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Surgical Drains: Indications, Types, and Complications

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Surgical drains are implants that allow removal of fluid and/or gas from a wound or body cavity. This broad definition includes nasogastric tubes, urinary catheters, vascular access ports, and ventriculoperitoneal shunts. However, covering all of these types of drains is beyond the scope of this review, which concentrates on drains used for wounds (traumatic or surgical), drains used in the peritoneal and pleural spaces, and negative pressure wound therapy. This review is part 1 of a 2-part series. Part 1 covers indications for drain use, types, benefits and drawbacks of each type, and common complications. Part 2 will cover drain placement techniques and postoperative care.

INDICATIONS
Drains can help the healing process by removing inflammatory mediators, bacteria, foreign material, and necrotic tissue. Drains can relieve pressure that can impair perfusion or cause pain, thereby decreasing morbidity and reducing inflammation; they enable monitoring for potential complications by allowing easy sampling of fluid during healing; and they can be used to address complications associated with dead space after a pathology report has determined that neoplasia resection is complete and margins are adequate.

The main indications for drain use include the need to eliminate dead space, remove existing fluid or gas, and prevent accumulation of fluid or gas. Dead space develops between tissues after disruption of subcutaneous connective tissues; it is undesirable because the fluid that typically fills this void provides a prime medium for bacterial growth. A review of 228 cases (33 cats and 195 dogs) found that closed suction drains were used for closure of traumatic wounds in 47.1% of cases; closure after tumor removal for 26.5%; closure of nonhealing wounds for 17.6%; and single cases of abscess treatment, amputation, and traumatic hernia repair.

DRAIN TYPES
Many types of drains are used in veterinary practice; some are commercially available and...
others can be made from catheters or tubing already present in most hospitals. The materials used for drains include latex, silicone, polyethylene, and polyvinyl chloride. The drain material determines which of several methods should be used to sterilize each type of drain. Material type also can affect wound healing because tissue reactions to different materials vary. Materials that cause the most reaction are red rubber catheters and latex; those that cause the least reaction are polyethylene, polyvinyl chloride, and silastic tubing (more biologically inert).

Drains are classified by various systems: open or closed and passive or active. Passive drains rely on gravity, body movement, pressure differentials, or overflow to move fluid or gas; active drains use intermittent or continuous negative pressure to pull fluid or gas from a wound or body cavity. Typically, passive drains are open systems and active drains are closed systems because they rely on negative pressure that is created by the drain.

Passive Drains
Passive drains are made of latex, polypropylene, or silastic rubber. These include Penrose drains, the type most commonly used in veterinary practice.¹,² The ubiquitous use of Penrose drains in many small animal practices results from their being readily available, easy to place, and inexpensive. Penrose drains are made of soft, tubular, radiopaque latex; are available in a variety of widths; and can be easily cut to a desired length (FIGURE 1). These drains are most commonly used in wounds, after surgery where dead space is present, or when accumulation of fluid is anticipated. They work by capillary action, gravity, overflow, or fluctuations of pressure gradients caused by body movement.

Use of Penrose drains is not always appropriate. Their use for abdominal drainage is not recommended because intraperitoneal pressure changes during respiration can cause retrograde movement of fluid or gas back into the peritoneal cavity.¹ Use of passive drains in the thoracic cavity is contraindicated because of the possibility of pneumothorax.

Although Penrose drains are tubular, fluid moves out of the body by capillary action along the external surface of the drain, not through the lumen. Drainage efficiency is directly proportional to the surface area of the drain. A common mistake made when using Penrose drains is to create fenestrations, which greatly decrease the functional surface area, thereby significantly decreasing the efficiency of the drain. In addition, fenestrations may increase the risk of tearing inside a wound, leaving foreign material that would require additional surgery to remove.

Because the action of Penrose and other passive drains relies on gravity, achieving optimal drainage depends on choosing the proper drain exit. These drains cannot be attached to suction because their soft, flimsy nature causes them to collapse, making suction ineffective. A passive drain should exit through a single stab incision, away from the primary incision, in the most dependent portion of the wound. Placing the drain exit in other areas can lead to decreased drain efficiency and fluid accumulation within the wound. The dorsal (or proximal) end of the drain should be either buried in

FIGURE 1. Penrose drain. Commonly used after surgery, Penrose drains are radiopaque and available in a variety of sizes (the drain in this image is 3/8 x 12 inches).

