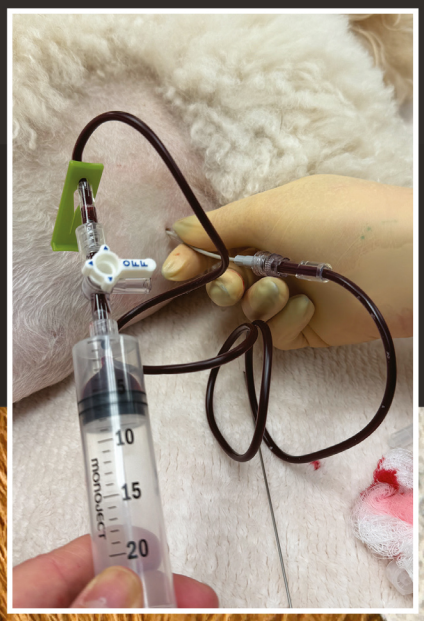
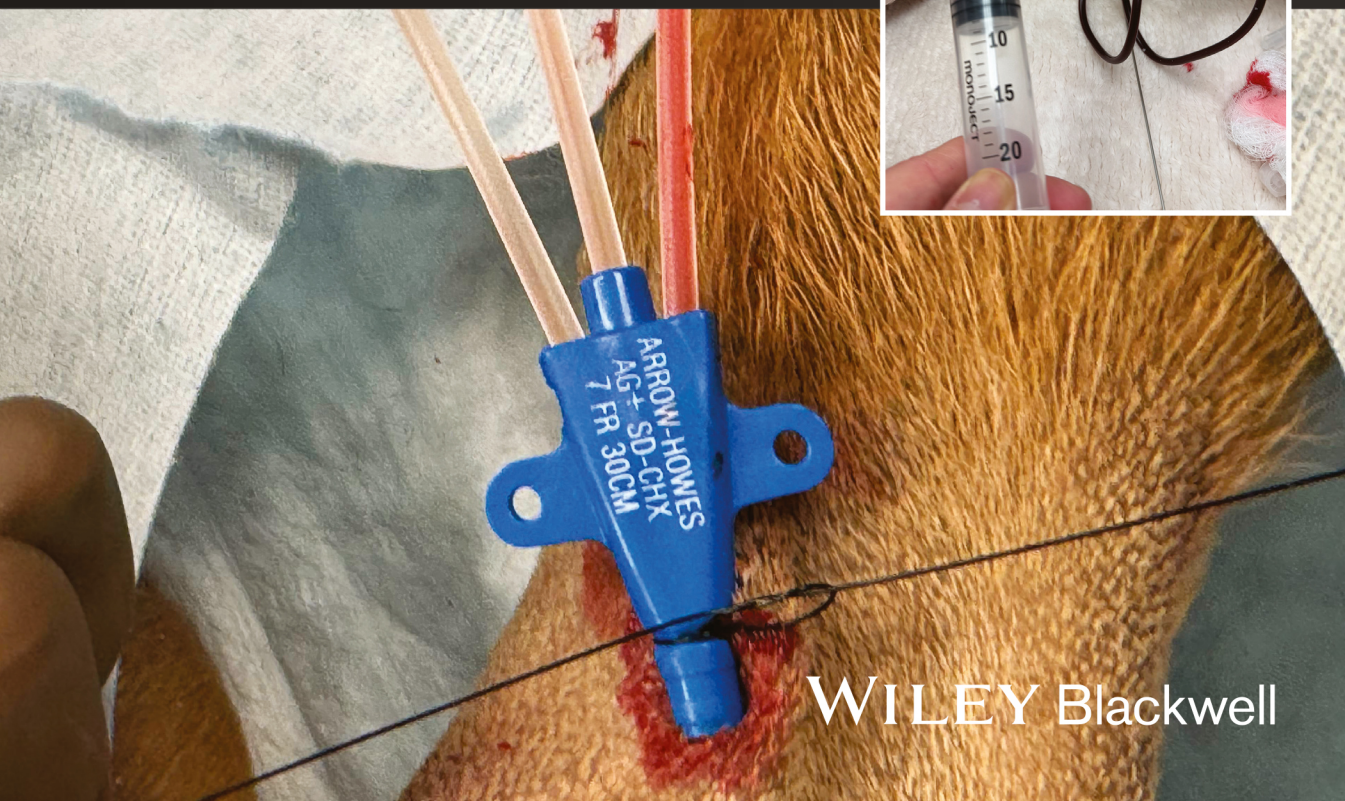
Third Edition

Veterinary Emergency and Critical Care Procedures

Timothy B. Hackett
Elisa M. Mazzaferro





WILEY Blackwell

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Preface

Years ago, while preparing to teach an emergency and critical care laboratory, we realized that there were no resources available that demonstrated step-by-step photos of life-saving emergency and critical care procedures. Although many of the procedures in this textbook are commonly performed in emergency hospitals, they may not be performed as frequently in busy day practices whose patients are often healthy. Over the years, we have met many hard-working, dedicated veterinarians and veterinary technicians attending our seminars and laboratories. They remind us that procedures we take for granted are infrequent and can be intimidating. A technician shared a story about a Basset Hound needing intravenous fluids, but vascular access was almost impossible. They remembered a photo in this book and then used it as a guide to place an auricular catheter. This exact scenario demonstrates why this book was published – to help everyone in the veterinary trenches save lives.

Timothy B. Hackett
Elisa M. Mazzaferro

List of Abbreviations

ALS	Advanced Life Support
ASAP	as soon as possible
BAL	bronchoalveolar lavage
BLS	Basic Life Support
BUN	blood urea nitrogen
CO2	carbon dioxide
CPR	cardiopulmonary resuscitation
CRI	continuous rate infusion
CT	computed tomography
DPL	diagnostic peritoneal lavage
ECG	electrocardiogram
FIP	feline infectious peritonitis
Fr	French
IO	intraosseous
IT	intratracheal
IV	intravenous
kg	kilogram
mg	milligram
min	minute
mL	milliliters
MODS	Multiple Organ Dysfunction Syndrome
PEA	pulseless electrical activity
POCUS	point-of-care ultrasound
RECOVER	Reassessment Campaign on Veterinary Resuscitation
ROSC	Return of Spontaneous Circulation
SIRS	Systemic Inflammatory Response Syndrome
TIVA	total intravenous anesthesia
VF	ventricular fibrillation
VT	ventricular tachycardia
µg	microgram

CHAPTER 1

Vascular Access Techniques

INTRODUCTION

A variety of methods can be used for placement of peripheral, central venous, and arterial catheters. If a peripheral or central catheter cannot be placed due to small patient size, severe hypovolemia or dehydration, or hypotension, intraosseous catheters can be placed in the femur, humerus, or wing of the ileum. This chapter will discuss indications, contraindications, and methodologies listed above.

Through-the-needle or over-the-wire central venous catheters can be placed in the jugular, medial saphenous, or lateral saphenous veins. The indications and contraindications for central venous catheter placement, irrespective of type, are similar.

The restraint for placement of peripheral and central venous catheters is the same, although local anesthesia is advised when entrance holes are made in the skin for placement of central venous catheters. Catheters should not be placed into the jugular vein in cases of increased intraocular or increased intracranial pressure or if there is thrombosis of the contralateral jugular vein.

The following series of images display the anatomic location of the jugular, cephalic, lateral saphenous, and medial saphenous veins.

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Fig. 1.1. Restraint for jugular catheterization. Place the patient in lateral recumbency and have an assistant restrain the head and the rear limbs. A second assistant may be required to restrain the forelimbs.



Fig. 1.2. Restraint for cephalic catheterization. Place the patient in sternal recumbency. Have an assistant hold the neck and head while pushing caudal to the elbow.



Fig. 1.3. Restraint for lateral saphenous vascular catheterization. Place the patient in lateral recumbency with the proposed site of catheter placement up. Have an assistant restrain the patient's head and neck. A second assistant can restrain the rear limbs and occlude the lateral saphenous vein proximally, caudal to the stifle.



Fig. 1.4. Restraint for medial saphenous catheterization. Place the patient in lateral recumbency with the proposed site of catheter placement down. Have an assistant restrain the patient's head and neck while occluding the medial saphenous vein proximally, close to the inguinal region.

PERIPHERAL CATHETERIZATION

Introduction

Peripheral venous catheters are the most common type of intravenous catheters placed in small animal patients. Peripheral catheters are easy to place and simple to maintain, and have minimal risks to the patient. Peripheral catheters can be used for infusion of crystalloid and colloid fluids, blood products, intravenous drugs, and anesthetic agents. In large breeds, larger-bore (16 to 18 gauge) catheters can sometimes be used for blood sample collection.

Supplies Needed

½- and 1-inch white adhesive tape to secure and wrap the catheter
Kling
Antimicrobial scrub solution
T-port or male adapter
Heparinized flush solution in a 3-mL syringe
    1000 units of unfractionated heparin/250 to 500 mL of 0.9% NaCl; bags of unused heparinized flush should be discarded after 24 hours.
Electric clipper and blades
Intravenous catheter

Indications

Infusion of crystalloid and colloid fluids
Infusion of blood products
Infusion of intravenous drugs
Induction of general anesthesia
Maintenance of total intravenous anesthesia
Blood sample collection

Contraindications

Burn, abrasion, or pyoderma over the catheter site
Thrombosis of vein selected for catheterization
Infusion of hyperosmolar solutions (parenteral nutrition, concentrated dextrose, and concentrated vasopressors such as norepinephrine)



Fig. 1.5. Restraint for cephalic catheterization. The animal is positioned in sternal recumbency, and the assistant draws one arm under the animal's neck, pulling the head toward the assistant's body, and then pushes the forelimb cranially while occluding the vessel at the elbow.

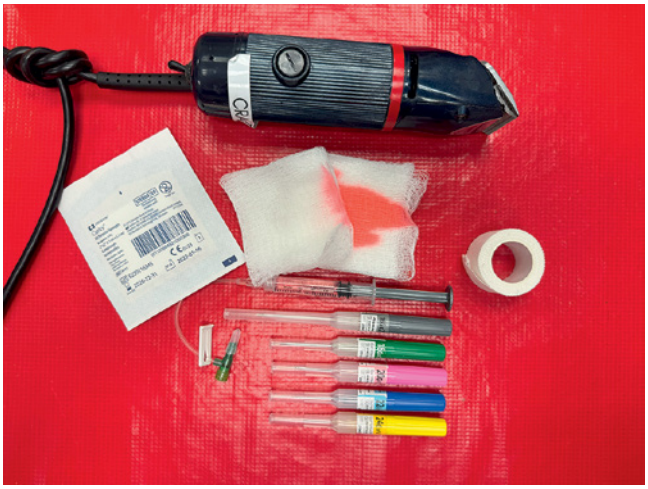


Fig. 1.6. Supplies needed for peripheral catheterization.



Fig. 1.7. Have an assistant restrain and clip the antebrachium circumferentially in between the elbow and carpus, and then aseptically scrub the clipped area.

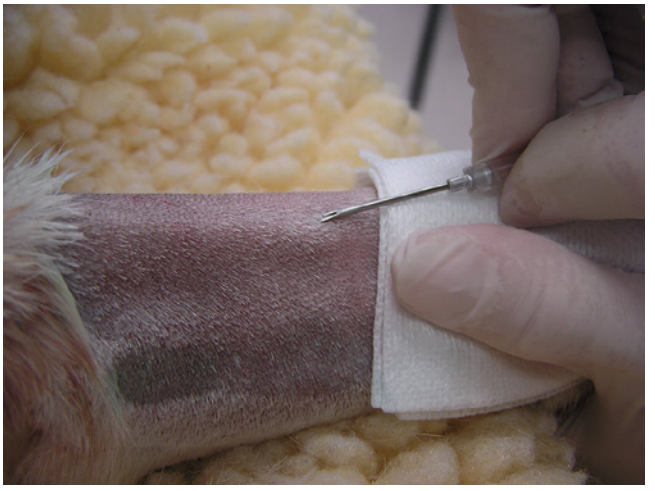


Fig. 1.8. If the skin is very tough, or if the animal is very dehydrated, make a small nick incision through the skin with the bevel of an 18-gauge needle. This technique is called "percutaneous facilitation," and will make the task of catheter insertion easier, as it prevents the catheter from becoming burred as it goes through the thickened or dehydrated skin and underlying tissue.

Helpful hint: Use care to avoid lacerating the underlying vessel when performing percutaneous facilitation.



Fig. 1.9a. Have an assistant occlude the vessel. Wearing gloves (nonsterile), insert the catheter needle through the skin at a 15° angle. Bluntly but gently penetrate the skin.



Fig. 1.9b. Watch for a flash of blood, the push the catheter off of the stylette into the vessel. Note: A gauze 4 x 4 square is placed distal to the proposed catheter insertion site to help prevent the catheter from being dragged through fur. It also helps prevent blood from wetting the skin and fur, which would prevent the tape from adhering and properly securing the catheter in place.



Fig. 1.10a. Have an assistant occlude the vessel just over the point of catheter insertion, and then remove the stylette.



Fig. 1.10b. Have an assistant occlude the catheter to prevent backflow of blood into your field.



Fig. 1.11. Tape the catheter around the hub and limb with a half-inch length of white adhesive tape.

Helpful hint: Make sure that the catheter hub and skin are completely dry, so that the tape will securely attach itself to the catheter hub and the catheter hub will not spin around, or else the catheter will not remain in place and will pull out of the vessel.



Fig. 1.12. Finish taping the catheter in place with layers of 1-inch white adhesive tape, Kling, Elasticon®, or Vetrap™.



Fig. 1.13. Place a T-port flushed with heparinized saline and flush the catheter.

CENTRAL VENOUS CATHETER PLACEMENT

Central venous catheters can be placed into the jugular, lateral saphenous, and medial saphenous veins. Central catheters can be used for infusion of crystalloid and colloid fluids, infusion of continuous or intermittent drugs, or infusion of hyperosmolar solutions including parenteral nutrition. An additional benefit of indwelling central venous catheters is ease of repeated blood sample collection without the need for repeated venipuncture. Many companies supply single- and multi-lumen over-the-wire products. Multi-lumen catheters are beneficial when multiple products are being infused into a patient simultaneously. The added ports allow vascular access without the needle for placement of multiple single-lumen central or peripheral catheters.

Supplies Needed

Sterile gloves
Antimicrobial scrub and solution
Central venous catheter(s)
Cotton roll gauze
Electric clipper and blades
Gauze 4 x 4 inch squares
Heparinized 0.9% saline flush solution
Kling bandaging material
T-port
1-inch white tape
Vetrap™

Indications

Crystalloid or colloid infusion
Continuous drug infusion
Infusion of parenteral nutrition or other hyperosmolar substances
Repeated blood sample collection

Contraindications

Coagulopathies
- Thrombocytopenia
- Thrombocytopathia
- Vitamin K antagonist rodenticide intoxication

Hypercoagulable states
- Hyperadrenocorticism
- Disseminated intravascular coagulation
- Protein losing enteropathy
- Protein losing nephropathy

Catheters should not be placed into the jugular vein in cases of increased intraocular or increased intracranial pressure or if there is thrombosis of the contralateral jugular vein.

The following series of images display the anatomic location of the jugular, cephalic, lateral saphenous, and medial saphenous veins.

OVER-THE-WIRE CATHETERS (SELDINGER TECHNIQUE)

Supplies Needed

Sterile gloves
Antimicrobial scrub solution
Number 11 scalpel blade
Lidocaine 2%
3-mL syringe with 24-gauge needle
Electric clipper and blades
1-inch white tape
3–0 nonabsorbable suture
Over-the-wire single of multi-lumen catheter kit
- Over-the-needle intravenous catheter
- Over-the-wire long catheter
- Vascular dilator
- J-wire for catheter introduction into the vessel

Needle holders
Suture scissors
Gauze 4 x 4 inch squares
Cotton bandage material
Kling
Elasticon® or Vetrap™

Indications

Frequent blood sample collection
Infusion of multiple drugs, fluids, blood products, or parenteral nutrition/hyperosmolar solutions

Contraindications

Venous thrombosis
Coagulopathies
Should not be placed in jugular vein in cases of increased intraocular or intracranial pressure

JUGULAR CENTRAL THROUGH-THE-NEEDLE CATHETER PLACEMENT

Through-the-needle catheters can be fed through a needle (supplied in some cases with the catheter) or through a smaller over-the-needle intravenous catheter. In the next series of images, a through-the-needle single-lumen long catheter is being placed into the jugular vein.



Fig. 1.14. Supplies needed for through-the-needle catheter placement.



Fig. 1.15. Place the patient in lateral recumbency.



Fig. 1.16. Aseptically clip and scrub over the proposed site of catheter placement.

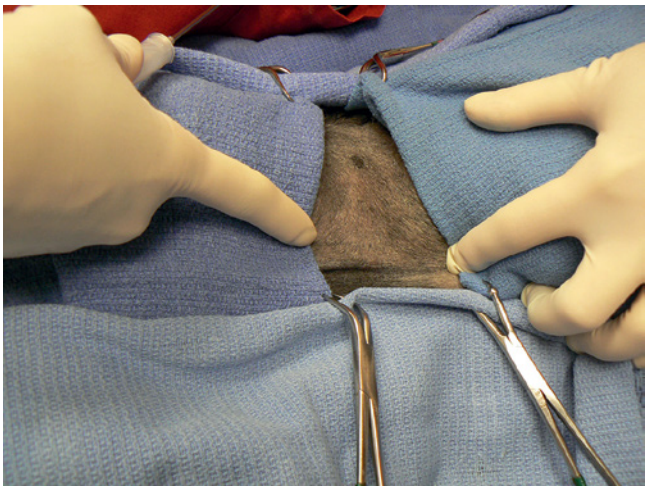


Fig. 1.17. Drape the sterile field, and then occlude the jugular vein at the thoracic inlet. Note the jugular vein under the skin.

Helpful hint: In overweight patients, the jugular vein may not be visible, even after occlusion at the thoracic inlet.

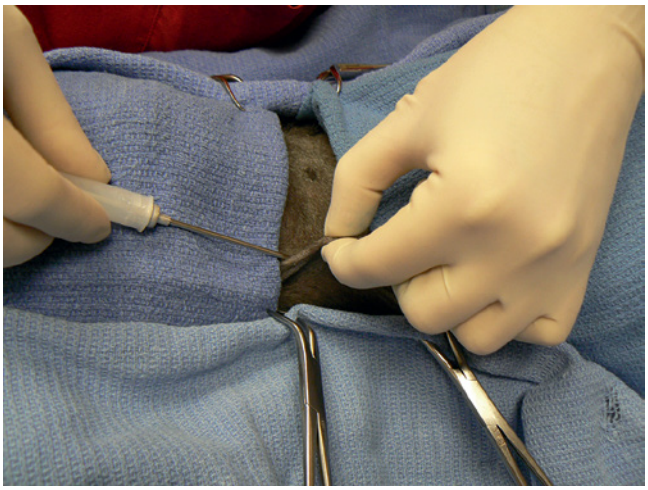


Fig. 1.18. Wearing sterile gloves, tent the skin over the proposed site of catheter insertion, and insert the needle through the skin.



Fig. 1.19. Insert the needle into the vessel. In some cases, you will feel a “pop” as the needle is inserted into the vessel. Watch for a flash of blood in the catheter. Once a flash of blood is observed, push the catheter through the needle into the vein.

Helpful hint: In extremely hypotensive or hypovolemic patients, a flash of blood may not occur.

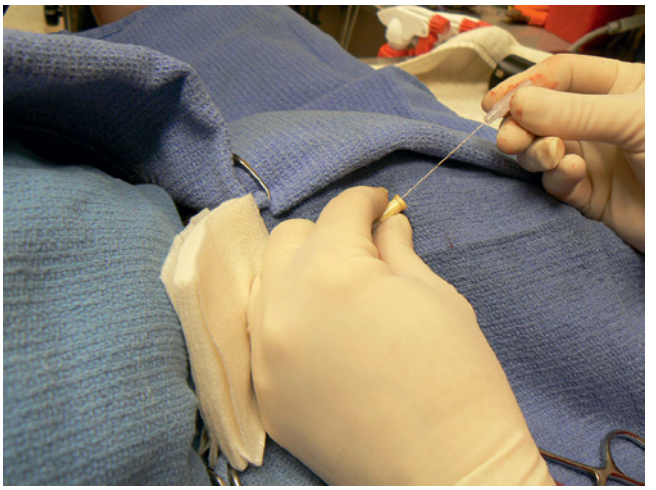


Fig. 1.20. Once the catheter is pushed to the hub securely, remove the stylette from within the catheter.

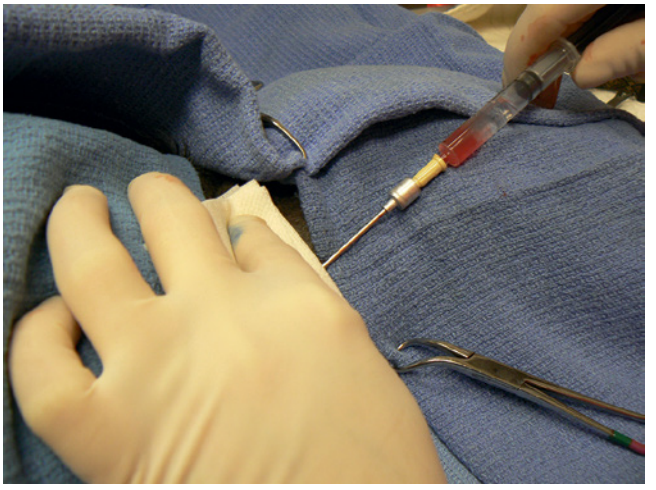


Fig. 1.21. Flush the catheter with heparinized saline.

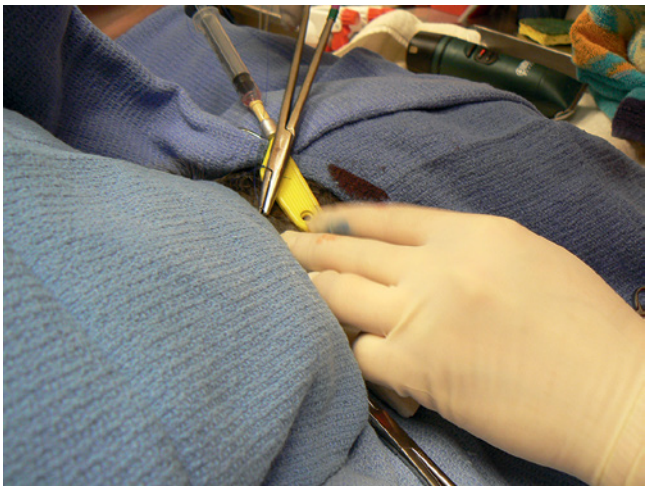


Fig. 1.22. Remove the needle from the vessel, and secure the plastic pieces over the needle for safety.

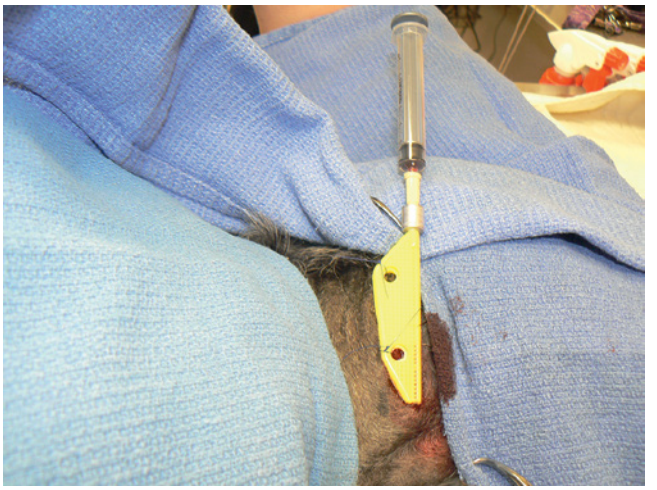


Fig. 1.23. Secure the plastic pieces and catheter hub in place to the skin.



Fig. 1.24. Place sterile gauze squares over the site of catheter insertion, and bandage in place first with lengths of 1-inch white adhesive tape.

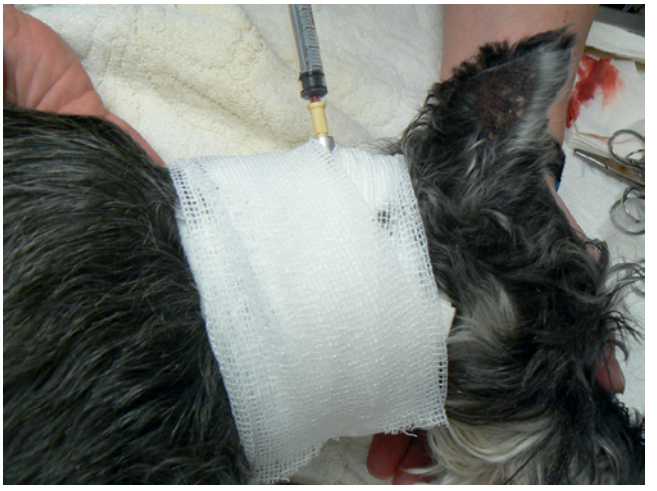


Fig. 1.25. Next, secure cotton roll gauze over the catheter site.

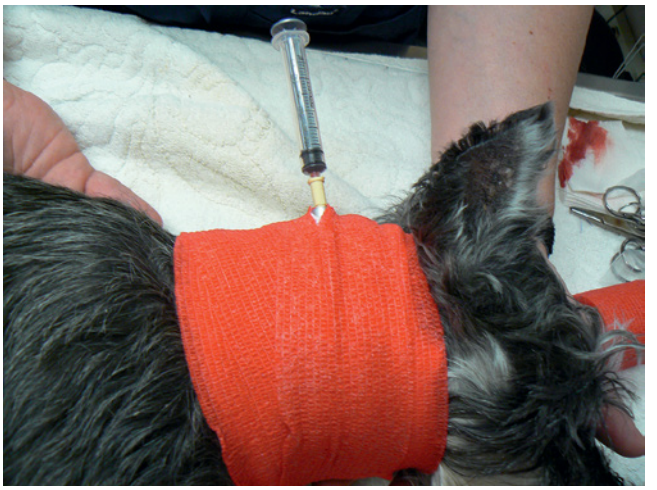


Fig. 1.26. Finally, secure a final outer layer over the catheter bandage. The next series of images will demonstrate an alternative method of placing a through-the-needle catheter using a short over-the-needle intravenous catheter in the medial saphenous vein of a cat.

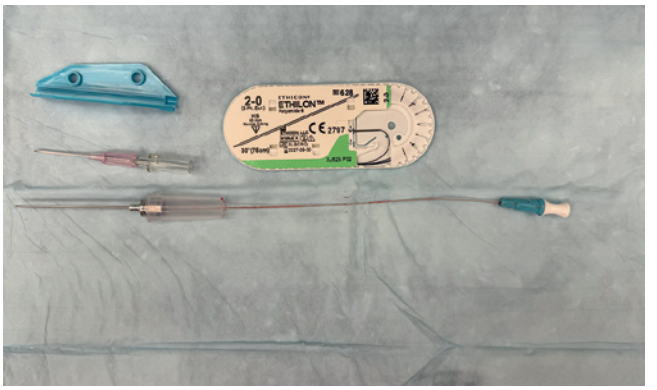


Fig. 1.27. Supplies needed for placement of a through the needle catheter. In this instance, the smaller over-the-needle catheter is inserted first into the medial saphenous vein and then the smaller longer through-the needle catheter will be inserted through the larger diameter short intravenous catheter. Some operators feel this is an easier method than using the large bore needle that is supplied and attached to the through-the-needle catheter.



Fig. 1.28. Place the patient in lateral recumbency. In this case, an assistant will occlude the medial saphenous vein proximal to the stifle.



Fig. 1.29. Clip the distal limb circumferentially in between the stifle and hock. As the assistant occludes the vessel, visualize the vessel as it courses under the skin. Aseptically scrub with antimicrobial scrub solution.

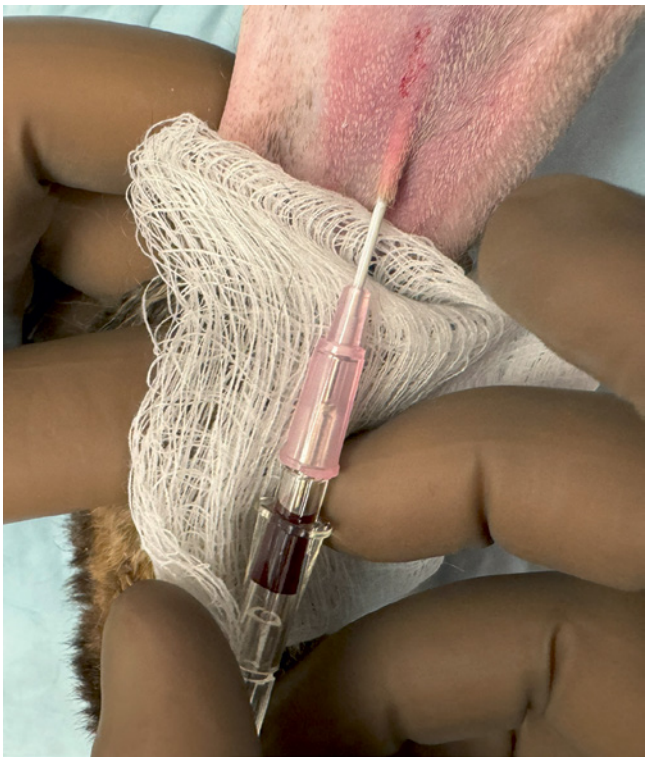


Fig. 1.30. Insert the needle of the over-the-needle catheter through the skin into the vessel. Watch for a flash of blood in the catheter hub, and then push the over-the needle catheter off of its stylette, into the vessel.

Helpful hint: To hold the vessel in place while you are attempting to insert the needle, pull the skin tightly around the back of the leg.



Fig. 1.31. Remove the stylette from the catheter. Do not let go of the catheter. Insert the cap into the hub of the catheter to prevent blood loss.



Fig. 1.32. Remove the long through-the-needle catheter from its attachment to the needle.



Fig. 1.33. Insert the long, through-the-needle catheter through the smaller intravenous catheter. Secure the proximal end of the catheter to the smaller IV catheter in the vessel. Note: The diameter of the smaller intravenous catheter must be larger than the diameter of the long through-the-needle catheter or else the catheter will not feed into the vessel. Depending on the manufacturer, the proximal end of the through-the-needle catheter may have a tip that can be securely fit to the hub of the smaller catheter.

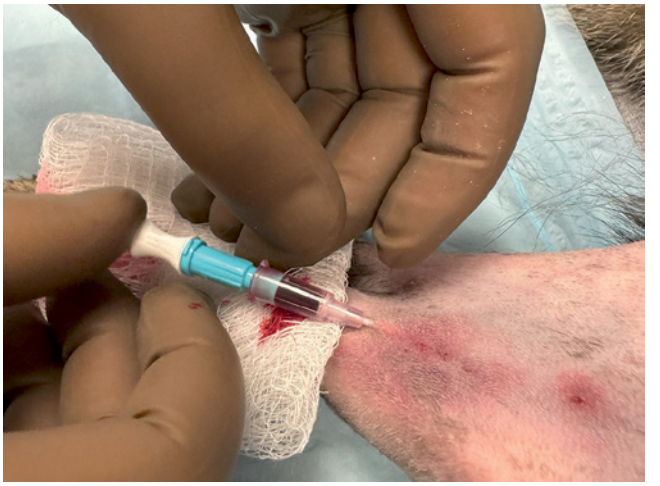


Fig. 1.34. Push the long catheter into the vessel to its entire length and secure the proximal port into the hub of the smaller catheter. (In this image, the long catheter hub is blue and the proximal end of the internal stylette is white.)



Fig. 1.35. Secure the hub of both catheters with ½-inch white tape.



Fig. 1.36. Remove the stylette from the long catheter (here, the white piece) and attach a t-port flushed with heparinized saline.



Fig. 1.37. Cover the catheter insertion site with a piece of sterile gauze.



Fig. 1.38. Wrap additional lengths of 1-inch white tape over and under the catheter, secured around the limb, to secure the catheter in place.



Fig. 1.39. Wrap the limb and catheter, starting distally, with cotton roll gauze.



Fig. 1.40. Secure the cotton roll gauze with Kling.



Fig. 1.41. Place a final wrap of Vetrap around the limb and catheter. The t-port can be secured to the lateral aspect of the limb for ease of sample collection.

LATERAL SAPHENOUS OVER-THE-WIRE (SELDINGER) CATHETER



Fig. 1.42. The skin is clipped and aseptically scrubbed as previously described. Insert the short, over-the-needle catheter through the skin into the lateral saphenous vein.

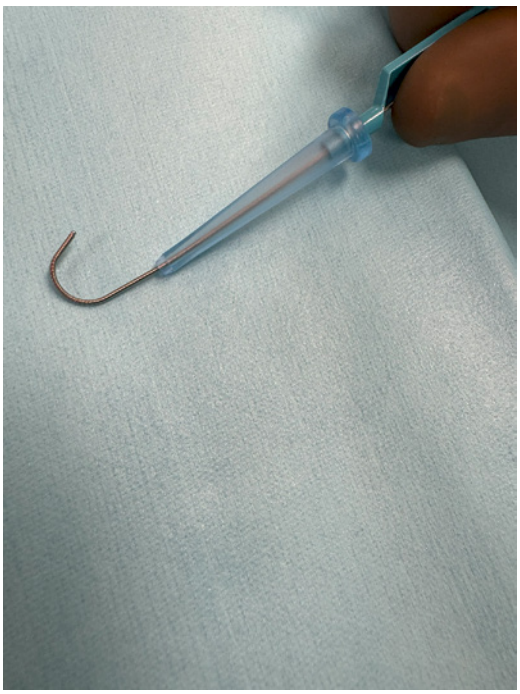


Fig. 1.43. The J-wire supplied with an over-the-wire catheter kit. The shape of the "J" is designed to avoid having the wire lacerate the vessel during advancement of the wire into the blood vessel.

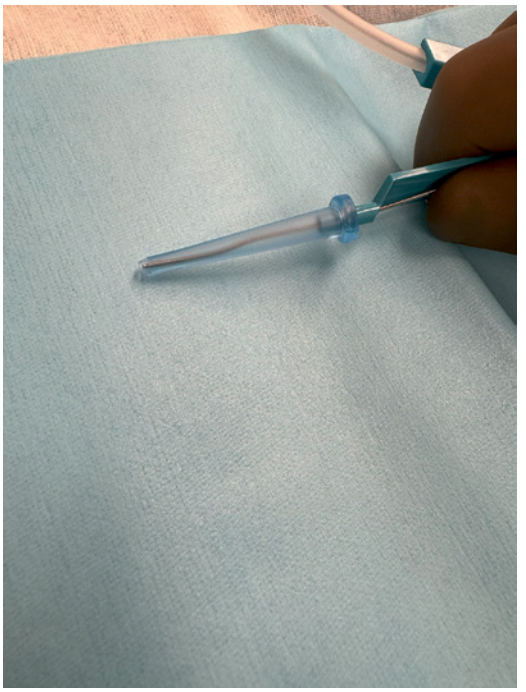


Fig. 1.44. Draw the “J” of the J-wire back into its introducer.

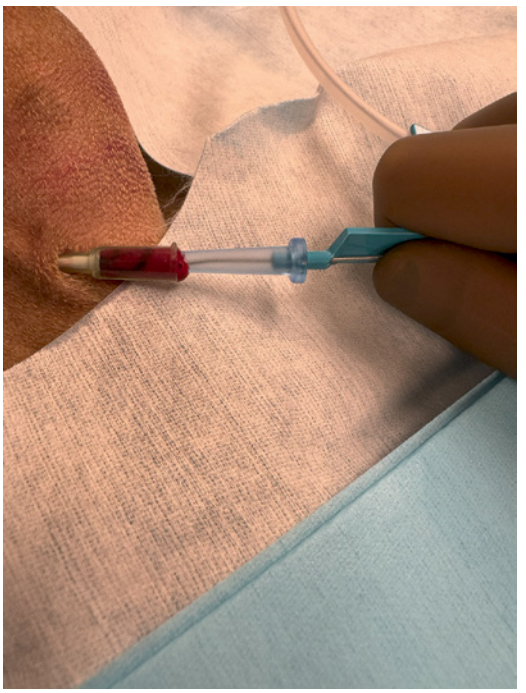


Fig. 1.45. Gently seat the introducer into the catheter hub, and insert the wire through the catheter hub into the vessel. Make sure to never let go of the wire.



Fig. 1.46. Remove the short catheter from the vessel and off of the wire.



Fig. 1.47. Insert the vascular dilator over the wire.

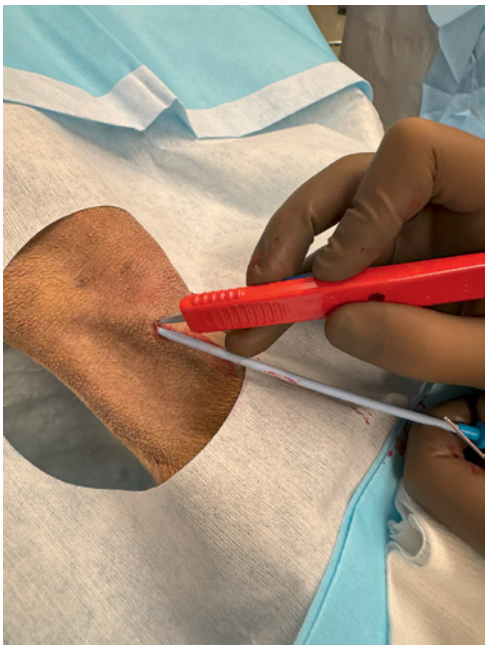


Fig. 1.48. Using the scalpel blade provided in the kit, make a small nick incision over the wire and vascular dilator prior to pushing the vascular dilator through the skin. Note: This step will allow sufficient space for the vascular dilator to enter the skin, then underlying vessel.



Fig. 1.49. Push the vascular dilator over the wire, through the skin incision, then into the vessel a short distance to enlarge the opening in the subcutaneous tissue and vessel. Remove the vascular dilator from the vessel and back over the wire.

Helpful hint: Hold the vascular dilator as close to the skin as possible, and push with a twisting motion into the vessel. Note: Place sterile gauze over the site as you remove the vascular dilator, to prevent excessive blood loss. You have just created a large hole in the vessel!

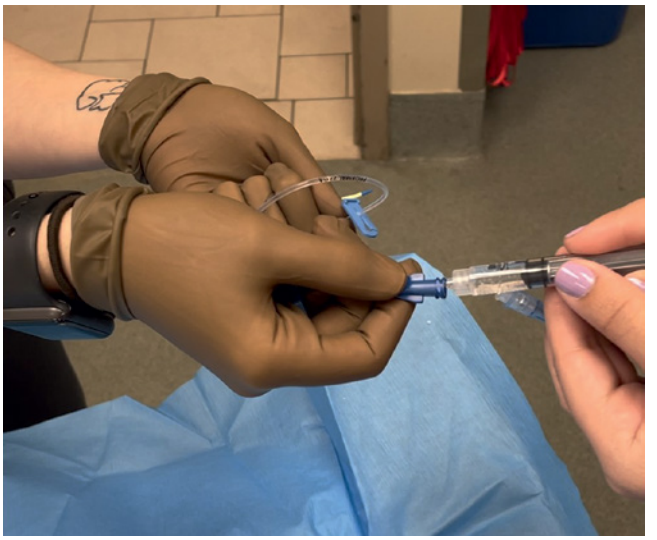


Fig. 1.50. Flush all ports of the over-the-wire catheter.

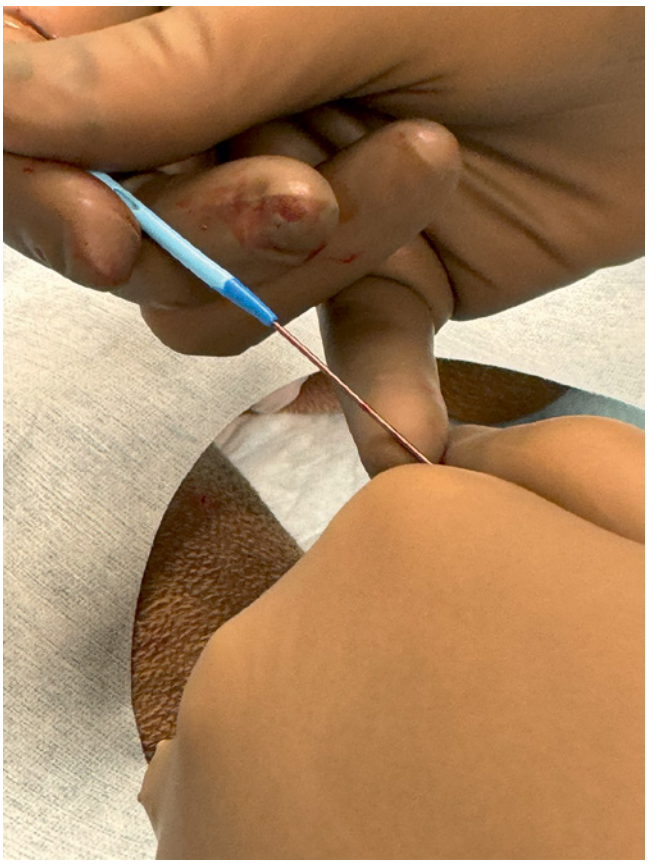


Fig. 1.51. Insert the catheter over the wire. Pull the wire slowly out of the vessel through the catheter, alternating by advancing the catheter and pulling the wire.



