient. It is known that increase in 20 mEq/L of acidity above the basal level after injection of insulin indicates incomplete vagotomy (insulin-induced hypoglycaemia stimulates the neurogenic phase of acid secretion in stomach in the presence of intact vagus nerve).

Q. Who first used insulin?

On 23rd January 1922, Frederick G Banting (a Canadian physician) and Charles H Best (a medical student) first used pancreatic extract in Toronto General Hospital on a severely diabetic patient named Leonard Thompson. Banting received The Nobel Prize along with another physician JJR Macleod (Professor of physiology) in the year 1923 for the discovery of insulin. November 14, the birth date of Sir FG Banting, was chosen as 'World Diabetes Day'.

Table 1.4: Available insulin preparations

Preparations	Time of action		
	Onset	Peak	Duration
Short-acting			
Lispro	<15 min	0.5–1.5 h	3–4 h
Aspart	<15 min	0.5–1.5 h	3–4 h
Glulisine	<15 min	0.5–1.5 h	3–4 h
Regular	30 min	2–3 h	4–6 h
Intermediate-acting			
NPH (isophane insulin)	2–4 h	6–8 h	10–16 h
Lente	2–4 h	6–8 h	10–16 h
Long-acting			
Glargine	1–4 h	None	24 h
Ultralente	4–6 h	10–18 h	16–24 h
Detemir	1–4 h	None	12–20 h
Degludec (ultra long-acting)	30–90 min	None	>24 h
Mixtures (Premix)			
70/30, 50/50, 75/25	30 min	7–12 h	10–16 h

- Values (time of action) are highly variable among individuals. Even in an individual, values vary depending on the site and depth of injection, skin temperature and exercise.
- *Insulin combinations:* 70/30 (70% NPH, 30% regular); 50/50 (50% NPH, 50% regular), and 75/25 (75% protamine lispro, 25% lispro), 70/30 (70% protamine aspart, 30% aspart) and 50/50 (50% protamine lispro, 50% lispro) are different premixed combinations used in clinical practice. NPH is Neutral Protamine Hagedorn.
- A new formulation of ultra rapid-acting inhaled insulin (Afrezza) has received FDA approval in 2014. In **diabetes with pregnancy**: drugs like metformin (in gestational diabetes with mild hyperglycaemia), glyburide (with caution) or insulin (regular, NPH, aspart, lispro) may be used.

Q. Insulin analogues (Table 1.4):

These insulin preparations are generated by modifying (i.e. changing the amino acid sequence by recombinant DNA technology) human insulin, and are useful in patients having repeated attacks of hypoglycaemia or show hyperglycaemia during some parts of the day while on regular insulin therapy. Among the six insulin analogues, three are short-acting or rapid-acting (lispro, aspart and glulisine) and three are long-acting (glargine, detemir and degludec) preparations.

Q. Insulin secretagogues and sensitisers:

Insulin secretagogues: Sulphonylureas and non-sulphonylureas (repaglinide and nateglinide). GLP-1 agonists exenatide and liraglutide (also known as 'Incretin mimetics'), and DPP-4 inhibitors sitagliptin, vildagliptin, linagliptin and saxagliptin are also insulin secretagogues.

Insulin sensitisers: Metformin and glitazones (e.g. pioglitazone).

- GLP-1 = glucagon-like peptide 1, DPP-4 = dipeptidyl peptidase-4
- Read 'oral hypoglycaemic agents' from the chapter on 'Diabetes mellitus' in 'Bedside Clinics in Medicine, Part I'.

Q. Uses of soluble or regular insulin:

1. In emergencies, it is the insulin of choice, i.e. ketoacidosis, infection, surgery, pregnancy, trauma.

2. To supplement depot insulin effects, if necessary.
3. Patients requiring >150 units of insulin/day.
4. Patients not controlled properly with depot insulins.

Q. Main types of therapeutic insulins:

1. Species	Bovine
	Porcine
	Human
2. Purity	Conventional
	Single peak
	Highly purified
3. Duration of action	Short-acting
	Intermediate-acting
	Long-acting

- Bovine insulin is more immunogenic, i.e. in relation to immunogenicity (antigenicity), Bovine >Porcine >Human insulin. Animal preparations (bovine or porcine) are no longer used.

Q. Goals of insulin therapy:

1. Alleviation of primary glycosuric symptoms.
2. Prevention of ketoacidosis and hyperosmolar coma; brings back the lost lean body mass.
3. Improvement in physical performance as well as sense of well being.
4. Diminution in foeto-maternal morbidity, foetal malformations.
5. Reduction in recurrent infections.
6. Delay, prevent or arrestation of micro- and macrovascular complications.

Q. Different insulin regimens:

1. Conventional insulin therapy (CIT).
2. Multiple subcutaneous injections (MSI).
3. Continuous subcutaneous insulin infusion (CSII).

Q. How to administer insulin?

Patient's education regarding insulin administration is important in treating diabetes mellitus.

1. Preferably, asepsis is maintained. Required dose of insulin is drawn into the syringe through a hypodermic needle.
2. A small, fine-bore hypodermic needle is now attached to the nozzle (or already attached) of the insulin syringe.
3. Preferable sites of injection are: anterior abdominal wall, upper outer arms, upper thighs or buttocks. The site is properly cleansed with spirit. Injection insulin is administered by SC route.
4. Now, a fold of skin and subcutaneous tissue is pinched-up by left thumb and index finger, and the hypodermic needle is introduced in the skinfold by right hand, from the top into the subcutaneous tissue. Insulin is injected and the needle is taken out with care (insulin leakage should be avoided).
5. Injection site is now covered and lightly pressed by a piece of cotton (rubbing should be avoided).

- The rotation of injection site should also be taught to the patient. Repeated injections in one site predispose to lipohypertrophy. Insulin injections are to be given deep subcutaneously. The sites have to be rotated so that a second injection does not fall within 1–2 cm of the previous injection site within 1 month of time. Look the injection sites for bruising, erythema or lipodystrophy.

Q. Alternative methods (i.e. other than syringe) of insulin delivery system:

i. Jet injectors.
ii. Pen devices.
iii. Insulin infusion pumps:
   a. 'Open' loop: Continuous subcutaneous insulin infusion (CSII).
   b. Closed loop (Biostator): Artificial pancreas.
iv. Nasal, oral, inhaler and rectal insulin: Not effective in practice at present.
v. Pancreas transplantation: Whole pancreas, segmental pancreas, islet transplant.

- Microprocessor based implantable pumps are now available which are more acceptable than CSII.
- 'Open' loop can be used by SC, IV or intraperitoneal route.

Q. Define brittle diabetes and insulin resistance:

a. ***Brittle diabetes:*** A small proportion of type 1 DM patients (1–2% of diabetic patients in practice) are unstable and difficult to control, and are referred to brittle diabetes. Actually, brittle diabetic is a patient whose life is constantly disrupted by episodic swings of hypoglycaemia and hyperglycaemia, whatever the cause may be and thus, it is difficult to manage. It is also known as unstable or labile diabetes.
b. ***Insulin resistance:***
   i. *Old view:* when >200 units of insulin/day are required to attain glycaemic control and to prevent ketoacidosis, it is arbitrarily said that insulin resistance exists.
   ii. *Modern view:* Daily intake of >1.5 units of insulin/kg of body weight, which is about twice the usual level necessary for full insulin replacement therapy (considering newer insulins).

- **Daily insulin production** by a normal pancreas in a healthy non-obese adult is 25–50 units.
- **Insulin resistance** is clinically diagnosed at the bedside by acanthosis nigricans, skin tags (acrochordons), central obesity, features of polycystic ovarian disease and lipodystrophy.

Q. Complications of insulin therapy:

1. Hypoglycaemia (commonest).
2. *Lipodystrophy:* Lipoatrophy (i.e. subcutaneous fat loss) and lipohypertrophy (i.e. fatty lumps).
3. Insulin resistance.
4. *Allergy:* Local, and rarely generalised.

5. Insulin oedema (rare but troublesome).
6. Weight gain, especially if the dose of insulin is increased inappropriately.
7. Sepsis.

Note

Read newer insulins from standard pharmacology or medicine textbooks.

THREE-WAY CANNULA

Q. Description (Fig. 1.13):

It is a T-shaped instrument with two inlets and one outlet. By adjustment, the outlet may be connected with either of the inlets.

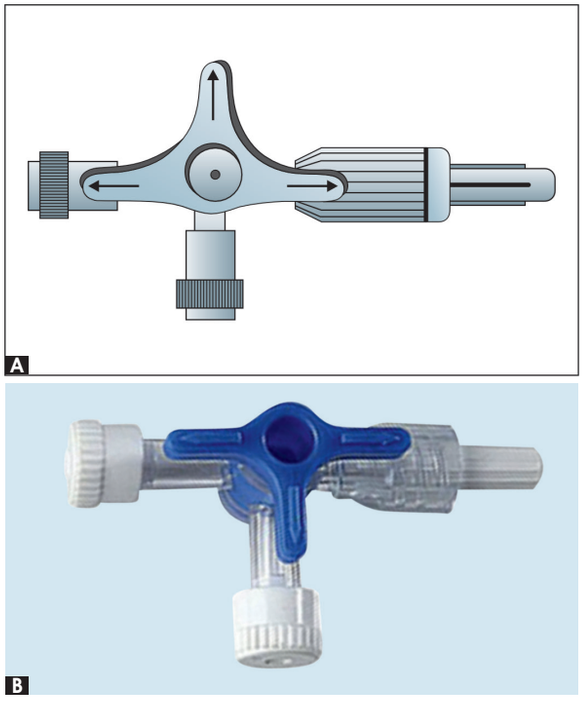


Fig. 1.13: Three-way cannula (adaptor)

Q. Different Uses:

1. To aspirate fluid from pleural, peritoneal or pericardial sac (fluid is withdrawn through one inlet by connecting a syringe with the cannula and by adjusting the screw, fluid in the syringe may be pushed into the kidney-tray via the outlet).
2. Through one inlet, IV fluid may be given (by an IV set) and the other inlet may be used for medications or monitoring central venous pressure (CVP).

ORAL REHYDRATION SALT (ORS)

Q. Presentation (Fig. 1.14):

The ORS is wrapped in an aluminium foil-packet or in a paper-packet.

Q. Indications for use:

To replace the fluid and electrolyte loss commonly as a result of vomiting and/or diarrhoea (i.e. acute gastroenteritis, cholera)—the 'oral rehydration therapy' (ORT).

Q. Composition:

As suggested by WHO (1971), the 'universal formula' is:

Ingredients	*Composition in g/litre of water*
NaCl (table salt)	3.5
$NaHCO_3$ (baking soda) or	2.5
Trisodium citrate dihydrate	2.9
KCl	1.5
Glucose (anhydrous)	20.0

Concentration in mEq/L: Na^+ 90, K^+ 20, Cl^-80, HCO_3^- or citrate 10, glucose 111 and osmolality 311.

Clinical Wisdom

The discovery of ORS is known as 'most medical advance of the century'. In 2002, WHO and UNICEF recommended use of 'new formula ORS' or **'low osmolarity ORS'**, especially for children with acute, non-cholera diarrhoea. It prevents hypernatraemia and increased stool output, especially in infants and young children. It can also be used in adults with strict vigilance to sodium concentration in blood.

The **ingredients** (g/litre of water) are NaCl 2.6, trisodium citrate dihydrate 2.9, KCl 1.5 and glucose (anhydrous) 13.5; **concentration in mEq/L** of low osmolarity ORS are: Na^+ 75, K^+ 20, Cl^- 65, citrate 10, glucose 75 and osmolality 245.

Fig. 1.14: Electrolyte sachet

Q. Method of preparation and application:

The content of the packet is dissolved in one litre of drinking water which is already boiled and then cooled, and should be used within 24 hours. It should be taken frequently as directed by the physician (depends on degree of dehydration).

Approximately, 50 mL/kg of body weight of ORS is given in first 4 hours in mild dehydration and 100 mL/kg of body weight is given similarly in moderate dehydration. Severe dehydration needs IV fluid therapy (along with ORS, 50–500 mL/kg of body weight).

Q. Advantages of use of ORS:

1. Reduces the cost of treatment (i.e. economical).
2. Easily administered at home (can be used easily by non-trained person).
3. It can be prepared easily at home by simple ingredients like sugar and common salt.
4. Practically, there is very little chance of fluid overload.
5. No pain or phlebitis (as occurs with IV fluid therapy).

Q. Disadvantages of use of ORS:

There are very few disadvantages of oral rehydration therapy like:

1. Unconscious patient (requires IV access).
2. Severe dehydration (needs IV fluid therapy).
3. Chance of fluid overload in CCF, chronic renal failure and in infants.
4. The taste may not be accepted by all (few ORS are added with rice flour and used in cholera, are really of very bad taste).
5. Patient may be reluctant to take it in the presence of incessant vomiting.

Q. Contraindications of ORS:

1. Severe hypertensive disorders.
2. Protracted vomiting.
3. Comatose patient.
4. Severe renal failure.
5. Chronic heart failure.
6. Intestinal obstruction.

Q. Principle of action of ORS:

Use of ORS is based on the observation that oral glucose (2%) enhances the intestinal absorption of salt and water (ATP-dependent pump for Na^+ absorption, i.e. glucose-facilitated Na^+ transport), even in the presence of diarrhoea.

Glucose may be replaced by sucrose (40 g of sucrose must be added as sucrose is broken down to equal amount of glucose and fructose). Cereals and other starchy foods (rice flour) may also replace glucose (starch is broken down into glucose and amino acids which facilitate Na^+ absorption)

- Fluids from cooked cereals, e.g. rice water may be used in tropics.

Q. Osmolality of blood, urine, stool and CSF:

Osmolality is the measurement of concentration of all solute particles per kilogram of solution.

Blood (plasma): 280–300 mOsmol/kg of water
Urine: 400–750 mOsmol/kg of water
Stool: 290 mOsmol/kg of water
CSF: 292–297 mOsmol/kg of water

- *Osmolality of plasma* (mOsmol/kg) = 2 [Na^+ (mmol/L) + K^+ (mmol/L)] + glucose (mmol/L) + BUN (mmol/L). Glucose and BUN are converted to mmol/L by dividing concentration in mg/dL by 18 and 2.8 respectively. Osmolality can also be measured by osmometry.

