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Successful use of ultrasound guided pecto-intercostal fascial plane block to provide intraoperative analgesia in four dogs undergoing median sternotomy

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OBJECTIVE
To evaluate the impact of pecto-intercostal fascial plane block on providing intraoperative analgesia in dogs undergoing median sternotomy.

ANIMALS
4 dogs.

CLINICAL PRESENTATION
The dogs were presented with a history of inappetence, lethargy and respiratory distress. Thoracic radiographs, point of care ultrasound, thoracocentesis, bronchoscopy and computed tomography was performed to characterize the disease.

RESULTS
4 male castrated, 5.3 ± 3 years old dogs weighing 19.7 ± 13.5 kg and belonging to Dalmatian, Beagle, Siberian Husky and Rottweiler breeds were included. Three dogs were diagnosed with suppurative pleural effusions because of pulmonary abscesses and one dog with spontaneous pneumothorax due to the presence of pulmonary bullae. All dogs underwent median sternotomy under general anesthesia to explore the thorax. A pecto-intercostal fascial plane block was performed by injecting local anesthetic bupivacaine in the parasternal fascial plane between the deep pectoral and external intercostal muscles to provide antinociception by anesthetizing ventral cutaneous branches of intercostal nerves second through sixth. Analgesia from the block resulted in reduced requirement of inhalant anesthesia and minimal requirement for opioid to augment analgesia intraoperatively.

CLINICAL RELEVANCE
Median sternotomy is required to perform thoracic surgery in dogs with various thoracic pathologies. Pecto-intercostal fascial plane block is a locoregional technique that can blunt nociception arising from the ventral thorax and can significantly improve perioperative patient care in dogs undergoing median sternotomy by providing effective intraoperative and potentially postoperative analgesia.

Surgical access to thoracic cavity is obtained either via lateral thoracotomy or median sternotomy. Only the median sternotomy allows access to entire thoracic cavity and therefore is indicated in any pathological condition that requires exploration of the thoracic cavity. In dogs, median sternotomies cause significant impairment in pulmonary function and pain.[1,2] Pulmonary dysfunction is characterized by decreased dynamic compliance, functional residual capacity and increase in pulmonary resistance and work of breathing, all increasing the risk of hypoxemia.[1] Pain associated with median sternotomies is intense and can be difficult to manage.[3] Opioids are mainstay drugs used to control acute perioperative pain but their use can result in various side-effects like perioperative nausea and vomiting (PONV), gastroesophageal regurgitation, sedation and respiratory depression.[4–7] It is suggested to employ balanced analgesic approaches by incorporating locoregional anesthesia techniques to achieve better pain control while at the same time minimizing the side-effects associated with systemic analgesic drugs.[8–10]

In dogs various locoregional anesthesia techniques including intercostal nerve block,[11–13] thoracic epidural,[11] thoracic paravertebral nerve block,[14,15]

serratus plane block,[16] and interpleural administration of local anesthetics[1,13] have been used to block nociception arising from thoracic surgical procedures. To specifically address nociception arising from the ventral aspect of the thorax, recently ultrasound guided parasternal fascial plane blocks including transversus thoracic plane block (TTP)[17-19] and pecto-interfacsial plane block (PIFB)[20] have been studied in dog cadavers. Use of parasternal blocks in humans have been shown to provide effective intraoperative and postoperative analgesia, decreased consumption of opioids intraoperatively and better pulmonary function in recovery.[21,22] Use of parasternal nerve blocks in humans undergoing cardiac surgery requiring sternotomy have been shown to significantly improve the results of enhanced recovery after surgery (ERAS) protocols.[23] To date there is only a single case report[24] that documented the use of TTP block as part of multimodal analgesic plan in a dog undergoing median sternotomy for a lung lobectomy. Locoregional analgesia has been shown to encourage early mobilization and return to normal behavior in dogs and has the potential to play a significant role in the development of veterinary specific ERAS protocols.[25,26]

Median sternotomy in dogs is an invasive surgical intervention and requires an aggressive perioperative analgesic planning.[4] Parasternal blocks in dogs[17-20] has the potential to significantly improve both intraoperative and postoperative pain management that could enhance overall perioperative care. To date there is no clinical data in dogs to show if the PIFB, a type of parasternal block is effective at blunting nociception arising from median sternotomy. The objective of this study was to specifically evaluate the impact of PIFB on providing intraoperative analgesia as assessed by the changes in physiological parameters, intraoperative utilization of opioids and requirement of inhalant anesthetic dose in 4 dogs undergoing median sternotomy.

