RESEARCH PAPER

Perioperative analgesic efficacy of lumbar erector spinae plane block in dogs undergoing hemilaminectomy: a randomized blinded clinical trial

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Abstract

Objective To evaluate the perioperative analgesic effect of the unilateral lumbar erector spinae plane block ($ESPB_L$) in dogs undergoing hemilaminectomy.

Study design Randomized, blinded clinical study.

Animals A total of 30 client-owned dogs undergoing thoracolumbar or lumbar hemilaminectomy for intervertebral disc extrusion (IVDE).

Methods Dogs were randomly assigned to receive a unilateral $ESPB_L$, performed either with 0.4 mL kg^{-1} ropivacaine 0.5% [group ROPI ($n = 15$)] or with saline solution [CNT group ($n = 15$)]. Dogs were premedicated intravenously (IV) with acepromazine 5 μg kg^{-1} and methadone 0.2 mg kg^{-1}, general anaesthesia was induced by administering IV midazolam 0.2 mg kg^{-1} and propofol to effect and maintained with isoflurane. Fentanyl was administered as rescue analgesia. Bradycardia [heart rate (HR) < 60 beats $minute^{-1}$] with hypotension was treated with atropine IV. The Short-Form of the Glasgow Composite Pain Scale was used pre- and postoperatively at 1, 2, 4, 8, 12, 16, 20 and 24 hours after extubation, and methadone 0.2 mg kg^{-1} was administered IV when pain score was ≥ 5/20. HR and end-tidal concentration of isoflurane (F_E'Iso) were compared between groups with ANOVA combined with a Dunnet's *post hoc* test. Time to the first rescue methadone and total dose of fentanyl (FEN_{tot}, μg kg^{-1} $hour^{-1}$) and methadone (MET_{tot}, mg kg^{-1}) in the first 24 postoperative hours were compared using unpaired Student's *t* test. Postoperative pain scores were compared with the Mann–Whitney test and atropine administration with a Fisher's exact test; $p < 0.05$.

Results HR, F_E'Iso, FEN_{tot}, MET_{tot} and atropine administration were significantly lower in group ROPI compared to CNT. Postoperative analgesic effect was significantly longer, and pain scores were significantly lower in group ROPI for all time points.

Conclusions and clinical relevance Unilateral $ESPB_L$ with ropivacaine reduced perioperative opioid consumption and the occurrence of bradycardia in dogs undergoing hemilaminectomy.

Keywords analgesia, dogs, erector spinae plane block, hemilaminectomy, opioid consumption, ultrasound-guided locoregional anaesthesia.

Introduction

Hansen type I intervertebral disc extrusion (IVDE) is the most prevalent cause of spinal cord injury in dogs (Rossi et al. 2020). This condition results from degeneration of the intervertebral disc and displacement of the *nucleus pulposus* into the vertebral canal, producing contusion and compression of the spinal cord and nerve roots (Fenn & Olby 2020). Surgery is considered the elective treatment to achieve spinal decompression and avoid irreversible damages (Moore et al. 2020). Hemilaminectomy is currently the most frequently described surgical approach in veterinary medicine (Fenn & Olby 2020).

Pain management can be challenging in dogs with IVDE. Severe pain is produced by compression of the spinal cord, nerve roots and meninges (Platt 2004). Furthermore, to perform a hemilaminectomy the dorsal approach to the thoracolumbar spine causes inherent soft tissue and bone trauma at the level of IVDE, eliciting pain recently described as severe to excruciating (Monteiro et al. 2023).