Fig. 1.52. The wire will eventually appear out one of the proximal ports.

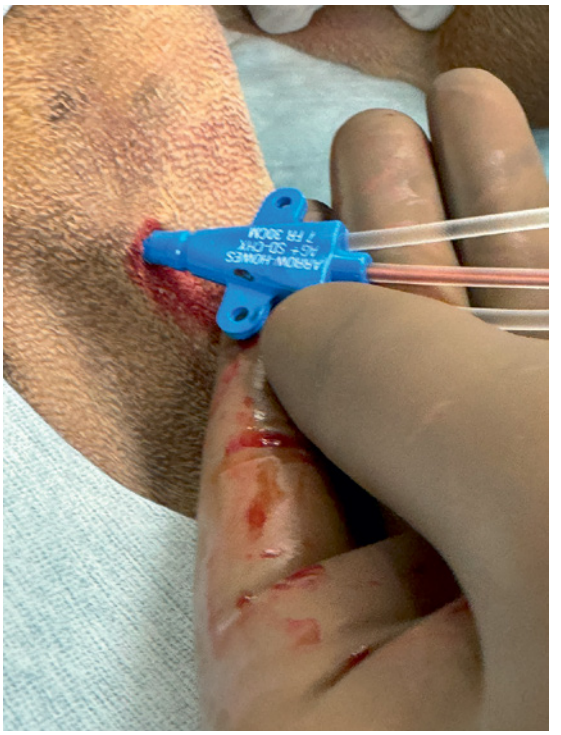


Fig. 1.53. Once the wire has passed through the proximal port of the catheter, grasp the wire and feed the catheter into the vessel.

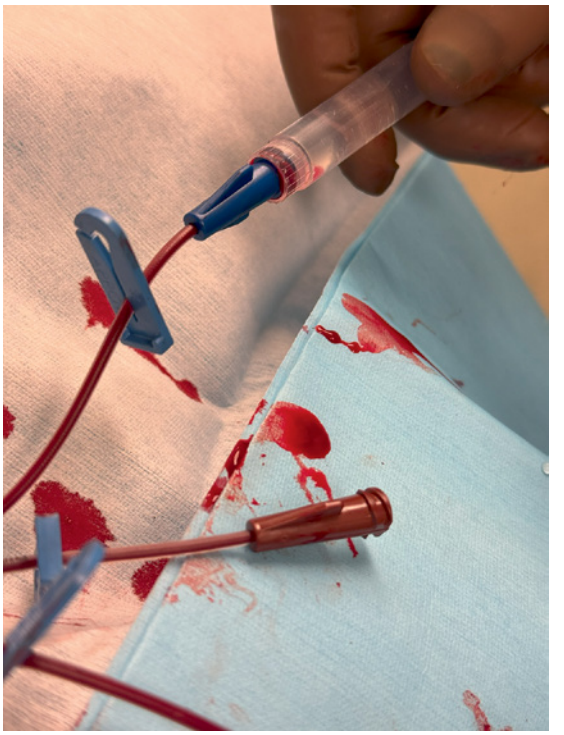


Fig. 1.54. Remove the wire, and then flush all ports of the catheter again with heparinized saline. Clamp each port.

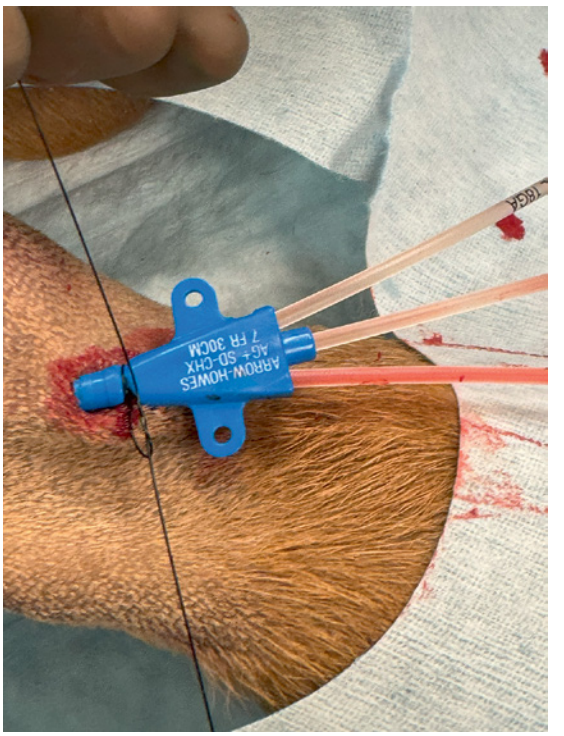


Fig. 1.55. Suture the catheter to the skin with nonabsorbable suture.



Fig. 1.56a. Bandage the catheter.



Fig. 1.56b. Bandage the catheter.

AURICULAR VENOUS CATHETER



Fig. 1.57. Clip and aseptically scrub along the lateral ear margin to visualize the vein.



Fig. 1.58. Have an assistant occlude the vessel proximally.



Fig. 1.59. Hold the ear in the non-dominant hand, and insert the over-the-needle catheter through the skin into the vessel. Watch for a flash of blood in the catheter hub.



Fig. 1.60. Once a flash of blood is observed in the catheter hub, push the catheter off of the stylette, into the vessel.



Fig. 1.61. Place a length of half-inch tape around the catheter hub and around the hub around the ear. Place a roll of cotton gauze under the ear during catheter wrapping. The roll of cotton allows the ear to fold, rather than remain flat.



Fig. 1.62. Place a second length of 1-inch white tape under the catheter, and around the ear in a similar manner.



Fig. 1.63. Place non-adhesive bandage material over the catheter. Note: Substances such as norepinephrine, which can cause extreme vasoconstriction or tissue damage if extravasation occurs, should not be infused through auricular catheters.

ARTERIAL CATHETERIZATION

Introduction

Arterial catheterization is a technique that is useful in nonambulatory critically ill small animal patients. Arterial catheters should be placed when repeated arterial blood samples are required, such as in patients with pulmonary or cardiac disease when monitoring of oxygenation and ventilation is desirable. Arterial catheters are also used for continuous invasive direct measurement of arterial blood pressure. Arterial catheters are most commonly placed in the dorsal pedal or coccygeal arteries, but also can be placed in the femoral and auricular arteries.

Supplies Needed

Electric clippers and blades
Antimicrobial scrub solution
Over-the-needle catheters (20-, 22-, and 24-gauge)
½- and 1-inch white tape
T-port or luer-lock male adapters (flushed with heparinized saline)
3-mL syringe(s) with heparinized saline
Permanent marker to label catheter
Stickers “Not for IV infusion”

Indications

Measurement of direct arterial blood pressure
Obtain blood samples for blood gas analyses

Contraindications

Abrasions, burn, pyoderma over site of catheter placement
Thromboembolic disease or hypercoagulability
Coagulopathy
Ambulatory patients that will disconnect catheter
Never to be used for blood sample, drug, or fluid infusion



Fig. 1.64. Place the patient in lateral recumbency. Clip and aseptically scrub over the proposed site of arterial catheter placement. Common insertion sites include the dorsal pedal, femoral, auricular, and coccygeal arteries.



Fig. 1.65. Palpate the pulse just distal to the tarsus to place a dorsal pedal catheter.



Fig. 1.66. Insert the over-the-needle catheter through the skin at a 30° to 45° angle. Once the needle is under the skin, palpate the arterial pulse again and direct the needle into the artery using very small movements. Watch carefully for a flash of blood in the catheter hub. Unlike venous catheterization, there is no “pop” felt as the catheter passes through the thick vessel wall.



Fig. 1.67. Once a flash of blood is observed in the catheter hub, feed the catheter off of the stylette into the artery.



Fig. 1.68. Remove the stylette. Arterial blood should flow in a pulsatile manner. A gauze 4 x 4 can be placed under the site to keep the area clean.



Fig. 1.69. Secure the catheter in place with a length of ½-inch white tape. Flush the catheter immediately with heparinized saline.



Fig. 1.70. Secure the arterial catheter in place with additional lengths of 1-inch white tape, similar to venous catheters.

Helpful hint: Make sure that the catheter hub and skin are completely dry, so that the tape will securely attach to the catheter hub. If the catheter hub is wet, the catheter will spin around and will not remain in place.



Fig.1.71. Attach a heparinized t-port to the arterial catheter.

(a)



(b)



Figs. 1.72a–b. Clearly label the arterial catheter, and also mark “not for IV infusion.”

VASCULAR CUTDOWN

Introduction

In small animal patients with severe hypovolemia, dehydration, and hypotension, percutaneous vascular access may be difficult or impossible. Surgical cutdown allows direct visualization of the vein for ease of catheter placement. Vascular cutdown is usually performed in emergency situations. Although sterile technique should be maintained at all times, the risk of introducing bacteria into the patient's vessel is great. For this reason, the cutdown should be performed only in emergencies, and then, the catheter changed to a percutaneously placed catheter as soon as the patient's intravascular blood volume and blood pressure have normalized.

Supplies Needed

Electric clippers and blades
Antimicrobial scrub solution
Sterile gauze 4 x 4 squares
Sterile gloves
Sterile surgical pack
- Scalpel handle
- Number 11 scalpel blade
- Field towels
- Towel clamps
- Tissue forceps
- Mosquito hemostats
- Metzenbaum scissors
- Needle holders

3–0 absorbable suture
14- to 18-gauge long through-the-needle or over-the-needle peripheral catheter
Heparinized saline flush solution
T-port connector or male adapter
Cotton roll gauze
Kling
Vetrap bandaging material

Indications

Catheterization of vessel in patients with extreme hypotension peripheral vasoconstriction or obesity where percutaneous vascular access is not possible
Infusion of crystalloid or colloid fluids
Infusion of blood products
Infusion of drugs
Obtain blood samples

Contraindications

Abrasion, burn, or pyoderma over catheter site
Direct percutaneous catheterization is possible

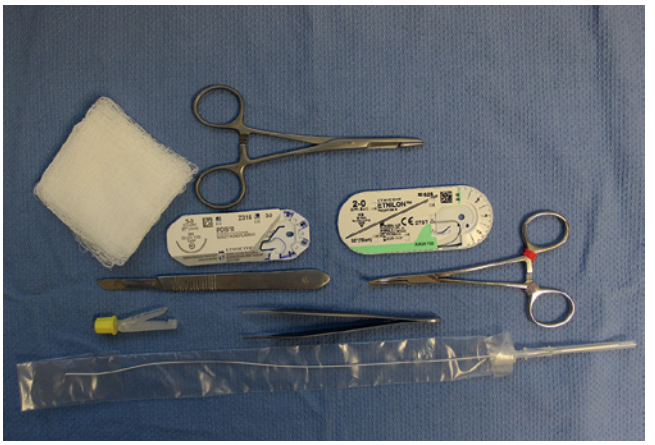


Fig. 1.73. Supplies needed for vascular cutdown



Fig. 1.74. After clipping the fur and aseptically scrubbing the clipped area, drape the surgical site with sterile field towels.



Fig. 1.75. Tent the skin over the site of proposed vascular catheterization. Incise the skin using a number 11 scalpel blade.

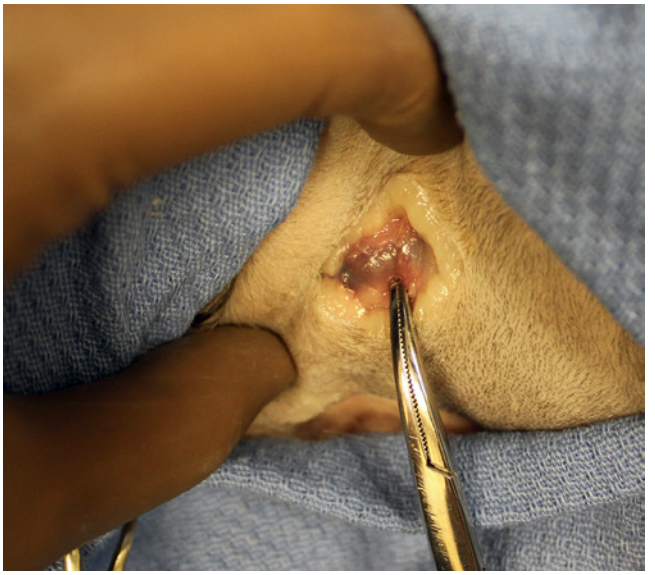


Fig. 1.76. Visualize the vessel under the skin incision.

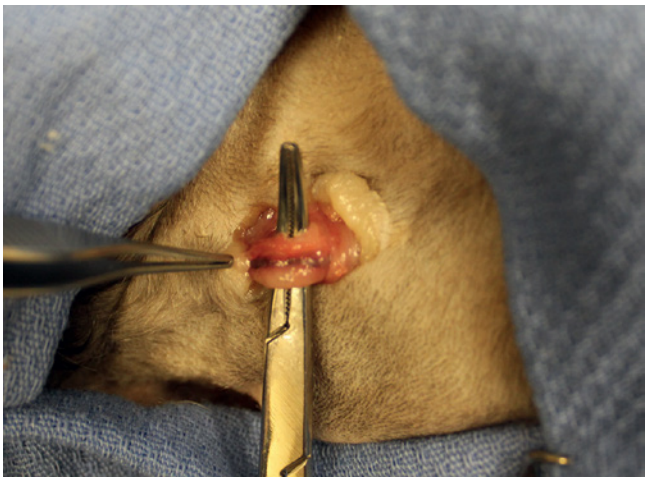


Fig. 1.77. Bluntly dissect the fascia over the vessel using a curved mosquito hemostat, then insert the hemostat under the vessel.

Helpful hint: Make sure that all of the fascia is dissected away from the vessel, or else attempts at placing the catheter into the vessel will be difficult.

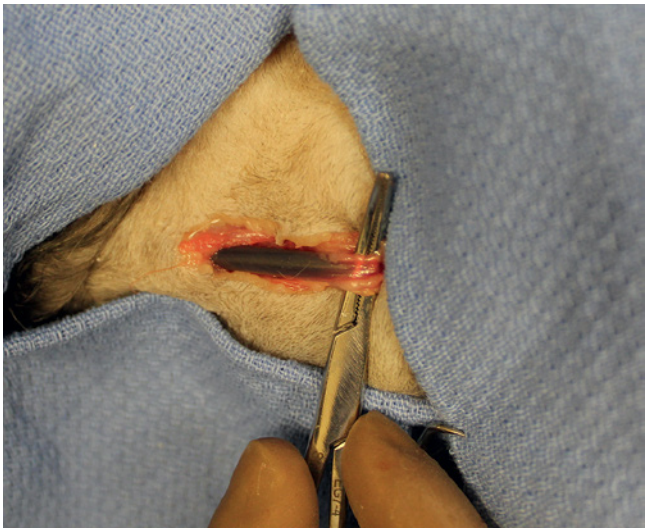


Fig. 1.78a. Lift the vessel to the skin surface.

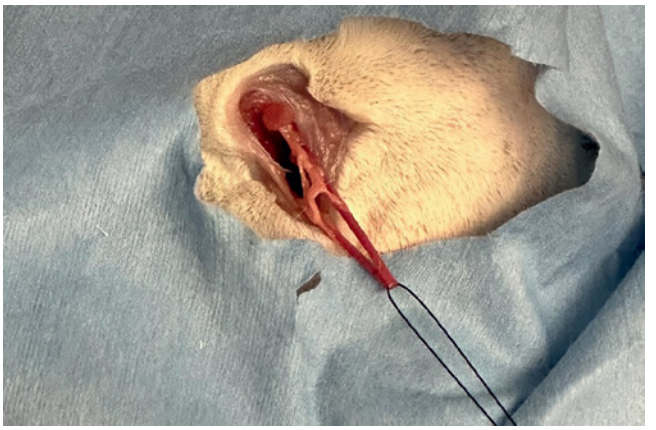


Fig. 1.78b. Absorbable stay sutures can be used to help elevated the vessel to the skin surface, as is shown in this cat jugular vein.



Fig. 1.79a. A catheter introducer can be used to help guide a catheter into an exposed vessel.

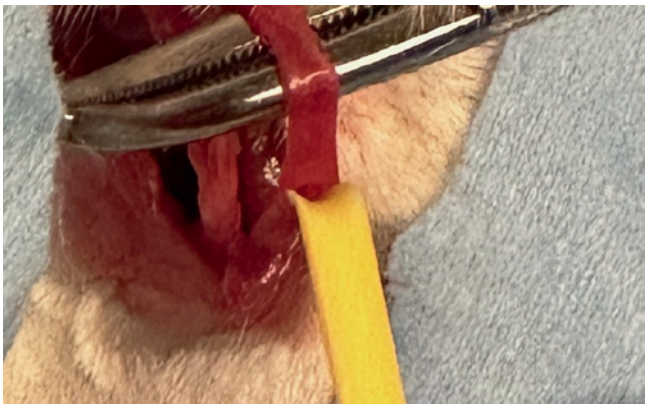


Fig. 1.79b. After carefully making a small nick incision in the vessel with a number 11 scalpel blade, insert the sharp point of the catheter introducer into the vessel, and use as a guide to insert the catheter into the vessel. This is useful for through the needle catheters.

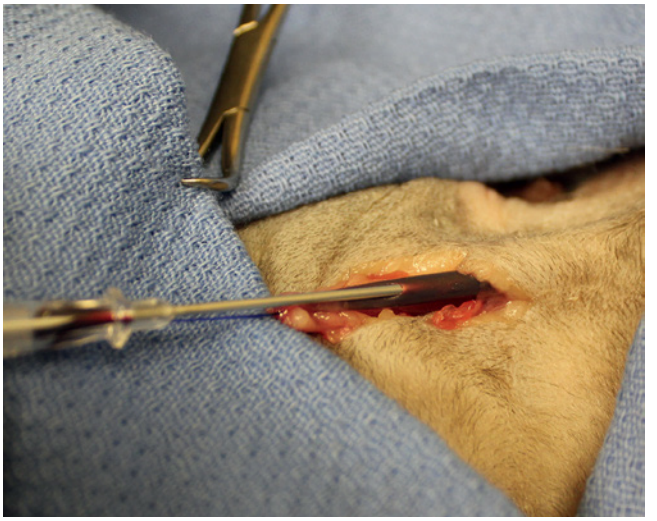


Fig. 1.80. With the vessel raised to the skin surface, gently puncture the vessel with the needle, then insert the needle for an over-the-needle, or in this case, a through-the-needle catheter into the vessel. Watch for a flash of blood in the hub of the catheter.



Fig. 1.81. Insert the catheter through the needle into the vessel.

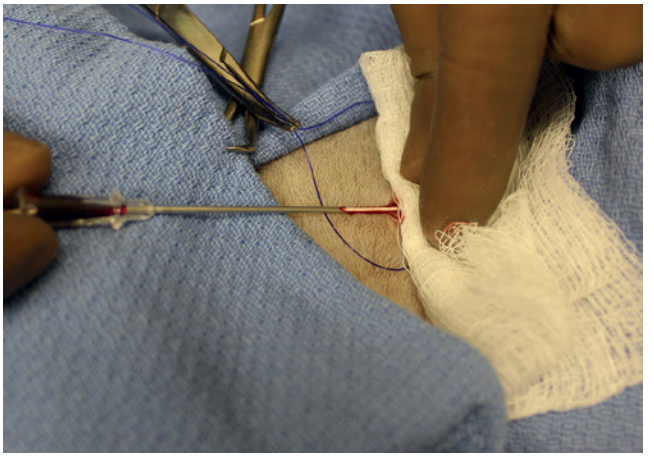


Fig. 1.82. Pull the needle off of the catheter. Do not let go of the catheter.

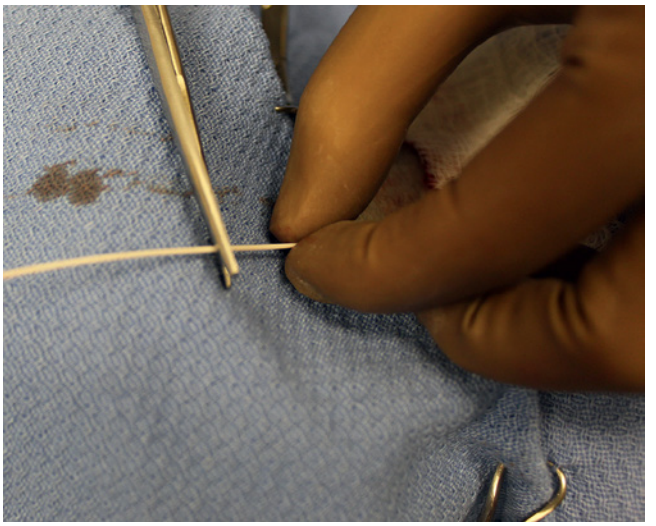


Fig. 1.83. For this type of catheter, cut the proximal end of the catheter to size using a sterile scissors. Leave room for placing the clam-shell adapter to the catheter.

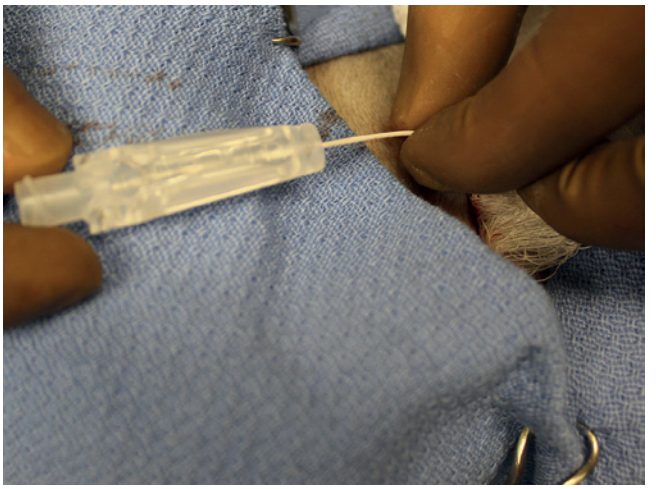


Fig. 1.84. Insert the proximal end of the catheter to the clam-shell adapter to the needle according to manufacturer's instructions. Next, attach a male adaptor or t-port flushed with heparinized saline to the luer-lock of the catheter.

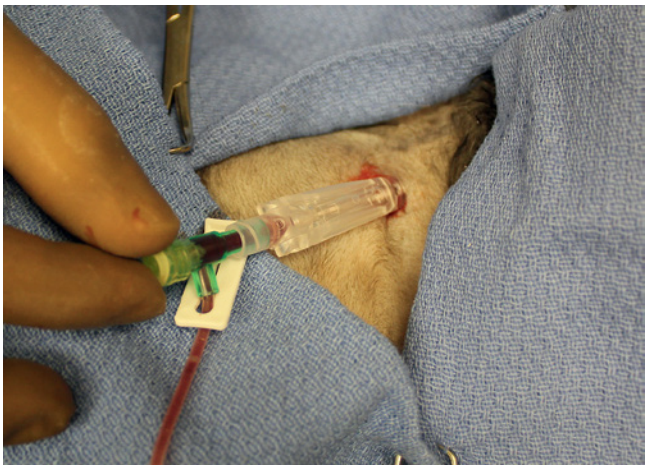


Fig. 1.85. Attach a t-port and flush the catheter with heparinize saline. Note: The catheter can then be taped in place. Suture the skin incision over the catheter using nonabsorbable sutures, then place a bandage over the catheter site. As vascular cutdowns are often performed in the most critically ill emergent patients where time is essential and sometimes sterility is not ideal, the catheter should be replaced with a percutaneous catheter, once the patient is more hemodynamically stable.

INTRAOSSEOUS CATHETERIZATION

Introduction

The most common need for intraosseous catheterization is for administration of crystalloid and colloid fluids, blood products, and drugs to pediatric or very small mammals or exotic species when vascular access is not possible. Any fluid, including blood products and parenteral nutrition, can be infused through an intraosseous catheter. Although intraosseous catheters are well-tolerated, the needle or catheter traverses the periosteum, making intraosseous catheters somewhat uncomfortable; therefore, the intraosseous catheter should be changed to a venous catheter whenever possible.

Supplies Needed

Electric clipper and blades
Antimicrobial scrub solution
Lidocaine 2%
1- to 3-mL syringe and 22 gauge needle
3-mL syringe with heparinized 0.9% saline flush solution
Number 11 scalpel blade
16- to 18-gauge bone marrow needles or spinal needles with stylette
20- to 22-gauge hypodermic needles
½- to 1-inch white tape
T-port or male adapter flushed with heparinized 0.9% saline flush solution
3–0 nylon suture
Optional Supplies: EZ-IO® device and catheter

Indications

Infusion of crystalloid and synthetic colloid fluids, and blood products
Infusion of drugs
Infusion of parenteral nutrition
When vascular access is not possible

Contraindications

Pyoderma or abrasion over site of intraosseous catheter placement
Ambulatory patients, as intraosseous catheter can become dislodged
When vascular access is possible

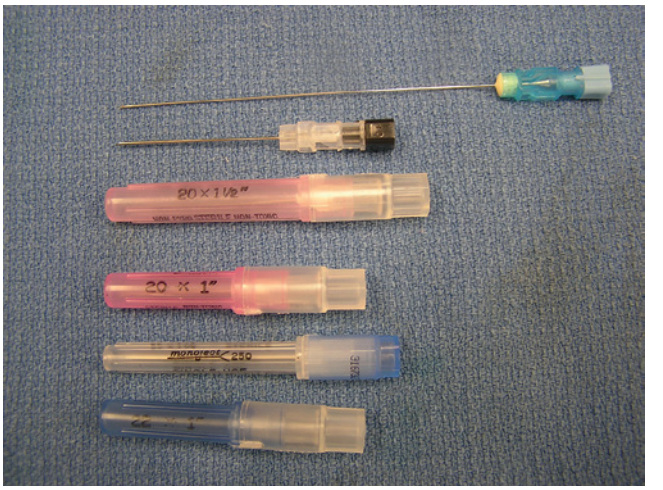


Fig. 1.86. Supplies needed for intraosseous catheterization.

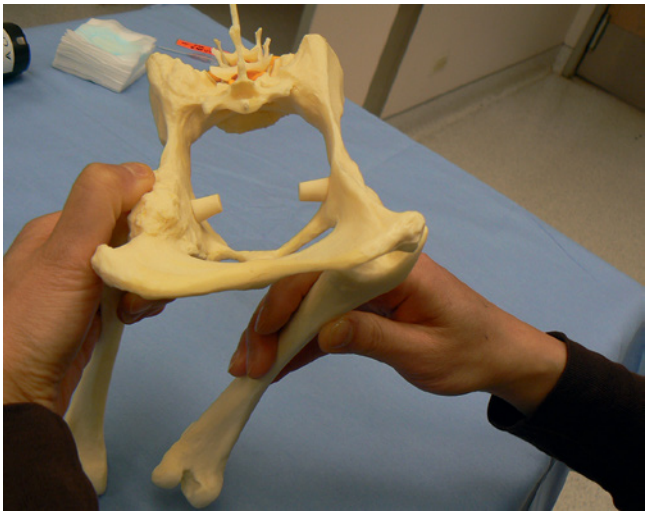


Fig. 1.87. Abduct the femur such that the stifle is pushed medially and the coxofemoral joint is open. This allows palpation of the intertrochanteric fossa of the proximal femur and allows the sciatic nerve to move out of the way of intraosseous catheter placement.

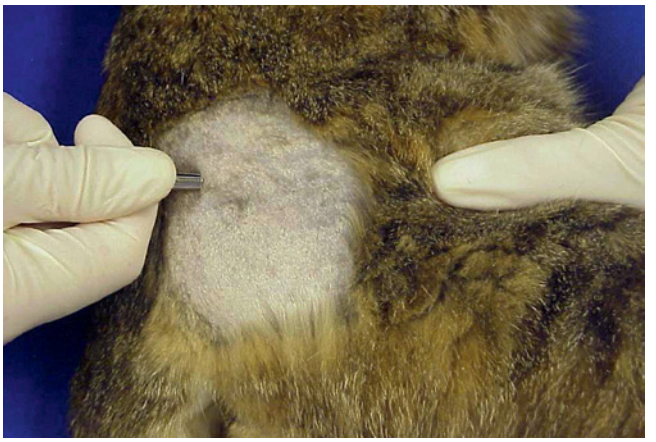


Fig. 1.88. Palpate the greater (major trochanteric fossa of femur). The intertrochanteric fossa drops off medially from the greater trochanter. Place a bleb of 2% lidocaine through the skin to the level of the periosteum. Insert the spinal or hypodermic needle through the skin into the intertrochanteric fossa. Once the needle is against the periosteum and bone at the bottom of the intertrochanteric fossa, push the needle in parallel with the femur. Use a simultaneous pushing and twisting motion to seat the needle into the medullary cavity. In larger animals, a stab incision can be made using a number 11 scalpel blade before insertion of the intraosseous needle to prevent tissue drag.

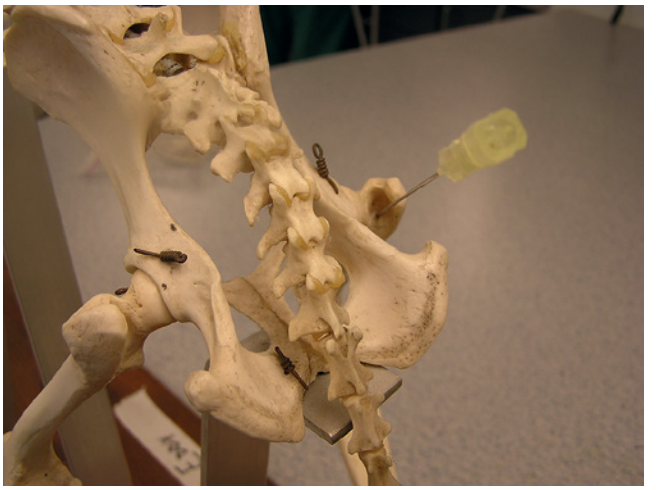
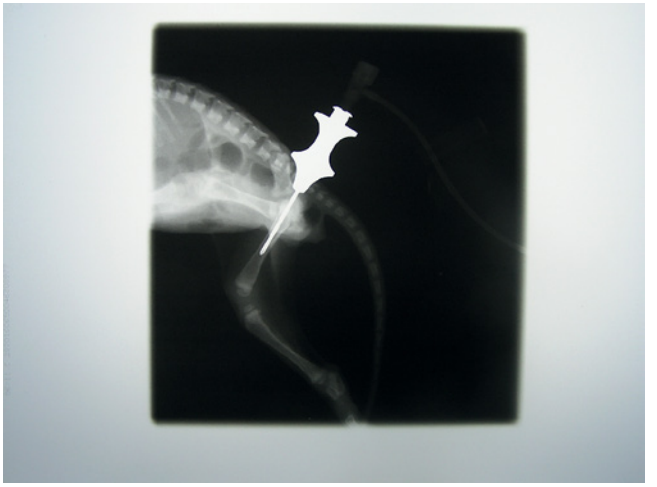


Fig. 1.89. Spinal needle placed into the intertrochanteric fossa of the femur in a skeleton model.

(a)



(b)



Figs. 1.90a–b. Once the needle is in the correct position, infuse a small amount of sterile 0.9% saline. The saline should flow freely. Check the placement of the intraosseous catheter with AP and lateral radiographs.

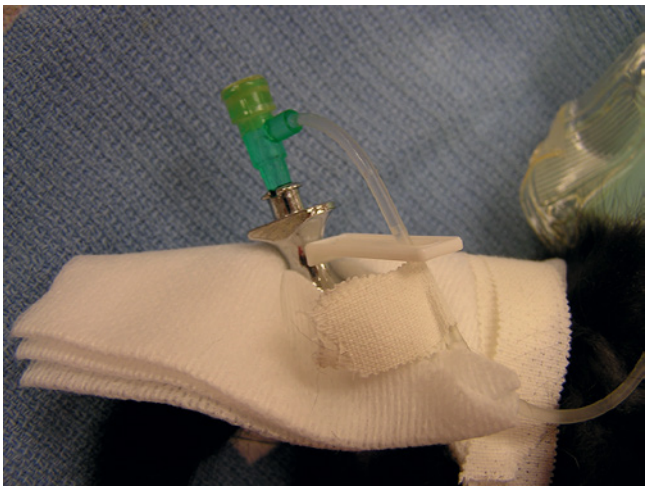


Fig. 1.91. Secure a piece of ½- or 1-inch tape around the hub of the catheter and the male adapter, secure tape around the body. Alternatively, make wings of white tape can be secured to the skin at the base of the catheter hub.



Fig. 1.92. Patients will tolerate the intraosseous (IO) catheter quite well.

Helpful hint: As soon as the patient is ambulatory and vascular access can be obtained, place an intravenous catheter and remove the intraosseous catheter.

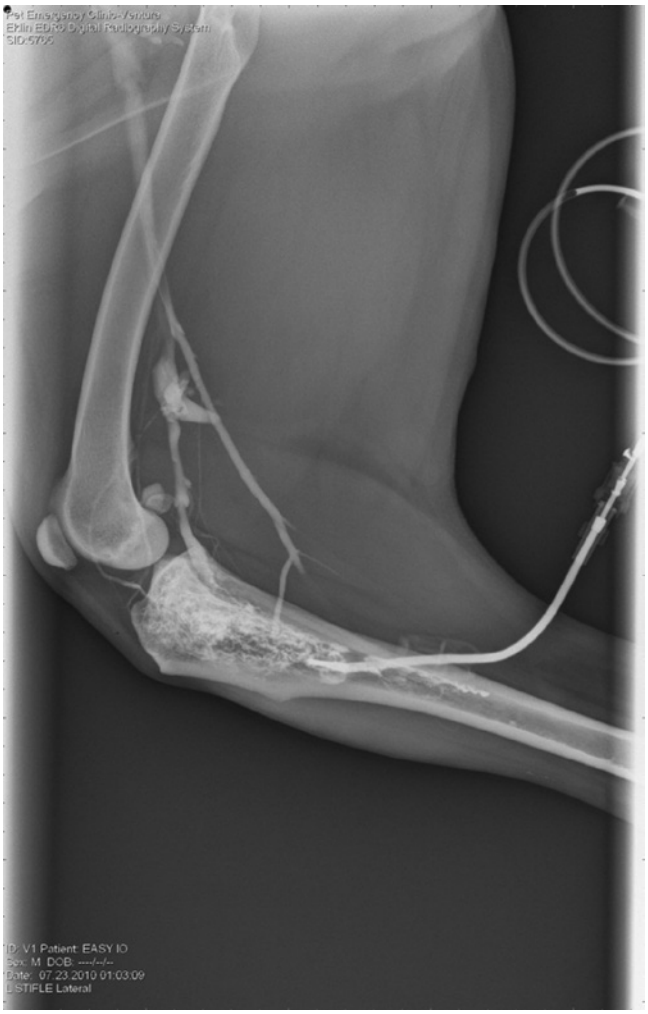


Fig. 1.93. Radiograph demonstrating immediate movement of iodinated contrast media into peripheral circulation as it is infused through the intraosseous catheter into the proximal tibia. Courtesy of Dr. Steve Mensack.

PLACEMENT OF INTRAOSSEOUS CATHETER PLACEMENT IN THE HUMERUS

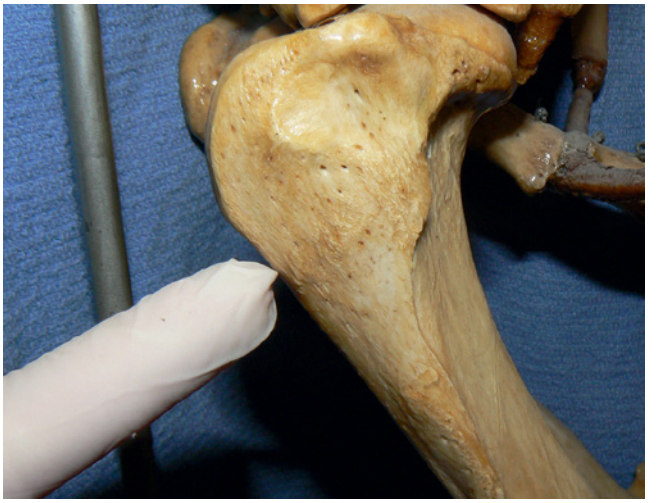


Fig. 1.94. Greater tubercle of the proximal humerus on a skeleton.



Fig. 1.95. Palpate the greater tubercle of the humerus.

Helpful hint: It is often necessary to flex and extend the shoulder several times to palpate the scapulohumeral joint, and then palpate the greater tubercle of the humerus.



Fig. 1.96. Infiltrate through the skin and underlying fascia to the level of the periosteum with 2% lidocaine (1 mg/kg).



Fig. 1.97. Make a small nick incision through the skin with a number 11 scalpel blade.



Fig. 1.98. Insert the IO catheter/Jamshidi IO needle device through the skin.



Fig. 1.99. Bend the limb such that the distal humerus/elbow is almost at a 90° angle to the scapulohumeral joint
Place the nondominant hand on the elbow, and the dominant hand on the IO. Push the IO catheter into the greater tubercle of the humerus, pushing with a simultaneous twisting motion.



Fig. 1.100. Once the catheter is seated in place in the marrow cavity, remove the internal stylette.



Fig. 1.101. Flush the catheter with sterile 0.9% saline solution. If seated properly, the flush will be easy, with minimal resistance.

INTRAOSSEOUS CATHETERIZATION USING THE EZ-IO DEVICE

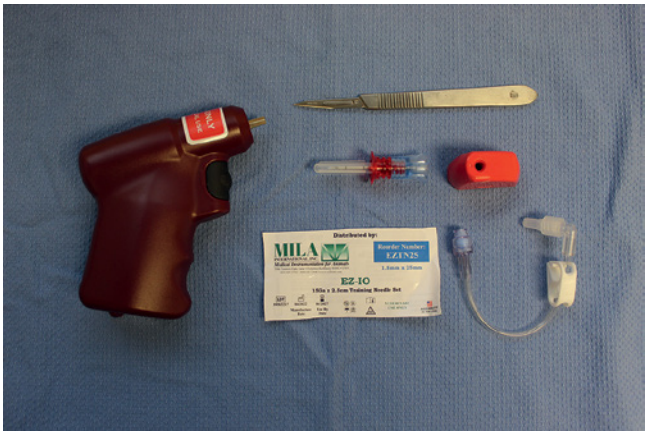


Fig. 1.102. Set-up for intraosseous catheterization using the EZ-IO device. The EZ-IO device is essentially a drill equipped with a disposable metal intraosseous catheter.



Fig. 1.103. Place patient in lateral recumbency, then clip and aseptically scrub the medial aspect of the proximal tibia on the exposed limb.



Fig. 1.104. Infiltrate the skin and underlying fascia with a small bleb of 2% lidocaine.

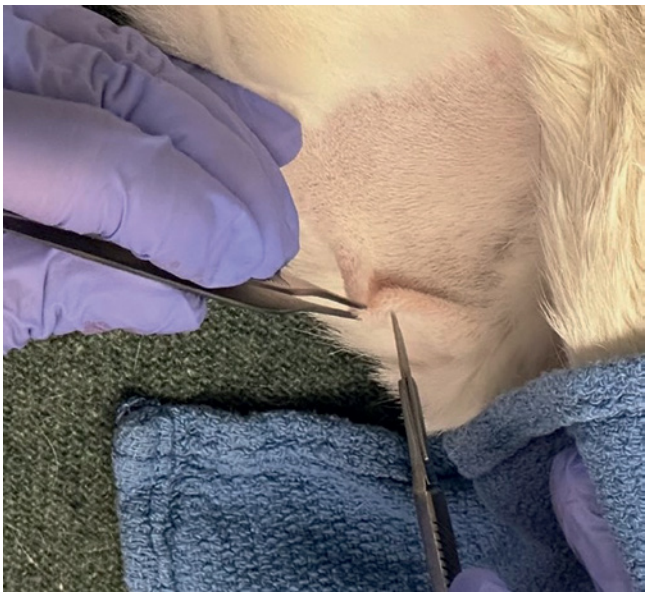


Fig. 1.105. Make a small nick incision over the proximal medial tibia through which the EZ-IO will be inserted.



Fig. 1.106. Palpate the flat portion of the proximal medial tibia and insert the EZ-IO catheter through the nick incision in the skin. Pushing the sharp end of the EZ-IO catheter against the periosteum of the bone while simultaneously engaging the drill apparatus until you no longer feel resistance.



Fig. 1.107. The EZ-IO catheter and stylette inserted in the proximal medial tibia.

