

Complications associated with the use of vascular access ports in dogs receiving external beam radiation therapy

Monique N. Mayer, DVM, MS, DACVR; Candace K. Grier, DVM;
Hiroto Yoshikawa, DVM; P. Brendon Ringwood, DVM, MS, DACVS

Objective—To assess the perioperative and postoperative complications associated with use of vascular access ports (VAPs) in the jugular and lateral saphenous veins of dogs requiring frequent anesthetic episodes for radiation therapy.

Design—Cohort study.

Animals—40 dogs referred to a veterinary teaching hospital.

Procedures—VAPs were used in 23 dogs, and intravenous catheters inserted in a peripheral vein were used in 17 dogs. The frequency of perioperative and postoperative complications associated with VAP use and the frequency of infection associated with intravenous catheter use were recorded. Results of bacterial culture of VAP tips and amount of time required for VAP placement and removal and for anesthetic induction were also recorded.

Results—VAP-associated perioperative complications included malposition of the catheter tip in 4 of 23 (17.4%) dogs. The VAP-associated postoperative complications included seroma formation in 7 (30.4%) dogs, breakage of port-anchoring sutures in 3 (13.0%) dogs, suspected fatal catheter-related septicemia in 1 (4.3%) dog, and temporary partial withdrawal occlusion in 18 of 255 (7.1%) anesthetic episodes.

Conclusions and Clinical Relevance—Placement of VAPs provided ready access in dogs receiving radiation therapy. Most complications were minor and self-limiting; however, a low risk of serious complications existed. Use of fluoroscopy to assess position of the catheter tip is recommended to decrease the risk of malposition. Immediate removal of a VAP is recommended when clinical signs of infection develop. Removal of a VAP at the completion of radiation therapy should be performed unless the benefit of continued vascular access outweighs the risks. (*J Am Vet Med Assoc* 2008;233:96–103)

Radiation therapy of veterinary patients generally involves 5 consecutive daily treatments/wk for 3 or 4 weeks. Immobilization of patients is required for accurate and precise administration of radiation and is commonly achieved by anesthetizing the animal. Intravenous access is desirable in these patients for administration of preanesthetic medications and anesthetic drugs and for administration of fluids to compensate for venodilation and cardiac depression caused by anesthesia. In our experience, use of intravenous catheters in a peripheral vein for patients receiving radiation therapy has been associated with some drawbacks, including an increase in the amount of time required for catheter placement, an increase in the number of staff members needed for inserting intravenous catheters in fractious animals, difficulty in catheter placement after repeated venipuncture, the need for a device to prevent patients from accessing their catheters, client acceptance of catheters for outpatient use, and loss of catheter patency between anesthetic episodes. A review of published data on the use of subcu-

ABBREVIATIONS

CI	Confidence interval
VAP	Vascular access port

taneous VAPs in human and veterinary patients supports a system that addresses these drawbacks.^{1–4} However, implantation and use of VAPs in human patients is associated with a risk of complications. Perioperative complications include malposition of the catheter tip, malfunction, hemorrhage, and pneumothorax. Postoperative complications include catheter occlusion, catheter breakage or disconnection, extravasation, port pocket seroma, port pocket infection, systemic infection, and thrombosis.^{5,6} Cancer patients may have predisposing factors that increase these risks, such as immunosuppression, recent surgery, and a hypercoagulable state.⁷ Thus, the study reported here was designed to assess the perioperative and postoperative complications associated with use of VAPs in the jugular and lateral saphenous veins of dogs requiring frequent anesthetic episodes for radiation therapy.

Materials and Methods

Animals—Dogs referred to the Western College of Veterinary Medicine for radiation therapy between Sep-

From the Department of Small Animal Clinical Sciences, Western College of Veterinary Medicine, University of Saskatchewan, Saskatoon, SK S7N 5B4, Canada. Dr. Ringwood's present address is Veterinary Emergency Clinic and Referral Centre, 920 Yonge St, Ste 117, Toronto, ON M4W 3C7, Canada.

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Address correspondence to Dr. Mayer.

tember 2005 and April 2007 were included in the study. Dogs were entered consecutively into the study. A CBC, serum biochemical analysis, urinalysis, thoracic radiography, and abdominal ultrasonography were performed on all dogs prior to VAP placement. When no medical contraindication existed for placement of a VAP, client consent for VAP placement was obtained and dogs received a VAP. When a medical contraindication to VAP placement existed (ie, neutropenia and hyperadrenocorticism) or clients declined VAP placement, an intravenous catheter was placed in a peripheral vein to provide venous access.