Q. Diarrhoea and dysentery:

Diarrhoea: It is defined as an increase in daily stool weight over 200 g but in a general sense, frequent passage of liquid or unformed stool is known as diarrhoea. It is divided into **acute** (lasting less than

Table 1.5: Differentiation between small bowel and large bowel diarrhoea

Features	Small bowel diarrhoea	Large bowel diarrhoea
1. Volume	Large	Small
2. Frequency	Less	More
3. Character	Soup-like, greasy	Mucinous, jelly-like
4. Colour	Light	Dark
5. Odour	Very offensive	Offensive
6. Nature	Uniformly watery	Mucoid, or watery with small pieces of fecal matter
7. Site of pain	Mid-abdomen (colicky and intermittent)	Lower abdomen (gripping and continuous)
8. Site of involvement	Small bowel or right colon	Left colon
9. Dehydration and shock	Unlikely	Common
10. Tenesmus	Absent	Present
11. Blood and WBC within stool	Rare	Common
12. Common pathogenic organisms	*Vibrio cholerae*, *E. coli*, Rota or Norwalk virus, *Campylobacter*	*E. histolytica*, *Shigella*

2 weeks—mainly the infective causes, e.g. Rota virus, *E. coli*, *Clostridium difficile*, cholera, and soon after dietary indiscretions), **persistent** (2–4 weeks) and **chronic** (lasting more than 4 weeks—chronic enteric infections, e.g. salmonellosis, giardiasis, hookworm infestation, amoebic colitis, intestinal tuberculosis, HIV infection; pancreatic insufficiency, coeliac disease, pellagra, Addison's disease, malabsorption syndrome, inflammatory bowel disease, e.g. ulcerative colitis and Crohn's disease, irritable bowel syndrome, lactose intolerance, diverticulitis, autonomic neuropathy, lactase deficiency, thyrotoxicosis or laxative abuse) types **(Table 1.5)**.

'Hyperdefecation' is characteristic of thyrotoxicosis. Frequent passage of small volume of formed stool is often associated with anorectal disorders (e.g. proctitis) or irritable bowel syndrome is known as 'pseudodiarrhoea'. Involuntary discharge of rectal contents is known as rectal incontinence, and is due to neuromuscular disorders or anorectal sphincteric disturbance (i.e. fecal incontinence).

Dysentery: Characterised by diarrhoea with blood and mucus in the stool as a result of acute inflammation of large gut, and clinically manifested by colicky abdominal pain, pyrexia and tenesmus (dysentery is basically of two types—amoebic and bacillary).

❍ **Tenesmus** is a feeling of incomplete evacuation with a constant desire for defecation.

Q. Mechanisms of diarrhoea in a nutshell:

a. *Secretory diarrhoea*, i.e. disruption of epithelial electrolyte transport, e.g. increased secretion of electrolytes in *V. cholerae* infection, villous adenoma of colon, etc.
b. *Osmotic diarrhoea:* Poorly absorbed solutes in lactose intolerance, maldigestion, or $MgSO_4$ or lactulose-induced.
c. *Exudative diarrhoea:* Occurs in the presence of blood and pus in the stool, e.g. IBD (ulcerative colitis and Crohn's disease) or food poisoning.
d. *Malabsorption diarrhoea:* Stool is bulky and extremely foul-smelling, e.g. in coeliac disease, etc.
e. *Motility disorder-induced diarrhoea:* Irritable bowel syndrome (IBS).

Q. What are the endocrine causes of diarrhoea?

1. Diabetes mellitus.
2. Hyperthyroidism.
3. Hypoparathyroidism.
4. Zollinger-Ellison syndrome.
5. Adrenal insufficiency.
6. Carcinoid syndrome.
7. Villous adenoma of colon.
8. Medullary carcinoma of thyroid.
9. VIPoma (pancreatic cholera).
10. Systemic mastocytosis.

Q. Common offenders in traveller's diarrhoea?

It is the passage of three or more unformed stool/day in a resident of a developed country travelling in a developing nation. The infection is usually food- or water-borne. The common offenders are:

a. *Bacterial:* Enterotoxigenic *E. coli*, *Campylobacter jejuni*, *Salmonella*, *Shigella*, enteroaggregative *E. coli*. *Yersinia enterocolitica*, *aeromonas* spp. and *Plesiomonas shigelloides* are rare causes.
b. *Viral:* Account for minority of illness (e.g. Rota virus, Norwalk virus).
c. *Parasitic: E. hystolytica*, *Giardia lamblia* and *cryptosporidia* spp.

Q. What is food poisoning?

Any disease of an infective or toxic nature caused by consumption of food or drink is food poisoning. The most common form is gastroenteritis, following consumption of food containing preformed toxins or infective organisms that are capable to produce toxins in the intestine. The common causes are preformed toxins (e.g. *Staphylococcus aureus*), enterotoxigenic *E. coli*. *Shegella*, *Salmonella*, *Campylobacter*, viruses, *Giardia lamblia*, *Clostridium*, heavy metals (e.g. arsenic), mushrooms, certain seafoods or botulinus toxin (botulism does not produce gastroenteritis but develops into potentially fatal paralytic illness). The common symptoms are nausea, vomiting, diarrhoea (may be bloody), abdominal pain and cramping, fever and malaise. Symptoms can start as early as one hour in case of *Staphylococcus aureus*.

Q. Acute infective diarrhoea in children:

The common causes are:

1. *Virus:* Rota virus (30–40%), Norwalk virus
2. *Bacterial:*
   a. *E. coli*—Enterotoxigenic strain (30-40%)
   b. *V. cholerae* (El Tor biotype)
   c. *Salmonella*
   d. *Shigella*
   e. *Campylobacter jejuni*
   f. *Clostridium difficile*
3. *Parasites: Glardia lamblia*, *Entamoeba histolytica*, *Plasmodium falciparum* (Algid malaria)
4. *Fungi: Candida albicans*.

Clinical Wisdom

V. cholerae and *E. coli* do not invade intestinal mucosa. Diarrhoea is an important determining factor leading to malnutrition in children. Breastfeeding should continue along with oral rehydration therapy in infantile diarrhoea.

Q Chronic diarrhoea in children:

1. Cow's milk allergy.
2. Coeliac disease.
3. Chronic pancreatitis.

4. Cystic fibrosis.
5. Secondary to PEM, or viral/bacterial enteritis.
6. Worm infestations.
7. Intestinal stasis.
8. Liver diseases.

Q. How ORS can be prepared at home?

a. Two teaspoonfuls of cane sugar + a pinch of table salt + a glass of water, or
b. 6–8 level teaspoonfuls of cane sugar (i.e. 40 g of sucrose) + one level teaspoonful of common salt (i.e. 5 g of NaCl) ± few drops of lemon + 1 litre of potable water.

- 20 g of glucose is equivalent to 40 g of cane sugar (sucrose), is equivalent to 50 g of rice flour (puffed rice powder).
- Rice-based ORS gives more nutritional benefits and helps to reduce the fluid output of diarrhoeal stool.

Q. Can a green coconut (water) replace ORS?

Previously it was said by some workers in this field that oral administration of 200 mL of green coconut water (GCW) for each litre of fecal loss would serve to maintain K^+-balance in cholera patients with prolonged diarrhoea. It is known that K^+ content of GCW is high, and Na^+ and glucose contents are low in comparison to ORS. Though GCW is a readily available, cheap, sterile refreshing drink (an average size GCW contains about 300 mL of fluid), it can never replace ORS because it is not a true replica of ORS.

THE STETHOSCOPE

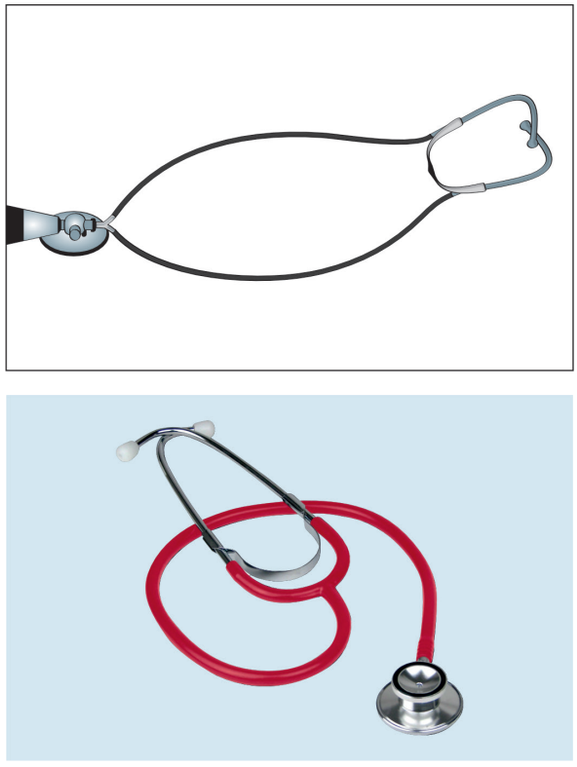


Fig. 1.15A: The stethoscope

Q. Description (Fig. 1.15A):

It has four parts such as 1. Chest piece, 2. Connecting tube, 3. Head piece, and 4. Ear piece.

1. Chest piece: Usually with a diaphragm and a bell, only one operates at a time. There is a valve that allows switching from diaphragm to bell and *vice versa*.

a. *The diaphragm:* It should be stiff and smooth to damp out low-frequency sounds, and unmask high-frequency sounds (>300 Hz). The thin plastic disc (usually having 4 cm diameter) is kept in position tightly by a metallic ring. The cardiac sounds best heard by diaphragm are, 1. All the diastolic and systolic murmurs due to different valvular lesions except mitral and tricuspid stenosis (MS/TS), 2. S_1 and S_2, and 3. Ejection click, pericardial knock, opening snap, etc.
b. *The bell:* Low-frequency sounds (80–150 Hz) are best heard by the bell. The bell (diameter of 2.5 cm) should be placed lightly on the site of auscultation (just enough to prevent room-noise leak) as firm pressure will tighten the underlying skin as a taut diaphragm (in that situation, low-frequency sounds will damp out and only high-frequency sounds are heard). The sounds best heard by the bell are, 1. Low-pitched diastolic murmur of MS and TS, 2. S_3 or S_4, 3. Foetal heart sounds, and 4. Venous hum.

2. Connecting tube: A single or double tube connects the head piece with the chest piece via a metallic connector (binaural connector) attached to the chest piece. A length of 12 inches (30 cm) is sufficient. A tall physician may add additional 3 or 4 inches. Internal lining should be smooth and is of 4-6 mm in diameter.

Long tubing attenuates high-frequency sounds. Very narrow tubes carry low-frequency sounds better, and high-frequency sounds are better carried by wider tubing.

3. Head piece: The two metal tubes of the head piece are attached together by a metallic U-connector.

4. Ear piece: The two metal tubes of the head piece end in two plastic ear pieces. Larger ear pieces are ideal as they prevent air leak. The usual stethoscope head piece is designed in such a way that the ear pieces point slightly anterioly to be in the same line with the external auditory canal.

- One should not replace the torn diaphragm with a small piece of X-ray plate because the X-ray plate is neither thin nor stiff. A beginner in medical curriculum should know every detail of a stethoscope.

Q. Criteria for a good (ideal) stethoscope:

1. *For high-frequency sounds:* Smooth, thin and stiff diaphragm.
2. *For low-frequency sounds:* Shallow bell with a large diameter.
3. Double tubing (more efficient for high-frequencies) with a metal clip which binds the tubes together.

Rene Laennec, reluctant to press his ear to chest of a young female patient, finds a solution in the wooden stethoscope

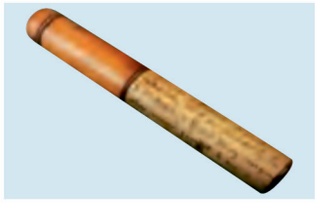


Fig. 1.15B: **Stethoscope** used by **Laennec**

4. Ear pieces should be largest possible one; soft and made of rubbery material.
5. Length and internal circumferential diameter of the connecting tubes should not cross 12 inches and 4-6 mm respectively; the inner lining of the tubes should be made smooth by 'vinyl tubing'.
6. There should be option for rotation of the metal head pieces so that ear pieces can be placed in the most comfortable position.
7. An extra pediatric-sized diaphragm and bell attached.

Q. Who invented the stethoscope?

The French physician Rene Theophile Hyacinthe (RTH) Laennec (1816) invented the stethoscope; his first instrument was a hollow wooden cylinder **(Fig. 1.15B)**. He died at the age of 46 years (1781–1826). His idea of listening heart sounds by a roll of thick paper landed in modern stethoscope with passage of time.

Later on, his instrument was modified by Arthur Lear and George Cammann to become the binaural instrument that is used today.

Q. Different uses:

Though *stethos* means 'chest', and *skopio* means 'to examine', the modern stethoscope is used for auscultation of various parts of the body, such as:

1. *Cardiovascular system:* Heart sounds, murmur, opening snap, ejection click, pericardial knock, pericardial rub, etc.
2. *Respiratory system:* Breath sound, vocal resonance, crepitations, rhonchi, pleural rub, pneumothorax click, etc.
3. *Abdomen:* Normal peristaltic sounds, renal artery bruit, venous hum, succussion splash and auscultopercussion in pyloric stenosis, hepatic and splenic rub, hepatic bruit, uterine souffle and foetal heart sounds.
4. *Head:* Bruit from cerebral arteriovenous malformation may be heard over cranium or closed eyes; bruit in Paget's disease.
5. *Neck:* Carotid bruit, cervical venous hum, thyroid bruit, conducted murmur of AS.
6. *Extremities:* Pistol shot sound, Duroziez's murmur, demonstration of Hill's sign.
7. Measurement of blood pressure (to listen Korotkoff sounds).
8. *Miscellaneous:* Subcutaneous emphysema, demonstration of parietal oedema.

- Worldwide, stethoscope symbolises a doctor. Stethoscope manufactured by renowned companies are Littmann, Harvey, Sprague, Leatham, etc. Besides the conventional variety, electronic, magnetic and digital stethoscopes are also available.
- Except the sounds best heard by the bell, all other sounds mentioned above are best auscultated by the diaphragm of stethoscope.

SPHYGMOMANOMETER

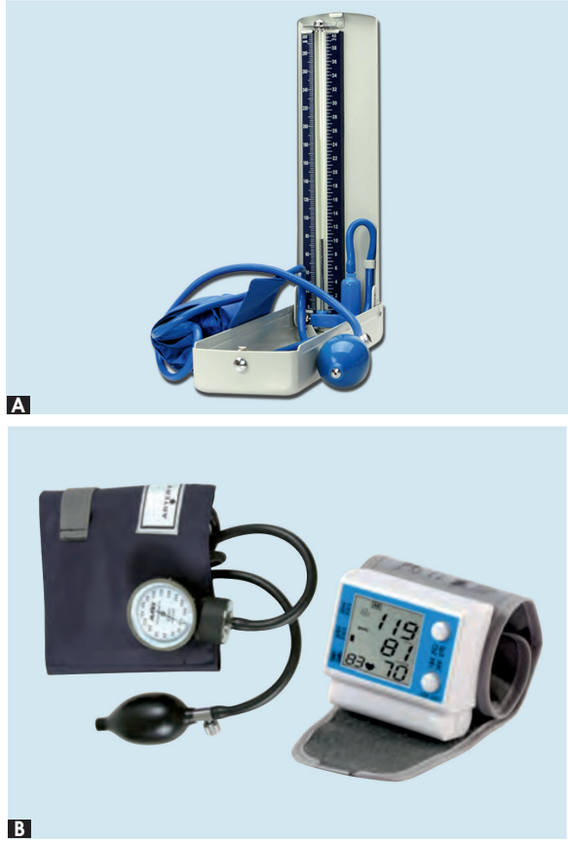


Fig. 1.16: Sphygmomanometer (A) Mercury column type; (B) Aneroid type

Q. Different uses:

They are:

1. To measure the blood pressure (BP).
2. Confirmation of,
   a. Pulsus paradoxus.
   b. Pulsus alternans.
   c. Water-hammer pulse.
3. To demonstrate postural hypotension.
4. To demonstrate Hill's sign in aortic regurgitation and low BP in lower limbs in coarctation of aorta.
5. Hess' capillary fragility test.
6. To assess the respiratory reserve (blow through the tube and observe the rise in mercury column).
7. In latent tetany (Trousseau's sign).
8. To draw venous blood.

