Intraoperative antinociception and postoperative analgesia following epidural anesthesia versus femoral and sciatic nerve blockade in dogs undergoing stifle joint surgery

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**Objective**—To compare analgesic efficacy of preoperative epidural anesthesia with efficacy of femoral and sciatic nerve blockade in dogs undergoing hind limb orthopedic surgery.

**Design**—Prospective randomized blinded clinical study.

**Animals**—22 dogs requiring stifle joint surgery.

**Procedures**—Dogs were premedicated with acepromazine and morphine, and anesthesia was induced with diazepam and propofol and maintained with sevoflurane in oxygen. Prior to surgery, a combination of 1.0% lidocaine solution with 0.25% bupivacaine solution was administered either into the lumbosacral epidural space (11 dogs) or perineurally along the femoral and sciatic nerves (11). Intraoperative nociception was assumed if heart rate or systolic blood pressure increased by > 10% from baseline, in which case fentanyl (2 µg/kg [0.9 µg/lb], IV) was administered as rescue analgesia. Following recovery from anesthesia, signs of postoperative pain were assessed every 30 minutes for 360 minutes from the time of local anesthetic administration via the modified Glasgow pain scale. Patients with scores > 5 (scale, 0 to 20) received hydromorphone (0.1 mg/kg [0.05 mg/lb], IV) as rescue analgesia and were then withdrawn from further pain scoring.

**Results**—Treatment groups did not differ significantly in the number fentanyl boluses administered for intraoperative rescue analgesia. Time to administration of first postoperative rescue analgesia was comparable between groups. Furthermore, there was no significant difference between groups in baseline pain scores, nor were there significant differences at any other point during the postoperative period.

**Conclusions and Clinical Relevance**—Femoral and sciatic nerve blocks provided intraoperative antinociception and postoperative analgesia similar to epidural anesthesia in dogs undergoing stifle joint surgery. (J Am Vet Med Assoc 2012;241:1605–1612)

Cranial cruciate ligament tear and medial patellar luxation are 2 of the most common orthopedic lesions of the hind limb in dogs and frequently cause moderate to severe signs of pain, therefore requiring surgical intervention. Patients undergoing surgical correction of cranial cruciate ligament or medial patellar luxation may have substantial intraoperative nociception and signs of postoperative pain. Regional anesthesia techniques, specifically epidural anesthesia and recently also PNB, are commonly used in a multimodal anesthetic protocol given their efficacy, wide margin of safety, and prolonged analgesic effects throughout the perioperative period.

Epidural analgesia is an established technique for the alleviation of intraoperative nociception and signs of postoperative pain in dogs undergoing hind limb orthopedic procedures. Compared with traditional IV administration of opioids, epidural local anesthetic delivery provides superior analgesia and decreases the need for additional opioids during the perioperative period for a longer duration. More recently, PNB has been described in dogs as an alternative regional analgesic technique for signs of pain originating in both the thoracic and pelvic limbs. In addition, appropriate injection volumes to provide adequate regional anesthesia and efficacy comparable to intra-articular local anesthetics have been established for femoral and sciatic nerve blocks in dogs undergoing stifle joint surgery. A recent meta-analysis of studies comparing epidural analgesia to PNB after major knee surgery in human patients concluded that PNB techniques are comparable in analgesic efficacy but differ in their adverse effect profiles. Peripheral nerve blockade was associated with less intraoperative hypotension and fewer

**Abbreviations**

<table>
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<tr>
<th>Abbreviation</th>
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<tr>
<td>MAC</td>
<td>Minimum alveolar concentration</td>
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<tr>
<td>PNB</td>
<td>Peripheral nerve blockade</td>
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<td>SAP</td>
<td>Systolic arterial blood pressure</td>
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postoperative adverse events such as nausea, vomiting, pruritis, and urine retention.14–19

To date, there is only 1 study20 in veterinary patients that has compared the efficacy of epidural analgesia with PNB, performed under electrolocation guidance, in dogs undergoing hind limb orthopedic surgery. Although that study20 found similar analgesic effects of the 2 techniques, the samples population of small and the epidural technique included morphine administration in addition to the local anesthetic, making the comparison with perineural local anesthetic administration alone more challenging. Therefore, the objective of the study reported here was to compare the efficacy of these 2 locoregional anesthesia techniques in inhibiting surgery-related nociception and providing postoperative analgesia for dogs undergoing stifle joint surgery by use of similar doses of local anesthetics for both locoregional techniques. It was hypothesized that single injection preoperative blockade of the femoral and sciatic nerves is as efficacious as a single injection preoperative administration of a local anesthetic epidurally into the lumbosacral epidural space in providing intraoperative antinociception and postoperative analgesia.