Anesthesia—A standard protocol for preanesthetic and anesthetic drugs and fluid administration was created for dogs receiving radiation therapy and VAP placement. Dosages were adjusted as necessary on the basis of concurrent medical conditions, complications during anesthesia, and signs of pain. Prior to each anesthetic episode, rectal temperature, pulse rate, and respiration rate were recorded. The standard anesthetic protocol was preanesthetic administration of diazepam (0.1 mg/kg [0.045 mg/lb], IV) and fentanyl (3 µg/kg [1.36 µg/kg], IV), induction with propofol (4 mg/kg [1.82 mg/lb], IV), and maintenance with inhaled sevoflurane (2% to 3% in oxygen, as needed). The standard fluid administration protocol was a balanced electrolyte solution^a (10 mL/kg/h [4.5 mL/lb/h], IV). For the 17 dogs without VAPs, the skin was aseptically prepared and a 20- or 22-gauge intravenous catheter^b was placed into a cephalic or lateral saphenous vein; an infusion of 6 mL of sterile saline (0.9% NaCl) solution was administered, followed by administration of preanesthetic drugs. For the 23 dogs with VAPs, drugs administered IV were injected through the VAP. An intravenous catheter was inserted in a peripheral vein and used for the first anesthetic episode prior to VAP implantation or when there was a contraindication to VAP use. Induction agents were administered 1 to 2 minutes after injection of preanesthetic drugs. Induction time was recorded for each anesthetic episode from the time of placement of the dog on the table to the passage of an endotracheal tube. Intravenous catheters were allowed to remain in a peripheral vein for 2 or 3 days; intravenous catheters were removed on Friday because of risk of loss of catheter patency and for patient comfort on Saturday and Sunday.

Surgical technique—Five surgeons placed the VAPs; the VAPs were placed prior to the start of radiation treatment. Two commercially available veterinary VAPs (5-F outside diameter^c [n = 9 dogs] or 7-F outside diameter^d [14]) were used. Prior to this study, none of the surgeons had implanted this type of VAP. Size of the VAP used was based on patient size and diameter of the vein used for VAP catheter placement and was determined by each surgeon at the time of implantation. In 4 dogs, a 5-F VAP was placed in a lateral saphenous vein. In 5 dogs, a 5-F VAP was inserted in a jugular vein; 4 of these 5 dogs weighed < 20 kg (< 44 lb). All 14 dogs that received a 7-F VAP weighed ≥ 20 kg. Each VAP was placed in a jugular vein (n = 19) unless the radiation treatment field included the jugular region or the patient had a brain tumor, in which case a lateral

saphenous vein (4) was used. The right or left jugular or lateral saphenous vein was chosen on the basis of ease with which the VAP could be accessed when the patient was in the planned radiation treatment position. Cefazolin (22 mg/kg [10 mg/lb], IV) was administered within 20 minutes after the initial incision for VAP placement. Interval from the first incision to completion of skin closure was recorded for VAP implantation and removal.

Length of the catheter for the VAP was determined on the basis of anatomic landmarks for the first 6 dogs entered into the study and by use of intraoperative fluoroscopy to assess position of the catheter tip for the subsequent 17 dogs receiving a VAP. In the 6 dogs that were not subjected to fluoroscopy, final position of the catheter tip was assessed by use of postoperative radiographs taken immediately after surgery.

Analgesics administered to dogs for VAP implantation included preoperative injection of hydromorphone (0.05 to 0.1 mg/kg [0.023 to 0.045 mg/lb], IV [n = 23 dogs]). When dogs were not receiving an anti-inflammatory drug at the time of referral, postoperative administration of meloxicam (0.2 mg/kg [0.091 mg/lb], SC, once; followed by 0.1 mg/kg PO, q 24 h [n = 15]) was initiated. Seven dogs were receiving a corticosteroid or nonsteroidal anti-inflammatory drug for pain not related to VAP placement or for antitumor effects at the time of referral to our facility, which included deracoxib (1.2 mg/kg [0.545 mg/lb], PO, q 24 h [n = 1]), prednisone (0.5 to 1.7 mg/kg [0.227 to 0.723 mg/lb], PO, q 24 h [5]), and dexamethasone (0.015 mg/kg [0.007 mg/lb], PO, q 8 h [1]). When a dog was receiving an anti-inflammatory drug at the time of referral, that drug was continued and meloxicam administration was not initiated. Additional analgesics included postoperative administration of tramadol (2.1 to 3.4 mg/kg [0.955 to 1.55 mg/lb], PO, q 8 h [n = 3]). Orally administered medications were continued for a minimum of 1 week after surgery. Depending on surgeon preference, bupivacaine (1.0 to 1.2 mg/kg [0.45 to 0.54 mg/lb], SC) was infused in the surgical incision.

VAP PLACEMENT IN A JUGULAR VEIN

Dogs were positioned in lateral recumbency to allow access to the appropriate jugular vein. A 1- to 1.5-cm longitudinal incision was made over the external jugular vein. A second transverse incision was performed dorsal to the wing of the first cervical vertebra. Blunt dissection was performed caudal to the incision over the wing of the first cervical vertebra to create a pocket for the port. A tunnel was created between the incisions via blunt dissection to allow for passage of the catheter from the port to the jugular vein. Blunt dissection was performed to expose the external jugular vein. Stay sutures of polydioxanone were placed around the proximal and distal parts of the exposed vein. The loops were elevated to temporarily prevent blood flow during catheterization. Depending on surgeon preference, a venotomy incision was used or the peel-away introducer needle was inserted caudad into the vein between the stay sutures. The introducer needle consisted of a needle stylet surrounded by a 5-F or 7-F catheter sheath. When used, the introducer needle was inserted

into the vein and the needle stylet was removed, which allowed the catheter sheath to remain in the vein. The port catheter was inserted into the vein through the catheter sheath, and then the peel-away catheter sheath was removed from the vein while the port catheter was held in place.