Different analgesic techniques have been reported in dogs, such as systemic administration of combinations of opioids, α_2-adrenoceptor agonists, ketamine and lidocaine (Pascal et al. 2020; Skelding et al. 2021), postoperative epidural administration of morphine (Aprea at al. 2012) and blind injection of local anaesthetic (LA) into the epaxial muscles (McFadzean et al. 2021). However, the locoregional anaesthetic technique, which has stimulated the greatest interest in the past few years, in both human and veterinary medicine, is the erector spinae plane block (ESPB). It consists of the injection of LA, under ultrasound (US) guidance, into the inter-fascial plane between the transverse processes of the thoracic or lumbar vertebrae and the erector spinae muscles. The aim is to desensitise the medial and lateral branches of the dorsal rami of the spinal nerves (DRSN). Cadaver studies conducted in dogs evaluated two approaches performed at different levels of the spine: a longitudinal approach for the thoracic portion ($ESPB_T$) (Ferreira et al. 2019; Portela et al. 2020) and a transversal approach for the lumbar spine ($ESPB_L$) (Medina-Serra et al. 2021). Cavalcanti et al. (2022) compared the two techniques in the thoracolumbar portion of the spine, from the eleventh thoracic (T11) to the second lumbar vertebra (L2), where an anatomical transition of the epaxial muscles occurs (Cavalcanti et al. 2022). The authors concluded that the transversal approach was more appropriate for injections caudal to T11. The main application of the ESPB reported in veterinary species is the provision of perioperative analgesia during spinal surgeries, such as hemilaminectomy (Portela et al. 2021). Benefits of including the $ESPB_T$ in a multimodal analgesic approach were described in retrospective studies (Portela et al. 2021, Viilmann et al. 2022). $ESPB_T$ has proven to effectively reduce perioperative opioid consumption and intra- and postoperative complications, when compared to a standard opioid-based analgesic protocol (Portela et al. 2021, Viilmann et al. 2022). Nevertheless, only one case report describes the implementation of the $ESPB_L$ in the anaesthetic management of a dog undergoing lumbar hemilaminectomy (Rodriguez Mulet et al. 2021). Randomized clinical trials (RCTs) investigating the analgesic efficacy of the ESPB are lacking.

Therefore, this study investigated the perioperative analgesic effect of the unilateral $ESPB_L$ performed with ropivacaine in dogs undergoing hemilaminectomy for Hansen type I IVDE. We hypothesized that unilateral $ESPB_L$ with ropivacaine would: 1) decrease the consumption of intra- and postoperative systemic analgesics and 2) reduce the occurrence of intraoperative cardiovascular complications.

Materials and methods

This blinded RCT was conducted at the Veterinary Teaching Hospital of the University of Liege. The Consolidated Standards of Reporting Trials (CONSORT) guidelines were applied (Schulz et al. 2010). Ethical approval was obtained from the competent Belgian authorities (Nr. 2531). By signing the informed consent, the owner agreed to enrol the dog in the study.

A total of 30 dogs of different breeds, ages and weights, undergoing thoracolumbar or lumbar hemilaminectomy for Hansen type I IVDE, with a modified Frankel score (MFS) between 3 and 5, were recruited for this study (Sharp & Wheeler 2005).

Prior to anaesthesia, each dog underwent a clinical examination, including body condition score (BCS) on a nine-point scale evaluation (Laflamme 1997). Based on the preoperative evaluation, only dogs with an American Society of Anesthesiologists (ASA) status II, with a BCS ranging between 3 and 6 out of 9, were included in the study. Exclusion criteria comprised intractable behaviour, skin infection at the site of the $ESPB_L$, history of previous hemilaminectomy or administration of corticosteroids or non-steroidal anti-inflammatory drugs (NSAIDs) within 24 hours prior to surgery. Pain was assessed using the Short Form of the Glasgow Composite Pain Scale (SF-GCPS) (Reid et al. 2007) on admission, to obtain basal values.

Preoperative management

The following anaesthetic protocol was used in all animals: after intravenous (IV) catheter insertion into one of the cephalic veins, maropitant 1 mg kg^{-1} (Cerenia; Zoetis, Netherlands), acepromazine 5 µg kg^{-1} (Tranquinervin; Dechra Veterinary Products, Netherlands) and methadone 0.2 mg kg^{-1} (Comfortan; Dechra Veterinary Products, Netherlands) were administered IV and lactated Ringer's (RL) solution (Vetivex; Dechra Veterinary Products, Belgium) was infused at 5 mL kg^{-1} $hour^{-1}$. Approximately 20 minutes later, anaesthesia was induced with midazolam 0.2 mg kg^{-1} (Dormazolam; Produlab Pharma BV, Netherlands) and propofol (Diprivan; Aspen Pharma Trading Limited, Ireland) IV titrated to effect. The trachea was intubated with a suitably sized endotracheal tube, and anaesthesia was maintained with isoflurane (Isoflutek; Alivira Animal Health, Spain) in an oxygen/air mixture, with a fraction of inspired oxygen (FIO_2) of 60%. The vaporizer was adjusted to maintain end-tidal isoflurane concentration (FE'Iso) at 1.2%. Prior to surgery, a computed tomography was performed under general anaesthesia to localize the IVDE. Subsequently, dogs were moved to the pre-surgery room, where the $ESPB_L$ was performed, after clipping and aseptic preparation of the skin. Dogs were divided into two groups using block randomization (https://www.random.org): dogs allocated in group ROPI received a unilateral US-guided $ESPB_L$ with 0.4 mL kg^{-1} of ropivacaine 0.5% (Ropivacaine hydrochloride; Fresnius Kabi, Belgium) while dogs in the control group (CNT) received 0.4 mL kg^{-1} of saline solution