Methods

Patient demographics and presentation

Computerized medical records of patients presented to the University of California-Davis, Veterinary Medical Teaching Hospital (VMTH) for the years 2022 through 2023 were reviewed using the keywords "median" and "sternotomy." Four male castrated, 5.3 ± 3 years old dogs weighing 19.7 ± 13.5 kg and belonging to Dalmatian, Beagle, Siberian Husky and Rottweiler breeds were included. Three dogs were initially presented to referring veterinarian and 1 was presented to VMTH with the symptoms of inappetence, lethargy, and respiratory distress. The dog presented to VMTH was also febrile. Referring veterinarians performed thoracic radiographs and diagnosed 2 dogs with pleural effusions and one dog with spontaneous pneumothorax before they were referred to VMTH. Thoracic radiographs and point of care ultrasound (POCUS) revealed pleural effusion in the dog presented to VMTH. Thoracocentesis was performed in all dogs with pleural effusion to characterize the nature of the effusion.

Perianesthetic management

Three dogs received hydromorphone (0.05 mg/kg, IM) and 1 dog received methadone (0.3 mg/kg, IM) for premedication. After an appropriate degree of sedation had been achieved, an IV catheter was placed in a peripheral vein. All dogs were preoxygenated for 5 minutes with 100% oxygen using a face mask and an oxygen flow rate of 5 L/min before anesthetic induction. Anesthesia was induced with ketamine (5 mg/kg, IV) in 2 dogs and with alfaxalone (1.5 mg/kg, IV) in 2 dogs, titrated to effect and in combination with midazolam (0.3 mg/kg, IV). Anesthesia was maintained with isoflurane in 3 dogs and sevoflurane was used in 1 dog, both delivered in 100% oxygen. An arterial catheter was placed in a dorsal pedal artery in all dogs for direct arterial blood pressure monitoring and arterial blood gas analysis. A multiparameter monitor (Datex-Ohmeda; GE Healthcare) was used in all dogs to record electrocardiogram, non-invasive and invasive arterial blood pressure, pulse-oximetry, end-tidal carbon dioxide and inhalant concentrations and esophageal body temperature. All dogs were administered lactated Ringer solution at a rate of 5 mL/kg/h throughout the procedure. Dogs were blood typed and crossmatched with donor blood products before the surgery. Three dogs underwent CT, bronchoscopy and median sternotomy as a single general anesthesia episode while the CT scan and bronchoscopy were performed on a different day than the median sternotomy surgery in 1 dog.

An ultrasound guided PIFB was performed in all dogs before transportation to the operating room (OR) for a median sternotomy.

