Received: 26 September 2022 | Revised: 21 January 2023 | Accepted: 21 February 2023

DOI: 10.1002/vrc2.586

Vet Record CaseReports

CASE REPORT

Companion or pet animals

Thoracic transversus plane block as part of a multimodal analgesia plan in a cat undergoing sternotomy

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Abstract

A 12-year-old, neutered, male, domestic shorthair cat presented for investigation of acute-onset respiratory distress and cough. Computed tomography scan showed bilateral pleural effusion and dorsal elevation of the trachea compatible with a mass effect. A median sternotomy was performed. Anaesthetic protocol consisted of premedication with intravenous methadone (0.2 mg/kg), induction with alfaxalone to effect and maintenance with isoflurane in oxygen. Transversus thoracic muscle plane block was performed injecting 0.4 mL/kg of 0.25% bupivacaine per side. Fentanyl (2 μg/kg) was administered as rescue analgesia once during surgery. The Glasgow Composite Pain Scale was assessed postoperatively. Methadone was given as rescue analgesia postoperatively when Glasgow pain score was greater than 5/20. The first administration of methadone was required at 8 hours after the transversus thoracic muscle plane block was performed. This case showed that the ultrasound-guided transversus thoracic muscle plane block is a feasible technique in feline patients as part of a multimodal analgesia plan in a cat undergoing sternotomy.

BACKGROUND

A thoracotomy is an invasive surgical procedure that allows access to the thoracic cavity and is associated with haemodynamic and ventilatory changes, which can be influenced by the patient's position on the operating table and by the introduction of artificial pneumothorax.[1]

More specifically, the thorax can be accessed through a median sternotomy, a procedure reported to cause significant intra- and postoperative nociception.[2,3] The intercostal nerves originating from T2 to T10 thoracic nerve roots are the ones responsible for the transmission of the pain sensation in the sternum and ventral thoracic region. These nerve roots divide into two distal muscular branches, which consist of a short branch entering the transversus thoracis muscle and a longer branch on the lateral side of the rib cage that enters the rectus abdominis.[4]

Several locoregional techniques have been described in human and canine patients to provide somatic analgesia during median sternotomy, including bilateral multiple intercostal nerve blocks of the intercostal nerves T2–T9 in canine patients undergoing median sternotomy. In a recent canine cadaveric study, the blinded technique has shown an efficacy of only 58.6% staining the target intercostal nerves.[5] This could lead to the failure of the block, incomplete analgesia and increased systemic analgesic requirements. The thoracic epidural anaesthesia has also been reported, although it carries technique- and drug-related risks of severe complications.[1] Other local anaesthetic techniques have been clinically described in veterinary medicine to provide analgesia to the ventral chest wall, including thoracic paravertebral block,[6] erector spinae plane block[7] and pecto-intercostal block.[8]

The transversus thoracic muscle plane (TTP) block is a regional anaesthesia technique used in human medicine with the main objective of providing perioperative analgesia in patients undergoing procedures such as sternotomy, sternal retraction, internal mammary artery harvesting, chest tubes placement and cardiac surgery.[9,10] Several studies about this technique in human medicine have shown that the injection of local anaesthetics between the transversus thoracic and intercostal muscles at the level of the fourth and fifth ribs next to the sternum will cause spread of the solution along the TTP, providing analgesia to the nerves innervating the aforementioned area.[11–16]

When performed bilaterally, ultrasound (US)-guided TTP block could be an alternative or an additional analgesic technique in patients undergoing median sternotomy, decreasing the number of injection points required to provide analgesia and the time of execution. A previous study suggested that this approach could be associated with less ventilatory impairment than other reported techniques, as the muscles affected

by the TTP block do not have an essential role in the patient's ventilation.[17]

A recent study by Alaman et al. described a transverse US-guided TTP block in canine cadavers. In this approach, a solution was injected between the transverse thoracic and internal intercostal muscles and showed that a single injection point technique was feasible in canine patient and resulted in staining of several intercostal nerves.[18]

To the authors' knowledge, the TTP block technique has not been described in feline patients. This case report describes the TTP block as an alternative to neuraxial techniques and as part of a multimodal analgesia protocol to improve pain management in a cat undergoing median sternotomy.