In dogs in which the length of the catheter was determined by use of fluoroscopy, the catheter was advanced to the cranial vena cava and the proximal end of the catheter was cut at the level of the connection to the port, with an additional 1 to 2 cm included to prevent tension during postural changes. In dogs in which the length of the catheter was determined by use of anatomic landmarks, the length of the catheter inserted into the jugular vein was equal to the distance between the caudal edge of the scapula and the venotomy site (measured with the neck and forelimbs in a neutral position, as recommended by the manufacturer). Length of the catheter was then extended from the venotomy site to the level of the connection to the port, again with an additional 1 to 2 cm included to prevent tension during postural changes; the proximal end of the catheter was then cut. The previously placed stay suture was then used to ligate the vein proximal to the venotomy incision to reduce hemorrhage. The distal stay suture was used to ligate the vein around the catheter distal to the venotomy site. The catheter was manipulated through the tunnel between the vein and port site. To prevent air embolism, the port was flushed with sterile saline solution via a Huber needle and then connected to the catheter. The port was aspirated to confirm patency, and it was then placed into the previously created pocket and sutured to the fascia of the underlying muscle with polydioxanone or polypropylene suture material. Sutures used to anchor ports to the underlying fascia included 2-0 polypropylene (n = 8 dogs), 0 polypropylene (7), 0 polydioxanone (2), 2-0 polydioxanone (1), and 3-0 polydioxanone (1). The port was again aspirated to confirm patency and then flushed with 6 mL of saline solution. The subcutaneous tissues were apposed by use of polydioxanone suture in a continuous pattern, and the skin was closed by use of polydioxanone suture in a continuous intradermal pattern.

VAP PLACEMENT IN A LATERAL SAPHENOUS VEIN

Dogs were positioned in lateral recumbency to allow access to the appropriate lateral saphenous vein. A longitudinal incision was made over the lateral saphenous vein immediately distal to the myotendinous junction of the gastrocnemius muscle. Another longitudinal incision was made at the caudal aspect of the gastrocnemius muscle at the same level. Blunt dissection cranial to the incision was used to create a pocket for the port, and blunt dissection between the 2 incisions was used to create a tunnel for the catheter. Blunt dissection was used to expose approximately 2 cm of the lateral saphenous vein. The catheter was placed into the vein by use of the technique described for jugular VAP placement, and the catheter was advanced to the caudal vena cava at approximately the level of the second lumbar vertebra. The position of the catheter tip was confirmed with fluoroscopy, and the proximal end of the catheter

was cut at an appropriate level and attached to the port. The port was placed into the previously created pocket and sutured to the fascia of the gastrocnemius and the popliteal muscle by use of polydioxanone or polypropylene suture material. Suture used to anchor ports to the underlying fascia included 2-0 polypropylene (n = 2 dogs), 0 polydioxanone (1), and 2-0 polydioxanone (1). Aspiration to confirm patency was performed before and after suturing of the port to the fascia. The port was flushed with 6 mL of saline solution, and the subcutaneous tissues and skin were closed by use of the same procedures described previously for VAP placement in a jugular vein.

VAP removal—Dogs were positioned in lateral recumbency as for VAP placement, and an incision was made almost exactly through the previous incision over the port. Blunt dissection was used to expose the port and proximal 1 to 2 cm of the catheter. Anchoring sutures were removed, and the port system was removed by gentle traction on the port catheter. Digital pressure was applied to the venotomy site for 5 minutes to control hemorrhage. The subcutaneous tissues and skin were apposed by use of polydioxanone suture in accordance with each surgeon's preference.

VAP access—For the 23 dogs with VAPs, all drugs and fluids administered IV were injected through the VAP for each anesthetic episode and all blood samples were collected via the VAP, unless there was a complication contraindicating VAP use. Complications considered a contraindication to VAP use included a seroma that interfered with a clinician's ability to palpate and identify the VAP and resistance during injection of saline solution.

Blood collection or drug administration via the VAP was performed in accordance with sterile techniques. Dogs were positioned in lateral or sternal recumbency, the port was palpated, and the overlying skin was prepared aseptically. Sterile gloves were worn during VAP accession. The port was digitally stabilized, and a 22-gauge Huber needle was inserted transdermally into the port septum perpendicular to the port. The needle was advanced until it reached the bottom of the port and then was withdrawn 1 to 2 mm. Aspiration with a 6-mL syringe was used to confirm patency. When blood collection was required, 3 mL of blood was withdrawn and discarded prior to collection of the sample. Prior to injection of drugs into the port, 6 mL of saline solution was infused. Six milliliters of saline solution was used to flush the port catheter after blood collection or drug injection.

Blood collection—The degree of hemolysis in blood collected through a VAP was assessed. Samples were collected by use of a VAP or by venipuncture and submitted to a diagnostic laboratory for a CBC and serum biochemical analysis. Samples were collected approximately halfway through each radiation protocol and on the last day of radiation treatment. Additional blood samples were collected at the discretion of the primary clinician (MNM or CKG). Degree of hemolysis was assessed visually by inspecting the plasma column in an Hct tube (16 blood samples) or by use of a serum

spectrophotometer^c (26 blood samples). A hemolysis score of none, slight, 1+, 2+, or 3+ was subjectively assigned by a laboratory technician for visual assessment of the tubes, and a score of none, slight, 1+, 2+, 3+, or 4+ was assigned by the spectrophotometer.

