

Ultrasound-guided erector spinae interfascial plane block for spinal surgery in three cats

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Abstract

Case series summary The erector spinae plane (ESP) block consists of an interfascial injection of local anaesthetic between the erector spinae muscle group and the transverse processes of the thoracic vertebrae. This block targets the dorsal rami of the thoracic spinal nerves to desensitise the cutaneous area near the dorsal midline, the paraspinal muscles, the dorsal vertebral laminae and the facet joints. The purpose of this case series is to describe the perioperative analgesic effect and complications of ultrasound-guided ESP block with bupivacaine in three cats undergoing spinal surgery. Only one cardiovascular response was recorded in this case series. Just one cat received intraoperative rescue analgesia. Cats 1 and 2 recorded just one high pain score in the first 24 h postoperatively, and cat 3 recorded three high pain scores. The total amount of methadone given in the 24 h postoperatively was 0.6 mg/kg in cat 1, 0.9 mg/kg in cat 2 and 0.8 mg/kg in cat 3. All three cats suffered mild and transient intraoperative complications, which were easily addressed. There were no postoperative complications.

Relevance and novel information This case series documents a novel locoregional anaesthesia technique as an alternative to traditional systemic analgesia. The technique is part of a multimodal analgesia approach for spinal surgery in cats. Perioperative analgesic effect and complications presented in this case series are evaluated and discussed.

Keywords: Analgesia; erector spinae plane block; ESP; hemilaminectomy; locoregional anaesthesia

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Introduction

A combination of regional anaesthesia and systemic analgesics as part of a multimodal technique is generally accepted as the optimal approach to providing pain relief.¹ In recent times, different types of interfascial plane blocks have been described with multiple clinical applications in veterinary medicine.^{2–4} The erector spinae plane (ESP) block was first described in human medicine by Forero et al in 2016.⁵ It consists of an interfascial injection of local anaesthetic between the erector spinae muscle group and the transverse processes of the thoracic vertebrae.^{5,6} This block aims to target the dorsal rami of the thoracic spinal nerves to desensitise the cutaneous area near the dorsal midline, the paraspinal muscles, the dorsal vertebral laminae and the facet joints.^{6–8} In human literature, clinical studies and case reports of

the ESP block have shown appropriate analgesia in diverse clinical scenarios, and most authors in human medicine agree that the ESP block has significant advantages, as it is an easy technique to perform and has a low risk of complications.^{9–13}

In veterinary medicine, the ESP block has been recently described in four experimental cadaveric studies in the thoracic and lumbar spine.^{14–17} Portela et al evaluated its clinical effect in dogs undergoing hemilaminectomy

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surgery, revealing satisfactory analgesia associated with significantly lower administration of intra- and postoperative opioids and intraoperative adjuvant analgesics, and a reduced incidence of intraoperative cardiovascular complications.¹⁸

This case series aims to describe the perioperative analgesic effect of ultrasound-guided ESP block with bupivacaine in three cats undergoing spinal surgery. To the best of our knowledge, analgesia with an ESP block has never been reported in cats.

Case series description

Clinical records from January 2019 to January 2021 were searched for feline spinal surgery cases where a preoperative ESP block was used for perioperative analgesia. Cases with incomplete files were excluded from the study. Data collected included breed, age, sex, body weight, indication for spinal surgery, surgical procedure, intervertebral space operated and side, preoperative drugs and doses administered, the dose of local anaesthetic administered for the ESP block, surgical time, cardiovascular response to surgical stimulation (CR), cardiovascular complications (bradycardia and hypotension), intraoperative rescue analgesia provided, rectal temperature at tracheal extubation, postoperative analgesia, 24h postoperative pain score, postoperative total opioid administration, time of first meal offered and time of first food intake post-intubation, and the incidence and nature of any complication. Heart rate (HR), respiratory rate, systolic arterial pressure (SAP), mean arterial pressure (MAP), diastolic arterial pressure, percentage of haemoglobin saturated with oxygen in arterial blood, end-tidal CO₂ and the end-expiratory fraction of inhalational anaesthetic agent were recorded (Datex Ohmeda S/5 Monitor; Datex Ohmeda) and mean \pm SD calculated. Means were calculated averaging the readings recorded every 5 mins in each animal. Pain score was evaluated with the Glasgow Composite Measure Pain Scale–Feline (CMPS-F).¹⁹ Bradycardia was defined as a HR <100 beats/min.²⁰ Hypotension was defined as a MAP <60 mmHg or SAP <90 mmHg²⁰ for at least two consecutive readings obtained at 5 min intervals. Cardiovascular response to surgical stimulation was defined as an increase of the HR, SAP or MAP >20% of the prestimulus value, with the prestimulus value being the value of the variable in the 5 mins before the stimulus itself.^{21–23}