9. As a rotating tourniquet in LVF.
10. To draw blood during blood donation.

- Sphygmomanometer was discovered by Scipione Riva-Rocci (Italy) in 1896.

Q. Types (Fig. 1.16):

There are two common types:
a. Mercury column type, and
b. Aneroid type or spring dial type (less accurate).

- Digital (electronic) BP instruments are used by lay people at home (third type).

Q. What is SP, DP, PP and MAP?

Systolic pressure (SP) reflects the cardiac output.
Diastolic pressure (DP) reflects the peripheral resistance.
Pulse pressure (PP) = SP minus DP; normal PP is 30–60 mm of Hg.

Mean arterial pressue (MAP) = DP+ 1/3rd of PP; normal MAP is approximately 100 mm of Hg.

- *Determinants of arterial pressure:* Two major determinants are cardiac output and peripheral resistance. Again, cardiac output is determined by stroke volume (it is related to myocardial contractility) and heart rate. Peripheral resistance is determined by vascular structure (i.e. anatomical changes in small arteries and arterioles) and vascular function.
- Diastolic pressure is the most important among all. SP reflects the cardiac activity over and above the peripheral resistance (i.e. indicates the constant load against which heart has to work) and thus, DP is a better guide to assess the haemodynamics in the body.
- MAP is a better indicator of perfusion to vital organs than SP.

Q. How to define blood pressure (BP)?

It is the lateral pressure exerted by the column of blood on the vessel walls while flowing through it.

Q. What is the normal BP (Table 1.6)?

It depends on age and sex of the individual, and also on many other parameters like build, exercise, posture, sleep, excitement, etc. High BP or **hypertension** is defined arbitrarily by the values which outrange the normal limits of BP as defined by British Hypertension Society or JNC-VIII. According to majority of definitions, upper limit of normal BP is 140/90 mm of Hg (<60 years). **Hypotension** is BP <90/60 mm of Hg.

Table 1.6: 2017 updated classification of blood pressure

BP category	Systolic BP (mm of Hg)	Diastolic BP (mm of Hg)
Normal	<120	<80
Elevated	120–129	<80
Stage I hypertension	130–139	80–89
Stage II hypertension	≥140	≥90

- Read JNC-VII (2003) and VIII (2014) for BP goal from any cardiology textbook. JNC stands for Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure.

Q. Ideal measurement of sphygmomanometer cuff:

1. *Length:* Should not be less than 10 inches.
2. *Width:*
   a. Adults: 5 inches.
   b. Young children: 3 inches.
   c. Infants: 1 inch.

- Width of 8 inches cuff should be used in legs (thigh) to avoid falsely elevated BP in adults. If an adult-sized cuff is used in a child, it will falsely record low BP and if an infant-sized cuff is used in an adult, it with falsely record high BP. Obese adults require wider cuff for arms (6 inches).

Q. How do you measure the BP?

Steps

1. The patient should lie flat on his back (SP may rise after sitting or standing) and should take rest for at least 15 minutes before recording of BP (BP should be recorded with the patient taking rest in a comfortable position and thus, casual recording should always be avoided). The patient should not smoke, consume caffeine or perform exercise at least half an hour before measurement.
2. Wrap the appropriate cuff (it has an inflatable rubber bladder inside) firmly and uniformly over the arm in such a way (rubber cuff should cover 80% of arm) that the lower border of the cuff remains at least 1 inch above the elbow joint. The arm should be kept in extended position at the heart level.
3. Keep the BP instrument (or spring dial) at the level of patient's heart. The midportion of the rubber bag present within the cuff should lie over the brachial artery. Raise the pressure upto 200 mm of Hg or till the radial pulse disappears. Now start deflating, while the point of reappearance of radial pulse indicates SP by 'palpatory method'. BP is first recorded by palpation and then by auscultatory method; now place the diaphragm of sthethoscope over the brachial artery, a little below the cuff ('auscultatory method'). The cuff is inflated again and the mercury column is raised to 20 mm of Hg above the SP which was recorded by palpatory method, and then deflated slowly (2 mm of Hg/second). The BP is usually measured to the nearest 2 mm of Hg.
4. During release of pressure (deflation), following variations of sounds are heard ('Korotkoff sounds', after their discoverer Nikolai Korotkoff, a Russian surgeon, in 1905). Phase I—Sudden appearance of tapping sound (indicates SP); Phase II—Murmur-like sound replaces the tapping sound; Phase III—Gong sound replaces murmur; Phase IV—Loud sound suddenly becomes muffled: Phase V—Disappearance of all sounds (indicates DP).

Clinical Wisdom

Previouly DP was recorded by phase IV but nowadays phase V (just disappearance of sounds) is taken granted for measuring DP (interobserver variations are minimum and more closely corresponds to directly measurred DP while recording phase V). Few countries record the BP as $^{150}/_{96–90}$ mm of Hg where the SP is 150, Phase IV—DP is 96 and phase V—DP is recorded as 90 mm of Hg.

5. For recording of blood pressure in legs, wrap the larger cuff in the thigh and place the stethoscope over the popliteal artery in the popliteal fossa while the patient lies in prone position.

- Where Korotkoff sounds remain audible in spite of complete deflation of the cuff (e.g. aortic incompetence, arteriovenous fistula, pregnancy), phase IV should be used for measurement of DP. The DP may be 0 (zero) in these condition.
- In young individuals <50 years of age, DP is more important as a risk factor whereas SP is important in persons >50 years of age. SP increases continuously with ageing; in elderly persons DP may decrease.

Q. Checklists for ideal BP measurement:

1. The patient should be 'relaxed'.
2. Arm placed at heart level. Tight clothing should be removed from the arm.
3. Correct size of bladder cuff without any leak.
4. Sphygmomanometer should be placed upright; aneroid type calibrated at regular interval.
5. Confirm systolic BP by palpation of radial artery; slow deflation in auscultatory method.
6. Avoid parallax error (eye should be kept at the same level with the sphygmomanometer).
7. Record two measurements at each visit.

Q. Does any variation exist in BP of two upper extremities?

Normally, in health, there may be a difference of 10 mm of Hg observed between right and left upper limb pressure. One must think of few special situations (like thoracic inlet syndrome, aneurysm of the aorta, pre-subclavian coarctation, supravalvular AS, Takayasu's disease, atherosclerosis of aorta) in the presence of significant pressure difference between two upper limbs.

Clinical Wisdom

Normally the SP in the lower limb is up to 20 mm of Hg higher than the SP in the upper limb, but DP remains the same. Recording of lower limb BP is important in coarctation of aorta or occlusive disease of aorta (low), and aortic incompetence (high). BP should always be measured in both upper and lower limbs, and in supine and erect posture. In SI units, BP is recorded in Kilopascal (kPa) and 1 kPa = 7.5 mm of Hg (approximately).

Q. What is auscultatory gap or silent gap?

Sometimes the initial sounds (which record SP) may disappear (after initial appearance) for some period just to reappear at a lower level, and this is auscultatory gap. If a physician is not careful, he may falsely record low SP (if he misses the initial sounds and starts recording after the gap). It is why, the mercury column should be raised up to 200 mm of Hg or more at the initial part of recording to minimise errors.

Clinical importance: Observed in certain patients with systemic hypertension.

Mechanisms

1. Venous distension.
2. Diminished flow velocity in arteries.

Q. Causes of systolic and diastolic hypertension:

a. *Systolic hypertension:* Atherosclerosis, aortic incompetence, complete heart block, etc.
b. *Diastolic hypertension*: Essential hypertension, parenchymal renal disease, Cushing's syndrome, pheochromocytoma, eclampsia, etc.
c. Divergent BP (high SP and low DP), e.g. 180/30 mm of Hg is seen in atherosclerosis, aortic incompetence.

Q. Causes of secondary hypertension:

Systemic hypertension is of two types: Essential and secondary. The secondary causes are:

i. Vascular:
   a. Coarctation of aorta.
   b. Non-specific aorto-arteritis.
ii. Renal:
   a. Acute and chronic glomerulonephritis.
   b. Diabetic nephropathy.
   c. Polycystic kidney disease.
   d. Renal artery stenosis.
   e. Chronic pyelonephritis.
   f. Renal involvement from collagen vascular diseases (e.g. SLE).
   g. Chronic renal failure:
iii. Endocrine:
   a. Cushing's syndrome.
   b. Pheochromocytoma.
   c. Conn's syndrome.
   d. Acromegaly.
   e. Hyperparathyroidism.
   f. Myxoedema.
   g. Congenital adrenal hyperplasia.
iv. *Drugs:* Oral contraceptive pills, corticosteroid, carbenexolone, oestrogens, sympathomimetic amines.
v. *Miscellaneous:* Pre-eclampsia or eclampsia, obstructive sleep apnoea, alcohol, obesity, diencephalic syndrome and porphyria.

Clinical Wisdom

Essential or idiopathic hypertension comprises 80–90% cases of hypertension and rest are secondary hypertension. Secondary hypertension is a consequence of specific disease or abnormality (so, though severe diastolic hypertension may occur, they are often treatable).

Q. Symptoms of hypertension:

It is a symptomless 'silent killer' though few patients may get a signal through occipital headache or dizzy spells.

Before declaring a person hypertensive, ≥2 BP recording at each visit for 3 or more occasions are necessary.

Q. What is postural or orthostatic hypotension?

Fall of 20 mm of Hg or more in SP, or 10 mm of Hg or more in DP in upright posture than in lying down posture is postural hypotension. If the patient complains of symptoms like light-headedness, dizziness, extreme weakness, blurring of vision or syncope, even a lesser degree of fall in BP may be considered as significant. First measure the BP in lying down position and then record BP **within 3 minutes of standing.** 'Postural drop' in BP is important bedside clue in syncope, and diabetes mellitus with autonomic neuropathy.

- Postprandial hypotension, i.e. fall of systolic BP occurs within 2 hours after a meal, while the patient (old age, diabetes, parkinsonism) may feel dizzy, light-headedness or faintness.

Q. Where the BP instrument may be used as a pneumatic tourniquet?

1. Emergency control of bleeding where other methods are not available.
2. To produce a bloodless field of operation.

Q. What is 'white-coat' hypertension?

Few patients (20%, especially women) show dramatic elevation of BP when measurements are carried out by a doctor in the chamber, outdoor or indoor. Thus, often it is called as office or clinic hypertension. Contrary to previous beliefs, it may be associated with target organ damage (e.g. LVH, carotid atherosclerosis). It is an important well-known cause of refractory hypertension. It has been observed that BP recordings by a senior consultant physician is higher than recording by a junior doctor, which is again higher than the BP recorded by a nursing staff. It is believed to be due to anxiety some people experience during visit to a clinic. Accurate diagnosis requires 24 hours ambulatory monitoring of BP.

Masked hypertension—normal office or clinic BP but there is elevated home BP (opposite to white-coat hypertension).

Q. Pseudo hypertension:

In old age, there is false recording of high BP as a result of stiff and non-compliant vessels (Osler's sign). Actually, the true intra-arterial BP is lower than the BP measured by sphygmomanometer.

Q. Labile hypertension:

The patients having high BP for sometimes, but not always, are known as labile hypertensives.

Q. Paroxysmal hypertension:

This (sudden shooting of BP) is classically seen in certain patients of pheochromocytoma, and is also known as episodic hypertension. This is diagnosed by repeated recordings.

Q. Transient hypertension:

In conditions like acute glomerulonephritis, pregnancy, acute myocardial infarction or CVA, systemic hypertension may be seen for a brief period of time and may be due to stress-induced or associated with a disorder having transient phase of hypertension.

Q. Hypertensive urgency and emergency:

Hypertensive urgency: High BP without any target organ damage and thus reduction of BP can be done gradually within 24 hours.

Hypertensive emergency: Markedly high BP with impending target organ damage which needs immediate control of BP (within minutes) in order to prevent further target organ damage.

Q. Isolated systolic hypertension (ISH):

When the SP is ≥140 mm of Hg and DP remains <90 mm of Hg, it is said that ISH is present and is commonly found in old age.

Q. Accelerated and malignant hypertension:

- Accelerated hypertension: Recent and rapid increase in BP with evidence of vascular changes in optic fundi but without papilloedema.
- Malignant hypertension: Severe accelerated hypertension with DP >140 mm of Hg with papilloedema and renal dysfunction (e.g. oliguria).

Q. Refractory hypertension:

The patients whose BP, in spite of full compliance, can not be reduced to 140/90 mm of Hg, and who are on three or more drug regimen (includes a diuretic in maximal doses) are considered to be refractory or resistant. Think of:

1. Non-compliance with drug therapy (commonest).
2. Inadequate treatment.
3. Failure to recognise secondary hypertension, e.g. pheochromocytoma, renal artery stenosis, etc.

Q. Indications of ambulatory BP recording:

1. BP recording shows unusual variability.
2. To rule out white-coat hypertension.
3. Hypertension resistant to treatment with three or more drugs.
4. Syncope suggesting orthostatic hypertension.
5. Borderline hypertension.

Q. Target organ damage (complications) in systemic hypertension:

a. *Heart and vessels:* Cardiac enlargement, LVF, angina pectoris, acute myocardial infarction, arteriosclerosis, dissecting aneurysm, peripheral vascular disease.

b. *Cerebrovascular*: TIA, cerebral haemorrhage, cerebral thrombosis, hypertensive encephalopathy and subarachnoid haemorrhage.
c. *Renal:* Impaired renal function, proteinuria, CRF, ARF.
d. *Eye:* Hypertensive retinopathy, retinal haemorrhage and exudate, papilloedema (malignant hypertension), central retinal vein thrombosis, sudden blindness.
e. *Nose:* Epistaxis

Clinical Wisdom

The purpose of treating hypertension is to reduce the risk of hypertensive complications.