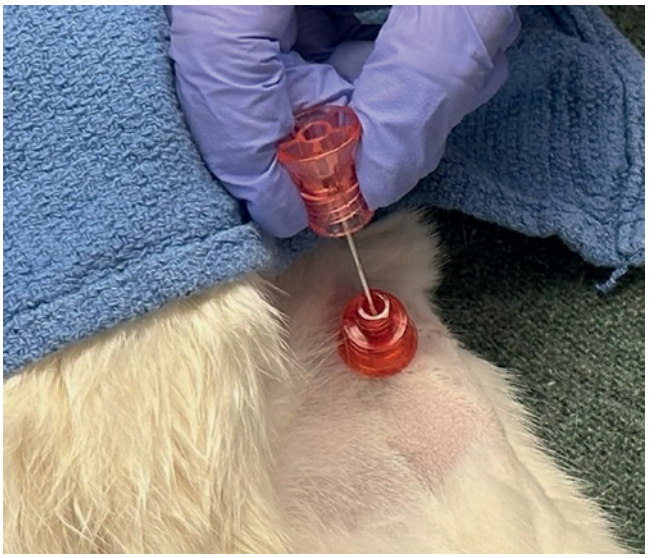


Fig. 1.108. Once the catheter is firmly inserted into the bone, remove the inner stylette from the EZ-IO catheter.



Fig. 1.109. Attach a t-port to the EZ-IO catheter and flush with sterile heparinized 0.9% saline.

THREE SYRINGE TECHNIQUE FOR BLOOD SAMPLE COLLECTION

The three-syringe technique is used for blood sample collection through peripheral short, long single-lumen sampling catheters, from multi-lumen or from arterial catheters. Depending on the size of the catheter and patient's intravascular volume status, the method can be successful at obtaining blood samples without the needle for percutaneous venipuncture.

Supplies Needed

3- to 6-mL syringe with 0.5-mL heparinized saline
Empty 1- to 12-mL syringe, depending on the volume of blood sample required
3- to 6-mL syringe filled with heparinized saline

Indications

Obtain venous or arterial blood samples for diagnostic testing without need for repeated venipuncture

Contraindications

Severe anemia
Catheter size precludes sample collection



Fig. 1.110. Supplies needed for blood sample collection using the three-syringe technique.



Fig. 1.111. Infuse 0.5 mL of heparinized saline into the catheter to flush the catheter. Using the same syringe, withdraw 3 mL of heparinized blood sample into the syringe. Save this sample in a sterile manner to give back to the patient.



Fig. 1.112. Use a second empty syringe, and withdraw the volume of nonheparinized blood required for diagnostic testing.



Fig. 1.113. Give the original heparinized sample back to the patient through a peripheral or central venous catheter. Flush that catheter with 1 to 3 mL of heparinized saline, and then clamp the t-port or reconnect intravenous fluids or other infusions to the catheter as indicated.

SUGGESTED READING

Hagley MJ, Hopper K, Epstein SE. Characteristics of arterial catheter use and related complications in dogs and cats in an intensive care unit. J Vet Emerg Crit Care 2021, 31(4):469–475.

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CHAPTER 2

Respiratory Emergencies: Thoracocentesis, Local Anesthesia for Rib Fracture, Management of Open Sucking Chest Wounds, and Thoracostomy Tube Placement

EMERGENCY AIRWAY ACCESS

Indications

Severe respiratory distress with upper airway obstruction and arytenoids cannot be visualized

Supplies Needed

Intravenous anesthesia
Gloves
Rigid polypropylene urinary catheter or red rubber catheter
Endotracheal tube
Tie gauze
Patient preparation: Place a peripheral cephalic catheter and induce general anesthesia with a rapidly acting anesthetic agent. Lubricate the eyes with ocular lubricant.

Drug	Dose (mg/kg)	Route of Administration
Alfaxalone	1–3	IV or IM
Ketamine	5.5–10	IV, with midazolam 0.5 mg/kg IV
Propofol	3–7	IV +/– midazolam 0.2–0.5 mg/kg IV

Veterinary Emergency and Critical Care Procedures, Third Edition. Timothy B. Hackett and Elisa M. Mazzaferro.
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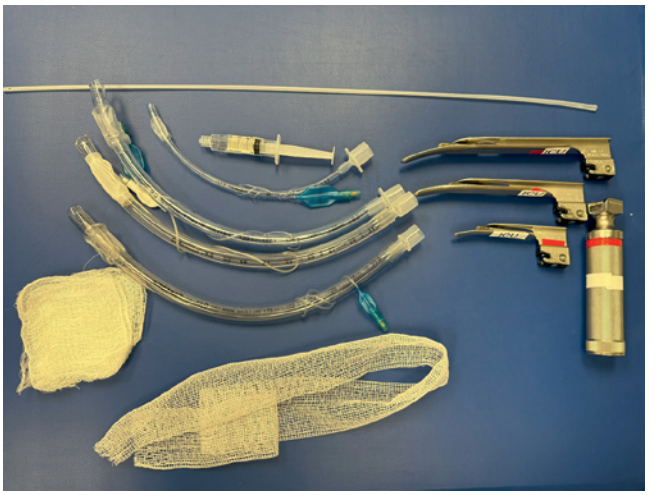


Fig. 2.1. Supplies needed for emergent airway intubation.

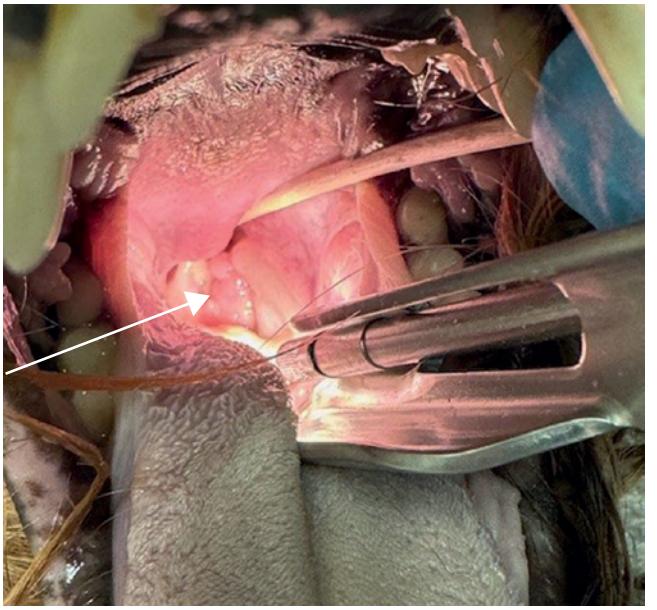


Fig. 2.2. The patient in the series of images had a firm but friable mass was affecting the left arytenoid cartilage in this patient, causing upper airway obstruction.

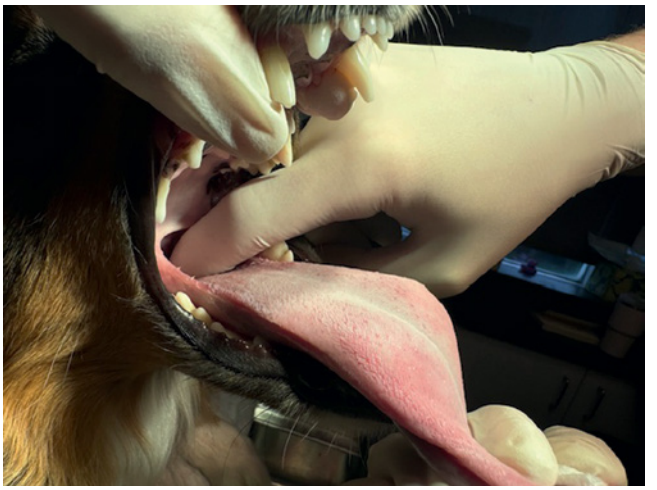


Fig. 2.3. Place the patient in sternal recumbency and insert your nondominant hand/fingers into the oral cavity to palpate in between the arytenoid cartilages at the most proximal portion of the airway.

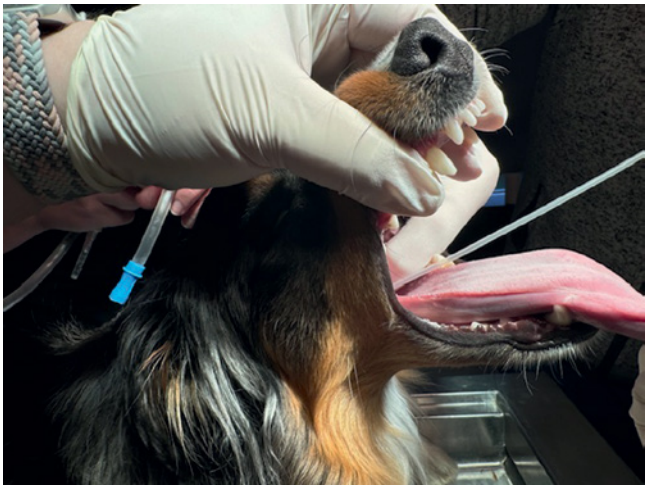


Fig. 2.4. Insert a rigid polypropylene catheter or red rubber catheter past your finger, through the middle of the space between the arytenoid cartilages, and into the trachea.

Helpful hint: The patient must be under complete intravenous anesthesia to prevent the handler from getting bitten. Suction may be required to remove debris, vomit or mucous from the caudal oral cavity.



Fig. 2.5. Cut the proximal end off of the polypropylene or red rubber catheter, and then pass an endotracheal tube over the polypropylene or red rubber catheter into the trachea.



Fig. 2.6. Remove the polypropylene or red rubber catheter once the endotracheal tube is placed into the trachea, then tie the tube in place.

TEMPORARY TRACHEOSTOMY TUBE PLACEMENT

Introduction and Indications

A temporary tracheostomy tube should be placed in cases of severe upper airway obstruction, trauma, or laryngeal or pharyngeal collapse, if long-term mechanical ventilation will be performed.

Supplies Needed

Sterile field towels (4)
Towel clamps (4)
Number 10 and number 11 scalpel blades
Scalpel handle
Small Gelpi retractors (2)
Sterile Metzenbaum scissors
Kelly hemostats (1, curved)
Sterile gauze, 4 x 4 inch squares
3–0 or 2–0 nonabsorbable nylon suture
Various sized tracheostomy tubes
Umbilical tape
Electric clippers and blades
Antimicrobial scrub
Sterile gloves

Contraindications

Tracheal injury
Tracheal obstruction distal to tracheostomy site

Patient Preparation

Place the patient under general anesthesia with a cuffed endotracheal tube in place. Difficult intubation may require placement of sterile polypropylene catheter into the trachea blindly by feeling in between arytenoid cartilages or placement of a Cook airway exchanger to allow sufficient oxygenation while the temporary tracheostomy tube is being placed. Place the patient in dorsal recumbency in a v-trough, and then clip the ventral cervical region from the ramus of the mandible caudally to the thoracic inlet and dorsally to the level of the epaxial muscles. In patients with long fur, clip the long fur short to ensure and maintain sterility of the surgical field and tracheostomy site. Make sure that the patient's position is not rotated. In some cases, the neck may need to be extended dorsally over a rolled towel, to push the trachea to the level of the skin.



Fig. 2.7. Setup for tracheostomy tube placement includes sterile drape material, towel clamps, two small Gelpi retractors, scalpel handle, numbers 10 and 11 scalpel blade, curved Kelly hemostat, Metzenbaum scissors, needle holder, thumb forceps, 2–0 or 0-suture material, and the tracheostomy tube.

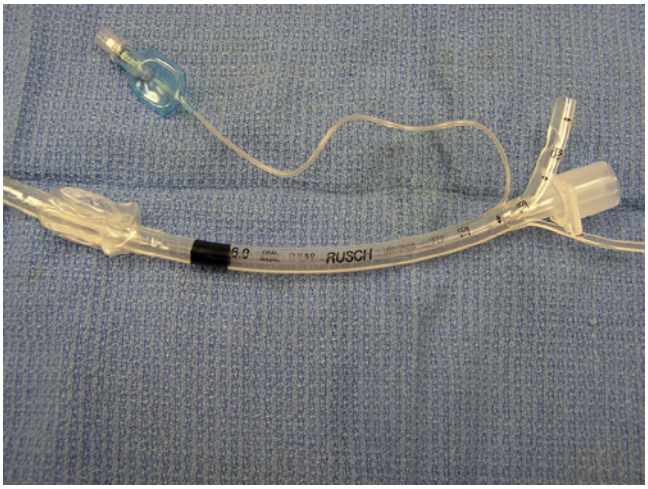


Fig. 2.8. If a prefabricated tracheostomy tube is not available, a tracheostomy tube can be made from a low-pressure cuffed endotracheal tube. To create a tracheostomy tube from an endotracheal tube, temporarily remove the female end adapter on the proximal end of the tube, and cut the proximal end of the tube proximally to size. Avoid cutting the tube required for insufflation of the balloon cuff. The sides of the endotracheal tube can be cut such that flaps are created that can be secured to lengths of umbilical tape to secure the tube in and around the neck. Reinsert the female adapter into the cut end of the endotracheal tube.

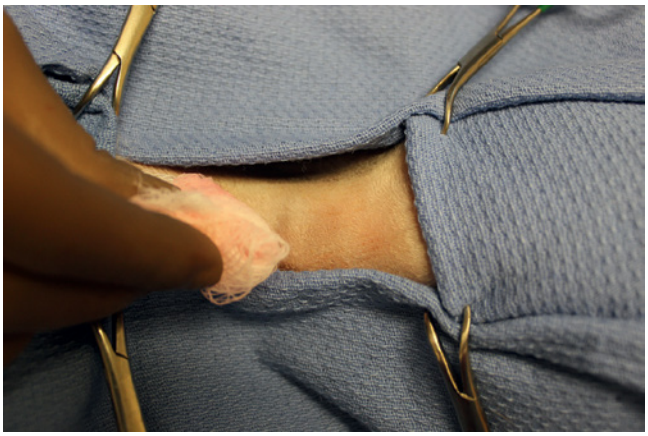


Fig. 2.9. Drape the sterile field with sterile drapes secured with towel clamps. Aseptically scrub the clipped area.

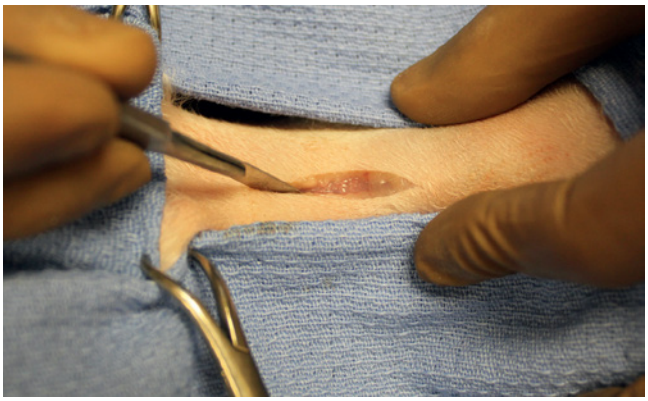


Fig. 2.10. Make a vertical skin incision over the trachea caudal to the larynx using a number 10 scalpel blade.

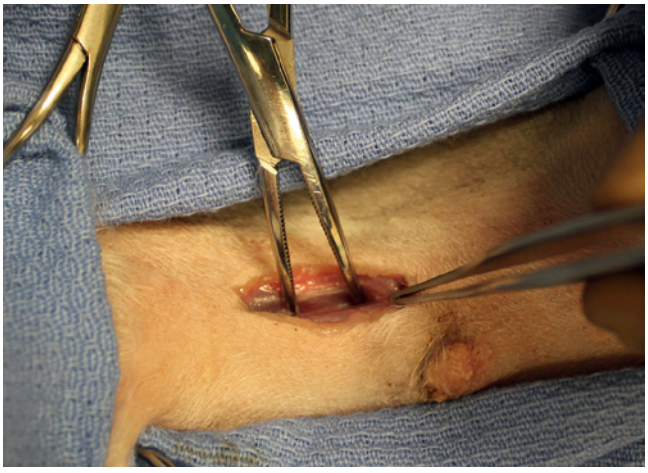


Fig. 2.11. Bluntly dissect the underlying fascia and sternohyoid muscles over the trachea using a curved Kelly hemostat until the trachea is exposed and visible. Use care to continue blunt dissection in one area to avoid shredding the sternohyoid muscle into strands.

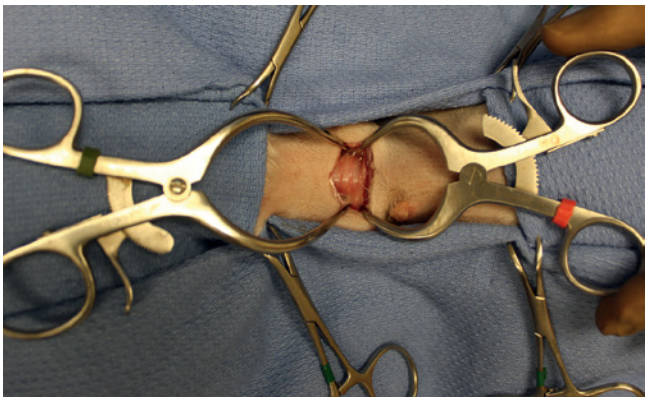


Fig. 2.12. Once the trachea is visible, secure small Gelpi retractors around the skin, underlying fascia and sternohyoid muscles to maintain visibility of the trachea.

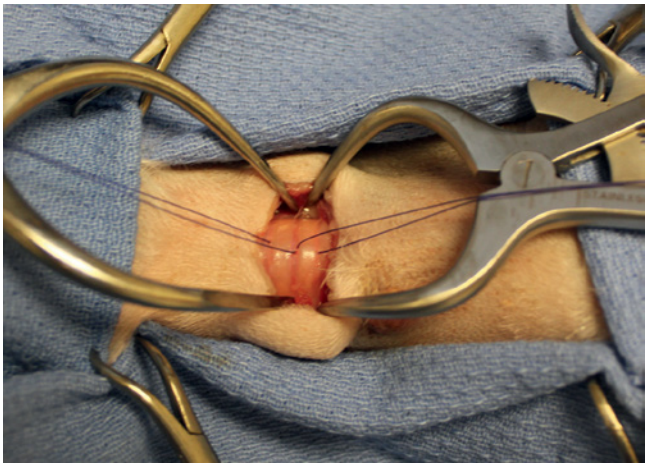


Fig. 2.13. Place two sutures around adjacent tracheal rings. Prior to placement of the stay sutures, have an assistant deflate the cuff of the endotracheal tube, if present.

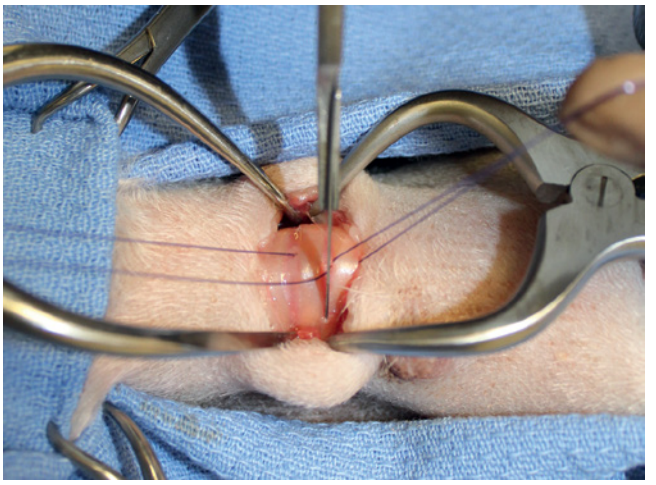


Fig. 2.14. Make a small incision in between tracheal rings. Take care to avoid cutting the stay sutures or small vessels, where bleeding can obscure visualization of the surgical site. Never cut more than 50% of the circumference of the trachea.

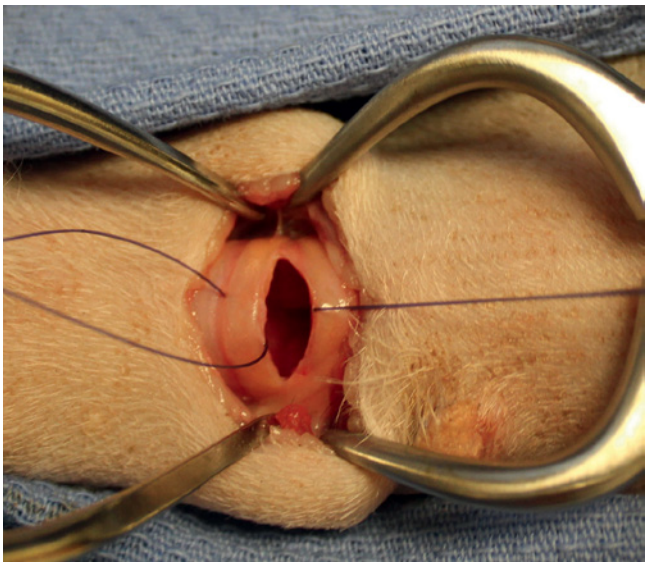


Fig. 2.15. Have an assistant remove the endotracheal tube. The tracheostomy site is now visible.

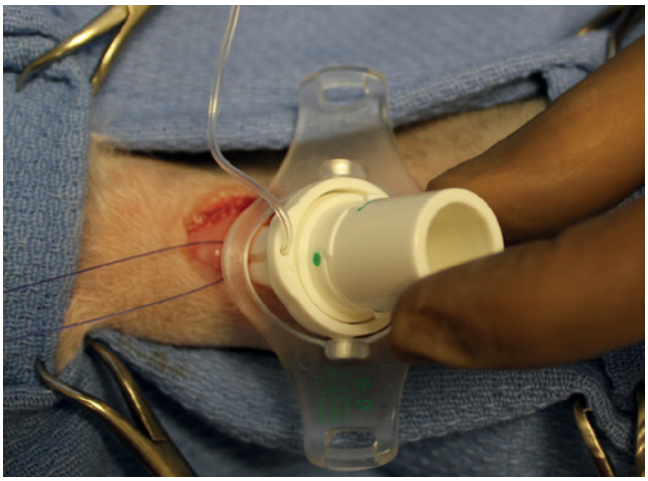


Fig. 2.16. Insert the tracheostomy tube and (internal obturator, if present) into the tracheostomy site, pulling the hole open by retracting the cranial and caudal stay sutures in opposite directions.

Helpful hint: Some prefabricated tubes also have an internal obturator with a rounded end that helps facilitate placement of the tracheostomy tube into the trachea.

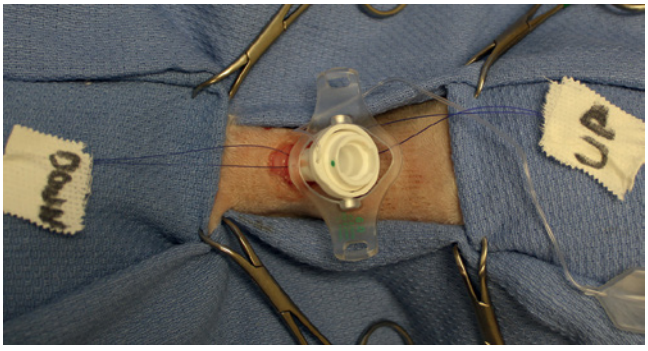


Fig. 2.17. If present, remove the internal obturator and replace with an inner cannula.



Fig. 2.18. Label the stay sutures “Up” and “Down” to identify each, in the event of tracheostomy tube occlusion or removal, the patient’s tracheostomy site can be quickly held open using the stay sutures.

Helpful hint: Larger prefabricated tracheostomy tubes have internal cannula that can be removed for ease of cleaning without need for removal of the entire tracheostomy tube if the tube becomes clogged with blood or mucus debris.

TRACHEOSTOMY TUBE CARE

The goal of tracheostomy tube is to maintain a patent airway until the cause of airway obstruction has been alleviated. Therefore, once a temporary tracheostomy tube has been placed, it is imperative that the patient remain hospitalized and observed 24 hours a day, due to the risk of dislodgement or obstruction of the tube, both of which can cause recurrence of airway obstruction. The steps involved in maintaining a temporary tracheostomy tube are as follows:

(1) Evaluate the patient at defined regular intervals. Note that more frequent interventions may be needed if the tube becomes dislodged or if the inner cannula of the tube becomes obstructed with blood or mucous debris.
(2) Preoxygenate the patient with flow-by oxygen at the tracheostomy tube entrance site prior to scheduled tracheostomy tube hygiene.
(3) Have all supplies needed for tracheostomy tube maintenance nearby and readily available at all times. Aseptic technique is absolutely essential to prevent iatrogenic introduction of bacteria into the patient's airway.
(4) Gently clean the lateral and ventral skin surrounding the tracheostomy site with an antimicrobial scrub solution and sterile water as needed to prevent moist dermatitis.
(5) Wearing sterile gloves, remove the inner cannula, if present, and replace with a new clean sterile cannula. (If the tracheostomy tube does not have an inner and outer cannula, skip this step.)
(6) Instill 0.5 to 3 mL of sterile saline into the tracheostomy tube, then introduce a sterile suction catheter into the tracheostomy tube and trachea to withdraw the fluid. Airway humidification can also be provided by having 10-minute sessions of nebulized sterile saline every 4 hours.
(7) If an inner cannula is present, following its removal, soak the tube in a sterile bowl with hydrogen peroxide diluted with sterile water or sterile 0.9% saline. The hydrogen peroxide will help break down debris.
(8) Next, scrub the debris from the cannula using a sterile small bottle brush or sterile pipe cleaners.
(9) Rinse the debris and hydrogen peroxide solution off of the tube,
(10) Place the tube in a sterile bowl filled with dilute antimicrobial solution (not scrub) such as chlorhexidine until needed.
(11) Rinse the antimicrobial solution off of the inner cannula prior to replacing it into the tracheostomy site.

THORACOCENTESIS

Introduction

Thoracocentesis can be both diagnostic and therapeutic in patients with pneumothorax or pleural effusion with respiratory distress. Thoracocentesis should be considered in any patient with respiratory distress and a short, choppy, shallow restrictive respiratory pattern. Conditions that can cause a restrictive respiratory pattern that can be improved with thoracocentesis include pleural effusion and pneumothorax. Thoracic auscultation in these cases usually reveals dull muffled heart and lung sounds when intrathoracic, extrapulmonary fluid or air are present. Other causes of restrictive respiratory pattern such as pain from rib fracture, flail chest, pulmonary contusions, pneumonia, pulmonary edema, and lower airway disease should be considered prior to thoracocentesis, or if thoracocentesis is unrewarding.

Supplies Needed

Electric clippers and blades
Antimicrobial scrub solution
Nonsterile gloves
20- to 22-gauge 1-inch needles
Three-way stop-cock
IV extension tubing
30- or 60-mL syringe
Collection basin for fluid
EDTA and red-topped tubes
Sterile culturettes
Port-A-Cul™ for bacterial culture

Indications

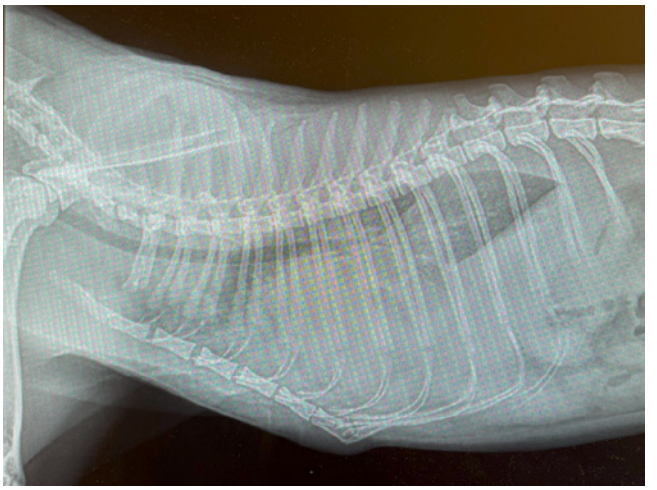
Diagnosis and management of:
Pleural effusion
- Chylothorax
- Feline infectious peritonitis
- Hemothorax
- Inflammatory fluid
- Neoplastic effusion
- Right-sided congestive heart failure
- Pyothorax

Pneumothorax

Caution and Contraindications

Caution must be exercised when draining chronic pleural effusions because fibrinous adhesions of the lung to the pleura can occur. In such cases, fluid may be pocketed and difficult to obtain without the use of an ultrasound, and iatrogenic pulmonary puncture can occur.

(a)



(b)



Figs. 2.19a–b. VD and lateral thoracic radiographs of a cat with pleural effusion.



Fig. 2.20. Provide flow-by or mask oxygen to the patient.

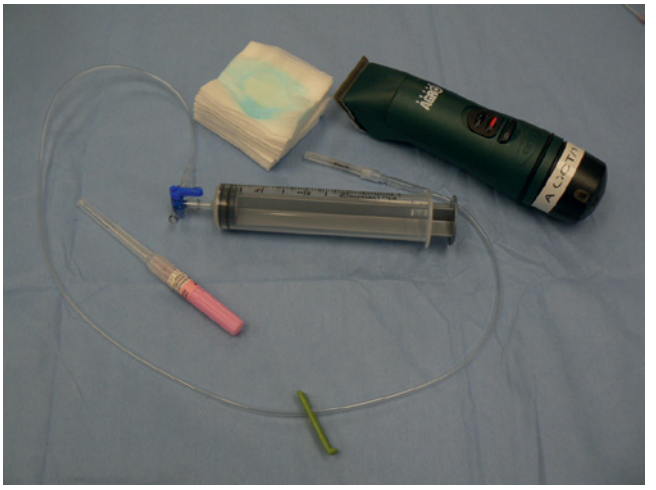


Fig. 2.21. Supplies needed for thoracocentesis.



Fig. 2.22. Point-of-care ultrasound can be useful in detecting pockets of pleural effusion.



Fig. 2.23. Ultrasound image of thorax with echogenic pleural effusion. The black area is fluid surrounding collapsed lung and fibrin (gray).

(a)



(b)



Figs. 2.24a–b. Clip a square in the middle of the thorax, then aseptically scrub the clipped area.



Fig. 2.25. The bevel of the needle is the slanted, open area of the needle tip through which fluid and air can be aspirated. The bevel should be directed up (dorsally) to remove air and down (ventrally) to remove fluid.

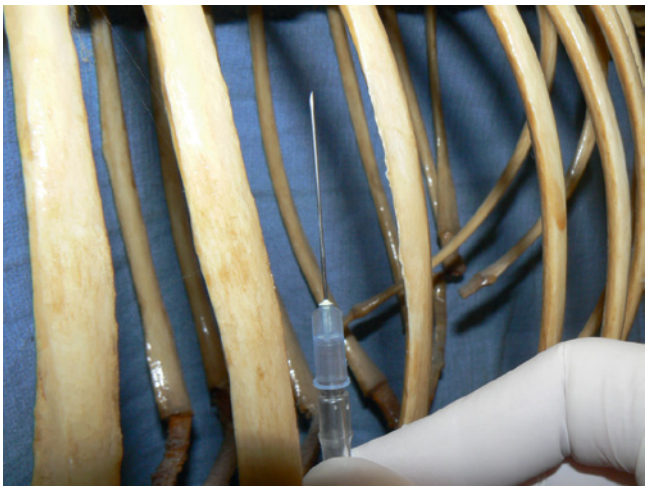


Fig. 2.26. Schematic of a canine thorax/skeleton showing the bevel of the needle. Find the bevel of the needle. Mark the hub of the needle or intravenous extension tubing in line with the bevel. This will allow the bevel of the needle to be rotated toward the center of the patient as the needle is inserted through the skin, perpendicular to the body wall.

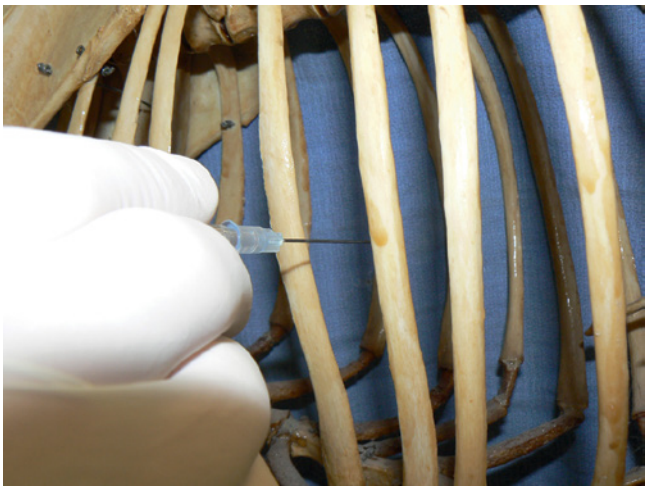


Fig. 2.27. Insert the needle through the skin and intercostal muscles in the center of the square that you have clipped and scrubbed.

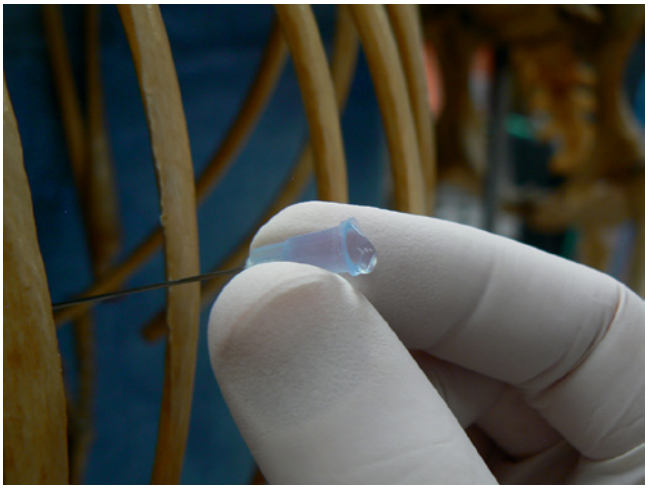


Fig. 2.28. Insert the needle in between rib spaces in the center of the clipped area. Alternatively, place a drop of sterile water or sterile 0.9% saline in the hub of the needle, then insert the needle perpendicularly in between rib spaces. Once the needle has entered the pleural space, the hanging drop of water or saline will be sucked into the needle and pleural cavity.

(a)



(b)



Figs. 2.29a–b. Inserting the needle into the pleural space of a cat and dog.



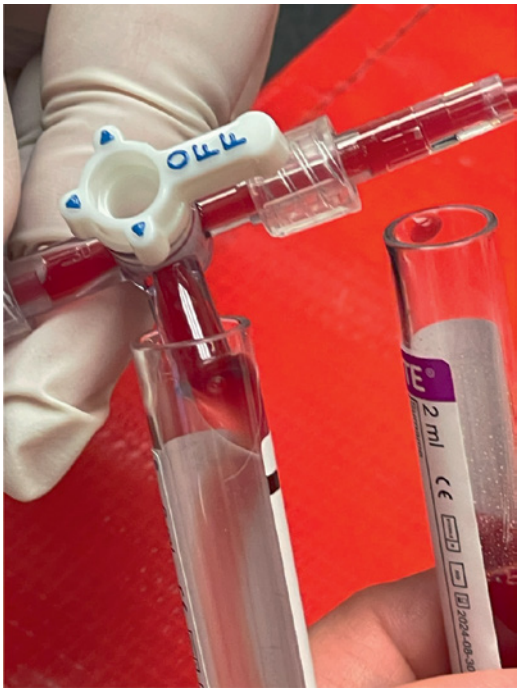
Fig. 2.30. Once the needle is inserted into the pleural space direct the needle parallel with the body wall to avoid iatrogenic lung puncture or laceration. The needle can be pivoted like the hands of a clock, such that the needle always stays parallel with the body wall. The bevel of the needle should be directed dorsally to obtain air and ventrally to obtain fluid.

Helpful hint: You may insert the needle directly into the epaxial muscles if you attempt to insert the needle too far dorsally on the thoracic wall. Inserting the needle into the center of the shaved box, then sweeping the bevel dorsally will increase your chances of a positive tap in cases of pneumothorax. Attach the male port of the length of intravenous extension tubing to the hub of the needle. Never let go of the needle.



Fig. 2.31. Have an assistant withdraw fluid or air from the pleural space.

(a)



(b)



Figs. 2.32a–b. Save fluid in plain and EDTA tube for cytology and analysis. Samples can also be used for aerobic and anaerobic culture if pyothorax is suspected. The remainder of fluid sample can be collected into a bowl or graduated cylinder for measurement.

MANAGEMENT OF AN OPEN SUCKING/PENETRATING CHEST WOUND

Introduction

Thoracic wounds secondary to blunt or penetrating trauma are a life-threatening emergency that must be treated immediately. Pneumothorax and secondary hypoxemia cannot resolve without restoring negative intrapleural pressure to allow lung expansion. This requires a tight seal over the wound, preventing communication of the atmospheric air with the pleural space. Once the thoracic wound has been sealed, thoracocentesis and thoracostomy tube placement can be performed to allow expansion of the lungs. Once the animal is stable, definitive wound management and repair can be performed.

Supplies Needed

Electric clippers and blades
Sterile lubricant gel or antimicrobial ointment
Sterile surgical gloves
Sterile scissors
Cotton roll gauze
Kling®
Elasticon® or Vetrap®

Indications

Penetrating or blunt trauma to the thorax, with open communication through the wound into the pleural space

Contraindications

Tension pneumothorax

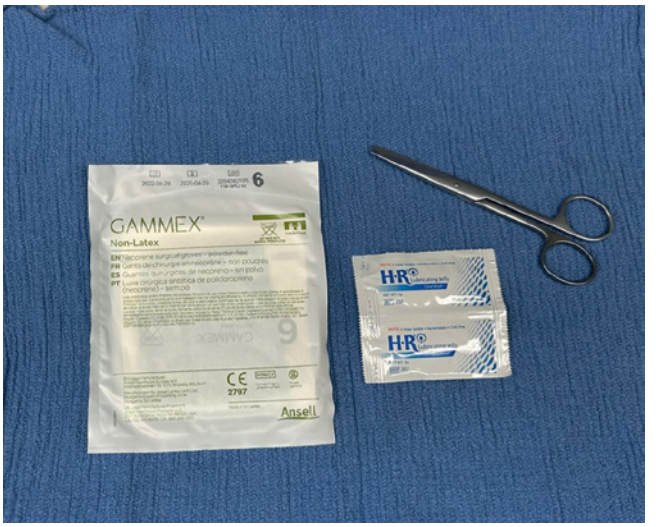


Fig. 2.33. Supplies needed for management of an open sucking chest wound.



Fig. 2.34. Clip a broad area around the thoracic wound, removing fur from around the entire wound. Place sterile gel or antimicrobial ointment on the skin around the entire wound.

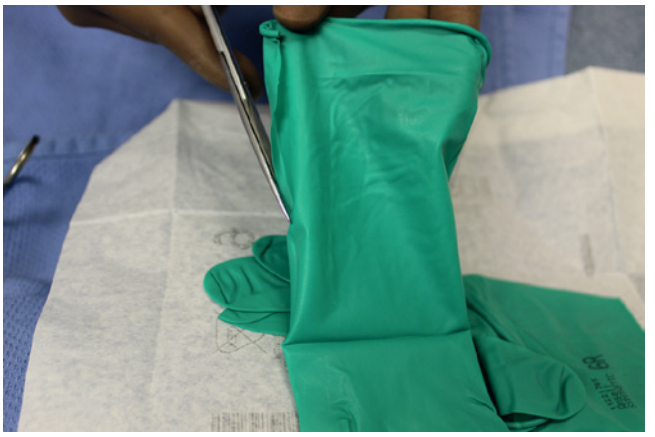


Fig. 2.35. Take a sterile glove and cut a piece large enough to cover the entire wound.

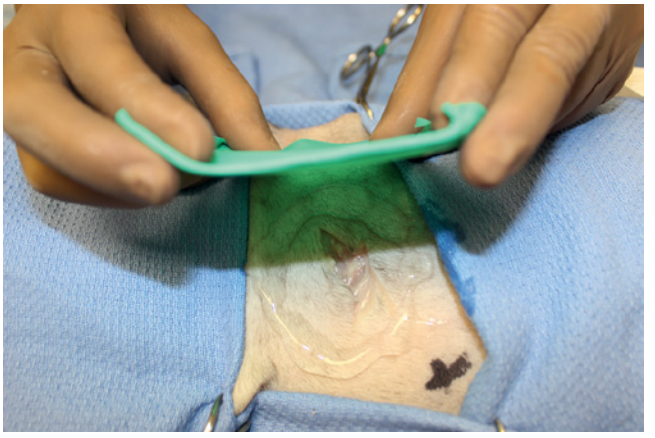


Fig. 2.36. Place the sterile glove over the wound.

