DROWNING IN DRAINAGE??

THE LIVERPOOL HOSPITAL SURVIVAL GUIDE TO DRAINS AND TUBES

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DROWNING IN DRAINAGE

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Drowning in Drainage

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Preface

Blocked drains, leaking drains, drains with suction, sump drains, drains with strict rules, drains with no rules, drains which fall out, drainage bags which leak- I'm drowning in drains and drainage, drowning in the mystery of it all. Will someone save me from the mess, the uncertainty, the errors and the surgeon's wrath? Will someone please explain?

This small practical manual is an attempt to provide some of the answers by assembling information about common surgical drains and by offering advice and guidelines about the care and trouble-shooting of these common devices. It is hoped to be of interest and value to ward nurses and junior hospital doctors, medical and nursing students, operating theatre nurses and surgical trainees. Even experienced surgeons may find it informative and some are sure to find issues for debate or disagreement.

If patient recovery and safety are improved by learning and debate which is stimulated by this little book, the goals of its production will be fulfilled.

Thank you to the many patients with whom we have learned so much of what is written here.

Stephen Deane
June 2004

Chapter I

Introduction

1 Introduction

1.1 Feedback Form

FEEDBACK FORM

We hope this pocket guide will at least go part of the way in helping to fill in the void that exists in an important aspect of daily surgical patient care which is often overlooked. While we try our best to include relevant and generally accepted information about the common surgical drains, we apologise for any error and omission that may have occurred. Any comment or suggestion will be most appreciated.

For comments, please fill out this form and send it to the address on the reverse side.

NAME:

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COMMENT:

Thank you for completing this feedback form. Please return this form to the following address:

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1.2 Acknowledgements

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1.3 A Few Things to Note

A FEW THINGS OF NOTE
Insertion techniques for various drains are NOT discussed in this book. Such information can be found in the appropriate textbooks, manuals, or clinical guidelines.

Discussions of drains and tubes contained herein refer to adult usage unless otherwise stated.

All drain and tube measurements quoted are of external diameter unless otherwise specified. e.g. 14 Fr Bellovac® has an external diameter of 4.6 mm and an internal diameter of 2.9 mm, while a 10 Fr Bellovac® has an external diameter of 3.4 mm and an internal diameter of 1.9 mm.

Conversions:

1 Fr= 1/3 mm, 10Fr ~3.3mm
1 inch = 2.54cm
1.33kPa = 10mmHg = 13.6 cmH2O
1 cmH2O = 0.74 mmHg = 0.098 kPa

Prices:

All prices listed in this book are in Australian dollars and are current at the time of publication. Prices may vary with time, and between suppliers, and therefore should only be used as a rough guide. The authors make no guarantee regarding the accuracy of these prices.

Chapter II

How it All Began..

2 How it All Began..

2.1 Drain History - Part 1

Drain development

Hippocrates advocated the release of pus from thoracic empyema and of ascitic fluid in liver disease. Pus was detected in the thorax by shaking the shoulders and listening for splashing sounds in the chest. Whichever side thought to have the greater amount of pus would be drained first. This was achieved by cutting down on the ninth rib and making a hole with a trocar. In some patients cautery was employed to burn a hole through the thoracic wall.

460- 377 BC

431- 404 BC

Peloponnesian war between Sparta and Athens.

Other historical events at the time...

Celsus devised methods of draining ascites with conical tubes, so shaped to prevent them falling out of the peritoneal cavity. They were made of lead or brass and a plug was used at the end of the tube to allow intermittent drainage.

Johann Scultetus was the first person to use capillary drainage by inserting a wick into a drainage tube to increase its efficiency.

2nd century AD

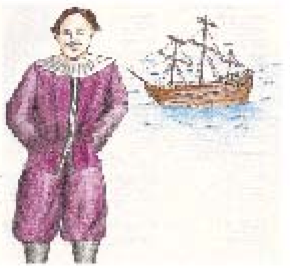
17th century AD

247-182 BC

1644 AD

Hannibal a general from the powerful city of Carthage (now near Tunis in Africa) led an army- with elephants- across the Alps in winter to attack Rome from the north.

Abel Tasman explored the north and west coasts of Australia.



2.2 Drain History - Part 2

Hunter Robb at the John Hopkins Hospital reported the first major bacterial study of drains which showed nearly 50 per cent of drains were contaminated with microorganisms.

Charles Brigham Penrose, a professor of gynaecology at the University of Pennsylvania, introduced the Penrose drain. He used a condom from which he cut off the end and inserted a strip of gauze (obviously not a great believer in contraception!).

1891

1897

1860-1861

1898

Robert Burke led an expedition cross Australia.

Pierre and Marie Curie, French scientists, observed radioactivity and isolated radium.

Chaffin developed the first commercial suction drain for use in deep or large abscess cavities where gravity drainage was insufficient.

Murphy introduced a simple inexpensive technique of intermittent suction by means of a syringe after radical mastectomy.

1932

1947

1933

1947

Hitler became Chancellor of Germany.

U.S. president Harry Truman introduced the Cold War doctrine: the U.S. offered to support groups fighting communism.

2.3 Drain History - Part 3

Closed system continuous suction drainage was introduced by Baron and Raffle in Great Britain.

Silicone rubber (Silastic) first became available and its advantages were reported by Santos et al. (1962) in the first modern experimental work on surgical drainage.

1950

1959

1950-1953
Korean War

1957

U.S.S.R. launched Sputnik 1 carrying Laika, a dog, which became the first living creature to travel into space.

The Firestone Rubber Company produced the first radiopaque Penrose drain by adding a mixture of barium during the manufacturing process.

Today, drains are a common sight in almost any surgical ward. With such wide usage of drains, their appropriate care, management and the interpretation of their performance are undoubtedly issues of vital importance.

1961

2004

1961
The U.S. government started sending troops to fight in the Vietnam War.

2004
Liverpool Hospital

Reference:

Robinson J. Surgical drainage: an historic perspective. *Br J Surg* 1986; 73: 422-426.

Chapter III

Why Use Them?

3 Why Use Them?

3.1 Reasons For Using Drains

REASONS FOR USING DRAINS

1. to **remove unwanted fluid/exudates/gas** which may serve as a breeding ground for infection or cause discomfort.
2. to **promote tissue apposition** which facilitates cavity closure and wound healing and reduces bleeding or exudate production.
3. to **monitor leakage** e.g. bile leak after biliary operations, urine leak after urological operations.
4. to **divert body fluids** away from a particular surgical site e.g. T-tube in common bile duct operations, or indwelling urinary catheter in urethral injuries.
5. to **facilitate subsequent access** to a cavity e.g. irrigation of pancreatic bed after resection of pancreatic necrosis and abscess.
6. to **allow injection of contrast** for radiographic studies such as T-tube cholangiogram.

Chapter IV

How Do They Work?

4 How Do They Work?

4.1 How Do They Work?

How Do They Work?

4.2 Some Physiological Considerations

SOME PHYSIOLOGICAL CONSIDERATIONS

If one assumes laminar flow in a drain, then Poiseulle's law states that

$F= dPpr^4 / 8nL$

where

F= flow of fluid through the drain lumen
dP= pressure difference between the two ends of a drain
p= 3.14 (approximately)
r=radius of the drain
n = viscosity of the fluid being drained
L= length of the drain

Based on Poiseuille's law, it can easily be seen that, while fluid is being continuously produced,

1. flow is directly proportional to the suction pressure(P) applied to the drain, and to the 4th power of the drain radius (r).

2. flow is inversely proportional to the viscosity(n) and the length of the drain (L).

So by doubling a drain diameter the flow can be increased 16 fold; by halving the length of a drain the flow can be doubled.

4.3 The Driving Force Behind Effluent Movement

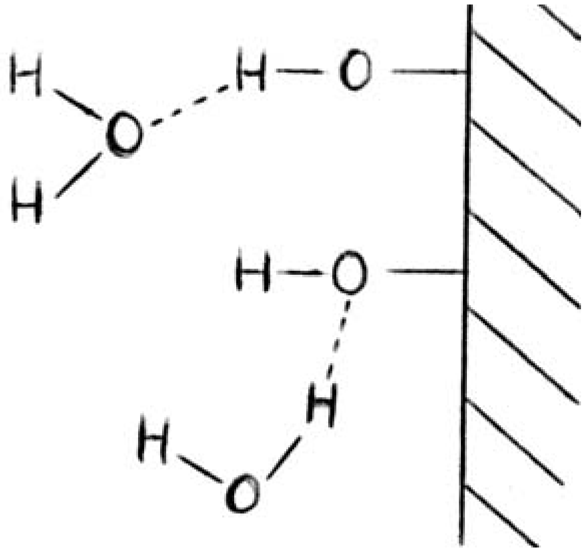
THE DRIVING FORCES BEHIND EFFLUENT MOVEMENT

1. **Gravity**- can help in wound drainage when the tip of the drain is inserted in the dependent part of the cavity, and the collection reservoir is placed below the body. This gravity aid may be lost

as the dependent part varies with the patient's position.

2. **Tissue pressure**- collapse of surrounding tissues can help force fluid or air out of wounds, body cavities, or visceral lumens.

3. **Capillary action**- occurs because water is sticky and water molecules stick to each other and to other substances, such as glass or cloth. Fluids tend to 'climb' up onto a piece of cloth, paper towel, or the wall of a narrow glass tube. In the case of a thin glass tube, water can climb up because of the strong hydrogen-bonding interactions between the water molecules and the oxygen atoms (and terminal hydrogen atoms) at the surface of the glass (SiO_2- surface oxygen atoms are typically bonded to hydrogen atoms). This 'climb' is counter-balanced by the downward pull of gravity. The narrower the tube the higher the liquid will climb, because a narrow column of liquid weighs less than a thick one. Similar adhesive forces also exist between water molecules and surface molecules of substances other than glass which facilitate movement of the drainage fluid out of wounds and cavities.



4. **Negative pressure**- can be created by manually expelling air from an expansile collection reservoir, or from machine generated suction (e.g. wall suction outlet, or portable vacuum generator).

4.4 Tract Formation

TRACT FORMATION

In some situations we rely upon the tract created for the drain and held open by the drain, to allow fluids to flow or be exuded around the drain, rather than through the drain lumen (e.g. corrugated drain, Penrose drain).

4.5 Drainage Malfunction

DRAINAGE MALFUNCTION

Fluid can stop flowing through a drain if

- fluid production ceases
- cavity being drained is completely evacuated and collapsed
- drain holes are blocked (by tissue, blood clots etc.)
- drain lumen is blocked (by blood or fibrin clots etc.)
- drain is kinked
- suction pressure source is inactivated or disconnected

Chapter V

Rules of Thumb

5 Rules of Thumb

5.1 Things to Keep in Mind

- **POINTS TO KEEP IN MIND**
-
- all drains are potentially DANGEROUS!
- the natural history of all drains is to MALFUNCTION!
- for every drain, there is a REASON!
- when the REASON is gone, the drain should be gone!
- UNDERSTANDING the reason will assist with the CARE of a drain!
- a drain should NOT EXIT a body cavity through the SURGICAL INCISION!
- a drain should reach the skin by the SHORTEST SAFE ROUTE!
- SIZE and LENGTH must be appropriate!
- a gravity drain must be placed in the deepest and MOST DEPENDENT recess of the cavity!
- drains must be inserted AWAY FROM DELICATE TISSUES e.g. nerves, vessels and anastomotic sites!
- a drain should be FIRMLY SECURED at its exit site (e.g. with braided suture) and at one other point (e.g. with adhesive tape)!

Chapter VI

What's the Reason? Prevention or Cure?

6 What's the Reason? Prevention or Cure?

6.1 Therapy vs Prophylaxis

PROPHYLAXIS vs THERAPY

Therapeutic drains - evacuate an existing collection of fluid.

Prophylactic drains - prevent the accumulation of such fluids.

Clinical and experimental data suggest that prophylactic drainage with the aim to reduce infection in clean operations is usually NOT indicated. In a multivariant analysis of drain use in 1487 hernia repairs by Simchen et al (1990), the use of prophylactic PASSIVE drains (refer to p. 57 for discussion of passive drains) was noted to be the single strongest predictor of wound infection. Another study by Reilly et al (1986) on 299 patients undergoing total knee replacement comparing CLOSED SUCTION drains (refer to p. 57, 96 for discussion of closed suction drains) versus no drainage showed no significant difference between the two groups in terms of wound infection rate.

For clean-contaminated wounds, prophylactic drainage offers some benefits which can probably be achieved equally well by the use of prophylactic antibiotics.

For the heavily contaminated wounds, concurrent use of antibiotics and prophylactic drainage may be of benefit. Delayed primary closure of such wounds, however, is probably just as effective and is advisable.

6.2 Reference

Reference

1. Dougherty S and Simmons R. The biology and practice of surgical drains Part I. Curr Probl Surg 1992; 29(8): 559-623.
2. Dougherty S and Simmons R. The biology and practice of surgical drains Part II. Curr Probl Surg 1992; 29(9): 638- 730.
3. Magee C, Rodeheaver G, Golden G and et al. Potentiation of wound infection by surgical drains. Amer J Surg 1976; 131: 547-549.

Chapter VII

What Do I Drain?

7 What Do I Drain?

7.1 List of Things to Drain

Some things you might want to drain

- Blood
- Bile
- Pus
- Urine
- Bowel anastomotic leaks
- Saliva
- Serum/lymph
- Pancreatic secretion

7.2 Things You Might Want to Drain

Blood

- Blood in the pleural cavity should be drained to allow the lungs to re-expand and the 2 layers of pleura to appose. This helps to stop further bleeding and to prevent scar formation around a partially collapsed lung, which may otherwise lead to restricted lung performance. It also helps to prevent infection of a clotted haemothorax resulting in an empyema.
- Blood in a wound cavity should be removed at the time of surgery and adequate hemostasis achieved. Drains must not be used as a substitute for meticulous surgical hemostasis. In large cavities such as the abdomen, a drain cannot evacuate blood from the entire cavity and inserting a drain simply because it was 'a little wet when we closed' accomplishes very little.

Bile

- Bile collections within the abdomen should be drained as they are irritating to the peritoneum and may become infected.
- T-tube drainage of the common bile duct is often performed after open exploration of the duct especially if instrumentation of the sphincteric region has been done; it prevents bile leakage by keeping bile duct pressure low.
- Subhepatic drainage is also needed after cholecystectomy if visible bile leakage is seen from the gallbladder bed which could not otherwise be well controlled. Biliary anastomoses may leak temporarily and subhepatic drainage is commonly used.
- Liver transection surfaces are also often managed with perihepatic drainage.

Pus

- Pus by itself is not a reason to insert a drain. Simple incision and drainage of pus from a superficial abscess cavity is often all that is needed.
- Deep abscess cavities with rigid walls that do not collapse after the evacuation of pus may require a drain to ensure a reliable tract exists between the abscess cavity and the outside for ongoing drainage.
- In a patient with peritonitis, in the absence of a rigid-walled abscess cavity or uncontrolled fistula, drainage is usually not indicated. Any drain placed will be walled off from the rest of the abdomen within 24-48 hours.

Urine

- Drains may be inserted after urological surgery to prevent the accumulation of urine within tissues. Urine collections may lead to tissue irritation and fibrosis as well as facilitate a superimposed infection.

Bowel anastomotic leaks

- Drains do not prevent anastomotic leaks, and in the abdomen they can rapidly be walled-off. They therefore may not be a reliable means to monitor anastomotic leaks nor would they necessarily be able to adequately evacuate a leak that has occurred.
- The presence of a drain may in some case promote anastomotic breakdown and leakage.
- Drains can still, however, be useful in relation to some anastomoses where leakage can be common and its adverse consequences can be great e.g. oesophagojejunal, biliary, or pancreatic.

Saliva

- After neck surgery that involves opening the aerodigestive tract, drains are commonly inserted to evacuate any saliva that may leak from the repair.
- Salivary leak can lead to a severe necrotizing mediastinal infection as well as disruption of suture lines.

Serum/ lymph

- Almost every wound, after it is closed, accumulates small pockets of serum. When these accumulations become large, they are termed seromas or lymphocoeles
- Seromas and lymphocoeles may need to be drained as they can be uncomfortable, become infected, or retard wound healing. Depending on the rate of fluid accumulation, these collections may be managed by repeated needle aspirations or drain insertion.
- Drains are often placed at the conclusion of certain operations in which extensive dissection is required or large flaps of tissue are raised and the incidence of a significant seroma formation is high. The volume of serum drained is monitored daily and when volume becomes sufficiently low (e.g. <20-30ml/day after a mastectomy) and the skin flaps appear to have adhered to the underlying tissue, drains are removed.
- Prevention of seromas or lymphocoeles is important in surgery involving prosthetic material e.g. vascular grafts, abdominal wall mesh, in order to minimise the chance of prosthesis infection.

Pancreatic secretion

- Although pure pancreatic juice in the abdominal cavity is not caustic per se, it should not be allowed to accumulate, since it can become infected or become activated and begin to digest the retroperitoneal fat and fascia.
- In pancreatic injuries, a drain should be placed in the pancreatic bed to evacuate pancreatic juice. It is left in place until drainage has ceased.
- In necrotizing pancreatitis complicated by a pancreatic abscess and requiring operative debridement, sump drains are often used to establish a firm drainage tract and to facilitate evacuation of liquefied pancreatic and retroperitoneal tissue.

