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)

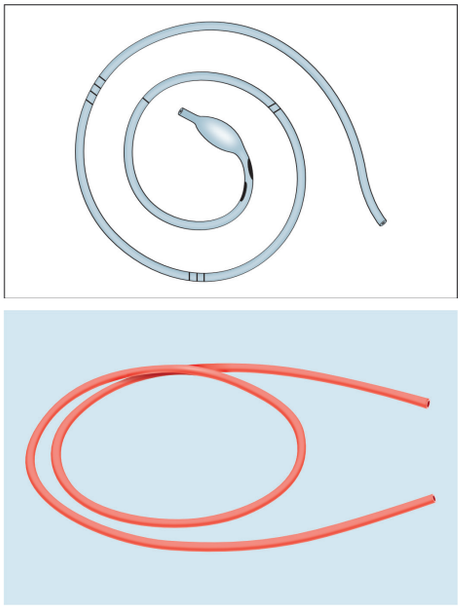


Fig. 1.1: Ryle's tube (polythene and rubber) showing markings

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.

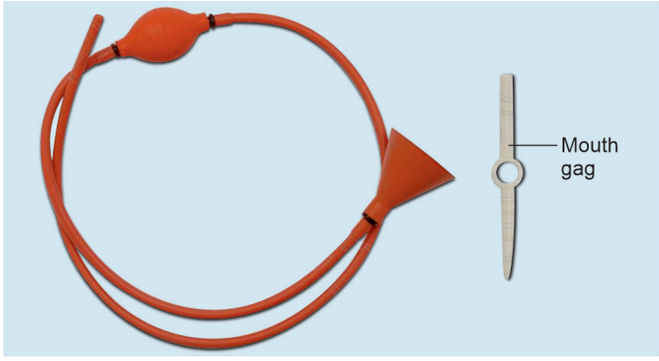


Fig. 1.2: Stomach wash tube (Ewald's)

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)

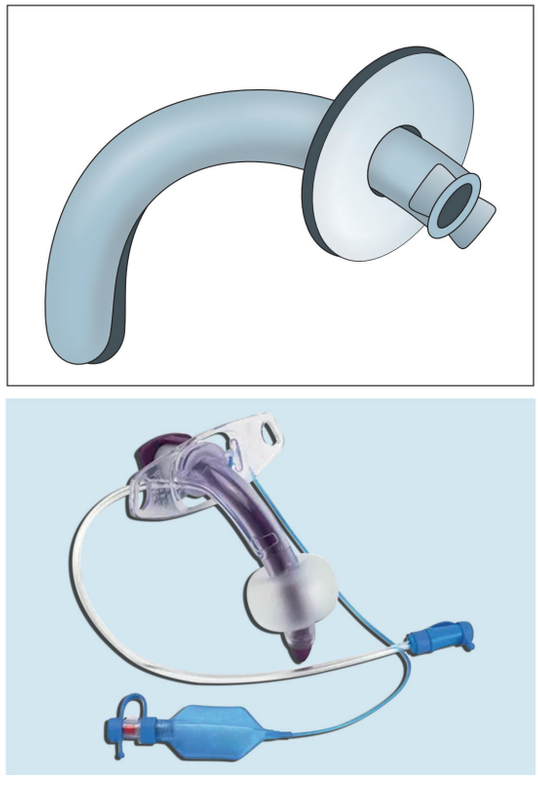


Fig. 1.3: Fuller's bivalved tracheostomy tube

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

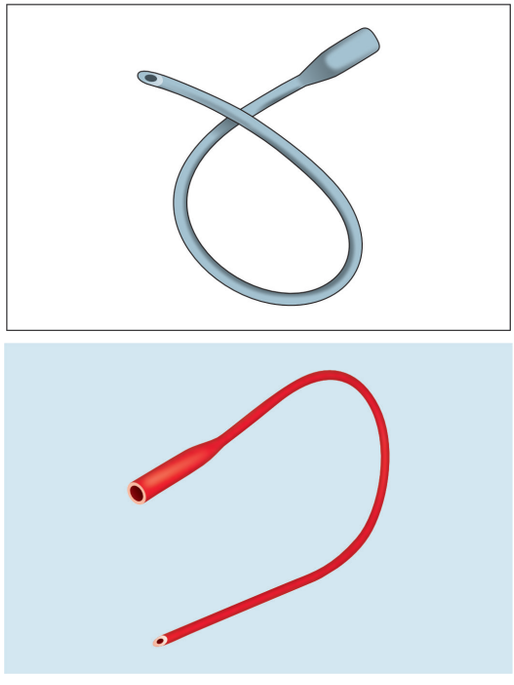


Fig. 1.4: Simple rubber catheter

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*.