The amount of methadone (Comfortan; Eurovet Animal Health) and ketamine (Narketan; Vetoquinol) provided intraoperatively was calculated by dividing the total amount administered, measured in mg (methadone) or μ g (ketamine), by the cat's body weight in kg and by the surgical time measured in hours (h). Furthermore, the amount of the same drugs administered during the first 24h postoperatively was calculated

by dividing the total amount administered by the cat's body weight (units as previously described). According to the standard perioperative care in our institution, anaesthetists were responsible for the postoperative analgesic plan. Opioid rescue analgesia was administered at the clinician's discretion using a pain scale (CMPS-F). A high pain score was defined as $\geq 5/20$. Pain assessment was performed at 1h intervals until midnight on the day of the surgery; subsequently, it was performed at 4h intervals. However, modifications to the protocol were possible based on clinical judgement (eg, pain score not obtained when an animal was resting after a long period of time of stress).

Ultrasound-guided ESP block procedure

The block was performed as described by Otero and Portela adapted for the lumbar vertebrae.⁶ The local anaesthetic drug used was bupivacaine 0.5% (MarcainPolyamp; AstraZeneca). The cats were positioned in sternal recumbency, and the skin area corresponding to the intervertebral space indicated for the surgery was previously clipped and aseptically prepared. A linear ultrasound transducer (12L-RS, 5–13 MHz; GE Healthcare) connected to a portable ultrasound machine (LOGIQ e; GE Healthcare) was used to aid local anaesthetic placement. To identify the vertebrae where the procedure was going to be performed, the vertebral spinous processes were counted back starting from the lumbosacral space. The transducer was positioned parallel to the dorsal midline of the identified vertebrae and adjusted to obtain a parasagittal view of the targeted vertebral transverse process, identified as a hyperechoic convex line with posterior acoustic shadowing. A 22G, 50mm needle (Ultraplex 360; B Braun Medical) connected to a 5ml syringe (Trojector-3; Troge Medical) was introduced in-plane, following a cranial-to-caudal direction, through the epaxial muscles until its tip contacted the dorsolateral aspect of the lumbar vertebrae transverse process (Figures 1 and 2). When the needle tip was visualised at the target, bupivacaine was injected following negative aspiration. The distribution of bupivacaine was observed in the interfacial plane between the longissimus lumborum muscles and the transverse process (Figure 3).

A total of four cats at our institution underwent spinal surgery with an ESP block. One was excluded owing to incomplete anaesthetic data. Details of signalment, indication for spinal surgery and surgical technique performed, location and side of the compressive myelopathy, the preoperative and induction drug administered, and bupivacaine dose for the ESP block are provided in Table 1. Surgery was performed in all cats on the lumbar spine. Spinal surgery was performed owing to the presence of an intradural–extramedullary mass-like lesion (histopathologically confirmed as a meningioma) in the spinal cord at the level of L4 (cat 1) and intervertebral disc



Figure 1 Positioning and scanning during erector spinae plane block. Note the transducer positioned parallel to the dorsal midline of the targeted lumbar vertebra and the needle insertion position cranial to caudal