Chapter VIII

What Are They Made Of?

8 What Are They Made Of?

8.1 Materials

MATERIALS

Being foreign bodies, all in situ drains induce some degree of tissue reactions (e.g. inflammation, thrombosis, fibrosis), with some drains more than others. While these responses are often unwanted, some of them serve a useful purpose under special circumstances e.g. a rubber drain used to induce a fibrotic tract.

- The softer the drain, the less likely it is to cause tissue erosion.
- Radiopacity is important to allow drain localisation on X-rays. This is usually achieved by incorporation of a radiopaque stripe along the length of the drain. Some silicone drains are barium-impregnated for this purpose.

Figure: Radiopaque line along the side of a drain

Material	Example	Properties
Latex rubber	Penrose drain	Soft and induces tract formation, surface prone to encru
Red rubber	Red-rubber tube catheter	Firm and induces tract formation.
PVC	Chest tube, Yeates	Firm and may induce some inflammation.
Silastic (silicone)	Jackson-Pratt® drain	Relatively soft and induces minimal inflammation.
Heparin coated silastic	Jackson-Pratt® drain (some types)	Aims to inhibit clot formation and achieve greater paten
Hydrogel coating	Some Foley's catheters, imaging guided percutaneous drains	Hydrogels are materials highly compatible with human t used to coat latex catheters (and also contact lens). The and produce a slippery surface which is resistant to enc
Polytetrafluoro-ethylene (PTFE)	Some Foley's catheters, Bonanno® catheter	This is latex bonded with Teflon to make it smoother tha Absorption of body fluid across the latex surface is also
Silicone elastomer	Some Foley's catheters	Latex with silicone bonding to its surfaces, making surfa and more resistant to encrustation. This also makes late absorbant.
Polymer hydromer	Some Foley's catheters	Latex bonded with polymer hydromer – smoother than l

8.2 Shape

SHAPES

- Most tubular drains are round in cross-section.
- Some (e.g. Jackson-Pratt® flat type) are rectangular in cross-section. This 'low-profile' theoretically helps to promote tissue plane approximation.

8.3 Internal Features

INTERNAL FEATURES

- Internal ridging present in some drains theoretically helps to prevent collapse and clogging (e.g. Jackson-Pratt® drain).
- Multiple lumen designs are used in some drains (e.g. Yeates, Blake®, and multi-lumen Jackson-Pratt®) in an attempt to achieve improved drainage and patency, and to minimize trauma on delicate tissues when placed on suction.

8.4 Reference

Reference:

1. Brooks A. How to perform urinary catheterization. Modern Medicine 1998; February: 114-119.

Chapter IX

Which is Which?

9 Which is Which?

9.1 Open vs Closed

OPEN VS CLOSED

Closed drains are generally preferable to open drains as they
- are associated with lower infection rate.
- reduce risk of contaminating staff and other patients.
- reduce nursing time (e.g. dressing changes and emptying) especially when there is a high output.
- allow more accurate measurement of drainage output.
- protect surrounding skin from irritating discharges.

Instances where open drains may be preferable
- Penrose for its softness and lower tendency to be blocked.
- where the output is low, open drains may offer greater patient comfort and mobility as there is no attached drainage collection reservoir .

9.2 Suction vs Passive (Non-Suction)

SUCTION VS PASSIVE (NON-SUCTION)

Closed drains can be divided broadly into those that employ suction and those that do not.

Passive drains work by pressure gradient, gravity effect, capillary action or a combination of these (see section 3).

While suction drains are more commonly used than passive ones, there are downsides as well as upsides with the use of suction.

Upsides
- Effective evacuation of effluent even where the pressure gradient may not otherwise favour the exit of effluent (e.g. negative pressure in pleural space) .
- Promotion of tissue plane apposition which can minimize bleeding and haematoma/ seroma formation.
- Applied suction force helps to keep drains clear from debris which may eventually obstruct the lumen if allowed to linger in drains for some time.
- Advantages of a closed system (see ‘Open vs Closed’ section)

Downsides
- Can lead to tissue collapse around a drain and obstruct drain orifices.
- Tissue erosion may occur especially if applied suction is high, drawing surrounding tissues up against the drain.
- May promote anastomotic leaks and retard healing of an existing fistula since suction promotes continuous drainage through the fistula tract.

9.3 Sump-Suction vs Closed Suction

SUMP-SUCTION VS CLOSED SUCTION

The word sump refers to a pit in which fluids collect (according to the Macquarie dictionary). Sump suction drains have, in addition to the main drainage lumen, a smaller vent lumen. This double lumen tube is known as the sump tube, while the cavity in which the drain tip lies (and fluids collect) is the 'sump'. When suction is applied, fluid is removed from the sump (cavity) until the drain holes are exposed. External air then enters the cavity through the vent lumen and passes around the drain before being sucked out through the drain holes. The air vent eliminates any negative pressure in the tissue/organ cavity surrounding the drain tip which otherwise would 'suck' in surrounding tissues. The sump suction system is thus an open suction system.

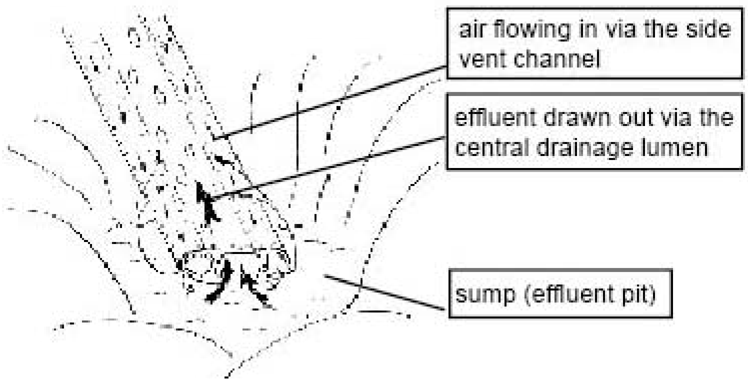


Figure: Dual-vent sump tube

Upsides (of sump suction)

- improved drainage due to air flow around the drain preventing surrounding tissues from collapsing onto drain holes. The passage of air may also be helpful in dislodging debris or clots that may otherwise block the drain holes.
- decreased risk of mechanical erosion of tissues resulting from suction pressure.
- advantages of suction drainage (see 'Suction vs Passive' section).

Downsides

- increased risk of airborne bacteria entering via vent. A study by Baker and Borchardt1 reported the degree of contamination from the air vent being proportional to the suction level. To address this problem, sump drains are manufactured with bacterial filters for the air vents.
- higher risk of mechanical trauma especially if left in situ for prolonged periods as these drains tend to be larger and stiffer than most closed suction drains.
- blockage of the small-bore air vent by retrograde flow of debris that may occur whenever suction is disconnected.
- decreased patient mobility as these drains are attached to continuous wall suction.

9.4 Reference

Reference:

1. Baker B and Borchardt K. Sump drains and airborne bacteria as a cause of wound infection. J Surg Res 1974; 17: 407-410.

Chapter X

Shopping for Drains

10 Shopping for Drains

10.1 The Ideal Drain

THE IDEAL DRAIN

The IDEAL drain should:

- Be simple to manage both by patient and staff
- Be easily removable
- Be relatively cheap
- Efficiently evacuate the effluent (or air) which it is intended to drain
- Not damage surrounding tissues
- Not potentiate infection or allow the introduction of infection from the external environment

10.2 Choosing the Right Drain for the Job

CHOOSING THE RIGHT DRAIN FOR THE RIGHT JOB!

The **4 Ws** of choosing drains:

1. **What** is being drained?

- Highly viscous or thick materials may need larger lumen drains to facilitate their passage and minimise blockage.
- Suction drains may be more effective than passive drains in removing thick secretions.

2. **Why** is the drain needed?

- Where tract formation is desired upon drain removal, drains made from materials that incite a strong inflammatory response such as latex or red rubber should be used.

3. **Where** is the drain located?

- Drains situated near delicate or vital tissues (e.g. large vessels) should be soft and incite minimal inflammation.
- Drains inserted into sterile environments (e.g. cerebral ventricles) should be of the closed system.
- Drains inserted into the negative pressure environment of the thoracic cavity require an underwater seal to prevent entry of air which can otherwise lead to a pneumothorax.

4. '**Waste** bin' size?

- High output drainage may require the use of wall suction and the larger collection device used with it. This lessens nursing time required and minimizes the potential for organisms to be introduced during frequent changes of collection bags.
- Low outputs should allow use of detachable collection bags to give patients greater mobility.

Figure: Wall collection reservoir

Note: latex allergy should be kept in mind when selecting drains even though most drains are either latex free or made of latex coated with another compound e.g. silicone.

Chapter XI

What Can Go Wrong?

11 What Can Go Wrong?

11.1 Mechanical Problems

MECHANICAL PROBLEMS

- Trauma to tissues during insertion and removal.
- Erosion of adjacent tissues- may lead to perforation or fistula formation. Where this involves large arteries, fatal haemorrhage may occur.
- Herniation of viscera through the drain tract.
- Anastomotic leak- drains are sometimes placed near anastomoses to evacuate fluid accumulation and to provide an early warning should anastomotic leak occur. Yet drains can also initiate or perpetuate such leakage through physical trauma, local inflammatory response, or by encouraging continuous flow of fluid or air through an existing anastomotic defect (especially if placed on suction). Minimization of such leaks can therefore be achieved by using small, soft drains made of low irritation material and using gentle or no suction.
- Flap necrosis may sometimes occur if suction drains are used. Here an artery supplying a part of the overlying skin flap is accidentally sucked into one of the drain holes and is subsequently kinked. Blood flow through the vessel ceases. The resultant ischaemia may appear as an overlying wedge of skin necrosis.

11.2 Physiological Problems

PHYSIOLOGICAL PROBLEMS

- Bacterial colonization and sepsis- Microorganisms can migrate back along both the inside and outside surfaces of a drain causing retrograde infection. Drain material provides a surface for bacteria to adhere to and to bypass the body's usual defences e.g. skin, tissue macrophages, mucosal IgA etc. Prevention of bacterial migration along the external surface of drains may be assisted by making a small stab incision for drain exit, placing exit sites away from the main wound and contaminated sites, and maintaining a clean exit site. Flutter or anti-reflux valves have been used to reduce internal retrograde infection. The most important preventative measure however is the removal of drains as soon as it is practical to do so.
- Loss of fluid and electrolytes
- Pain- Can lead to complications e.g. pulmonary atelectasis from poor inspiratory effort, deep venous thrombosis from decreased mobility.
- Pneumothorax/ pneumoperitoneum-
- by allowing entry of air during insertion or, in the case of open type drains, during normal use.
- Restricted mobility- the use of vacuum reservoirs instead of wall suction offers greater mobility for patients.

11.3 Drain Malfunction

DRAIN MALFUNCTION

- Migration- a drain may fall out if not properly secured or accidentally pulled. It may also fall into a wound.
- Blockage- from external factors (e.g. kinking, suture too tight) or internal factors (e.g. clots, tissue debris).
- Vacuum failure (for suction drains) may be due to:
    - Partial withdrawal so that some of the drain holes are outside the skin.
    - A break in the external part of the drain- tubing system e.g. from cracking, accidental

penetration, or disconnection.
- Loss of vacuum in the suction device e.g. failure to empty, open cap or connector.

Chapter XII

Surviving with Drains

12 Surviving with Drains

12.1 Some Questions to Ask Youself

SOME QUESTIONS TO ASK YOURSELF

- Why was the drain placed?
- Is the drain secure?
- Is the drain doing its job?
- Is it creating nuisance?
- How long does the drain need to stay in for?
- Has it completed its job?

12.2 A Systematic Approach to Drains

A SYSTEMATIC APPROACH TO DRAINS

The Patient
- Is the patient well? An unwell patient may suggest drain complications e.g. a blocked drain may lead to an infected collection, hydrocephalus, or an enlarging pneumothorax.

The Skin Exit Site
- Is there evidence of leakage or inflammation?
- Is the drain secure?

Drain Tubing and Connections
- Are all the tubing and connectors attached properly?
- Is there any damage along the way?
- Is there a kink?
- What is in the drain tubing?

The Collection Reservoir
- What is coming out?
- Unexpected drainage volume or type should always raise the alarm that something is wrong (e.g. the presence of blood where there should not be blood may be a sign of erosion into an adjacent blood vessel; the presence of faecal material in an anastomotic bed drain after a bowel operation suggests anastomotic breakdown).

How much is coming out?
- Little or no output usually means the drain has finished its job or that it is blocked, or is dislodged from its intended drainage site. Excessive drainage may indicate the development of a fistula, or sometimes tissue irritation caused by the drain .
- What is the trend of drainage output?
- Accurate 24 hour totals are necessary for making decisions about drain management.

Suction (if connected)

Wall suction
- Is the correct regulator connected? LOW wall suction regulator should usually be used for continuous suction.
  What is the reading on the pressure gauge? Pressure which is too low to adequately move the effluent defeats the purpose of suction drainage, while pressure which is too high poses a risk of serious tissue erosion (see p. 113 for pressure setting guidelines)

- Closed suction
  Is the reservoir vacuum maintained?
- Sump suction
  Is air entering the air vent (audible hiss)?

12.3 Troubleshooting

Common scenarios encountered when working with drains:

1. Blocked Drain
2. Leaking Drain
3. Loose Drain
4. Drain retraction
5. Drain falling out
6. Broken Drain/ Tubing
7. Inflamed Drain Exit Site
8. Atypical Drainage Fluids
9. High Drainage Output
10. Vacuum Failure for Suction Drains
11. Final Reminder

12.4 Blocked Drain

Blocked Drain

1) Recognise problem
Blockage should be suspected when there is a sudden drop in drainage output, lower output than expected, or no output at all.

2) Identify cause
Causes may include overly tight sutures, kinking, in-growth or collapse of surrounding tissues, or debris accumulation and blood clots in the lumen. Commonly a drain is blocked due to lumenal debris which may not be visible from external inspection.

3) Adopt strategy

a. Aspirate
After ruling out external compression, a drain can usually be unblocked by aspirating or increasing suction on the drain. The drain may be put on high suction for 30 seconds to see if the obstruction can be overcome.

b. 'Milk'
Manual 'milking' of debris out through the drain can help to dislodge the obstruction or break it up into smaller debris. This can be done by gently squeezing the tube between your thumb and index finger while moving your fingers along the tubing towards the suction bottle.

c. Flush
Failing aspiration and milking, one may attempt to flush the drain with sterile saline using aseptic technique (antiseptic prep, sterile gloves/ syringes/ drapes) with appropriate protections including masks and eye protections. This can push back in any debris too large to be aspirated through the drain. Flushing also helps to reestablish drainage where tissue collapse or adhesion around the drain interferes with its function. If there is any doubt at all whether a drain can be safely flushed or not, this should NOT be attempted until it is discussed with the team registrar or consultant.

4) Notify team
Where basic attempts at unblocking a drain fail, the surgical registrar or consultant should be notified.

5) REMEMBER:
Unexpected fall in drain output may result from drain dislodgement rather than blockage (e.g. T-tube dislodged from bile duct or nephrostomy dislodged from renal pelvis).

12.5 Leaking Drain

Leaking Drain

1) Identify cause
Leakage occurring around the exit site of a suction drain is usually due to a blocked drain rather than a perforation in the drain. The drainage fluid may find its way out along the external surface of the drain when the lumen is blocked. Leakage around the tubing or connections are due to damaged tubing or loose connections.

2) Adopt strategy
This may require unblocking the drain, or replacing the tubing and tightening of connections as appropriate.

12.6 Loose Drain

Loose Drain

1) Recognise problem
Virtually all drains need to be well secured, preferably at two points.

2) Identify cause
Causes may include drain-securing suture cutting through the skin, loose knot tying, or traction on the drain.

3) Adopt strategy

a. Re-secure
Loose drains must be re-secured appropriately and promptly. For most drains this usually involves putting a stitch through the skin next to the drain exit site under local anaesthetic, then tying the suture securely around the drain.
Extra security can be provided by taping the drain/ tubing to the skin.Open drains should be prevented from falling into the drainage cavity e.g. by passing a safety pin through the drain.

4) Notify team
The team surgical registrar should be notified.

12.7 Drain Retraction

Drain retraction

1) Identify cause
Drain retraction is due to a loose drain being pushed in e.g. during dressing change or from patient movement.

2) Notify team
The surgical registrar or consultant should be notified.

3) Adopt strategy

a. Re-secure
This should be dealt with as a loose drain. Drains suspected to have partially retracted inside a wound should be left in place and properly re-secured. Attempts at pulling the drain back out should be avoided unless the distance of retraction is known e.g. drain retraction witnessed or length at skin surface marked. Otherwise any attempt to pull the drain back out may lead to the drain being dislodged altogether.

b. Re-position
Drains that have clearly retracted inwards should be pulled out to an adequate length to permit subsequent removal before being re-secured.

12.8 Drain Falling Out

Drain falling out

1) Identify cause
This is due to a loose drain being tugged or pulled.

2) Adopt strategy

a. Re-secure
A drain that has only partially migrated out should be re-secured. It should NOT be pushed back in as the externalized part is now contaminated.