VAP maintenance—Monthly flushing of the VAP was recommended to referring veterinarians for 7 dogs in which the VAP was not removed at the end of radiation therapy. Aseptic technique for accessing the port, as described previously, was recommended, followed by flushing of the VAP catheter with 6 mL of sterile saline solution and then with 2 mL of saline solution that contained 100 U of heparin/mL.

Perioperative and postoperative complications—The frequency and nature of perioperative and postoperative complications were recorded. A digital photograph was taken of the VAP surgical site 24 hours after surgery. Type and dose of analgesics for signs of pain related to VAP implantation were recorded. Malposition of the catheter tip was defined as the catheter tip at a location other than the cranial vena cava (for VAPs in a jugular vein) or caudal vena cava (for VAPs in a lateral saphenous vein). Catheter occlusion was categorized as partial withdrawal occlusion (could infuse saline solution but could not withdraw blood) and complete occlusion (could not infuse saline solution or withdraw blood). The VAPs were used for administration of anesthetic drugs and fluids despite partial withdrawal occlusion. Clinical signs of infection were assessed before each radiation treatment and included local redness, swelling, heat, evidence of pain, and discharge at the VAP surgical site or intravenous catheter site; rectal temperature; pulse rate; and respiration rate. A routine CBC was performed halfway through radiation treatment and on the last day of treatment; results were assessed for evidence of subclinical infection.

Bacterial culture—The distal tip of the port catheter was submitted after VAP removal for aerobic and anaerobic bacterial culture in 15 dogs. Specimens were inoculated onto brain-heart infusion medium, which was incubated aerobically at 37°C in an atmosphere of 5% carbon dioxide and anaerobically at 37°C. When a culture yielded negative results at 18 hours, the inoculated brain-heart infusion medium was subcultured aerobically and anaerobically on blood agar and MacConkey agar. Antimicrobial susceptibility testing was performed on bacterial isolates.

Statistical analysis—Mean anesthetic induction times were compared between dogs with a VAP and dogs with an intravenous catheter, between dogs with a VAP in a jugular vein and dogs with a VAP in a lateral saphenous vein, and between dogs with a 5-F VAP and dogs with a 7-F VAP by use of a separate-variance independent samples *t* test. Values of *P* < 0.01 were considered significant.

Results

Age, body weight, sex, and tumor type for dogs receiving a VAP and dogs receiving an intravenous catheter in a peripheral vein were summarized. The 23 dogs

that received a VAP (12 neutered males, 10 neutered females, and 1 sexually intact female) were 1.2 to 13.2 years of age (mean, 7.8 years) and weighed 6.8 to 56.0 kg (15.0 to 123.2 lb), with a mean of 29.9 kg (65.8 lb). The 17 dogs that received an intravenous catheter in a peripheral vein (7 neutered males, 7 neutered females, 2 sexually intact females, and 1 sexually intact male) were 4.1 to 13.6 years of age (mean, 8.7 years) and weighed 5.9 to 48.0 kg (13.0 to 105.6 lb), with a mean of 24.4 kg (53.7 lb). Breeds represented included Golden Retriever (*n* = 5), Labrador Retriever (3), Rottweiler (3), Beagle (3), Border Collie (2), Nova Scotia Duck Tolling Retriever (2), Bassett Hound (1), Lhasa Apso (1), German Shepherd Dog (1), Soft Coated Wheaten Terrier (1), Springer Spaniel (1), Cocker Spaniel (1), Rhodesian Ridgeback (1), Bichon Friese (1), Collie (1), Bloodhound (1), and American Pit Bull Terrier (1); there were 11 mixed-breed dogs. Tumor type included soft tissue sarcoma (*n* = 15), mast cell tumor (13), carcinoma (5), meningioma (3), plasma cell tumor (1), acanthomatous ameloblastoma (1), melanoma (1), and lymphoma (1).

VAP implantation and removal—The time required for VAP implantation (from first incision to completion of skin closure) ranged from 25 to 90 minutes (mean, 49.1 minutes; 95% CI, 42.0 to 56.2 minutes). The VAPs were in place for 9 to 691 days (mean, 100.6 days). The VAPs were removed at the end of treatment in 16 dogs (3 from a lateral saphenous vein and 13 from a jugular vein), 3 months after the end of treatment in 1 dog (lateral saphenous vein), and 16 months after the end of treatment in 1 dog (jugular vein). Initially, clients were given the option of allowing the VAP to remain in place at the end of radiation treatment. Of the 17 clients offered this option, 6 elected to allow the VAP to remain in place. After a dog with suspected catheter-related septicemia died, VAP removal was recommended for patients at the completion of radiation therapy unless there was a need for continued vascular access. In addition, after the dog with the suspected catheter-related septicemia died, clients whose dogs were alive and had a VAP were contacted, and removal of the VAP was recommended when continued vascular access was not required.

For the 18 dogs that had VAP removal at our facility, time required for removal ranged from 8 to 55 minutes (mean, 19.8 minutes; 95% CI, 13.7 to 25.9 minutes). For the dog in which it required 55 minutes for VAP removal, the catheter could not be withdrawn from the jugular vein via traction applied to the catheter at the incision over the port and a second incision was required to remove the jugular ligatures before the catheter could be withdrawn. This catheter was found to have suture retention beads that prevented easy withdrawal of the catheter from the vein. These beads are typically included only on catheters used for research purposes, and the beaded catheter had been inadvertently included with the VAP by the manufacturer. Of the 5 dogs that did not have their VAP removed at our veterinary medical teaching hospital (all of which were in a jugular vein), 2 died of tumor recurrence with the VAP in place and 3 had the VAP removed by a referring veterinarian.