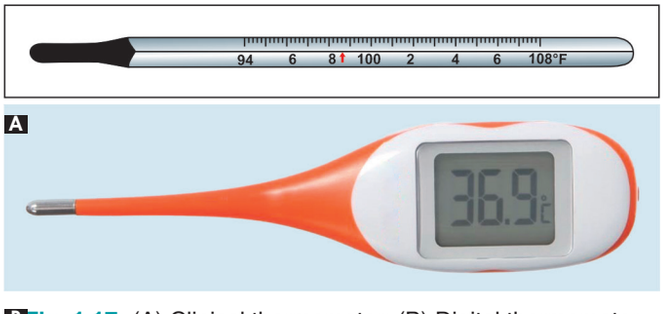
Q. Classification of 'hypertensive retinopathy':

It is divided into 4 grades (Keith-Wagener-Barker classification):

- *Grade I:* Thickening of arterial wall, increased tortuosity and narrowing of arteriole though red blood column is seen; AV ratio is 1:2 (normal AV ratio is 3 : 4).
- *Grade II:* Grade I plus AV nipping and reduction of arterial calibre in comparison to vein. 'Copper wire'-like arteries seen without any visible red blood column; AV ratio is 1:3.
- *Grade III:* Grade II plus flame-shaped haemorrhages and cotton-wool exudates. 'Silver wire' arteries seen without any visible blood column; AV ratio is 1:4.
- *Grade IV:* Grade III plus papilloedema. 'Fibrous cord'-like arteries seen without any visible blood column (malignant hypertension).

- From minute to minute, BP varies with emotion, exercise, respiration, tobacco or alcohol consumption, temperature, pain, etc.
- In atrial fibrillation, multiple (at least three) BP recording with averaging is advisable.
- Blunting of the day-night BP pattern (i.e. nighttime BP is 10–20% lower than daytime BP) is seen in sleep apnoea and autonomic neuropathy. On standing, in health, SP falls but DP rises.

CLINICAL THERMOMETER



B **Fig. 1.17:** (A) Clinical thermometer; (B) Digital thermometer

Q. Description (Fig. 1.17)

Clinical thermometer is used to record body temperature.

1. A glass tube with markings (graduations), usually 11 cm long.
2. Constricted terminal part containing mercury with the other end sealed.
3. Small lumen inside with constriction at the neck.
4. Cross-section of the body of glass tube is triangular.
5. Indication of normal temperature (98.6°F or 37°C) by an arrow-mark.

- Previously Fahrenheit scale (F) was used in the thermometer. Nowadays, temperature is recorded in Centigrade or Celsius scale (C). The formula of conversion of temperature is:

$$\frac{C}{5} = \frac{F - 32}{9}$$

- The kink inside the clinical thermometer prevents the return of mercury column when the thermometer is taken out of body. The triangular cross section (i.e. prism-like) magnifies the thin mercury line into a wider strip to help in easy reading.
- Recently, a tympanic membrane thermometer (i.e. electronic thermometer placed in the ear) is used for fast and accurate recording of core temperature. 'Digital thermometer' directly records the temperature. Lower-oesophageal temperature closely reflect the core temperature.

Clinical Wisdom

Temperature recording sites: Oral, axillary, rectal, temporal (thermometer placed on forehead) and tympanic membrane.

Q. Temperature range graduated in the thermometer:

It is 94° to 108°F in Fahrenheit scale, and 35° to 42°C in Centigrade scale.

Q. Procedure of recording temperature:

The thermometer should be washed properly with soap-water or any antiseptic solution. In hospitals, it is usually immersed in antiseptic solution. Clean with tap water before using it. Always shake the thermometer before use so that the mercury level comes below the arrow-mark. Before taking oral temperature, the patient should not consume anything hot or cold. Before keeping the thermometer inside the oral cavity, warn the patient not to bite it but to hold it by the lips while the mercury bulb is placed under the tongue.

Clean the axilla of sweat before putting the thermometer there. In infants, the temperature may be taken in groin with thigh flexed over the abdomen. The patient should not bath before recording axillary temperature.

After recording the temperature (thermometer is kept under tongue or axilla for at least two minutes), shake the thermometer again to send the mercury column beyond normal temperature. Now record the temperature in a white paper with date and time.

Q. Clinical thermometer—which type of thermometer it is?

It is a maximum thermometer. Higher temperature once attained, does not return to normal spontaneously. Clinical thermometer does not reflect the minimum temperature.

Thermometer used for weather report are made of ether or alcohol (instead of mercury), and reflects the minimum temperature. They are minimum thermometer.

Q. What is habitual hyperthermia?

In some persons, the normal temperature is above 98.6°F and is often in the range of 99°–100.5°F. Though rare, these patients run from physician to physician to allay their anxiety. The diagnosis can be made firmly after a certain period of close observation of the pateint.

Q. What is malignant hyperthermia?

In this inherited disorder, the temperature shoots from 102.2°F to 107.6°F in response to certain anaesthetics like halothane, methoxyflurane, cyclopropane or by muscle relaxants like succinylcholine. The high temperature results from muscular contraction. The situation is tackled by cooled ice, 100% O_2, fluids and diuretics (to reduce myoglobinuria and hyperkalaemia), $NaHCO_3$ (to combat metabolic acidosis), and dantrolene sodium.

Neuroleptic malignant syndrone (NMS) is probably a variant of malignant hyperthermia and is usually associated with use of neuroleptic drugs, e.g. phenothiazines, butyrophenones or haloperidol. NMS is characterised by hyperthermia, altered sensorium, muscular rigidity and autonomic dysfunction (pallor, tachycardia, sweating, labile BP). The mortality rate is high. Similar treatment as adopted in malignant hyperthermia is advocated here.

- Rectal temperature > oral > axillary or groin temperature by 0.5–1°F.
- Vide 'Charts on temperature' in the section on 'Charts' (this book) and the section on 'Abnormal temperature' in 'Bedside Clinics in Medicine, Part I' for further reading.

TUNING FORK

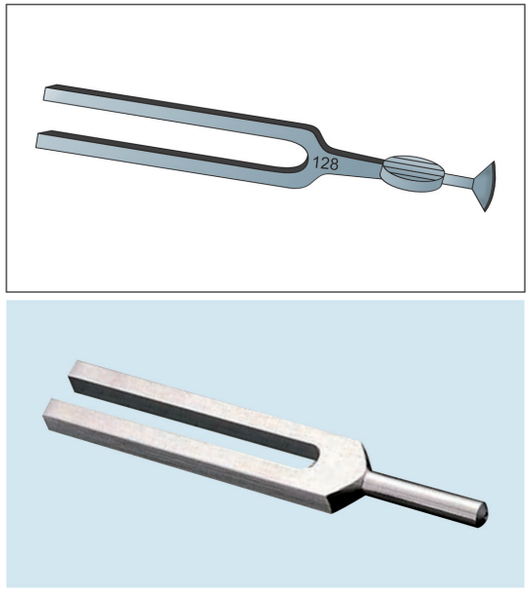


Fig. 1.18: Tuning fork (frequency 128 cycles/second)

Q. Description (Fig. 1.18):

This Y-shaped instrument has two limbs, a common stem and a disc-like base. Tuning fork produces vibration with constant frequency like 128, 256 or 512 cycles/second (Hz). The frequency is written on the instrument where the two limbs join. The tuning fork is made of steel.

Q. Different uses:

Classically the tuning fork is used for two purposes—

1. Testing of vibration sense (128 or 256 cycles/sec.).
2. Testing of hearing and quality of deafness (256 or 512 cycles/sec.).

Q. Test for vibration sense:

Vide the section on 'Charcot joint' in 'Bedside Clinics in Medicine, Part I'.

Q. Causes of loss of vibration sense:

1. Old age (physiological; even the ankle jerk may be lost in patients over 70 years).
2. Peripheral neuropathy (loss of vibration sense is an early feature in diabetes mellitus) or radiculopathy (prolapsed intervertebral disc).
3. Lesion in the posterior column (e.g. compressive or non-compressive myelopathy; classically tabes dorsalis).
4. Cortical lesion (e.g. lesion in the parietal lobe).

- Vibration sense is carried through posterior column; in diseases affecting posterior column, patient complains of ataxia (sensory ataxia). In syringomyelia and multiple sclerosis, vibration sense may be affected alone.

Q. Tests for hearing:

There are two 'tuning fork tests' which differentiate the quality of deafness.

A. Rinne's Test

A vibrating tuning fork is placed by the side of the ear to be tested. Mask hearing in the other ear by giving pressure of tragus on external acoustic meatus. Ask the patient to raise his finger when he can no longer hear any sound. After receiving the signal, the base of the fork is placed on the mastoid process and ask him again whether he can hear any sound. If he says 'no' to your question, the Rinne's test is positive and if says 'yes', the test becomes negative.

Interpretation: In persons with normal hearing, the air conduction (AC) is always greater than bone conduction (BC), i.e. AC>BC, that is to say Rinne's test is positive. If BC>AC, Rinne's test is said to be negative. So Rinne's test is positive in normal persons and in nerve type (sensorineural) deafness, and the test becomes negative in conductive deafness. It is to be remembered that in sensorineural deafness, AC>BC though both are less than normal.

B. Weber's Test

A vibrating tuning fork is placed on the centre of the vertex in the middle line. A normal individual hears the sound equally on both sides.

In sensorineural deafness, the sound is better heard in the normal or healthy ear, i.e. localisation is on the normal side. But in conductive deafness, the localisation is on the affected or abnormal side. The explanation goes like this: In sensorineural deafness, both AC and BC are reduced whereas in conductive deafness, only AC is reduced but BC is relatively increased (as ambient noise is excluded).

Interpretation: 'Lateralised' or not.

Q. Causes of deafness:

Deafness is of two types:

a. Conductive deafness—as a result of impacted wax, damage to tympanic membrane, otosclerosis, eustachian tube blockage, CSOM, etc.
b. Sensorineural deafness—due to damage of cochlear nerve and organ of Corti, presbycusis (i.e. hearing loss by natural ageing), Ménière's disease, acoustic neuroma, fracture of petrous part of temporal bone, drugs like aminoglycosides, pontine lesion, etc.

❍ In clinical practice, deafness is further investigated by audiometry (pure-tone) and brainstem evoked potentials in order to come to a definite aetiological diagnosis.

Q. How to differentiate between organic and hysterical loss of vibration sense?

Place the tuning fork on either side of forehead in turn. As the frontal bone is acting as a single unit, the sensation of vibration is perceived/not perceived on both sides even by the patients having organic lesion. Hysterical patients say that they can not feel the vibration on the side of 'sensory loss'.

HAMMER

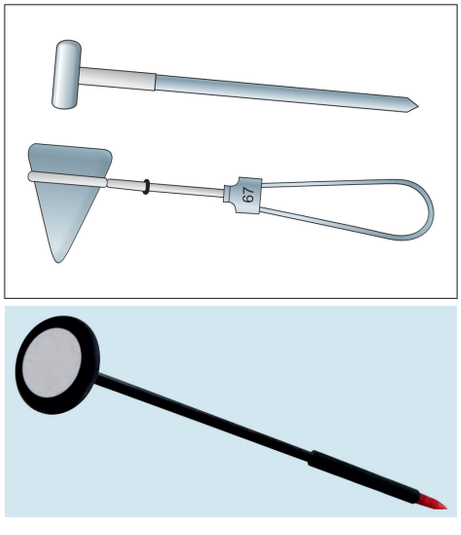


Fig. 1.19: Hammer (rounded and conical variety)

Q. Synonyms:

Percussion hammer, patellar hammer or tendon hammer.

Q. Why the name patellar hammer?

Knee jerk was the first tendon reflex to become a regular part of the neurological examination, and this is why it is also known as patellar hammer.

Q. Parts of a hammer (Fig. 1.19):

1. Rounded (Queen square reflex hammer) or conical (triangular, i.e. Taylor hammer)—the striking end is made of rubber.
2. Shaft (plastic) with a blunt tip for elicitation of different superficial reflexes (abdominal, plantar response). The blunt tip present within the metallic shaft is seen after unscrewing two parts of the shaft.

Q. What is an ideal hammer?

A hammer with a firm and flexible shaft (made of plastic) is an ideal one.

Q. Different uses:

For elicitation of:

1. Deep reflexes or jerks (percuss the stretched tendon concerned).
2. Superficial reflexes (use the shaft with blunt tip).
3. Fasciculation (strike a big muscle).
4. Myotonia (strike the thenar eminence of palm).
5. Chvostek's sign (tap the facial nerve in front of the ear)—twitching of facial muscles are seen in tetany.
6. While percussing the chest, hammer may be used as 'percussing finger'.

Note

Read all superficial (especially plantar response) and deep reflexes in details.

PIN

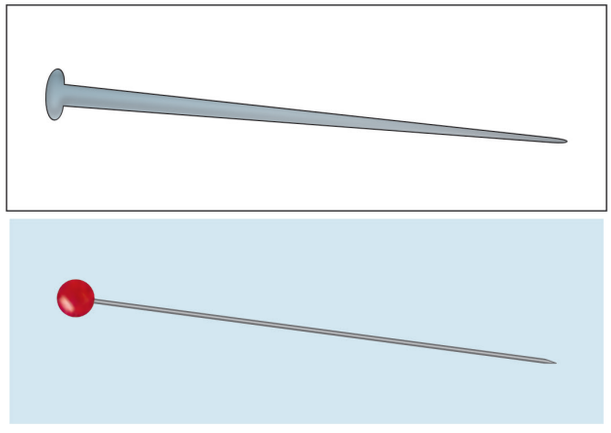


Fig. 1.20: Pin (the usual one and the red hat-pin)

Q. Different uses (Fig. 1.20):

1. Testing of pain sensation (e.g. peripheral neuropathy).

2. Testing of crude touch sensation: By the pinhead (especially in leprosy).
3. Blanching reaction in telangiectasia (with special reference to spider naevi): The pinhead is used.
4. Confrontation perimetry: With special reference to a large pin having red or white-head (hat-pin).
5. Elicitation of plantar response may be carried out by a blunt pin (in a desperate situation).

Note

Read leprosy in details.

COTTON

Fig. 1.21: Cotton packet and swab stick

Q Different uses (Fig. 1.21):

1. Haemostasis, wiping secretions, as a dressing material or to cleanse the local part before IV or IM injection when soaked in methylated spirit.
2. Touch sensation: When a small piece of cotton wool is twisted into a fine hair, it can be used for testing of fine touch sensation and the blunt end may be applied for crude touch sensation (with special reference to leprosy and sensory function testing in clinical neurology).
3. Corneal reflex.
4. Test of olfactory nerve: Test objects (e.g. oil of peppermint) are soaked in cotton and presented to the patient.
5. Gag reflex is done by a piece of cotton wrapped in a broom-stick.
6. For preparation of throat swab, conjunctival swab or rectal swab (see photo for 'swab stick').
7. Cortical sensation: One point localisation and sensory extinction.

Note

Read leprosy and corneal reflex in details.