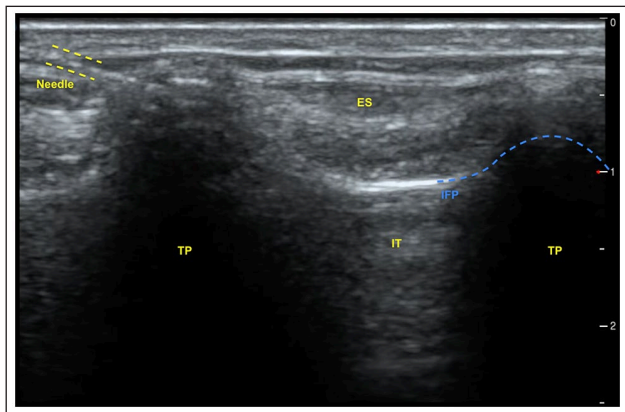


Figure 2 Ultrasound image and landmarks of an erector spinae plane block. Ultrasonographic visualisation of the needle positioning prior to the injection of the local anaesthetic in the interfacial plane. The needle tip is contacting the dorsal aspect of the targeted lumbar transverse process. ES = erector spinae complex; TP = transverse process; IT = intertransversarii lumborum muscles; IFP = interfacial plane

extrusion at the intervertebral disc L2–L3 (cat 2) and L3–L4 (cat 3). The surgical procedures performed were hemilaminectomy along with durectomy and excision of the mass in cat 1, hemilaminectomy in cat 2 and mini-hemilaminectomy in cat 3.

All cats were premedicated with 0.1 to 0.2 mg/kg methadone (Confortan; Eurovet Animal Health) and 2–10 µg/kg of medetomidine (Sedator; Dechra) administered intravenously (IV), and anaesthesia was induced 15–20 mins later with alfaxalone IV (Alfaxan Multidose;

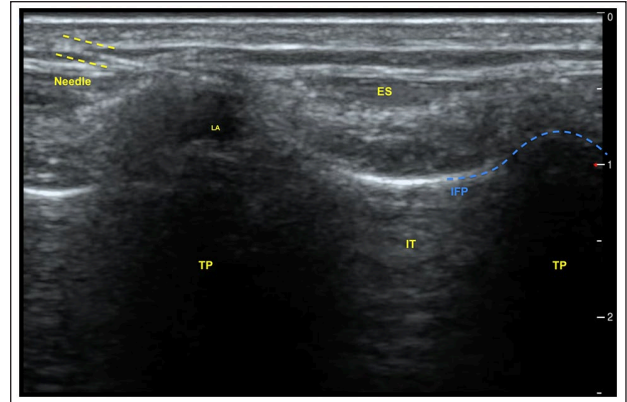


Figure 3 Ultrasound image and landmarks of the erector spinae plane block. Ultrasonographic visualisation of the needle positioning after the injection of the local anaesthetic in the interfacial plane. Note the distribution of the local anaesthetic observed in the interfacial plane between the erector spinae muscle and the lumbar transverse process. ES = Erector spinae complex; TP = transverse process; IT = intertransversarii lumborum muscles; LA = local anaesthetic; IFP = interfacial plane

Jurox), given to effect. The cats' tracheas were intubated, and anaesthesia was maintained with isoflurane (IsoFlo; Zoetis) in 100% oxygen delivered via a circle system. All ESP blocks in this study were performed by the same anaesthetist (MM). The intraoperative data collected are shown in Table 2.

All three cats suffered episodes of hypotension during the surgery. Cat 1 had two contiguous episodes of hypotension treated with ephedrine IV 0.1 mg/kg. Cat 2 had two episodes of hypotension and bradycardia at the beginning of the surgery, which were treated with a single dose of glycopyrrolate IV at 10 µg/kg. Cat 3 also had two episodes of hypotension. However, it was treated with glycopyrrolate IV on three occasions (doses were 5, 10 and 7.5 µg/kg, respectively). Cat 2 was the only one that registered episodes of bradycardia (a total of five readings during the surgery). The same cat also showed an episode of apnoea (<5 mins) shortly after the ESP block was performed. This complication was solved by decreasing the isoflurane from 1.5% to 1% and providing manual intermittent positive pressure ventilation.