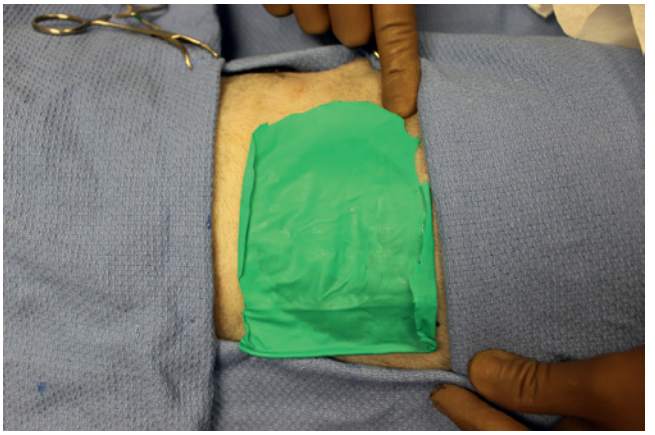


Fig. 2.37. Sterile glove is in place, creating a barrier or seal between the atmosphere and the pleural space.

LOCAL ANESTHETIC BLOCKS FOR RIB FRACTURES OR FLAIL CHEST

Introduction

The pain associated with rib fractures impairs a patient's ability to adequately ventilate and thus move oxygen into the lungs. Hypoxemia from blunt thoracic trauma, pneumothorax or pulmonary contusions is exacerbated by impaired ventilatory capacity. Rather than placing an external circumferential wrap around the thorax that will further restrict thoracic excursions during inhalation, injecting local anesthesia to the nerves supplying the affected ribs can greatly improve ventilatory function.

Supplies Needed

3- to 6-mL syringe
22-gauge, ¾-, and 1½-inch needles
Lidocaine 2%
Electric clippers and blades
Antimicrobial scrub

Indications

Rib Fractures

Contraindications

Known sensitivity to local anesthetic drugs



Fig. 2.38. Setup for local anesthesia of the ribs includes 2% lidocaine, a 3- to 6-mL syringe, 25-gauge needle.

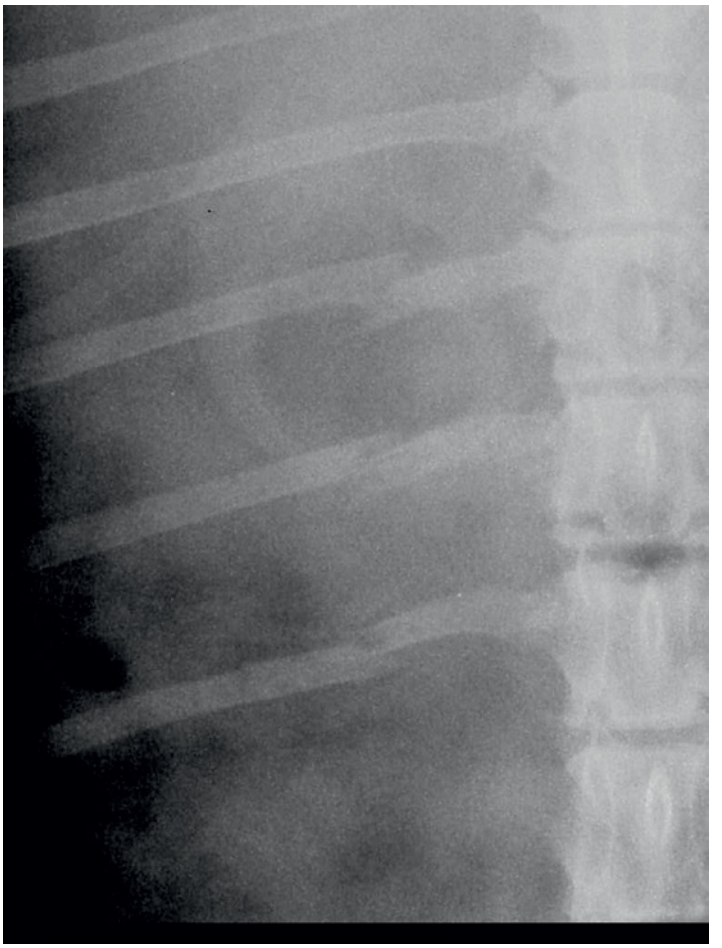


Fig. 2.39. Radiograph demonstrating fractures of the eleventh to thirteenth ribs on the right.

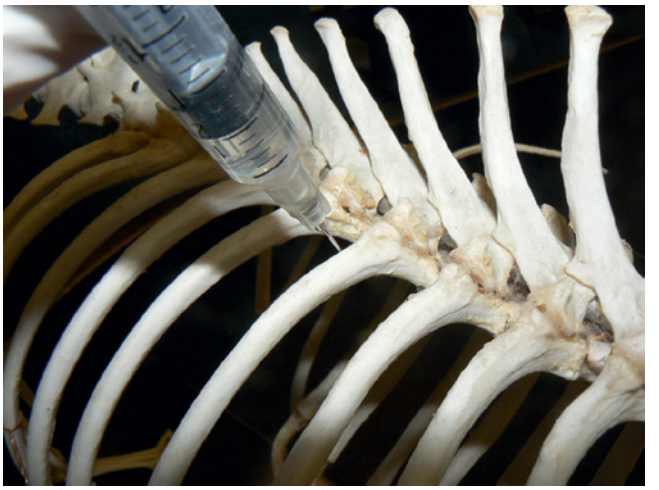


Fig. 2.40. Demonstration on a skeleton where the needle is inserted at the dorsocaudal aspect of the rib.



Fig. 2.41. Aseptically scrub the lateral thorax with chlorhexidine, then draw up 1-mg/kg 2% lidocaine. This volume can be diluted with sterile 0.9% saline to an adequate volume to provided local anesthesia for all affected ribs, in cases where multiple rib fractures are present.

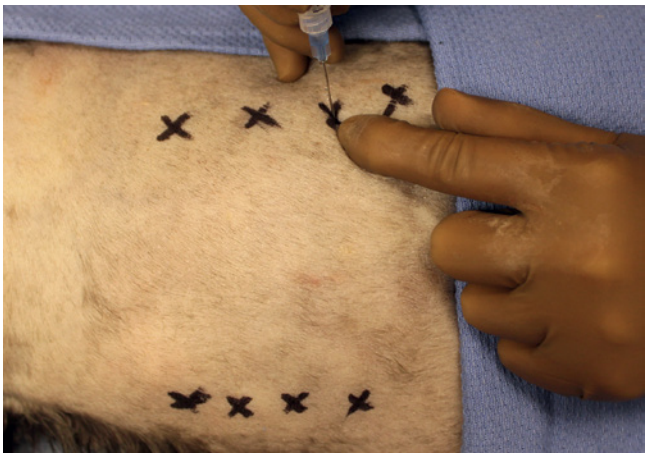


Fig. 2.42. Insert the needle perpendicular to the dorsocaudal aspect of the rib, aspirating to ensure no blood is present prior to injecting.

THORACOSTOMY TUBE PLACEMENT

Introduction

Placement of a thoracostomy tube can be life-saving in cases of tension pneumothorax or recurrent simple pneumothorax. Once a thoracostomy tube has been placed, it can be connected to a suction apparatus that continuously drains free air within the pleural space until the primary lung pathology has had time to heal. Hypoxemia is treated or prevented by allowing the lungs to remain expanded.

In other cases, the tube can be used to infuse then evacuate sterile 0.9% saline from the pleural cavity during medical management of pyothorax. A small amount of fluid will develop simply because of the presence of the tube within the pleural cavity. Tubes can be removed if air production has ceased for at least 24 hours. Cytology is used to determine the ongoing need for thoracic drainage when treating inflammatory pleural effusion. White blood cell count and morphology, along with the absence of bacteria, are useful indices for tube removal.

Supplies Needed

Sterile gloves
Electric clippers and blades
Antimicrobial scrub solution
2% lidocaine with 24-gauge needle
3- to 6-mL syringe
Sterile surgical pack
- Sterile field towels (4)
- Towel clamps
- Number 10 scalpel blade
- Scalpel handle
- Needle holders
- Mayo scissors
- Thumb forceps
- Hemostats

Sterile 4 x 4 inch gauze squares
Trocarized thoracic drainage tube with trocar stylette
Sterile drapes
3–0 to 2–0 nonabsorbable suture
1-inch tape
Christmas tree adapter
Three-way stop-cock
IV extension tubing
Surgical wire (22 gauge)
Wire cutters
Antimicrobial ointment
Indications
Pneumothorax

Continuous Suction
Intermittent suction
Pleural effusion
Pleural lavage for medical management of pyothorax

Contraindications

Coagulopathies
Pleural adhesions

THORACOSTOMY TUBE – TROCAR



Fig. 2.43. Supplies needed for placement of a trocarized thoracostomy tube.

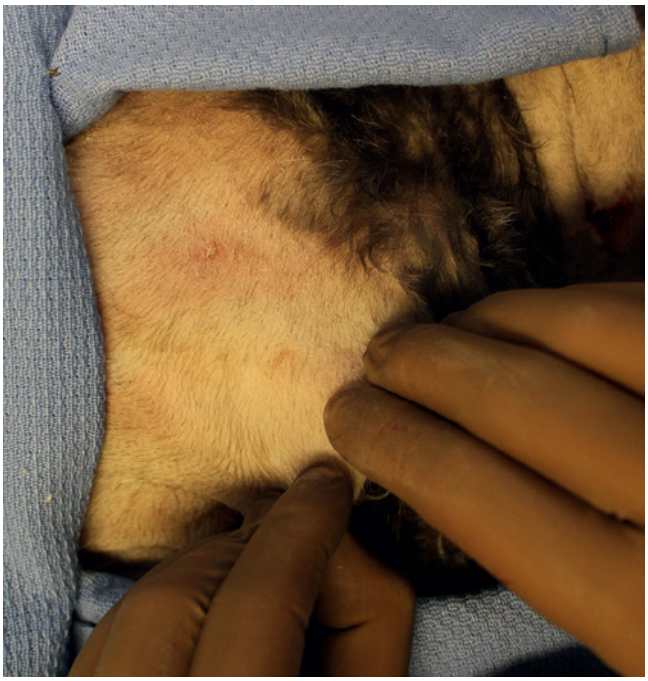


Fig. 2.44. Clip and aseptically scrub the lateral thorax as previously described. In this series of images, the patient's head is to the right. Have an assistant pull the skin on the lateral thorax cranioventrally toward the elbow.

Helpful hint: Having an assistant pull the skin cranioventrally will help to create a tunnel after the tube has been placed, and will allow for dissection directly in between rib spaces without creating excessive space through which air can enter the thorax from around the tube site.

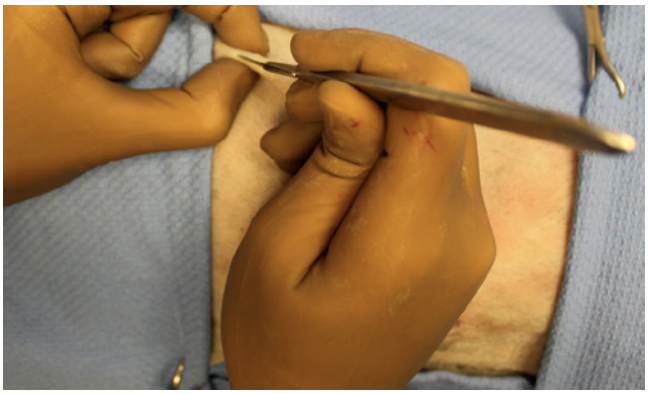


Fig. 2.45. Pick up the skin at the dorsal aspect of the seventh to ninth intercostal space and make a small stab incision using a scalpel blade.

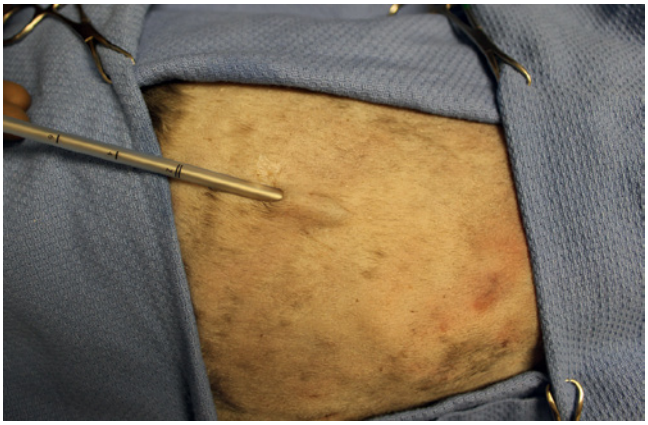


Fig. 2.46. Insert the trocarized thoracostomy tube through the skin incision and create a small tunnel such that the tip of the trocar can be inserted through one of the seventh to ninth intercostal spaces.



Fig. 2.47. Grasp the trocarized tube at the base and push through the intercostal space until you feel a “pop”.

Helpful hint: Grasping the tube at the base will allow you to have better control over the trocar and prevent it from being pushed into the thorax too deeply. Pushing the tube in with excessive force can cause the tip of the trocar to lacerate the lungs, heart and great vessels. An alternate method of inserting a thoracostomy tube using a hemostat, rather than a trocar is shown below.



Fig. 2.48. Remove the trocar from the thoracostomy tube and clamp the preattached clamp to prevent air from entering the thorax.

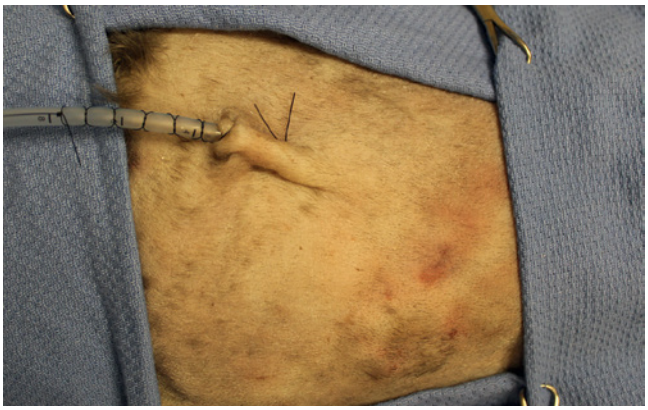


Fig. 2.49. Place a horizontal mattress suture around the tube to decrease space around the tube entrance site where air could potentially enter the thorax. Next, place a purse-string suture around the skin incision, and then secure the suture with a finger-trap.

ALTERNATE METHOD OF THORACOSTOMY TUBE PLACEMENT WITHOUT A TROCAR

Steps 1 through 3 above are identical.

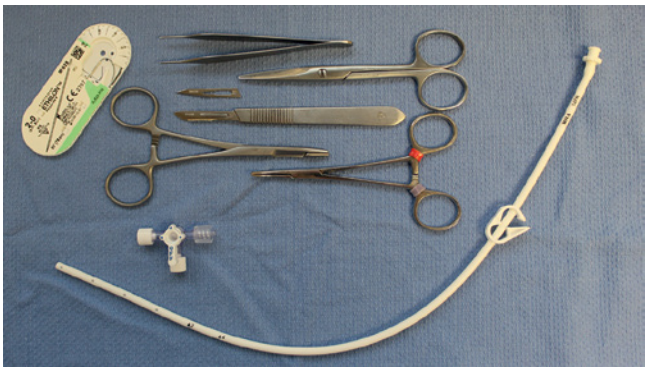


Fig. 2.50. Setup required for placement of a non-trocarized thoracostomy tube using a hemostat.

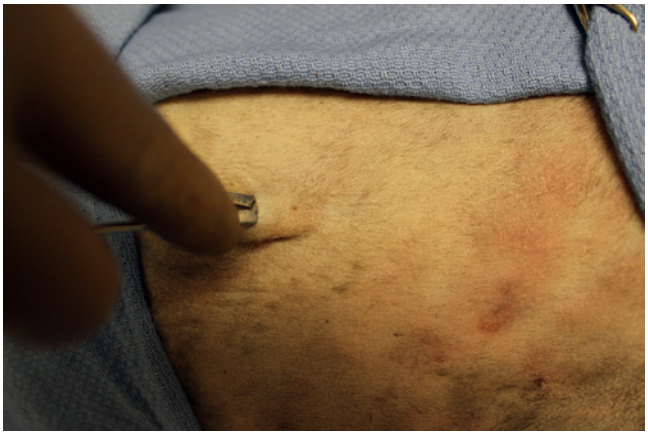


Fig. 2.51. Insert a hemostat through the skin incision, over the seventh to ninth intercostal space.



Fig. 2.52. Gently push the tip of the hemostat through the intercostal space until you feel a "pop". Keep the jaws of the hemostat open and push the silicone chest tube through the hole created into the thorax, pushing the tube cranially and ventrally.

Helpful hint: If a silicone thoracostomy tube is not available, a red rubber catheter can be inserted instead. If the red rubber catheter or silicone thoracostomy tube is not rigid enough to be pushed into the thorax, a rigid sterile silicone urinary catheter can be placed through the tube to facilitate placement into the thorax.

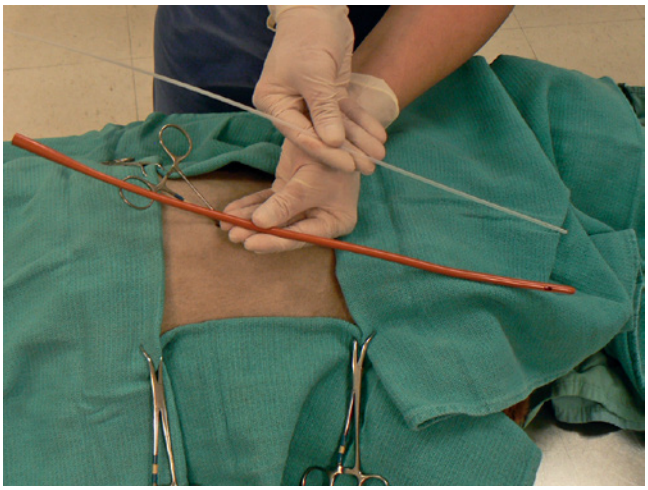


Fig. 2.53. Measure the red rubber catheter from the tube entrance site to the fifth intercostal space. A polypropylene rigid catheter that is smaller in diameter than the red rubber catheter can be inserted into the red rubber catheter to make the device more rigid during insertion.

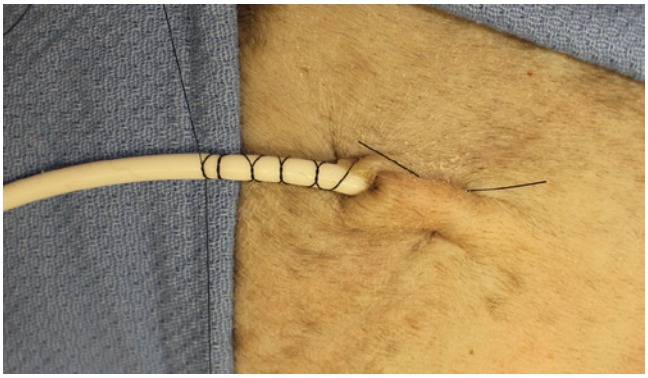


Fig. 2.54. Place a horizontal mattress suture and a finger-trap suture around the tube as previously described.

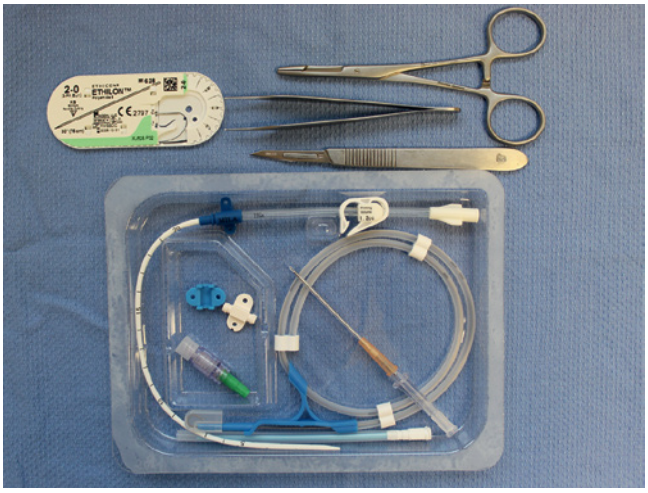


Fig. 2.55. Supplies needed for placement of an over-the-wire thoracostomy tube.

THORACOSTOMY TUBE PLACEMENT USING OVER-THE-WIRE SELDINGER TECHNIQUE

Supplies Needed

Prefabricated over-the-wire thoracostomy tube kit
Electric clippers and blades
Antimicrobial scrub
Number 11 scalpel blade
Scalpel handle
Lidocaine 2%
Thumb forceps
Needle holder
Nonabsorbable suture (3–0)

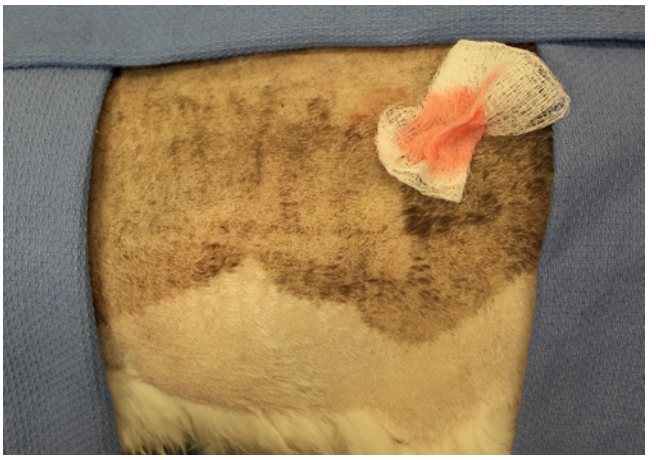


Fig. 2.56. Clip then aseptically scrub the lateral thorax then injection of local anesthesia as previously described.

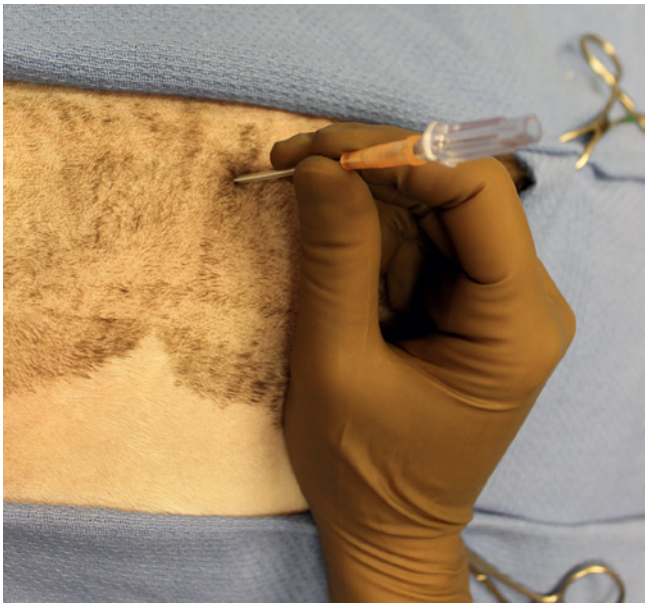


Fig. 2.57. Insert the over-the-needle catheter perpendicularly through the intercostal muscles at the seventh to tenth intercostal space.

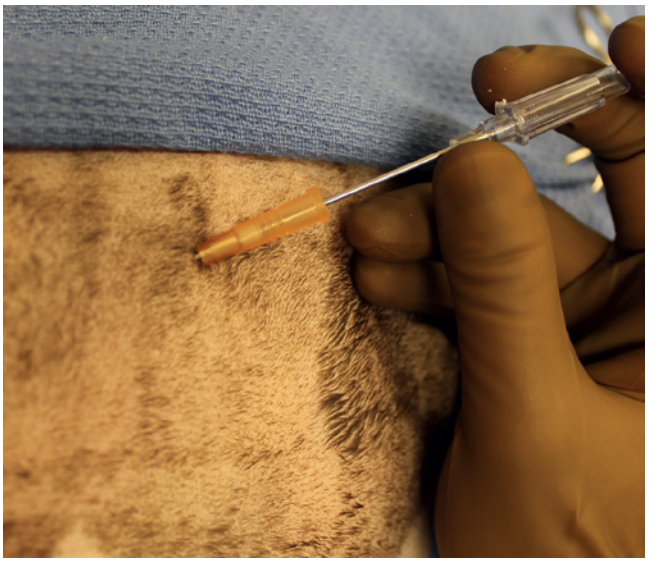


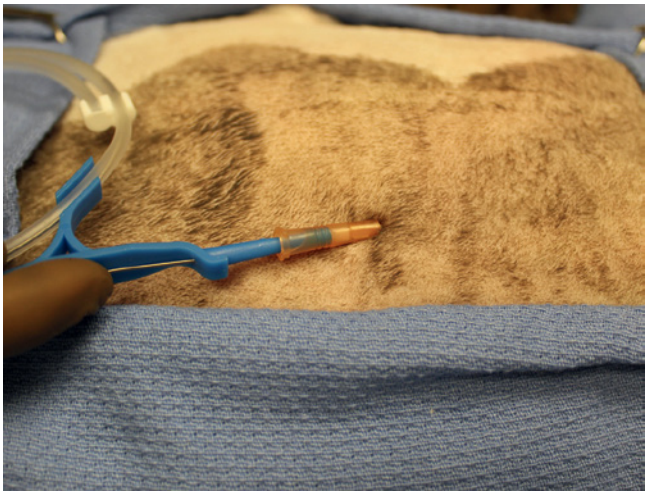
Fig. 2.58. Push the needle and catheter into the thorax then remove the stylette. Place a gloved finger over the catheter hub to prevent air from entering the thorax.

(a)



Figs. 2.59a–c. The J wire is curved to prevent laceration of the lung and great vessels. Pull the J-wire back into the introducer so the end is flush with the tip of the introducer. Insert the introducer into the hub of the catheter, and then push the J-wire through the catheter into the thorax. Never let go of the wire.

(b)



(c)



Figs. 2.59a–c. (*Continued*)

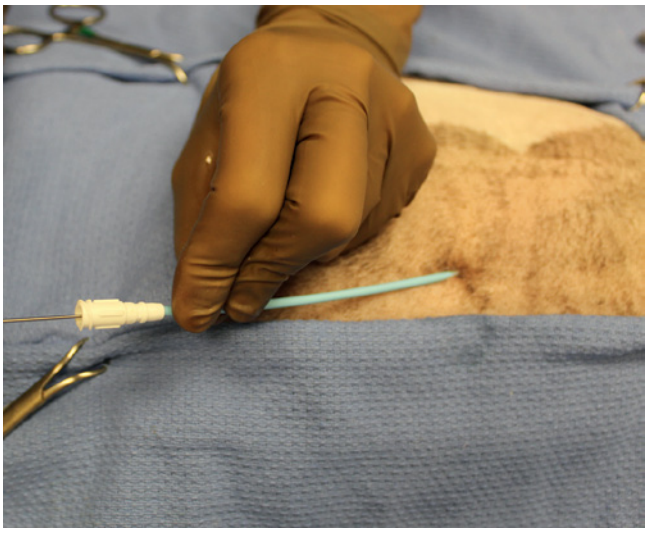


Fig. 2.60. Remove the catheter, and then insert the dilator over the wire, pushing the dilator through the subcutaneous tissue and intercostal muscles using a twisting motion.

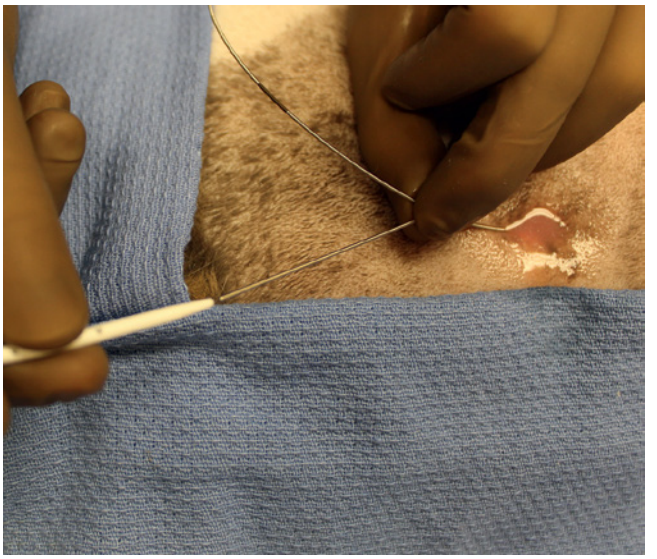
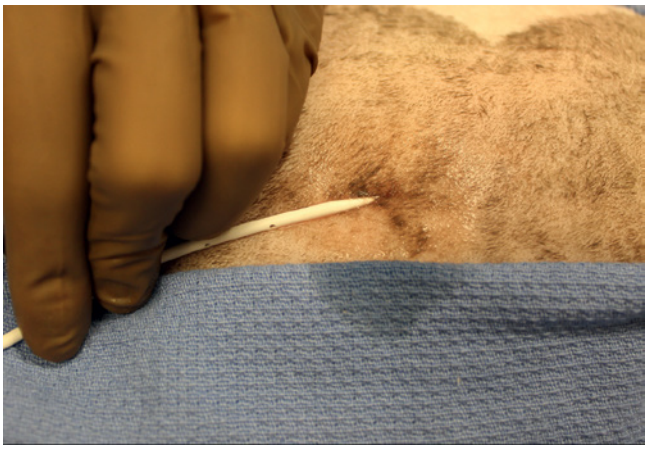
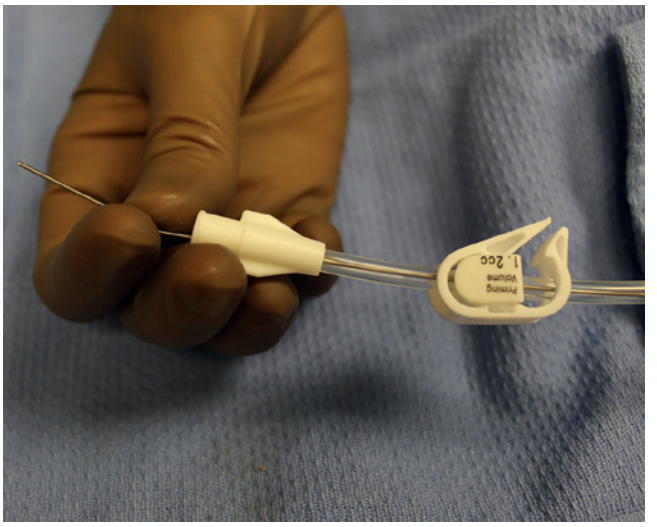


Fig. 2.61. Remove the dilator from the wire, and then insert the thoracostomy catheter/tube tip over the J-wire.

(a)



(b)



Figs. 2.62a–b. Push the thoracostomy tube over the wire into the thorax by alternating pushing the tube and pulling the wire back through the tube until the wire exits the proximal end of the tube.

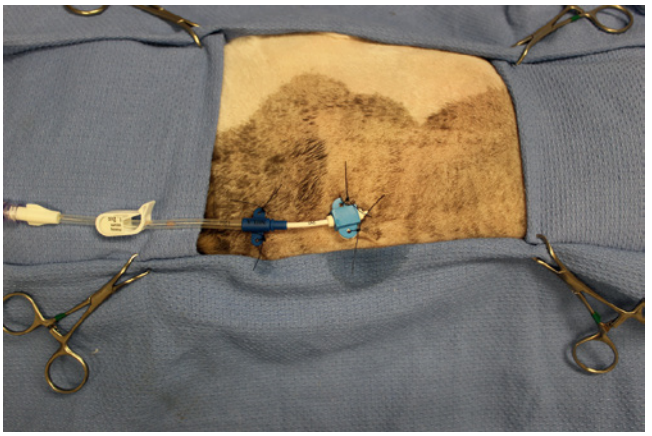


Fig. 2.63. Suture the catheter in place then cover with impermeable bandage material.

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CHAPTER 3

Oxygen Supplementation and Respiratory Sampling Techniques

NASAL AND NASOPHARYNGEAL OXYGEN CATHETER PLACEMENT

Introduction

The placement of a nasal or nasopharyngeal tube is a quick and simple means to provide supplemental oxygen to the hypoxic patient. Nasal and nasopharyngeal oxygen catheters are well-tolerated, require minimal equipment, and are easy to maintain.

Supplies Needed

Feeding tube or red rubber catheter
3–0 Nonabsorbable suture
2% lidocaine or proparacaine
Permanent marker
Sterile lubricating gel or ointment
1-mL syringe case
Flexible extension tubing
Humidified oxygen source
Rigid Elizabethan collar

Indications

Hypoxemia due to any cause

Veterinary Emergency and Critical Care Procedures, Third Edition. Timothy B. Hackett and Elisa M. Mazzaferro.
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Contraindications

Laryngeal obstruction
Nasal or facial trauma
Epistaxis
Coagulopathies
Nasal mass lesions
    Neoplasia
    Foreign bodies
    Fungal infection
Relatively contraindicated in patients with intracranial mass lesions or elevated intracranial pressure due to risk of sneezing and increasing intracranial pressure during catheter placement

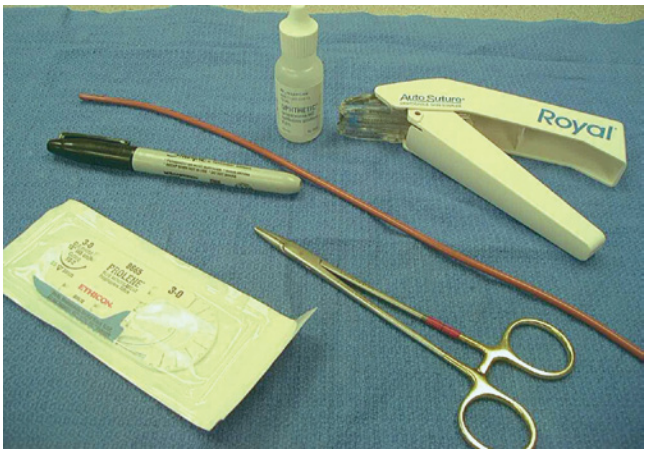


Fig. 3.1. Supplies needed for placement of a nasal or nasopharyngeal oxygen supplementation tube.

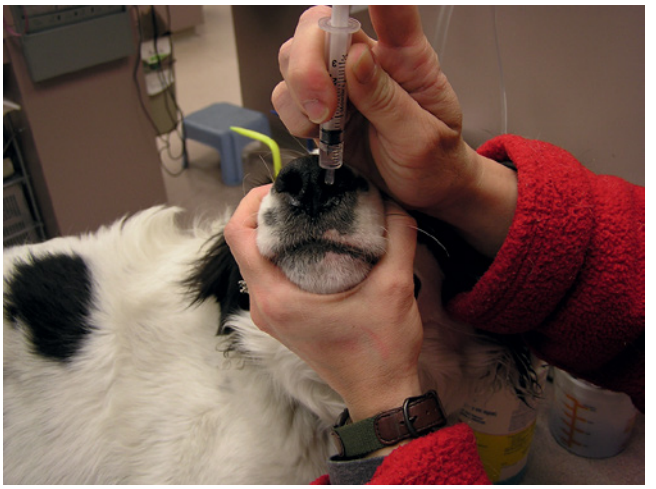


Fig. 3.2. Instill several drops of dilute 2% lidocaine or proparacaine into the nostril, tilting the patient's nose upward to assure coating of the nasal mucosa with the topical anesthetic.



Fig. 3.3. For placement of a nasal oxygen catheter, the tip of the tube is placed to the level of the lateral canthus of the eye, and the portion adjacent to the tip of the nose is marked with a permanent marker.

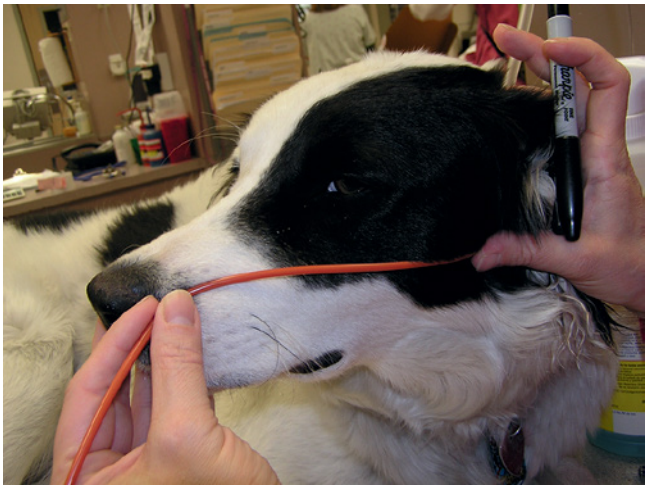


Fig. 3.4. For placement of a nasopharyngeal oxygen catheter, the tip of the tube is measured from the ramus of the mandible to the tip of the nose, and marked accordingly.

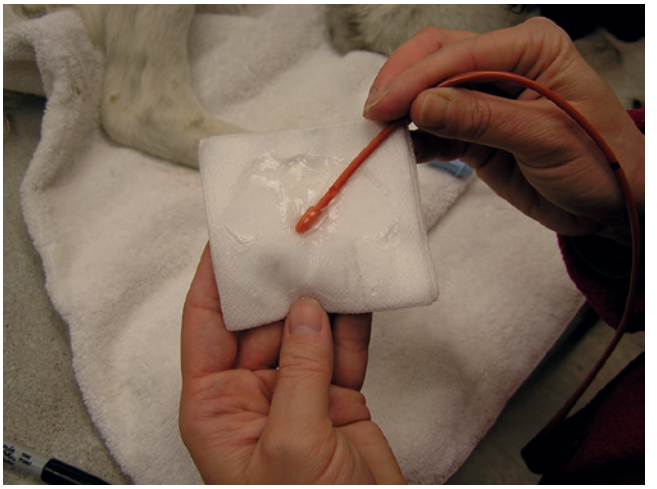


Fig. 3.5. Lubricate the tip of the tube with sterile lubricant jelly or ointment.



Fig. 3.6. Hold the tube as close to its tip, adjacent, and as close to the nostril as possible. Hold the patient's muzzle with the other hand while an assistant restrains the patient. Direct the tube ventrally and medially into the nostril to the level of the mark on the tube.



Fig. 3.7. When placing a nasopharyngeal oxygen catheter, pinch the dorsolateral portion of the external nares medially, and then push the nasal philtrum dorsally as you attempt to pass the tube into the nasopharynx. This maneuver will help facilitate passing the tube into the ventral nasal meatus, and then into the nasopharynx.



Fig. 3.8. Place a stay suture adjacent to the nostril, and then secure the tube to the stay suture with another length of suture. If the tube becomes dislodged, the stay suture can remain in place, avoiding this somewhat uncomfortable step when you replace the tube.



Fig. 3.9. Suture the tube to the stay suture with a finger-trap. Place a second and third suture over the dorsal nasal planum and on top of the head, or the lateral maxilla and zygomatic arch. Immediately place a rigid Elizabethan collar to prevent the patient from pawing at the tube and causing iatrogenic removal. Oxygen flow rates of 50 to 100 mL/kg/min are well-tolerated, provided that the oxygen source is humidified to prevent drying of the nasal mucosa. Topical proparacaine (0.5%) can be instilled as necessary for patient comfort.

Helpful hint: Avoid the whiskers when suturing, because trapping the whiskers in the suture can cause patient discomfort.

OXYGEN HOOD

Introduction

Oxygen hoods are an excellent method of providing short-term supplemental oxygen support to the hypoxemic patient. Hoods are available commercially or can be manufactured using a rigid Elizabethan collar, plastic wrap, and adhesive tape. The patient can become hyperthermic, so must be monitored closely to prevent hyperthermia. Extremely small patients and pocket pets can be placed directly into a hood for supplemental oxygen without the stress of any handling.

Supplies Needed

Commercially available oxygen hood or rigid Elizabethan collar
Plastic wrap
Adhesive tape
Flexible oxygen tubing
Humidified oxygen source

Indications

Hypoxemia of any cause

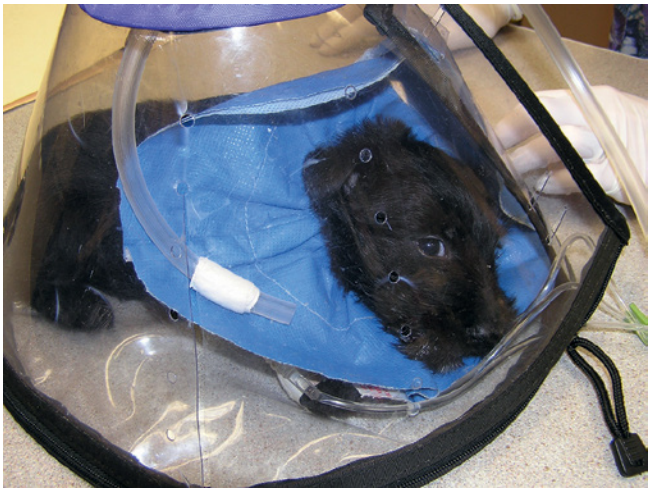
Contraindications

Anxiety and intolerance of the hood
Hyperthermia
Panting



Fig. 3.10. Commercially available oxygen hoods.

(a)



(b)



Figs. 3.11a–b. In some cases, a small puppy or kitten or exotic species can be placed directly into an oxygen hood to create a small oxygen cage.



Fig. 3.12. To manufacture your own oxygen hood, cover the front three-fourths of a rigid Elizabethan collar with plastic wrap.