Locoregional technique

The dogs were positioned in dorsal recumbency and sandbags and/or a technician helped to keep the dogs in dorsal recumbency. The hair from both hemithoraces including sternum was clipped and the area was scrubbed with chlorhexidine and 70% isopropyl alcohol. A 15-6 MHz linear array ultrasound transducer (Edge 2 Ultrasound System; Sonosite Inc) was initially positioned on the ventral midline in a sagittal orientation at the level of fourth and fifth intercostal space and then moved laterally until the deep pectoral muscle and external intercostal muscles were visualized.[20] The transducer was then slowly moved cranially to a position at the level of second and third intercostal spaces making sure all the required musculoskeletal structures were still visible **(Figure 1)**. Injection was performed using a 22-gauge, 6.25 cm long spinal needle (Luer lock, Regular Quincke Bevel; Jorgensen Laboratories) in 1 dog and a 22-gauge, 8.75 cm long spinal needle was used in 3 dogs. The spinal needle was attached to the local anesthetic syringe via a pediatric T-port extension (Interlink system; Baxter Healthcare Corp). The needle was inserted in-plane in a caudo-cranial direction until the tip of the needle was positioned in the appropriate
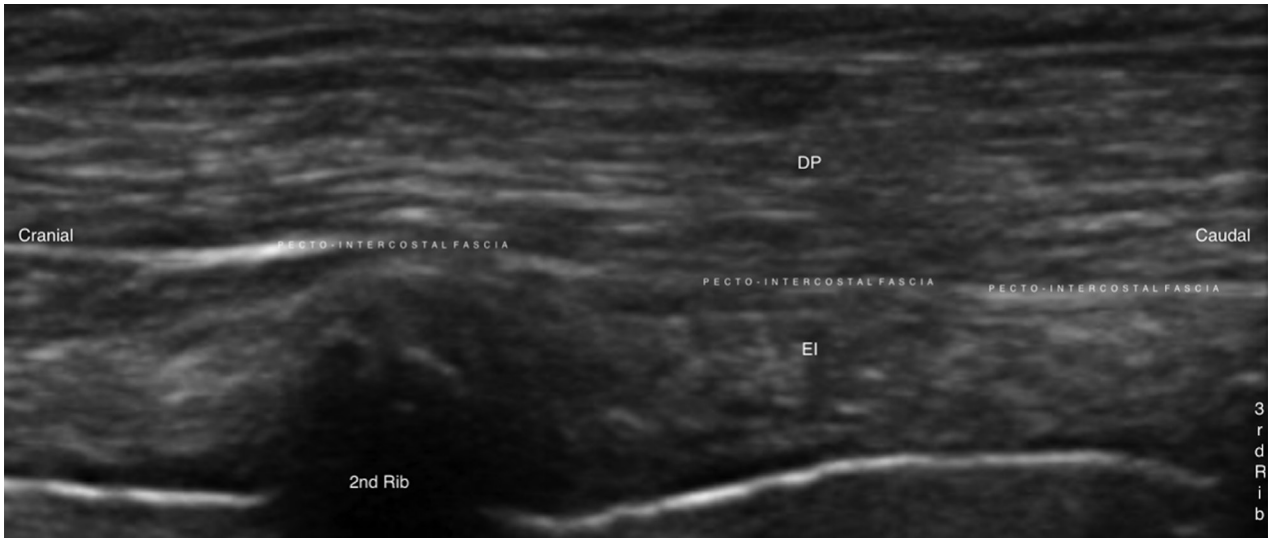
Figure 1—Ultrasonographic anatomy of pecto-intercostal fascial plane at the level of second intercostal space in an 8-year-old 33.5-kg castrated male Rottweiler dog undergoing median sternotomy for thoracic exploration. DP = Deep pectoral muscle. EI = External intercostal muscle. PECTO-INTERCOSTAL FASCIA = Interfascial plane between DP and EI.

fascial plane between the deep pectoral and external intercostal muscles **(Figure 2)**. A small amount of drug was injected to notice hydrodissection of the correct fascial plane and once confirmed, 0.1 mL/kg bupivacaine was injected, and the spread of the drug was observed **(Figure 3)**. The spinal needle was then removed, and the transducer was slowly moved caudally while staying in the same parasternal plane and centered on fourth and fifth intercostal spaces. Using the same approach as above another 0.1 mL/kg bupivacaine was injected. The spinal needle was removed again, and transducer was moved further caudally to center on sixth and seventh intercostal spaces and another 0.1 mL/kg drug volume was injected in the appropriate fascial plane. This resulted in a total volume of 0.3 mL/kg in 1 hemithorax.

Another 0.3 mL/kg total drug volume was injected in the contralateral hemithorax as three 0.1 mL/kg bupivacaine injections in the fascial plane between the deep pectoral and external intercostal muscles at the level of second and third intercostal spaces, fourth and fifth intercostal space, and sixth and seventh intercostal spaces. Needle entry into the pecto-intercostal fascial plane was coupled with a distinct popping sensation on several occasions. The total volume of bupivacaine used to perform PIFB was 0.5 mL/kg in 1 dog and 0.6 mL/kg in 3 dogs. One dog received a total of approximately 1 mg/kg dose of 0.17% bupivacaine while other 3 dogs received a total of 2 mg/kg of 0.3% bupivacaine. All injections were performed by a single operator (ASC).