MEASURING TAPE

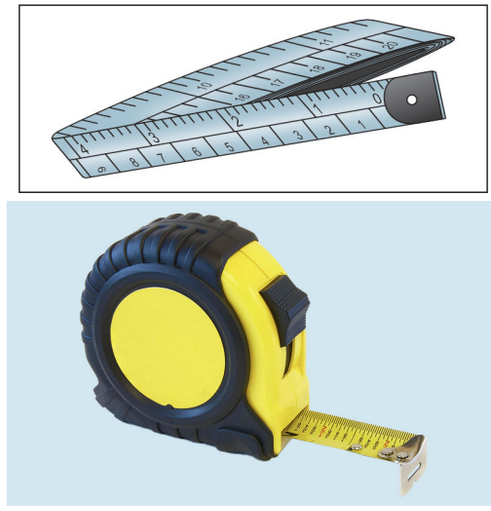


Fig. 1.22: Measuring tape

Q Different uses in clinical medicine:

It helps in the measurement of:

1. Abdominal girth in ascites (serial measurement is important).
2. Thyroid enlargement (at the most prominent part of the swelling in neck).
3. Expansion of the chest (especially in emphysema).
4. Head circumference (especially in hydrocephalus).
5. Assessment of nutrition (helpful in obesity and malnutrition).
6. To assess body mass index (BMI) and waist-hip ratio in obesity.
7. Height (e.g. cretinism, Marfan's syndrome).
8. To confirm wasting or hypertrophy of muscles.

TONGUE DEPRESSOR

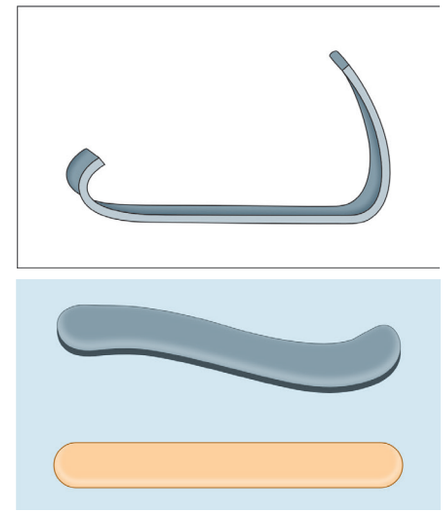


Fig. 1.23: Tongue depressor (L-shaped and straight variety)

Table 1.7: Differentiation between acute follicular tonsillitis and faucal diphtheria

Features	Tonsillitis	Diphtheria
1. Onset	Sudden	Gradual
2. Limitation of 'patch'	Only to enlarged tonsils	Tonsils and neighbouring structures like palate, pillars of the fauces may be involved
3. Toxicity	Little	More toxic than tonsillitis
4. Membrane or patch	The membrane or patch is yellowish and not adherent, and *can be easily separated* without any bleeding surface	Greyish and adherent, and *cannot be easily separated*. It leaves a bleeding surface after separation
5. Trismus	May be present	Absent
6. Cervical lymphadenopathy	+	++
7. Rise of temperature	100°–104°F	99°–100°F

Q. Synonym (Fig. 1.23)

Spatula; spatula is straight but tongue depressor is L-shaped, i.e. having an angulation with a holding part (hold by the physician) and a broader depressor part (part that depresses the tongue).

Q. Which part of the tongue is pressed?

Usually the anterior 2/3rd of the tongue is pressed. Never touch the posterior 1/3rd (gag reflex may occur) of the tongue.

Q. Different uses:

1. Examination of the throat and oral cavity (teeth, gum, cheek, tongue, fauces and tonsils, palate, oropharynx).
2. 'Spatula test' in tetanus.
3. Detection of posterior nasal bleeding.
4. Removal of foreign body (e.g. fish bone) from the tonsils, throat or posterior part of the tongue.
5. Elicitation of gag reflex.
6. Indirect laryngoscopy.
7. It helps to open the mouth for oral toilet or suction in a comatose patient; oral surgery.

Clinical Wisdom

Detection of caries teeth, gingivitis, candidial infection in buccal mucosa and tongue, patch tonsil, diphtheritic patch, aphthous ulcer, movement of palate as a part of IXth and Xth cranial nerve examination, spatula test in tetanus, Koplik's spot in measles and palatal ulcer in SLE are subjects of interest in general medicine.

Q. Causes of 'patch tonsil' (Table 1.7):

Patch or membrance seen over tonsils in situations like:
1. Acute follicular tonsillitis.
2. Faucal diphtheria.
3. Oral thrush or candidial infection.
4. Agranulocytosis.
5. Acute lymphoblastic leukaemia.
6. Vincent's angina (spirochaetes and fusiform bacilli).
7. Infectious mononucleosis.
8. Milk curd (in neonates and infants).
9. Tonsil stones (debris calcification).

❍ These are the causes of fever with 'membrane in the throat'.

Q. Causes of lock-jaw or trismus:

Trismus develops due to sustained involuntary spasm of masticatory muscles and is seen in: 1. Tetanus, 2. Impacted wisdom teeth, 3. Peritonsillar abscess, dental abscess, Ludwig's angina, 4. Acute follicular tonsillitis, 5. Temporo-mandibular osteoarthritis or rheumatoid arthritis, 6. Drug-induced dyskinesia (metoclopramide, phenothiazines), 7. Tetany, strychnine poisoning, 8. Parotitis, mumps, 9. Hydrophidae group of snake bite, 10. Rabies, 11. Malignant hyperthermia, 12. Hysteria.

Q. What is 'spatula test'?

In health, touching the posterior pharyngeal wall by spatula produces reflex opening of mouth. In tetanus, paradoxically mouth closes in such a way that the spatula cannot be taken out easily. Thus, spatula test is positive in tetanus.

Note

Read tetanus, diphtheria, measles and bulbar palsy in details.

TORCH

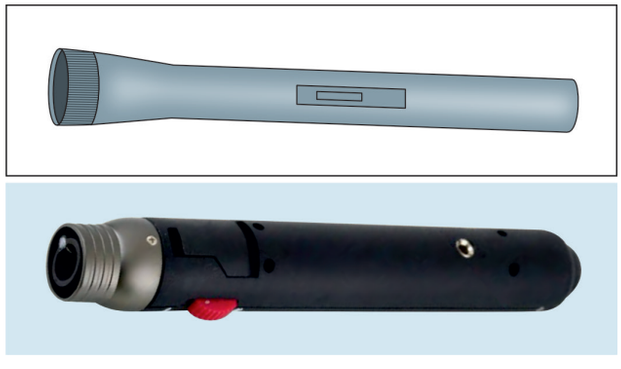


Fig. 1.24: Pencil torch

Q. Different uses (Fig. 1.24):

1. Pupillary reaction: Light reflex (bilateral fixed and dilated pupil often helps in declaring 'death').
2. Test of perception of light (PL) and projection of rays (PR) while assessing visual acuity.
3. Examination of pupil, oral cavity and throat, external ear, nose; anus, rectum and vagina.

4. Testing of photophobia (especially in meningitis).
5. Often epigastric pulsation is better seen when a torch is lighted tangentially over the epigastrium; in congenital hypertrophic pyloric stenosis, a torch is focused over the abdomen from right side of the body for better demonstration of slow peristaltic waves while the examiner looks from the baby's left side.
6. Transillumination test in hydrocele.

Clinical Wisdom

A clinician must carry a torch along with the stethoscope whether in emergency duty or in ward round. Read pupillary changes in details.

PLAIN GLASS TEST TUBE

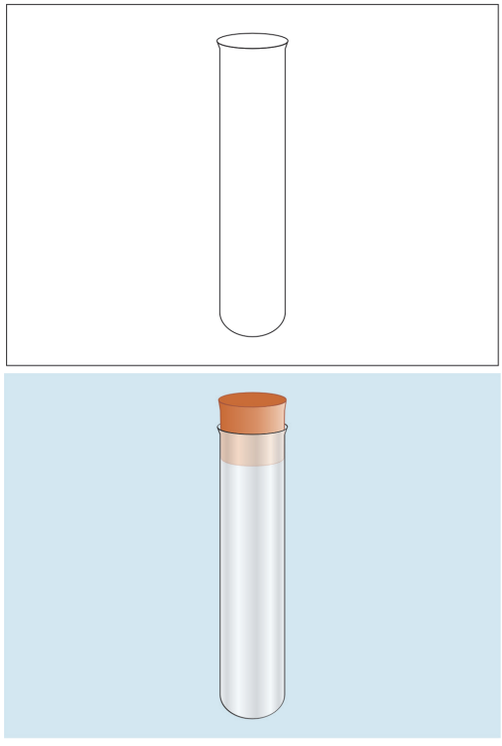


Fig. 1.25: Plain glass test tube

Q. Different uses (Fig. 1.25):

1. For the collection of blood sample for:
   a. Grouping and cross-matching.
   b. Serum electrolytes.
   c. Serum urea, creatinine, sugar, uric acid, and other biochemical tests, and
   d. Liver function tests.
2. For the collection of urine sample for routine examination (R/E) and culture-sensitivity (C/S) test.
3. For the collection of gastric juice sample for analysis/detection of AFB in a suspected case of pulmonary tuberculosis (especially in children who cannot expectorate sputum, and often swallow it).
4. For the collection and analysis of CSF for physical, biochemical, cytological and bacteriological examination.
5. Sputum collection for Gram's staining, detection of AFB and malignant cells, RBC, etc.
6. For the collection of pleural fluid, pericardial fluid, ascitic fluid and drained pus from liver abscess for the purpose of physical, biochemical, cytological and bacteriological examination.
7. Two test tubes containing cold (5°–10°C) and hot (40°–45°C) water for assessment of temperature sensation in clinical neurology.
8. For the collection of throat swab, rectal swab, high vaginal swab, conjunctival swab or wound pus material (a sterile test tube with a cotton swab stick is used).

- The test tube should be sterilised where it is used for bacteriological examination, e.g. in 2, 3, 4, 5, 6 and 8.
- **Throat swab** examination is necessary in acute tonsillitis, diphtheria and acute rheumatic fever.

CONDOM

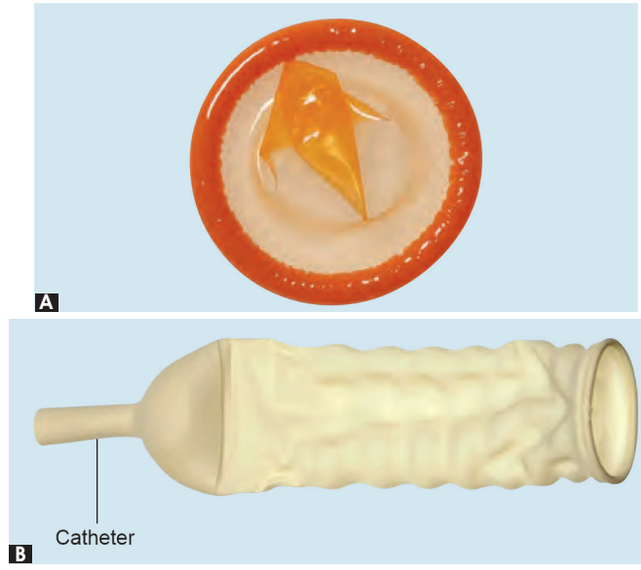


Fig. 1.26: (A) Condom; and (B) Condom catheter

Q. Description (Fig. 1.26A):

Usually it is of two kinds, i.e. latex (most widely used) and natural skin-type. Condoms may be made from other materials like polyurethane, polyisoprene, or lamb intestine. The Indian condom is usually 17.5 cm long and 4.4–5.4 cm wide. Latex condoms are preferable as HIV has been shown to leak through natural skin-type condoms.

Q. Different uses:

1. Most widely used barrier contraceptive device for males (i.e. protection for unplanned pregnancy—birth control).
2. Safe sex: Prevents sexually transmitted diseases (STD) with special reference to AIDS, hepatitis B infection, gonorrhoea, syphilis, non-gonococcal urethritis and genital herpes.

3. Often it is used for 'condom catheterisation' (prevents soiling of bed and bed-sore formation, and as the catheter is not introduced per urethra, there is less chance of development of UTI).

- Condoms are easily available, safe, cheap, durable, waterproof, disposable and having no side effects. Globally, condom is now promoted (especially in clients of commercial sex-workers) to prevent transmission of HIV infection.
- Condoms lubricated with spermicides (nonoxynol-9) are also available. A female condom is also usable, which is made of nitrile.

Q. How 'condom catheterisation' is done (Fig. 1.26B)?

Make a small nick at the tip of the condom and through it, a Malecot's or Foley's catheter is passed in such a way that the flower of Malecot's catheter rests on the nick. Now the condom is put around the penis with the help of adhesive tapes. The other end of the catheter is connected to the urosac. Condom catheterisation is valuable in (a) incontinence of urine, and (b) in comatose patients where the urinary output is to be measured.

Clinical Wisdom

Charles Goodyear of America invented rubber in 1839 while first rubber condom was produced in 1855. Condoms have an expiry date. Nowadays flavoured condoms are available to make sex more enjoyable.

AIRWAY TUBE

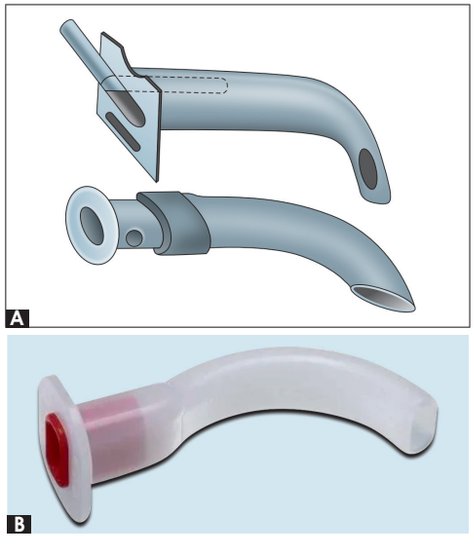


Fig. 1.27: (A) Airway tube (metal and rubber); (B) Actual photograph

Q. Available varieties (Fig. 1.27):

The slightly curved orpharyngeal airway tube is made either of:

a. Metal, or

b. Rubber.

They help entry of air into the patient's airway. This instrument is also known as 'mouth gag airway'.

Q. Different uses:

1. Unconscious patients.
2. Patients under anaesthesia.
3. During an episode of convulsions (e.g. epilepsy).

It is inserted into the mouth:

a. To prevent the tongue from falling back (the curvature of the tube is so made that it draws the tongue forwards),

b. To assist suction,

c. To prevent the endotracheal tube being bitten by the teeth during anaesthesia, and

d. To prevent the tongue bite (e.g. convulsions).

Multiple openings are present at the inner end, so that some of the openings may remain open when others are blocked by mucus plugs. Keeping the tube in boiling water for 30 minutes or autoclaving sterilises the instrument.