LEARNING POINTS/TAKE-HOME MESSAGES

- Ultrasound-guided transversus thoracic plane block was efficient as part of multimodal plan of anaesthesia for sternotomy surgery in a cat.
- Given the 8-hour duration of nerve blockade offered by bupivacaine, extra systemic analgesia requirement is expected 8 hours after the transversus thoracic plane block.
- Locoregional anaesthesia techniques may be used as an alternative to the traditional opioids-based therapy to provide intraoperative analgesia in sternotomy procedures in cats.

CASE PRESENTATION

A 12-year-old, neutered, male, domestic shorthair cat presented for investigation of acute-onset respiratory distress and cough.

On presentation, the cat showed aggressive behaviour, but remained alert and responsive on physical examination. The mucous membranes were pink and moist, and capillary refill time was 2 seconds. The cardiac auscultation was dull, but it did not identify any murmur or arrhythmia; heart rate (HR) was 200 beats per minute, and femoral pulses were slightly reduced in quality but synchronous. The thoracic auscultation revealed dull heart and lung sounds, and respiratory rate (RR) was 48 breaths per minute. He had increased respiratory effort, with significant abdominal component. The rest of the physical examination was unremarkable.

A 24-gauge catheter (Surflash IV Catheter, Terumo, Europe) was placed in the right cephalic vein. A bilateral thoracic point of care ultrasound was performed, and it showed a severe amount of bilateral pleural effusion, which was immediately drained with a total of 480 ml of haemorrhagic (packed cell volume 7%) fluid obtained. Venous blood gas analysis revealed moderate respiratory acidosis (pH 7.28, reference interval [RI]: 7.35–7.47) and hypercapnia (PCO_2 59.2 mmHg; RI: 37.0–47.0), with no other abnormalities detected. The rest of the blood analysis (haematology and biochemistry) did not show any abnormalities.

Transthoracic echocardiogram revealed underlying hypertrophic cardiomyopathy. However, the left-sided filling pressure appeared to be normal, making it unlikely to be the cause of pleural effusion.

Computed tomography (CT) was performed, and marked tracheal displacement secondary to mass effect by a mediastinal mass and marked pleural effusion were observed, together with a reduced lung volume and cranioventral alveolar pattern.

The large cranial mediastinal mass filled the entire cranial thorax, extending caudally to the fourth rib, and displaced the trachea dorsally and to the right.

The mass was heterogeneously soft tissue attenuating, with multifocal rounded to coalescing hypoattenuating regions (24–53 HU), and it was mildly contrast enhancing (Omnipaque 300; GE Healthcare, UK). This mass had marked mass effect, displacing the heart and lungs caudodorsally.

Based on the clinical findings, the emergency and critical care and soft tissue surgery departments recommended surgical intervention, which consisted of an exploratory median sternotomy performed that same day.

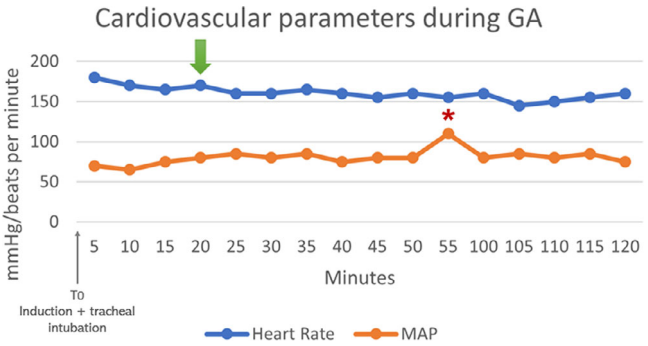

FIGURE 1 Cardiovascular parameters (mean arterial blood pressure and heart rate) recorded every 5 minutes during the duration of general anaesthesia. The red mark indicates when fentanyl was administered and the green arrow indicates when the transversus thoracic plane was performed. GA, general anaesthesia; MAP, mean arterial blood pressure.