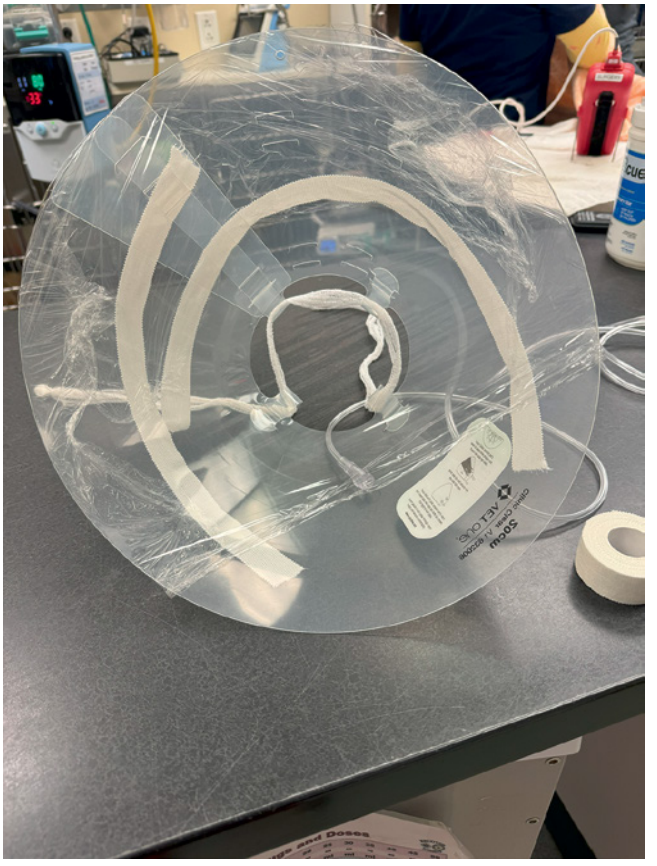


Fig. 3.13. Secure the plastic wrap in place with adhesive tape.



Fig. 3.14. Secure the hood around the patient's head with a length of gauze. Insert a length of flexible oxygen tubing into the side of the hood and administer supplemental humidified oxygen at 50 to 100 mL/kg/min.

TRANSORAL WASH

Introduction

A transoral wash may be performed whenever samples of the airway are required for bacterial or viral culture, or to obtain cells for cytologic evaluation. Although bronchoalveolar lavage is considered to be the gold standard for obtaining airway samples, it requires specialized equipment and a deep plane of general anesthesia. Samples obtained from a transoral wash may be cultured for bacteria or viruses and may be evaluated for neoplastic cells, bacteria, fungal infection, or parasitic organisms or ova.

Supplies Needed

Sterile endotracheal tube
Sterile gloves
Sterile 0.9% saline
Sterile red rubber or rigid polypropylene catheter
Port-a-Cul™ culture swabs
Lavendar and red-topped vials

Indications

Obtain bacterial or viral cultures from airway
Obtain cells for cytologic evaluation of airway

Contraindications

Condition in which light-plane general anesthesia is determined to be too dangerous in a very unstable patient

Limitations

Samples obtained may be more reflective of large airways, and not reflective of what is deeper in the lungs.



Fig. 3.15. Supplies needed for sample collection via transoral wash.

Helpful hint: Have all necessary supplies prepared and in place before placing the patient under anesthesia.



Fig. 3.16. After induction of anesthesia, wear sterile gloves to pass a new, sterile endotracheal tube in as sterile a manner as possible. Have flow-by oxygen supplementation and an Ambu-bag available. Be prepared to give supplemental breaths to the patient in between airway washes.



Fig. 3.17. Pass a red rubber tube or rigid polypropylene catheter through the endotracheal tube into the patient's airway.

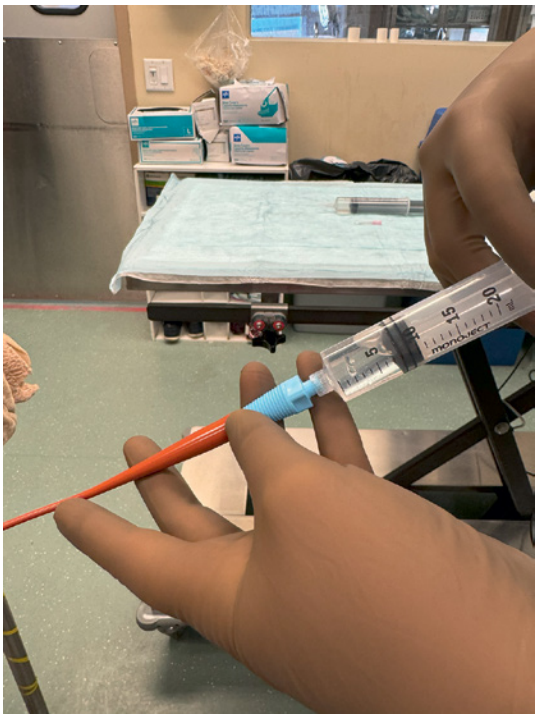


Fig. 3.18. Instill 5 to 10 mL of sterile 0.9% saline into the airways via the red rubber or polypropylene catheter, then vigorously coupage the patient's thorax.



Fig. 3.19. Following instillation of sterile saline into the trachea, have an assistant coupage the thorax bilaterally.



Fig. 3.20. Withdraw the fluid from the polypropylene catheter. Note: Not all of the fluid instilled will be withdrawn from the airways.

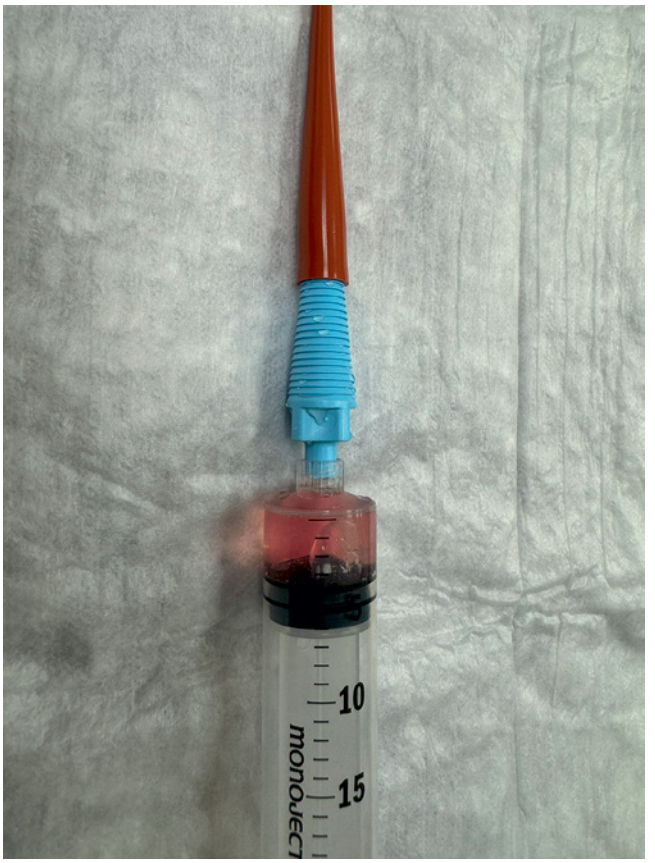


Fig. 3.21. The sample collected can be submitted for fluid analysis, cytology, and bacterial/viral cultures as indicated.

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CHAPTER 4

Pericardiocentesis

INTRODUCTION

Pericardial tamponade and even small amounts of fluid within the pericardial space can greatly impede cardiac preload and, subsequently, cardiac output. The recognition of and rapid removal of pericardial effusion can be life-saving in some patients.

Supplies Needed

Electric clippers and blades
Antimicrobial scrub solution
1-mL syringe with 25-gauge ¾-inch needle
Number 11 scalpel blade
14- or 16-gauge long over-the-needle catheter
30- or 60-mL catheter-tip syringe
Three-way stop-cock
Intravenous extension tubing
Bowl or graduated cylinder for sample collection
Red-topped and EDTA tubes
Electrocardiogram (ECG) monitor

Indications

Pericardial effusion impairing cardiac preload and cardiac output
Diagnosis of inflammatory and neoplastic pericardial effusions

Contraindications

Coagulopathies secondary to Vitamin K antagonist rodenticide intoxication

Veterinary Emergency and Critical Care Procedures, Third Edition. Timothy B. Hackett and Elisa M. Mazzaferro.
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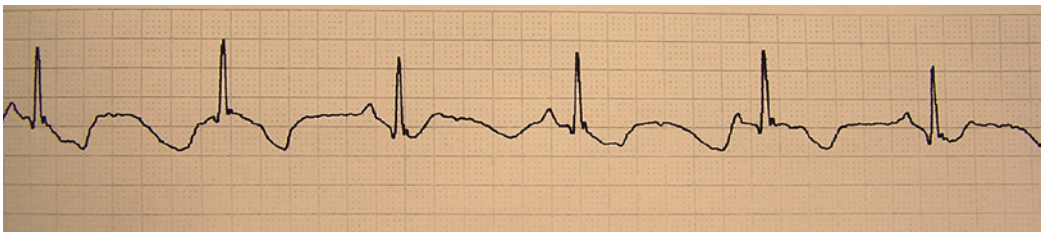
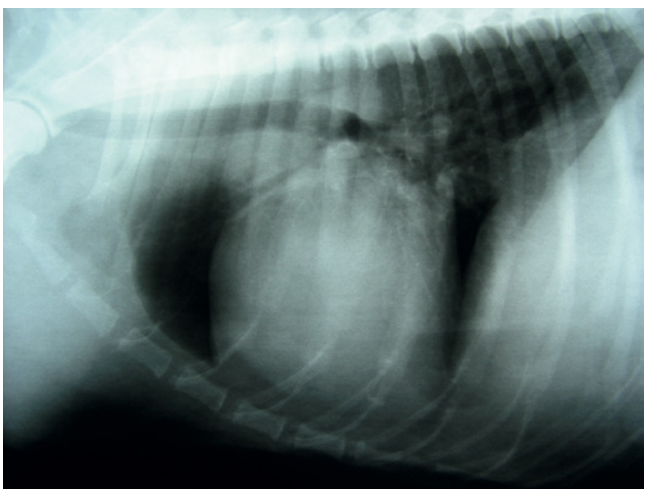


Fig. 4.1. Electrical alternans is a characteristic ECG abnormality observed when the heart is floating and swinging within the fluid in the pericardial sac, creating small, then larger ECG complexes. Low-amplitude ECG waveforms can also be associated with pericardial effusion, although they can also be associated with severe obesity, hypothyroidism, hypothermia, and hypovolemic shock.

(a)



(b)



Figs. 4.2a–b. Ventrodorsal and lateral thoracic radiographs from a patient with pericardial effusion, demonstrating a large globoid cardiac silhouette.

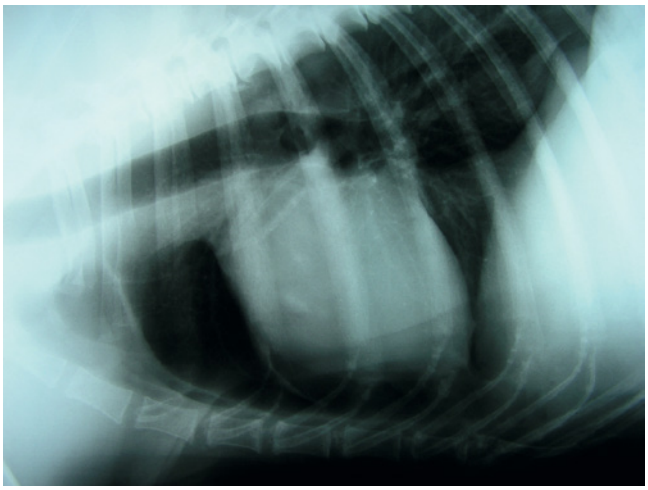


Fig. 4.3. Lateral thoracic silhouette from a dog with minimal pericardial effusion. Note the relatively normal-sized cardiac silhouette, elevation of the heart from the sternum and enlarged caudal vena cava.

Helpful hint: The cardiac silhouette may appear normally sized on the ventrodorsal, dorsoventral, or lateral thoracic radiographs if the pericardial effusion is acute and has occurred quickly, without time for the pericardium to stretch. The patient with acute pericardial effusion may demonstrate severe cardiovascular compromise without radiographic signs of a globoid cardiac silhouette. The clue will be to evaluate the caudal vena cava, and if enlarged, pericardial effusion should be suspected. The heart may appear elevated from the sternum due to lack of inflow of blood into the right heart due to tamponade. One may suspect pneumothorax. If the patient is stable enough, perform a ventrodorsal radiograph. Dogs with pericardial effusion will have pulmonary vessels to the edge of the thorax and cranial to the diaphragm to the edges of the periphery; dogs with pneumothorax will not have pulmonary vessels to the level of the periphery.

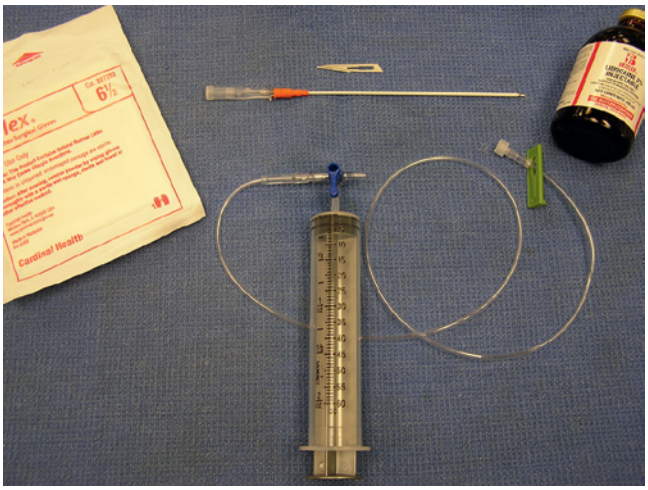


Fig. 4.4. Supplies needed to perform a pericardiocentesis include antimicrobial scrub solution, a number 11 scalpel blade, sterile gloves, 14- or 16-gauge long over-the-needle catheter, 2% lidocaine, small syringe with 25-gauge needle, IV extension tubing, three-way stop-cock, and 30- or 60-mL syringe.



Fig. 4.5. Clip a large area of fur on the right lateral thoracic wall, caudal to the point of the elbow (fifth to seventh intercostal space).



Fig. 4.6. Aseptically scrub the clipped area with antimicrobial scrub.



Fig. 4.7. Insert a bleb of 2% lidocaine dorsal to the sternum and just caudal to the point of the elbow or at the fifth to seventh intercostal space.



Fig. 4.8. Rescrub the clipped area and drape with sterile field towels. Make a small nick incision through the anesthetized area of skin using a number 11 scalpel blade. Note: Attach the patient to an ECG monitor, if available, to monitor for cardiac dysrhythmias while performing the pericardiocentesis.



Fig. 4.9. Wearing sterile gloves, insert the over-the-needle catheter through the nick incision and through the body wall at the fifth to seventh intercostal space. Watch for dysrhythmias on the ECG monitor.



Fig. 4.10. Watch for a flash of blood in the hub of the catheter.



Fig. 4.11. Once a flash of blood is observed, push the catheter off of the stylette, and then remove the stylette.



Fig. 4.12. Attach the hub of the catheter to the male end of the length of IV extension tubing, then withdraw fluid from the pericardial sac.

Helpful hint: Removal of even a small amount of fluid can drastically improve cardiac output by improving cardiac filling.



Fig. 4.13. Place a small amount of pericardial fluid in plain and EDTA-sample tubes for fluid analysis. Watch the plain tube carefully for the presence of a clot. Clot formation may indicate an active bleed. Set aside some of the fluid for culture, in the event that the fluid is due to bacterial or fungal pericarditis.

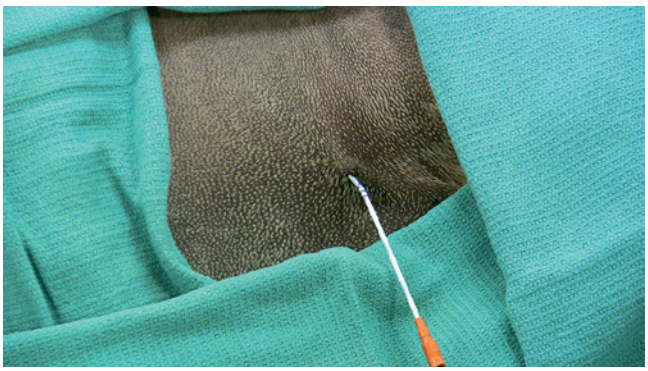


Fig. 4.14. The pericardial catheter can be sutured in place with a finger-trap suture in cases where repeated pericardiocentesis may be needed. Note: Over-the-wire pericardial catheters are available from some manufacturers.

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CHAPTER 5

Nutritional Support and Orogastric Lavage

INTRODUCTION

Nutritional support of the critically ill patient is important to provide necessary proteins, carbohydrates, and lipids for energy and repair processes in a variety of illnesses. The placement of an enteral feeding tube for nutritional supplementation is preferred over parenteral nutrition and should be considered in any patient that has a functional gastrointestinal tract. This chapter describes the placement and maintenance of a variety of enteral feeding devices, including nasoesophageal, nasogastric, and esophagostomy tubes.

NASOESOPHAGEAL AND NASOGASTRIC TUBES

Introduction

Nasoesophageal and nasogastric feeding tubes should be considered in any patient that requires short-term enteral nutritional support when the patient either cannot or will not voluntarily eat and has no esophageal disorder. Specialized veterinary liquid enteral diets are commercially available for use with nasoenteral feeding. In addition to providing enteral nutrition, nasogastric tubes can be used to suction air and fluid from the stomachs of patients with severe ileus.

SUPPLIES NEEDED

Needle holders
Proparacaine or other topical drops or lubricant
Lubricating gel
Nonabsorbable suture (2–0 or 3–0)
5- to 10-Fr feeding tube or red rubber catheter
Permanent marker
Elizabethan collar

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Indications

Short-term enteral nutrition in patients that are inappetent
Suctioning of gas or fluid from stomach in patients with severe ileus

Contraindications

Epistaxis
Esophageal disease/dysfunction
- Megaesophagus
- Esophageal foreign body or stricture

Nasopharyngeal trauma
Recumbent or unconscious patients
Regurgitation
Thrombocytopenia

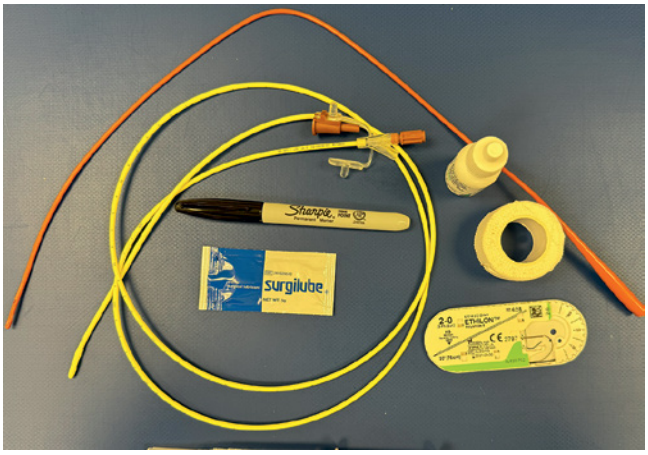


Fig. 5.1. Supplies needed for placement of a nasoenteral feeding tube include the enteral feeding tube or red rubber catheter, topical anesthetic such as proparacaine, lubricating gel, nonabsorbable suture, permanent marker, and needle holders.



Fig. 5.2. Tilt the patient's head upward toward the ceiling and place several drops of topical anesthetic into the nostril.



Fig. 5.3. Measure the tube from the tip of the nose to the last rib for nasogastric placement. If you prefer to place a nasoesophageal tube when gastric suctioning is not necessary, measure the tube from the tip of the nose to the mid-thorax.



Fig. 5.4. Mark the tube with a permanent marker at the measurement of the tip of the nose. Prefabricated tubes often have preprinted centimeter measurements.



Fig. 5.5. Lubricate the tip of the with lubricating gel.



Fig. 5.6. Insert the tip of the tube into the ventromedial portion of the patient's nostril.

Helpful hint: Hold the tube as close to the patient's muzzle as possible, to prevent excessive movement and to prevent the patient from sneezing the tube out during placement. Push the patient's nose toward the ceiling when passing the tube to extend the neck, and then direct the patient's nose ventrally once the tube is at the point of the pharynx. Watch for a swallowing motion as the patient should swallow the tube.



Fig. 5.7. The tube is inserted to the correct location as premeasured then marked with permanent marker.

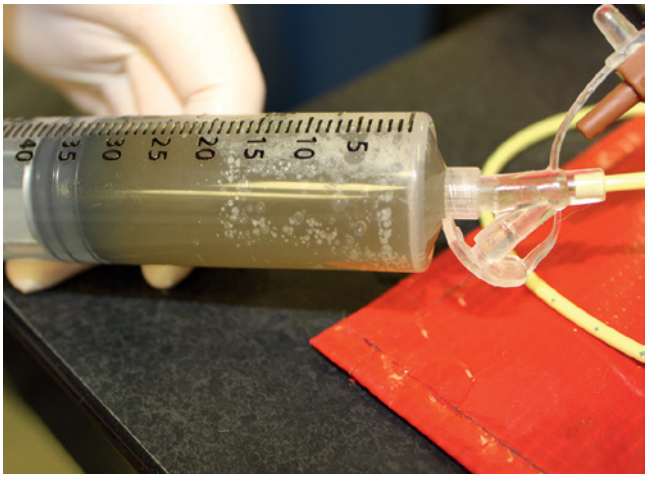


Fig. 5.8. If the tube is located in the stomach correctly, aspiration of gastric contents can be used as an indicator of correct placement.

Helpful hint: Taking an abdominal radiograph is always a good idea, as some tubes can be inserted too far and may not always allow for complete aspiration of air or fluid, depending on the location of the distal tube in the stomach and patient position.



Fig. 5.9. Secure the tube with suture as close to the nostril as possible without causing an acute turn or kink that could cause the tube to occlude.



Fig. 5.10. Place a finger-trap suture around the tube to decrease tension on the suture.



Fig. 5.11. Suture the tube to the side of the face, near the ramus of the mandible.



Fig. 5.12. The tube is secured in place. An Elizabethan collar should be worn at all times to prevent the patient from scratching and dislodging the tube.

Helpful hint: If the tube is bothersome to the patient and is causing sneezing, apply more topical anesthetic as needed to minimize patient discomfort. Check the placement of the tube with a lateral thoracoabdominal radiograph. Once correct tube placement has been confirmed, the tube can be used immediately. Always start a feeding by instilling a small amount of sterile water. At any time if the patient coughs during instillation of water, repeat thoracic radiograph(s) to make sure that the tube is not in the trachea. Upon tube removal, make sure that the tube is kinked well, and then pull briskly, to prevent fluid from entering the trachea and lungs.

ESOPHAGOSTOMY TUBES

Introduction

Placement of an esophagostomy tube should be considered whenever a patient is inappetent because it either will not or cannot voluntarily eat (i.e., severe maxillofacial trauma, oral or oropharyngeal neoplasia or mass effects, and inappetence). Esophagostomy tubes are simple to place, require minimal equipment, and can be used immediately. An esophagostomy tube is contraindicated in patients that cannot protect their airway, have vomiting or regurgitating, or have functional or mechanical esophageal disease such as megaesophagus, severe esophageal erosions, neoplasia, or strictures.

Supplies Needed

Surgical Instruments
- Number 10 scalpel blade
- Scalpel handle
- Needle holders
- Mayo scissors
- Rochester carmalt (curved)

Nonabsorbable suture (various sizes, depending on the size of the tube and patient)
Permanent marker
Red rubber catheter or other prefabricated esophagostomy tube
Electric clipper and blades
Antimicrobial scrub
Christmas tree adapter
Male adapter
Bandage material or prefabricated esophagostomy tube collar
Gauze 4 x 4 inch squares
Cotton roll gauze
Kling
Elasticon® or Vetrap™
Optional equipment: Esophagostomy tube insertion device

Indications

Inappetence
Maxillofacial trauma
Oropharyngeal neoplasia, mass lesions, surgery
Severe dental disease

Contraindications

Vomiting
Regurgitation
Esophageal stricture or foreign body
Megaesophagus
Conditions that make patient unable to protect its airway
- Severe cough
- Pneumonia

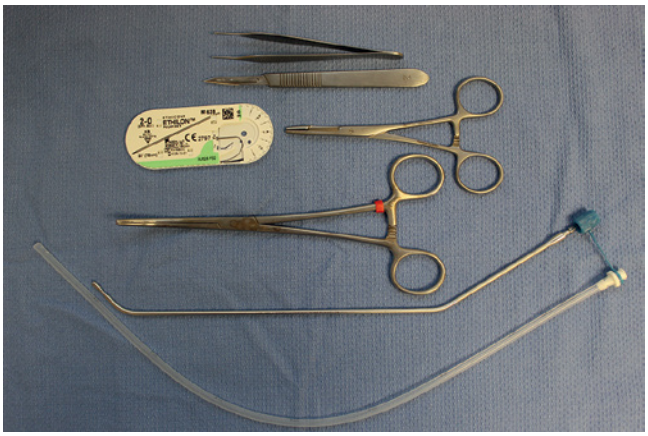


Fig. 5.13. Supplies needed for placement of an esophagostomy tube include a scalpel handle and scalpel blade (Number 15 or Number 11 preferred over Number 10 blade, to avoid making the entrance site into the skin too large), thumb forceps, needle holder or straight needle with nonabsorbable suture, and the esophagostomy tube. In this photo, the Mila esophagostomy tube is pictured along with the introducer. If a prefabricated tube or introducer is not available, a red rubber catheter and a curved Carmalt can be used for placement. Depending on the size of the patient 14- to 20-Fr red rubber catheters can be used. If a red rubber catheter is used, cut the distal end of the tube on a diagonal proximal to the holes in the tube to increase the diameter of the tube through which food is passed.

Helpful hint: Take care that the cut edges are smooth to prevent irritation to the esophagus.



Fig. 5.14. Anesthetize and intubate the patient. Place the patient in right lateral recumbency. Clip and the left lateral neck from the ramus of the mandible caudally to the thoracic inlet and dorsally and ventrally to midline. Aseptically scrub the clipped area. Measure the distal end of the tube from the mid-thorax to the tube entrance site in the left lateral cervical region. Mark the tube at the point of insertion with a permanent marker. Prefabricated tubes sometimes have measurements already printed on the tube.



Fig. 5.15. Drape the clipped area with sterile field towels and secure the towels with towel clamps. Gently pull the tongue rostrally, then insert Rochester carmalt into the mouth down into the throat into the esophagus. As the patient is intubated, the carmalt will automatically enter the esophagus. Direct the curved tips laterally to the skin at the level of the mid-cervical region. You should be able to palpate the tips of the carmalt under the skin with your fingertips. Take care to visualize the jugular vein and direct the tips of the Carmalt dorsal to the jugular vein. In this photo, the jugular vein can be visualized ventral to the index finger, while the tip of the index finger is palpating the tips of the carmalt.



Fig. 5.16. Open the tips of the carmalt and palpate. Using a number 11 scalpel blade, make a stab incision through the skin and underlying fascia, into the esophagus through the open tips of the carmalt. Using the scalpel blade, make a nick incision through the skin over the tips of the carmalt.



Fig. 5.17. Close the tips of the carmalt, and then push the tips of the carmalt through the edges of the skin incision.

Helpful hint: In some cases, it may be necessary to gently incise the esophagus over the tips of the carmalt. Make sure to keep the tips of the carmalt in sight, so as to create only one hole in the esophagus.

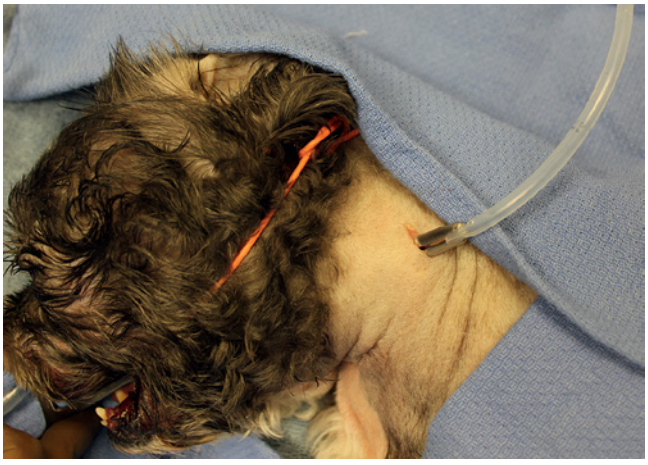


Fig. 5.18. Grasp the distal end of the esophagostomy tube and clamp it in the tips of the carmalt.

Helpful hint: At this point, it is easy to also grasp the tissue in the mouth, oropharynx, or esophagus within the hinges of the carmalt. If this occurs, it will not be easy to bring the tube forward rostrally. If you are having difficulty, push the tube and carmalt caudally back through the skin incision, open the hinges of the carmalt, redirect the carmalt slightly, and then repeat grasping the distal end of the esophagostomy tube procedure without the tissue closed within the hinges of the carmalt.



Fig. 5.19. Pull the carmalt and esophagostomy tube rostrally out of the mouth. The proximal end of the esophagostomy tube will be facing caudally at this point.

Helpful hint: If you are not able to bring the tube rostrally through the oral cavity, make sure that the esophagostomy tube or carmalt is not wrapped around the tie-gauze of the endotracheal tube.



Fig. 5.20. Unclamp the distal end of the esophagostomy tube from the carmalt, and then turn and push the distal end of the esophagostomy tube caudally back into the esophagus. Take care to avoid getting the tube stuck on the endotracheal tube and the tie that secures the endotracheal tube in place.

Helpful hint: Make sure that the patient is well-anesthetized before attempting this step to avoid biting your fingers with stimulation in the mouth.



Fig. 5.21. While pushing the distal end of the esophagostomy tube caudally into the esophagus, pull gently on the proximal end of the tube to create some tension until you feel the tube "flip."

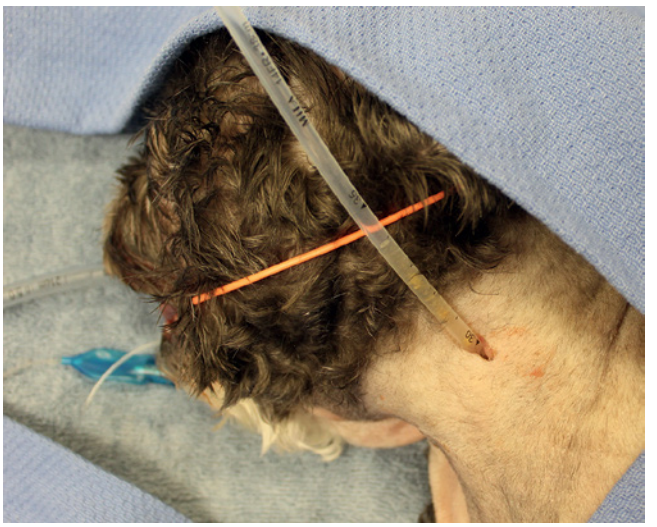


Fig. 5.22. The esophagostomy tube has "flipped" rostrally toward the front of the patient and is in position, where the distal end of the tube is in the esophagus. At this point, gently twist the tube to make sure it is in the correct place.



Fig. 5.23. Place a holding suture or loose purse-string suture around the tube entrance site. Leave the ends of the suture long.

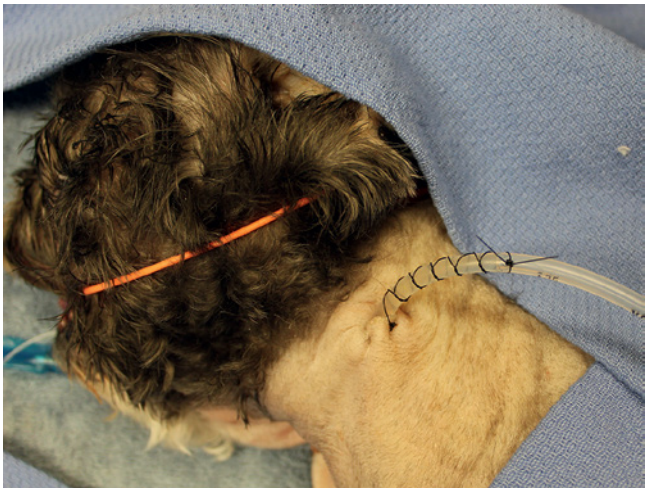


Fig. 5.24. Use the long suture ends to secure a finger-trap suture around the base of the tube, where it enters the skin to further secure the tube in place.

PLACEMENT OF ESOPHAGOSTOMY TUBE USING INTRODUCER



Fig. 5.25. Place the anesthetized patient in right lateral recumbency. Measure from the proposed tube entrance site to the mid thorax.



Fig. 5.26. Clip and aseptically scrub the left lateral cervical region as previously described. Insert the distal end of the tube into the mouth and into the esophagus. The distal end of the esophagostomy tube should be inserted to the mid thorax as measured.

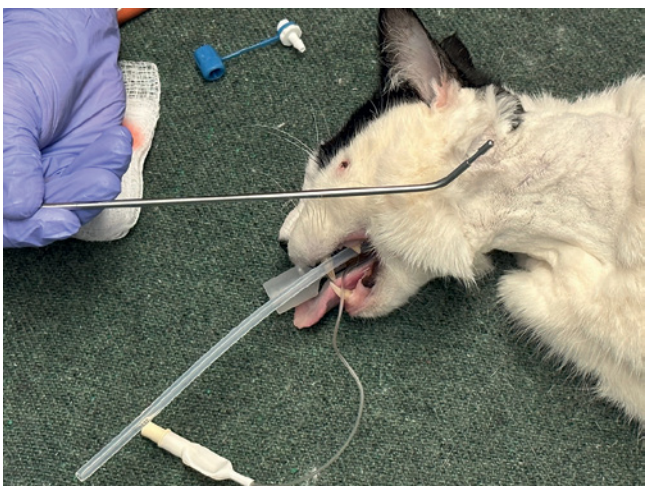


Fig. 5.27. Prepare to insert the introducer into the mouth. Note the distal end of the introducer is curved, to be directed laterally to the skin surface once it is inserted into the esophagus.



Fig. 5.28. Push the introducer into the mouth to the level of the esophagus and tube entrance site. Carefully visualize and avoid the jugular vein. Direct the distal end of the introducer laterally to the skin.

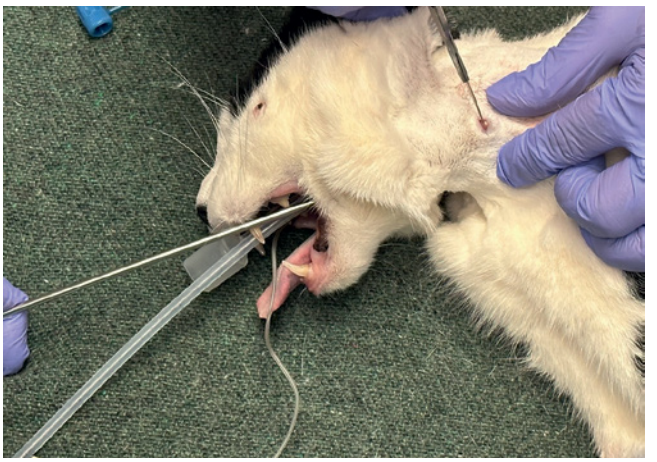


Fig. 5.29. Palpate the end of the esophagostomy tube introducer under the skin. Make a small incision through the skin over the tip of the introducer using a number 11 scalpel blade.



Fig. 5.30. Push the end of the introducer through the skin.

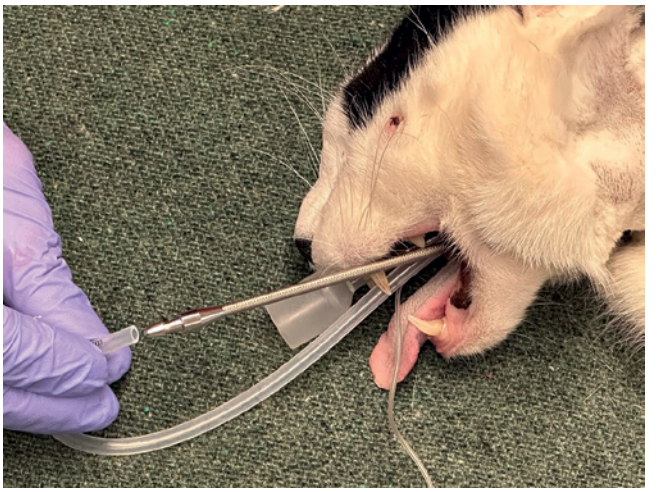


Fig. 5.31. Attach the proximal end of the esophagostomy tube to the distal end (noncurved) of the introducer.



Fig. 5.32. Pull the introducer with the esophagostomy tube attached caudally and laterally, out through the skin incision.



Fig. 5.33. The esophagostomy tube in place. Secure the esophagostomy tube with a purse-string and finger trap sutures as previously described.

OROGASTRIC LAVAGE

Introduction

Orogastric lavage is an important method for removal of ingesta from the stomach of animals that have ingested toxic substances or excessive food, a condition known as "food bloat." The technique should be performed only in animals placed under general anesthesia with a cuffed endotracheal tube in place, and maintained on gas or intravenous anesthesia and oxygen. Orogastric lavage should be considered whenever a patient is not able to vomit, or if induction of emesis is contraindicated in animals with neurologic abnormalities that cannot protect their airways.

Supplies Needed

Orogastric tube or 60-mL conical shaped syringe
Two buckets or bowls, depending on large or small patient size
Warm tap water
Lavage pump
Mouth gag
1-inch white tape or permanent marker

Indications

Removal of toxins
Removal of food from stomach
Gastric decompression

Contraindications

Should not be performed in awake, nonintubated animals that cannot protect their airway
Gastric perforation
Removal of caustic substances



Fig. 5.34. Place the patient in sternal or lateral recumbency following induction of general anesthesia. Measure the orogastric tube from the tip of the nose to the last rib.



Fig. 5.35. Mark the tube with a piece of 1-inch white tape or permanent marker.



Fig. 5.36. Lubricate the tube with water soluble lubricant.

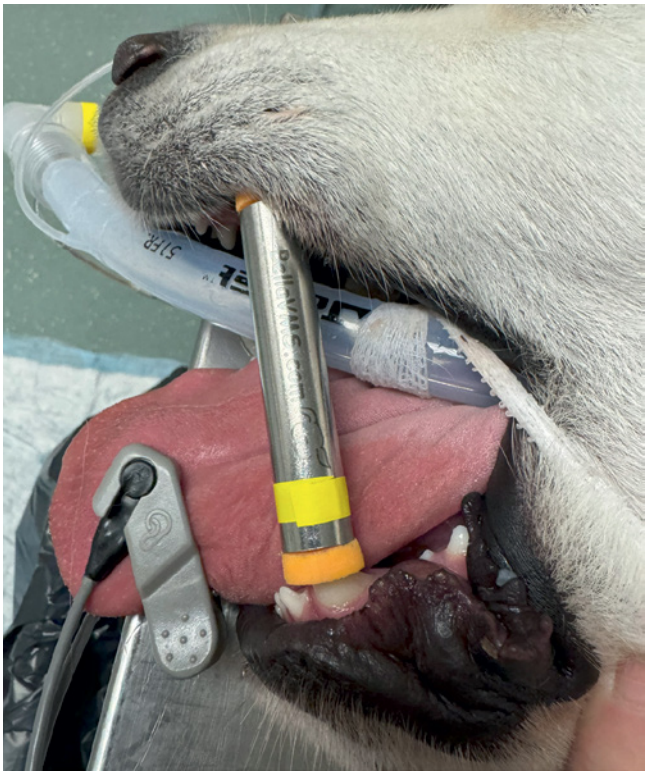


Fig. 5.37. Place a mouth gag into the mouth to keep the jaws open. Insert the lubricated tube through the mouth, into the esophagus to the level of the last rib, into the stomach.



Fig. 5.38. Attach the proximal end of the orogastric tube to the lavage pump (or 60-mL conical tipped syringe filled with tap water warmed to body temperature), and instill tap water into the stomach. Monitor the patient for respiratory distress or excessive abdominal distension. Disconnect the proximal end of the orogastric tube from the lavage pump and allow fluid and gastric contents to flow into a second collection bucket. Save specimens for lateral toxicologic analysis, if necessary. If you are using a red rubber catheter in a small patient, aspirate on the empty 60-mL syringe to aspirate gastric contents into the syringe, then empty into a bowl.



Fig. 5.39. To remove the tube, kink the end of the tube as you are removing it from the patient's stomach and esophagus, to prevent residual fluid from leaking from the tube as it is removed.

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CHAPTER 6

Urinary Catheter Placement, Urohydropulsion, and Temporary Antepubic Cystostomy Catheter Placement

URINARY CATHETER PLACEMENT IN MALE AND FEMALE DOGS

Introduction

Placement of a urinary catheter often serves a dual purpose in critically ill small animal patients. In nonambulatory animals, a urinary catheter attached to a closed collection system is invaluable in maintaining cleanliness and preventing urine scald and decubital ulceration. Urine collection and quantitation is often necessary when assessing hydration and perfusion parameters and renal function. Finally, urethral catheterization and maintenance of an indwelling urinary catheter is necessary in the treatment of urethral obstruction in cases of feline lower urinary tract disease and urethral calculi. This chapter describes the placement of various types of urinary catheters in male and female dogs and cats.