VENFLOW OR INTRACATH

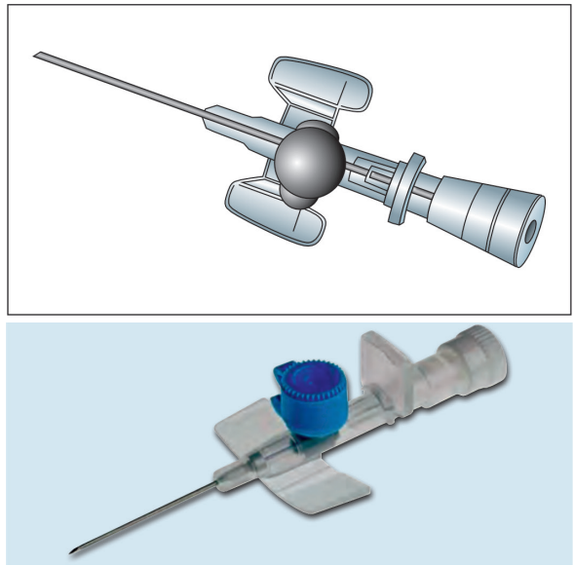


Fig. 1.28: Intracath

Q. Description (Fig. 1.28):

It has two parts:

1. *Inner:* Metallic stylet or needle (for proper guiding into the vein).
2. *Outer:* Polythene cannula or sheath.

Q. Uses:

This type of indwelling venous catheter (also known as angiocatheter) is required when the intravenous access is needed for a longer period (e.g. 24–72 hours).

Q. Procedure of introduction:

After puncturing a long vein, the whole of the intracath is gently introduced into the vein. The inner metallic needle is now withdrawn cautiously, keeping the outer polythene cannula within the vein. The polythene cannula is now ready to be connected with a venous line.

Q. Complications:

1. Counter-puncture and haematoma formation.
2. Thrombophlebitis.

Q. Advantages of 'intracath' over scalp vein set:

The intracath:

1. Can be kept within the vein for a longer time in comparison to scalp vein set.
2. Minimum chance of counter-puncture of the vein (scalp vein set often faces this hazard).
3. It produces less thrombophlebitis, and
4. There is no question of heparinisation of the channel.

Clinical Wisdom

Intravenous line access is preliminary step in the management of dehydration, peripheral circulatory failure, cardiac arrest, shock and unconscious patient. The IV access in day-to-day practice is done by (i) simple IV needle, or (ii) intracath, or (iii) scalp vein set.

METERED DOSE INHALER (MDI)

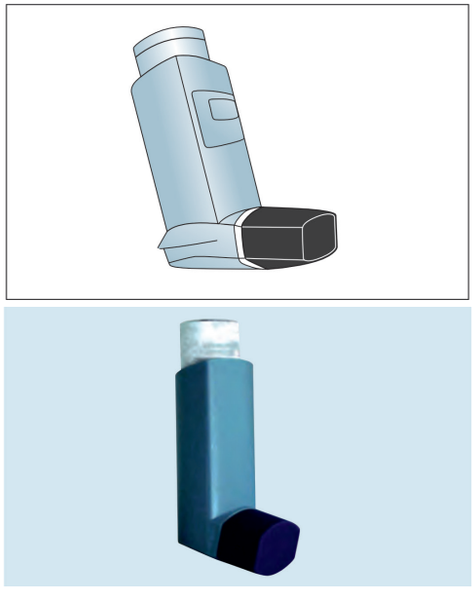


Fig. 1.29: Metered dose inhaler

Q. What is MDI?

For the past two to three decades, inhaled medicines are commonly used for bronchial asthma or chronic obstructive pulmonary disease (COPD) patients. These medicines are breathed directly into the lungs, where they are really needed. The devices used to deliver the medicine to the lung are known as '**inhalers**'. Inhalers can be of many types, e.g.

a. Spray inhaler (also called metered dose inhaler).
b. Powder inhaler (also called rotahaler).
c. Nebulisers (for giving higher doses).

The inhalers deliver drugs like β_2-agonist (salbutamol, terbutaline, salmeterol, formoterol), corticosteroids (beclomethasone, budesonide, fluticasone), anticholinergics (ipratropium bromide) or mast cell stabiliser (sodium chromoglycate) in **aerosol form** which is the preferred mode of treatment for obstructive airway disease.

Q. Description (Fig. 1.29):

This is an L-shaped tube made of plastic and consists of mouthpiece, and a tube which holds the canister (contains drug in a pressurised aerosol form) of medicines to be inhaled. The mouthpiece has a cover (cap).

Q. Method of use:

1. Take off the cap of the mouthpiece. Shake the canister 5–6 times.
2. Breathe out through the mouth, till the end of normal respiration.
3. Place the aerosol nozzle (mouthpiece) between the lips. Start to breathe in, press the canister and keep breathing in steadily, rapidly and deeply till full inspiration.
4. Remove the inhaler from the mouth. Hold the breathe for 10 seconds or as long as one find it comfortable. Now breathe out
5. After 1–2 minutes, get ready to breathe in for the second puff, if necessary.
6. Lastly, rinse the mouth with plain water (to prevent oral infections).

❍ As the device delivers a measured (fixed) dose of medicine, the instrument is called metered dose inhaler. In spite of good technique, only 15% of the contents are inhaled and rest 85% are deposited on the walls of the pharynx, and ultimately swallowed by the patient.

Q. Advantages and disadvantages of MDI:

Advantages:

1. Rapid onset of action.
2. Very small dose of the drug is necessary to have desired effect.
3 Very little medicine is allowed to reach other parts of the body, i.e. chances of side effects tend to be minimum.
4. It is cost-effective and easier to carry.

Disadvantages:

1. The major limitation of the mode of administration is that training and skills are required to coordinate actuation of drug from MDI (i.e. needs hand-breath coordination).
2. Pharyngeal infection (e.g. candidosis with inhaled corticosteroios) if the device is not properly cleaned at a regular interval.

Q. What is a rotahaler (Fig. 1.30A)?

Powder inhalers are devices that deliver a measured dose of medicine in a **powdered form** (i.e. a breath-activated dry powder inhaler). The transparent rotahaler breaks a capsule (rotacap) in the powdered form and the patient inhales the powder in the aerosol form through

the mouthpiece of rotahaler. It is easier to use than MDI, and thus suitable for children and aged patients but needs to reload capsule each time.

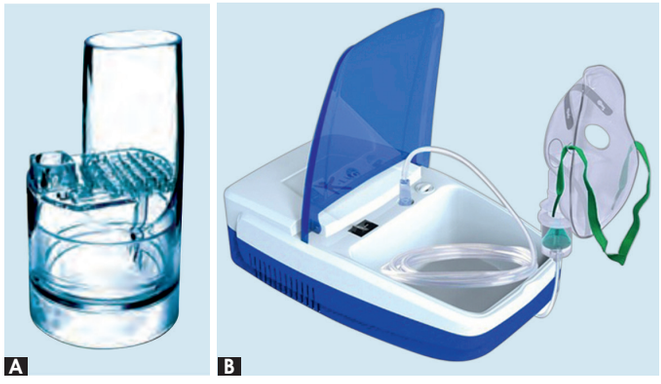


Fig. 1.30: (A) Rotahaler; and (B) Nebuliser

Q. What is a nebuliser (Fig. 1.30B)?

Nebulisers are used for giving higher doses of medication at times when breathing becomes very difficult. This is a machine that transforms the medicine (salbutamol, beclomethasone, ipratropium bromide) into a **fine mist**, which can be breathed in by normal breathing, via a facemask or a mouthpiece. The nebuliser chamber is connected to the nebuliser and oxygen mask on either side, so that nebulised drug would be inhaled along with oxygen. Its cost is more and an electrical power source is required though patient's coordination is not required and modification of doses is not difficult. Nebulisers are used in hospitals or nursing homes, for the management of acute severe asthma or acute exacerbation of COPD patients.

SPACEHALER

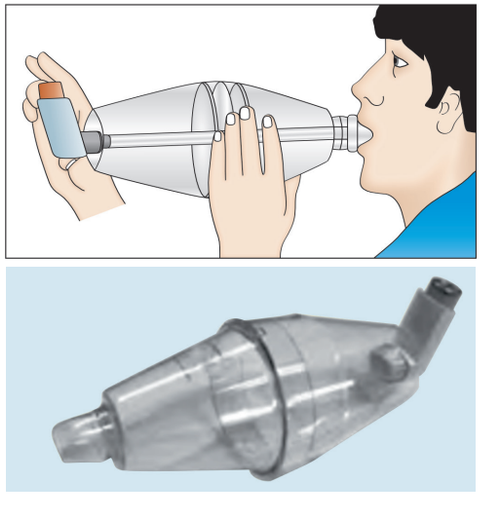


Fig. 1.31: Spacehaler

Q. Description (Fig. 1.31):

This device consists of two smooth conical plastic cylinders (one fits into the other producing a 'space'). At one end there is a mouthpiece through which the patient inhales the medicine and at the opposite end the metured dose inhaler (MDI) is placed through an inlet. It is also known as 'volumatic' or 'spacer'.

Q. Method of use:

Assemble the spacehaler by pushing the notch of one half into the slot of the other half of cylinder. After shaking the MDI well, fit it into the spacehaler. Rest of the steps are similar to the use of MDI.

Spacehalers are designed to reduce velocity of the particles so that less drug is deposited in the mouth.

Q. Advantages and disadvantages:

Advantages:

1. It makes the spray inhaler (MDI) easier to use and added to its effectiveness. The drug delivered from the MDI is not misused or lost because it is kept within a 'space'.
2. Strict coordination of the patient (i.e. aerosol activation and inhalation) is not required as the patient breathes in the cylinder.
3. Chances of development of oral candidosis with inhaled corticosteroid is reduced.
4. Low cost, portable, no electricity required (in comparison to nebuliser).
5. Useful in children and in the elderly.
6. Less drug is deposited in the mouth in comparison to MDI.

Disadvantages:

The device is big to carry in person.

- **"Nelson's inhaler"** is an earthenware steam vocal inhaler for a patient of sinusitis, cough, coryza or sore throat; singers and orators are also benefitted. The pot is filled with hot water and mixed with menthol, tincture benzoin or eucalyptus oil, when the patients inhales its vapour.

AMBU BAG

Q. Description (Fig. 1.32A):

The mnemonic AMBU stands for ambulatory manual breathing unit. It is a manual resuscitation kit for temporary CPR. A shutter valve intervenes between the bag and the face mask. Ambu bag is a hand-held device which is used to provide intermittent positive-pressure ventilation (IPPV) to patients with inadequate breathing.

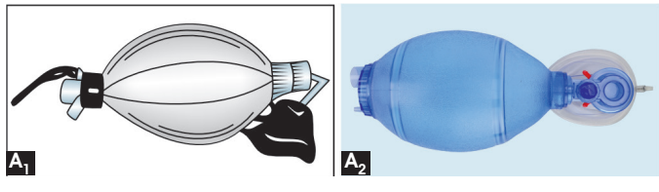


Fig. 1.32A: Ambu bag

Air (enriched with oxygen) enters into the patient's lungs through a tracheostomy or endotracheal tube after squeezing the bag. When the pressure is released,

the bag inflates 'automatically' (the elastic recoil of the chest results air to leave the lungs). There is a risk of developing injury to lungs due to overstretching. This apparatus serves the purpose of mouth-to-mouth respiration.

Oxygen (face) mask **(Fig. 1.32B)** is a oxygen therapy device which covers the patient's nose and mouth, and attaches to an oxygen tank to deliver oxygen to the lungs. Nasal cannulas (have two prongs and sit below the nose) and face masks are commonly used to deliver oxygen to patients when needed.

Fig. 1.32B: Oxygen mask

ENDOTRACHEAL TUBE

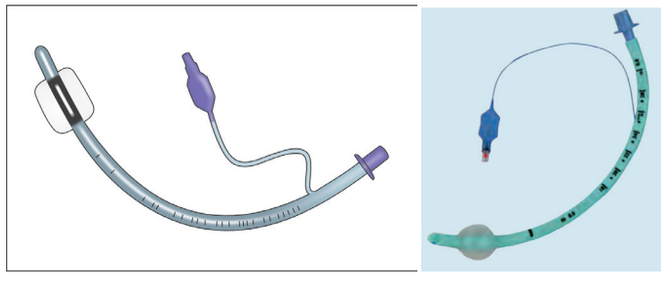


Fig. 1.33: Endotracheal tube with cuff

Q. Description (Fig. 1.33):

As the name implies, the tube is introduced within the trachea through laryngeal opening via mouth. The tube may be of polyvinyl chloride (PVC) or rubber-made. PVC variety is less irritant and can be kept for a longer period.

The endotracheal tube may be cuffed or uncuffed. The 'cuffed endotracheal tube' has a small balloon at the upper end and indicates tension in the cuff. A small tubing along the body of the tube helps in inflation of the cuff. The balloon should always be inflated with air upto 10–20 mL for an adult (never with water). The size of the tubes indicate their internal diameter and usually it is 7.5 mm for females and 7.5–8 mm for males. Cuffed tubes are preferred as they keep the tube in position.

Q. Procedure of endotracheal intubation:

It is an emergency procedure when an endotracheal tube passes from oral cavity into the trachea for providing adequate ventilation in patients with respiratory failure.

Indications

1. Acute respiratory failure as a result of COPD, massive pneumonia or respiratory muscle paralysis, in an attempt to give positive-pressure ventilation (by cuffed endotracheal tube).
2. To carry out artificial respiration in a patient of cardio-respiratory arrest.
3. Respiratory difficulty in an unconscious patient—clear the airway and prevent aspiration.
4. During general anaesthesia.
5. Severe angio-oedema of the larynx in anaphylaxis.
6. Respiratory depression in poisoning like morphine, diazepam.
7. Before giving gastric lavage in an unconscious patient.

Procedure

Pre-anaesthetic medication and anaesthesia are not required. The patient is positioned supine with neck hyperextended and chin in the midline:

a. *Oral intubation:* First, the oral cavity is cleared of secretions. The oropharynx, nasopharynx and vocal cords are visualised with the help of a laryngoscope; the lubricated endotracheal tube of appropriate size is then passed through the vocal cords and positioned in the trachea. Now the chest is auscultated for breath sounds (to confirm the air entry on both sides). If breath sounds are equal on both the sides, the cuffed endotracheal tube is then inflated with an aim to keep the tube in position, and to prevent aspiration.

b. *Transnasal intubation:* Nose as an entry point may be used in a more conscious patient. Presence of nasal polyp and deviated nasal septum make the passage of the tube difficult. Instillation of 1% ephedrine drops in the nostrils helps in easy passage of the tube through the nasal cavity. After entering the oropharynx, the procedure is the same as 'oral intubation' (i.e. a laryngoscope helps in visualisation of vocal cords and the passage of the tube within the trachea). Though it is a blind insertion, oral feeding is possible. This approach is suitable for long-term ventilation.

- After introduction, Ambu bag is connected to it and ventilation is started. Lignocaine spray, muscle relaxants and sedation can be used. Proper positioning of the tube is checked by presence of good audible breath sounds present bilaterally and absence of gurgling sounds over upper abdomen.