FIGURE 2. Incorrect placement of a Penrose drain. Having both a dorsal and a ventral exit does not increase drain efficiency and can increase risk for infection by allowing bacteria and other contaminants to enter the dorsal exit.
the wound or secured with a single suture that penetrates the skin and is tied externally. When removing this drain, this external suture must first be cut to prevent tearing of the drain and potentially leaving drain fragments in the wound. Another common mistake when placing Penrose drains is making 2 stab incisions, 1 dorsal and 1 ventral (or distal), and exiting the drain through both incisions (FIGURE 2). Having the drain exit in 2 places increases the risk for infection and decreases drain efficiency. A dorsal exit will not increase drainage efficiency, and gravity will enable contaminants to move into the wound. Creating a dorsal exit also limits your ability to bury the ventral end of the drain in the deepest portion of the wound, thereby decreasing the drain's effectiveness. Exceptions to this principle include wounds in the inguinal or axillary areas, where there is significant movement, which can lead to the drain acting as a 1-way valve and causing subcutaneous emphysema. In these areas, a second exit can allow air to escape; preferably, a closed suction drain can be used.

To further decrease the risk for ascending infection, passive drains should be covered with a sterile absorbent bandage that is placed and aseptically changed before any strike-through (exudate that has soaked the outer layer of the bandage) is present. Without a bandage, egressing fluid can lead to severe skin irritation and excoriation in addition to increasing the risk for ascending infection (FIGURE 3). In addition, uncovered drains are accessible for the patient to bite off, leaving the buried portion within the wound and requiring additional surgery to remove it. Placing bandages over the drain also provides a way to roughly estimate fluid production, which helps the clinician determine when to remove the drain.

Active Drains

Active drains are closed systems that collect fluid into a reservoir. This reservoir prevents saturation of bandage material, decreases the risk for ascending infection, and can limit exposure of hospital staff or other patients to contaminated fluid. Active drains apply an artificial pressure gradient to pull fluid or gas from a wound or body cavity. Negative pressure increases the efficiency of active over passive drains, enables placement of the drain exit in any position, can remove fluid against gravity if necessary, and can be used to collapse dead space. The negative pressure of active drains can be continuous or intermittent. Continuous negative pressure optimizes drain function and can reduce the amount of time the drain is in place. Continuous suction also decreases the opportunity for bacteria to proliferate in static fluid. Intermittent negative pressure should optimally be based on the volume of fluid or gas being evacuated. A negative pressure of 80 mm Hg allows fluid evacuation and collapses dead space without damaging the tissue in the area of the drain. The types of active drains described in this article are Jackson-Pratt drains and thoracostomy (chest) tubes.

Jackson-Pratt Drains

These commercially available drains are commonly used in veterinary practice (FIGURE 4). They apply continuous suction through a collapsible grenade-style collection reservoir. When the reservoir is collapsed and attached to the drain tubing, it creates negative pressure that pulls fluid through radiopaque fenestrated tubing. These systems are simple to use, available in different...
sizes, and can be cut to the desired length. Closed suction drains can also be made from extension sets or butterfly catheters. Extension sets can be fenestrated and attached to a syringe. The plunger can be drawn back and held in place with a safety pin or hypodermic needle to maintain the desired amount of negative pressure (FIGURE 5). Similarly, a butterfly catheter can be adapted for use as a drain for small areas or smaller patients by cutting off the syringe adapter, fenestrating the tubing, and placing the needle into Vacutainer tubes (FIGURE 6). To avoid breaking or kinking the tubes during fenestration, take care to limit the size of the fenestrations to holes less than one-third the diameter of the tubing.

Regardless of the type of closed suction drain used, proper placement is crucial for optimal function. The fenestrated portion is buried in the deepest portion of the wound or where fluid accumulation is anticipated. The drain tubing is exited through the skin away from the primary incision or wound closure. Because any air that enters the system will affect the negative-pressure gradient, care must be taken to ensure that the system is closed. The wound closure or incision must also be completely closed. To avoid premature loss of the drain, the exit site must be sealed and the drain secured (FIGURE 7). In some instances, antibiotic or petroleum-based ointment placed over the incision or drain exit can help form an airtight seal. In addition, the drain exit is secured with purse-string and finger-trap sutures.