Supplies Needed

Electric clippers and blades
Antimicrobial scrub solution
Sterile gloves
1-inch white tape
20- to 30-mL syringe
Sterile 0.9% saline solution
Sterile field towels
Urine collection system/bag
Sterile lubricating jelly
Christmas tree adapter
3–0 nonabsorbable suture
Foley or red rubber catheter

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Feline urinary catheter
For female dogs:
- Vaginal speculum
- Sterile otoscope head
- Light source

Indications

Maintenance of patient cleanliness in nonambulatory patients
Urine collection for urinalysis
Urine output monitoring
Treatment of urethral obstruction
Urethral trauma
Urethral prolapse

Contraindications

Not indicated in patients that are ambulatory and do not have urethral obstruction, or do not require urine output monitoring.

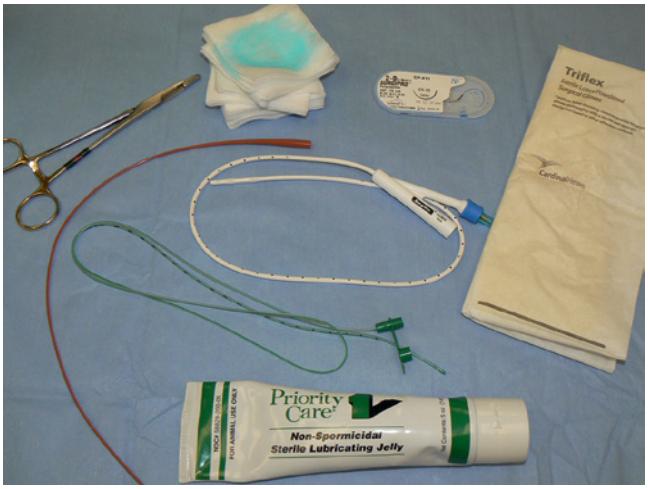


Fig. 6.1. Supplies needed for placement of a urinary catheter can differ in males and females. Required supplies include electric clippers and blades, antimicrobial scrub solution, sterile gloves, sterile 0.9% saline solution, 20- and 30-mL syringes, 1-inch white tape, 3- to 6-mL syringes, sterile needle holder, nonabsorbable suture, sterile field towels, urinary catheter, sterile lubricating jelly, Christmas tree adapter, light source, and a closed urine collection system. For female urinary catheter placement, a sterile vaginal speculum or sterile otoscope head and light source may come in handy.



Fig. 6.2. Clip fur close to the tip of the prepuce.

Helpful hint: Use care to not cause skin irritation.



Fig. 6.3. Retract the prepuce to expose the penis, and then scrub the tip of the prepuce and penis with antimicrobial scrub solution.



Fig. 6.4. For non-Foley catheters, measure the catheter from the tip of the penis to the urinary bladder. This is to ensure that you do not insert the catheter too far into the urinary bladder, which could cause it to coil and create a knot making it difficult or impossible to remove.

Helpful hint: Use care to not contaminate the catheter by touching it to the patient's fur.

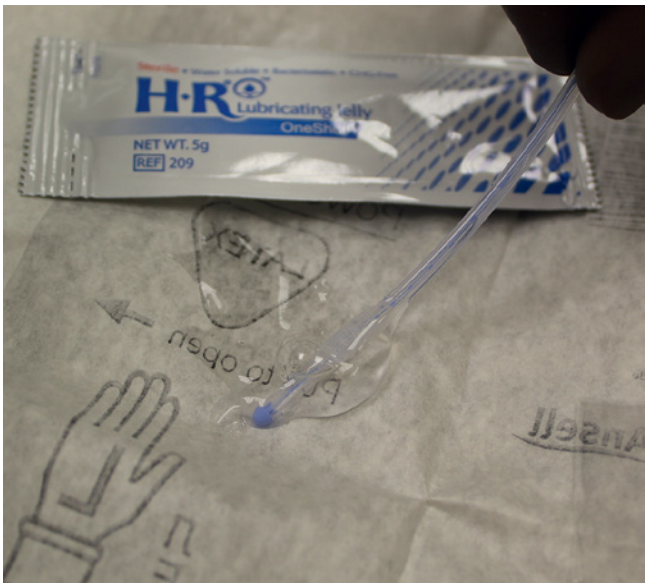


Fig. 6.5. Wearing sterile gloves, lubricate the tip of the urinary catheter.



Fig. 6.6. Gently insert the catheter into the distal urethra.



Fig. 6.7. Push the urinary catheter through the urethra into the urinary bladder until urine flows.

Helpful hint: Once the catheter is in the urinary bladder, urine should flow freely from the catheter. Use caution if a urinary rupture is suspected, because urine may not flow readily due to leakage into the abdominal cavity.

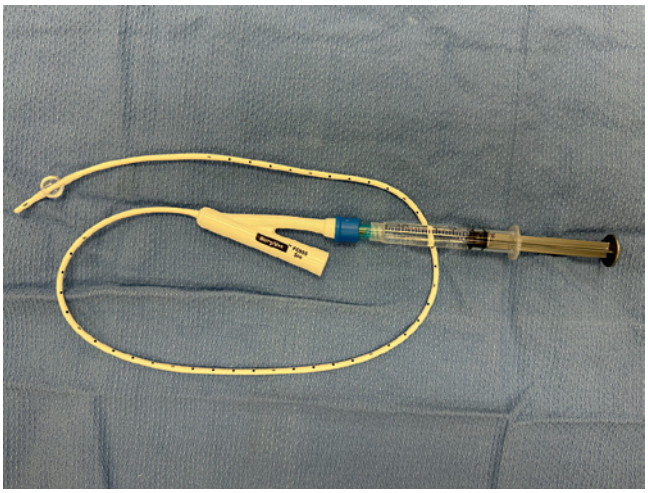


Fig. 6.8. Inflate the balloon of the Foley catheter and remove any internal stylette, if present. You can now release the prepuce and allow it to fall back to its normal anatomic position.



Fig. 6.9. Attach the catheter to a closed collection system.



Fig. 6.10. The catheter can be sutured to the skin, to prevent tension on the catheter and tip of the penis.

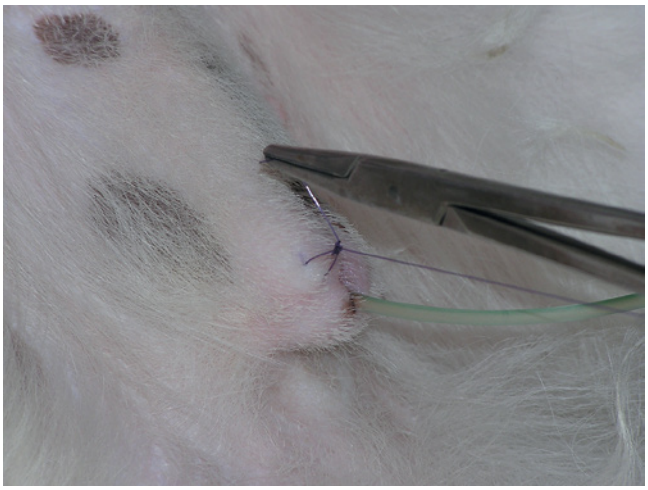


Fig. 6.11. If the catheter does not have a Foley balloon, an alternative method of securing the urinary catheter is to first place a stay suture at the end of the patient's prepuce. This suture will be used to secure the prepuce to tape attached to the urinary catheter.

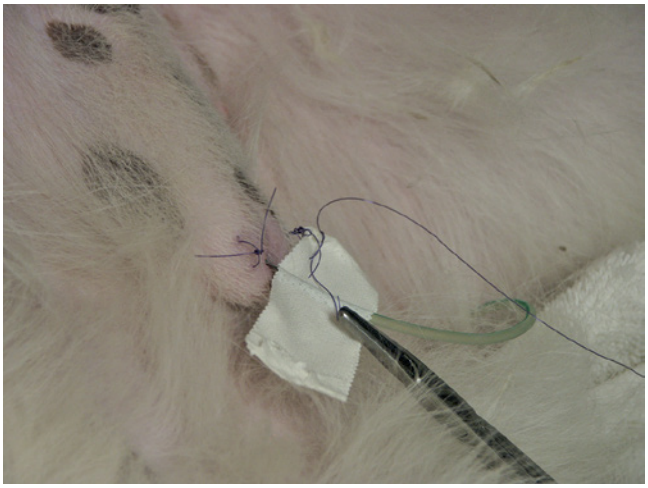


Fig. 6.12. Attach a length of white adhesive tape to the urinary catheter, and then secure the tape to the stay suture(s) in the prepuce.

Helpful hint: Make sure that the tape and catheter are completely dry and that the tape is securely attached to the catheter to prevent it from slipping.



Fig. 6.13. Supplies needed for placement of a urinary catheter in a female dog.

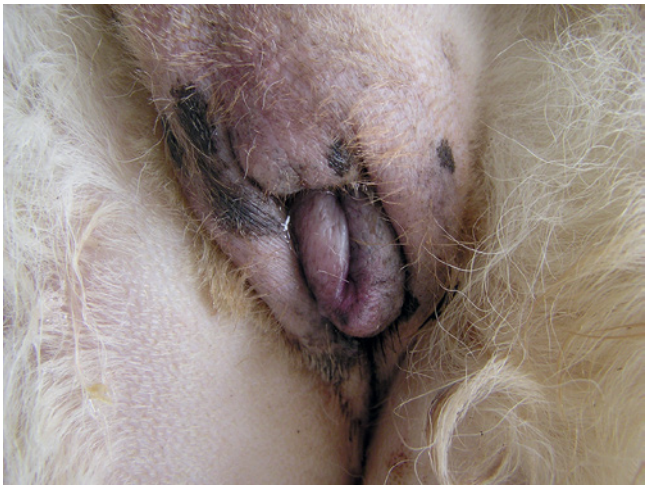


Fig. 6.14. Gently clip the fur around the vulva.

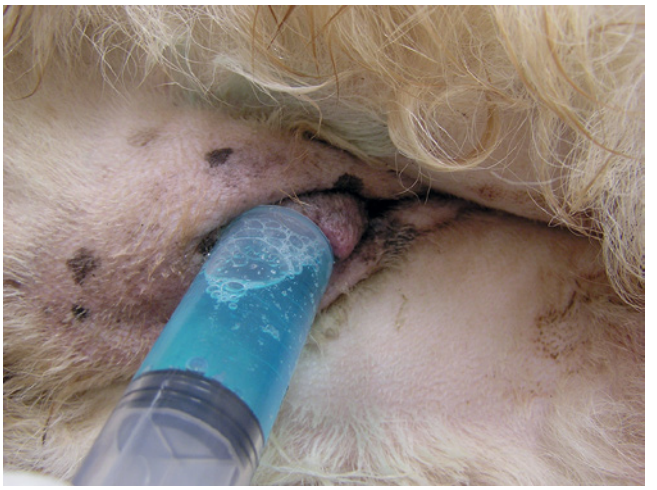


Fig. 6.15. Aseptically scrub the external vulva with antimicrobial scrub solution, and flush the vulva.

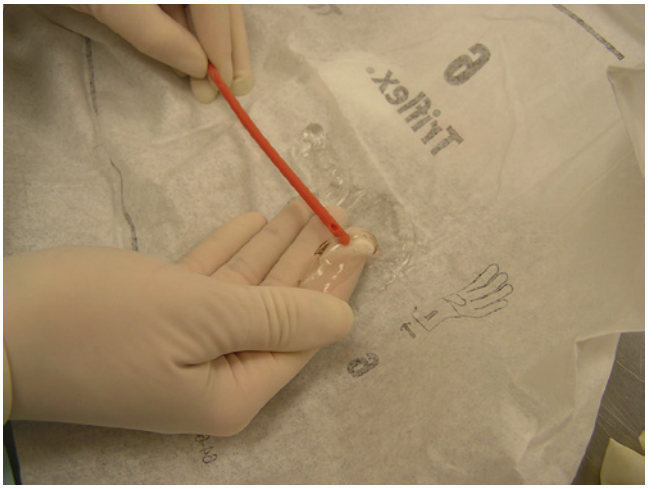


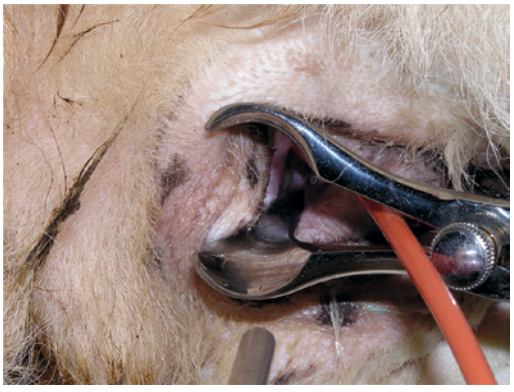
Fig. 6.16. Wearing sterile gloves, lubricate the tip of the sterile urinary catheter with sterile lubricant.



Fig. 6.17. Lubricate the index finger of your nondominant hand, and insert it into the patient's vagina. Palpate for the urethral papilla on the ventral floor of the vagina.

Helpful hint: Curve the tip of your index finger ventrally, so that once you insert the catheter into the vagina, the catheter will "dip" toward the ventral vaginal floor and slide into the urethra.

(a)



(b)



Figs. 6.18a–b. If you are not successful at the catheterization using the "blind" technique, you can lubricate and insert a sterile vaginal speculum or sterile otoscope head or sterile 6-mL syringe case into the vagina and visualize the urethral papilla to facilitate catheter insertion.



Fig. 6.19. If a Foley catheter is used, insert sterile 0.9% saline to inflate the balloon at the catheter tip.



Fig. 6.20. Urine will flow from the catheter once it has successfully been introduced into the urinary bladder. In rare cases, no urine will flow if the urinary bladder is empty or has been ruptured.



Fig. 6.21. Attach the catheter to a closed collection system after you observe urine flowing.



Fig. 6.22. Gently pull on the urinary catheter until you feel slight resistance as the balloon becomes seated snugly in the apex of the urinary bladder near the urethra.

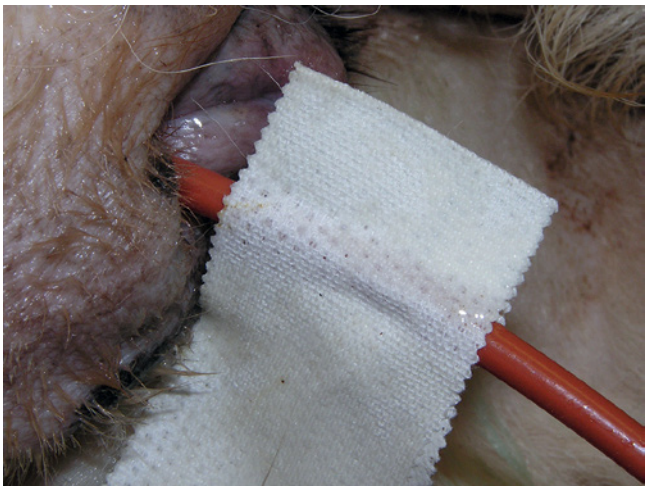


Fig. 6.23. If a Foley catheter is not used, place a length of 1-inch white tape around the catheter near the vulva. Place two stay sutures of nonabsorbable suture material on either side of the vulva.

Helpful hint: Make sure that the catheter is completely dry and that the tape is secured firmly to the catheter or the catheter will slip.

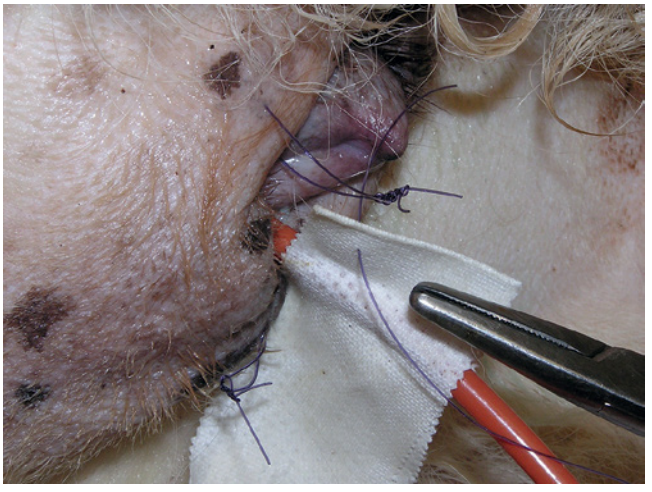


Fig. 6.24. Suture the stay sutures to the white tape.

URETHRAL CATHETERIZATION IN MALE AND FEMALE CATS

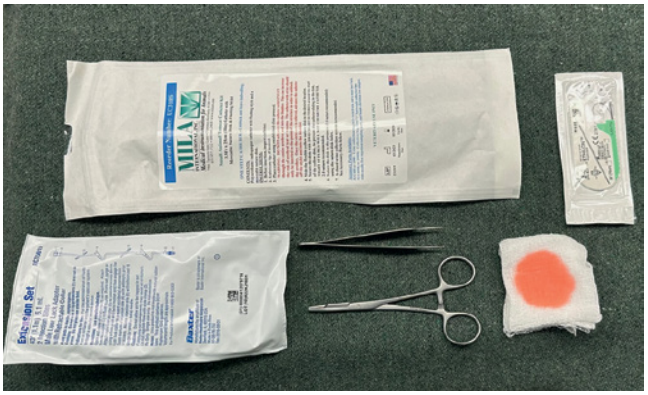


Fig. 6.25. Supplies needed for feline urethral catheterization.



Fig. 6.26. Place the patient in lateral or dorsal recumbency, according to operator preference.



Fig. 6.27. Wearing sterile gloves, reflect the tail dorsally and cranially, and then extrude the penis from the prepuce, grasping the prepuce tightly at the base of the penis between your thumb and index finger. This prevents the prepuce from slipping back over the penis.



Fig. 6.28. In some cases, keep the penis extruded is challenging, so a rat tooth forceps or small mosquito hemostat can be used to keep the penis exteriorized.

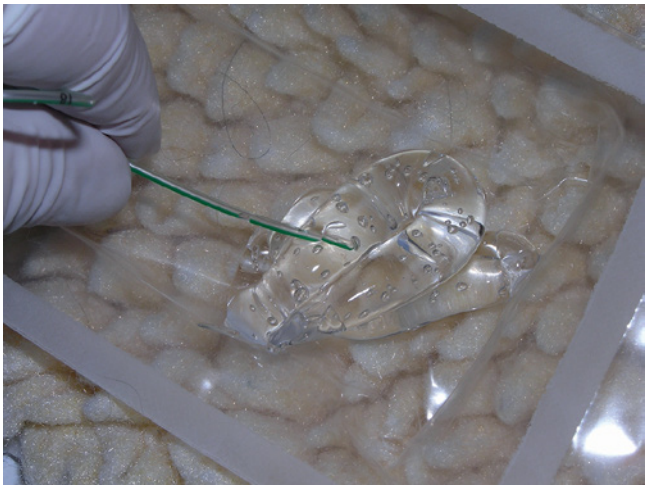


Fig. 6.29. Lubricate the tip of the urinary catheter with sterile lubricating jelly.



Fig. 6.30. Insert the lubricated catheter unto the urethra and advance as far as possible.

Helpful hint: You may feel a “gritty” sensation if urethral calculi or crystals are present.



Fig. 6.31. The urinary catheter in place. It can be used to obtain a sterile urine sample and flush the urinary bladder until the urine becomes more clear.

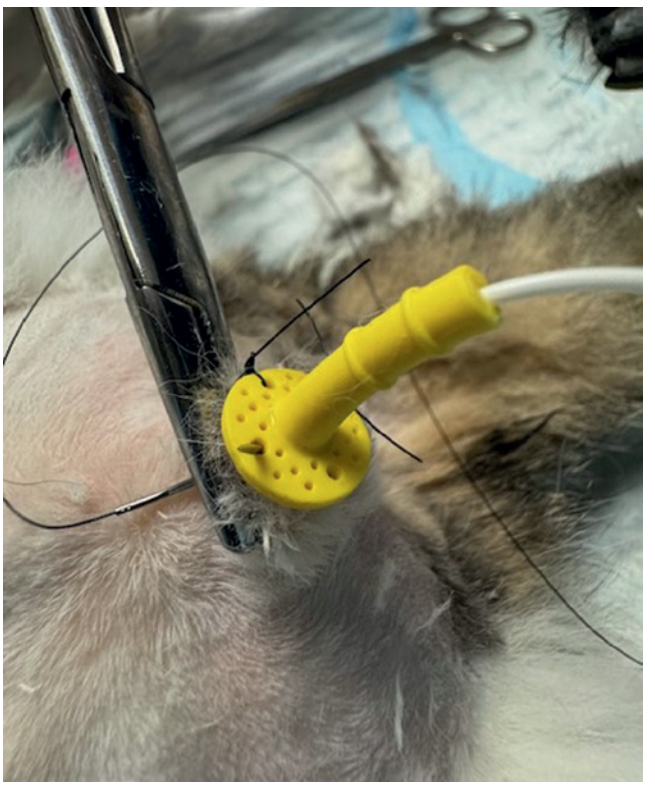


Fig. 6.32. Suture the urinary catheter in place to the prepuce using nonabsorbable suture.



Fig. 6.33. Attach the urinary catheter to a closed collection system, and then secure the urinary catheter line to the tail using 1-inch white tape.

Helpful hint: Make sure to not kink the catheter or line, or else this could result in failure of urine to drain from the urinary bladder. Place an Elizabethan collar on the patient to prevent iatrogenic patient removal of the catheter.



Fig. 6.34. Urinary catheter placement in the female cat.



Fig. 6.35. Scrub the exterior vulva with antimicrobial scrub.

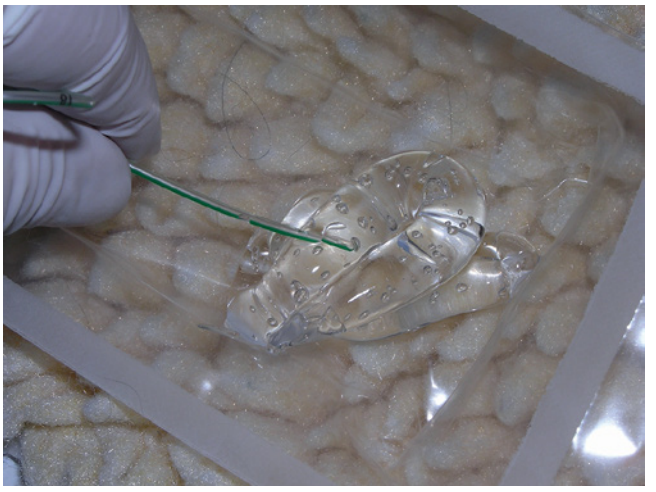


Fig. 6.36. Wearing sterile gloves, lubricate the tip of a urinary catheter with sterile lubricating jelly.

Helpful hint: Placing the urinary catheter in the freezer will make it more rigid and easier to place. Measure the urinary catheter from the urinary bladder to the vulva to ensure that you don't insert the catheter too far into the urinary bladder.

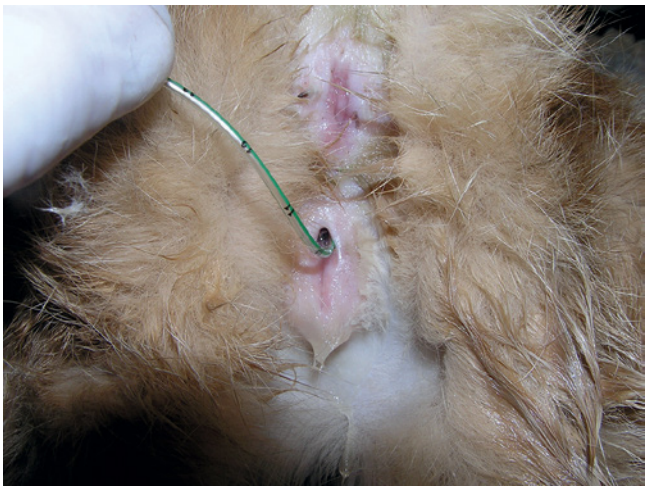


Fig. 6.37. Insert the tip of the catheter into the ventral vulva and push cranially as you pull the edges of the vulva caudally. The catheter tip should slip into the urethral papilla and then into the urinary bladder. Placement is confirmed by aspirating urine from the bladder.



Fig. 6.38. Secure the catheter to the skin with nonabsorbable suture.



Fig. 6.39. Attach the catheter to a closed collection system. Secure the collection system to the tail with a length of 1-inch white tape.

UROHYDROPULSION

Introduction

Urohydropulsion is a procedure that is sometimes required to pass a urethral catheter in a male dog that has urethral calculi causing an obstruction. In most cases, the patient must be placed under general anesthesia to minimize discomfort and to allow sufficient relaxation of the urethra to allow optimal placement of the urinary catheter. The goal of the urohydropulsion is to push the urethral calculi back into the urinary bladder until definitive removal via cystotomy can be performed. The supplies required for urohydropulsion are the same as for placement of a urinary catheter.



Fig. 6.40. Supplies needed for urohydropulsion.



Fig. 6.41. Place the patient in lateral recumbency and prepare the tip of the prepuce and penis as previously described.



Fig. 6.42. Lubricate the catheter tip with sterile lubricant.

Helpful hint: When attempting to hydropulse urethral calculi back into the urinary bladder a rigid, sterile polypropylene catheter or a red rubber catheter that has been put into the freezer work best. Foley catheters are not rigid enough to help dislodge the urethral calculi, which are often lodged adjacent to or caudal to the os penis.



Fig. 6.43. Place a small amount of sterile lubricating jelly and sterile saline into a 20-mL syringe.



Fig. 6.44. Insert the catheter into the tip of the penis, and then attach the 20-mL syringe to infuse the sterile lubricating jelly mixed with sterile saline.



Fig. 6.45. Have an assistant lubricate a gloved index finger.



Fig. 6.46. Have the assistant insert the lubricated gloved index finger into the rectum, and alternating compression and relaxation on the ventral floor of the rectum to occlude then relax pressure on the urethra as it passes over the floor of the pelvis.

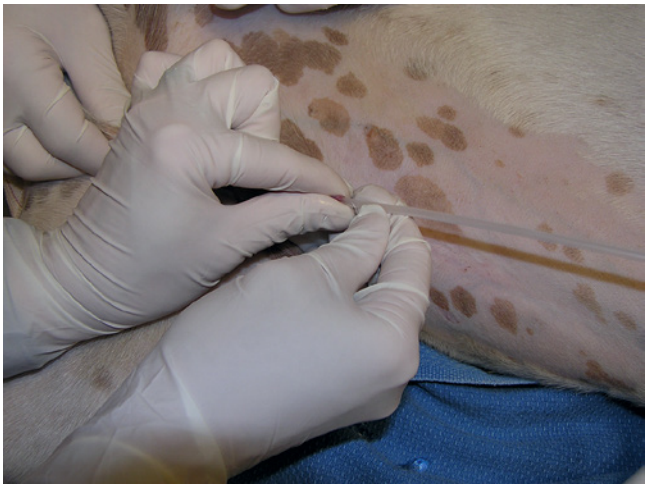


Fig. 6.47. Pinch the distal penis closely around the catheter between your thumb and index finger to keep the fluid in the penile urethra.



Fig. 6.48. Using the 20-mL syringe, inject and pulse the mixture of sterile lubricating jelly and sterile saline into the catheter, as the assistant compresses and relaxes pressure on the pelvic urethra. This technique will alternately increase then decrease pressure in the urethra to dislodge the urethral calculus and retropulsed it back into the urinary bladder. Once the calculus has been dislodged, pass a soft urinary catheter and secure it in place until surgical removal of the calculus can be performed.

TEMPORARY ANTEPUBIC CYSTOSTOMY TUBE PLACEMENT

Introduction and Indications

When urethral catheterization is not possible or if the patient is too unstable to perform a cystostomy or perineal urethrostomy due to acid–base and electrolyte derangements, placement of a temporary antepubic cystostomy catheter using local anesthesia can be life-saving to keep the urinary bladder drained. Once the patient is more stable and acid–base and electrolyte abnormalities have been corrected, definitive surgery can be performed.

Contraindications

Urethral catheterization is possible
Pyometra
Transitional cell carcinoma of the urinary bladder

Supplies Needed

Foley balloon tipped catheter
Lidocaine 2%
Electric clippers and blades
Antimicrobial scrub
Sterile field towels (4)
Towel clamps (4)
Number 10 and number 11 scalpel blades
Scalpel handle
Kelly hemostats (2)
Metzenbaum scissors
Absorbable suture (3–0)
Nonabsorbable suture (3–0)



Fig. 6.49. Supplies needed for placement of a temporary antepubic cystostomy catheter.



Fig. 6.50. Place the patient in dorsal recumbency and clip the caudoventral abdomen from the umbilicus caudally to the pubis and laterally to the folds of the flank.

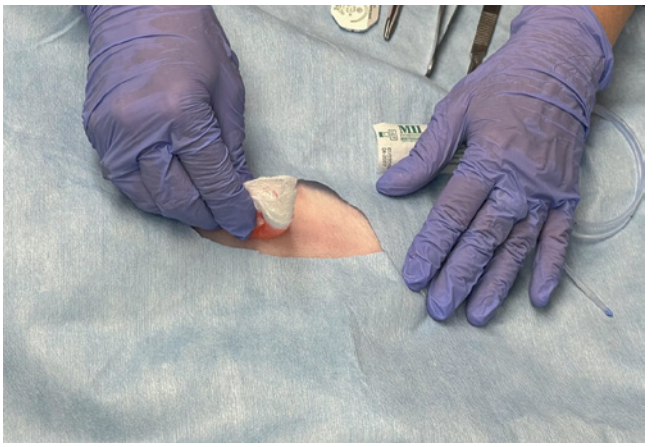


Fig. 6.51. Aseptically scrub the clipped area.



Fig. 6.52. Insert 1-mg/kg 2% lidocaine through the skin, underlying subcutaneous tissue and external abdominal oblique muscles.

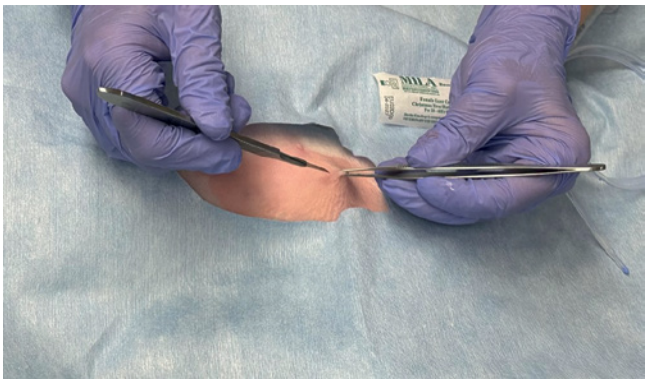


Fig. 6.53. Use a thumb forceps to pick up the anesthetized skin, then make a small stab incision through the skin using a number 10 scalpel blade.

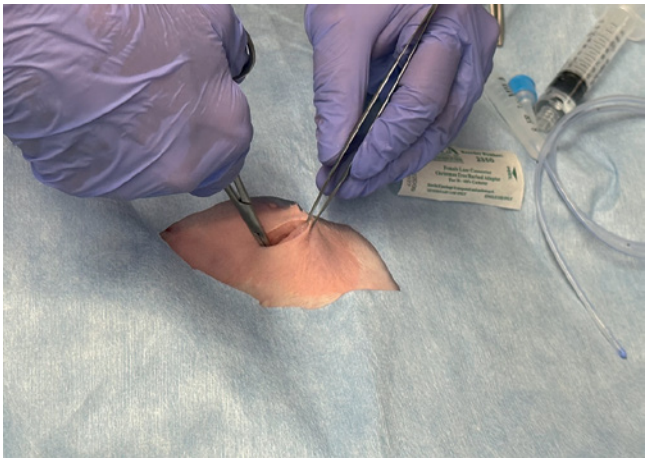


Fig. 6.54. Bluntly dissect through the subcutaneous tissue to the level of the external abdominal oblique muscle using a Kelly hemostat.

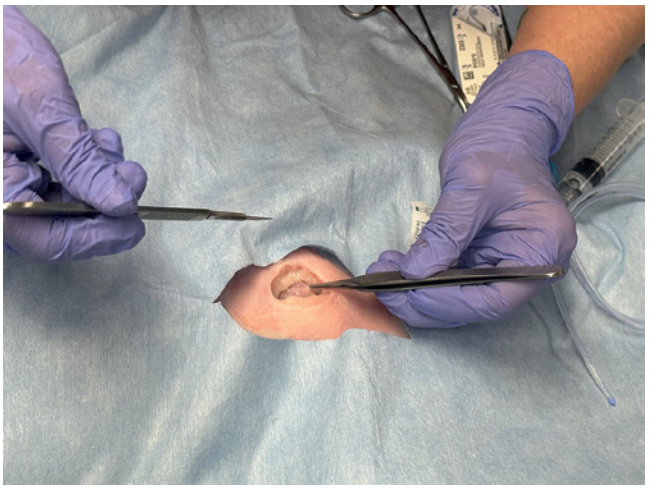


Fig. 6.55. Pick up the external abdominal oblique muscle with a thumb forceps and make a small stab incision through the muscle.

Helpful hint: Use caution to avoid nicking the underlying urinary bladder.

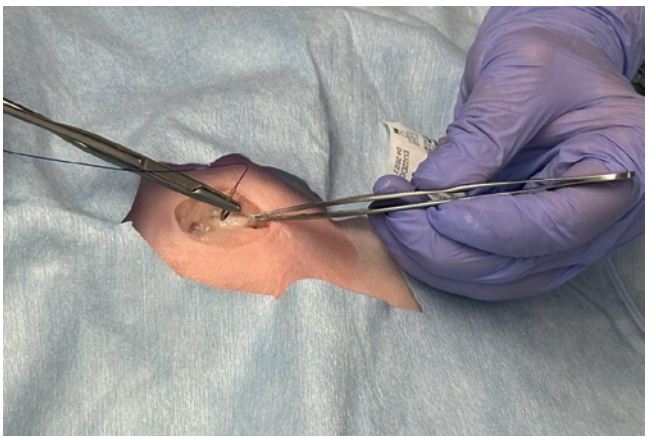


Fig. 6.56. Use a thumb forceps to pick up the urinary bladder, and then place a purse string suture in the urinary bladder using absorbable suture.

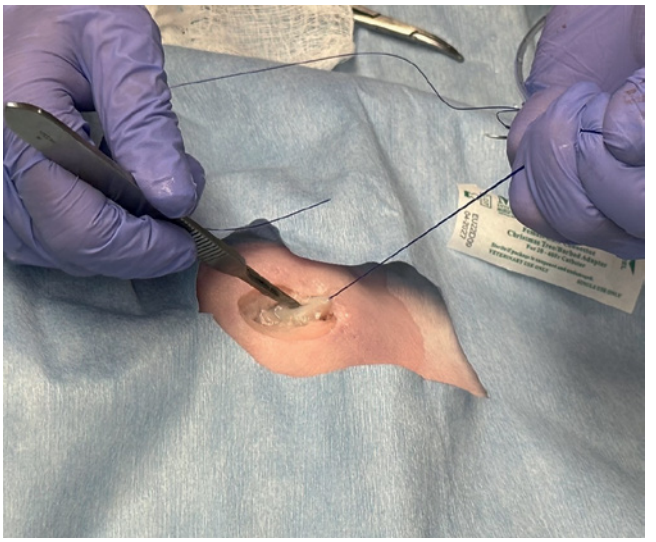


Fig. 6.57. Make a small nick incision into the urinary bladder through the middle of the area delineated by the purse string suture.

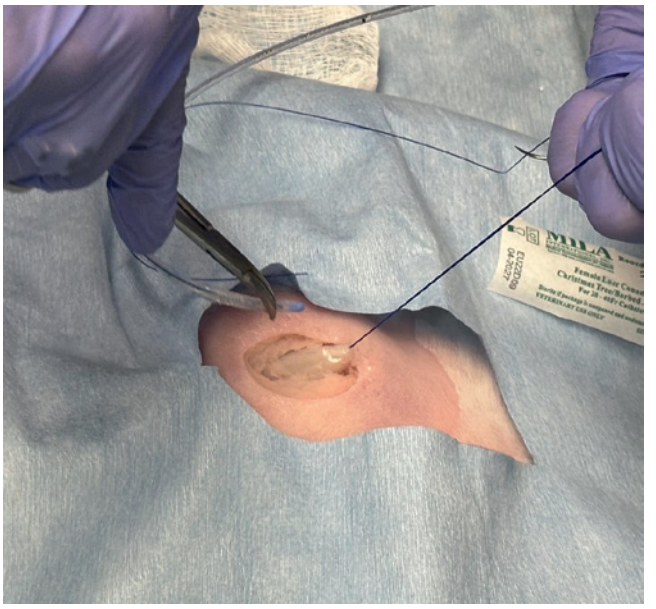


Fig. 6.58. Insert the urinary catheter into the urinary bladder.



Fig. 6.59. Inflate the balloon of the Foley urinary catheter.

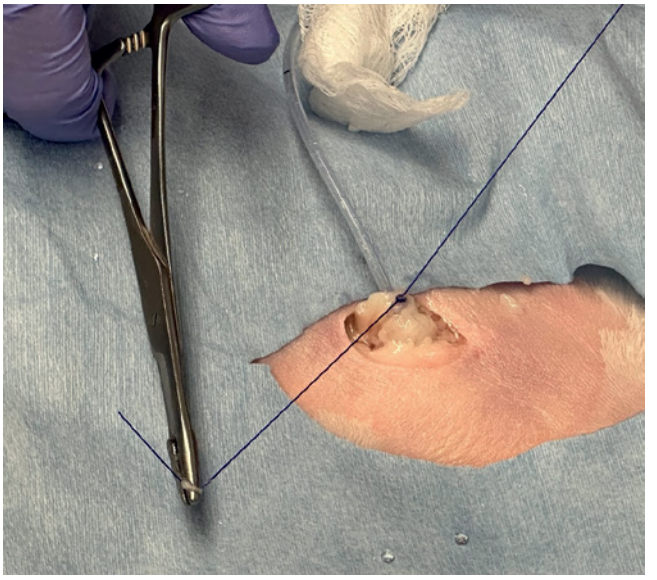


Fig. 6.60. Tie the purse string suture around the urinary catheter.



Fig. 6.61. Suture the subcutaneous layer with absorbable suture. Then, secure the skin incision with a second purse string suture. Plastic catheter adapters can be secured around the tube to allow suture to the skin. The tube should then be attached to a closed collection system and the abdominal incision covered with a bandage.

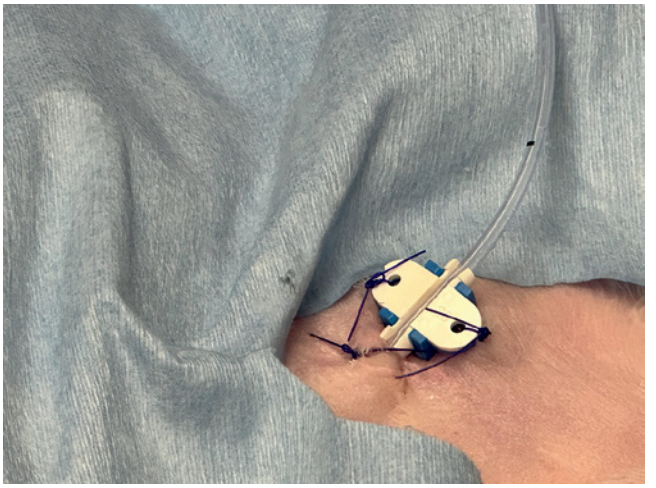


Fig. 6.62. Cystostomy catheter secured to the skin.

SUGGESTED READING

Beck AL, Grierson JM, Ogden DM, Hamilton MH, Lipscomb VJ. Outcome and complications associated with tube cystostomy in dogs and cats: 76 cases (1995–2006). J Am Vet Med Assoc 2007, 220(8):1184–1189.

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Dornbush JA, Vojt T, Selmic LE. Urethral catheterization of small female cats and dogs weighing less than ten kilograms: the two-catheter technique. J Am Vet Med Assoc 2023, 261(8):1.

Yanshan E, Fick ME, Long Mays E. Case report: utility, complications, and short-term outcome in three dogs managed with percutaneous pigtail cystostomy catheters for urethral obstruction. Front Vet Sci 2023, doi:https://doi.org/10.3389/fvets.2023.1200406.