Figure 2—Spinal needle positioned at pecto-intercostal fascial plane at the level of second intercostal space in an 8-year-old 33.5-kg castrated male Rottweiler dog undergoing median sternotomy for thoracic exploration.
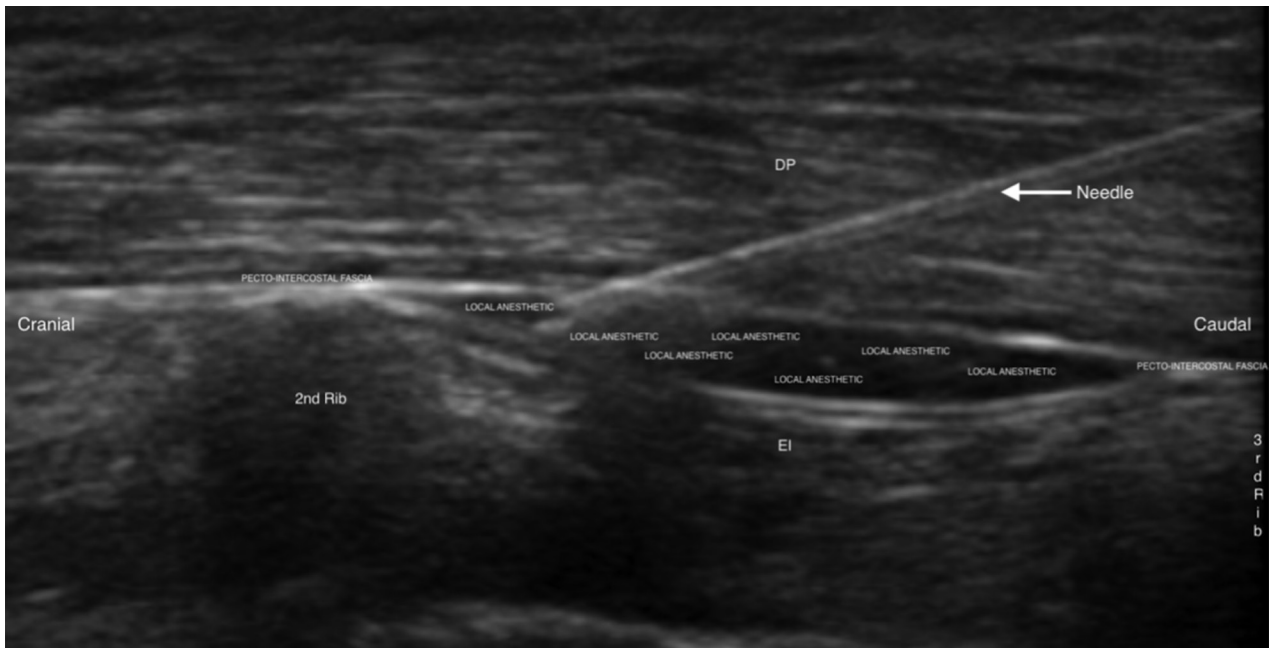
Figure 3—Pecto-intercostal fascial plane block illustrating hydrodissection of fascial plane between deep pectoral and external intercostal muscles at the level of second intercostal space in an 8-year-old 33.5-kg castrated male Rottweiler dog undergoing median sternotomy for thoracic exploration. LOCAL ANESTHETIC = Local anesthetic bupivacaine.

Intraoperative period

Patient physiologic variables were recorded on the anesthesia record every 5 minutes and the end-tidal concentration of inhalant anesthetics was recorded every 15 minutes. Additional doses of an opioid were administered based on the assessment of anesthetic depth and changes in the physiological variables. Two dogs required an IV dopamine infusion to manage hypotension intraoperatively. In 1 dog, the dopamine infusion was started immediately after the first direct mean arterial pressure (MAP) measurement of 58 mm Hg was obtained in the OR. This dog received dopamine infusion at a median rate of 8 µg/kg/min (range, 5 to 12 µg/kg/min). In the other dog, the dopamine infusion was started in the anesthesia preparation area before moving into the OR when the systolic pressure measured by Doppler sphygmomanometry was 85 mm Hg. This dog received dopamine at a median rate of 5 µg/kg/min (range, 3 to 7.5 µg/kg/min).

All dogs received incisional infiltration with long-acting formulation of bupivacaine (Nocita; Elanco) during surgical closure. One dog received methadone (0.3 mg/kg, IV) and 1 received hydromorphone (0.05 mg/kg, IV) during surgical closure.

Postoperative period

At the end of the surgery, all dogs were transported to the intensive care unit for recovery and continued post-operative care. Two dogs received carprofen (2.2 mg/kg, IV) after extubation, 2 dogs received a fentanyl CRI (0.05 to 0.08 µg/kg/min), and 2 dogs received intermittent hydromorphone (0.05 mg/kg, IM) for post-operative pain management. Postoperatively, respiratory function deteriorated in 1 dog, and the dog remained oxygen dependent 5 days after surgery. This dog was hypoxemic at initial presentation, required oxygen support and had a history of idiopathic epilepsy and was receiving multiple anti-seizure medications including phenobarbital, levetiracetam, and potassium bromide. The other dogs were transitioned to intermediate care ward within 24 hours after surgery.