Materials and Methods

Study design and study population—The study was designed as a randomized prospective, single-blinded clinical trial. Twenty-two client-owned dogs of various breeds, ages, and sex scheduled for surgical cranial cruciate ligament or medial patellar luxation repair at the Center for Animal Referral and Emergency Services were studied after the study protocol was reviewed by the University of Pennsylvania Animal Care and Use Committee and written informed consent was obtained from each client. For animals receiving NSAIDs in the period prior to surgery, treatment was discontinued 24 hours before surgery. Based on the findings of preanesthetic physical examination, routine hematologic assessment, and serum biochemical analysis, the animals were judged to be systemically healthy and well hydrated and thermoregulated as having a physical status 1 according to the American Society of Anesthesiologists. Food was withheld from dogs for 12 to 18 hours prior to surgery, but dogs had free access to water until the time of premedication administration. Dogs were randomly assigned via a computer-generated random numbers list to 2 treatment groups as follows: 11 dogs received local anesthetic solution epidurally into the lumbosacral space (epidural anesthesia group), and 11 dogs received local anesthetic solution perineurally along femoral and sciatic nerves in the operated limb (femoral and sciatic nerve blockade group). Any patient with a contraindication for locoregional anesthesia (e.g., coagulation abnormalities and skin infections in the dorsal lumbosacral area or in the skin over the area where the nerves were located) was excluded from the study, as were animals weighing < 10 kg (22 lb).

Anesthetic protocol—All dogs received IM administration of acepromazine (0.02 mg/kg [0.009 mg/lb]) and morphine (0.3 mg/kg [0.14 mg/lb]) 45 minutes prior to intravenous catheter placement. A catheter of appropriate size was placed aseptically in the right or left cephalic vein and then anesthesia induced with diazepam (0.3 mg/kg, IV) and propofol (2 to 6 mg/kg [0.9 to 2.7 mg/lb], IV) at doses that allowed for orotracheal intubation. Anesthesia was maintained with sevoflurane in oxygen delivered to the patients via an agent-specific out-of-circuit precision vaporizer, a fresh gas flow rate of 10 to 20 mL/kg/min (4.5 to 9.1 mL/lb/min), and a semiclosed breathing circuit system for small animals. All patients were mechanically ventilated to maintain the end-tidal carbon dioxide concentration at 35 to 40 mm Hg, with a pressure-cycled, volume-limited respiratory cycle to deliver 8 to 10 breaths/min at a peak inspiratory airway pressure of 10 to 20 cm H2O. The end-tidal sevoflurane concentration was maintained at a volume of 1.9% to 2.1% to ensure appropriate depth of anesthesia (stage 3 plane). If, during surgery, the heart rate or SAP increased above preoperative values (baseline) by > 10% in response to surgical stimulation and the patient was considered on the basis of physical signs to be at an adequate anesthetic depth, a bolus of fentanyl (2 µg/kg, IV) was administered and repeated until heart rate and SAP returned to baseline values. A balanced crystalloid solution was infused at a rate of 10 mL/kg/h throughout the anesthetic period. Hypotensive events (SAP < 80 mm Hg) were treated with a bolus of the crystalloid solution (10 mL/kg, IV), and the total amount given was recorded. Patients that had hypotension that was unresponsive to fluid administration were treated appropriately with either an anticholinergic (glycopyrrolate, 0.01 mg/kg [0.45 µg/lb]) or an inotropic agent (dopamine; 5 to 20 µg/kg/min [2.3 to 9.1 µg/lb/min]) at the discretion of the anesthetist.

Instrumentation and intraoperative monitoring—Continuous monitoring of anesthetic depth included physical signs (jaw tone, palpebral reflex, eyelid position, limb withdrawal reflex, and spontaneous movement) as well as changes in heart rate, SAP, and respiratory rate. A multiparameter patient monitor was used to record heart rate (beats/min) and rhythm via lead II ECG, arterial blood oxygenation via pulse oximetry (%) with a clip probe placed on the tongue, esophageal body temperature (°C), end-tidal carbon dioxide concentration via capnography, inspired and expired concentrations of O2 via a paramagnetic sensor, and end-tidal sevoflurane concentration (volume %) via infrared spectrometry. The SAP (mm Hg) was measured with a Doppler ultrasound probe placed on the palmar aspect of the carpus and the cuff connected to a manometer and placed around the respective antebrachium.