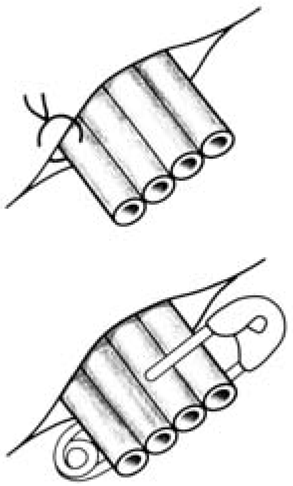


Figure: Re-securing the drain

b. Examine
If a drain has fallen out completely, a careful look should be made to ensure that no part of the drain is left inside.

c. X-ray
If there is any doubt, an X-ray should be performed.

3) Notify team

The appropriate surgical registrar/ consultant must be notified.

12.9 Broken Drain/ Tubing

Broken Drain/ Tubing

1) Identify cause
This is usually from repetitive physical trauma with potential contributing factors including manufacturing defects or drain weakness as a result of prolonged use and contact with digestive enzymes in body fluids.

2) Adopt strategy

a. Replacement
If breakage occurs to the external part of the drain or tubing, then the drain might still be able to carry out its job. It may be reconnected to a new reservoir or have tubing replaced as appropriate.

b. Removal
If the break is flush with the skin exit site, then it should be VERY CAREFULLY removed so as not to push it further inside the wound. Firm grip with an instrument should be maintained and the drain slowly withdrawn.

If the break is deep to the skin exit site but is visible from the outside then it may still be possible to remove by grasping it firmly with an appropriate instrument (an artery forcep can be very useful here). This should be done using aseptic technique with care to avoid pushing the broken part further inside or creating tissue bleeding which may further obscure vision.

c. X-ray
An X-ray may help to confirm the drain position.

d. Seek help
Help from an experienced person should be sought if any difficulty is anticipated.

e. Operation
Intraoperative removal of the drain under X-ray guidance or an open procedure may be necessary.

3) Notify team
The appropriate surgical registrar/ consultant must be notified.

12.10 Inflamed Drain Exit Site

Inflamed Drain Exit Site

1) Recognise problem
Minimal redness can often be seen around drain exit sites due to local irritation and does not need any treatment.

2) Identify cause
Cellulitis at the drain exit site may appear as a more pronounced zone of redness, warmth, and tenderness. Systemic inflammatory response as indicated by fever or tachycardia may also be present.

Purulent discharge at the drain exit site must be examined closely to distinguish between purulent drainage fluid coming up around the outside of the drain and local abscess collection (unusual).

3) Adopt strategy
Cellulitis around a wound can often indicate inadequate drainage or debridement and that local surgical intervention may be required. Otherwise, it may be treated with an appropriate antibiotic covering for skin organisms e.g. Staphylococcus aureus and Streptococcus spp. as well as any other relevant organisms.

Where there is an abscess collection, the treatment is drainage using appropriate aseptic technique. This can usually be done by a simple incision after infiltration with local anaesthetic. Antibiotics are NOT indicated unless there is significant associated cellulitis or systemic immunosuppresion.

Small amounts of purulent discharge may persist around drains which have been in place beyond the acute postoperative phase. This only needs the usual local care as for a small wound. Antibiotics are NOT required.

12.11 Atypical Drainage Fluid

Atypical Drainage Fluids

1) Identify cause
Unexpected fluids coming up from around a drain or in the drain lumen may be due to anastomotic leaks, or drain erosion into adjacent structures e.g. bowel, bladder, or blood vessels.

a. Blood
Bleeding can be deep or superficial, early or delayed. Early bleeding can usually result from a vessel being accidentally pierced by the trocar during insertion or by the drain stitch. Delayed bleeding may indicate erosion of a vessel by the drain anywhere along the drain tract. Erosion into blood vessels may appear as an initial 'herald bleed' consisting of a brief and brisk fresh bleed which may be followed by a more catastrophic haemorrhage at a later stage.

b. Anastomotic leaks
Anastomotic leaks may be verified by testing for appropriate biochemical markers e.g. amylase for suspect pancreatic anastomotic leak, or creatinine for urinary tract anastomotic leak. If the concentration of the particular biochemical marker in the drainage fluid is significantly higher than the serum concentration then leakage should be suspected.

The likelihood of tissue erosion is increased by fragility of the local tissues (e.g. in the presence of local inflammation, infection, or necrosis), the use of large or rigid drains, and the use of continuous high pressure suction which sucks surrounding tissues into the drain holes.

2) Notify team
The appropriate surgical registrar/ consultant must be notified.

3) Adopt strategy

a. Deal with bleeding
Superficial bleeding will usually settle with local pressure but may need suture control. Deep bleeding may need angiography or surgery. The team registrar or consultant must be notified of any significant bleeding.

b. Deal with anastomotic leak or tissue erosion
Depending on the size of the communication and the structure involved, approaches may involve observation only, reducing or stopping suction, partial withdrawal of the drain, removal of the drain,

or intraoperative repair of the communication.

12.12 High Drainage Output

High Drainage Output

1) Identify cause
Sudden increase in drain outputs usually signifies a complication (e.g. anastomotic leak, or erosion into adjacent organs).

2) Notify team
The team registrar or consultant must be notified of such changes.

3) Adopt strategy
Management steps appropriate to the cause should be undertaken.

12.13 Vaccum Failure For Suction Drains

Vacuum Failure for Suction Drains

1) Identify cause
When the vacuum suction reservoir fills with air, loss of vacuum has occurred. It may be the result of an air leak in the actual drain or the connecting tubing. Air leak from the drain is often due to the drain not being pushed in far enough or being accidentally pulled out such that some of the drain holes lie external to the skin. Air is then drawn in through these holes when suction is applied. Vacuum failure may also occur as a result of a problem with the actual reservoir e.g. failure to close a cap or presence of a puncture in the reservoir. Less commonly, this may be due to the development of a communication between the drainage cavity and a hollow viscus or the external environment (e.g. wound dehiscence).

2) Adopt strategy
Any drain hole outside the skin should be covered with occlusive bandaging to stop the air leak. Air leaks elsewhere in the system should be stopped preferably by tightening of connections and/or replacement of any defective component. Otherwise occlusive tape may also be used to seal such defects.

3) Notify team
If no air leak or suction reservoir defect is found, an opened wound edge or some abnormal communication from the drainage cavity (e.g. fistula development into an adjacent hollow viscus) ought to be suspected. The team MUST be notified.

Refer to the specific section on the particular drain for further details on trouble-shooting of the following:
PEG feeding tube (p.137)
Pig-tail catheter (p.94)
Sump drain (p.113)
Urinary catheter (p.169)
V.A.C.® Therapy™ (p.159)

12.14 Final Reminder

FINAL REMINDER

THE NATURAL HISTORY OF ALL DRAINS IS TO MALFUNCTION!

IF IN ANY DOUBT ABOUT THE PROBLEM OR THE SOLUTION, CALL THE RESPONSIBLE SURGICAL REGISTRAR OR CONSULTANT ASAP!

Chapter XIII

Open Drains

13 Open Drains

13.1 Open Drains

Open Drains

Open drains are passive drains. Unlike the closed ones, these do not come with their own drainage bags. Instead, the effluent may be directed into overlying dressings or into a wound drainage/ colostomy bag (e.g. Coloplast® bag) applied directly over the exit of the drain.

Figure: A wound drainage bag

Types of open drains include:

1. Corrugated Drain
2. Penrose Drain
3. Yeates drain

13.2 Corrugated Drain

Corrugated Drain

Material: PVC (red rubber corrugated drains are now rare)

Size: 250 x 25mm, 400x 25mm sheets

Cost: $$

Figure: A corrugated drain

Features:

- The corrugations provide an increased surface area for capillary action of fluid and also serve as channels for fluid flow.

13.3 Penrose Drain

Penrose Drain

Material: Latex rubber, silicone

Sizes: ¼ x 6, ½ x6, ¾x 6, 1x 6 inches

Cost: $

Figure: Penrose drain in infected foot

Features:

- The drain is quite floppy like a rubber glove and its walls usually collapse together. It serves as an escape for effluent when there is a pressure gradient between the cavity being drained and the external environment.
- Less likely to be blocked by tissue ingrowth or debris as it is usually collapsed. Drainage occurs when there is sufficient pressure forcing effluent out through and around the drain.
- Induces fibrotic tract within 7 to 10 days.

13.4 Yeates Drain

Yeates drain

Material: PVC
Size: width- 50mm (18 lumens), 25mm width (9 lumens) , length- 250 mm
Cost: $$$

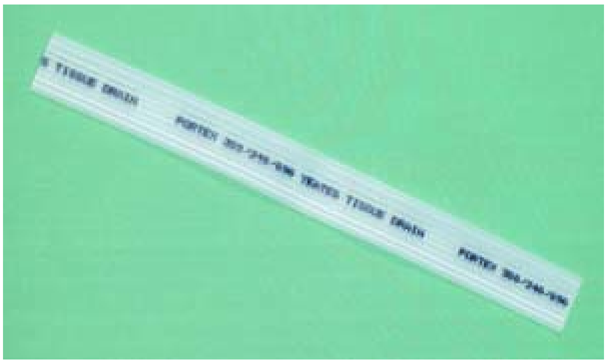


Figure: A Yeates drain

Features:

- Consists of a series of approx 2mm diameter PVC tubes attached side by side; these can be peeled off individually to make the drain narrower.
- Allows drainage both through the lumens and along the exterior of the tubes. This makes the drain especially suited for large fluid volumes. The multiple small diameter tubes also helps to draw fluid out by capillary action.

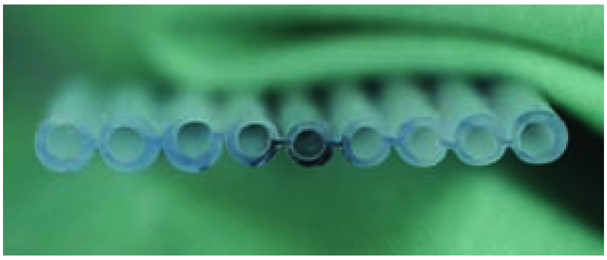


Figure: Cross-sectional view of a Yeates Drain

Chapter XIV

Closed Drains

14 Closed Drains

14.1 Closed Drains

CLOSED DRAINS

RADIOLOGICALLY GUIDED PERCUTANEOUS DRAINS
These include the 'pig-tail catheters' which are multi-purpose drains, and the percutaneous transhepatic biliary drains.

CLOSED PASSIVE DRAINS
1. Pig-tail Catheters
2. Percutaneous Transhepatic Biliary Drains
3. Urinary Catheter
4. Intercostal Catheter

CLOSED SUCTION DRAINS
1. Bellovac®
2. Blake® drain
3. Exudrain®
4. Hemovac®
5. Jackson-Pratt®

14.2 Pig-Tail Catheters

Pig-tail Catheters

Material: Latex with hydrogel coating

Size: 8, 10, 12, 14 French

Cost: $$$$

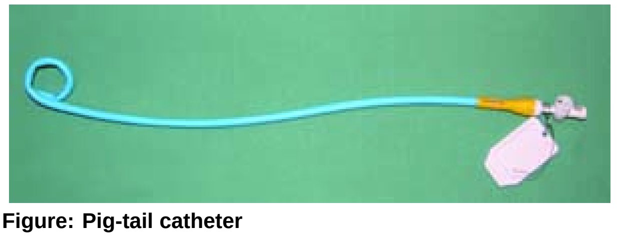


Figure: Pig-tail catheter

Features:
- Pig-tail catheters, as the name suggests, have a spiralled tip which is straightened during insertion by means of a guide wire. Once correctly placed, the tip can be 'locked' in the curled position by means of a string in the lumen which is placed under tension by turning a lock at the external end of the drain. This curled tip helps to prevent any accidental dislodging of the drain.
- The drain has about 5 side-holes for drainage spaced 1cm apart from the catheter tip.
- Can be used for drainage of collections in most locations including the renal pelvis (i.e. as a nephrostomy tube).

Figure: Pig-tail catheter here being used as a nephrostomy tube in a patient with obstructive renal calculus

Dealing With A Blocked Pig-tail Catheter

- May be dealt with in a similar manner to any other drain that may be inserted in the same location and for the same purpose.
- Often an obstructed drain is unblocked by passing a stiff wire down the lumen under X-ray guidance.
- Flushing with urokinase has been advocated as a way of unblocking obstructed drains. This has the advantage of dissolving the content of the collection being drained as well. Subsequent drainage will therefore be easier with a lower chance of re-obstructing. However, the use of urokinase is expensive. Consideration should also be given to whether urokinase may cause clot dissolution in the drainage cavity, leading to problematic bleeding.

Removing A Pig-tail Catheter

- The curled drain tip (internal end) must firstly be straightened. This can be achieved either by cutting off the external part of the drain (thereby cutting the tensioning string inside) or preferably by turning the lock (which, in the 'close' position, puts tension on this string) at the external end of the drain to 'open'. The 'close' and 'open' positions of the lock is usually indicated on the drain. The rest of the removal process should be done as with any other drain.
- If difficulty is experienced in pulling out the drain despite having done the above step, the drain tip may still be curled inside due to incorrect loosening of the tension string. SEEK HELP from a more experienced staff member.

Figure: Pig-tail catheter lock

14.3 Percutaneous Transhepatic Biliary Drains

Percutaneous Transhepatic Biliary Drains

Material: Latex with hydrogel coating

Size: 8, 10, 12, 14 Fr

Cost: $$$$

Features:

- The design here is the same as with the multi-purpose pig-tail catheters except that there are more side-holes along the drain extending back to about 15 cm from the tip (instead of 5 cm with multi-purpose catheters). When placed across the sphincter of Oddi, the extra proximal holes allow the catheter to serve as a stent. Bile from the upper part of biliary tree will enter the proximal side-holes and run within the biliary catheter before exiting into the duodenum via the distal side-holes.

14.4 Urinary Catheter

Please see the following link - Urological Catheters

14.5 Intercostal Catheter

Please see the following link - Intercostal Catheter

14.6 Closed Suction Drains

CLOSED SUCTION DRAINS

A typical closed suction setup consists of:

1. a radiopaque drainage catheter
2. connectors and connection tubing
3. a closed suction reservoir which generates vacuum when air is expelled from it by squeezing. As the suction reservoir gradually fills up with effluent, the vacuum will correspondingly decrease until the reservoir is fully inflated back to its former shape.
4. one-way valves at the inlet and outlet of the suction reservoir to prevent reflux of drainage fluid back into the wound (inlet valve) or from the collection bag back into the suction reservoir (outlet valve)
5. a changeable collection bag

NOTE
That drainage holes along the side of these drains must ALL be located inside the drainage cavity for suction to be effective. Any hole which lies outside the skin will prevent suction from being established.

Types of open drains include:

1. Bellovac®
2. Blake® drain
3. Exudrain®
4. Hemovac®
5. Jackson-Pratt®

14.7 Bellovac

Bellovac®

Material: PVC

Size:
- diameter-10 Fr, 14 Fr, 18 Fr
- reservoir- 220ml
- collection bag- 700 ml

Cost: $$$

Features:

- Suction reservoir is in the shape of a bellows which generate an initial pressure of -90 mmHg (-12 kPa).
- Clamps are present at the inlet (i.e. wound end) and outlet (i.e. collection bag end) of the suction reservoir in addition to the one-way valves, to prevent backward flow of effluent in the system during activation and emptying of the suction reservoir (see diagram on page 98).

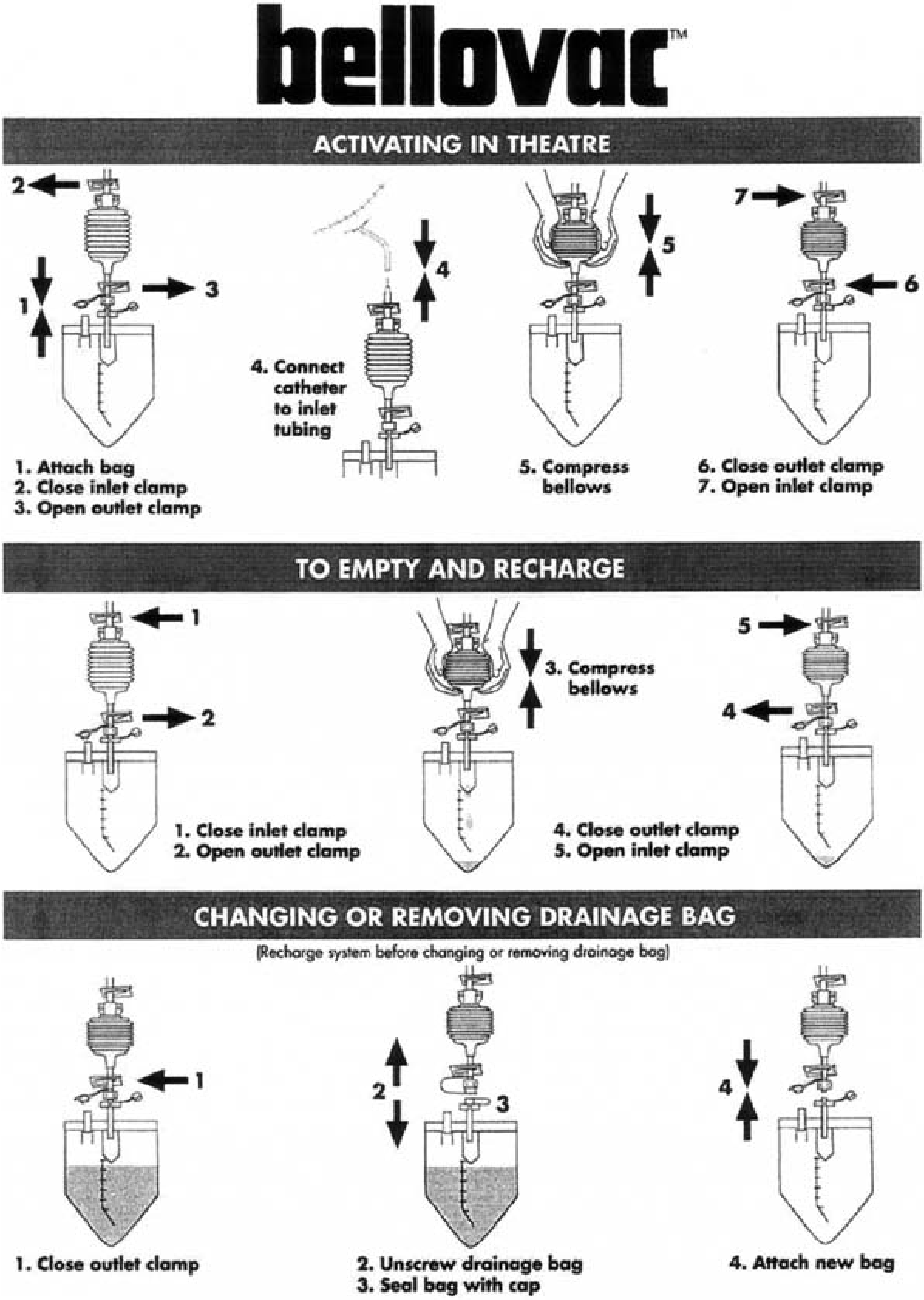


Figure: Bellovac® drain care wall-chart shown on the following page has been reproduced with kind permission

from AstraZeneca Pty Ltd.