Results

Medical record search revealed ten dogs that underwent median sternotomy during the search period and 4 dogs that received PIFB for perioperative pain management were considered eligible for inclusion in the case series. Three dogs were diagnosed with a pyothorax based on the characteristics of the pleural effusion and 1 dog was diagnosed with spontaneous pneumothorax. Bronchoscopy in the 3 dogs with pyothorax did not reveal any foreign body. All dogs underwent median sternotomy to explore the thoracic cavity. Thoracic exploration revealed pulmonary and mediastinal abscessation, granulomas and pulmonary bullae in different dogs. The dog with spontaneous pneumothorax also underwent gastroscopy after median sternotomy to retrieve a corn cob foreign body that was discovered on the pre-surgical CT.

Three dogs were assigned an American Society of Anesthesiologists physical status classification of 3 and 1 dog received a status classification of 4. The total duration of general anesthesia (from induction of anesthesia to tracheal extubation) was 6.25 ± 1.93 hours while the median sternotomy took 2.5 ± 0.6 hours to complete. The first incision was made 52 ± 5 minutes after the PIFB was performed.

Dr. Arthur Guedel proposed various stages of anesthesia to characterize CNS depression and

suggested that plane 2 of stage III (stage of surgical anesthesia) provides medium anesthetic depth for surgery that is characterized by adequate muscle relaxation, sluggish palpebral reflex, absent laryngeal reflexes, presence of corneal reflex and stable respiration and pulse rate. Intraoperatively, the vaporizer setting was altered by the anesthetist to maintain a medium anesthetic plane by assessing the palpebral reflex and degree of muscle relaxation by assessing eye position and jaw tone. Median (range) end-tidal isoflurane in 3 dogs during anesthesia was 1.05% (range, 1% to 1.5%), 1.35% (range, 1.1% to 1.9%), and 1.05% (range, 0.9% to 1.2%). Median (range) end-tidal sevoflurane in one dog under anesthesia was 1.85% (range, 1.7% to 2.1%). Only 1 dog received 2 μg/kg doses of fentanyl intravenously at the time of initial incision and during incisional closure because the anesthetist considered anesthetic depth to be inadequate due to the presence of brisk palpebral reflex and increased jaw tone. This dog did not require any additional opioid intraoperatively. None of the dogs required any blood products perioperatively.

Due to poor prognosis in the dog that remained oxygen dependent, humane euthanasia was performed 5 days after the surgery. The other dogs remained comfortable post-operatively and were transitioned to oral carprofen (2 mg/kg, PO) and gabapentin (10 ± 2 mg/kg, PO) for analgesia. Two dogs were discharged within 48 hours. One of these dogs underwent partial lung lobectomy of distal aspect of the caudal portion of left cranial lung lobe and distal aspect of right middle lung lobe to remove pulmonary bullae and 2 pyogranulomatous lesions were removed from the diaphragm in the other dog. In the third dog, although the pain was considered appropriately controlled, fluid production collected by a thoracic drain decreased to an appropriate amount only 5 days after surgery and the dog was discharged at that time.

Discussion

Median sternotomy is considered a very painful procedure that demands aggressive pain management perioperatively. Use of locoregional analgesia has the potential to enhance patient care by blunting the nociception intraoperatively during the intense surgical stimulation and postoperatively as well depending on the type of drug used and its dose. A locoregional analgesic technique is considered effective if it allows to achieve medium anesthetic depth at a lower inhalant anesthetic concentration, physiological variables like heart rate (HR) and MAP change minimally due to any nociception and requirement of additional systemic analgesics is reduced perioperatively.[27–29] Although a 20% increase in HR and MAP has been used as a criterion to evaluate success of a locoregional block,[27] recently it was proposed that change in the MAP has 100% sensitivity in predicting response to nociception in animals at a medium plane of anesthetic depth.[29] Changes in MAP in the dogs of present case series were within 20% though

2 dogs receiving dopamine displayed exaggerated changes in MAP at few instances that were associated with the use of dopamine. No change in anesthetic depth was noticed during these changes in MAP and MAP was reduced when the dose of dopamine was decreased. Although we did not measure the minimum alveolar concentration (MAC) of inhalants in these dogs but using the published MAC of isoflurane[30] and sevoflurane[31] in dogs it is easily appreciated that all dogs required < 1 MAC intraoperatively to achieve a medium plane of anesthetic depth. In addition, only 1 dog required small additional dose of fentanyl to augment anesthesia.