Perioperative complications—Malposition of the catheter tip was detected in 4 dogs, each of which had a VAP in a jugular vein. Malposition of the catheter tip was detected in 3 of 6 dogs for which the length of catheter was determined by use of anatomic landmarks (Table 1). Postoperative radiography revealed the tip of the catheter in the azygous vein in 2 dogs, and a second surgery was immediately performed to reposition the catheter tip in the cranial vena cava (Figure 1). The tip of the catheter was located in the right atrium in 1 dog. This catheter was not repositioned.

Malposition of the catheter tip was detected in 1 of 17 dogs for which the length of catheter was determined by use of intraoperative fluoroscopy. In this dog, the catheter tip was visible in the cranial vena cava by use of fluoroscopy prior to the catheter being cut to the appropriate length. Thoracic radiography performed 14 days after VAP implantation revealed that the catheter tip was in the pulmonary artery, and the VAP was removed. In all dogs, blood loss during VAP placement was < 5 mL, as estimated by the surgeon. No other perioperative complications were recorded.

Postoperative complications—Seroma of the port pocket was detected in 7 dogs (Table 1). All 7 dogs had a VAP in a jugular vein. Interval until resolution of the seroma ranged from 2 to 14 days (mean, 6.9 days; 95% CI, 2.9 to 10.8 days). In 3 dogs (16 anesthetic episodes), the VAP was temporarily not used for administration of drugs or fluids because of the seroma. In all affected dogs, the seroma resolved without treatment. No clinical signs consistent with infection of the port pocket were detected in dogs with a seroma. No evidence of infection was detected on the CBCs performed halfway through treatment and on the last day of treatment.

Partial withdrawal occlusion affected the VAP in 5 dogs (18 anesthetic episodes). The VAPs were used for induction and fluid administration despite this complication. In all 5 dogs, partial withdrawal occlusion resolved with subsequent use of the VAPs. None of the dogs had complete catheter occlusion.

Breakage of port-anchoring sutures was detected in 3 dogs, and a second surgery was required to resuture the port to the underlying fascia. Ports were initially sutured in place with 2-0 polypropylene in these 3 dogs.

The ports were resutured to the underlying fascia with 0 polypropylene (2 dogs) and 2-0 polypropylene (1 dog).

No clinical signs of infection at the VAP surgical site were detected in 22 dogs. Infection with thrombosis was suspected in 1 dog that did not have the VAP removed at the end of radiation treatment. This dog had been referred to our veterinary medical teaching hospital for radiation therapy of an incompletely resected grade 2 soft tissue sarcoma of the right elbow joint region. The dog was not treated at our facility for the suspected infection. Medical records were obtained from the veterinary clinics at which the complication had been diagnosed and the dog treated. The dog was

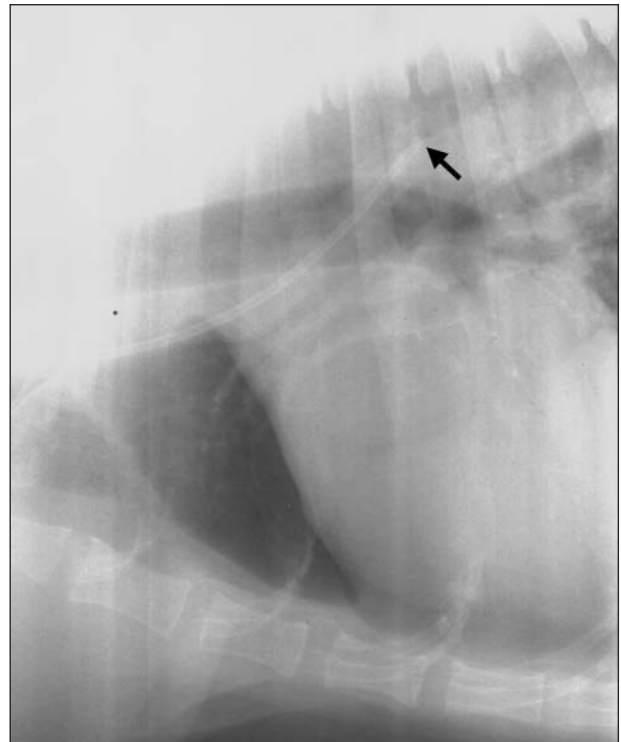


Figure 1—Lateral radiographic view of a dog with a VAP after surgery was completed to implant the VAP in a jugular vein by use of recommended anatomic landmarks. The dog was positioned in left lateral recumbency. Notice that the tip of the catheter is malpositioned and is visible within the azygous vein (arrow).

Table 1—Perioperative and postoperative complications in 23 dogs after implantation of a VAP.