14.8 Blake Drain

Blake® drain

Material: Silicone

Size: 10, 15 & 19 Fr

Cost: $$$

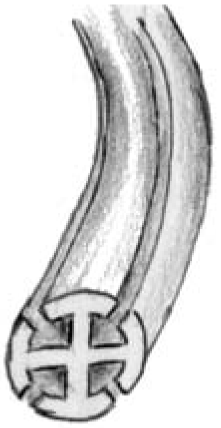


Figure: Blake® drain

Features:
- Instead of having drain holes, there are four channels running along the sides of the drain. This design attempts to maximize the area for fluid entry and to avoid blockage caused by tissues collapsing on the drain holes found in many other drains.
- Can be connected to the portable suction/ drainage bag setup of other drains e.g. Exudrain® or Hemovac®.

14.9 Exudrain

Exudrain®

Material: PVC

Size:
- diameter-10 Fr, 14 Fr, 18 Fr
- reservoir capacity- 100ml
- collection bag- 700 ml

Cost: $$$

Features:
- Suction reservoir is in the shape of a bulb which can generate an initial pressure of –75 mmHg (–10 kPa).
- Clamps are present at the inlet (i.e. wound end) and outlet (i.e. collection bag end) of the suction reservoir in addition to the one-way valves to prevent backward flow of effluent in the system during activation and emptying of the suction reservoir

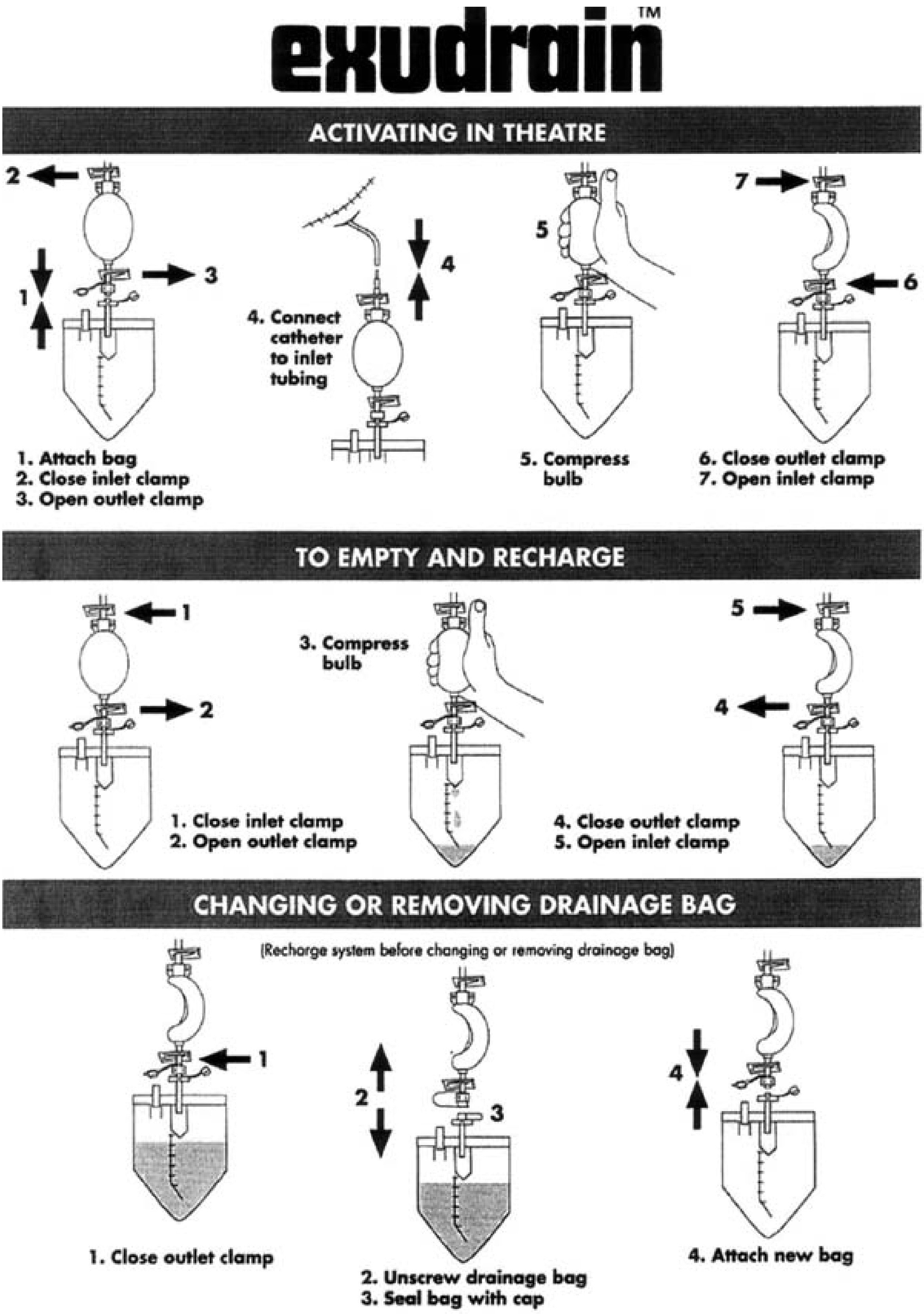


Figure: Exudrain® drain care wall-chart shown has been reproduced with kind permission from AstraZeneca Pty Ltd. Diagram and instructions shown are current at the time of printing.

14.10 Hemovac

Hemovac®

Material: Silicone (flat drains), silicone/PVC (round drains)

Size:
- Drain-
  Round drain- 10 Fr (= 3.2 mm= 1/8"), 15 Fr, 19 Fr (=6.4mm=1/4")
  Flat drain- 7mmx20 cm, 10mmx 20cm, 7mmx30cm, 10mmx30cm
- Reservoir-
  100ml bulb type
  400ml spring-loaded cylinder type
- Collection bag-
  150 ml & 450ml

Cost: $$$

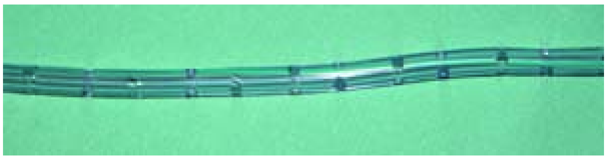


Figure: Close up of a Hemovac® drain

Features:
- Some are 'hydrocoated' to minimize potential blockage by clots.
- Suction reservoir is in the shape of a short cylinder, the two circular ends of which are held apart by a spring mechanism. Once compressed, the spring will attempt to force apart the two ends and in doing so it creates a vacuum.
- A one-way valve at the proximal end of the suction reservoir prevents drained effluent from going back into the wound.
- A one-way valve at the exit port of the suction reservoir stops any effluent from being sucked back into the suction device by the vacuum.
- Y- connectors are available to permit attachment of 2 drains into one suction reservoir.
- Wall suction adapter allows connection to wall suction tubing also.

Figure: Hemovac® drain setup

14.11 Jackson-Pratt Drain

Jackson-Pratt®

Material:
- Silicone (flat drains),
- Silicone/PVC (round drains)

Size:
- Drain dimensions-
  flat drain- 4mm x7mm x20cm, 4mm x10mm x20cm
  round drain- 7,10, 15, 19 Fr diameter
- Reservoir size
  Bulb comes in 100 and 400 ml capacities
  Spring loaded reservoirs are 400ml
- Collection bag
  800 ml

Cost: $$

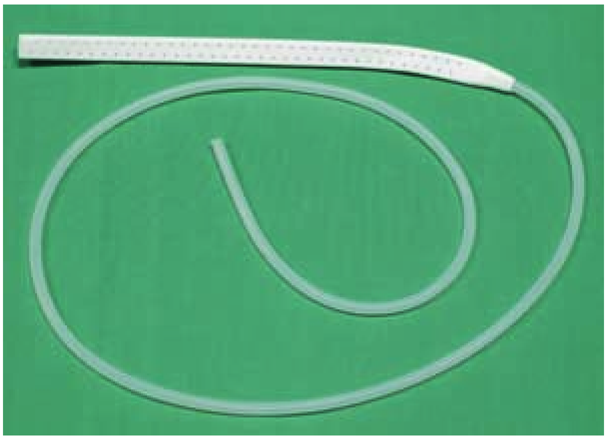


Figure: Jackson-Pratt® drain

Features:
- These drains are available in the conventional round and flat types, as well as the multi-lumen design. The multiple lumens are interconnected by internal portals.
- Suction is established by squeezing the reservoir to get rid of air while the air exit port is uncapped. This port is then capped and the vacuum created in the reservoir will draw in drainage fluid. Vacuum pressure decreases as it fills with fluid/air and expands.
- Reservoirs are available in the bulb and spring loaded types.
- Clear plastic reservoir and graduations allows drainage to be measured.
- Y- connectors are available to permit attachment of 2 drains into one suction reservoir.
- Wall suction adapters allow connection to wall suction tubing.

Figure: Cross-sectional view of a flat type Jackson-Pratt® drain

Chapter XV

Sump Suction Drains

15 Sump Suction Drains

15.1 Sump Suction Drains

SUMP-SUCTION DRAINS

15.2 Axiom Sump Drain

Axiom® sump drain

Material: PVC/Silicone

Size:
- Internal Diameter
  Dual sump- 8.5mm (central lumen)
  Uni sump- 6.5 mm (central lumen)
- Length
  Dual sump- 35 & 50 cm,
  Uni sump- 45 cm

Cost: $$$

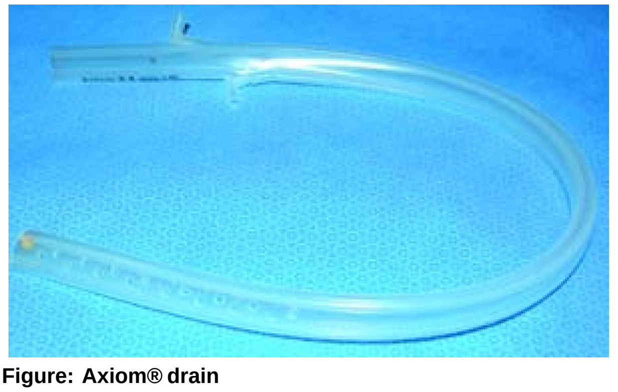


Figure: Axiom® drain

Features:
- Has either 1 or 2 side vents running parallel to the main central lumen.
- Recommended vacuum pressure by manufacturer is 40-100 mmHg.
- Bacterial filters can be fitted to the vents to minimize the potential for bacteria to enter the wound while air is drawn in.
- Because of its efficient drainage (discussed on p. 58), it is especially suited to the drainage of irritant discharges or those that contain activated digestive enzymes (e.g. high small bowel and pancreatic fistulae).
- Relative rigidity and large size may lead to mechanical erosion of adjacent tissues if left in for prolonged periods.
- May be used as an irrigation drain. The sump vent is designed so that it would accept the male leur connector of an I.V. giving set. Fluid is infused via one of the side vents to enter the wound before being sucked out through the main lumen.

Figure: Cross section of an Axiom® drain

Note:
When air filters are installed, the amount of airflow through the vents are reduced approximately 7 folds e.g. airflow of 21 litres/min without the air filters are reduced to 3 litres/min after installation of the filters

15.3 Salem Sump Drain

Salem® sump drain - use the following link

15.4 Sump Drain Care

Sump Drain Care

- Suction adjustments should start at the lowest setting on the gauge and increase gradually until flow begins and bubbling is heard through the vents. Vacuum over 100 mmHg may partially collapse the drain.
- Constant rather than intermittent suction should be used.
- A collection trap employing a simple underwater seal may be used instead of the dry trap (i.e. collection bottle) as this would help managing staff to see the constant bubbling and be sure that the sumping action is working.
- To prevent reflux during vacuum failure or disconnection, the drainage tubing and trap should be below the wound level.

15.5 Wall Suction Pressure Setting

Wall Suction Pressure Setting

- Sump drains require attachment to wall suction.
- Wall suction offers the advantage of accurate adjustment of pressure usually ranging from -10 to - 400 mmHg (approx -53 kPa max). On the other hand the vacuum pressure generated by suction reservoir of the closed suction drains is preset, usually in the range of 60- 125 mmHg.
- Wall vacuum outlets can be attached to 2 types of regulators- low wall-suction regulators and high wall-suction regulators.

1. Low wall-suction regulator
Low wall-suction regulator permits adjustment of pressure up to –180 mmHg (–25 kPa) and is used mainly for continuous suction drainage. It is commonly adjusted to about -40 mmHg (–5kPa) of pressure.

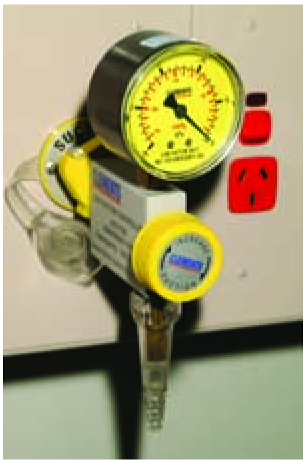


Figure: Low wall suction regulator

2. High wall-suction regulator

High wall-suction regulator permits adjustment up to –400 mmHg and is largely used for temporary large volume or high pressure suction e.g. airway suction or attempts at unblocking an obstructed drain. Prolonged use of high wall suction may lead to tissue trauma (the risk is also present with low wall suction but is much lower).

Figure: High wall suction regulator

A general guide to vacuum pressure settings[1]:

INDICATION / SETTING	RECOMMENDED VACUUM PRESSU
Delicate tissue	25-74 mmHg
Heavier exudates or where large areas of dead space must be reduced	75-250 mmHg
To encourage active adhesion formation between healing surfaces	200- 400mmHg
To open drain occlusions or to move large volumes of fluid quickly	250-350 mmHg

15.6 Trouble-Shooting Sump Drains

TROUBLE-SHOOTING SUMP DRAINS

The approach to drain problems should follow the same principles as with most other drains with particular attention to the following points:

Blockage of air vents
- Blocked vent(s) should be suspected when the sound of air flowing through the vent(s) is no longer audible.
- The small air vent lumen can easily be obstructed by reflux of drainage fluid, irrigation/ flush fluid, or debris e.g. during suction disconnection.
- If there is any doubt about blocked air vents, they should be flushed (usually with normal saline, followed by air).
- A clogged or wet bacterial air filter can also impair vent function. If a filter's performance is questionable, it should be replaced or removed.
- It can lead to loss of the sumping action, and the sump drain effectively becomes a closed suction drain.
- Attempts at unblocking the drain may be facilitated by running irrigation fluid through the side vent with the filters removed. Air should then be flushed through. DO NOT IRRIGATE THROUGH THE FILTERS.

Leakage of fluid from air vents
- Indicates an obstruction of the main lumen. The drain now effectively becomes an open passive drain.
- Requires unblocking of the main lumen. Plugging up the side vents with bacterial filters or other spigots is NOT the solution!

15.7 Reference

Reference:

1. Fay M. Drainage Systems. Their role in wound healing. AORN journal 1987; 46: 442-455.
2. Axiom Sump Operation Check List. Edwards Medical 1990.

Chapter XVI

Cardiothoracic Drains

16 Cardiothoracic Drains

16.1 Drains and the Pleural Space

WHAT IS THE PLEURAL SPACE?

- Is only a potential space since the parietal and visceral pleura are normally in contact with each other throughout their entire area.
- Pressure normally varies from –2cm H2O at end expiration to –35 cmH2O during inspiration.
- Accumulation of fluid or air here can compress the underlying lung. Large accumulations can lead to shifting of the mediastinum and compression of the mediastinal vessels.