Clinical Wisdom

Before introduction, the cuff should be deflated first. Rubber tube is kept for 24 hours whereas the PVC tube may be kept up to 7 days.

Q. Contraindications of endotracheal intubation:

1. Trauma/injury/carcinoma or obstruction present in the upper respiratory tract.
2. Laryngospasm.

Q. Complications:

1. *Obstruction:* As a result of blockage by secretions, kinking or compression.
2. Intubation of either bronchus may lead to collapse of the lung (corrected by withdrawing the tube above the carina).
3. Tracheal dilatation as a result of overdistension by the cuff—infection—stenosis (tracheal or subglottic).
4. Trauma to the lips, teeth, tongue, upper respiratory tract (commonest) and vocal cords.
5. Mucosal oedema and ulceration of trachea (pressure necrosis of trachea may lead to fistula formation).
6. Aspiration during attempted intubation.
7. Dislodgement of teeth.
8. Increased intracranial tension.
9. Hoarseness of voice after extubation.
10. Long term: Vocal cord oedema, lacerations or paralysis.

❍ A **laryngoscope** (an endoscope for larynx) is used to pass an endotracheal tube properly as well as to visualise the upper respiratory tract upto the vocal cords.

PULSE OXIMETER

Fig. 1.34: Pulse oximeter

Q. Description (Fig. 1.34):

Pulse oximetry is a mode of non-invasive (i.e. painless) and continuous measurement of blood oxygen saturation (SpO_2). It is a small clip-like device that is attached to a body part like fingertip, toe or an earlobe. Most of the monitors also display the pulse rate. It is commonly used in emergency room and critical care setting (e.g. ICU); however, the diseases where it is commonly used are heart failure, COPD, bronchial asthma, anaemia, pneumonia or sleep disorders. Acceptable normal range of SpO_2, without lung pathology is 95–99%. It works with an electronic processor and a pair of light emitting diodes facing a photodiode through fingertip of the patient.

PROCTOSCOPE (ANAL SPECULUM)

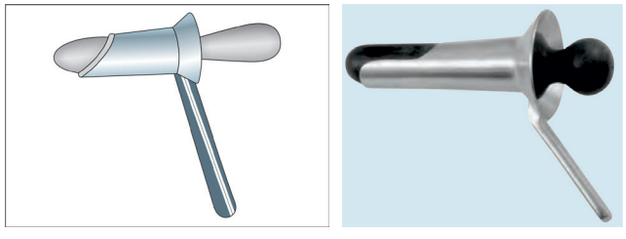


Fig. 1.35: Proctoscope

Q. Description (Fig. 1.35):

This is a 3-inch long instrument, and has two parts:

a. *A cannula (the body or flange):* One end is sharp and the other end is wide.
b. *Obturator:* The blunt end of the obturator (trocar) fits well into the sharp end of the cannula.

+

It needs a source of light (i.e. torch).

Q Different uses:

1. To visualise the anal canal for examination of fissure, internal haemorrhoids (piles), ulcer, growth, polyp, anorectal strictures, etc.
2. For injecting sclerosing agents (5% phenol in almond oil or 3% sodium morrhuate) in the submucous coat of the rectum and the anal canal through the mass of piles.
3. As a primary investigation of ano-rectal discomfort or pain.

Q. Procedure of introduction:

1. The patient is usually placed in the left lateral position (preferred with right leg flexed and left leg extended, or in the 'knee-elbow' position. Inspection outside the anus and digital rectal examination are performed to exclude any painful condition.
2. The lubricated assembled proctoscope is now pushed upwards and forwards towards the umbilicus until the anal canal in passed, while asking the patient to take deep inspirations; the instrument is then directed posteriorly (towards the sacral hollow) to enter into the rectum proper.
3. The obturator is withdrawn and the lower rectum is visulazied with the help of a torch when the light is thrown through the cannula. Now the cannula is gradually withdrawn, and the rectum and the anal canal are visualized for any pathology.

Q. Exciting factors to have internal piles:

1. Straining at defecation (e.g. chronic constipation).
2. Pregnancy, uterine tumours.
3. Portal hypertension, e.g. cirrhosis of liver.
4. Persistent straining at urination (e.g. BHP).
5. Carcinoma of the rectum.
6. Regular lifting of heavy weight.
7. Obesity.
8. Anal intercourse.

Q. Indications of rectal biopsy in clinical practice:

Rectal biopsy is done through sigmoidoscope or anoscope in:

1. Carcinoma of the rectum.
2. Hirschsprung's disease.
3. Amyloidosis.
4. Any tumour, polyp or mass in rectum.
5. Ulcerative colitis or Crohn's disease.

6. Intestinal amoebiasis, schistosomiasis (rare).
7. To determine causes of stool mixed with blood, mucus and pus

❍ **'Flatus tube'** is a stout rubber tube, which is open at both ends, and is used for removal of flatus when the tube is introduced through anus for 10–20 cm. The other end of the tube is placed in a bowl of water. It is commonly used in sigmoid volvulus, intussusception and for barium enema.

RENAL BIOPSY

Q. Indications:

1. Nephrotic syndrome (especially in adults).
2. Persistent asymptomatic proteinuria (more than 1 g/day).
3. Persistent haematuria (after extensive evaluation).
4. Acute and chronic renal failure (especially if unexplained).
5. Systemic diseases with renal involvement, e.g. diabetes mellitus, SLE, amyloidosis, Henoch-Schonlein purpura.
6. Transplanted kidney for acute allograft rejection.
7. Thin glomerular basement membrane (GBM) disease.
8. Sometimes, in rapidy progressive glomerulonephritis (RPGN).
9. To follow-up cases of glomerulonephritis (for prognosis).

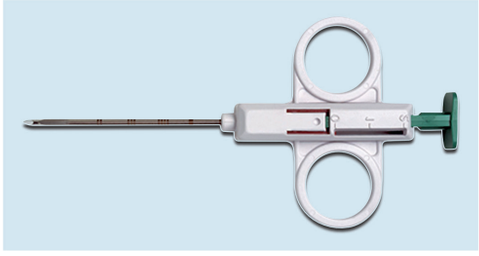


Fig. 1.36: Trucut renal biopsy needle

❍ As renal involvement may be patchy, a single biopsy specimen may not reflect the whole pathology.

Q. Contraindications:

1. Non-cooperative patient.
2. Severe bleeding diathesis.
3. End-stage renal disease (ESRD).
4. Severe uncontrolled disease.
5. Patients having solitary functioning kidney.
6. Perinephric abscess, hydronephrosis, hypernephroma or polycystic kidney disease.
7. Severe uncontrolled hypertension during the procedure.
8. Pre- and post-haemodialysis (as heparin is used during dialysis).

Q. A must before biopsy (prerequisites):

1. Renal function tests, i.e. urinalysis, serum urea and creatinine.
2. A full explanation of events is given to the patient.
3. Written informed consent of the patient or relatives.
4. A specialised centre with arrangement for ultrasonic control.
5. Normal platelet count with normal coagulation profile (BT, CT, PT, aPTT).
6. Normal or near-normal blood pressure.
7. An IVP or renogram is performed to confirm that both kidneys are functioning.
8. One unit of grouped and cross-matched blood should be in hand.

Q. Procedure of performing renal biopsy (transcutaneous):

1. Position of the patient: prone with arms abducted, with a hard pillow placed under the abdomen so that the loins are slightly raised.
2. Pre-medication (30 minutes before the procedure): By oral or slow IV injection of 10 mg diazepam.
3. The kidney is localized by USG and the biopsy site is marked with a pen. Ideally, biopsy should be done under USG or fluoroscopic guidance.
4. Strict asepsis (by sterile mask, gloves, gown and drapes) is maintained; clean the area with antiseptic solution and inject local anaesthetic (2% lignocaine solution) along the biopsy track.
5. A small nick is made over the selected site of puncture. Instruct the patient to hold the breath and the 'Trucut needle' (may refer to the section on 'Liver biopsy needle' in page 13) is introduced through the small nick **(Fig. 1.36)**. When the needle is within the muscles, its movements are limited but as soon as it enters the kidney, its outer end sways in a wide arc with respiratory movements. Confirm this repeatedly and satisfy that the needle has reached kidney tissue.
6. The stylet is now removed and the prong is introduced through the outer coat into the renal parenchyma. A resistance to further movement is felt at this moment. The needle is advanced further over prongs so that it traps the kidney tissue incised by the prongs (the patient holds his breath during biopsy). The whole assembly is now rotated through 360° and the needle is taken out with prongs very rapidly with the trapped biopsy specimen. The biopsy tissue is sent to experienced pathologist to be examined by conventional staining (light microscopy), electron microscopy, and by immunoperoxidase or immunofluorescence.
7. After-care: A pressure dressing is applied over the biopsy site and the patient is placed on his back in bed for 24 hours (helps haemostasis). The patient is asked to drink plenty of fluids to prevent clot colic. The pulse, BP and respiration are checked regularly. Ask the patient to report any untoward symptom or haematuria (a common and natural complication). The patient is discharged on the next day with an

advice to avoid heavy lifting or gardening for next 2 weeks.

- To avoid injury to renal vessels, ideal biopsy site is usually the lower pole of kidney. Vim-Silverman's needle may be used instead of Trucut needle.
- In a bilateral lesion of kidney, preferably the left side is chosen for biopsy.

Q. Complications:

1. Microscopic haematuria (20%).
2. Profuse haematuria and clot formation leading to urinary obstruction.
3. Pain in loins, sometimes referred to shoulder.
4. Perirenal haematoma, retroperitoneal haemorrhage.
5. Bowel perforation.
6. Acute pancreatitis.
7. Arteriovenous aneurysm formation.
8. Infections causing renal abscess.
9. Shock.
10. Death (rare).

PARACENTESIS ABDOMINIS (Ascitic Tapping)

Indications:

It is a procedure to aspirate ascitic fluid by puncturing the abdominal wall. Actually they are divided into diagnostic and therapeutic indications. As a whole, they are:

1. Diagnostic paracentesis (e.g. cirrhosis, tuberculous or malignant ascites): Physical, biochemical, cytological and bacteriological study.
2. Severe abdominal discomfort or cardio-respiratory embarrassment.
3. Refractory to medical therapy.
4. Danger of strangulation of umbilical hernia, if present.
5. Paracentesis may allow better abdominal examination, needle biopsy of liver, scanning or USG.

- 2, 3, 4 and 5 are therapeutic indications.

Clinical Wisdom

Explain the procedure to the patient and obtain written informed consent.

Q. Contraindications:

1. Cirrhosis of liver with impending hepatic coma.
2. Bleeding diathesis.
3. Severe jaundice.
4. Acute abdomen.
5. Pregnancy.
6. Very restless, non-cooperative patient (relative contraindications).

Q. Procedure of ascitic tapping:

1. At first, urinary bladder should be emptied. The patient lies supine or semi-reclined with a back-rest. He/she is reassured and explained the procedure.
2. Under strict aseptic precautions, an IV needle (large bore) is introduced (in a zig-zag track to prevent constant oozing of fluid after paracentesis) at any one of the sites mentioned below:
   a. Midway between symphysis pubis and umbilicus (bladder must be evacuated), or
   b. Junction of lateral 1/3rd and medial 2/3rd of the right or left spino-umbilical line.
3. The needle is connected with a rubber tubing which drains the ascitic fluid slowly into a collecting bag or bottle (an IV infusion set may serve the purpose). In one sitting, usually 1–2 litres of fluid may be drained over 4–6 hours. In case of cirrhosis of liver, 'large volume paracentesis' may be done by 3–5 litres of fluid aspirated in single sitting with 6–8 g/litre of salt-free albumin infusion. Diagnostic aspiration requires 20–50 mL ascitic fluid approximately.
4. After the paracentesis, the puncture site is sealed with tincture benzoin. Now the ascitic fluid is sent for physical, biochemical, cytological and bacteriological study; culture of the fluid may be done.

- Usually pre-anaesthetic medication and local anaesthesia are not required. In a restless patient, the skin and the subcutaneous tissue may be infiltrated with 2% lignocaine solution.
- In a small collection of peritoneal fluid, paracentesis may be tried in sitting posture of the patient.
- An abdominal binder may be placed, and fastened slowly and steadily as fluid starts coming out.

Clinical Wisdom

Protein loss is replaced by salt-free albumin to avoid hazardous reduction in plasma volume. To maintain the homeostasis, especially in cirrhosis of liver, it is better to run albumin (best substitute), blood, normal saline, 5% dextrose, dextran or haemaccel during paracentesis abdominis.

Q. Causes of dry tap:

Failure to obtain ascitic fluid on attempted aspiration may be due to:

1. Needle blockade by omental patch.
2. Perforation of a viscus.
3. Presence of very little fluid which could not be targeted blindly.

Q. After-care:

The patient is monitored for next 24–48 hours for development of any complication.

Q. Complications:

1. Sudden cardio-respiratory distress or shock (if appears during the paracentesis, immediately stop tapping the fluid)—i.e. haemodynamic instability due to rapid removal of fluid.

2. Vasovagal attack.
3. Introduction of infection (peritonitis).
4. Precipitation of hepatic coma (the compressed porto-caval shunts open up and nitrogenous materials reach the brain by-passing the liver may precipitate hepatic encephalopathy).
5. Perforation of hollow viscus (bladder or bowel).
6. Protein depletion (5 litres of ascitic fluid may contain 50–100 g of protein).
7. Constant oozing of fluid (especially in tense ascites or malignant ascites).
8. Haemorrhage.

Clinical Wisdom

Peritoneal biopsy is done with Cope's needle in a suspected case of tuberculous or malignant ascites, or ascites of uncertain origin.

- Previously, **trocar and cannula** were used to tap ascitic fluid, aspirate pus from amoebic liver abscess or for suprapubic aspiration of urine from urinary bladder (Fig. 1.37). As this is a crude method, trocar and canula are not used now.

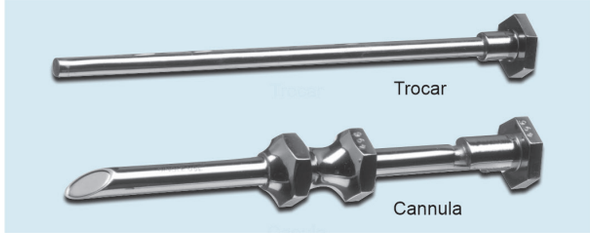


Fig. 1.37: Trocar and cannula

PARACENTESIS THORACIS (Pleural Fluid Tapping/Thoracentesis)

Q. Indications:

It is a procedure by which the chest wall is punctured to aspirate pleural fluid. The indications are:

1. *Diagnostic:* For physical, biochemical, cytological and bacteriological study of pleural fluid to come to a definitive diagnosis. Approximately, 20–50 mL of fluid should be aspirated.
2. *Therapeutic:* If there is,
   i. Respiratory distress,
   ii. Massive collection,
   iii. Bilateral pleural effusion,
   iv. Rapid collection, and
   v. Suspected secondary infection of effusion.