CHAPTER 7

Abdominocentesis and Diagnostic Peritoneal Lavage

ABDOMINOCENTESIS

Introduction

Abdominal paracentesis (abdominocentesis) is a useful and inexpensive technique to identify abdominal effusion, particular in patients with acute abdominal pain or unexplained fever. With the widespread availability of cage-side point-of-care ultrasound in small animal medicine, ultrasound-guided abdominocentesis can help identify small pockets of abdominal effusion to remove. If ultrasound is not available, blind abdominocentesis or diagnostic peritoneal lavage (DPL) may need to be performed. Evaluation of any fluid obtained often aids in the diagnosis and helps to guide therapy. Abdominal effusion can be classified according to its cellularity and protein content as transudates, modified transudates, and exudates. Causes of modified transudates and exudates include neoplasia, septic and nonseptic inflammation, and hemorrhage. Additionally, biochemical evaluation of the fluid for blood urea nitrogen, creatinine, potassium, amylase, lipase, bilirubin, glucose, and lactate used in addition to cytology can aid in the diagnosis of various conditions including uroabdomen, pancreatitis, and bile or septic peritonitis.

Supplies Needed

20- to 22-gauge 1- to 1½-inch needles
Gloves
Electric clippers and blades
3- to 6-mL syringe
Antimicrobial scrub
Sterile EDTA and red-topped tube
Port-a-Cul™ sterile culturettes for bacterial isolation

Veterinary Emergency and Critical Care Procedures, Third Edition. Timothy B. Hackett and Elisa M. Mazzaferro.
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Indications

Diagnosis of hemoabdomen, uroabdomen, bile, or septic peritonitis and/or neoplastic effusions

Contraindications

Penetrating abdominal wounds (exploratory laparotomy required)

Limitations

Abdominocentesis performed without ultrasound-guidance can be falsely negative in the presence of retroperitoneal effusion (urinary tract leakage, hemorrhage, neoplasia, and abscess) or if small volume (<7 mL/kg) of abdominal effusion is present.

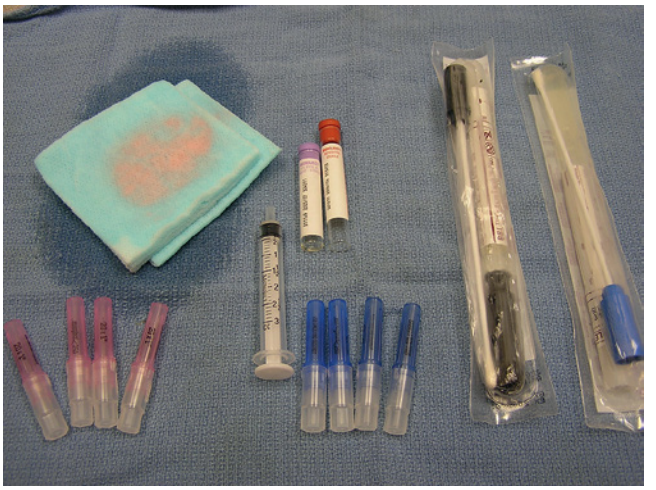


Fig. 7.1. Supplies needed to perform abdominocentesis.



Fig. 7.2. Four quadrant locations for needle placement, if ultrasound guidance is not available.



Fig. 7.3. Clip and aseptically scrub a 4-cm^2 area on the ventral abdomen with the umbilicus in the center of the clipped area.



Fig. 7.4. Insert the needle cranial and to the right of the umbilicus, twisting gently as the needle is inserted into the peritoneal cavity, to push any hollow organ away from the tip of the needle. If the fluid does not flow freely, repeat insertion of the needle as previously described in the following locations: to the left and cranial, to the right and caudal, and to the left and caudal to the umbilicus.

Helpful hint: In some cases, fluid will not flow freely until a second needle is inserted into the peritoneal cavity, leaving the first needle in place.



Fig. 7.5. Gently aspirate if the fluid does not flow freely.

Helpful hint: Abdominocentesis may be falsely NEGATIVE with this technique if less than 5 to 7 mL/kg of abdominal effusion is present.



Fig. 7.6. Save fluid in a sterile red-topped and EDTA tubes for cytology, biochemistry, and bacterial analyses.

DIAGNOSTIC PERITONEAL LAVAGE

DPL can be performed in patients with acute abdominal pain and unexplained fever when four-quadrant abdominocentesis is negative, and when an abdominal ultrasound or CT scan are not available. DPL is more sensitive when small volumes of peritoneal effusion are present and when there is rupture of a hollow viscus, particularly after blunt or penetrating trauma. DPL can also be used to identify and evaluate the character of abdominal effusion postoperatively if a Jackson-Pratt drain is not in place.

Supplies Needed

20- to 22-gauge, 1- to 1½-inch needles OR 16- to 20-gauge 1½ over-the-needle catheter
Sterile red topped and lavender tubes for sample collection
3- to 6-mL syringes
Electric clippers and blades
Antimicrobial scrub
Sterile gloves
Isotonic crystalloid solution (Normosol-R, Plasmalyte-A, Lactated Ringer's, 0.9% saline) warmed to body temperature (37 °C)
Intravenous fluid administration set/line
Rapid infusion IV pressure bag
Sterile field towels (4)
Towel clamps
Optional supplies: Over-the-wire DPL kit

Indications

Identification and characterization of small amounts of abdominal effusion when abdominal paracentesis is negative

Contraindications

Penetrating injury into the peritoneal cavity that requires exploratory laparotomy

Limitations

DPL is insensitive in making a diagnosis of retroperitoneal effusions (hemorrhage, urinary tract leakage from kidney or ureters, neoplasia, and abscess). A limitation of this technique is that any fluid collected must be interpreted carefully, because dilution of total cell count and chemical analysis always occurs.



Fig. 7.7. Supplies needed for diagnostic peritoneal lavage.



Fig. 7.8. Place the patient in lateral recumbency and clip then aseptically scrub a 10-cm area of the ventral mid abdomen, with the umbilicus in the center. Drape the clipped area with sterile field towels secured with towel clamps.

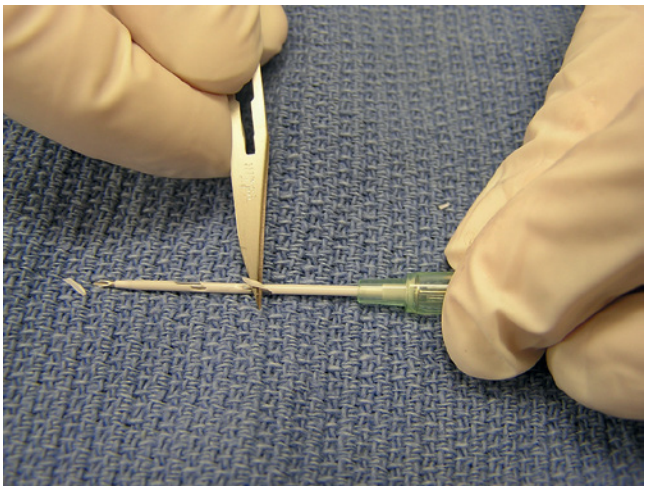


Fig. 7.9. Wearing sterile gloves, use a number 10 scalpel blade to fenestrate side-ports in an over-the-needle catheter.

Helpful hint: Use care to avoid making a hole larger than 50% of the circumference of the catheter. A large hole will weaken the catheter and increase the risk of it breaking off into the peritoneal cavity.



Fig. 7.10. Wearing sterile gloves, insert the over-the-needle catheter into the abdominal cavity and to the right of the umbilicus, at the level of the nipples. Advance the catheter slowly and with a gentle twisting motion to avoid iatrogenic puncture of the abdominal organs.



Fig. 7.11. Withdraw the stylette from the catheter, and examine the catheter hub for the presence of any fluid. If fluid is present, withdraw it using a 3-mL syringe.

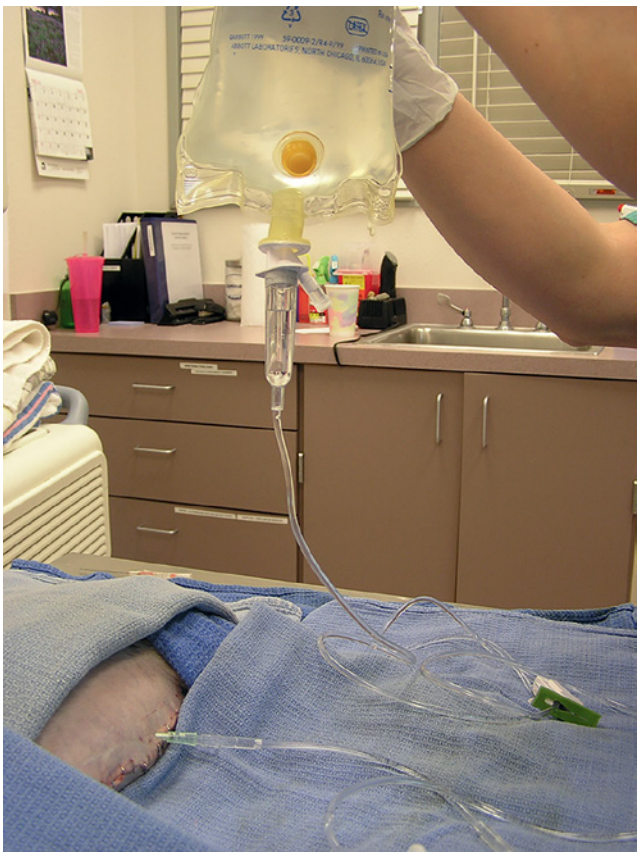


Fig. 7.12. If no fluid is present, instill 10 to 20 mL/kg of warmed isotonic crystalloid fluid into the peritoneal cavity over a period of 3 to 5 minutes. Watch the patient carefully for signs of respiratory distress or abdominal discomfort; if either of these signs occur, stop the abdominal infusion.



Fig. 7.13. Remove the catheter, then gently roll the patient from side to side or allow an ambulatory patient to walk while you massage the abdomen to redistribute the fluid that you have just infused into the peritoneal cavity. Lay the patient in lateral recumbency and aseptically prepare the abdomen for a four-quadrant abdominocentesis. Ideally, remove at least 0.5 to 1 mL of the lavage fluid to analyze for cytology and bacterial culture.

Helpful hint: In most cases, the majority of fluid that you have infused will not be recovered. Only small amounts of the infused fluid will be recovered for analyses. Any biochemical analyses performed will be diluted and therefore not accurate when a DPL has been performed.

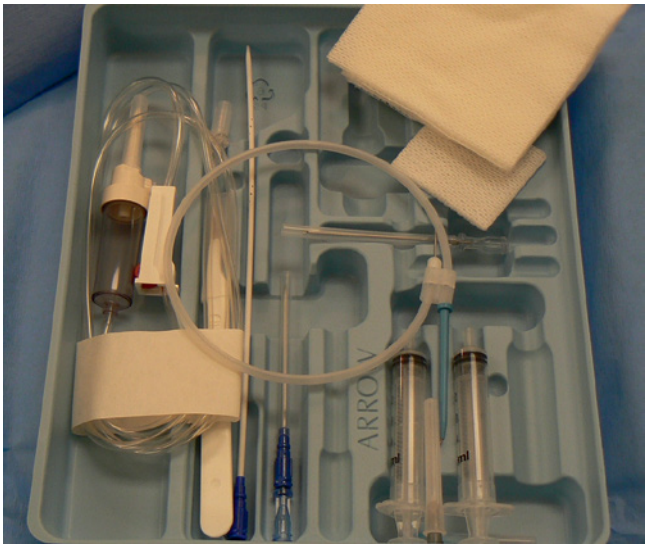


Fig. 7.14. Over-the-wire DPL kit contains an over-the-needle catheter and hypodermic needle through which a J-wire can be inserted into the peritoneal cavity. The kit also includes the J-wire and peritoneal lavage catheter. Depending on the manufacturer, some kits also include a scalpel, gauze, syringes, and an intravenous fluid infusion line.



Fig. 7.15. Clip and aseptically scrub the patient's ventral abdomen, and then drape the area with sterile field towels or surgical drape material.



Fig. 7.16. Infiltrate the skin and abdominal muscles just lateral to the umbilicus with 1-mg/kg 2% lidocaine (0.5 mg/kg in cats).

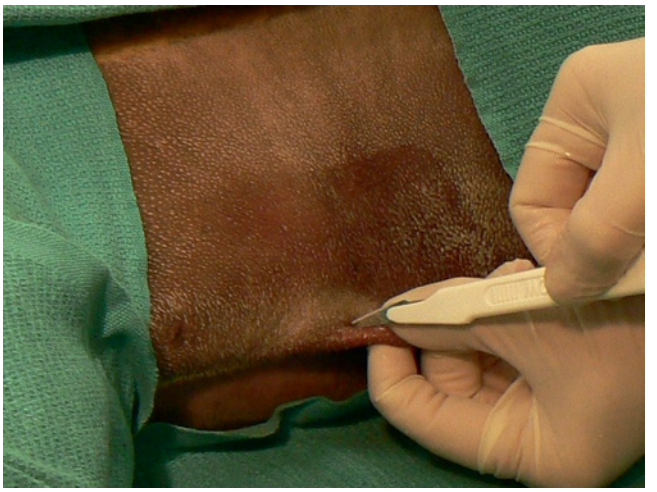


Fig. 7.17. Tent the skin over the anesthetized area, and make a small nick incision using the scalpel blade.

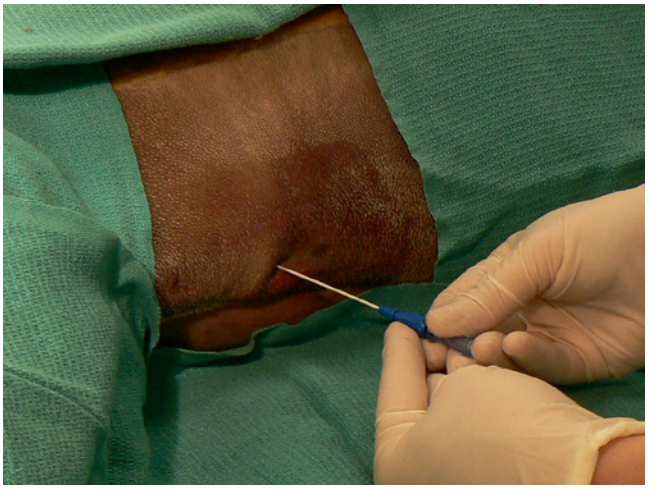


Fig. 7.18. Insert the over-the-needle catheter or hypodermic needle through the nick incision in the skin, through the abdominal musculature, and into the peritoneal cavity. Twist and the needle/catheter is inserted and penetrates into the peritoneal cavity to push any hollow viscera away from the tip of the needle.

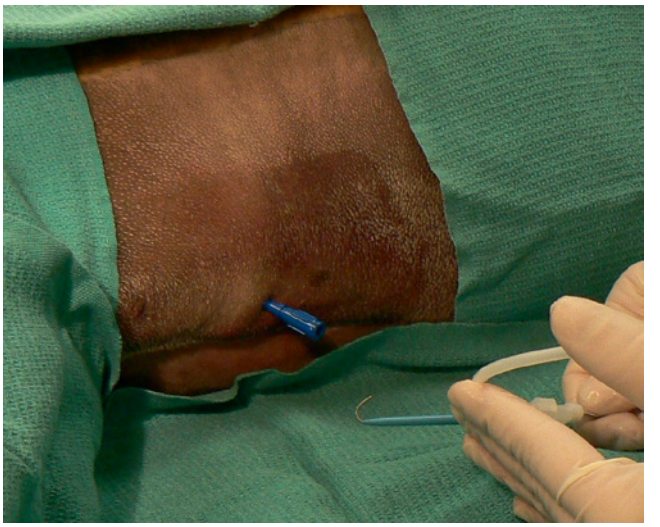


Fig. 7.19. Remove the stylette from the catheter. Retract the J-wire into its sheath. Insert the J-wire adapter into the catheter or hypodermic hub.

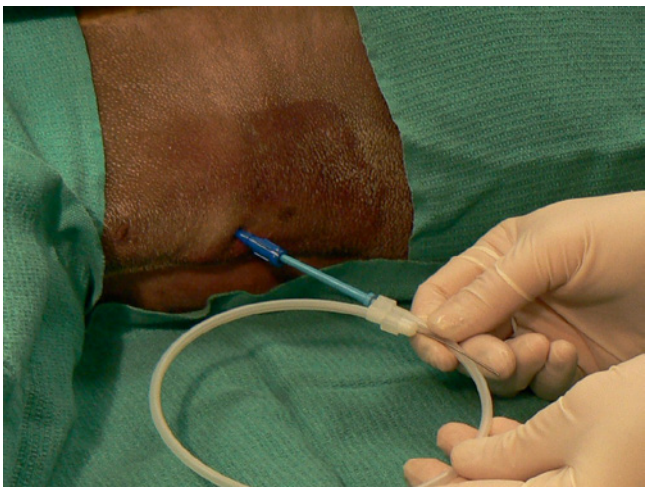


Fig. 7.20. Push the J-wire through the catheter or hypodermic needle into the peritoneal cavity.

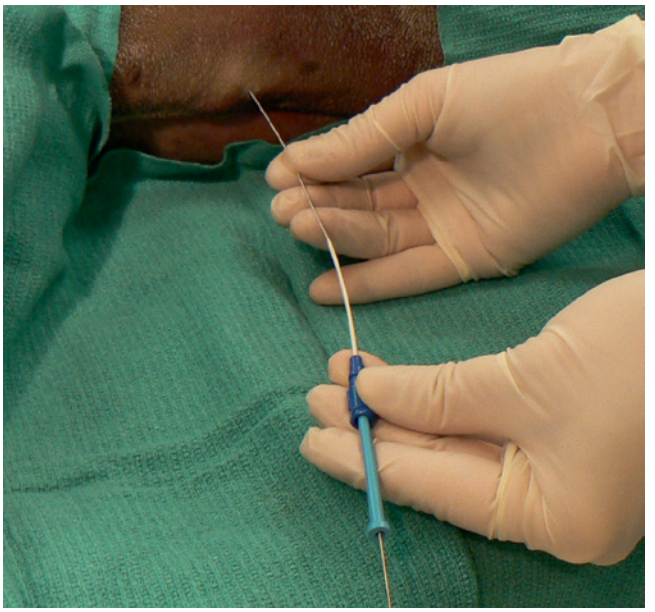


Fig. 7.21. Remove the catheter or hypodermic needle off of the J-wire, leaving the J-wire in place within the peritoneal cavity.

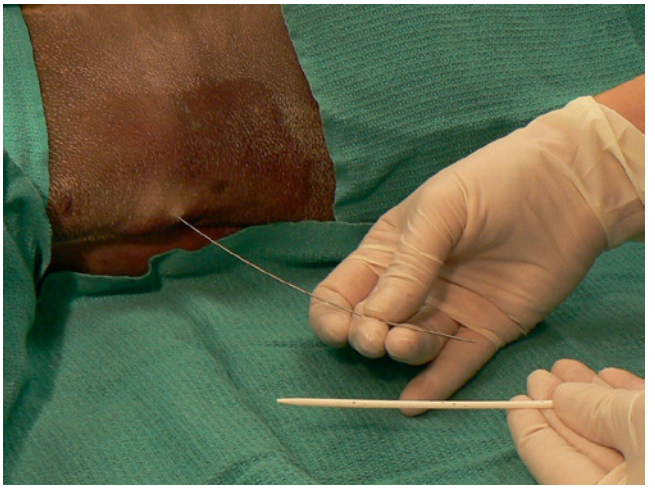


Fig. 7.22. Next, pass the DPL catheter over the J-wire, into the peritoneal cavity. Note the multiple holes in the catheter to facilitate drainage.

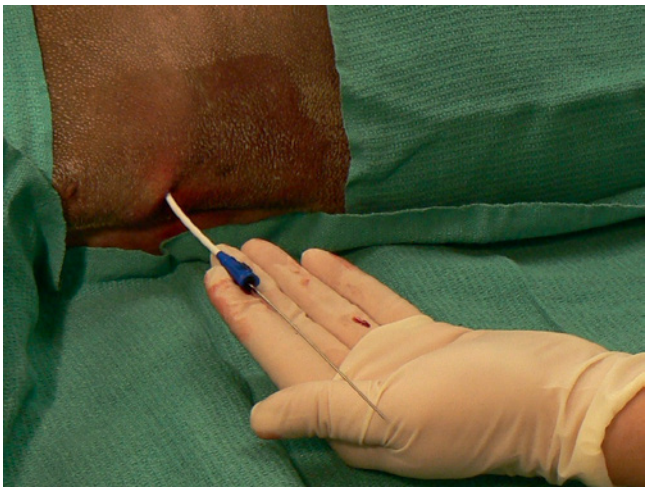


Fig. 7.23. The DPL catheter is inserted into the peritoneal cavity to its hub.

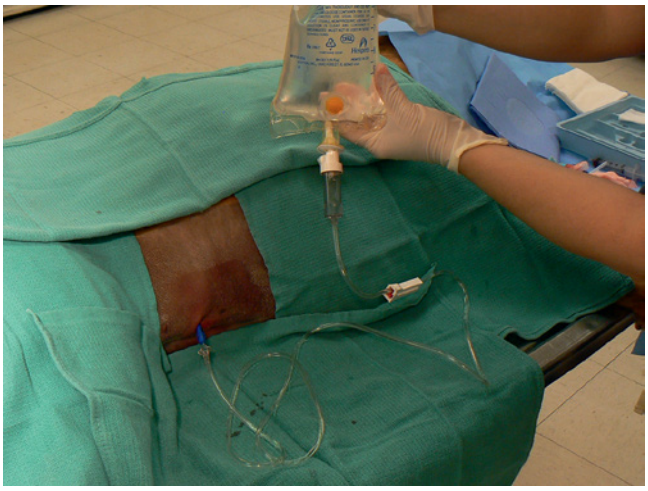


Fig. 7.24. Instill 10- to 20-mL/kg isotonic warmed crystalloid fluids into the abdominal cavity over a period of 3 to 5 minutes. Watch the patient carefully for signs of respiratory distress or abdominal discomfort; if either of these signs occur, stop the abdominal infusion. If able, walk an ambulatory patient around for several minutes. If the patient is nonambulatory, roll the patient from side to side, massaging the abdomen gently to evenly distribute the lavage fluid throughout the peritoneal cavity.

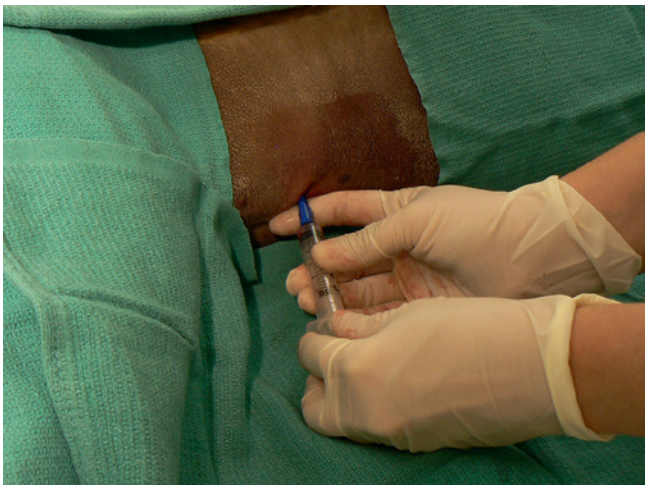


Fig. 7.25. Aspirate fluid from the abdomen with a routine four-quadrant abdominocentesis. Alternatively, if the catheter is going to be used for multiple lavages, for example a patient with pancreatitis, the catheter can be secured to the body wall with a purse-string and finger-trap sutures, then bandaged in place. It is important to maintain sterility at all times, as leaving the catheter in place can be a potential source of iatrogenic nosocomial infection.

ABDOMINAL DRAINAGE CATHETER

Introduction

Placement of a temporary abdominal drainage catheter is useful in situations of temporary peritoneal dialysis or drainage of uroabdomen, when a pigtail catheter is not available. The drainage catheter can be used until definitive exploratory laparotomy can be performed, or until the catheter becomes clogged with fibrin or omentum.

Supplies Needed

Electric clippers and blades
Sterile field towels (4)
Towel clamps
Number 10 or 11 scalpel blade
Scalpel handle
3-mL syringe with ¾- to 1½-inch 22-gauge needle
2% lidocaine
Curved mosquito hemostats
Thumb forceps
Mayo scissors
Trocarized thoracic drainage catheter (16 to 22 Fr) OR red rubber catheter (16 to 22 Fr)
2–0 nonabsorbable suture
3–0 absorbable suture
Christmas tree adapter
1-mL syringe
IV infusion tubing
Sterile bag for collection and drainage of fluid
Antimicrobial ointment
Bandage material

Indications

Temporary drainage of uroabdomen until definitive repair of urethral or urinary bladder leakage is performed.
Intermittent lavage and dilution of inflammatory processes such as pancreatitis/sterile peritonitis

Contraindications

Known bowel perforation
Septic peritonitis
Hypoalbuminemia
Penetrating abdominal injury



Fig. 7.26. Supplies needed for placement of an abdominal drainage catheter.

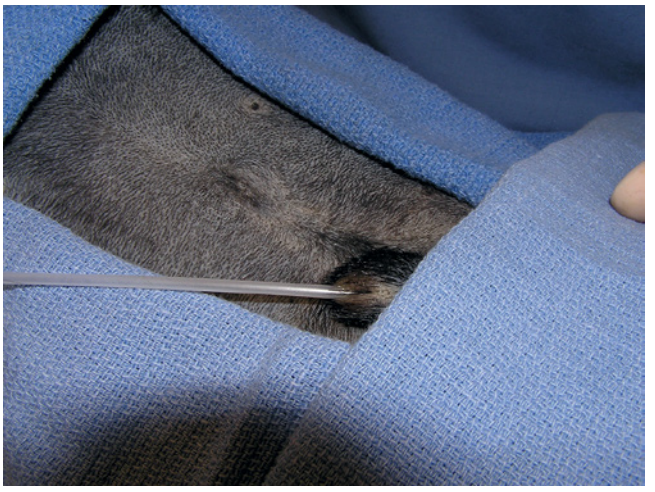


Fig. 7.27. Clip the ventral abdomen from the level of the umbilicus caudally to the level of the pubis and laterally to the folds of the flank. In male dogs, it is beneficial to place a urinary catheter first.



Fig. 7.28. Aseptically scrub the clipped area, then drape with sterile field towels secured with towel clamps. Infuse 1-mg/kg 2% lidocaine (0.5 mg/kg in cats) just caudal and to the right of the umbilicus. Insert the needle through the ventral abdominal musculature and infuse the local anesthetic as the needle is withdrawn.

Helpful hint: Disconnect the syringe from the needle, and leave the needle in place so that you remember where the local anesthetic has been infused.



Fig. 7.29. Pick up the skin at the site of local anesthetic infusion using a thumb forceps, and then make a small stab incision through the skin into the subcutaneous tissue with the scalpel blade.

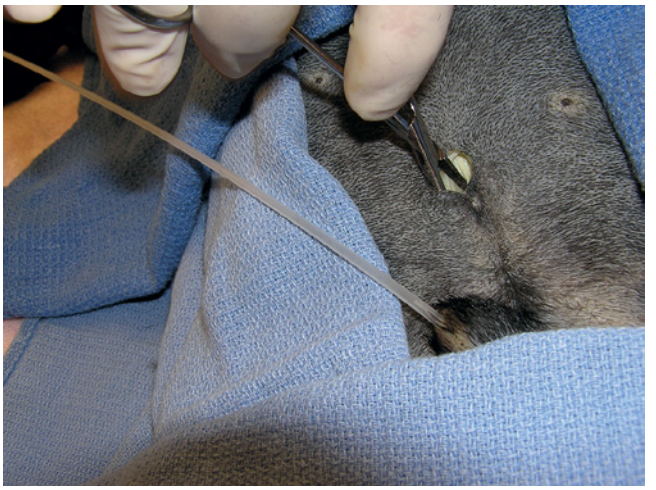
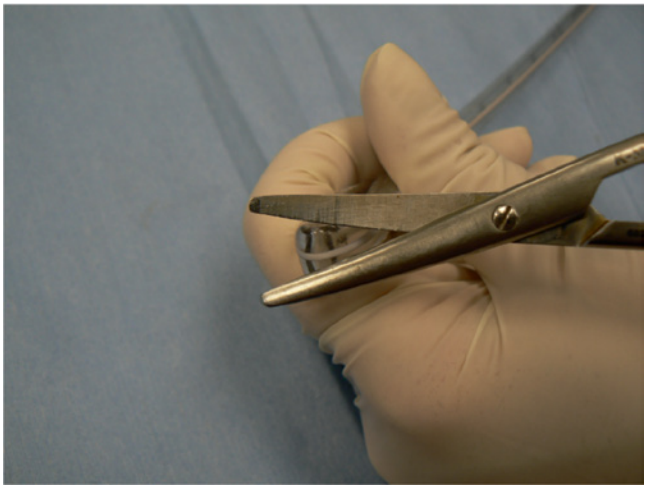


Fig. 7.30. Bluntly dissect through the subcutaneous tissue to the level of the external rectus abdominis muscle using mosquito hemostats.



Fig. 7.31. Visualize the external rectus abdominis muscle and pick it up with a thumb forceps. Make a small stab incision through the rectus abdominis into the peritoneal cavity using a scalpel blade.

(a)



(b)



Figs. 7.32a–b. Cut additional side holes in a trocarized thoracic drainage catheter or a red rubber catheter. Make sure to cut no more than 50% of the circumference of the tube, to prevent iatrogenic weakening.

Helpful hint: Some trocarized catheters have a radiopaque line. If present, cut the most proximal side-hole on the radio-opaque area, so that you can visualize with abdominal radiographs that the holes are all inserted into the peritoneal cavity and have not been placed or migrated subcutaneously.

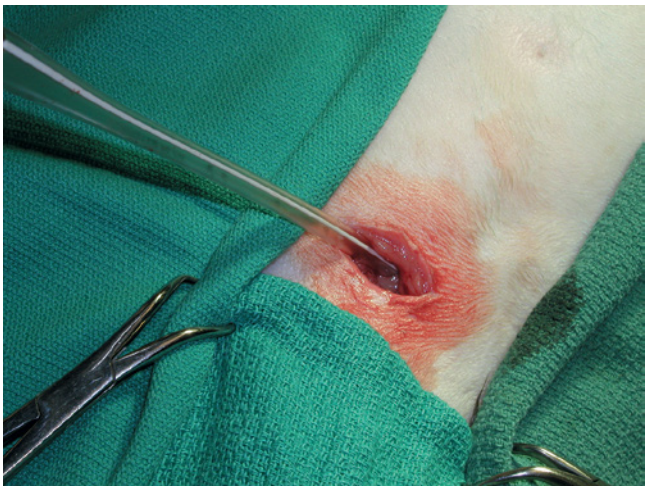


Fig. 7.33. Insert a trocarized or red rubber catheter into the peritoneal cavity.



Fig. 7.34. Immediately connect the proximal end of the catheter to a Christmas tree adapter or 1-mL syringe connected to a closed collection system.



Fig. 7.35. Using absorbable suture, secure a purse-string suture into the external rectus abdominis, and around the tube. Make sure that the sutures are not too tight to prevent tube removal at a later date. Using nonabsorbable suture, secure a second purse-string suture in the skin around the tube. Leave the ends of the nonabsorbable suture long, so that you can secure the tube with a finger trap.

Helpful hint: Make sure that the throws of suture and knots crimp or pinch the tube snugly, to prevent tube migration.

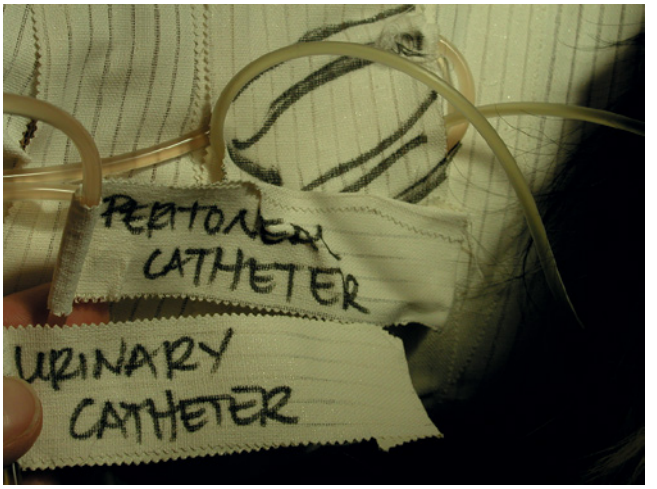


Fig. 7.36. Place a cut piece of 4×4 inch gauze and antimicrobial ointment over the tube entrance site. Bandage the tube to the abdomen and cover with layers of cotton roll gauze, Kling and Vetrap™.

Helpful hint: Make sure that the cranial layer of adhesive tape adheres to the piece of fur, to prevent the bandage from migrating caudally. Label the bandage and draw an outline of the tube, to prevent iatrogenic cutting of the tube during bandage removal.

SUGGESTED READING

Connally HE. Cytology and fluid analysis of the acute abdomen. Clin Tech Sm Anim Pract 2003, 18(1):39–44.

Crosby J, Humm K, Cook SD. Retrospective evaluation of the use of small-bore wire-guided catheters for the management of peritoneal effusion in cats and dogs. J Vet Emerg Crit Care 2023, 33(1):91–97.

Walters JM. Abdominal paracentesis and diagnostic peritoneal lavage. Clin Tech Sm Anim Pract 2003, 18(1):32–38.

CHAPTER 8

Cardiopulmonary Resuscitation

INTRODUCTION

Cardiopulmonary resuscitation (CPR) can make the difference between life and death in a dying animal. CPR involves the administration of supplemental oxygen, artificial/manual ventilation, and manual thoracic or cardiac compressions to deliver oxygen from the lungs to the peripheral tissues (namely, the brain and heart) during cessation of spontaneous and effective respiration and cardiac output. In addition, by providing circulation, carbon dioxide and other waste products from the peripheral tissues are delivered to the lungs and into the external environment. Depending on the cause of cardiac and respiratory arrest, operators have a 3% to 28% chance of success, provided that the underlying condition that resulted in respiratory and/or cardiac arrest can be immediately reversed. The veterinary RECOVER initiative (Reassessment Campaign on Veterinary Resuscitation) has developed evidence-based consensus veterinary CPR guidelines to standardize CPR training and techniques to help improve approach to CPR and hopefully, outcome, in veterinary patients.

Supplies Needed

3- to 12-mL syringes
22-gauge hypodermic needles
ECG
Capnograph
Endotracheal tubes (various size)
Gauze to secure endotracheal tube
Ambu-bag
Laryngoscope
Step stool

Veterinary Emergency and Critical Care Procedures, Third Edition. Timothy B. Hackett and Elisa M. Mazzaferro.
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Drugs
- Amiodarone
- Atipamezole
- Atropine
- Epinephrine
- Esmolol
- Flumazenil
- Lidocaine
- Naloxone
- Yohimbine or atipamezole
- Sodium bicarbonate
- Vasopressin

Indications

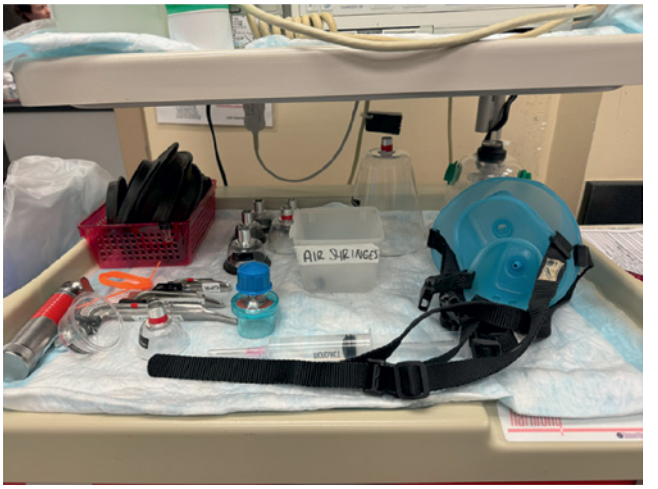
Loss of spontaneous ventilation/respiration and cardiac output

Contraindications

Irreversible underlying process that has caused the cardiopulmonary arrest
- End-stage cancer
- End-stage renal or hepatic disease
- End-stage neurologic disease
- End-stage cardiac or respiratory disease
- Sepsis or systemic inflammatory response syndrome (SIRS)
- Disseminated intravascular coagulation
- Acute respiratory distress syndrome
- Multiple organ failure (MODS)

Supplies Needed for a Crash Cart

(a)



(b)



Figs. 8.1a–b. The top open shelf of the crash cart contains laryngoscopes with various sized laryngoscope blades, face-masks, material to tie in endotracheal tubes, and various sized syringes to inflate the endotracheal tube cuffs.



Fig. 8.2. The top drawer of the crash cart contains clean endotracheal tubes of various sizes to fit a wide range of patients, laryngoscope blades, and a stylette to aid in endotracheal intubation, when necessary.



Fig. 8.3. The second drawer of the crash cart contains drugs used in standard cardiopulmonary resuscitation, based on RECOVER Guidelines. Drugs include atropine, epinephrine, naloxone, antisedan, flumazenil, sodium bicarbonate, and lidocaine.



Fig. 8.4. The third drawer of the crash cart contains Yankauer and other suction equipment/tubes to help suction/clear the patient's airway, when needed.

Helpful hint: Having a crash cart of box stocked with needles, syringes, laryngoscope with various laryngoscope blades, endotracheal tubes, and all of the drugs/equipment necessary for easy access and use during CPR. A chart with drug doses is milligrams/kg and milliliters is an invaluable resource during CPR. An important standard of care is to re-stock the crash cart whenever it is opened, to make sure all supplies are present, functioning and of sufficient quantity to perform a CPR code.

CLOSED-CHEST CPR

BASIC LIFE SUPPORT – Repeat in 2-minute cycles, changing rescuers performing compressions at each cycle change.

Basic life support involves starting thoracic compressions, intubating the patient and manually ventilating for the patient. The steps below are continued in 2-minute cycles, changing the person performing the thoracic compressions at each cycle change.



Fig. 8.5. Place the patient in lateral or dorsal recumbency. The position is dependent on both patient size and conformation. (Fig 8.5a) For keel-chested (narrow-chested) breeds of dog (Italian Greyhound, Saluki, Afghan hound, etc.), place in lateral recumbency with compressions directly over the heart. (Fig 8.5b) For barrel-chested breeds of dog (English and French bulldog), place in dorsal recumbency and perform compressions over the sternum. In this instance, this is demonstrated on an anesthetized pug. (Fig 8.5c) For round-chested breeds of dog (chest is as wide as it is deep, e.g., Labrador and Golden retriever, etc.), place in lateral recumbency and perform compressions over the widest portion of the thorax. For small dogs and cats, circumferential compressions by cupping the sternum and thorax in one's hand and compressing the thorax may be used (Fig 8.5d).



Fig. 8.6. Stand on a stool to get more leverage and start 100 to 120 compressions/minute. If a stool is not available, the patient can be resuscitated on the floor and the person performing compressions can kneel next to the patient. Remember to lock the elbows and push with the weight of the torso, rather than bending the elbows and using the strength of the forearms alone to compress the thorax.

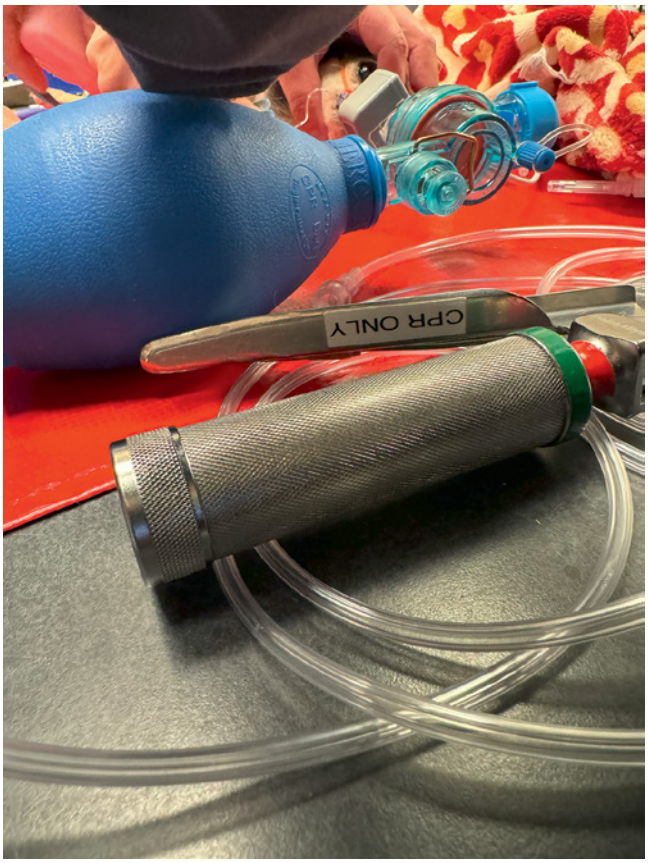


Fig. 8.7. Have another rescuer clear the airway and intubate the patient with an endotracheal tube, using a laryngoscope.