WHY DRAIN THE PLEURAL SPACE?

- **Indications** include evacuation of fluid (e.g. blood, exudate, pus, lymph) or air from the pleural space. Causes may be spontaneous, traumatic, secondary to an underlying disease process, or after surgery involving opening of the pleural space.
- **Primary goal** of drainage is to permit the lungs to expand and to maintain apposition between parietal and visceral pleura.

HOW?

- **Large calibre chest tubes** (intercostal catheters) are usually used as they can drain fluids more efficiently and are less likely to be blocked.
- **Pleural Catheters** may be used for drainage of small pneumothoraces or thin effusions.
- **An Underwater Seal** is required in most instances of pleural drainage to prevent a pneumothorax resulting from air entering the drain system. Small pleural drains/catheters, when used for small effusions in the absence of an air leak, may sometimes be connected directly to a portable suction reservoir or a drainage bag without an underwater seal.
- **Placement**- the traditional view had been to place the drain towards the base of the pleural cavity for fluid drainage, and towards the apex for air drainage. Current view, however, is that it does not matter provided there is no loculation of fluid within the pleural cavity and that the drain is connected to suction (as is usually the case).
- In a**cute thoracic trauma** chest drains can often be the definitive mode of therapy. As the lung has a low pressure vascular system, lung expansion and apposition against the parietal pleura facilitates vessel compression and clotting of lacerations.
- For **chronic pleural effusions**, re-expansion should be gradual to prevent development of pulmonary oedema secondary to increased pulmonary capillary permeability. Drainage should not exceed 1 L during the first 30 minutes or 2 L during the first 24 hours.

16.2 Which Drain?

Common drains used in Cardiothoracic Surgery:

1. Intercostal Catheter
2. Pleural Catheter
3. Mediastinal Drains

16.3 Intercostal Catheter

Intercostal Catheter

Material: PVC

Size: 12- 40 Fr

Cost: $

Figure: Intercostal Catheter

Features:

- Markers are printed on the drain at 2, 4, 6,…20 cm intervals from the last side hole of the drain (i.e. the hole closest to the underwater seal) to allow easy determination of how far the drain is inside the chest cavity.
- A radiopaque line is incorporated into the drain; the line is interrupted by the side hole closest to the skin exit site, allowing this hole to be located on chest X-ray.
- A LARGE DRAIN (28 Fr or above) should be used in haemothorax to minimise obstruction by clots. For air or low viscosity effusions a 24 French or even smaller size catheters may be used with caution.
- An underwater seal must be connected to the drain (further discussed in subsequent sections).

16.4 Pleural Catheter

Pleural Catheter

Material: hydrogel coated latex

Size: 12 Fr x 20 cm long

Cost: $$$$

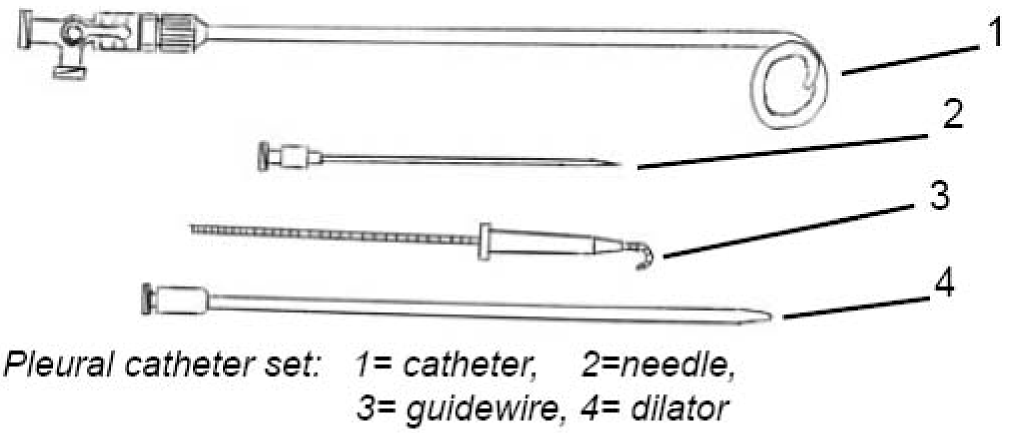


Figure: Pleural Catheter Set

Features:
- a pig-tail catheter with a stopcock and a one-way valve to allow aspiration and prevent entry of air which may otherwise lead to a pneumothorax.
- Insertion via the Seldinger technique.

16.5 How to Manage These Drains

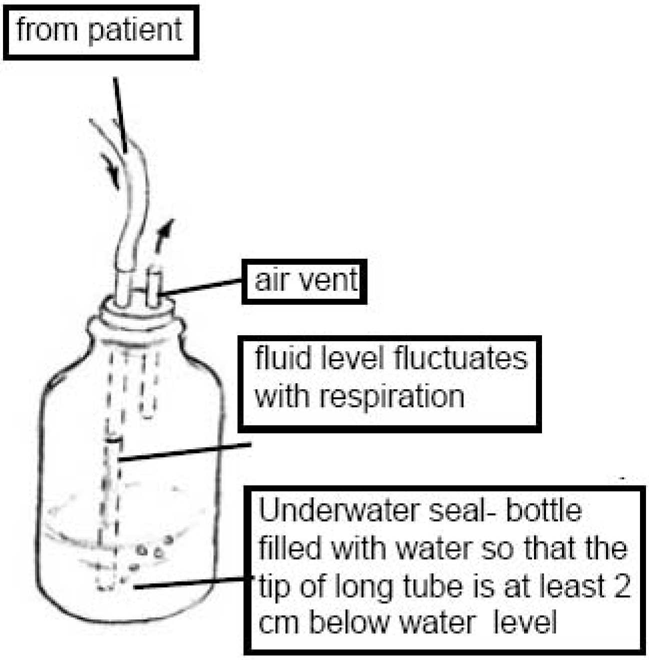
HOW TO MANAGE THESE DRAINS?

1. One-bottle drainage systems
2. Two-bottle drainage systems
3. Three-bottle drainage systems

16.6 One Bottle System

1-bottle system: Underwater seal

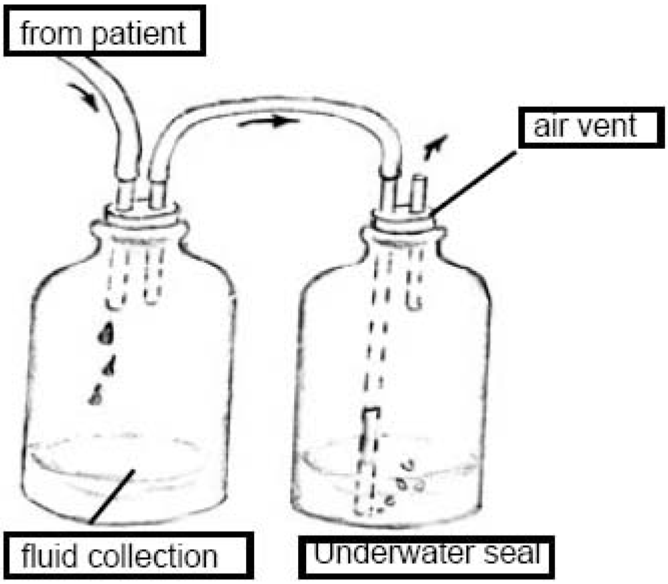
Bottle: underwater seal. The chest drain is connected to a long tube which passes into a column of water. The chamber containing this water is sealed at the top except for a shorter tube passing through its top seal. The end of the shorter tube lies well above the water level. During expiration the intrapleural pressure rises above atmospheric pressure and air from a pneumothorax is forced out from the pleural space through the long tube and bubbles out under water. Blood or other fluids will also be expelled and will add to the fluid volume in the bottle. During inspiration, the intrapleural pressure is less than atmospheric pressure but air cannot be sucked back in because the tip of the tube is underwater. The natural tendency of the lung to collapse is balanced by the hydrostatic pressure of the column of water which rises in the longer tube.



16.7 Two Bottle System

2-bottle system: Trap and underwater seal

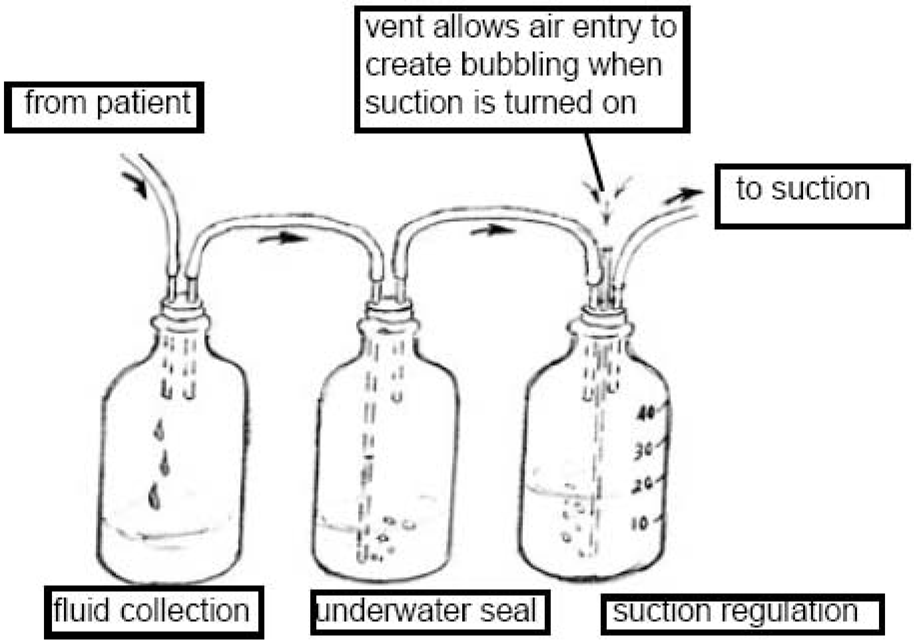
Bottle 1: the trap. Any fluid drained from pleural cavity remains in bottle 1 and can be accurately measured.
Bottle 2: underwater seal, where air will be expelled. Here the water level remains constant.



16.8 Three Bottle System

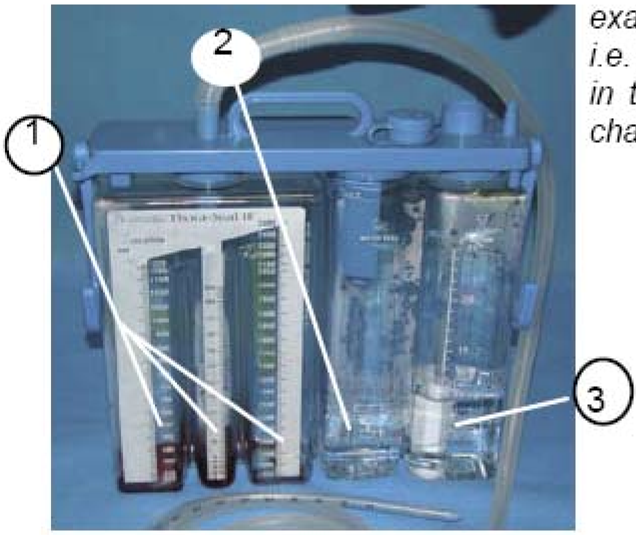
3-bottle system: Trap, underwater seal and suction regulator

Bottle 1: the trap.
Bottle 2: underwater seal (should always be filled to the pre-marked fill line)

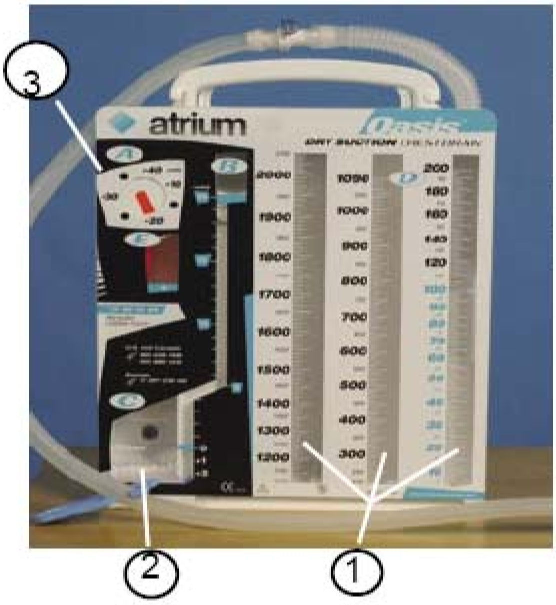


Bottle 3: suction regulator. The amount of vacuum is directly proportionate to how far the tip of the central tube is below the water surface (e.g. suction of –20cm H_2O is achieved by placing tip of tube 20 cm below surface). This central tube is connected to wall suction. The wall vacuum setting

does NOT affect the amount of vacuum applied to the chest tube as long as it is great enough to create bubbling in this 3rd chamber. This chamber may need to be topped up regularly to the correct setting as the fluid evaporates.



example of a 'wet' drain i.e. where there is water in the suction regulating chamber



example of a 'dry' drain- here there is no water in the suction regulating chamber. Suction pressure is adjusted by turning a dial to the appropriate setting.

1= fluid collecting chamber
2= underwater seal
3= suction regulating chamber

16.9 Working with Chest Drains

2. The Chest Drain Setup

Consists of:

- a straight or angulated tip catheter
- an underwater seal chamber to prevent air from being sucked into the pleural space by the negative intrathoracic pressure
- a fluid collecting chamber
- a vacuum regulating chamber
- tubing connecting the drain to the underwater seal, and connecting the suction regulating

chamber to the wall-suction outlet (if suction is used).

Note:
The 3 mentioned chambers are usually all housed in the one compartmental plastic chest drainage unit

3. Balanced Chest Drainage
- is a complex 3 bottle system used for pneumonectomy patients.
- designed to maintain the optimal intrapleural pressure (-6 cm H2O) of the pneumonectomy space. Using this system, the mediastinum remains in the ideal physiologic position for the first 2 to 3 days.
- Suction should never be placed on the system and any adjustment should be done in consultation with the consultant surgeon.

4. Caring for Chest Drains

You Should
- watch for post-expansion pulmonary oedema if a large effusion has been drained.
- do daily chest X-rays until the drain is removed.
- regularly inspect the drain exit site.
- tape all connections securely.
- if a drain falls out, seal the wound and obtain a repeat chest X-ray immediately if the patient is otherwise well (beware of the patient in respiratory distress as he/she may be developing a tension pneumothorax and require immediate reinsertion of a chest tube without waiting for a chest x-ray!).
- usually have the suction regulating chamber attached to low wall suction unless otherwise instructed.
- always keep the drainage unit below chest level of the patient as lifting above chest level can cause the contents of the drain to siphon back into the chest.
- consider low pressure suction or turning off suction altogether if a persistent air leak occurs after the lung has fully expanded and a bronchopleural fistula is suspected.
- immediately reconnect the drain and tubing if disconnection occurs and ask patient to cough; the increased intrapleural pressure during coughing helps to expel any air that may have been sucked in when the drain was disconnected.

You Should NOT

- clamp a drain except when changing the bottle as it can result in a tension pneumothorax.
- push a chest drain back into the pleural space as the external part is now contaminated and doing so can precipitate pleural infection or empyema. If there are drain holes outside the skin, these holes may be covered with petroleum jelly impregnated gauze and taped in to prevent a pneumothorax from occurring. However, it is preferable to remove and replace the tube.

5. Knowing What The Chest Drainage unit Is Trying To Tell You[1]:

Underwater seal chamber		Interpretation
Swinging	*Bubbling*	
Yes	Yes	Indicates air leak (can be from the lung or somewhere along the circu bubbling reflects the amount of air leak, while the swinging reflects th within the pleural space. Swinging is only seen if suction is not applie unit, and decreases as the lung re-expands.
No	No	Usually indicates resolution of air leak and effusion, with lung re-expa however that the tube is not obstructed. Sometimes a pleural collecti and therefore not drained yet still give the same appearance.
No	Yes	Indicates a possible connection or system air leak. Can temporarily c tube right at the skin exit and if the bubbling continues then the leak i patient. A hissing sound may point to the leak. Tape all connections s
Yes	No	May be seen with partial or total pneumonectomy and in diseases inv lung compliance (stiff lungs)

Note:
Swinging should be looked for as a rise and fall of the fluid level in the tube located in the underwater seal chamber.
Bubbling should be looked for in the underwater seal chamber; as indicated earlier, the suction regulation chamber should always be bubbling.

6. Removing Chest Drains

- Chest drains are left in place until the drainage has tapered off, usually less than 100 mls in 8 hours but may vary depending on the reason for placement.
- Explain to patient what you're going to do.
- Insert a closure stitch across the edges of the exit wound before withdrawing the drain. Preferably a closure stitch is already inserted at the time of drain insertion. Here one only needs to tie this stitch upon drain removal.
- Cut the stitch which is securing the drain.
- Ask patient to take a deep breath then withdraw the drain at the height of inspiration.
- Tie the stitch with tension maintained on the suture so that air is not sucked into the pleural space.
- Perform a post-procedure chest X-ray to exclude a pneumothorax.

- REMEMBER- someone must be delegated with the responsibility of removing the closure suture after 1 week!
- An alternative method of chest tube removal involves placement of a vaseline gauze dressing, covered by a plain gauze dressing, over the chest tube exit site as the tube is withdrawn; no closure suture is required. This technique is particularly suitable when the chest tube has been passed into the intercostal space via a subcutaneous tunnel; the dressing must stay in place for 5-6 days to allow the wound to seal.