Every cat in the study showed episodes of cardiovascular variability. Cat 1 had four increases of >20% in SAP and MAP. Cat 2 had two increases of the MAP. Cat 3 had an increase of MAP and one of HR.

Of the eight events identified in all cats, five were an isolated increase of >20% of the prestimulus value followed by a recorded value similar to prestimulus and no change in the dose of the general anaesthetic agent or rescue analgesia was required. Two of these eight events occurred immediately after administration of ephedrine to treat hypotension (cat 1).

Table 1 Details of signalment, indication for spinal surgery and surgical technique performed, location and side of the compressive myelopathy, the preoperative and induction drug administered, and bupivacaine dose for the erector spinae plane (ESP) block

Cat number	Breed	Age (years)	Sex	Weight (kg)	Indication for surgery	Surgical procedure	Location	Side	Preoperative drugs		Induction drug	ESP dose (mg/kg)
									Methadone (mg/kg)	Medetomidine (μ g/kg)		
1	DSH	10	FN	4.05	Large right-sided intradural-extradural mass L4	Hemilaminectomy and durotomy	L4-L5	R	0.12	10	Alfaxalone	2.46
2	DSH	10	FN	3.3	Intervertebral disc extrusion	Hemilaminectomy	L2-L3	L	0.15	10	Alfaxalone	2.27
3	DSH	16	MN	5.57	Intervertebral disc extrusion	Mini-hemilaminectomy	L3-L4	R	0.2	2	Alfaxalone	1.79

DSH = domestic shorthair; FN = female neutered; MN = male neutered; R = right; L = left

The only event that fitted our criteria of CR and action was required (rescue analgesia provided, increase in the percentage of isoflurane or both) occurred in cat 3, and it could truly be considered a CR. A dose of 0.2 mg/kg methadone was administered after the CR was noted in cat 3 (0.09 mg/kg/h), and 20 mins after this CR, a dose of 500 μ g/kg ketamine was given as a bolus (0.5 mg/kg).

All three cats recovered uneventfully from the general anaesthesia. Cat 1 was hypothermic at the time of extubation (34.9°C).

The postoperative analgesia plan was similar in all three cats. Oral analgesia consisted of meloxicam (0.15 mg/kg first dose and 0.05 mg/kg maintenance q24h) and gabapentin (10 mg/kg q8h). Postoperative rescue analgesia was necessary on three occasions for cat 1, on six occasions for cat 2 and on four occasions for cat 3. The total doses of methadone given in the 24h postoperative period were 0.6 mg/kg, 0.9 mg/kg and 0.8 mg/kg, respectively. Median pain scores for the first 24h postoperatively were 2/20 (range 0–6) in cat 1; 3/20 (range 1–8) in cat 2; and 4/20 (range 2–8) in cat 3. Cats 1 and 2 had just one high pain score ($\geq 5/20$) in the 24h after surgery, 6/20 at 22h post-surgery and 7/20 at 2h post-surgery, respectively. Cat 3 had three high pain score evaluations: 6/20 at 4h, 8/20 at 9h and 5/20 at 20h post-surgery. The same cat also received ketamine as a continuous infusion rate for 24h postoperatively (110 μ g/kg/24h). None of the cats ate the first meal offered, at hours 4, 3 and 4, respectively. Cat 1 ate the first meal at hour 20 post-surgery, cat 2 at hour 8 and cat 3 did not eat during the first 24h postoperatively. No other complication was found in the postoperative phase in any cat.

Discussion

This case series describes the perioperative analgesic effects of ultrasound-guided ESP block with bupivacaine in three cats that underwent lumbar spinal surgery.