0.9% (Mini-Plasco NaCl; Braun, Germany). $ESPB_L$ was performed on the ipsilateral side of the planned hemilaminectomy by the same anaesthetist (M.D.), using an along visual axis technique (Di Franco et al. 2021). A 14 MHz high-frequency linear transducer (L7HD3VET; Clarius Mobile Health, BC, Canada), connected to a touchscreen tablet (iPad Air, fifth generation; Apple, CA, USA) was positioned at the level of the spinous process of the vertebra immediately caudal to the IVDE, in a transversal plane. The $ESPB_L$ was performed as described by Medina-Serra et al. (2021), with a 22 gauge spinal needle (Becton Dickinson; Spain) of adequate length, targeting the lateral aspect of the mammillary process of the vertebra one segment caudal to the IVDE (Cavalcanti et al. 2022). Correct positioning was confirmed by the visualization of hydrodissection between the mammillary process of the vertebra and the *longissimus lumborum* muscle. The anaesthetist in charge of the block and intraoperative monitoring, as well as the surgeon were blinded to group allocation.

Intraoperative management

Dogs were then moved to the operating room and connected to a rebreathing system (Universal F; Kingsystem, IN, USA). Volume-controlled ventilation (Prima 320; Penlon, UK) was applied during the whole procedure to maintain end-expiratory CO_2 concentration ($P_E'CO_2$) between 35 and 45 mmHg (4.6−5.9 kPa). Heart rate (HR), peripheral arterial haemoglobin saturation (SpO_2), systolic, mean and diastolic arterial blood pressures measured by oscillometry (SAP, MAP, DAP), respiratory rate (f_R), $P_E'CO_2$, F_E'Iso and F_IO_2 were continuously monitored using a multiparameter monitor (VT9000 Multimonitor; Veterinary Technics, the Netherlands) and recorded every 5 minutes, starting from T0 (placement of the surgical drapes).

A 20% increase in HR or MAP from the corresponding values at T0 for more than 1 minute was considered to be a sign of nociception (Wenger et al. 2005) and a bolus of 2 μg kg^{-1} of fentanyl (Fentadon, Dechra Veterinary Products, Netherlands) was administered IV. In case the cardiovascular values did not return to baseline values (T0) within 5 minutes, a continuous infusion of fentanyl was started at 0.5 μg kg^{-1} $hour^{-1}$ and increased by 0.5 μg kg^{-1} $hour^{-1}$ every 5 minutes, until the variables returned to the pre-stimulation values (Tayari et al. 2019). Timing and total dose of rescue fentanyl (bolus or infusion) (FEN_{tot}, μg kg^{-1} $hour^{-1}$) were recorded. FEN_{tot} was obtained by dividing the total dose of fentanyl administrated by the duration of surgery and the weight of the dog. The following surgical steps of hemilaminectomy were considered to identify a specific time for rescue analgesia: S_1, skin, subcutaneous and fascial tissue incision; S_2, elevation of musculature from the vertebral lamina(e); S_3, removal of the articular process(es); S_4, drilling of the vertebral lamina and pedicle(s); S_5, decompression of the spinal cord; S_6, fascial plane suturing; S_7, subcutaneous tissue and skin suturing.

In case of hypotension (MAP < 60 mmHg), F_E'Iso was reduced by 0.1% every 5 minutes. If hypotension persisted despite F_E'Iso of 0.8%, 10 mL kg^{-1} of RL was administered over 10 minutes. If hypotension persisted, noradrenaline (Noradrenaline; Aguettant, Belgium) infusion was started at 0.05 μg kg^{-1} $minute^{-1}$ and increased by 0.05 μg kg^{-1} $minute^{-1}$ every 5 minutes until MAP ≥60 mmHg. In the presence of bradycardia (HR < 60 beats $minute^{-1}$) causing concurrent hypotension, atropine (Atropine sulfate; Oterop, Belgium) (20 μg kg^{-1} IV) was administered.