Surgical procedures—Following induction of anesthesia, the patients’ surgical sites were clipped of hair and the skin disinfected for aseptic surgery. Cruciate ligament repair was performed by use of 1 of 3 methods: tibial plateau leveling osteotomy, lateral suture stabilization, or use of a commercial cruciate ligament repair system. In addition, the stifles joint was approached and explored via arthrotomy or arthroscopy prior to surgical correction of the orthopedic lesions. Medial luxation of the patella was corrected via arthrotomy with deepening trochleoplasty, tibial tuberosity transposition, and soft tissue imbrication as clinically indicated. All surgeries were performed by 2 board-certified surgeons (DAP and BB).
Locoregional anesthetic administration—In each patient, the site for both lumbosacral epidural anesthesia and femoral and sciatic nerve blocks were clipped of hair and prepared for aseptic needle insertion, and the skin was punctured with a 20-gauge needle at all sites to ensure that the investigator collecting perioperative data was unaware of the locoregional anesthesia technique applied in a certain patient. All epidural injections and nerve blocks were performed under general anesthesia by an anesthesiologist prior to start of surgery, and data were collected by the investigator who was unaware of the locoregional technique used.

For the epidural anesthesia group dogs, epidural administration of local anesthetic solution involved the insertion of a 20-gauge spinal needle (length, 2.5 or 3.0 inches) into the lumbosacral epidural space via a standard technique previously described. Needle entrance into the epidural space was verified by applying the loss of resistance technique. The local anesthetic solution was administered in a volume of 0.2 mL/kg (0.09 mL/lb), but not to exceed 6 mL total, and contained a combination of 1.0% lidocaine and 0.25% bupivacaine. This combination of lidocaine (2 mg/kg) and bupivacaine (0.5 mg/kg [0.23 mg/lb]) has been successfully applied in clinical practice at the University of Pennsylvania. The dose regimen has been slightly modified from an original report in 1997 by Cruz et al. Dogs were then placed in lateral recumbency with the surgical limb in the dependent position and thorax elevated for 10 minutes to prevent cranial migration and allow appropriate distribution of the local anesthetic.

For femoral and sciatic nerve blockade group dogs, the femoral and sciatic nerve blocks were performed via a nerve stimulator and a 20-gauge insulated stimulating needle (length, 2 or 3 inches). This electrolocation-guided needle insertion technique involves stimulation of the peripheral nerves via an insulated stimulating needle placed in their vicinity and an initial stimulator setting of 2 mA, 2 Hz, and 0.1 milliseconds for single pulse duration. The optimal localization of each individual nerve can be determined by observation of a characteristic contraction of the corresponding muscle groups innervated by the particular nerve being isolated. The current strength is then decreased until a muscle contraction is still present at 0.4 to 0.5 mA but absent below 0.3 mA. Thereafter, the local anesthetic solution is injected. The injection extension of the insulated needle is primed with the local anesthetic solution and then flushed with 0.4 mL of saline (0.9% NaCl) solution after injecting the test solution.

In this study, the femoral nerve was targeted as it exited the femoral canal between the sartorius and pectineus muscles. It innervates the quadriceps femoris muscle. The saphenous nerve branches off at the level of the hip joint just before leaving the ilioispoas muscle and then runs parallel to the femoral artery. With the dog in lateral recumbency, the femoral artery was palpated and the stimulating needle inserted cranial to the artery and caudal to the medial belly of the sartorius muscle perpendicular to the limb. Once the needle was inserted 0.5 to 1.0 cm deep into the tissue, it was angled caudally 20° to 30° and further advanced until a muscle twitch was noticed in response to electrical stimulation. Correct femoral nerve location was confirmed by observation of a flexion of the hip joint, extension of the stifle joint, and contraction of the quadriceps femoris muscle.

The sciatic nerve is formed by 2 branches: the tibial nerve medially and the common peroneal nerve laterally. The sciatic nerve passes between the middle and the deep gluteal muscles and then exits the pelvis through the greater sciatic foramen and descends protected by the greater trochanter of the femur. The PNB was performed proximal to the division of the nerve into the tibial and common peroneal nerve branches. With the patient placed in lateral recumbency, the greater trochanter and the ischiatric tuberosity were palpated. The stimulating needle was inserted one-third of the distance between these 2 landmarks, closer to the greater trochanter, perpendicular to the skin. Correct sciatic nerve isolation was confirmed by observation of a characteristic muscle twitch pattern including dorsiflexion of the foot. The PNB of these 2 nerves was obtained by injecting a combination of 1.0% lidocaine solution and 0.25% bupivacaine solution in a total volume of 0.1 and 0.3 mL/kg (0.05 and 0.14 mL/lb) in the vicinity of the femoral and sciatic nerves, respectively, as described by Campoy et al.

Data collection during the intraoperative phase—Following the administration of local anesthetics, patients were moved to the operating room and positioned for surgery. From this point forward, anesthesia was administered and data were recorded by the same investigator who performed anesthesia. Baseline physiologic parameters such as heart rate, respiratory rate, and SAP as well as end-tidal carbon dioxide concentration were recorded and the mean calculated over a 10-minute period prior to beginning of surgery, with recordings repeated every 5 minutes throughout the anesthetic period thereafter. In addition, the number of treatments with crystalloid fluid boluses, anticholinergic and inotropic drugs, and fentanyl boluses was recorded. Finally, the following events were marked along the time axis in the data collection sheet: T1 as the 10-minute period prior to beginning of surgery (baseline), T2 as the moment of towel clamp placement, T3 as the moment of skin incision, T4 as the period covering the principal surgical joint procedure, T5 as the period of wound closure, and T6 as the period of postsurgical radiographic examination.