Complication	VAP location	VAP size	Outcome
Perioperative Malposition of catheter tip (n = 4)	Left jugular vein (n = 3) or right jugular vein (1)	5-F (n = 1) or 7-F (3)	Repositioned catheter (n = 3) or removed VAP (1)
Postoperative Seroma formation (n = 7)	Left jugular vein (n = 5) or right jugular vein (2)	5-F (n = 1) or 7-F (6)	Resolved after 2 to 14 days (mean, 6.9 days)
Partial withdrawal occlusion (n = 5)	Left jugular vein (n = 3), right jugular vein (1), or right saphenous vein (1)	5-F (n = 2) or 7-F (3)	Resolved after 1 to 9 anesthetic episodes (median, 3 anesthetic episodes)
Breakage of port-anchoring sutures (n = 3) Catheter-related septicemia (n = 1)	Left jugular vein (n = 3) Left jugular vein	5-F (n = 1) or 7-F (2) 7-F	Resutured Died 131 days after VAP placement

examined by the referring veterinarian for swelling over the port site and in the ventral neck region 84 days after VAP implantation. The swelling did not appear to cause the dog pain, and there was no evidence of tumor recurrence at the primary tumor site. Meloxicam (0.1 mg/kg, PO, q 24 h) was initiated, and the swelling resolved initially but recurred 14 days later. Cephalexin (22 mg/kg, PO, q 8 h) was started. Bacterial culture of fluid aspirated from the swelling yielded negative results. The swelling again resolved. At that time, VAP removal was recommended to the referring veterinarian and the owner of the dog during consultations with the authors; however, this recommendation was declined. The dog was again examined by the referring veterinarian because of acute onset of lethargy 121 days after VAP implantation. The VAP had been flushed monthly in accordance with the protocol described for VAP maintenance, and the most recent flush had been performed on day 108 (13 days before onset of lethargy). The dog was febrile (rectal temperature, 41.5°C [106.7°F]), and thoracic radiography revealed a mild, diffuse, bronchointerstitial pattern. A CBC revealed thrombocytopenia (79.9×10^9 platelets/L; reference range, 170 to 400×10^9 platelets/L). Ampicillin (22 mg/kg, IV, q 24 h) was initiated (day 1 of treatment), and enrofloxacin (10 mg/kg [4.55 mg/lb], IV, q 24 h) and metronidazole (10 mg/kg, IV, q 12 h) were started on day 2. The febrile condition resolved on day 3, and cardiac ultrasonography revealed no evidence of gross valvular vegetative lesions. Bacterial culture of a urine sample yielded negative results. On day 4 of treatment, the dog was dyspneic and cyanotic and was transferred to a specialty hospital. Administration of ampicillin (22 mg/kg, IV, q 8 h), enrofloxacin (9 mg/kg [4.10 mg/lb], IV, q 12 h), and metronidazole (13 mg/kg [5.91 mg/lb], PO, q 12 h) was continued. Three blood samples collected at 30-minute intervals and transtracheal wash fluid were submitted for bacterial culture, but no organisms grew. On day 5, the VAP and proximal portion of the external jugular vein were surgically removed and a surgical biopsy specimen of the cranial left lung lobe was obtained. Histologic examination of the resected portion of the external jugular vein and lung revealed subacute thrombosis in the jugular vein and acute-to-subacute interstitial pneumonia with alveolar proteinosis. No organisms grew on bacterial culture of the jugular vein, lung, or VAP catheter tip. Thoracic radiography on day 5 revealed a diffuse, bronchointerstitial pattern similar to that for thoracic radiography on day 1 of treatment. After clinical improvement on days 6 and 7, the dyspnea worsened on day 8 and imipenem (7.7 mg/kg [3.5 mg/lb], IV, q 8 h) was initiated. A CBC revealed an inflammatory leukogram with a left shift. Partial thromboplastin time, prothrombin time, and platelet count were within reference ranges. The dog transiently improved on day 9 of treatment, but its condition deteriorated again on day 10. A single dose of amikacin (15.4 mg/kg [7.0 mg/lb], IV) was administered, but unfortunately, the dog died (131 days after VAP placement). Cause of death was suspected to be VAP-related septicemia, but it could not be confirmed because the owner declined postmortem examination.

Intravenous catheters in peripheral veins—No clinical signs of catheter-site or systemic infection were

recorded in dogs with an intravenous catheter in a peripheral vein.

Induction time—Induction time was recorded for 301 anesthetic episodes (205 for a VAP in a jugular vein, 50 for a VAP in a lateral saphenous vein, and 46 for an intravenous catheter in a peripheral vein). Induction time for use of a VAP ranged from 4.0 to 15.7 minutes (mean, 7.8 minutes; 95% CI, 7.5 to 8.0 minutes). Mean induction time for dogs with a VAP in a jugular vein (7.5 minutes; 95% CI, 7.2 to 7.7 minutes) differed significantly ($P < 0.001$) from the mean induction time for dogs with a VAP in a lateral saphenous vein (8.9 minutes; 95% CI, 8.2 to 9.7 minutes). Mean induction time did not differ significantly between dogs with a 5-F VAP and dogs with a 7-F VAP. Induction time for dogs with an intravenous catheter in a peripheral vein ranged from 5.0 to 20.1 minutes (mean, 8.4 minutes; 95% CI, 7.3 to 9.4 minutes). Mean induction time did not differ significantly between dogs with a VAP and dogs with an intravenous catheter in a peripheral vein.

Blood collection—Forty-two blood samples were collected (33 by use of a VAP and 9 by venipuncture of an external jugular vein). Slight hemolysis was evident in 2 of 9 samples collected via venipuncture, and 1+ hemolysis was evident in 1 of 33 samples collected by use of a VAP. For all 3 samples with evidence of hemolysis, analysis was performed by use of the spectrophotometer.