Duration of anaesthesia (from induction to extubation), duration of surgery, incidence of hypotension and bradycardia and any further perioperative complications were recorded. At the end of surgery, isoflurane was turned off and, once the animal returned to breathing spontaneously, mechanical ventilation was stopped. Each dog was then moved to the recovery room and tracheal extubation was performed once swallowing reflex was restored. Duration of anaesthesia (from induction to extubation), duration of surgery, incidence of hypotension and bradycardia and any further perioperative complications were recorded.

All dogs received meloxicam (Meloxidolor; Dechra Veterinary Products, the Netherlands) 0.2 mg kg^{-1} IV during recovery and gabapentin (Gabapentin; Sandoz, Belgium) 10 mg kg^{-1} *per os* eight hourly during the postoperative period.

Surgery

All surgeries (thoracolumbar or lumbar hemilaminectomies) were performed by three residents of the European College of Veterinary Surgeons (ECVS) with different levels of experience, following a standard technique (Kerwin et al. 2018). All surgeries were performed under direct supervision of a board-certified (Dip. ECVS) surgeon (P.P.).

Postoperative data assessment

SF-GCPS was used to assess pain during the postoperative period. Pain was evaluated at 1 hour (T1), 2 hours (T2) and then every 4 hours (T4, T8, T12, T16, T20, T24) for 24 hours after extubation. When the pain score was ≥ 5/20, 0.2 mg kg^{-1} of methadone was administered IV and pain was reassessed ~1 hour after administration. In case of a pain score ≥ 5/20, the dog received an additional dose of 0.2 mg kg^{-1} IV of methadone. The total dose of rescue methadone (MET_{tot}, mg kg^1) administered in the first 24 postoperative hours, as well as the time from the block to the first rescue methadone was recorded and compared between groups. Pain was assessed by final year veterinary students or interns who were previously trained by M.D. and A.T. in the use of the SF-GCPS and were unaware of the treatment.

Statistical analysis

The number of animals to be enrolled in the study was calculated based on the primary aim: decrease in the requirement of intraoperative fentanyl and postoperative methadone. With an α of 0.05, and a β error of 0.2, a decrease of 70% in the fentanyl requirement in the $ESPB_L$ group and a mean fentanyl infusion of 1.25 ± 0.75 μg kg^{-1} $hour^{-1}$ indicative of a successful peripheral nerve block (Vettorato et al. 2013)-a minimum of 12 dogs were required in each group. For methadone, a decrease of 60% from a total mean dose of 1.2 ± 0.6 mg kg^{-1} over the first 24 postoperative hours was calculated and the number of dogs required in each group was 11. The minimum number of dogs to be enrolled was increased to 15 to address potential losses of dogs or higher standard deviations. The normality of data distribution was evaluated with the D'Agostino–Pearson test. Skewed data were expressed as median and range while those normally distributed as mean and standard deviation. An unpaired Student's *t* test was used to compare body weight, duration of the block, anaesthesia, and surgery, FEN_{tot}, MET_{tot} and postoperative analgesic effect duration between groups. For HR, f_R, SAP, MAP and FE'Iso values, an analysis of variance (ANOVA) test for repeated data was used to evaluate the trend within each group. A Dunnet's *post hoc* test was used to compare values at T0 with all the subsequent times. A Mann–Whitney test was used to compare age, BCS and the preoperative and the different postoperative pain scores (T1, T2, T4, T8, T12, T16, T20, T24). A Chi-square test was performed to evaluate the number of fentanyl boluses and the use of noradrenaline in both groups. Data regarding atropine administration were compared with a Fisher's exact test.

Statistical difference was considered significant for $p < 0.05$. Prism Version 6.0 (GraphPad Software Inc., CA, USA) was used to analyse data.

Table 1 Group, breed, modified Frankel score (MFS) and localization of intervertebral disc extrusion (IVDE) of the dogs enrolled in the study. Dogs were allocated to one of two groups: group CNT, receiving the lumbar erector spinae block ($ESPB_L$) with saline solution; group ROPI, receiving $ESPB_L$ with ropivacaine 0.5%. L (lumbar vertebrae), T (thoracic vertebrae). CNT, control; ROPI, ropivacaine.