At the end of surgery, general anesthesia was discontinued, and patients were moved to a quiet recovery area following tracheal extubation. Analgesics were not administered before emergence from anesthesia unless the patient had required 3 or more fentanyl boluses throughout the perioperative period, in which case it was assumed that nociception was not controlled adequately and thus indicated a failure of the locoregional anesthesia technique. Those patients were to receive hydromorphone (0.1 mg/kg, IV) prior to extubation and were not included in the postoperative phase of the study because of ethical concerns regarding withholding analgesia when evidence suggested that the locoregional technique had failed.

Data collection during the postoperative phase—Severity of postoperative pain was assessed in all animals by 1 evaluator (AMC) unaware of the locoregional an-
esthetically applied, using the modified Glasgow pain scale (0 = no pain to 20 = worst pain possible). Once the endotracheal tube was removed and the dogs became aware of their surroundings, an initial baseline pain scoring was performed. Each patient was reevaluated every 30 minutes for up to 360 minutes from the time of local anesthetic administration, and the pain score was recorded at 8 time points. To enter the postoperative evaluation phase of the study, each patient had to have a pain score ≤ 5. Patients with scores > 5 at this time or any later time point received rescue analgesia in the form of hydromorphone (0.1 mg/kg, IV) administration and were subsequently withdrawn from further pain scoring. All other dogs received hydromorphone (0.1 mg/kg) following the last pain scoring at 360 minutes. To address the potential for poor recoveries due to anxiety or CNS excitation, single or repeated (if needed) IV boluses of acepromazine (5 μg/kg) were given provided the patient did not have signs of pain upon palpation of the surgery site. Patients unresponsive to acepromazine administration could receive IV hydromorphone (0.1 mg/kg) to enhance the tranquilizing effect of the neuroleptic agent but were then withdrawn from further pain scoring.

**Statistical analysis**—All data are reported as mean ± SD. Homogeneity of patient distribution and clinical management (including breed, sex, affected limb, surgery time, surgical technique, intraoperative fentanyl boluses, fluid boluses, and anticholinergic and inotropic drug support) by group was explored with the aid of the Fisher exact test. Age, body weight, and other interval variables were examined in regard to group by use of Kruskal-Wallis tests.

The intraoperatively recorded values for heart rate, SAP, end-tidal sevoflurane concentration, and end-tidal carbon dioxide concentration were compared between groups at the 6 event points (T1 through T6). The T1 value represents the mean of data recorded in the 10-minute period prior to beginning of surgery (baseline), the T4 value represents the mean of data recorded between events T3 and T5, the T5 value represents the mean of data recorded during wound closure, and the T6 value represents the mean of data recorded during radiographic examination at the end of anesthesia. Data recorded at T2 through T6 were compared with T1 baseline data. Event-related measures including heart rate, SAP, and end-tidal sevoflurane concentration were statistically analyzed. Normality was confirmed and variables transformed as needed on the basis of the Tukey ladder test. Analysis was performed via a random intercept regression model allowing for subject specific intercepts and fixed effects comprising group, event, and a group by event interaction. The intraoperative end-tidal carbon dioxide concentrations were compared via an ANOVA for repeated measures. The time at which first postoperative analgesic administration occurred by group was explored with Kaplan-Meier survival analysis and Cox regression test. Postoperative pain scores were transformed to normality via a power transformation suggested by the Tukey test and verified with the Shapiro-Francia test. Transformed scores were then analyzed by use of 2-sample t tests.

Commerically available software was used for all statistical analysis. For all comparisons, values of \( P < 0.05 \) were considered significant.