Patient was premedicated with methadone (0.2 mg/kg intravenously [IV]; Comfortan, Dechra Veterinary Products, UK). Twelve minutes after the premedication and 5 minutes after the oxygen supplementation via face mask (5 L/min of 100% oxygen), alfaxalone (2 mg/kg; Alfaxan Multidose, Jurox, UK) was administered IV to induce general anaesthesia. The trachea was intubated with a 4.5-mm internal diameter cuffed endotracheal tube (ETT), and anaesthesia was maintained with isoflurane (Iso-Vet 1000 mg/g, Piramal Critical Care, UK) (end tidal concentration 1.0%–1.3%) in 100% oxygen using a paediatric T-piece with adjustable pressure-limiting valve.

Before the administration of isoflurane, the ETT cuff was inflated until no leaks were noted following positive pressure applied on the airway by manual ventilation. A multiparameter monitor (B40, GE Healthcare, USA) was used for monitoring of electrocardiography, pulse oximetry (SpO_2), mainstream capnography (end-tidal carbon dioxide [$PET'CO_2$] in mmHg), Pitot tube spirometry, inspired and expired concentrations of oxygen and isoflurane (%), invasive blood pressure via arterial cannulation of the left dorsal pedal artery (24-gauge catheter) and oesophageal temperature (°C).

All data were collected every 5 minutes (Figure 1). After aseptical preparation of the right cervical region, a small incision was performed in the skin over the region of the

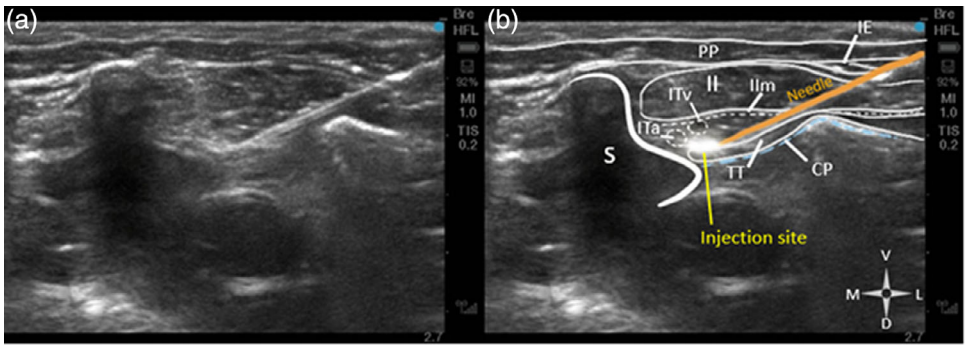

FIGURE 2 (a) Anatomical structures visualised during ultrasound-guided transverse approach to the transversus thoracic plane block at the fourth intercostal space in the cat, with the needle advanced at the injection site. (b) The same visualisation of the ultrasonographic anatomic structures, with the edges of the main structures highlighted to allow identification of the muscles (solid grey lines), the internal intercostal membrane (short dashed lines), costal pleura (blue dashed lines), the needle (solid orange line) and injection site (white, large, solid mark). CP, costal pleura; D, dorsal; IE, external intercostal muscle; II, internal intercostal muscle; IIm, internal intercostal membrane; ITa, internal thoracic artery; ITv, internal thoracic vein; L, lateral; M, medial; PP, pectoralis profunda muscle; S, sternum; TT, thoracis muscle; V, ventral.