The ventral thoracic wall is supplied by terminal branches of intercostal nerves arising from the second through tenth thoracic nerves and in dogs the ventral cutaneous branches of the second through sixth intercostal nerves specifically supply the sternum, midline skin, costal pleura, and other related structures.[17] Parasternal locoregional techniques include the TTP and PIFB and both techniques intend to inject local anesthetic solution into an interfascial plane that contains these ventral cutaneous branches of the intercostal nerves. The TTP achieves this by injecting the local anesthetic in the fascial plane between the transverse thoracic and internal intercostal muscles[17,19] while the PIFB requires injecting the local anesthetic in the fascial plane between the deep pectoral and external intercostal muscles lateral to the sternum.[20]

Although no safety data are available with either of these techniques, since the TTP block requires penetration of interfascial plane that is deeper and relatively closer to the pulmonary pleura, it may carry a relatively higher risk of inadvertent thoracic cavity puncture, internal thoracic artery puncture and penetration of the apex of the heart near sternum.[20] Our experience with performing the PIFB is in line with a previous cadaver study[20] that suggested easy identification of the PIF plane and associated musculoskeletal structures and appreciation of a pop when the PIF plane is entered. Also, the PIF plane is relatively superficial that allows a greater distance from thoracic vasculature and pleura.

A cadaver study evaluated the spread of 2 volumes of new methylene blue dye.[20] A low and high volume of 0.25 mL/kg and 0.5 mL/kg, respectively, was injected as a single injection in the PIF plane between the fourth and fifth ribs. No significant difference was noticed between volumes and both volumes failed to stain all the necessary superficial ventral branches required to desensitize the whole sternum and surrounding structures. A more consistent nerve staining and dye spread was appreciated with the larger volume, but in the absence of any difference in the number of nerves stained, the authors recommended to use the low volume. The large volume also caused occasional staining of nontargeted subscapular and axillary nerves. The authors further emphasized that a different injection technique may result in better spread of the drug. Studies conducted to evaluate the TTP technique in dogs have suggested that multiple injection sites may be required

to provide better spread of the injectate.[17,19] The author of the present case series modified the PIFB technique that was described in dog cadavers in a hope to achieve better spread of the local anesthetic in the PIF plane. To improve spread of the local anesthetic and potentially cover all the necessary superficial ventral branches we used a total of 3 injections at different sites in each hemithorax instead of a single injection as performed in the cadaver study. Based on the noticed efficacy of this technique in these dogs it seems that we were able to achieve this objective but in the absence of an actual study, the true spread of the drug could not be predicted. The spread of an injectate in cadavers could be quite different from in vivo spread. In any case, it is difficult to predict the spread of the drug and block efficacy in vivo if the original technique had been used in these dogs.

Although we used a total of 6 injections to perform the PIFB block, due to the relatively superficial location of the PIF plane, the risk associated with multiple injections was deemed low. Due to multiple injections, it could take variably long time to perform this block depending upon the experience level of the operator. We decided to use a volume similar to the low volume evaluated in the cadaver study since it was shown to not be inferior to the high volume and use of low drug mass also mitigates the risk of systemic toxicity from local anesthetics. Further we kept the total dose of bupivacaine ≤ 2 mg/kg to avoid any systemic toxicity. We used 0.3 mL/kg volume for each hemithorax in 3 dogs instead of the 0.25 mL/kg used in the cadaver study. It is unknown if this slightly larger volume may have spread to any nontargeted areas, but no signs suggesting blockade of the subscapular and/or axillary nerves were recorded.

All dogs were extubated 4.1 ± 0.6 hours after the PIFB was performed and appeared comfortable in recovery. Bupivacaine is a longer lasting local anesthetic, so it is possible that the effect of the PIFB was still present during recovery from anesthesia. Since the dogs received other systemic analgesics around that time, the contribution of the PIFB to postoperative analgesia cannot be assessed. Post operative analgesic planning was handled by individual clinicians from the primary service.

The disease in the dog that was discharged 5 days after the surgery was characterized by marked inflammation in the thoracic cavity and it underwent mediastinectomy, subtotal pericardectomy, and partial right middle lung lobectomy. It is possible that this inflammation resulted in delay in the reduction of fluid production in this dog that delayed hospital discharge.

Parasternal locoregional techniques have been suggested as an important part of ERAS protocols in humans undergoing thoracic interventions that require median sternotomy.[21-23] Our experience with PIFB in dogs undergoing median sternotomy suggests that it can enhance perioperative care significantly by improving the quality of intraoperative analgesia. This is a new technique in veterinary medicine and additional cadaver and clinical studies in dogs are required to better understand the impact of different drug volumes and injection techniques on not only the spread of the drug but potential contribution to postoperative analgesia and complications that may arise from its use.

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Disclosures

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