**Results**

Twenty-two dogs were entered into the study; 1 dog was excluded owing to a failure in the blinding procedure for the investigator collecting data. Thus, 21 dogs met all inclusion criteria and had data included for analysis. Ten dogs were neutered males, and 11 dogs were spayed females. Dogs in the 2 treatment groups (11 epidural anesthesia group dogs and 10 femoral and sciatic nerve blockade group dogs) ranged in age from 2 to 12 years (epidural anesthesia group dogs, 5.1 ± 1.9 years; femoral and sciatic nerve blockade group dogs, 5.6 ± 2.7 years). Body weight of dogs in the 2 treatment groups ranged from 11.2 to 60.3 kg (24.6 to 132.7 lb); epidural anesthesia group dogs had a mean body weight of 27.2 ± 13.8 kg (59.8 ± 30.4 lb), and femoral and sciatic nerve blockade group dogs had a mean body weight of 33.3 ± 3.7 kg (73.3 ± 8.1 lb). Treatment groups did not differ significantly in demographic data, including sex (epidural anesthesia group dogs, 6 castrated males and 5 spayed females; femoral and sciatic nerve blockade group dogs, 4 neutered males and 6 spayed females), breed distribution, body mass, operated limb, orthopedic disease and type of surgical repair, or duration of surgery (epidural anesthesia group dogs, 86 ± 30 minutes; femoral and sciatic nerve blockade group dogs, 70 ± 38 minutes). Cardiovascular performance between groups was also comparable as evidenced by minimal need for additional IV fluid therapy or drug treatments. Of 11 epidural anesthesia group dogs, 3 dogs received 1 bolus of fluid and 2 received 2 boluses of fluid; of 10 femoral and sciatic nerve blockade group dogs, 3 dogs received 1 bolus of fluid and 1 received 2 boluses of fluid. One of 11 epidural anesthesia group dogs and 3 of 10 femoral and sciatic nerve blockade group dogs received an anticholinergic drug. One of 11 epidural anesthesia group dogs and 2 femoral and sciatic nerve blockade group dogs received inotropic support in the form of dopamine administration. Finally, no significant differences between groups were noted for heart rate, SAP, and end-tidal sevoflurane concentration measured at T1 through T6 (Table 1), and end-tidal sevoflurane concentration did not need to be readjusted in response to stimuli once baseline data had been recorded. The mean of the end-tidal carbon dioxide concentrations recorded did not differ significantly between groups (epidural anesthesia group dogs, 37.2 ± 1.7 mm Hg; femoral and sciatic nerve blockade group dogs, 37.1 ± 1.7 mm Hg).

The total number of fentanyl boluses needed to provide adequate antinociception was not significantly \( (P = 0.55) \) different between epidural anesthesia group dogs (7 fentanyl boluses) and femoral and sciatic nerve blockade group dogs (3 fentanyl boluses). Of the 11 epidural anesthesia group dogs, 3 dogs required 1 bolus of fentanyl and 2 dogs required 2 boluses of fentanyl. Of the 10 femoral and sciatic nerve blockade group dogs, 3 dogs required 1 bolus of fentanyl. Of the 10 femoral and sciatic nerve blockade group dogs, 1 dog was assessed with a baseline pain score > 5 following awakening from anesthesia and therefore received hydromorphone for rescue analgesia; the other 9 femoral and sciatic nerve blockade group dogs entered the postoperative observation period. The time
discussed in the Methods section. PNB was performed by an anesthesiologist using 0.25% bupivacaine solution and lidocaine solution in a 1:1 ratio. The mean baseline scores on the Glasgow pain scale were not different between the treatment groups at any time point (P = 0.93). However, Kaplan-Meier survival analysis did not indicate a significant difference in pain scores between epidural anesthesia and sciatic nerve blockade group dogs (0.57 ± 0.89) and femoral and sciatic nerve blockade group dogs (0.44 ± 0.35) and epidural anesthesia group dogs (0.57 ± 0.89). Only 1 epidural anesthesia group dog received a single dose of rectal analgesia upon emergence from anesthesia. Likewise, for the remainder of the postoperative period, no significant differences were detected in mean pain scores between groups at any time point between 30 and 360 minutes on the Glasgow pain scale. One dog in the femoral and sciatic nerve blockade group had sciatic nerve deficits for approximately 18 hours after PNB, but signs were completely resolved 30 hours after PNB.

Discussion

The data of the present study supported our hypothesis that in dogs undergoing surgery to correct a cranial cruciate ligament tear or medial patellar luxation, single injection preoperative blockade of the femoral and sciatic nerves with 1.0% lidocaine solution and 0.25% bupivacaine solution is comparable to preoperative lumbosacral epidural anesthesia with the same local anesthetic combination in its efficacy to relieve intraoperative nociception and postoperative pain. We tested a combination of 1.0% lidocaine and 0.25% bupivacaine solutions based on our long-standing positive experiences with this local anesthetic mixture for epidural anesthesia and analgesia in our clinical canine patient population. Combining the 2 local anesthetics for lumbosacral epidural anesthesia and analgesia in dogs undergoing hind limb or abdominal organ surgeries was first reported in 1997 by Cruz et al, who demonstrated that a combination of lidocaine and bupivacaine produced a longer duration of analgesia, compared with lidocaine alone; better muscle relaxation, compared with bupivacaine alone; and the same duration of analgesia as with bupivacaine alone. Being both amide-type compounds, lidocaine and bupivacaine are similar in some of their physicochemical properties (especially pKa and hence lipid membrane permeability), yet different in other properties (lipid solubility and protein binding). This explains why onset of analgesia may not be different between the 2 agents after lumbosacral epidural anesthesia during the study period of 360 minutes. For the postoperative phase of the study, mean baseline scores on the Glasgow pain scale did not differ significantly (P = 0.67) between epidural anesthesia group dogs (0.44 ± 0.35) and femoral and sciatic nerve blockade group dogs (0.57 ± 0.89). Only 1 epidural anesthesia group dog received a single dose of rectal analgesia upon emergence from anesthesia. Likewise, for the remainder of the postoperative period, no significant differences were detected in mean pain scores between groups at any time point between 30 and 360 minutes on the Glasgow pain scale. One dog in the femoral and sciatic nerve blockade group had sciatic nerve deficits for approximately 18 hours after PNB, but signs were completely resolved 30 hours after PNB.