Helpful hint: One of the most common mistakes made during CPR is failure to use a laryngoscope to intubate the patient, which results in esophageal, rather than tracheal intubation.

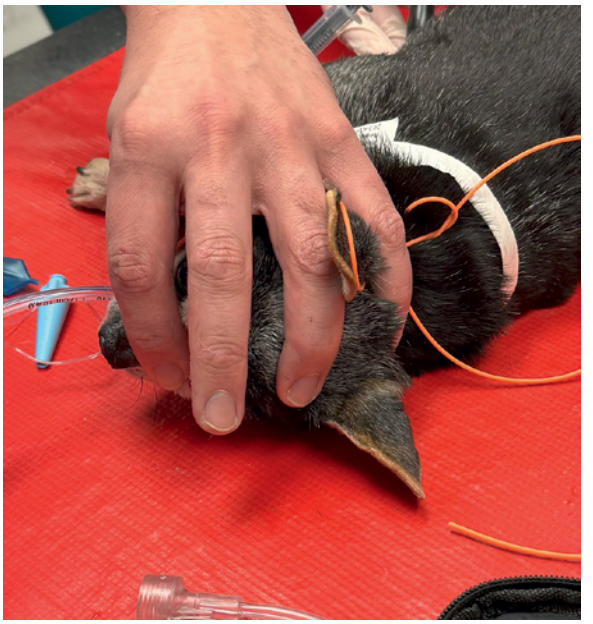


Fig. 8.8. Secure the endotracheal tube in place, then inflate the cuff.



Fig. 8.9a. Attach an oxygen source, ambu-bag, and end-tidal CO_2 monitor to the endotracheal tube, and then manually ventilate every 6 seconds.

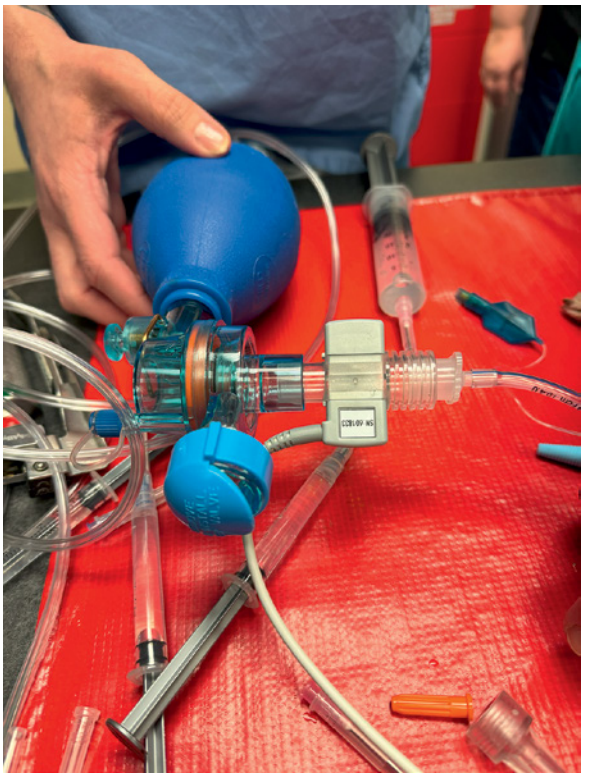


Fig. 8.9b. Attach the capnograph to the end of the endotracheal tube, in between the endotracheal tube and ambu-bag.

ADVANCED LIFE SUPPORT (ALS)

Advanced life support involves establishing intravenous or intraosseous access, attaching electrocardiogram (ECG) and capnograph, and administering intravenous, intraosseous, or intratracheal drugs to the patient. For any drug such as an opioid, alpha-2 agonist, or benzodiazepine that can be reversed with a reversal agent, reverse the drug as soon as vascular or intraosseous access is established.

Advanced life support is performed simultaneously, while two operators are performing external thoracic compressions and establishing airway access, and then manually ventilating for the patient.



Fig. 8.10. Attach the ECG leads with ultrasound gel. (a) NOTE: The attached PowerPoint and figures below. Please adjust the arrows to make contiguous with the boxes.

- EOC = Every Other Cycle
- PEA = Pulseless Electrical Activity
- VF = Ventricular Fibrillation
- VT = Ventricular tachycardia
- IV = Intravenous
- IO = Intraosseous
- ECG = Electrocardiogram
- ETCO2 = End-Tidal, CO2, ideal is >18 mm Hg during CPR

(b) CPR ECG algorithm

- PEA = Pulseless Electrical Activity
- VF = Ventricular Fibrillation
- VT = Ventricular tachycardia
- ECG = Electrocardiogram

Helpful hint: If an electrical defibrillator is available, use care to **avoid isopropyl alcohol** to moisten the ECG clips, because it can result in flames during electrical defibrillation.

Table 8.1. Have an assistant draw up drugs as necessary using the following guide:

Drug	ECG rhythm/indication	Dose	Route of administration
Atropine	Asystole or PEA	GIVE ONCE ASAP during ALS 0.04–0.054 mg/kg IV/IO	IV, IT, IO
Epinephrine	Asystole or PEA	Repeat every other cycle 0.01 mg/kg IV/IO 0.02 mg/kg IT	IV, IT, IO
Vasopressin	Asystole or PEA	0.8 U/kg IV/IO 1.2 U/kg IT	IV/IO/IT
Amiodarone	VF or VT refractory to electrical defibrillation (cats)	5 mg/kg IV/IO over 2–4 minutes	IV, IO
Lidocaine	VF or VT refractory to electrical defibrillation (dogs)	2 mg/kg IV/IO over 2–4 minutes	IV/IO
Esmolol		0.5 mg/kg IV/IO over 3–5 minutes, followed by CRI 50 mcg/kg/min	IV/IO
Sodium bicarbonate	Prolonged CPR > 15 minutes pH < 7.0	1 mEq/kg IV/IO	IV/IO

- ECG = electrocardiogram
- IV = intravenous
- IO = intraosseous
- IT = intratracheal
- PEA = pulseless electrical activity
- VF = ventricular fibrillation
- VT = ventricular tachycardia

Table of Drugs Used for Reversal:

Drug	Indication	Dose	Route of administration
Atipamezole	Reversal of alpha-2 agonist drugs	100 mcg/kg	IV/IO
Flumazenil	Reversal of benzodiazepines	0.01 mg/kg	IV/IO
Naloxone	Reversal of opioids	0.04 mg/kg	IV/IO

Helpful hint: All of the above drugs **EXCEPT** for sodium bicarbonate can be administered into the trachea if vascular or intraosseous access is not available.

Helpful hint: In addition to having a stocked crash cart, use of charts to follow algorithms and drug doses in milligrams/kg and milliliters total volume to infuse are invaluable resources during CPR.

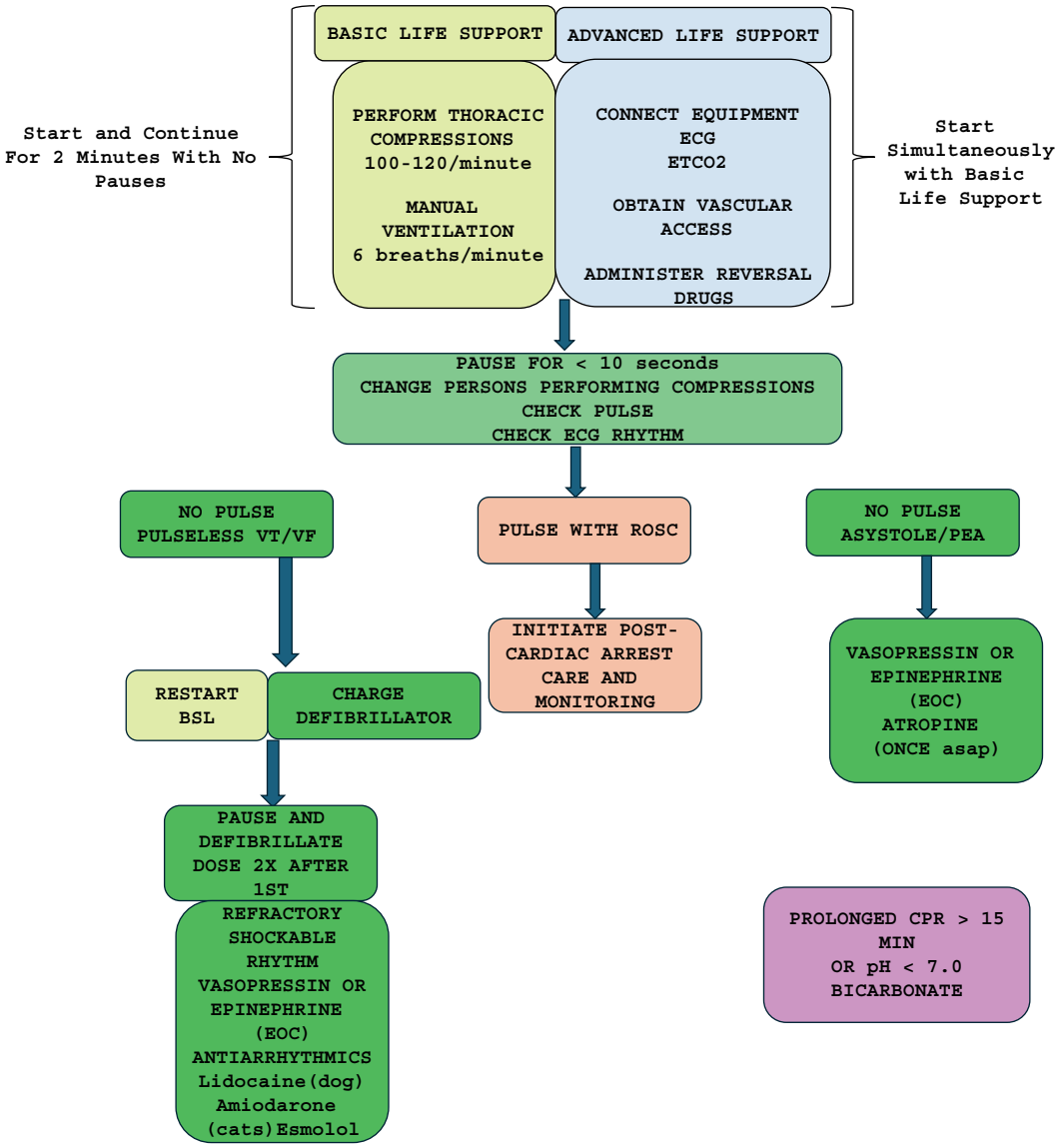


Fig. 8.11a. Basic and advanced life support algorithm from RECOVER guidelines, 2024.

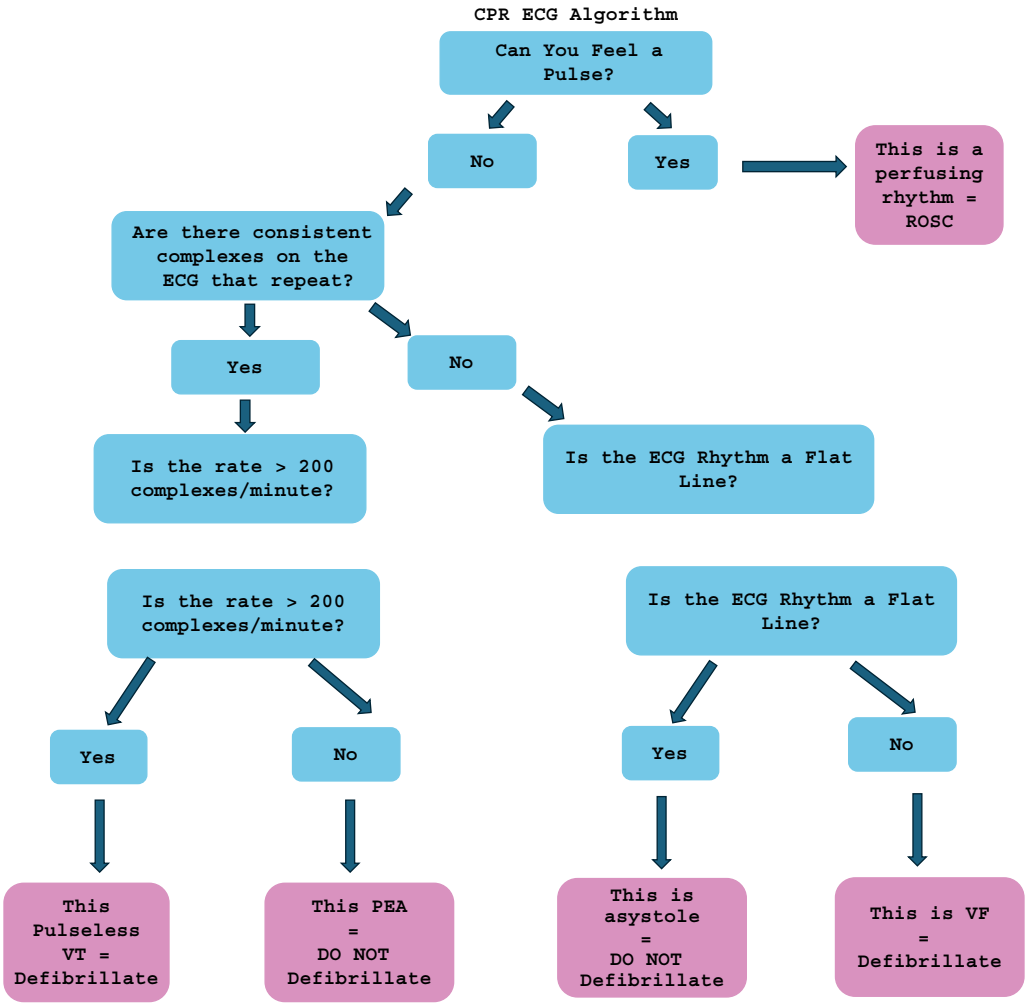


Fig. 8.11b. ECG algorithm from RECOVER guidelines, 2024.



Fig. 8.12. To administer drugs into the trachea, insert a rigid polypropylene or red rubber catheter into the endotracheal tube to the level of the patient's carina, then instill the drug, followed by 5 to 10 mL 0.9% sterile saline. Next, reattach the ambu-bag and re-initiate manual ventilation every six seconds.

If no return of spontaneous circulation (ROSC) occurs within two to three minutes of initiating CPR, or if any of the following conditions exist, the decision must be made whether to initiate open-chest CPR.

In the following circumstances, open-chest CPR should be initiated immediately.

- Cardiac arrest during thoracic or abdominal surgery. If cardiac arrest occurs during abdominal surgery, the linea incision should be extended cranially to the sternum and a cut made through the diaphragm such that the surgeon's hand or fingers can enter the thorax and perform manual cardiac compressions.
- Obesity
- Pneumothorax
- Pericardial effusion
- Penetrating thoracic wound
- Pleural effusion
- Flail chest or isolated rib fractures
- Diaphragmatic hernia
- Unwitnessed cardiac arrest

OPEN-CHEST CPR

Indications

- No ROSC after 2 to 3 minutes
- Any of the above conditions are present

Contraindications

- The underlying condition(s) that resulted in cardiopulmonary arrest are end-stage or irreversible.

Supplies Required

Electric clipper and blades
Number 10 scalpel blade
Scalpel handle
Mayo scissors
Red rubber catheter (3 or 5.5 Fr)
Absorbable suture (2–0, 3–0)
Nonabsorbable suture or skin staples
Sterile saline (0.9%, warmed to body temperature)
Suction apparatus
Thoracostomy tube



Fig. 8.13. Supplies needed for open-chest CPR.

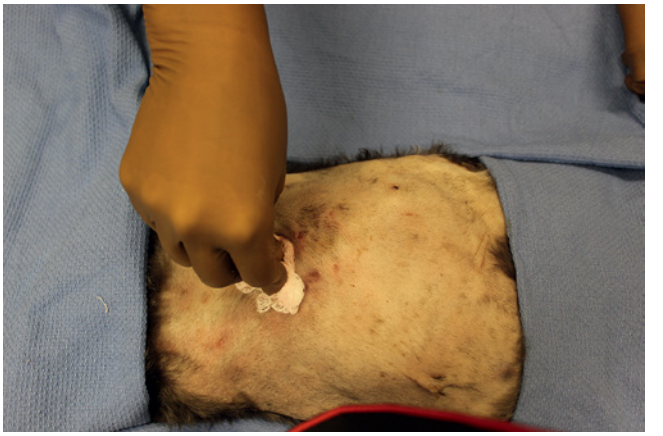


Fig. 8.14. Place the patient in right lateral recumbency and on the left lateral thorax, clip a wide strip caudal to the elbow, dorsally and ventrally to midline. Do a quick aseptic scrub, removing fur and debris from the lateral thorax.



Fig. 8.15. Make an incision through the skin and underlying fascia caudal to the elbow, starting dorsally to ventrally over the fifth to seventh intercostal spaces.



Fig. 8.16. Ask your assistant to briefly stop breathing for the patient as you make a stab incision through the intercostal muscles into the pleural space using the tips of the Mayo scissors. Use the tips of the Mayo scissors in a sliding motion to extend the intercostal incision dorsally and ventrally.

Helpful hint: The ribs along the costochondral junction can be clipped to allow retraction of the ribs laterally to provide better exposure of the heart.



Fig. 8.17. Pull the ribs laterally to expose the heart.

Helpful hint: Finechetto rib spreader retractors can be used to open the intercostal space. Using the Mayo scissors, cut the costochondral junction just dorsal to the sternum can also aid in visualization of the heart.



Fig. 8.18. Visualize the phrenic nerve as it passes over the heart.



Fig. 8.19. Pick up the pericardium at the apex of the heart using a thumb forceps, and using the Mayo scissors, make a small incision in the pericardium. Take care to avoid cutting the phrenic nerve.



Fig. 8.20. Insert your fingers into the hole in the pericardium and rip the pericardium to expose the heart.

Helpful hint: Ripping the pericardium, rather than using a scissors to cut the pericardium, helps to ensure that the phrenic nerve is not cut.



Fig. 8.21. Grasp the heart and squeeze from apex to base as the heart fills. Note: In this small patient, the heart is squeezed in between the fingertips. In larger patients, the heart can be grasped from apex to base and squeezed with the ventricles in the palm of your hand like you are shaking someone's hand. When open-chest CPR is used, the operator can feel the heart fill with blood in between manual compressions of the ventricles.

Helpful hint: Use caution to avoid pulling the heart away from the great vessels.

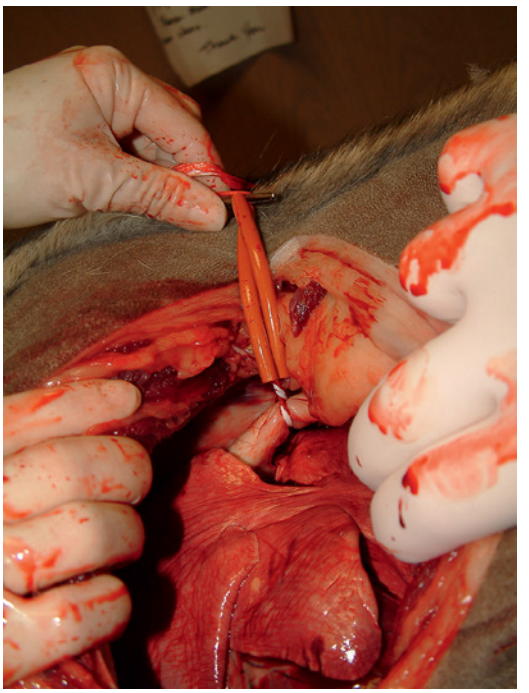


Fig. 8.22. A small (3 or 5.5 Fr) red rubber catheter can be secured around the caudal aorta to maintain blood flow to the brain and heart during CPR. This tourniquet should be removed every 7 minutes to restore perfusion to the caudal part of the body.

CLOSING THE THORAX AFTER OPEN-CHEST CPR

If CPR is successful and there is ongoing ROSC, the thorax must be closed. First, lavage the thorax with copious amounts of warmed sterile 0.9% saline and suction the fluid. The pericardial sac can remain open. Place a thoracostomy tube into the thorax, with the entrance caudal to the thoracotomy site. This will be used to evacuate air and residual fluid from the pleural space.



Fig. 8.23. Close the intercostal muscles, then subcutaneous layer using absorbable suture in simple continuous suture patterns.

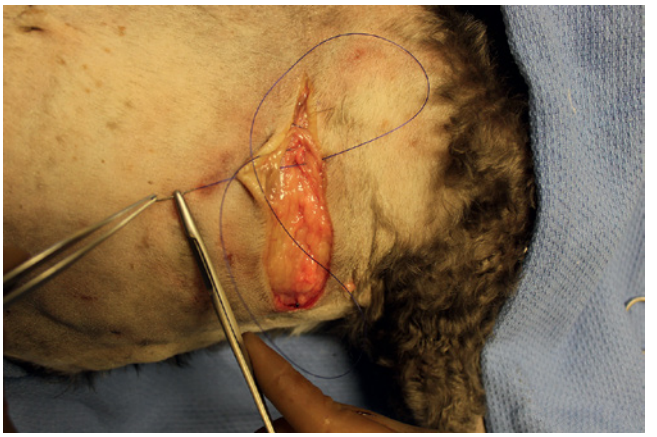


Fig. 8.24. Close subcutaneous and subcuticular layers in simple continuous patterns using absorbable suture.



Fig. 8.25. Close the skin with Ford interlocking nonabsorbable suture or skin staples.

SUGGESTED READING

Fletcher DJ, Boller M. Updates in small animal cardiopulmonary resuscitation. Vet Clin North Amer Sm Anim 2013, 43(4):971–987.

Fletcher DJ, Boller M. Fluid therapy during cardiopulmonary resuscitation. Front Vet Sci 2021, 7:625361.

Hoehne SN, Balakrishnan A, Silverstein DC, Pigott AM, Tart KM, Rozanski EA, Powell LL, Boller M. Reassessment campaign on veterinary resuscitation (RECOVER) initiative small animal CPR registry report. J Vet Emerg Crit Care 2023, 33(2):143–155.

Jack MW, Wierenga JR, Bridges JP, Baltzer WI, Crosse KR. Feasibility of open-chest cardiopulmonary resuscitation through a transdiaphragmatic approach in dogs. Vet Surg 2019, 48(60):1042–1049.

RECOVER, https://recoverinitiative.org/2024-guidelines/.

Warang AM, Mann FA, Middleton JR, Wagner-Mann C, Branson K. Comparison of left fourth and fifth intercostal space thoracotomy for open-chest cardiopulmonary resuscitation in dogs. J Vet Emerg Criti Care 2021, 31(3):331–339.

Ward MJ, Blong AE, Walton RA. Feline cardiopulmonary resuscitation: Getting the most out of all nine lives. J Fel Med Surg 2021, 23(5):447–461.

CHAPTER 9

Continuous Rate Infusions

INTRODUCTION

For some drugs, it is necessary to maintain constant plasma and tissue levels and pharmacologic effect. Infusions minimize fluctuations in drug levels. Drugs with a narrow therapeutic spectrum, and those with rapid onset and elimination, can be titrated to the individual patient with continuous intravenous administration. Continuous rate infusions (CRIs) can be administered using an intravenous drip set or infusion pump system.

Drugs are commonly administered as CRIs for sedation, analgesia, anesthesia, vasopressor and inotropic support, and for antiarrhythmic therapy. Recent advances in small animal emergency and critical care also use CRIs of glucocorticoids such as hydrocortisone and some antibiotics during the treatment of sepsis (Table 9.1). For simplicity, drugs can be mixed into the patient's daily maintenance fluids, provided that there is no contraindication to mixing the drug with the crystalloid fluid's pH, electrolytes or buffers. **Careful attention to units is necessary to ensure accuracy when formulating infusions.**

PHARMACOKINETICS

Drug levels in plasma begin to rise when an intravenous CRI begins. A plateau of plasma drug concentration is reached when the rate of administration reaches the rate of elimination. This is known as the steady state. A drug reaches the steady state between five and seven elimination half-lives, with five corresponding to 95% of the steady-state drug concentration and seven corresponding to 99% of the steady-state drug concentration. The onset of drug action tends to occur at 31/3 half-lives, a time that corresponds to 90% of the steady-state drug concentration.

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Table 9.1. Table of drugs commonly administered as constant rate infusions. All drugs are administered as µg/kg/min unless denoted by an asterisk*, which are administered as U/kg/min.

Drug	CRI dosage (µg/kg/min unless*, then U/kg/min)	Elimination half-life (hours)	Time to steady state, 7 half-lives (hours)
Anesthesia/analgesia drugs			
Buprenorphine	0.017–0.015	5.9	41.3
Butorphanol	1.7–16.7	1.53	10.71
Diazepam	1.7–16.7	0.25	1.75
Fentanyl	0.05–0.3	2.6	18.3
Hydromorphone	0.17–0.83	0.57	3.99
Ketamine	0.83–33.3	1.02	7.15
Morphine	0.83–16.7	0.6	4.2
Propofol	50–400	1.33	9.33
Antiarrhythmic drugs			
Lidocaine	15–80	1.73	12.13
Cardiovascular/vasopressor drugs			
Diltiazem	5–20	5	1.75
Dobutamine	2–20	0.04	0.29
Dopamine	1–10	0.11	0.82
Furosemide	2–15	1	7
Isoproterenol	0.04–0.08	0.05	0.35
Norepinephrine	0.05–2	0.004	0.03
Sodium nitroprusside	1–3	72	504
Vasopressin	0.0005–0.0004*	0.09	0.63
Miscellaneous			
Hydrocortisone	5–8.3	1.9	13.3
Insulin- regular	0.0015*	0.28	1.98
Metoclopramide	0.04–0.3	1.5	10.5

CALCULATIONS

µg/kg/min infusions are converted to mL/hr pump rates using the following formulae:

µg/kg/min × body weight (kg) = µg/min × 60 min/hr = µg/hr ÷ µg/mL of solution = mL/hr

To incorporate infusion into mL/hr total fluid requirements:

µg/kg/min × body weight (kg) = µg/min × 60 min/hr = µg

added to a known volume of crystalloid fluid administered by a pump each hour.

To convert the concentration per volume to an equivalent drug dose in a larger dilution volume:

$$\text{Volume solution}_1\ (\text{mL}) \times \text{Concentration}_1\ (\text{mg/mL}) = \text{Volume}_2\ (\text{mL}) \times \text{Concentration}_2\ (\text{mg/mL})$$

Web-based, smart phone, or dedicated computer software CRI calculators can be used to minimize errors in drug calculation of commonly used infusions.

SUGGESTED READING

Marks SL. Ch 78: Constant rate infusions. Textbook of Veterinary Internal Medicine, 8th edition. Ettinger ST, Feldman EC, Cote E (eds). Elsevier, Inc. St. Louis, MO, 2016, pp. 308–310.

CHAPTER 10

Product Guide and Supplies

CHAPTER 1: ARTERIAL AND VENOUS CATHETERIZATION

Over-the-Needle Catheter

24 gauge × 20 mm (0.75 inch)

Mila International, Inc., Florence, KS, USA www.milaint.com. Catalogue# IV2419

Sur-Flo®, Terumo Companion Animal Health, Elkton, MD, USA. Terumotmp.com/products/veterinary Catalogue #SROX2419V

22 gauge × 25 mm (1 inch) IV2225

Mila International, Inc., Florence, KS, USA www.milaint.com. Catalogue# IV2225

Sur-Flo®, Terumo Companion Animal Health, Elkton, MD, USA. https://www.terumotmp.com/products/veterinary.html Catalogue #SROX2225V

20 gauge × 25 mm (1 inch) IV2025

Mila International, Inc., Florence, KS, USA www.milaint.com. Catalogue# IV2025

20 gauge × 25 mm (2 inch)

Sur-Flo®, Terumo Companion Animal Health, Elkton, MD, USA. wwwterumotmp.com/products/veterinary Catalogue #SROX2051V

18 gauge × 1¼ inch

Sur-Flo®, Terumo Companion Animal Health, Elkton, MD, USA. wwwterumotmp.com/products/veterinary Catalogue #SROX1832V

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18 gauge × 2 inch

Sur-Flo®, Terumo Companion Animal Health, Elkton, MD, USA. wwwterumotmp.com/products/veterinary Catalogue #SROX1851CA

16 gauge

Sur-Flo®, Terumo Companion Animal Health, Elkton, MD, USA. wwwterumotmp.com/products/veterinary Catalogue #SROX1651CA

Central Venous Catheterization

Through the Needle

Veincath, 20 gauge × 30 cm (12 in. catheter) with 18 gauge introducer, Mila International, Inc., Florence, KS, USA www.milaint.com. Catalogue# V2030

Intracath 16 gauge × 24″ IV catheter/needle unit with wire stylet (14 gauge × 2″ needle) Argon Medical Devices, Inc., Athens, TX, USA REF384905

Intracath 19 gauge × 12″ IV catheter/needle unit with wire stylet (17 gauge × 2″ needle) Argon Medical Devices, Inc., Athens, TX, USA REF384904

Long-Line Catheter Catheter-Through-the Catheter Introduction Style Mila International, Inc., Florence, KS, USA www.milaint.com.

24-gauge catheter adjustable up to 25 cm (10 inch), Catalogue# LL2425

20-gauge catheter adjustable up to 45 cm (18 inch), Catalogue# LL2045

19-gauge catheter adjustable up to 45 cm (18 inch), Catalogue# LL 1945

19-gauge catheter adjustable up to 90 cm (36 inch). Catalogue# LL 1990

Long-Term Multi-Lumen Using Guidewire Introduction Mila International, Inc., Florence, KS, USA www.milaint.com.

5 Fr × 13 cm (5.25 inch) triple lumen catheter, Catalogue# LL 1990#: SA5FD13

5 Fr × 25 cm (10 inch) triple lumen catheter, Catalogue# LL 1990#: SA5FD25

7 Fr × 15 cm (6 inch) triple lumen catheter, Catalogue# LL 1990#:SA7FD15

7 Fr × 20 cm (8 inch) triple lumen catheter, Catalogue# LL 1990#:SA7FD20

7 Fr × 30 cm (12 inch) triple lumen catheter, Catalogue #:SA7FD3

Intraosseous Catheterization Mila International, Inc., Florence, KS, USA www.milaint.com.

18 gauge × 2 cm (0.78 inch), Catalogue #:BMAN 18

15 gauge × 3 cm (1.25 inch) Catalogue #:BMAN15

22 gauge × 15 cm (6 inch) Catalogue#: 2206

20 gauge × 20 cm (8 inch) spinal needle, Catalogue#:2008

EZ-IO Intraosseous Catheter Kit Mila International, Inc., Florence, KS, USA www.milaint.com

Power Driver EZPD-3

Needle 15 gauge × 1.5 cm, Catalogue #:EZ1515

Needle 15 gauge × 2.5 cm, Catalogue #: EZ1525

Needle 15 gauge × 4.5 cm, Catalogue #: EZ 1545

Training Needle 15 gauge × 1.5 cm, Catalogue #: EZTN15

Training Needle 15 gauge × 2.5 cm, Catalogue #: EZTZ25

Training Needle 15 gauge × 4.5 cm, v EZTN45

Carrying Case Soft Sided, Catalogue #: EZC-S

CHAPTER 2: THORACOCENTESIS, THORACOSTOMY TUBE

Thoracostomy Tube Mila International, Florence, KS, USA, www.milaint.com

Chest Tube Guidewire Insertion 14 gauge × 20 cm (8 inch), Catalogue #:CT1410

Guidewire Inserted Chest Tube Mila International, Florence, KS, USA, www.milaint.com

14 gauge × 20 cm (8 inch), various fenestration and number of side holes CT1404, CT 1410

12 gauge × 20 cm (8 inch) Catalogue #: CT1206

12 gauge × 30 cm (12 inch) Catalogue #: CT1210

Chest Tube with Sharp Trocar and Adapters

10 Fr–32 Fr × 19 cm–34 cm (7.5 to 13.5 inch), CTT10S, CTT12S, CTT14S, CTT16, CTT20, CTT24, CTT28, CTT32

Silicone Chest Tubes

12 Fr–30 Fr 38 cm–55 cm (15–22 inch) CT1215, CT 1415, CT2015, CT2022, CT3022

Red Rubber Tubes for Thoracic Drainage Tube: Canine Urinary Catheter, Cardinal Health™ 200, LLC, Waukegan, IL, USA, www.cardinalhealth.com

8 Fr × 22″ Kendall™ Feeding Tube and Urethral Catheter, Ref #:8890710810

10 Fr × 16″ Kendall™ Feeding Tube and Urethral Catheter, Ref #:8890701017

5 Fr × 16″ Kendall™ Feeding Tube and Urethral Catheter, Ref #:8890700514

12 Fr × 16″ Kendall Feeding Tube and Urethral Catheter, Ref #:8890701215

Argyle™ Trocar Catheter- https://www.cardinalhealth.com/

8 Fr Ref #: 8888560805

10 Fr Ref #: 8888 561019

12 Fr Ref #: 8888561027

16 Fr Ref #: 8888561043

20 Fr Ref #: 8888561043

24 Fr Ref #: 8888561050

28 Fr Ref #: 8888561068

32 Fr Ref #: 8888561076

Tracheostomy Tubes – Mila International, Florence, KS, USA, www.milaint.com

3.5 mm ID × 4.8 m OD – Length 40 mm TTC35

4.0 mm × 5.4 mm OD, length 41 mm TTC40

4.5 mm × 6.1 mm OD, length 42 mm TTC4

mm ID × 6.7 mm OD, 6 mm ID × 9.2 mm OD, length 71 mm TTC50

5.5 mm ID × 7.4 mm OD, 46 mm TTC55

5 mm × 8.6 mm OD, length 66 mm TTCIC50, additional cannula 5 mm ID with 15 mm connected IC50

6 mm ID × 9.2 mm OD, length 71 mm TTCIC60

Additional cannula – 6 mm ID – with 15 mm connector IC60

7 mm ID × 10.4 mm OD, length 73 mm TTCIC70

Additional cannula – 7 mm ID with 15 mm connector IC70

8 mm ID 11.4 mm OD – length 76 mm TTCIC80

Additional cannula – 8 mm ID with 15 mm connector IC80

CHAPTER 3: OXYGEN SUPPLEMENTATION

Mila International, Florence, KS, USA, www.milaint.com, Nasal Oxygen Catheter

8 Fr × 50 cm (20 inch) Catalogue OC820

10 Fr × 50 cm (20 inch) Catalogue OC1020

12 Fr × 50 cm (20 inch) Catalogue OC 1220

Red Rubber Tubes for Nasal oxygen catheterization: Canine Urinary Catheter, Cardinal Health™ 200, LLC, Waukegan, IL, USA, www.cardinalhealth.com.

8 Fr × 22″ Kendall™ Feeding Tube and Urethral Catheter, Ref #:8890710810

10 Fr × 16″ Kendall™ Feeding Tube and Urethral Catheter, Ref #:8890701017

5 Fr × 16″ Kendall™ Feeding Tube and Urethral Catheter, Ref #:8890700514

12Fr × 16″ Kendall Feeding Tube and Urethral Catheter, Ref #:8890701215

CHAPTER 4: PERICARDIOCENTESIS

Mila International, Florence, KS, USA, www.milaint.com,

Fenestrated centesis catheter 18 gauge × 9 cm (3.5 inch) with three side holes near distal end Catalogue 1804F

Fenestrated centesis catheter 16 gauge × 7.5 cm (3 inch) with three side holes near distal end Catalogue 1604F

Fenestrated centesis catheter 14 gauge × 13 cm (5.25 inch) with three side holes near distal end Catalogue 1412F

Fenestrated centesis catheter 14 gauge × 9 cm (3.5 inch) with three side holes near distal end Catalogue 1404F

Fenestrated centesis catheter 12 gauge × 13 cm (5.25 inch) with three side holes near distal end Catalogue 1212F

BD Angiocath, Becton Dickinson and Company, Franklin Lakes, NJ, USA

16 gauge × 5.25 inch REF 382259

CHAPTER 5: ENTERAL FEEDING AND OROGASTRIC LAVAGE

Nasogastric Feeding Tube with Stylet, Mila International, Florence, KS, USA, www.milaint.com,

3 Fr × 25 cm (10 inch) NG310S

5 Fr × 56 cm (22 inch) NG522S

6 Fr × 56 cm (22 inch) NG622

6 Fr × 91 cm (36 inch) NG 636

8 Fr × 109 cm (43 inch) NG843

8 Fr × 140 cm (55 inch) NG 855

10 Fr × 91 cm (36 inch) NG1036

10 Fr × 109 cm (43 inch) NG1043

10 Fr × 140 cm (55 inch) NG1055

12 Fr × 109 cm (43 inch) NG 1243

Esophagostomy Tube Mila International, Florence, KS, USA, www.milaint.com,

14 Fr length adjustable up to 75 cm (30 inch) E1430

18 Fr length adjustable up to 75 cm (30 inch) E1830

Esophagostomy Tube Tunneler use for sizes 10 and 14 Fr Tubes ETUN14

Esophagostomy Tube Tunneler use for sizes 18 Fr Tubes ETUN18

CHAPTER 6: URETHRAL CATHETERIZATION, URINARY HYDROPULSION, ANTEPUBIC CYSTOSTOMY CATHETER

Feline and Small Dog Urethral Catheterization

Tomcat/Small Animal Urinary Catheter- Length Adjustable Mila International, Florence, KS, USA, www.milaint.com, Catalogue #:CT1410

- 3.5 Fr, catheter, length adjustable up to 15 cm (6 inch) UC306
- 3.5 Fr, catheter, length adjustable up to 15 cm (6 inch), with stylet UC 3065
- 3.5 Fr – catheter length adjustable up to 25 cm (10 inch) UC 310
- 3.5 Fr – catheter length adjustable up to 25 cm (10 inch), with stylet UC 3105
- 5 Fr – catheter length adjustable up to 15 cm (6 inch) UC 506

5 Fr – catheter length adjustable up to 15 cm (6 inch), with stylet UC5065

5 Fr – catheter length adjustable up to 25 cm (10 inch) UC510

5 Fr – catheter length adjustable up to 25 cm (10 inch), with stylet UC 5105

Surgivet Slippery Sam™ Tomcat urethral catheter with https://northamerica.covetrus.com

3.5 Fr × 14 cm, Ref #:073380

Argyle™ open-end catheter with adapter 4- Covidien™

4½″ Ref #:8890703013

Silicone Foley 2-way Balloon Catheter – Jorvet, Jorgensen Laboratories, Loveland, CO

8 Fr, 3 cc, Catalogue #: JO693D

6 Fr, 1.5 cc, Catalogue # JO693A

10 Fr, 3 cc Catalogue #: J693C

Canine Urinary Catheterization Mila International, Florence, KS, USA, www.milaint.com, Catalogue #:CT1410

5 Fr × 30 cm (12 inch) with 1 cc balloon Catalogue #:UC 512

5 Fr × 55 cm (21 inch) with 1 cc balloon, Catalogue #: UC521

6 Fr × 30 cm (12 inch) with 1.5 cc balloon, Catalogue #: UC612

6 Fr × 60 cm (24 inch) with 1.5 cc balloon, Catalogue #: UC624

6 Fr × 90 cm (36 inch) with 1.5 cc balloon, Catalogue #: UC636

8 Fr × 30 cm (12 inch) with 3 cc balloon, Catalogue #: UC8124

8 Fr × 60 cm (24 inch) with 3 cc balloon, Catalogue #: UC824

8 Fr × 90 cm (36 inch) with 3 cc balloon, Catalogue #: UC836

10 Fr × 30 cm (12 inch) with 5 cc balloon, Catalogue #: UC1012

10 Fr × 45 cm (18 inch) with 5 cc balloon, Catalogue #: UC1018

10 Fr × 90 cm (36 inch) with 5 cc balloon, Catalogue #: UC1036

Surgivet Clearview Foley Catheter, Smiths Medical ASD, Inc., Minneapolis, MN, USA, www.smiths-medical.com

5 Fr, 55 cm Catalogue#: CFC655

8 Fr, 55 cm Catalogue #; FC855

Canine Urinary Catheter, Cardinal Health™ 200, LLC, Waukegan, IL, USA, www.cardinalhealth.com

8 Fr × 22″ Kendall™ Feeding Tube and Urethral Catheter, Ref #:8890710810

10 Fr × 16″ Kendall™ Feeding Tube and Urethral Catheter, Ref #:8890701017

5 Fr × 16″ Kendall™ Feeding Tube and Urethral Catheter, Ref #:8890700514

12 Fr × 16″ Kendall Feeding Tube and Urethral Catheter, Ref #:8890701215

3.5 Fr × 16″ Kendall Feeding Tube and Urethral Catheter, Ref #:8890700316

Closed System Urine Collection Kits, Mila International, Florence, KS, USA, www.milaint.com

600 cc to 2000 cc Closed system, Catalogue #s: UC600K, UC1000K, UC2000K

Urine Collection Bag, Jorvet, Jorgensen Laboratories, Loveland, CO

Urine Drainage Bag Ref # AS326

CHAPTER 8: CARDIOPULMONARY RESUSCITATION

CPR Charts – https://veccs.org/product-category/recover

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