The ESP block desensitises the cutaneous area near the dorsal midline, the paraspinal muscles, the dorsal vertebral laminae and the facet joints.^{6–8} The clinical data obtained from this report suggest that the ESP block is a feasible technique, and is potentially effective in providing perioperative analgesia for lumbar spinal surgery in cats, which is in line with the results observed in human and canine reports.^{9–13,18}

The dose of bupivacaine used was 1.8–2.5 mg/kg, which was always below the toxic dose.²⁴ The differences in doses and volumes in this case series arise from the retrospective nature of this report. Standardisation of the volume and concentration is required for future studies in cats.

Several complications were found in this case series. Transient hypotension occurred in all cases. Bradycardia, hypothermia and transient apnoea post-ESP block were only reported once. Hypotension is a common anaesthetic complication in cats.²⁰ A possible cause of hypotension

Table 2 Intraoperative data collection

	HR mean (bpm)	RR mean (bpm)	SAP mean (mmHg)	MAP mean (mmHg)	DAP mean (mmHg)	SpO ₂ % mean	ETCO ₂ mean (mmHg)	FEIAA mean (%)	Surgery time (mins)
Cat 1*	126 ± 13	7 ± 2	111 ± 24	86 ± 31	65 ± 25	–	50 ± 2	1 ± 0	75
Cat 2	102 ± 5	17 ± 0	100 ± 6	69 ± 11	52 ± 13	100 ± 0	31 ± 1	1 ± 0	75
Cat 3	116 ± 13	18 ± 3	94 ± 12	71 ± 9	54 ± 10	98 ± 0	37 ± 4	1 ± 0	130

Data are mean ± SD unless otherwise stated

*In cat 1, SpO₂ % was monitored but not recorded regularly enough to obtain a representative value in the mean calculation

HR = heart rate; bpm = beats per min; RR = respiratory rate; SAP = systolic arterial pressure; MAP = mean arterial pressure; DAP = diastolic arterial pressure; SpO₂ % = percentage of haemoglobin saturated with oxygen in arterial blood; ETCO₂ = end-tidal carbon dioxide; FEIAA = end-expiratory fraction of inhalational anaesthetic agent

could be the spread of bupivacaine resulting in sympathetic blockade. However, a cadaveric study in dogs comparing the transversal and longitudinal approaches with ESP block illustrated that the spread of the local anaesthetic drug into the epidural canal and intravascularly was only found using the transversal approach, which was not used in these cases; therefore, spread of bupivacaine resulting in sympathetic blockade is less likely.¹⁶ However, the most common side effects of alpha (α)-2 agonists are bradycardia and hypotension, after an initial period of vasoconstriction. Bradycardia associated with the use of α -2 agonists and opioids has also been reported.²⁵ In our cases, treatment with ephedrine and glycopyrrolate ameliorated low blood pressure and low HR. Hypothermia in cats is not an unusual finding owing to their high surface area to body mass ratio and the effects of the drugs received for premedication and general anaesthetic.²⁰

Eight events of an increase of >20% of the prestimulus HR, SAP and MAP values were recorded in this case series, but only one was clearly associated with nociception and considered a CR. Cat 1 had four cardiovascular episodes in total. The first two were single spurious results unrelated to surgical stimulation and no action was required. The final two episodes were immediately after ephedrine administration (increase of HR and MAP). Cat 2 had two isolated recordings of increased MAP unrelated to nociception (no action required). Cat 3 had two episodes. The first was a single spurious reading of increased MAP (no action required). The second event was an increase in HR judged to be linked to nociception. An dose of 0.2mg/kg IV of methadone was administered followed 20mins later by 0.5mg/kg of ketamine. Ketamine was given at the anaesthetist's discretion, despite of a lack of clinical signs of nociception at the time. A study in dogs showed that subjects receiving an ESP block caudal to L1 for lumbar hemilaminectomy were 18.6% more likely to require rescue analgesia than dogs with a thoracic ESP block.¹⁸ Thus, it is not surprising that intraoperative rescue analgesia was required in 1/3 cases reported here.