The need for intraoperative rescue analgesia in the form of IV administration of a fentanyl bolus (2 μg/kg) was similar in both treatment groups, with only 5 dogs (3 epidural anesthesia group dogs and 2 femoral

Table 1—Means ± SD values of heart rate, SAP, and end-tidal sevoflurane concentration in dogs treated prior to stifle joint surgery with 1.0% lidocaine and 0.25% bupivacaine solutions administered either into the lumbosacral epidural space (11 dogs) or perineurally along the femoral and sciatic nerves (10 dogs).

<table>
<thead>
<tr>
<th>Time</th>
<th>Heart rate (beats/min)</th>
<th>SAP (mm Hg)</th>
<th>End-tidal sevoflurane concentration (vol%)</th>
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<tr>
<td></td>
<td>EPI ± FS</td>
<td>EPI ± FS</td>
<td>EPI ± FS</td>
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<tr>
<td>T1</td>
<td>106 ± 22</td>
<td>101 ± 22</td>
<td>93 ± 23</td>
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<tr>
<td>T2</td>
<td>105 ± 25</td>
<td>99 ± 24</td>
<td>92 ± 16</td>
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<td>T3</td>
<td>111 ± 23</td>
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<td>T5</td>
<td>104 ± 23</td>
<td>107 ± 32</td>
<td>91 ± 21</td>
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<tr>
<td>T6</td>
<td>107 ± 23</td>
<td>106 ± 18</td>
<td>92 ± 19</td>
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</table>

and sciatic nerve blockade group dogs) requiring the administration of fentanyl. In addition, the overall administration of fentanyl was considered minimal, compared with common dosing of the opioid in the clinical setting. Overall, an adequate plane of anesthesia could be maintained at end-tidal sevoflurane concentration at or below the typical MAC of sevoflurane reported for dogs (1.8% to 2.3%). Moreover, in both groups, end-tidal sevoflurane concentration was below the reported MAC of sevoflurane that is associated with suppression of autonomic responses to noxious stimulation in 50% of dogs studied. This further supports the assumption that both locoregional anesthetic techniques were effective. The observations of the present study are in contrast to findings in a previous study by Rasmussen et al, who failed to show a clinical benefit of a reduction in perioperative pain when blocking the saphenous, tibial, and common peroneal nerves with 0.5% bupivacaine solution prior to cruciate ligament repair in dogs. However, a limitation of that study was that administration of the local anesthetic in the vicinity of the respective nerves was performed in a blinded fashion, which always entails the risk that the block was ineffective. The use of a peripheral nerve stimulator to locate the target nerve has been shown to markedly improve the success rate and safety of the PNB technique in human patients. In the present study, an electrolocation-guided PNB technique was applied as recently described for femoral and sciatic nerve blocks in dogs. The successfully performed PNB of the 2 nerves in each of the femoral and sciatic nerve blockade group dogs in the present study further emphasizes the advantage of applying an electrolocation-guided approach in animals. Similarly, in a prospective clinical trial comparing the analgesic efficacy of continuous femoral nerve blockade with continuous epidural analgesia after total knee arthroplasty, human patients had equivalent postoperative pain relief, range of movement, and rehabilitation. Additional studies in human patients have found equivalent analgesic efficacy of these 2 locoregional anesthesia techniques during the perioperative period. Notably, PNBs in patients undergoing various orthopedic surgical procedures have been associated with superior same-day recovery and decreases in hospital readmissions.

In the postoperative phase of the study, dogs in both groups had similarly low pain scores for a comparable duration of time. All of the dogs entered the postoperative evaluation period, with the exception of 1 femoral and sciatic nerve blockade group dog that had signs of pain in excess of a score of 5, despite having not required any intraoperative fentanyl rescue analgesia. Murell et al demonstrated that the modified Glasgow pain scale consistently discriminates between mild, moderate, and severe pain in dogs undergoing both soft tissue and orthopedic surgery. In their study, overall mean pain scores in animals undergoing both types of surgery were < 5, corresponding to moderate pain on a visual analog scale. Furthermore, a study comparing analgesic efficacy of intraarticular to epidural morphine administration showed similarly low pain scores in both groups.