- Instillation of drugs (cytotoxics, tetracycline) are done in malignant pleural effusion.
- Most clinicians opine that aspiration of 1 litre of fluid in one sitting is sufficient to relieve cardio-respiratory embarrassment. Pleural aspiration needle can be used for both thoracentesis and pericardiocentesis.

Q. Contraindications:

There is no absolute contraindication. The relative contraindications are:

1. Coagulation disorders or platelet abnormality.
2. Patient with severe cough or hiccough.

Q. Procedure of thoracentesis:

1. The total procedure is explained to the patient to make him/her comfortable and relaxed. Obtain the written informed consent.
2. The patient remains semi-reclined with a back-rest, or preferably sitting and leaning forward position with arms folded before him/her and kept over a cardiac table (folded arms are placed over a pillow).
3. The site of aspiration may be:
   a. 6th intercostal space (ICS) in the midaxillary line, or
   b. 7th ICS in the posterior axillary line, or
   c. 8th ICS in the scapular line.
   d. Loculated or encysted effusion: Area of maximum dullness is the site of puncture (may require USG-guidance for actual localisation).
4. The local part is prepared under strict aseptic condition by spirit, iodine or ether. The site of aspiration is infiltrated from the skin up to parietal pleura through subcutaneous tissue with 2% lignocaine solution. The pleural aspiration needle (16–19 gauge, may be an IV needle) is inserted right angle to the skin, just above the upper border of the lower rib (nerves and intercostal vessels traverse along the lower border of the rib) to avoid injury to intercostal vessels and nerves, till the parietal pleura is punctured with a 'give away' sensation (pleural puncture may be associated with bouts of cough). The needle is then attached to a three-way cannula (adaptor), and the cannula is in turn connected with a 50 mL syringe. Application of suction in the syringe draws pleural fluid into the syringe which is pushed into a kidney-tray via the outlet of three-way cannula by adjusting its screw.
5. Fluid should be aspirated slowly and as much as possible until it is harmful for the patient (therapeutic aspiration). Few clinicians advocate not to aspirate more than 1 litre of pleural fluid on the first occasion because of the risk of development of acute pulmonary oedema.
   Repeat aspiration may be done after 3–4 days, after a check X-ray chest to note the amount of fluid remained/collected or amount of expansion of the passively collapsed lung.
6. If the patient complains of cough, respiratory distress, tightness in the chest or becomes severely restless, the aspiration must be abandoned immediately.
7. The puncture site is sealed with tincture benzoin when the paracentesis is over. The patient should be monitored for next 24–28 hours for development of

any complication. Analgesics may be prescribed to relieve pain.

8. A post-thoracentesis routine chest X-ray may be taken (to rule out hydropneumothorax, for assessment of residual fluid and for a better view of lung fields). The fluid is sent for biochemistry, microscopy, cytology and culture.

Clinical Wisdom

Appropriate site of puncture should be the area of maximum dullness on percussion or through the 'triangle of safety'. Nowadays, USG-guided aspiration is preferred.

Q. Clue to aetiological diagnosis at the time of thoracentesis:

Look for the colour of the fluid. If it is:

1. Clear—Hydrothorax.
2. Straw-coloured—Tuberculous **(Fig. 1.38)**.
3. Haemorrhagic—Malignancy **(Fig. 1.39)**.

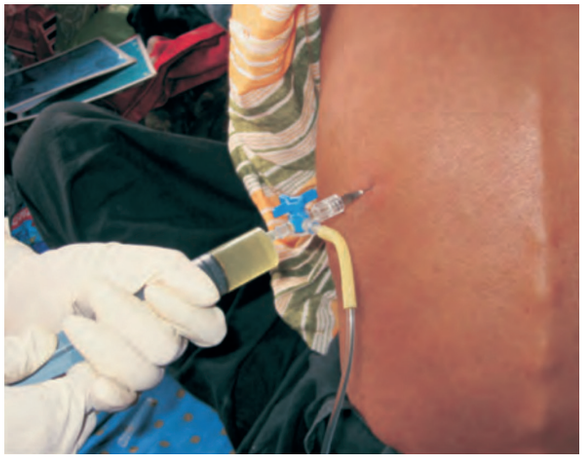


Fig. 1.38: **Paracentesis thoracis** performed with the help of a three-way cannula in tuberculous pleural effusion (aspirating straw-coloured or amber-coloured fluid)

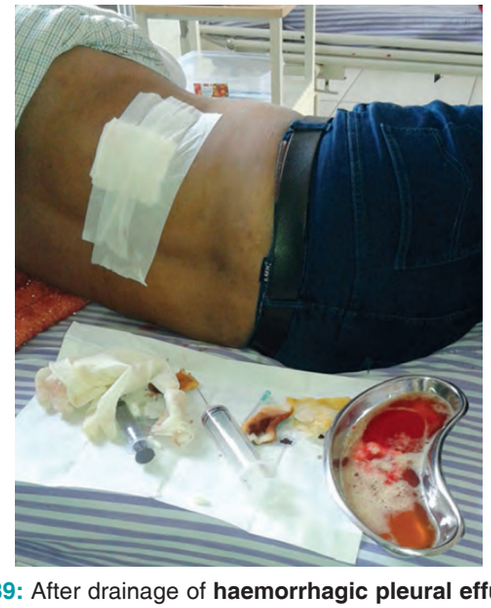


Fig. 1.39: After drainage of **haemorrhagic pleural effusion** in a patient of bronchogenic carcinoma

Fig. 1.40: Draining of **empyema thoracis**

4. Milky white—Chylous.
5. Thick pus—Empyema thoracis **(Fig. 1.40)**.
6. Rapid reaccumulation after aspiration—very much suggestive of malignancy.

Q. Complications:

1. Pleural shock (as a result of vagal stimulation—Vasomotor collapse).
2. Empyema thoroacis (i.e. introduction of infection).
3. Hydropneumothorax (latrogenic).
4. Acute pulmonary oedema or re-expansion pulmonary oedema (non-cardiogenic)—if large volume of fluid is aspirated or the fluid is aspirated very rapidly, unilateral.
5. Air embolism.
6. Injury to intercostal vessels and nerves; injury to liver or spleen.
7. Haemothorax.
8. Cardio-respiratory embarrassment with circulatory collapse.
9. Subcutaneous emphysema.
10. Post-thoracentesis pleural pain (may develop pleural rub).
11. Late complication (rare)—intercostal artery aneurysm.

Q. Causes of dry tap:

Fallure to obtain pleural fluid on attempted aspiration may be due to:

1. Empyema thoracis having very thick pus.
2. Encysted pleural effusion (needs USG- or CT-guided aspiration).
3. Interlobar or subpulmonic effusion (needs CT-guided aspiration).

4. A case of thickened pleura, tumour of pleura or massive consolidation of lung rather than pleural effusion (X-ray picture and clinical features may be misleading/simulating).

Clinical Wisdom

Pleural biopsy is done by Abram's or Cope's needle. If planned, it should be done at the first chance of pleural aspiration. Common **indications** are pleural malignancy, lymphoma, tuberculosis, and pleural effusion of unknown aetiology. Abram's needle is a punch biopsy needle which is introduced through the skin after making a small incision by a scalpel, while position of the patient remaining the same as thoracentesis. After removing the stylet, let the pleural fluid come out; the parietal pleura is punched and the needle is lastly withdrawn with a slight rotational movement. The small piece of parietal pleura (the biopsy specimen) is collected from the notch of the needle. Complications are similar to thoracentesis.

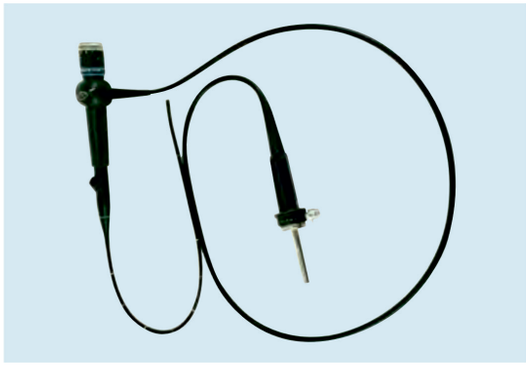


Fig. 1.41: Bronchoscope (an endoscope) for visualising the inside of lungs and airways

- A **bronchoscope** may be flexible **(Fig. 1.41)** or rigid. It is commonly used for diagnosis of bronchogenic carcinoma.

PERICARDIOCENTESIS (Pericardial Aspiration)

Q. Indications:

Removal of fluid from pericardial sac is indicated in:

1. Diagnostic aspiration (physical, biochemical, cytological and bacteriological study, culture of the fluid) of unexplained pericardial effusion: About 20–50 mL fluid is removed.
2. Therapeutic aspiration (as much as possible): If there is:
   i. Cardio-respiratory embarrassment (i.e. in cardiac tamponade),
   ii. Rapid accumulation of fluid,
   iii. Massive collection of fluid, and
   iv. Persistent collection of fluid.

Q. Procedure of pericardiocentesis:

1. The patient reclines comfortably at 45° with a back-rest. The total procedure is explained to the patient to get his/her full cooperation, and to make him/her comfortable and relaxed. Obtain the written informed consent.
2. The site of aspiration may be any one of the four:
   a. Epigastric or xiphisternal,
   b. Apical,
   c. Parasternal, or
   d. Posterior route.

   Prerequisites:
   i. At present, blind pericardiocentesis is avoided (ultrasound-guided preferred). It is recommended to be performed under ECG and echocardiographic monitoring.
   ii. Strict asepsis (sterile mask, gloves, gown and drapes) is maintained.
   iii. In an anxious and restless patient, pre-anaesthetic medication is done by slow IV injection of 10 mg diazepam. Midazolam may be given.
   iv. The skin and subcutaneous tissue of the site of aspiration are infiltrated by 2% lignocaine solution.
3. Any of the above mentioned sites may be selected but usually epigastric or xiphisternal route is preferred (usually recommended and safest route).
   a. *Epigastric or xiphisternal:* The needle (a pleural aspiration needle or an IV needle) is inserted 0.5 cm below and to the left of the xiphoid process and directed posteriorly towards the left shoulder at an angle of 45° to the skin. After piercing the skin, subcutaneous tissue and diaphragm (a resistance is felt), the needle enters the pericardial cavity. It is the safest route since it is extrapleural and carries less chance of injury to coronary, pericardial and internal mammary arteries. Now the needle is connected with a 50 mL syringe with or without placing a short rubber tube or three-way cannula in between the needle and the syringe. Application of suction in the syringe draws pericardial fluid into the syringe. The needle is further advanced slowly by about 5 cm and the aspiration continued cautiously. If the needle hurts the myocardium (if advanced too far), a crunching sensation is felt; immediately draw back the needle for 2–3 cm to place the tip of the needle again in the pericardial cavity.

      In few centres, an ECG electrode is attached with the needle by a crocodile clip. As soon as the needle touches the heart, the ECG shows a negative deflection while on slight withdrawal of the needle (i.e. needle in the pericardial cavity), ECG reflects a normal tracing. Requisite amount of pericardial fluid is aspirated in this way.
   b. *Apical:* It carries the risk of injuring the coronary arteries. In the 5th Intercostal space, the needle is inserted outside the apex beat but inside the outer edge of cardiac dullness.
   c. *Parasternal:* This route carries the risk of injuing the internal mammary artery. The needle is inserted in the left 4th or 5th intercostal space just to the left of the sternum. In a massive pericardial effusion,

the aspiration may be done in the similar way from the right side of the sternum.

d. *Posterior route:* Pericardial fluid is aspirated from below the inferior angle of the left scapula posteriorly.

4. After aspiration, the needle is removed and the punctured site is sealed with tincture benzoin.
5. After-care: Rest in bed for 24 hours is essential with nothing per mouth for first 4 hours. Hourly monitoring of pulse, respiration, BP and temperature are done for next 24 hours (clinical and ECG). Analgesics, sedatives or antibiotics are given whenever indicated. In suspected complications (pneumo-/haemothorax or pneumo-/haemopericardium), a chest X-ray may be taken.
6. Send the pericardial fluid for necessary examination in the laboratory.

Clinical Wisdom

Prior to aspiration, confirm the presence of pericardial effusion by chest X-ray or echocardiography. Before doing aspiration, facilities of cardio-respiratory resuscitation including arrangement for defibrillation should be available. Repeated and rapid collection of fluid in uraemia, neoplasia and trauma may require window pericardiectomy.

Q. How to treat cardiac tamponade?

1. It is a life-threatening condition and immediate pericardiocentesis is to be done to prevent shock and acute heart failure. Even removal of a small amount of fluid relieves the patient. It is preferably done in an ICU **(Fig. 1.42)**.
2. In the absence of pericardiocentesis, treat with parenteral inotropic support along with IV normal saline. Diuretics and nitrates are contraindicated.

❍ Cardiac tamponade is a condition where there is collection of fluid in the pericardial sac, in an amount sufficient to produce serious obstruction to inflow of blood to the ventricles and thus, results in acute heart failure.

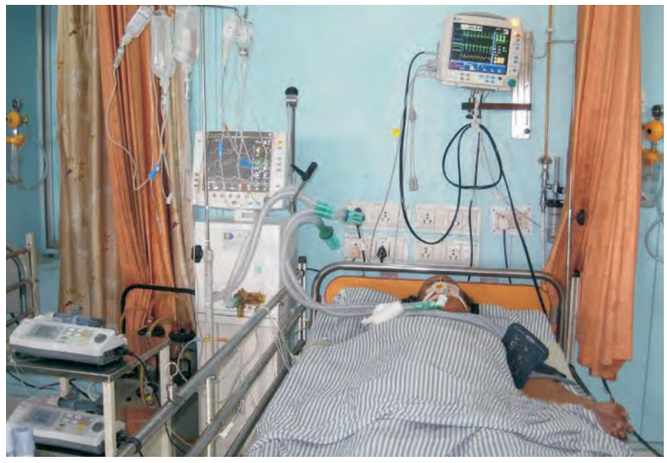


Fig. 1.42: An **ICU (intensive care unit)**, also known as ITU (intensive therapy unit/intensive treatment unit) or CCU (critical care unit) for treatment of severe and life-threatening illness by highly-trained staff

Q. Complications:

1. Vasovagal attack or shock.
2. Arrhythmias (e.g. ventricular tachycardia) and sudden death.
3. Injury to the myocardium or lung.
4. Trauma to coronary/internal mammary arteries.
5. Puncture of right atrium or pulmonary conus is rare but may be life-threatening.
6. Pneumopericardium, haemopericardium or pyopericardium.
7. Contamination of left pleural space (especially when a pyopericardium is drained in the apical route).
8. Pain in the left shoulder.
9. Injury to liver or diaphragm in subcostal (i.e. epigastric) approach.