Postoperative rescue analgesia was standardised for all three cases as per hospital protocol. Methadone was given pro re nata at the clinician's discretion. The CMPS-F was

used to improve pain assessment accuracy and decrease potential side effects. A study in dogs illustrated that administration of methadone, regardless of pain score, after orthopaedic procedures significantly increased the risk of vomiting, dysphoria and reduced food intake.²⁶ Cats 1 and 2 had just one high pain score in the first 24h postoperatively, while cat 3 presented three elevated scores. However, postoperative rescue analgesia was given on three occasions for cat 1, on six occasions for cat 2 and on four occasions for cat 3. CMPS-F showed an enhanced discriminatory ability of pain evaluation; nevertheless, CMPS-F is not exempt from misclassification.¹⁹ The fact that the cats with pain scores <5 received methadone could indicate misclassification or treatment based on the clinician's personal preference.

The authors consider the result of the ESP block effect in cat 3 to be questionable. This cat was the only one that required rescue analgesia during the procedure. It presented three pain scores >4/20 in the first 24h postoperatively, even with the addition of a ketamine continuous rate infusion. The longitudinal approach for the ESP block has shown inferior accuracy of local anaesthetic injection in the ESP compartment compared with the transversal approach in dog cadavers.¹⁶ Furthermore, the lack of reports and clinical experience with this technique in cats could logically result in suboptimal outcomes.

Conclusions

This case series proposes that the ESP block is a suitable addition to perioperative analgesia options in cats undergoing lumbar spinal surgery. Nevertheless, anatomical studies and randomised prospective controlled studies comparing the use of ESP block with traditional analgesia as part of multimodal analgesic management for spinal surgery in cats are required to understand better this novel, ultrasound-guided locoregional technique.

Conflict of interest The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Ethical approval The work described in this manuscript involved the use of non-experimental (owned or unowned) animals. Established internationally recognised high standards ('best practice') of veterinary clinical care for the individual patient were always followed and/or this work involved the use of cadavers. Ethical approval from a committee was therefore not specifically required for publication in *JFMS Open Reports*. Although not required, where ethical approval was still obtained, it is stated in the manuscript.

Informed consent Informed consent (verbal or written) was obtained from the owner or legal custodian of all animal(s) described in this work (experimental or non-experimental animals, including cadavers) for all procedure(s) undertaken (prospective or retrospective studies). For any animals or people individually identifiable within this publication, informed consent for their use in the publication (verbal or written) was obtained from the people involved.