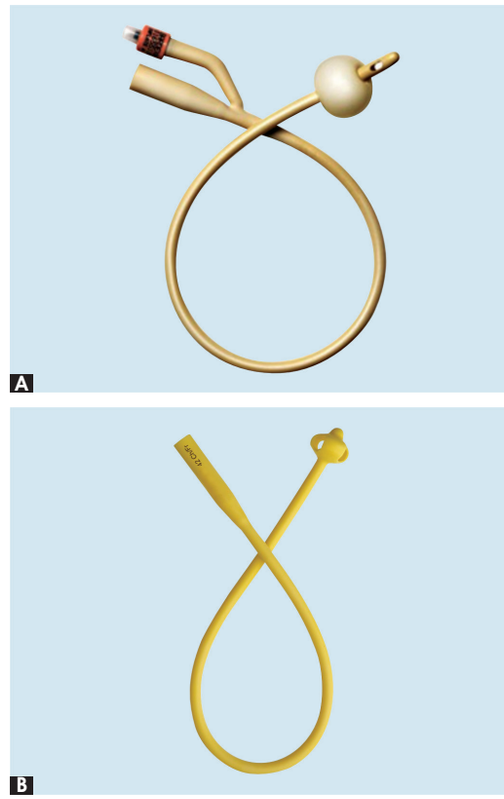


Fig. 1.5: (A) Foley's catheter; (B) Malecot's catheter

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:

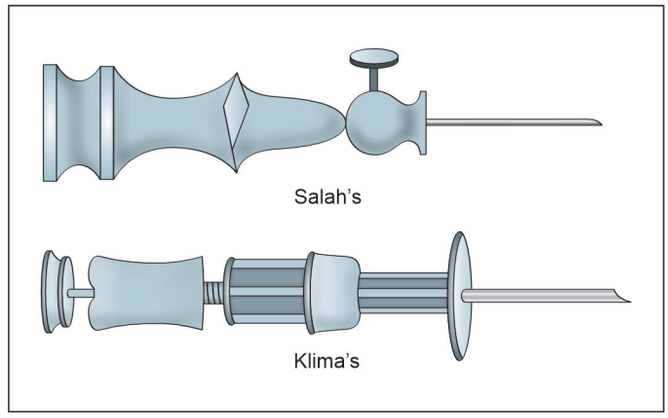
1. False passage.
2. Eye of the catheter remaining above the urine level in the bladder—a little adjustment of the catheter brings out urine.
3. Catheter is blocked.
4. Dealing with anuria instead of retention of urine.

- 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



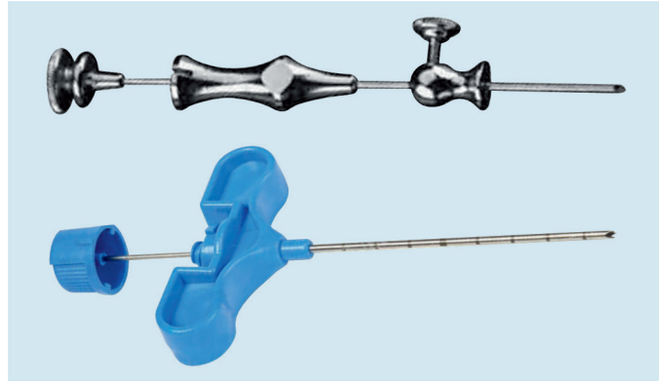


Fig. 1.6A: Sternal puncture needle (Salah's and Klima's variety)

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.