The present study was not specifically designed to assess differences in cardiovascular performance during surgery. Interestingly, both groups appeared to be similar with respect to the need for hemodynamic support in the form of anticholinergic drug, inotropic drug, and fluid boluses administered, although one might have expected a more prominent hypotensive effect in epidural anesthesia group dogs, compared with femoral and sciatic nerve blockade group dogs, and hence greater need for supportive treatment. Significantly more severe hypotension has been associated with epidural anesthesia, compared with PNB-mediated analgesia. We might not have observed such a difference in the study reported here because the local anesthetic solutions were of relatively low concentration or did not spread far enough cranially to cause vasodilation in a large enough area to cause substantial changes in the systemic hemodynamic parameters recorded. Postoperative adverse effects were not specifically recorded as part of the outcome analysis; however, only 1 femoral and sciatic nerve blockade group dog had a notable complication. This patient continued to have sciatic nerve deficits for approximately 18 hours after PNB, but signs were completely resolved by 30 hours after treatment. In human patients undergoing major knee surgery, the incidence of postoperative nausea, vomiting, and urinary retention is reported to be less with PNB techniques, compared with epidural anesthesia. Finally, although the overall incidence of neurologic complications is rather low with both of these techniques, evidence in human patients suggests that when they do occur, they are more severe with neural techniques.

The purpose of this study was to access the anti-nociceptive and analgesic efficacy of the 2 techniques in a clinical setting. It may have been interesting to include an opioid-only control group to demonstrate that both regional block techniques provided better antinociception and analgesia, compared with no regional block; however, the standard of practice for hind limb orthopedic procedures in this practice calls for epidural analgesia, which precluded such a control group. Overall sample size was small, and we could not control the degree of nociception or pain incurred in the dogs of this study population prior to anesthesia and surgery. Second, the nature and severity of the original stifle joint lesion and its duration (ie, whether acute or chronic) as well as anti-inflammatory and analgesic drug treatment prior to surgery were not controlled. Specifically, with chronic pain, different and more complex nociceptive pathways can be involved in transmission and processing of nociceptive stimuli (commonly referred to as central sensitization or hyperalgesia), and response to treatment may greatly vary, compared with that in an acute pain situation. To overcome the potential problem of patients being subject to variable degrees of intraoperative noxious stimulation dependent on the surgical repair technique chosen, we randomly assigned dogs to each treatment group.

There were other possible limitations of our study that might have compromised our ability to detect a significant difference in the efficacy of the 2 locoregional anesthesia techniques in inhibiting intraoperative nociception and providing postoperative analgesia. One might have been that premedication with morphine provided such profound and long-lasting analgesia and sevoflu-
rane MAC-sparing effects that any remaining nocicep-
tion and signs of pain were too weak to assess the an-
tinoceptive and analgesic potential of either mode of
locoregional anesthesia. However, it is unlikely that the
low dose of morphine (0.3 mg/kg, IM) administered at
90 to 105 minutes prior to surgery still had major anti-
nociceptive or analgesic actions at the time the efficacy
of the 2 locoregional techniques was assessed during
and after surgery, particularly considering the pharma-
cokinetics of morphine in dogs. 13

In conclusion, the study showed that femoral and
sciatric nerve blocks provided intraoperative antinoci-
cceptive and postoperative analgesic effects comparable
to those of lumbosacral epidural anesthesia for canine
patients undergoing stifle joint surgery. A much larger
study is needed to fully assess the safety and adverse ef-
fect profile associated with PNB in dogs, but it appears
that femoral and sciatic PNB can serve as an alternative
to epidural anesthesia and analgesia for dogs undergoing
surgery of the stifle joint.