Bacterial culture—Fifteen catheter tips for VAPs (12 in a jugular vein and 3 in a lateral saphenous vein) were submitted for aerobic and anaerobic bacterial culture after surgical removal. Five catheter tips yielded a culture (1+ *Staphylococcus intermedius* for 2 catheter tips [1 in a jugular vein and 1 in a lateral saphenous vein], 1+ hemolytic [double halo of hemolysis] *Staphylococcus aureus* for 1 catheter tip in a jugular vein, and *Staphylococcus* spp for subculture of 2 catheter tips [1 in a jugular vein and 1 in a lateral saphenous vein]). Bacterial culture of catheter tips from 4 of 5 dogs with partial withdrawal occlusion yielded growth (1+ *S. intermedius*) for 1 catheter tip.

Discussion

The recommendation for location of the catheter tip for a VAP in a jugular vein is the cranial vena cava.¹ The tip should be in a high-flow or turbulent area and have minimal contact with the wall of the vessel.³ Placement in the heart is not recommended because of the risk of endocardial irritation and arrhythmia.³ In the study reported here, use of the manufacturer's recommended anatomic landmarks to determine catheter length for VAPs in jugular veins did not reliably allow placement of the catheter tip in the desired location. Therefore, intraoperative fluoroscopy to assess tip placement prior to cutting the catheter to the desired length for both jugular and lateral saphenous vein locations is recommended by the authors. Reassessment of the tip location after the port has been anchored with sutures is also recommended because variability in location of the port within the subcutaneous pocket may change the location of the catheter tip. In addition, in the dog in which the catheter tip was located in the pulmonary

artery, the authors believe that the catheter tip was inadvertently advanced into the pulmonary artery before the catheter was cut and attached to the port. In this dog, fluoroscopy was performed prior to cutting the catheter to the desired length but not after attachment of the catheter to the port. It is possible that other dogs in this study in which the position of the catheter tip was assessed by fluoroscopy prior to cutting the catheter and attaching it to the port also had an inadvertent change in catheter tip position.

When fluoroscopy is not available, the position of the catheter tip can be assessed by use of radiography. When anatomic landmarks are used to determine the length of the catheter inserted into a jugular vein, the authors advise slight modification of the manufacturer's recommendations. Because the position of the catheter tip was past the desired location in 3 dogs in which catheter length was determined by use of anatomic landmarks, the authors recommend measuring the distance between the venotomy site and spine of the scapula instead of measuring the distance between the venotomy site and caudal edge of the scapula.

Malposition was detected only in dogs with a VAP in a jugular vein, possibly because of a smaller (ie, shorter length) acceptable location of the catheter tip for dogs with a VAP in a jugular vein (ie, cranial vena cava) than for dogs with a VAP in a lateral saphenous vein (ie, caudal vena cava). It is possible that the location of the catheter tip changed after radiographic or fluoroscopic examinations because position of the catheter tip was not reassessed prior to VAP removal.

Seroma formation was the most common postoperative complication in the dogs of this study (7/23 [30.4%]). Elimination of dead space by use of sutures in the subcutaneous tissues and placement of the port within the pocket so that the port is not directly beneath the incision are recommended to decrease the risk of seroma formation.³ We adhered to these recommendations for the dogs in our study.

Partial withdrawal occlusion can result from the formation of a fibrin flap at the tip of a catheter, a catheter tip that is located against a vessel wall, or a sharp bend in a catheter that occludes the lumen.³ The frequency of this complication was low; this complication resolved with subsequent catheter use and did not prevent use of these catheters for induction of anesthesia.

The 3 dogs in which suture breakage was detected were young (14, 35, and 38 months old, respectively), large-breed, and active dogs. The amount of activity (running off-leash or jumping) that the dogs had at home may have contributed to suture breakage, and limiting activity to walking while restricted on a leash during the first 2 weeks after VAP placement is recommended.

The importance of *Staphylococcus* organisms grown on subcultures for 2 VAP catheter tips is uncertain and may represent contamination during sample collection or handling. The 1+ *Staphylococcus* spp cultured from 3 VAP catheter tips were important and were considered a potential source of infection that may have led to clinically undetected bacteremia in these dogs.

Infection is one of the most common serious complications of subcutaneously located VAPs in human oncology patients.⁵ Electron microscopy of indwelling

central venous catheters in human cancer patients has revealed a biofilm layer, which consists of microorganisms adherent to a layer of fibrous glycocalyx, on the surface of virtually all catheters.⁸ The pathogenesis of infection related to indwelling catheters has been associated with this biofilm layer, although a low proportion (3%) of patients with colonization by microorganisms develop catheter-related bacteremia.⁸ The biofilm environment inhibits antimicrobial diffusion, decreases antimicrobial uptake by organisms, and protects organisms from antimicrobial agents.⁹ In dogs with port pocket or systemic infection, surgical removal of the VAP has been recommended because of the increased resistance of biofilm-associated organisms to antimicrobial treatment and the poor response to antimicrobial treatment without implant removal.³ This recommendation is supported by the lack of response to antimicrobial treatment for the dog that had a suspected catheter-associated septicemia in the study reported here. The risk of septicemia may be minimized by closely monitoring for signs of infection and prompt removal of the VAP when such signs are detected. Routine VAP removal at the completion of radiation treatment is recommended, unless there is a continued need for vascular access for chemotherapy or other medical or surgical procedures. None of the dogs with an intravenous catheter in a peripheral vein had clinical signs of infection; however, the number of dogs in our study was too low to compare the frequency of infection between dogs with a VAP and dogs with an intravenous catheter.