References

- Grubb T and Lobprise H. **Local and regional anaesthesia in dogs and cats: overview of concepts and drugs (part 1)**. *Vet Med Sci* 2020; 6: 209–217.
- Campoy L. **Locoregional anesthesia for hind limbs**. *Vet Clin North Am Small Anim Pract* 2019; 49: 1085–1094.
- Re M, Blanco J and Gómez de Segura IA. **Ultrasound-guided nerve block anesthesia**. *Vet Clin North Am Food Anim Pract* 2016; 32: 133–147.
- Boesch JM. **Advances in pain management: palliative care applications**. *Vet Clin Small Anim Pract* 2019; 49: 445–461.
- Forero M, Adhikary SD, Lopez H, et al. **The erector spinae plane block a novel analgesic technique in thoracic neuropathic pain**. *Reg Anesth Pain Med* 2016; 41: 621–627.
- Otero PE and Portela DA. **Manual of small animal regional anesthesia**. 2nd ed. Buenos Aires: Ciudad Autonoma de Buenos Aires, 2019.
- Forsythe WB and Ghoshal NG. **Innervation of the canine thoracolumbar vertebral column**. *Anat Rec* 1984; 208: 57–63.
- Evans H and de Lahunta A. **Spinal nerves**. In: Miller's anatomy of the dog. 4th ed. St Louis, MO: Elsevier, 2013, pp 611–657.
- Chin KJ, Adhikary S, Sarwani N, et al. **The analgesic efficacy of pre-operative bilateral erector spinae plane (ESP) blocks in patients having ventral hernia repair**. *Anaesthesia* 2017; 72: 452–460.
- Tulgar S, Kose HC, Selvi O, et al. **Comparison of ultrasound-guided lumbar erector spinae plane block and transmuscular quadratus lumborum block for postoperative analgesia in hip and proximal femur surgery: a prospective randomized feasibility study**. *Anesth Essays Res* 2018; 12: 825–831.
- Tulgar S, Kapakli MS, Senturk O, et al. **Evaluation of ultrasound-guided erector spinae plane block for postoperative analgesia in laparoscopic cholecystectomy: a prospective, randomized, controlled clinical trial**. *J Clin Anesth* 2018; 49: 101–106.
- Singh S and Chowdhary NK. **Erector spinae plane block an effective block for post-operative analgesia in modified radical mastectomy**. *Indian J Anaesth* 2018; 62: 148–150.
- Kot P, Rodriguez P, Granell M, et al. **The erector spinae plane block: a narrative review**. *Korean J Anesthesiol* 2019; 72: 209–220.
- Portela DA, Castro D, Romano M, et al. **Ultrasound-guided erector spinae plane block in canine cadavers: relevant anatomy and injectate distribution**. *Vet Anaesth Analg* 2020; 47: 229–237.
- Ferreira TH, St James M, Schroeder CA, et al. **Description of an ultrasound-guided erector spinae plane block and the spread of dye in dog cadavers**. *Vet Anaesth Analg* 2019; 46: 516–522.
- Serra RM, Foster A, Plested M, et al. **Lumbar erector spinae plane block: an anatomical and dye distribution evaluation of two ultrasound-guided approaches in canine cadavers**. *Vet Anaesth Analg* 2021; 48: 125–133.
- Otero PE, Fuensalida SE, Russo PC, et al. **Mechanism of action of the erector spinae plane block: distribution of dye in a porcine model**. *Reg Anesth Pain Med* 2020; 45: 198–203.
- Portela DA, Romano M, Zamora GA, et al. **The effect of erector spinae plane block on perioperative analgesic consumption and complications in dogs undergoing hemilaminectomy surgery: a retrospective cohort study**. *Vet Anaesth Analg* 2021; 48: 116–124.
- Reid J, Scott EM, Calvo G, et al. **Definitive Glasgow acute pain scale for cats: validation and intervention level**. *Vet Rec* 2017; 180: 449. DOI: 10.1136/vr.104208.
- Robertson SA, Gogolski SM, Pascoe P, et al. **AAFP feline anesthesia guidelines**. *J Feline Med Surg* 2018; 20: 602–634.
- Wynands J, Wong P, Townsend G, et al. **Narcotic requirements for intravenous anesthesia**. *Anesth Analg* 1984; 63: 101–105.
- Novello L, Corletto F, Rabozzi R, et al. **Sparing effect of a low dose of intrathecal morphine on fentanyl requirements during spinal surgery: a preliminary clinical investigation in dogs**. *Vet Surg* 2008; 37: 153–160.
- Sarotti D, Rabozzi R and Corletto F. **Efficacy and side effects of intraoperative analgesia with intrathecal bupivacaine and levobupivacaine: a retrospective study in 82 dogs**. *Vet Anaesth Analg* 2011; 38: 240–251.
- Chadwick HS. **Toxicity and resuscitation in lidocaine- or bupivacaine-infused cats**. *Anesthesiology* 1985; 63: 385–390.
- Slingsby LS, Bortolami E and Murrell JC. **Methadone in combination with medetomidine as premedication prior to ovariohysterectomy and castration in the cat**. *J Feline Med Surg* 2015; 17: 864–872.
- Bini G, Vettorato E, de Gennaro C, et al. **A retrospective comparison of two analgesic strategies after uncomplicated tibial plateau levelling osteotomy in dogs**. *Vet Anaesth Analg* 2018; 45: 557–565.