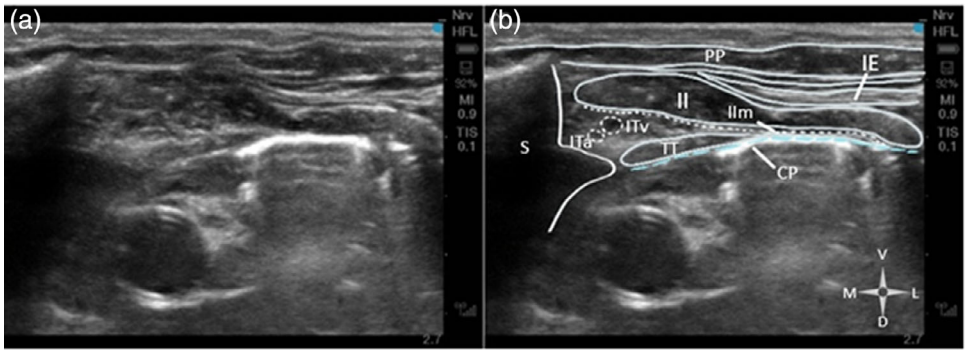

FIGURE 3 (a) Anatomical structures visualised during ultrasound-guided transverse approach to the transversus thoracic plane block at the fourth intercostal space in the cat. (b) Anatomical structures highlighted to improve visualisation of the muscles (solid grey lines), the internal intercostal membrane (short dashed lines) and costal pleural (blue dashed lines). CP, costal pleura; D, dorsal; IE, external intercostal muscle; II, internal intercostal muscle; IIm, internal intercostal membrane; ITa, internal thoracic artery; ITv, internal thoracic vein; L, lateral; M, medial; PP, pectoralis profunda muscle; S, sternum; TT, thoracis muscle; V, ventral.

jugular vein and a 4.5 Fr, 6-cm long jugular catheter (Multicath Forward, Vygon, Germany) was placed by the Seldinger technique. The depth of anaesthesia was monitored with the use of clinical parameters such as the jaw tone, eye position and palpebral reflex and the HR, RR and blood pressure.[19]

After the patient was surgically prepared for surgery, the US-guided TTP block (Figure 2) was performed using a 1.5-inch, 22-gauge spinal needle (BD Spinal Needle; BD Medical, Franklin Lakes, NJ, USA). The needle was inserted in a ventrolateral-to-dorsomedial direction with an in-plane technique at the level of fourth intercostal space using a 15-6 MHz linear transducer (SonoSite, Washington, USA) (Figure 3), and it was advanced through the pectoralis profunda, rectus abdominis, external and internal intercostal muscles, and internal intercostal membrane until the tip was positioned into the TTP, ventral to transversus thoracic muscle (Figure 4). To confirm the presence of the needle tip into the target plane, a small amount of the injectable solution was slowly administered until a small pocket of fluid was visualised between the internal intercostal membrane and the transversus thoracis muscle. 0.25% Bupivacaine hydrochloride (0.4 ml/kg; Marcain Polyamp Steripack 0.25%, AstraZeneca, UK) was injected per side. The performance of the TTP block required 5 minutes.

The patient was transferred to the surgical theatre and was positioned in dorsal recumbency. At this stage, the patient was connected to a paediatric circle rebreathing system with 15-mm internal diameter tubing. Pressure-controlled mechanical ventilation (Mindray WATO Ex-35, Shenzhen, China) was initiated, with a peak inspiratory pressure (PIP) of 8–10 cmH_2O. The RR was adjusted to achieve normocapnia ($PET'CO_2$ between 35 and 45 mmHg). RR and inspiratory: expiratory ratio during mechanical ventilation varied between 10 and 16 breaths per minute and 1:2 and 1:3, respectively.

A median sternotomy was performed using the Colibri Sagittal Saw to split the sternebrae. The mediastinal attachments were broken down with monopolar electrocautery and Ligasure vessel sealing device. Diffuse multilobular lesions were present throughout the mediastinal, pleural surface and within the plica cava. The ventral aspect of the mediastinum was debrided from the pericardium with Ligasure, and the tissue was submitted for histopathology and culture.

The lesions within the plica cava were debulked. The thorax was lavaged, and a submerged breath hold was performed with no evidence of leakage from the pulmonary parenchyma. A pleural port was placed through a right-sided incision and sutured to the latissimus dorsi using 4/0 Prolene. The median sternotomy was closed routinely.