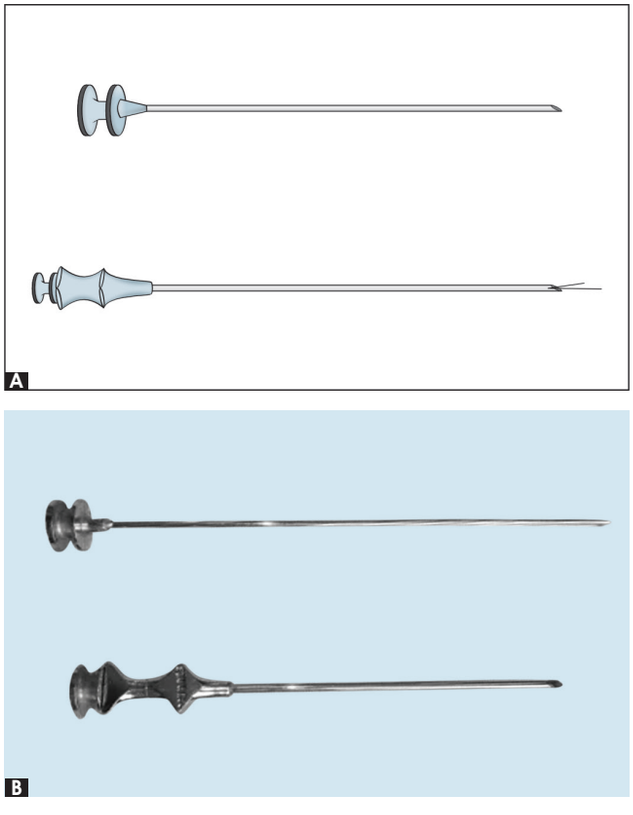


Fig. 1.7: (A) Liver biopsy needle (the solid stylet; and outer hollow needle with inner split needle within); (B) Actual photograph

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

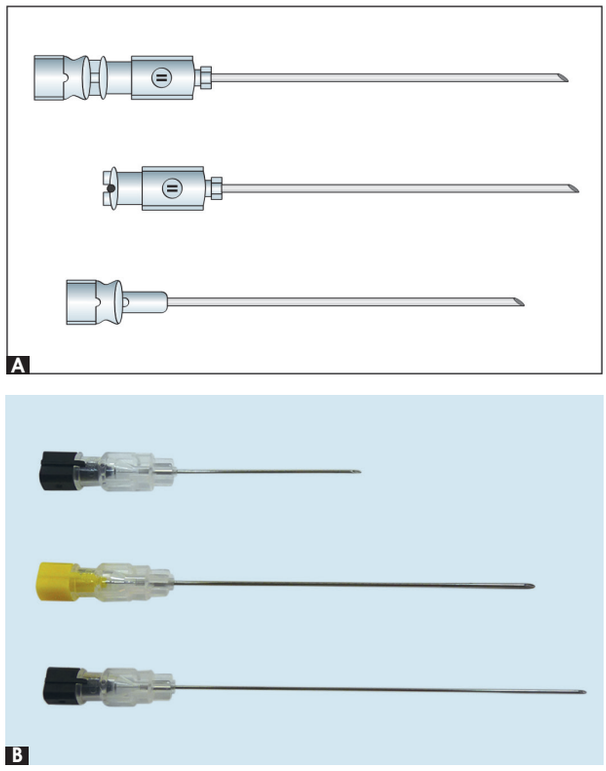


Fig. 1.8: (A) Lumbar puncture needle (the complete set, the needle proper and the stylet presented sequentially); (B) Actual photograph