**Thoracostomy Tubes**

These drains are used to evacuate fluid or air from the pleural space. The tubes are made of latex or PCV and are flexible but resistant to collapse. Commercially available thoracostomy tubes have trocars to enable rapid placement. To prevent iatrogenic pneumothorax, thoracostomy tubes are always used as closed systems. They are also used as active drains; the suction is

![FIGURE 4](image1.png)

**FIGURE 4.** Commercially available closed suction Jackson-Pratt drain.

![FIGURE 5](image2.png)

**FIGURE 5.** Homemade closed suction drains created from supplies that are readily available in most hospitals. (A) Drain made from extension set and syringe. (B) Fenestrations made in the needle end of the extension set after the needle adapter has been removed. (C) Bobby pin used to hold the plunger and create the desired level of negative pressure; a needle or safety pin could also be used.
usually intermittent, although it can be continuous when fluid or gas are rapidly or continuously accumulating in the pleural space. These tubes are secured in a similar fashion to other closed suction drains; purse-string and finger-trap sutures ensure a seal at the tube entrance and prevent the drain from accidentally being pulled out.

The size of the chest tube should be appropriate for the condition being treated. A general recommendation is that the tube be approximately the same size as a mainstem bronchus (which can be approximated from a chest radiograph). However, a recent ex vivo study showed that the efficiency of small- and large-bore chest tubes in cadavers was similar for removing known amounts of air, low viscosity fluid, and high viscosity fluid. For cases of pyothorax, author M.S.M. has had to replace small-bore thoracostomy tubes with larger bore tubes. Many patients need thoracostomy tubes on both sides of the chest; for others, a unilateral chest tube is sufficient.

Placement of chest tubes may or may not require anesthesia. Most patients are anesthetized to reduce pain and prevent movement during placement, but for critically ill patients, anesthesia may not be needed (or may be risky). A small stab incision is made over the dorsal aspect of the 10th or 11th rib. Tubes are tunneled under the skin and muscle and should enter the thoracic cavity around the 7th or 8th intercostal space. Management of thoracostomy tubes requires extreme care; if they become open to the environment, they can cause a life-threatening pneumothorax.

In summary, advantages of active drains over passive drains include:

- decreased risk for ascending infection
- ability to be used in areas that are difficult to bandage
- decreased risk for skin excoriation
- accurate assessment of volume of fluid being produced
- easy collection of fluid for cytology or chemical analysis with less possibility of environmental contamination of the fluid
- ability to collapse dead space

Negative-Pressure Wound Therapy

Negative-pressure wound therapy (NPWT) is a type of closed, active drain system that uses subatmospheric pressures. It has been shown to improve wound perfusion. NPWT decreases interstitial edema,
stimulates fibroplasia, and enhances angiogenesis, although the exact mechanisms of these actions are not completely understood.\textsuperscript{11} NPWT leads to earlier wound closure because of accelerated granulation tissue formation, reduced bacterial colonization, and reduced wound edema and exudate.\textsuperscript{9,11} Unlike the drains previously discussed, NPWT can be used in open wounds or incisions, providing access for treatment.

During drain placement, a coarse, open cell foam is laid directly over the wound and a specialized drain tubing is placed over the foam. An occlusive dressing is applied to create a seal around the wound; to create the negative pressure, this seal must be maintained. Tubing is attached to the drain unit and constant negative pressure is applied (\textbf{FIGURE 8}). A pressure of $-125$ mm Hg increases microvascular blood flow and is recommended; pressures greater than $-400$ mm Hg inhibit blood flow and should not be used.\textsuperscript{12}

Indications for NPWT use in veterinary medicine include the following:\textsuperscript{11}

- acute and chronic wounds
- abscesses
- degloving injuries
- burns
- dehisced incisions
- adjunct therapy for skin flaps and skin grafts
- compartment syndrome
- necrotizing fasciitis or severe vasculitis

\begin{figure}
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\caption{\textbf{FIGURE 8.} Negative-pressure wound therapy provides a way to remove exudate from a wound without requiring wound closure. (A) Large wound present after initial debridement. (B) Open cell foam placed in the wound bed. (C) Occlusive dressing applied to create a seal and maintain a closed system. (D) Drain placed in the occlusive dressing and connected to a vacuum source and collection system.}
\end{figure}

NPWT is also beneficial after application of free skin grafts, especially during the first critical week after application.\textsuperscript{13} Because skin grafts are fenestrated, other drain techniques would be ineffective. The negative-pressure system may help stabilize the graft by reducing fluid accumulation under the graft and may help reduce the possibility of bacterial contamination and necrosis of the graft, thereby increasing the chances of success versus catastrophic failure.\textsuperscript{13} The recommended pressures for use over a skin graft are lower, $-65$ to $-75$ mm Hg.