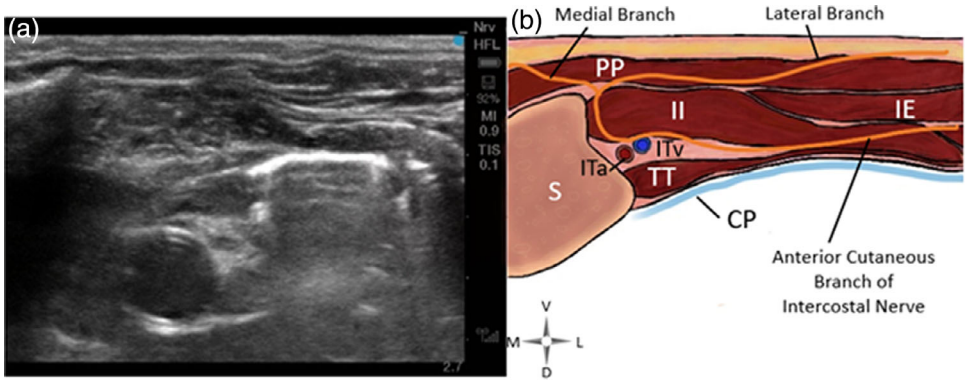

FIGURE 4 (a) Anatomical structures visualised during ultrasound-guided transverse approach to the transversus thoracic plane (TTP) block at the fourth intercostal space in the cat. (b) Diagram illustrating de anatomical structures, including muscles and nerves relevant for the TTP block. CP, costal pleura; D, dorsal; IE, external intercostal muscle; II, internal intercostal muscle; ITa, internal thoracic artery; ITv, internal thoracic vein; L, lateral; M, medial; PP, pectoralis profunda muscle; S, sternum; TT, thoracis muscle; V, ventral.

The duration of the surgery was 90 minutes, and the duration of the anaesthesia was 120 minutes.

During anaesthesia, there were no periods of hypotension (defined as mean arterial pressure [MAP] <60 mmHg). One bolus of fentanyl 2 μg/kg was required as rescue analgesia due to nociceptive response (defined as a sudden increased in HR and/or MAP of 20% over baseline values)[20] during manipulation of the pleura (Figure 1). Thermal support was provided through a 3M Bair Hugger Warming Blanket System.

Once the surgery was finished, the patient was positioned in sternal recumbency. Following drainage of the fluid and air from the thorax, a stepwise lung recruitment manoeuvre was performed. Starting with a PIP of 10 cmH_2O, the PEEP was increased in steps of 5 cmH_2O every five breaths until a PIP of 25 cmH_2O was reached. After five breaths, the PEEP was subsequently reduced by steps of 2 cmH_2O until the PIP became 10 cmH_2O.

The recruitment manoeuvre transiently reduced the MAP by 10 mmHg. The inspired fraction of oxygen was progressively decreased until the patient was able to show an SpO_2 of 98% breathing room air.

The patient was extubated 15 minutes after the discontinuation of isoflurane. At this time HR, MAP and oesophageal temperature were 100 beats per minute, 60 mmHg and 35.8°C, respectively.

OUTCOME AND FOLLOW-UP

Recovery was uneventful, and the patient was transferred to the intensive care unit. Postoperative pain was evaluated using the Glasgow Composite Measure Pain Scale Short Form (CMPS-SF)[21] every hour by trained veterinary nurses. Methadone 0.1–0.2 mg/kg was administered IV if the CMPS-SF was more than 5/20 (Figure 5).

Additional postoperative analgesia included bupivacaine (1 mg/kg) administered through the thoracic drain every 6 hours (until its removal the day following surgery) and meloxicam (0.05 mg/kg IV) every 24 hours.

Methadone was not required until 8 hours following the TTP block when the pain score was 8/20 (methadone 0.2 mg/kg IV was administered).

Three hours after administration of this dosage (11 hours after the TTP block), the cat showed again signs of discomfort (CMPS-SF 10/20) so a continuous-rate infusion (CRI) of ketamine (0.2 mg/kg/h) was started for the next 11 hours, and the administration of methadone (0.2 mg/kg) every 4 hours was continued.

The following day, the values of CMPS-SF decreased, and the cat showed less signs of discomfort, so the ketamine CRI was stopped, and the methadone dosage was reduced to 0.1 mg/kg every 4 hours and stopped by the end of the day. Venous blood gas was collected and showed no abnormalities at this stage.

Histopathology examination of the pleural nodules revealed an epithelioid mesothelioma (papillary subtype). Neoplastic emboli were seen in the sternal lymph node. Palliative treatment was elected by the owners.

Forty-eight hours after the surgery, the cat was settled and discharged to the owners, with palliative treatment with NSAIDs and advised close monitoring of RR and effort in case of future drainage of the chest was required.