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

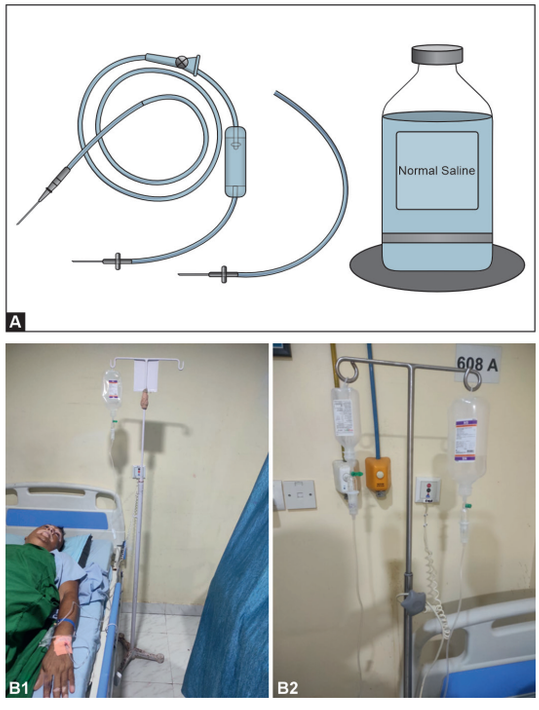


Fig. 1.9: (A) Drip tube, airway tube and the IV fluid bottle; (B_1 and B_2) Real life scenario

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):

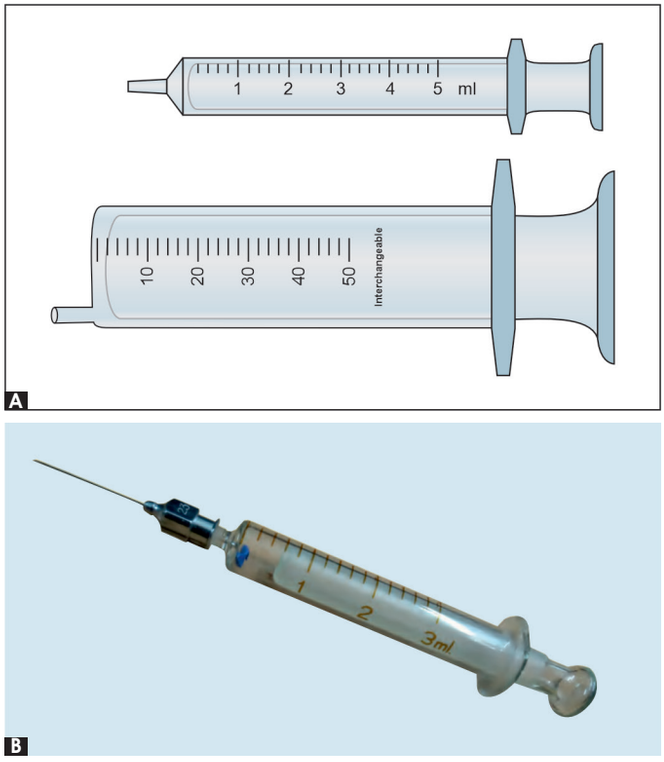


Fig. 1.10: (A) 5 and 50 mL syringes; (B) Syringe with needle

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

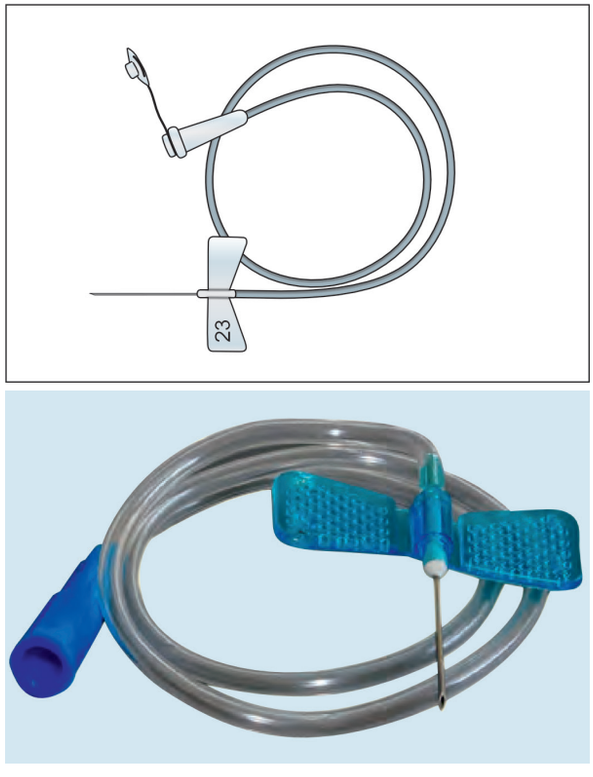


Fig. 1.11: Scalp vein set (size 23)

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.