Venous wall thrombosis was detected in 27 of 72 (38%) human cancer patients with indwelling central venous catheters.¹⁰ In that study, catheter-related infection was evident in 7 of 72 (9.7%) human patients and was limited to patients who also had mural thrombosis, which led those authors to suggest a possible association between thrombosis and infection. The dog with suspected catheter-related septicemia in our study had histologically confirmed thrombosis in the external jugular vein; however, this was the only patient in our study for which histologic examination of the jugular vein was performed.

The significant increase in mean induction time when a VAP in a lateral saphenous vein was used, compared with the mean induction time when a VAP in a jugular vein was used, may have resulted from difficulty in palpating the edges of the port on the lateral aspect of the hind limb. There is not as much mobile skin at the port site in a lateral saphenous vein, compared with that at a port site in a jugular vein, and an easily palpable circumference of the port assisted the clinicians and technicians when inserting a Huber needle into the port septum. It is possible that the difference in mean induction time between dogs with a VAP in the lateral saphenous and jugular veins was attributable to a difference between the groups for some factor other than VAP location. Some of the additional variables affecting induction time that may have differed between the groups of dogs included temperament of each dog, technician experience with regard to use of VAPs, and the anesthetic drug protocol. Relative to overall time for anesthetic induction and recovery, patient handling, and radiation treatment, the difference in induction

times between the 2 VAP sites was not of clinical relevance. Lack of a difference between induction times by use of VAPs and intravenous catheters in a peripheral vein was not unexpected; although vascular access via an intravenous catheter inserted in a peripheral vein does not require aseptic preparation of the skin and may therefore be more rapid than vascular access via a VAP, dogs required placement of a new intravenous catheter at least twice per week and more frequently when the catheter lost patency.

It has been suggested in studies^{11,12} in human patients that blood samples collected through catheters have a higher rate of hemolysis than is evident for blood samples collected by use of venipuncture, possibly because of a smaller diameter of catheters or higher syringe pressure during suction used to collect samples from catheters. In the study reported here, we did not detect a higher proportion of hemolysis in blood samples collected by use of VAPs than by use of venipuncture, although the number of blood samples examined was relatively small. This result is consistent with that in a study¹³ in which investigators compared blood samples collected by use of venipuncture and VAPs in cats, which revealed no visible difference in degree of hemolysis between the 2 methods of blood collection.

Ideally, the study reported here would have been better had we compared the rate of infection between dogs with VAPs and dogs with intravenous catheters in a peripheral vein; however, on the basis of our hypothesized low frequency of infection as a complication for both groups and the relatively small number of dogs referred for radiation therapy, the authors did not anticipate a sufficient number of dogs in the study to enable us to detect a difference between the 2 groups. In addition, it would have been desirable for dogs in this study to have been randomly assigned to receive a VAP or intravenous catheter after receiving client consent for inclusion in the study. However, because only 23 of 40 owners gave consent for placement of a VAP, this would have limited the number of dogs in the study even further. The small number of induction times available for dogs with intravenous catheters may have decreased our ability to detect a difference between induction times for dogs with a VAP and dogs with an intravenous catheter in a peripheral vein. In addition, the number of dogs with a VAP in a lateral saphenous vein was too small to detect any possible difference in perioperative and postoperative complication rates and surgical placement times between dogs with a VAP in a lateral saphenous vein or a jugular vein.

The use of a VAP in a jugular or lateral saphenous vein in 23 dogs receiving radiation therapy was associated with seroma formation in 7 (30.4%) dogs, malposition of the catheter tip in 4 (17.4%) dogs, and breakage of port-anchoring sutures in 3 (13.0%) dogs and partial withdrawal occlusion in 18 of 255 (7.1%) anesthetic episodes. It also may have possibly been associated with a VAP-related fatal infection in 1 dog. The fatality attributed to the suspected VAP-related infection may have been prevented by prompt removal of the VAP when clinical signs of infection developed.

The most common complications with use of VAPs were considered minor. Use of manufacturer-recommended anatomic landmarks to determine the appropriate catheter length did not reliably result in placement of the catheter tip in the desired location, and tip location should be assessed by use of intraoperative fluoroscopy or radiography. Dogs with a VAP should be monitored closely for signs of infection, including local redness, swelling, heat, signs of pain, discharge, and an increase in rectal temperature, and removal of the VAP at the completion of radiation therapy should be performed unless the benefit of continued vascular access outweighs the risk of infection. Because of the potential for infection, it is critical to strictly use aseptic techniques during VAP placement and subsequent access.

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- a. Normosol-R, Abbott Laboratories, Montreal, QC, Canada.
 - b. BD Insyte IV catheter, BD Medical, Franklin Lakes, NJ.
 - c. Le Port, provided by CompanionPort, Norfolk Vet Products, Skokie, Ill.
 - d. Le Grande, provided by CompanionPort, Norfolk Vet Products, Skokie, Ill.
 - e. Hitachi 912 automatic analyzer, Boehringer Mannheim, Mannheim, Germany.
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