DISCUSSION

This is the first case report describing the use of US-guided TTP block during a median sternotomy in a cat. As mentioned above, this procedure is associated with severe intra- and postoperative pain if insufficient analgesia is provided.[22] Poor perioperative analgesia can impair the normal functioning of the respiratory and cardiovascular systems, leading to longer hospitalisation periods and potential development of chronic neurogenic pain.[23]

In human medicine, the US-guided TTP block is a locoregional analgesia considered an effective and safe technique with a high success rate, reducing the requirement for systemic opioids to provide pain relief in patients undergoing thoracic surgery. In veterinary medicine, the clinical use of this block has been reported by Fernández and Merlin in a dog undergoing median sternotomy and lung lobectomy.[24] However, it has never been described to provide perioperative analgesia in feline patients undergoing thoracic surgery.

In a previous cadaveric study conducted by Alaman et al., non-intrapleural staining was observed after any injection, which seems to be in accordance with what the authors experienced in this case, as the only nociceptive response noticed during the procedure was related to the pleural manipulation.

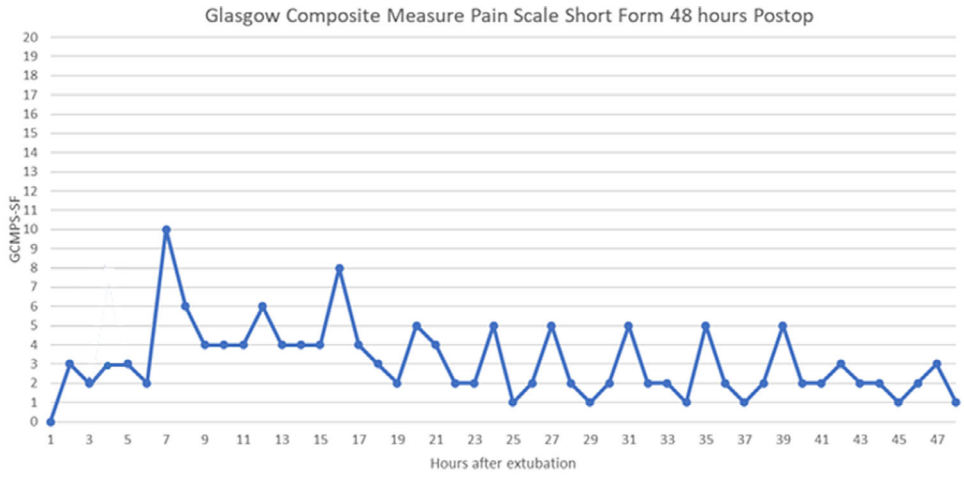

FIGURE 5 Glasgow Composite Measure Pain Scale Short Form (GCMPS-SF) recorded hourly for a period of 48 hours after surgical procedure.

In order to provide the extra analgesia required for the pleura, bupivacaine was administered through the thoracic drain every 6 hours during the postoperative period, starting 6 hours after the TTP block. Unfortunately, there is not enough evidence to elaborate how much extra analgesia it might provide.

The first methadone required in the postoperative period was administered 8 hours after the TTP block. This was considered the first painful episode after the block was performed, and during this post-block period of 11 hours, the cat did not show any more signs of the previous aggressive behaviour.

Bupivacaine is typically associated with an onset time of 15 minutes and effect duration of 6–8 hours when administered alone,[25] although some studies have shown longer duration of action of the analgesic effect when administered in an interfascial plane block.[26,27] Considering the reported pharmacodynamic properties of bupivacaine and the previously mentioned results, the authors hypothesised that the nerve blockage duration was approximately 8–11 hours, with increased systemic analgesic requirement after this period.

Levobupivacaine, the left isomer of bupivacaine, is a long-acting local anaesthetic that has shown lower toxicity on the central nervous system and cardiovascular system in cases of overdose or involuntary intravascular injections, although its anaesthetic power is slightly lower than that of bupivacaine.[28] However, bupivacaine was the drug selected due to clinical availability.