Contraindications for NPWT use include the following:\textsuperscript{11}

- severe dermatitis or poor skin condition around the wound
- large amounts of necrotic or devitalized tissue
- coagulopathies
- exposure of major vessels
- open joints
- wounds that contain neoplastic tissue
- untreated osteomyelitis
- a situation in which 24-hour care is not available should any NPWT apparatus malfunction

\textbf{COMPLICATIONS AND FAILURES}

Inappropriate use of drains can lead to complications that include infection and increased overall patient morbidity. Inappropriate placement can also increase the risk for incision dehiscence or delayed/failed wound healing. Drains cannot compensate for inadequate debridement, inappropriate wound care, or improper surgical technique. With regard to closed suction drains, a retrospective study showed that the risk for major complications is low (4 [0.02\%] of 228 patients) and the risk for minor complications is mild to moderate (35.3\% of cats and 33.8\% of dogs).\textsuperscript{3} Despite the low risk for major complications, drain placement can lead to the following issues.

\textbf{Infection}

Use of drains leads to higher rates of infection, the most common complication.\textsuperscript{14} One study showed an infection rate after clean surgeries in dogs to be 15.6\%.\textsuperscript{3} Retrograde bacterial contamination, including nosocomial infection, can occur with high frequency but is significantly lower when closed suction drainage is used.\textsuperscript{15-17} In addition to ascending infection, foreign body reaction to the drain itself may make the wound more susceptible to infection.\textsuperscript{14} Recommendations for
reducing the chance of bacterial contamination include removing the drain as soon as indicated and following strict aseptic protocols during placement and management.3

Vascular Damage
During placement of active drains, care should be taken to avoid placing them near arteries to avoid pressure necrosis of the arterial wall.18 One report describes 2 patients in whom placement of an active drain was followed by hemorrhage; both patients recovered after drainage was temporarily discontinued and fluid resuscitation provided.18

Spread of Neoplastic Cells
In surgical oncology, use of drains is controversial. Although many surgical oncology patients have areas of dead space or rely on complex skin reconstruction that can benefit from drain placement, drains can disrupt tissue away from the primary surgery site and seed these areas with neoplastic cells.2 This effect increases the area that has to be addressed if margins are not adequate and additional surgery, chemotherapy, or radiation therapy is required.

Dehiscence
Other complications associated with drains typically result from improper placement and tube size selection. Poor placement can lead to incision infection or dehiscence, which could potentially lead to herniation of abdominal viscera. Suture line dehiscence is a recognized complication of drains.14 Drains should not be placed directly under an incision line and should not exit through the suture line. Direct contact with a healing incision can lead to a foreign body reaction and increased risk for incisional complications.14

Blockage
Closed suction drains can become clogged or lose suction, causing drain failure. Fenestrated drains placed in the abdominal cavity can become occluded by omentum. To decrease the risk for omental occlusion, the drain can be placed between the liver and the diaphragm (FIGURE 9). Clogging is often identified when drains are pulled and clots and fibrinous material are noted to have taken the shape of the drain (FIGURE 10).

Drain Failure
Loss of negative pressure can result in drain failure if the tube exit site is substantially larger than the tube
and a purse-string suture is not placed. Loss of suction can also be caused by dehiscence of the wound closure or incision.

Electrolyte Imbalance
A major complication of drain use can be changes in electrolyte and/or serum protein levels. Electrolytes should be monitored closely in cases of high fluid production because loss of large volumes of proteinaceous fluid can lead to metabolic derangements and hypoproteinemia.16,17

Pneumothorax
Thoracostomy tube complications can be life-threatening. If the system suddenly becomes open, severe pneumothorax can ensue. This event can be avoided by providing redundant systems to ensure that accidental opening does not occur. A simple system is placement of a clamp and a 3-way stopcock on the tube. Adequate staff training should minimize accidental opening of both the stopcock and clamp; however, should this occur, negative pressure can be rapidly re-established if the tube is still in place.

In addition to knowing the indications for drain use, different drain types, benefits and drawbacks of each drain type, and common complications, successful drain use also involves proper drain placement, monitoring, and timing of removal. Knowledge of these concepts will help you maximize the effectiveness of drains while minimizing complications. These concepts will be covered in part 2 of this review (to be published in the July/August issue).

**References**