7. Points of Note Regarding Chest Tubes

- Chest drains may exit the skin in the epigastric area. These should not be mistaken for a mediastinal drain.
- When drainage is required for long periods (weeks or even months), e.g. in patients with empyema, rib resection may allow more efficient drainage. A piece of rib is removed at the site of drainage to permit a large tube to be inserted and the space to be explored by finger or forceps. As the infection fuses the lung to the chest wall, this type of tube can be converted to 'open drainage' without risk of producing a pneumothorax.

16.10 Mediastinal Drains

MEDIASTINAL DRAINS

1. Why use them?
Indications may include drainage of pericardial effusions or mediastinal collections e.g. after cardiac surgery. The main goal is to allow monitoring of blood loss and prevention of blood or fluid accumulation that may otherwise cause a pericardial tamponade.

2. Which drains?
The drain used may be an intercostal catheter for large amounts of drainage, or other drains (e.g. a Blake drain) for smaller amounts of drainage. More than one large intercostal catheter (28 –30 Fr) may be used.

3. Where are they situated?
Placement is usually anterior and/or inferior to the heart or in an area at risk of subsequent bleeding. Exit site is usually in the epigastrium.

4. How to care for them?
Management is similar to that of pleural drains. These usually also need connection to an underwater seal especially if breach of the pleura is suspected.

They are left in place until drainage has tapered off, usually less than 50 to 100 mls over 8 hours but this depends on the reason for placement.

16.11 Reference

Reference:

1. Product information for Thora-seal® III Chest Drainage Unit. Tyco Health Pty Ltd.

Chapter XVII

Gastrointestinal Drains

17 Gastrointestinal Drains

17.1 Nasogastric Tubes - NGT

NASOGASTRIC TUBES (NGT)

17.2 Fine Bore Feeding NGT

Fine Bore Feeding NGT

Material: radiopaque polyurethane coated with hydromer

Size: 8-12 Fr

Cost: $$

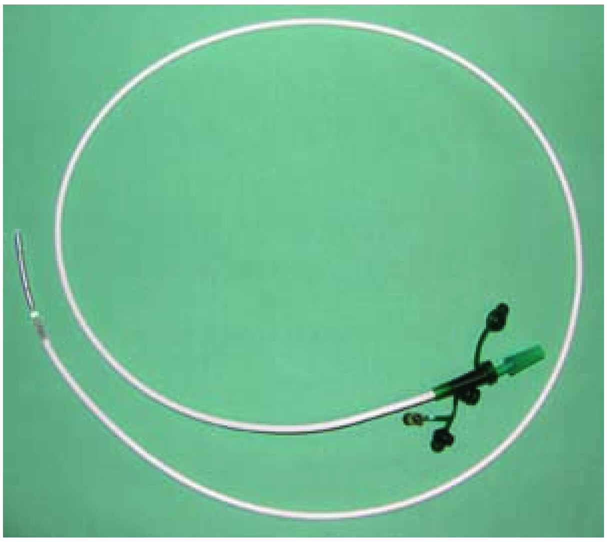


Figure: Fine Bore Feeding NGT

Features :

- Quite small and soft therefore creating minimal trauma to the upper aerodigestive tract and may be used for long periods (weeks).
- Has a central guide wire that stiffens the drain during insertion and facilitates position checking on X-ray post insertion.
- Is only suited for feeding, not suitable for aspiration (due to the small lumen and the tendency for the soft walls to collapse together on application of suction).
- May need to be placed endoscopically or at surgery in order to achieve placement in the proximal jejunum.

17.3 Ryle’s Tube

Ryle's Tube

Material: PVC

Size:
- Diameter 8, 10, 12 ... 20 Fr
- Length- 105 cm

Cost: $

Figure: Ryle's Tube

Features:
- Single lumen tube.
- Can be used for short term nasogastric feeding.
- Can be used for free drainage or intermittent aspiration of gastric contents.
- Corrosion resistant steel balls sealed into the tube at the distal end and markings at 50, 60, 70 cms from the tip to assist accurate placement.
- A radiopaque line is incorporated into the tube to allow placement checking on X-ray.

17.4 Salem Sump tube

Salem Sump Tube

Material: PVC

Size: 6- 18 Fr

Cost: $

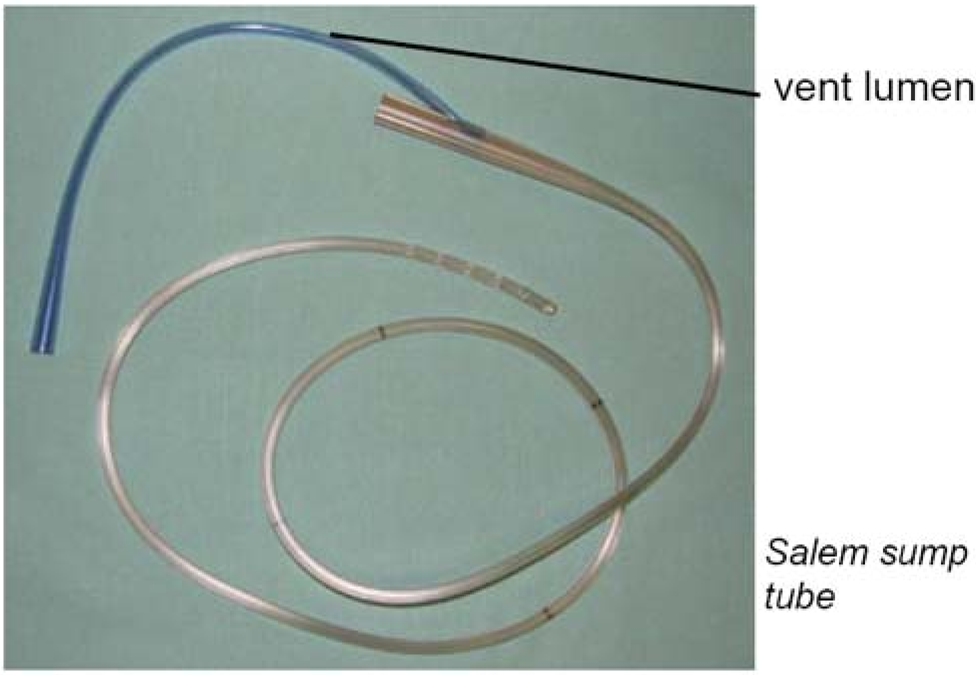


Figure: **Salem Sump Tube**

Features:

- Salem tube is a sump tube that can be used for continuous or intermittent aspiration of the stomach.
- The side vent has a 'blue pigtail' end that facilitates flushing of the vent (usually with air). This blue pigtail should NOT be plugged off when the tube is connected to continuous suction, as doing so will obstruct the vent and impede the sumping action of the drain, causing gastric erosion.
- The vent should be flushed with 15ml of air and the main lumen flushed with 30ml of Normal Saline every 4 hours to ensure patency. The vent is best clamped or crimped closed when the main channel is being irrigated. The vent is patent when it "whistles" continuously (with salem tube connected to continuous suction).
- If the tube is used for free drainage of gastric content or for nasogastric feeding, it should be managed as a single lumen tube by plugging the blue vent tube. For these purposes, however, a Ryle's tube may be more appropriate.
- Recommended continuous suction pressure by manufacturer is 30-40 mmHg.

Refer to section on Axiom® Sump Drain for other aspects of sump drains including trouble-shooting.

17.5 PEG Tube

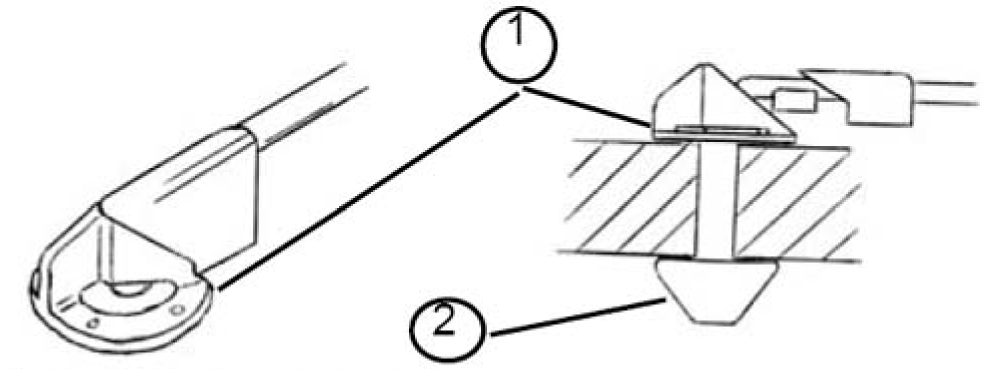
P.E.G. (Percutaneous Endoscopic Gastrostomy)

PEG tubes are feeding tubes introduced into the stomach percutaneously, with endoscopic guidance.

Material: silicone (no latex)

Size: 16, 20, 28 Fr

Cost: $$$$$



1= skin disc, 2= bumper

Figure: PEG Tube

Features:

- These are inserted with guidance by gastroscopy.
- Held in place by a disc or dome internally and by a similar disc externally to prevent migration of the PEG tube.
- Can stay in for up to 18-24 months before a change is required.
- The original PEG tubes were mushroom-tipped with an inner crossbar. To remove, the tube would be pulled out leaving the crossbar to pass in the stool. Other PEG tubes have rigid catheter heads and often require endoscopy for removal.

Why use them?

- Patients who are unable to swallow due to neurological disorders such as stroke or mental retardation.
- Patients who are unwilling or unable to maintain nutritional intake due to severe debilitation.
- When prolonged enteral tube feeding is required and NGT complications are to be avoided or NGT cannot be passed.

What can go wrong?

- Bleeding around PEG insertion site.
- Infection of the PEG exit site, local abscess formation, or peritonitis from leakage of gastric content into the peritoneum. Risk of peritonitis is particularly high if the tube is removed prematurely especially within the first week of insertion during which a tract has not matured properly around the tube.
- Blockage of tube.
- Dislodgement may occur with accidental pulling.
- Aspiration pneumonia.
- Gastrointestinal complaints e.g. bloating, diarrhoea (especially with feeds containing a high osmotic load).

17.6 Feeding Jejunostomy Tube

Feeding Jejunostomy tube

A feeding jejunostomy is an artificial passage between the jejunum and the anterior abdominal wall for the purposes of feeding. A Foley's catheter is often used as the feeding tube.

Material: refer to Foley's catheter (section on Urological Drains)

Size: most commonly a 16 or 18 Fr Foley's catheter is used; large size is preferred in order to minimise risk of blockage.

Cost: as for Foley's catheter.

Features:
- The tip may be cut off to facilitate change of a blocked tube with a guidewire at a later date.
- The tract made between the jejunum and the abdominal wall should be self-closing when the tube is removed after a few weeks.

Why use them?
- Patients at high risk of aspiration (e.g. mental obtundation or abnormal upper gastrointestinal motility) as jejunostomy feeding carries a lower risk of aspiration compared to PEG feeding (food is introduced more distally in the gastrointestinal tract).
- Where rest of the proximal gastrointestinal tract is required (e.g. operations involving high gastrointestinal tract anastomoses; pancreatitis).

What can go wrong?
- Similar to PEG's except the risk of aspiration is significantly lower.

17.7 Caring for PEG and Jejunostomy Tubes

CARING FOR PEG & JEJUNOSTOMY FEEDING TUBES

May be cared for as a regular drain with particular attention to:

- **Regular flushing** to prevent blockage e.g. with 20ml H2O every 4 hours and after each drug or feed administration. This is especially important for the jejunostomy feeding tube as it is significantly smaller than a PEG tube.
- Medications should be administered, whenever possible, in syrup or suspension form.
- A **blocked tube** should be flushed with water first. If this fails then Coca Cola®, sodium bicarbonate or pancreazymin may be tried. If the above is unsuccessful and the jejunostomy has been in place for 5 days or more, it is usually safe to change it after discussion with the consultant surgeon. This should be done under X-ray guidance to check the position with an injection of radiopaque contrast. Here one passes a guidewire down the lumen of the tube and out the tip of the catheter, removes the existing catheter and passes a new catheter in over the guidewire.
- A dislodged tube should immediately be replaced with a Foley's catheter by an experienced medical officer if the tube has been there long enough for a tract to be well formed. The catheter chosen should be of the same size or the next lower size which may be passed through the tract without trauma. This should not be delayed as the tract may close down in under an hour.

The team consultant must be notified.

- Abdominal pain should raise suspicion of peritonitis which would need prompt surgical exploration in addition to resuscitation and intravenous antibiotic. The responsible registrar or consultant must be notified immediately!
- Radiological contrast study via the tube may be helpful in defining tube position, leakage etc.

IF DOUBT EXISTS ABOUT THE POSITION OF A FEEDING TUBE, FEEDING MUST BE CEASED WHILE THE DOUBT IS PROMPTLY RESOLVED!

17.8 T-Tubes

A T-tube (also called Kehr's T-tube) is a hollow T–shaped tube with the transverse limb placed most commonly within the common bile duct while the long limb exits through a hole in the common bile duct (CBD), traverses the peritoneal cavity and abdominal wall before emerging from the skin surface.

T-tube insertion is usually done after an exploration of the common bile duct. Bile usually drains freely out through the T-tube in the early post-operative period because of distal narrowing secondary to duct oedema and spasm of the sphincter (as a result of instrumentation during the operation).

Material: Available in 100% latex, 100% silicone, and latex rubber with silicone coating.

Size:
- Diameter- 10, 12,...24 Fr
- Dimensions- 10x 80 cm, 30x 100 cm

Cost: $$$

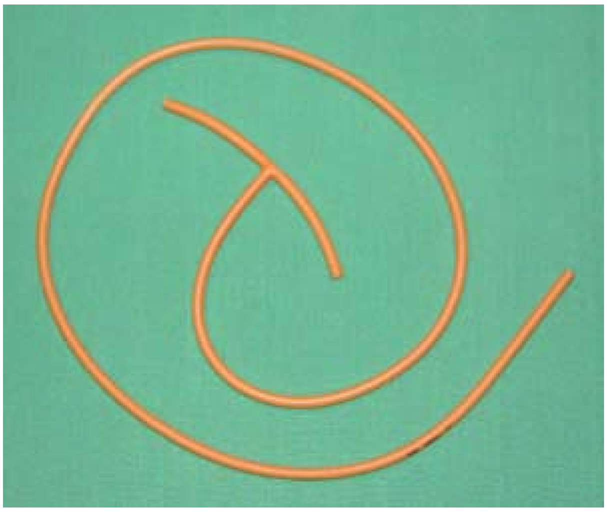


Figure - T-Tube for Biliary Drainage

Features:
- The traditional latex material promotes tract formation after 10-14 days. This ensures that the irritant bile does not enter the peritoneum upon removal of the drain. With silicone coated drains, some clinicians leave T-tubes in for up to 3-4 weeks. The manufacturer's suggestion, however, is that a period of between 1-2 weeks on average may still be adequate for development of a tract prior to removal of silicone drains.
- Main purpose is to prevent free leakage from the bile duct by maintaining low CBD pressure in the early stage of healing.
- Allows subsequent injection of contrast into the CBD for a T-tube cholangiogram to look for retained stones in the duct.
- May permit removal of retained stones/ debris, using X-ray guidance, if seen on cholangiogram.

What can go wrong?
- Accidental dislodgement can lead to bile peritonitis. If a bile-duct T-tube fails to drain 150 ml or more of bile daily or suddenly reduces output over a few hours, urgent T-tube cholangiogram is required to determine if the tube is still properly placed in the bile duct; such tubes must NOT be presumed to be blocked (unless an obvious external compression is seen and the bile output

returns to previous trend after the compression is relieved).
- Bile leak post T-tube extraction.
- Introduction of infection into the biliary tree.
- Air entry into the biliary tree (bubbles can appear as filling defects and be mistaken for stones).
- Persisting fistula if distal bile duct is occluded or narrowed.

Removing them
- Should only be done in cases of normal T-tube cholangiogram.
- Clamping of the T-tube is often done 24 hours before performing a T-tube cholangiogram as it:

a - promotes drainage distally before cholangiogram is done,minimising residual air bubbles.

b - pressurizes the biliary tree to a small extent so that when the T-tube is unclamped to perform a cholangiogram, bile will flow out of the T-tube, preventing air from being drawn into the biliary tree.

17.9 Peritoneal catheter

Peritoneal catheter

Same as the pleural catheter except it is used for draining ascites.