References
1. Innes JF, Bacon D, Lynch C, et al. Long-term outcome of sur-
gery for dogs with cranial cruciate ligament deficiency. Vet Rec
2000;147:325–328.
2. Valverde A. Epidural analgesia and anesthesia in dogs and cats.
3. Hoecler M, Harvey R, Lidbetter D, et al. Comparison of peri-
operative analgesic protocols for dogs undergoing tibial plateau
morphine or morphine and bupivacaine for postoperative anal-
gesia and analgesia with an opioid analgesic and orthope-
5. Lemke KA, Dawson SD. Local and regional anesthesia. Vet Clin
7. Wengen S. Brachial plexus block using electrolocation for pan-
sic effect of lidocaine and bupivacaine used to provide a bra-
cial plexus block for forelimb surgery in 10 dogs. Vet Rec
9. Campoy L. Fundamentals of regional anesthesia using nerve stu-
limation in the dog. In: Gledis R, Ludders JW, eds. Recent advances in
veterinary anesthesia and analgesia: companion animals. Ithaca, NY:
International Veterinary Information Service, 2008;A1416.0408.
Available at: www.ivis.org/advances/Anesthesia_Gledis/campoy/
10. Campoy L, Martin-Flores M, Looney AL, et al. Distribution of
a lidocaine-methylene blue solution staining in brachial plexus,
lumbar plexus and sciatic nerve blocks in the dog. Vet Anaesthesia
11. Mahler S, Adogwa A. Anatomical and experimental studies of bra-
cial plexus, sciatic and femoral nerve-location using peripheral nerve
12. Rasmussen L, Lipowitz A, Graham L. Development and verifi-
cation of saphenous, tibial and common peroneal nerve block
techniques for analgesia below the thigh in the non-chondro-
postoperative analgesia in dogs undergoing stifle arthroscopy.
pared with peripheral nerve blockade after major knee surgery:
a systematic review and meta-analysis of randomized trials. Br J
Anaesthesia 2008;100:154–164.
blockade or epidural analgesia after total knee replacement: a prospec-
16. Davies AF, Segar EP, Munloch J, et al. Epidural infusion or com-
bined femoral and sciatic nerve blocks as perioperative analge-
analgesic technique on the surgical outcome and duration of rehab-
morphine, continuous epidural analgesia and continuous 3 in 1
block on postoperative pain and knee rehabilitation after unilat-
analgesia with combined continuous femoral-sci-
tic nerve blocks after total knee replacement. Anesthesiology
ral and sciatic nerve block (FS) is a good alternative to epidural
anaesthesia (EPI) for tibial plateau level osteotomy (TPLO)
in the dog. Vet Anaesthesia Analg 2010;37:34.
123–131.
22. Ilf I, Moons EP. Evaluation of extradural pressure waves and the
‘lack of resistance’ test to confirm extradural needle placement
23. Cruz ML, Luna SPL, Clark RMO, et al. Epidural anaesthesia
using lignocaine, bupivacaine or a mixture of lignocaine and
form of the Glasgow pain scale in a veterinary teaching centre
anaesthesia with lignocaine, bupivacaine and lignocaine/bupi-
blocage simultané de plusieurs nerfs—I—évaluation du mélange
27. Taboada M, Rodriguez J, Valino C. What is the minimum effec-
tive volume of local anesthetic required for sciatic nerve block-
de? A prospective, randomized comparison between a poplite-
29. Kazama T, Ikeda K. Comparison of MAC and rate of rise of alve-
olar concentration of sevoflurane with halothane and isoflurane.
bupivacaine and their combination on the minimum alveolar concen-
the minimum alveolar concentration of sevoflurane in dogs.
32. Boscain P, Monnet E, Mama K, et al. A dog model to study ovary,
ovarian ligament and visceral pain. Vet Anaesthesia Analg 2011;38:
260–266.
the MAC (BAR) of sevoflurane in dogs. Vet Anaesthesia Analg


From this month’s *AJVR*

**Accuracy of three-dimensional and two-dimensional ultrasonography for measurement of tumor volume in dogs with transitional cell carcinoma of the urinary bladder**

James F. Naughton et al

**Objective**—To determine the accuracy of 3-D and 2-D ultrasonography for quantification of tumor volume in dogs with transitional cell carcinoma (TCC) of the urinary bladder.

**Animals**—10 dogs with biopsy-confirmed TCC.

**Procedures**—The urinary bladder of each dog was distended with saline (0.9% NaCl) solution (5.0 mL/kg), and masses were measured via 3-D and 2-D ultrasonography. Masses were also measured via 3-D ultrasonography after bladders were distended with 2.5 and 1.0 mL of saline solution/kg. Subsequently, the bladder was deflated and distended with CO2 (5.0 mL/kg); CT was performed after IV contrast medium administration. Tumor volumes were calculated via 3-D ultrasonography, 2-D ultrasonography, and CT (reference method) and compared via ANOVA, Deming regression, and Bland-Altman plots. Repeated-measures ANOVA was used to assess effects of bladder distension on 3-D tumor volume measurements. Repeatability of measurements was estimated via the coefficient of variation for each method.

**Results**—Repeatability was considered good for all 3 methods. There was no significant difference in tumor volume measurements obtained via 3-D ultrasonography at different degrees of urinary bladder distension. Results of Deming regression and Bland-Altman plots indicated excellent agreement between tumor volume measurement with 3-D ultrasonography and CT, but not between 2-D ultrasonography and CT.

**Conclusions and Clinical Relevance**—Tumor volume in dogs with TCC of the urinary bladder was accurately measured via 3-D ultrasonography. Use of 3-D ultrasonography can provide a less expensive and more practical method for monitoring response to treatment than CT and was more accurate than 2-D ultrasonography. (*Am J Vet Res* 2012;73:1919–1924)