Alpha2-receptor agonists used as adjuvants for nerve blockage have shown to prolong the duration of analgesia, with dexmedetomidine being the most efficient.[29] However, alpha2-receptor agonists have been associated with increased risk of cardiovascular adverse events in brachial plexus blockage in humans.[30]

Nevertheless, there is lack of evidence about this combination in veterinary patients, and further studies are needed to elaborate if the addition of dexmedetomidine to the TTP block with bupivacaine may improve the duration and/or the quality of the blockage.[31]

One of the main consequences of thoracic surgery on pulmonary function is the reduction in functional residual capacity, which can result in alveolar collapse. In addition to this, the administration of opioids, such as fentanyl, has been associated in humans and veterinary patients with depression of respiratory drive after an IV bolus or CRI.[30]

The authors believe that the addition of the TTP block in this case as part of the multimodal analgesic protocol allowed the reduction of opioids consumption during the perioperative period until 8 hours post-block, which potentially may help maintaining better pulmonary function and improving recovery quality.

Furthermore, the addition of TTP block as part of the anaesthetic protocol instead of other locoregional analgesia, such as intercostal nerve blocks or thoracic epidural, has proved to have some benefits as it does not affect the innervation of intercostal muscles, which could help in reducing the respiratory depression and possible complications and risks associated with other analgesic techniques.[10] To the authors' knowledge, TTP block-related complications have not been reported in veterinary medicine yet.

Possible complications described in humans include local anaesthetic toxicity, vascular or pleural puncture, pneumothorax and anaphylactic shock.[30]

Regarding injection technique, previous recent studies described a transversal approach introducing the spinal needle in a ventro-medial-to-dorso-lateral direction using an in-plane technique with one-point[18] or two-point injection[32] at the level of the fifth intercostal space or the third and sixth intercostal spaces, respectively.

In this case, the transverse approach selected was using a single injection point at the level of the fourth intercostal space and in a dorso-lateral-to-ventro-medial direction. This approach is slightly different to the one described by Alaman et al.

The decision to modify approach was based on the small size of the patient, considering that the volume injected could be enough to obtain adequate spreading with a single injection, and a better visualisation of the in-plane technique could be achieved in a dorso-lateral-to-ventro-medial direction.

One limitation of this case is that the intraoperative nociceptive response evaluation was based on changes in cardiovascular parameters, which could have been not reliable in intrathoracic procedures. Another limitation is that the postoperative Glasgow Composite Measure Pain Scale Short Form was performed by different operators, which could have introduced bias in the evaluation.

Although the use of neuromuscular blockers could have facilitated surgical manipulation,[33] it was not administered in this case due to the short duration of the procedure.

Considering that the use of this local blockage has been described in human medicine to provide analgesia in patients undergoing different types of procedures as previously mentioned,[9] it is difficult to determine the effectiveness of the US-guided TTP block to provide adequate level of analgesia in different painful or nociceptive procedures.[31]

In the present case, satisfactory level of analgesia was provided with the addition of transverse US-guided TTP block with bupivacaine in a cat undergoing median sternotomy, and it suggests that the TTP block may be a useful adjuvant for procedures involving median sternotomy in feline patients.

Nevertheless, further clinical studies are required to determine the best US-guided approach and the usefulness of this technique to provide adequate level of analgesia in different procedures affecting the sternum and ventral thoracic area.

AUTHOR CONTRIBUTION

All authors were involved in the perioperative case management. Bartolome Rico Pérez anaesthetised the patient, performed the US-guided TTP block and was involved in the immediate postoperative care, collected data for the case report and wrote the case report. Cristina Parra Martínez was involved in case management, wrote the case report and is author of the images included. Carolina Palacios Jiménez supervised the case and critically revised the written report.

CONFLICT OF INTEREST STATEMENT

The authors declare they have no conflicts of interest.

FUNDING INFORMATION

The authors received no specific funding for this work.

ETHICS STATEMENT

Ethics approval was not required for this case.

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How to cite this article: Pérez BR, Martínez CP, Jiménez CP. Thoracic transversus plane block as part of a multimodal analgesia plan in a cat undergoing sternotomy. Vet Rec Case Rep. 2023;e586. https://doi.org/10.1002/vrc2.586