Chapter XVII

Neurosurgical Drains

18 Neurosurgical Drains

18.1 External Ventricular Drain (EVD)

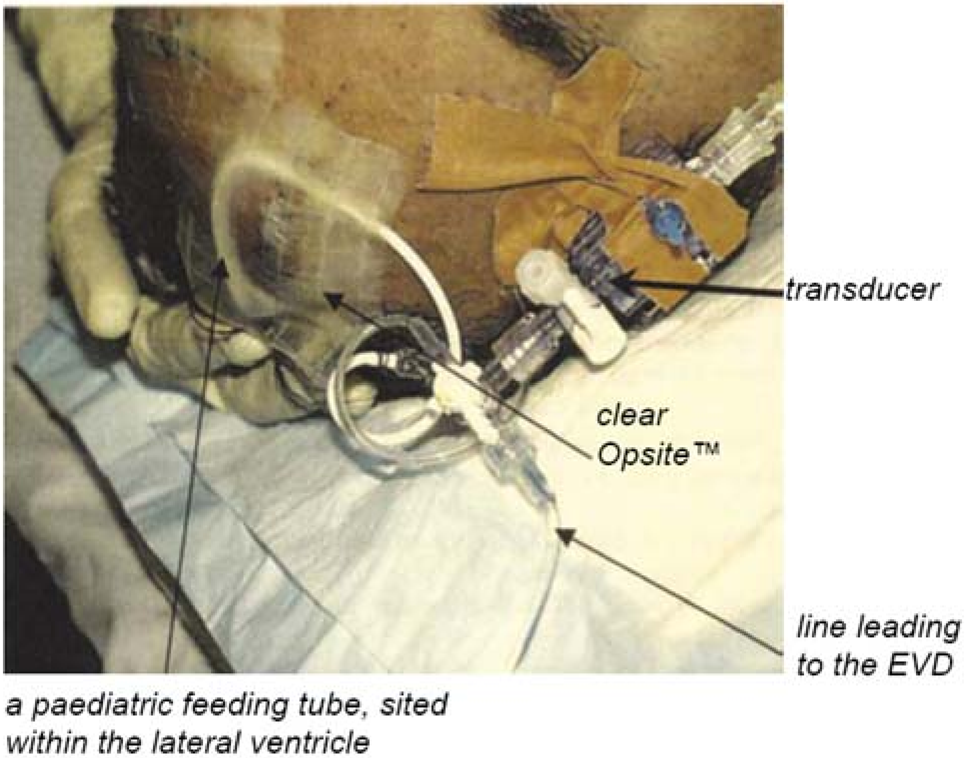
External Ventricular Drain (EVD)

Material: silicone

Size:

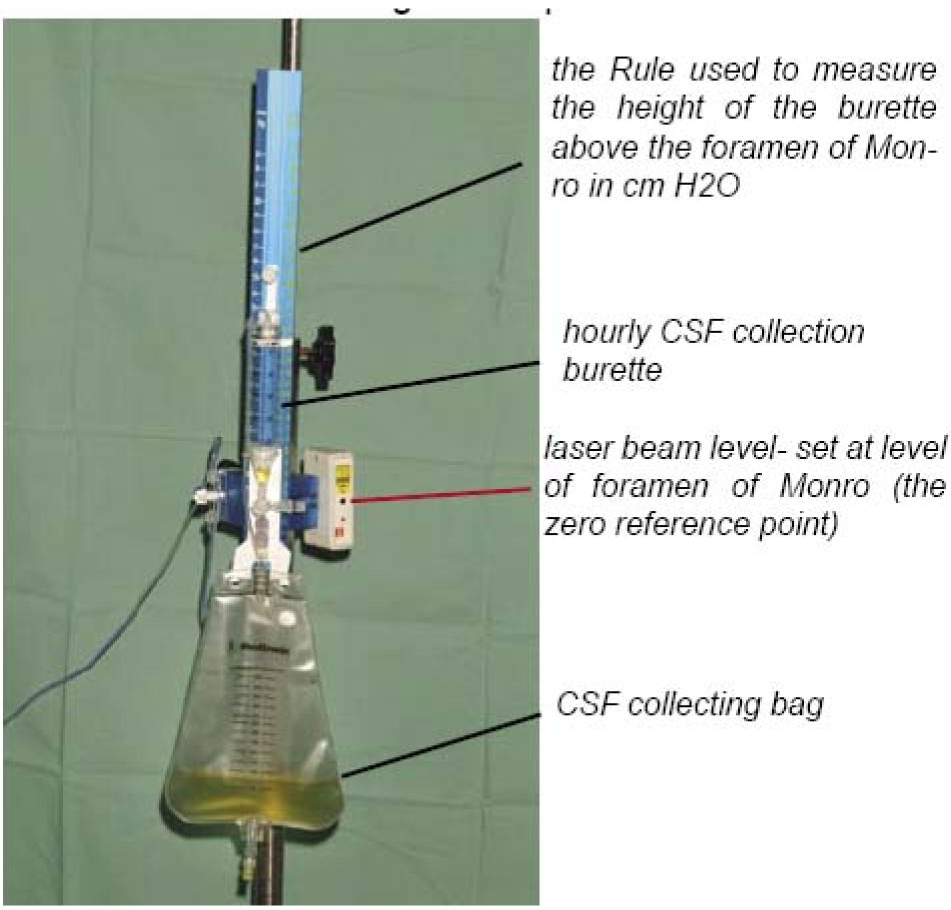
- Inside diameter/ Outside diameter- 1.3/2.5 mm, 1.5/2.8 mm, 2.6/4.9 mm, 2.0/3.1 mm
- Length- 20, 23 , 35 cm.

Cost: $$$$$



Features:
Setup consists of:

- a drain tube (can be an infant feeding catheter). Sometimes a dual lumen catheter is used to allow simultaneous CSF (cerebral spinal fluid) drainage and monitoring of ICP (intracranial pressure).
- a 3-way tap allowing cerebrospinal fluid sampling as well as injection of medications.
- connection tubing with stop-cockCFSF scale measured in cmH2O (1cm H2O = 0.73 mmHg) mounted on an IV drip pole.
- an hourly measurementCFF collecting burette with a stop-cock and microbial barrier air vent.
- aCFF collecting bag (usually holds about 600ml) with microbial barrier air vent.
- a pressure transducer which may be connected depending on whether ICP monitoring is required.



The CF scale often employs a laser 'spirit-level'. The zero reference point is adjusted so that it is at the same level as the foramen of Monro (1cm above the temporomandibular joint). The burette can then be moved up or down on the CF pressure scale to allow drainage at the appropriate ICP (e.g. if it is placed at 15cmH2O then CF will only be drained into the burette if the ICP is greater than 15 cmH2O).

Where are they located?
EVD is usually inserted via a burr hole into the anterior horn of the right lateral ventricle.

Why use them?

- ICP monitoring (e.g. severe head injuries, subarachnoid haemorrhage grade III-V, hydrocephalus).
- Drainage of CF (e.g. for management of increased ICP or as a temporary drainage in patients with infected shunts).
- Monitor CF constituents (e.g. chemistry or cytology).

When should you avoid them?

- coagulopathy
- effaced (i.e. severely compressed) ventricles

What can go wrong?

- **Blockage -** may be due to blood clots, brain tissue fragments, or collapse of the ventricular walls around the catheter tip as a result of overdrainage (the latter is more common in patients with small ventricles).
- **Infection** - ventriculitis or meningitis.

- **Intracerebral haemorrhage** - may occur as a result of puncturing blood vessels during insertion, or overdrainage causing brain tissue collapse and tearing away from the dura thereby rupturing blood vessels.
- **Oedema** of the brain (or even haemorrhage) may occur as a result of frequent puncture of the brain.

Some Basic Trouble-shooting

- Raised ICP

-Causes related to malfunction of the drain may include blocked or closed EVD, or bag being too high.

-Signs include decreased LOC (level of consciousness), headache, nausea/ vomiting, increased BP or bradycardia (Cushing's reflex), or pupil changes.

-Action: check for above causes where possible and IMMEDIATELY notify neurosurgical team.

- No drainage

-Causes may include CF pressure equal to or lower than the pressure set on the CF scale, or blocked EVD.

-Action: notify neurosurgical team.

Reference:

Liverpool Health Service. Corporate manual of patient care, June 2002.

Chapter XIX

Plastic Surgical Drains

19 Plastic Surgical Drains

19.1 VAC System

V.A.C. ®(Vacuum-Assisted Closure) System

V.A.C.® Therapy™ is a non-invasive technique whereby negative pressure is delivered in a uniform manner to the wound. The wound is sealed over by an occlusive plastic film which prevents entry of bacteria. The vacuum removes secretions from the wound and reduces bacterial colonisation. It also encourages arterioles to dilate, improving blood flow and healing.

SETUP
Consists of:

- a foam dressing cut to the shape of the wound and applied over it. The foam is latex free and available in 2 types:

Black foam (polyurethane)
Black foam has reticulated or open pores, and is hydrophobic (repels water) which enhances exudates removal. It promotes faster granulation tissue growth than the denser foam and is the more commonly used of the two.

White Versafoam
White Versafoam is a dense hydrophilic (moisture retaining) foam with high tensile strength and non-adherent properties. Due to the higher density, a higher minimum pressure of 125 mmHg is needed. This foam is recommended for situations where:

a. granulation tissue growth into the foam needs to be more controlled.
b. patient cannot tolerate the black foam due to pain.
c. there are sensitive structures nearby e.g. minimally covered blood vessels, tendons, or grafts.

- suction tubing which can be inserted into the foam directly (V.A.C.® Classic system), or by applying the T.R.A.C.™ pad at the end of the tubing to the foam (T.R.A.C.™ system).
- occlusive film dressing which covers the foam/ tubing unit.
- a V.A.C.® negative pressure unit which can be set to deliver intermittent or continuous suction between 50-200 mmHg depending on patient comfort.

Cost: $$$$$

V.A.C.® used in an abdominal wound

V.A.C.® negative pressure unit

canister (collects wound fluids and debris)

19.2 Applying the VAC

APPLYING THE V.A.C.®

1. **Debride and clean** wound bed, remove as much eschar/ slough as possible, and achieve good haemostasis.
2. **Cut foam** to dimensions that will allow gentle placement of the foam into the wound. DO NOT pack the foam into the wound. Multiple pieces of foam may be used side by side or on top of one another as long as there is good contact surface between them for even distribution of negative pressure. (record the number of pieces used in the patient chart especially if tunnelling).
3. Trim and **place the occlusive plastic drape** over the foam dressing leaving about 3-5 cm margin for contact with adjacent skin. Adjacent skin should be dry (may need skin prep or degreasing agent).
4. **Insert tubing:**

Classic system - cut a small slit in the drape and cut into the foam for 0.5-1cm depth. Place the tubing into this slit and seal the tube/ drape junction with additional strips of drape.

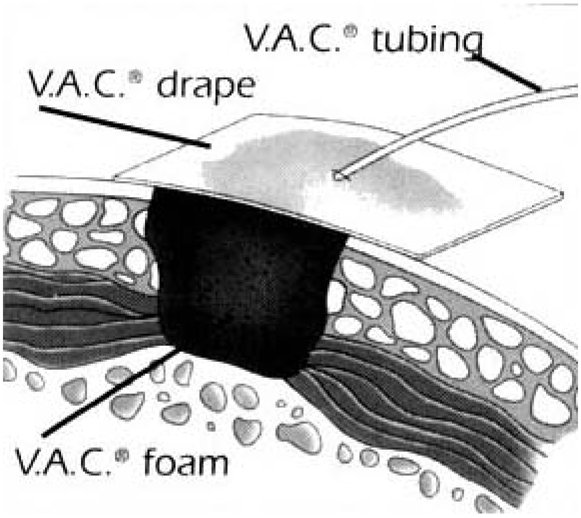


Figure: V.A.C.® Classic tubing application

T.R.A.C.™ system - cut a 2 cm diameter hole in the drape (not foam) by lifting the center of it up with your thumb and forefinger. Apply the T.R.A.C.™ pad directly over this hole. DO NOT cut off the T.R.A.C.™ pad and insert the T.R.A.C.™ tubing into the foam as this will cause the unit to alarm.

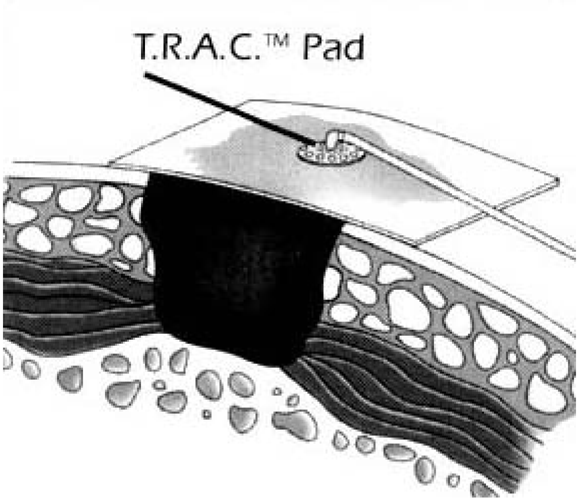


Figure: T.R.A.C.™ Pad application

5. **Install the canister** into the V.A.C.® unit- it should click into place.
6. **Connect dressing tubing** to canister tubing.
7. **Open both clamps** (one on each tubing).
8. Turn V.A.C.® unit on, adjust pressure setting, then press THERAPY ON/OFF button to activate therapy.
9. **Observe for collapse of foam** dressing as negative pressure is generated (should see this within a minute). Hissing sound indicates a leak which should be sealed over with a strip of drape.

19.3 Continuous vs Intermittent Therapy

CONTINUOUS VS INTERMITTENT THERAPY

Experiments in porcine models suggest that intermittent therapy with 5 min active and 2 min inactive can stimulate faster granulation tissue formation than continuous therapy. It is recommended by the manufacturer however that the initial 48 hours of therapy should be on continuous therapy to help evacuate as much as possible of the initial exudates. Continuous therapy throughout the treatment period is also advisable if:

- patients report significant discomfort during intermittent therapy.
- there is difficulty maintaining an air tight seal.
- there are tunnels or undermined areas which may need continuous suction to hold the wound together. Unstable structures (e.g. unstable chest wall) may also benefit from continuous suction to stabilize the wound.
- there is still a high amount of drainage from the wound.

19.4 Recommended Treatment Guidelines

RECOMMENDED TREATMENT GUIDELINES

Application	Cycle	Target pressure
Acute/traumatic wounds	Continuous 1st 48 hrs; then intermittent	Black foam-125 mmHg; White foam-125-175 mmHg. Titrate up for more drainage
Wound dehiscence	As above	As above
Pressure ulcers	As above	As above
Chronic ulcers	As above	Black foam- 50-125 mmHg; White foam-125-175 mmHg.
Meshed grafts	Continuous throughout	Black foam- 75-125 mmHg; White foam- 125 mmHg. Titrate up.
Flaps	As above	Black foam- 125-150 mmHg; White foam- 125-175 mmHg. Titrate up for more drainage.

Note: DO NOT leave negative pressure off for more than 2 continuous hours in any 24 hour period as bacterial proliferation may occur.

19.5 When Should You Avoid using V.A.C.®?

When Should You Avoid using V.A.C.®?

- malignancy in the wound
- untreated osteomyelitis
- exposed blood vessels or organs in wound bed
- necrotic tissues with eschar present
- non-enteric and unexplored fistula

19.6 When To Be Careful?

When To Be Careful?

- patients with active bleeding, difficult wound haemostasis, or on anticoagulants.
- if placed near blood vessels or other organs, make sure these are covered with a protective layer e.g. fascia, tissue, or other protective barriers.
- weakened or irradiated tissues.

19.7 Dealing with the Difficult VAC

DEALING WITH THE DIFFICULT V.A.C.®

Wound pain

- change intermittent to continuous therapy.
- decrease vacuum pressure (no lower than 50 mmHg for black foam or 125 mmHg for white foam for V.A.C.® to work efficiently).
- use white foam instead of black foam.
- acute painful episodes e.g. during dressing change may be dealt with either by introducing 1% xylocaine down the tubing (disconnect from canister tubing first) or injecting 1% xylocaine directly into the foam and clamp off the tubing for 15-30 minutes.

Seal failure

- ensure dry, non-greasy skin. May need skin prep/ degreaser (e.g. No-Sting™).
- frame wound with a skin barrier to enhance seal (e.g. liquid Opsite™).
- reduce foam height at wound edge by cutting/ beveling it.
- secure the tubing properly to prevent pulling on drape which may cause recurrent leaks.
- circumferential drape is required for excessively weepy extremities. The edges can be stabilized with elastic wrap e.g. Coban™.

Tunnelling

- Initial dressing: a piece of foam should be fashioned so that it can be inserted into the tunnel gently. The neck should be wider than the distal end to ensure the opening into the tunnel is held open. This foam should go all the way to the end of the tunnel and protrude about 2cm into the main wound cavity to have good contact with the main foam dressing.
- For subsequent dressing changes, as the drainage decreases, the tunnel foam should be made progressively shorter by 1-2cm than the existing tunnel length to encourage collapse of the distal end of the tunnel and allow the wound to granulate from distal to proximal.

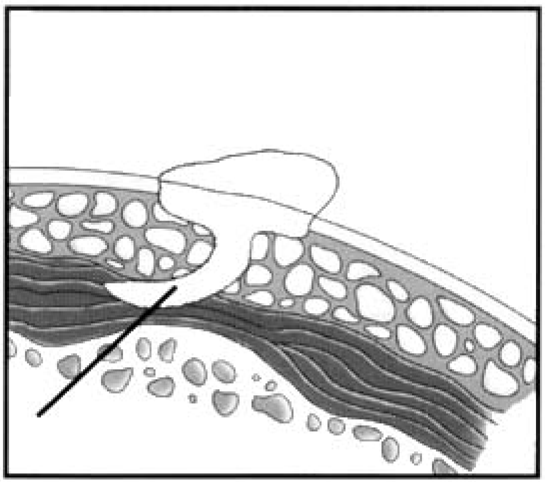


Figure: Initial dressing- foam goes to the end of the tunnel

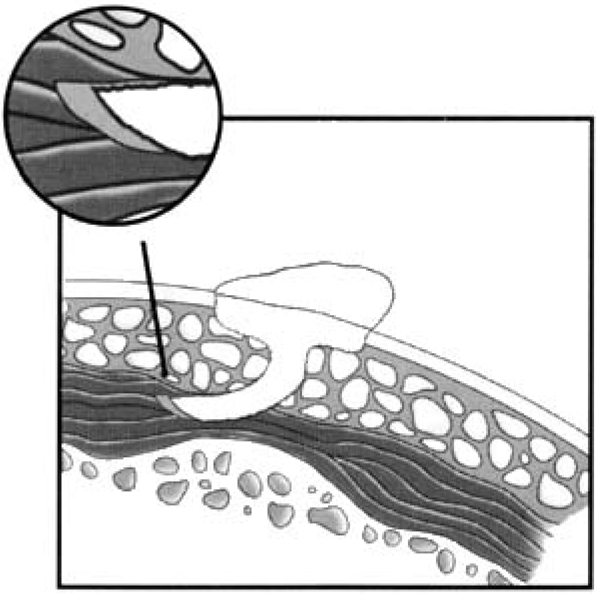


Figure: Subsequent dressing change, foam is cut 1-2 cm shorter than the length of the tunnel to promote closure of the tunnel from distal end.

Small wounds

- Dressings of small and deep wounds may be facilitated by applying a larger piece of foam on top of the smaller foam in the wound. The tubing can then be applied on top of this larger foam.

Wounds with exposed structures in the base

- Healthy exposed tendons, nerves, or vessels should be covered with a layer of muscle, fascia, or a layer of non-adherent dressing before applying the V.A.C.®
- V.A.C.® foam may be applied directly over mesh or intact peritoneum/ mediastinal membrane.
- Applying a V.A.C.® foam over bowel which is covered by mesh may produce granulation tissue on the bowel resulting in adhesions.

Surrounding skin not tolerating frequent dressing changes

- Cut the drape around the foam but leave the drape overlying the surrounding skin intact. After cleaning the wound and changing the foam, the new drape can go over the previous drape without being in direct contact with the surrounding skin.

19.8 Trouble-Shooting VAC Therapy

TROUBLE-SHOOTING V.A.C.® THERAPY™

The spinal cord injury patient who suddenly develops tachycardia or hypertension soon after starting V.A.C.® Therapy™

- Switch off the V.A.C.® therapy to see if this settles after a while as the V.A.C.® therapy may cause sensory stimulation that leads to autonomic hyper-reflexia.

Change in colour of exudates being drained

- Changes from serous to serosanguineous or blood stained drainage may be expected as increased perfusion accompanies granulation tissue development. Any sudden increase in bright red blood in the tubing or canister requires immediate assessment, however, as this may indicate erosion into a vessel. The V.A.C.® unit should be stopped while an assessment is done.

V.A.C.® unit alarms:

Alarm type	Notification	Ren
Canister full	Visual message on screen accompanied by audible alarm.	Change canister.
Tubing is blocked	Visual message on screen accompanied by audible alarm.	Make sure tubing clam kinked or pinched tubir
Tubing/ dressing has a leak	Visual alarm within 2 mins followed by an audible alarm within 5 mins, then unit will turn itself off.	Identify and patch any Ensure T.R.A.C.™ cor locked. Ensure caniste
Therapy is not activated	Visual message accompanied by audible alarm after 15 mins.	Turn therapy on.
Battery low	Visual message accompanied by audible alarm before shut down.	Connect unit to a main recharge battery.

19.9 References

Reference:

V.A.C.® Therapy™ Clinical Guidelines. Jan 2003.

Chapter XX

Urological Drains

20 Urological Drains

20.1 Urethral Drains

URETHRAL CATHETERS

Indications for insertion:
- Urinary retention
- Incontinence
- Monitoring of urine output
- Trauma

20.2 Foley's Catheter

Foley's Catheter

Material:
- PVC or plastic- cheap and for short term use (7- 14 days), but these are fairly rigid therefore not often used.
- latex – cheap and mainly for short term use (7-14 days) as they tend to become obstructed if left in for long periods due to interaction between catheter materials and urine.
- Polytetrafluoroethylene (PTFE) catheters- are made from latex bonded with Teflon to make it smoother, and is adequate for medium term use (up to 4 weeks).
- silicone/ hydrogel-coated latex catheters – more suited for long term placement (up to 12 weeks).
- polymer hydromer coated latex catheters- smoother and suitable for long term use (up to 12 weeks).
- pure silicone catheters- more expensive than the others, and suitable for long term placement, especially in patients with latex allergy.

Note:
1. *Patients with latex allergies or sensitivity (may occur after long term latex catheter use) should use the silicone or Teflon catheters.*
2. *Even for 'long-term' catheters, it is advisable to change them every 4 weeks.*

Size:
- 6-24 Fr (2-8 mm)
- 14 F is commonly used in woman while 16 F for men.
- The standard adult catheter length is about 45 cm and can be used for both sexes while special shorter 'female catheters' with length of about 25 cm are available and may be more comfortable or discreet for the female patient. The shorter catheter must NOT, however, be used in males as urethral damage may result from inflation of the balloon while the catheter is still in the urethra.
- Larger catheters should be used where there is significant haematuria especially with clots which can easily obstruct smaller catheters.
- Be aware that larger catheters are more likely to cause damage to the urethra.
- Down-sizing during a catheter change for patients with long term IDC use may result in urine leak around the catheter as the urethra is accustomed to the larger calibre.

Cost: $

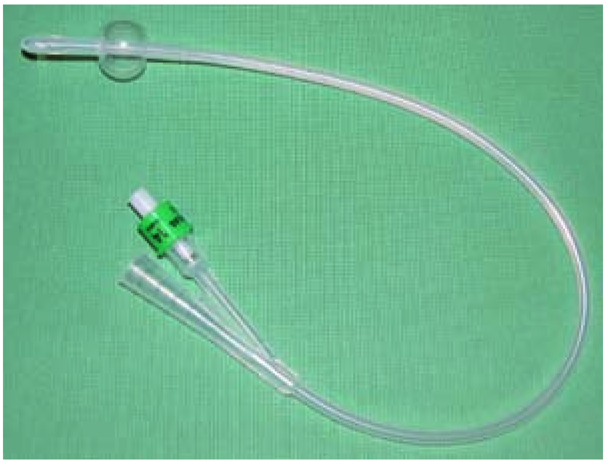


Figure: Foley's Catheter

Features:

- a Foley's catheter has 2 lumens- one lumen to allow inflation of a balloon at its tip and the other is for urine drainage.
- balloon near the catheter tip helps to prevent dislodgement. Most adult catheters have balloons capable of accommodating 5-10 ml (3 ml in paediatric ones) but can go up to 80ml in specialized urological catheters. The larger size balloons are used to help exert pressure and control bleeding after prostate surgery.
- catheter tips are commonly straight but some may have an angled tip (Coude's tip) which is designed to help overcome the angulation (during insertion) caused by the bladder neck and the middle lobe of the prostate in men.
- introducers may be used to aid difficult insertions. An introducer is a malleable metal rod than runs down the lumen of the catheter and can be shaped to maintain a particular angulation to facilitate insertion. These may cause serious urethral trauma if improperly used, and should be USED BY EXPERIENCED CLINICIANS ONLY!
- drainage of urine is commonly into a bag with or without an outlet tap. These bags exist in 1-2 litre capacities and may have an hourly urine measure chamber. For inpatients these bags are usually hung by the bed side. For improved mobility, however, there are also smaller 'leg bags' that can be strapped around the patient's leg.
- Catheter valves, which can be connected directly to catheters, eliminate the need for collection bag and allow the independent and mobile patient to intermittently empty his/her bladder urine directly into the toilet.

20.3 3-Way Catheter

3-Way Catheter

A 3-way catheter is similar to a Foley's catheter with a few exceptions:

- It has 3 lumens. The 3rd lumen allows intermittent or continuous irrigation by connecting it to an intravenous fluid infusion set.
- It is used when irrigation of the bladder is required (e.g. for patients with significant haematuria and clots which may block a Foley's catheter).
- These catheters tend to be larger than the Foley's catheter and hence are more likely to cause trauma to the urethra during insertion.
- It may have a 'whistle tip' instead of the usual round shaped tip. The sharper whistle tip catheter should generally be avoided unless the user is experienced as it can potentially cause more trauma.
- More expensive ($$$)

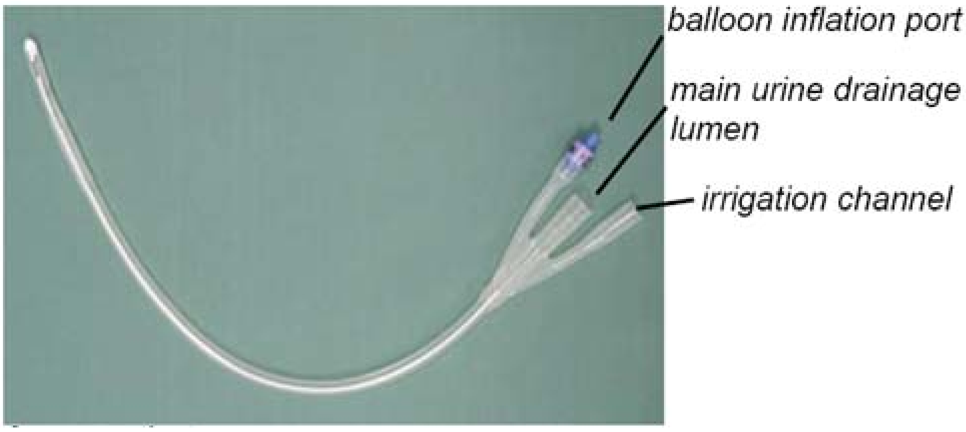


Figure: 3-Way Catheter

20.4 Single Lumen Catheter (in/out)

Single Lumen Catheter (in/out)

Material: PVC

Size: 12 Fr

Cost: $

Figure: In/ Out Catheter

Features:
- Cheap.
- does not have a balloon to retain the catheter in situ.
- mainly suited for patients who do intermittent self-catheterisation .

20.5 What Can Go Wrong?

WHAT CAN GO WRONG?

- Blockage – is often by blood clots. Can usually be unblocked by flushing with saline. If repeated blockage occurs, larger Foley's catheter or a 3-way catheter may be used.

- Bladder spasm- may be experienced by some patients and can be quite distressing. It may be mistaken for urinary retention from catheter blockage as the patient complains of severe bladder discomfort yet no urine comes out. This can be clarified by flushing the catheter which would be patent in the case of bladder spasm. Anticholinergic medications (e.g. oxybutynin) may be useful in treating this problem. Spasm may be associated with urine leakage around the catheter and changing to a larger catheter will not help but may aggravate the spasm even more. Here a smaller catheter may help to reduce the spasm due to lessened irritation.
- Urinary tract infection – the catheter provides a conduit for inward bacterial migration. It bypasses the mucosal defences of the lower urinary tract. UTI risk is increased with prolonged catheter placement. Bacterial entry may also occur from contamination of connections during bag changes and emptying.
- Bacteraemia may occur during catheter insertion.
- Paraphimosis: Failure to pull the foreskin back over the glans penis after insertion of IDC may result in paraphimosis if the foreskin is tight as it may constrict around the glans penis leading to impaired venous drainage and swelling distally.
- Urethral trauma: Traumatic insertion may lead to creation of a false passage or rupture of the urethra, especially in men. This may lead to subsequent scarring and stricturing of the urethra as the scar contracts.

20.6 Suprapubic Catheters

SUPRAPUBIC CATHETERS

Foley's catheters are also used for long-term suprapubic placement. Insertion of these may be done under local analgesia in the ward with an introducer system (e.g. the Adacath®), or intraoperatively for more difficult insertions. For short-term drainage, however, small catheters (e.g. the Bonanno® catheter) can often be inserted with relative ease in the ward.

Why use them?

- urethral obstruction (e.g. prostate enlargement, stricture).
- suspected or confirmed urethral trauma .
- inability to tolerate urethral catheter.
- patient preference (e.g. to minimize interference with sexual activity).

Foley's Catheter

- see page 165.

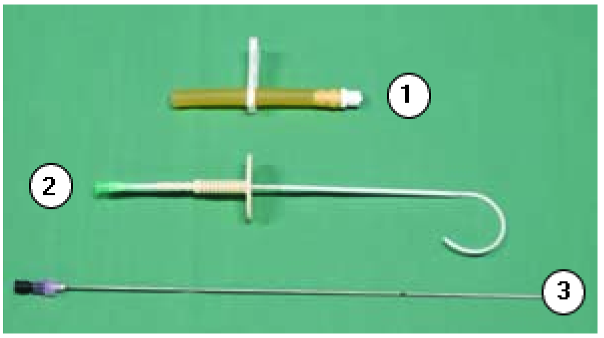
20.7 Bonanno® Catheter

Bonanno® Catheter

Material: Teflon coated latex

Size: 10, 12, 14 Fr

Cost: $$$$



1 = adapter-clamp
2 = catheter with sleeve which slides along the catheter to straighten its curled tip
3 = puncture needle

Features:

- Supplied as part of a kit with a rigid introducer which is used to pierce the abdominal wall before the Bonanno® catheter is passed over it.
- Mainly suitable for draining urine only, given the small size of the catheter. Presence of blood or large sediments may require use of larger Foley's catheters.

20.8 Dealing with a Non-Deflating Foley's Catheter

DEALING WITH THE NON-DEFLATING FOLEY'S CATHETER

- Usually due to malfunction of the inflation valve caused by external clamping, crushing or kinking of the inflation channel. The valve can also become obstructed by crystallization when non-sterile fluid is used to fill the balloon.
- Inflation valve should be tested by introducing 1-2 ml of water down the valve. This should go in easily. Aspiration should then be attempted to see if the valve now works.
- Deflating the balloon:

1. Cutting the balloon port proximal to the inflation valve effectively removes the role of the valve and should allow the water in the balloon to drain.
2. If the balloon still does not deflate then the obstruction is along the length of the catheter. Passing a lubricated guidewire may be able to dislodge the obstruction.
3. If guidewire cannot unblock the obstruction, a 22-gauge central venous catheter can be passed over the guidewire. When the catheter tip is into the balloon, the wire can be removed, and the balloon should drain.
4. Failure of above manoeuvres mandates rupture of the balloon either by chemical or mechanical means. In women, a transurethral approach can be used that involves applying continuous, steady pressure on the catheter to cause part of it to show through the urethral meatus, followed by piercing of the balloon with a needle. This technique should not be used in men.

20.9 References

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Chapter XXI

Removing Them

21 Removing Them

21.1 When To Remove Them

WHEN TO REMOVE THEM?

Drains should be removed as soon as they are not needed because the longer a drain stays in place, the higher the risk of complications developing. Timing of removal is influenced by:

Why was it inserted?

- When a drain is inserted to decompress an abscess or drain the site of necrotic tissue, the drain should be left in place long enough to establish a temporary sinus tract before removal. This is to channel any further leakage onto the skin and external environment once the drain is removed, and to prevent leakage of fluid into an adjacent body cavity.
- When a drain is used to prevent accumulation of a haematoma, it can usually be taken out after 24- 48 hours as haematoma formation mainly occurs during this period.
- When a drain has been placed to manage bile leakage, it can be removed when the bile leakage has ceased.
- When a drain has been inserted to prevent seroma formation, its removal will depend upon the size of the wound, nature of the wound, presence of prosthetic material, and potential complications if a seroma develops.

How much comes out of the drain?
Drains can often be removed once drainage yield has decreased sufficiently. Cessation of drainage is not always achievable. It is important to realize that a drain is a foreign body and its presence alone can induce fluid secretion. Where a tract communicates with a hollow viscus, drainage may also persist as long as the drain remains (especially when continuous suction is applied), and removal of the drain will expedite tract closure.

What comes out of the drain?
This will be dependent upon the particular circumstances.

Drain problems?
Blocked drains should generally be removed if they cannot be unblocked as they no longer serve any purpose.

21.2 How To Remove Them

HOW TO REMOVE THEM?

Drain removal should not simply be a matter of 'cut the suture and yank it out'. Drains are made from a variety of materials- some are quite stiff while others quite supple. This basic difference should be taken into account during removal.

1. Release suction on suction drains prior to removal.
2. Loosening up of the drain should be done if possible, especially for a drain that has been in for some time. For round drains, this can be by rotating the drain to 'break' it free. For flat ones, gentle movement from side to side can achieve this.
3. Firm grasp of shortest length should be done to minimize patient discomfort. This is especially important for the supple drains such as those made from silicone or rubber which can stretch for some distance then suddenly break free causing undue pain to the patient. Using one finger on each side of the drain exit site one should first stabilize the skin around the drain with firm pressure. With the other hand the drain should be grasped as close to the skin as possible.

4. Steady gentle traction should be used to remove the drain rather than sudden jerky movements.

Drain ' shortening'

- Abdominal drains are sometimes 'shortened' (i.e. drawn back in increments) before they are completely removed or fall out.
- This is to promote gradual closure of the tract left behind as the drain comes out.
- The drain should be re-secured after each shortening to prevent retraction or extrusion.

Chapter XXII

Reading List

22 Reading List

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