Group	Breed	MFS	Localization IVDE
ROPI	Chihuahua	4	L2–L3 left
	Mix breed	3	L1–L2 right
	French Bulldog	3	L4–L5 left
	Dachshund	4	T12–T13 right
	French Bulldog	4	T13–L1 right
	Poodle	4	L1–L2 left
	French Bulldog	4	L1–L2 right
	Poodle	3	L2–L3 right
	French Bulldog	4	L4–L5 left
	Dachshund	4	L2–L3 left
	Dachshund	3	T13–L1 right
	French Bulldog	3	L5–L6 right
	French Bulldog	4	L1–L2 right
	Dachshund	5	T12–T13 right
	Dachshund	3	T12–T13 right
CNT	Dachshund	5	T11–T12 right
	Cocker spaniel	3	L5–L6 left
	French Bulldog	4	L4–L5 left
	French Bulldog	3	T11–T12 right
	Dachshund	4	L2–L3 left
	French Bulldog	4	L1–L2 left
	French Bulldog	3	L3–L4 right
	Cocker spaniel	3	L1–L2 right
	Shi Tzu	4	T11–T12 right
	Jack Russell Terrier	3	L2–L3 right
	French Bulldog	4	L4–L5 left
	French Bulldog	3	L5–L6 left
	French Bulldog	4	L4–L5 right
	Dachshund	4	T11–T12 left

Results

A total of 30 dogs, classified as ASA II, undergoing thoracolumbar or lumbar hemilaminectomy for Hansen type I IVDE were enrolled in this study. The age was 48 (36–156) months in group ROPI and 60 (10–152) months in group CNT; the weight was 9.8 ± 4.7 kg and 11.9 ± 3.7 kg in group ROPI and in group CNT, respectively. BCS was 5 (4–6) in both groups. No statistically significant differences were detected between groups regarding age, weight or BCS. Breeds, MFS and IVDE localization are reported in Table 1. No differences were found regarding the preoperative pain score between groups.

No statistically significant differences were detected among groups regarding duration of anaesthesia and surgery (Table 2). HR and FE'Iso were significantly lower in group ROPI at several time points [Fig. 1(a), (b)]. No statistically significant differences were found between the surgical time points within each group for these variables. No statistically significant differences were found in SAP and MAP between the surgical time points within each group and between the two groups (Fig. 1c and d).

A significant difference between groups ($p < 0.005$) was detected regarding the rescue fentanyl administered during surgery: at least one rescue fentanyl bolus was administered in seven of 15 dogs in group ROPI. None of dogs in group ROPI needed a fentanyl infusion. In group CNT, at least one rescue fentanyl bolus was administered in all dogs. A total of eight of 15 dogs in group CNT received a fentanyl infusion. FEN_{tot} was significantly lower ($p < 0.0001$) in group ROPI than in group CNT (0.7 ± 0.9 μg kg^{-1} $hour^{-1}$ *versus* 4.3 ± 1.3 μg kg^{-1} $hour^{-1}$). Data and distribution of the use of rescue fentanyl are summarised in Tables 3 and 4.

Time elapsed between the $EPSB_L$ and the first rescue methadone was significantly longer ($p < 0.0005$) in group

Table 2 Duration of anaesthesia and surgery (minutes) in the two groups. Group CNT, receiving the lumbar erector spinae block ($ESPB_L$) with saline solution; group ROPI, receiving the $ESPB_L$ with ropivacaine 0.5%. Results are presented as mean ± standard deviation. CNT, control; ROPI, ropivacaine.

Group	Duration of anaesthesia (minutes)	Duration of surgery (minutes)
ROPI	144 ± 21.7	82.6 ± 22.2
CNT	158.3 ± 30.1	94.6 ± 27.4

ROPI than in group CNT (17.2 ± 8.7 hours *versus* 5.6 ± 7.4 hours). Pain scores in group ROPI were significantly lower than in group CNT at each time point ($p < 0.0005$) (Fig. 2). MET_{tot} administered in the first 24 postoperative hours in group ROPI was significantly lower ($p < 0.001$) compared to group CNT (0.1 ± 0.2 mg kg^{-1} *versus* 0.9 ± 0.05 mg kg^{-1}). A total of nine of 15 dogs in group ROPI and two of 15 dogs in group CNT did not receive any rescue analgesia during the first 24 postoperative hours.

Hypotension was recorded only in group CNT (three of 15 dogs): normotension was restored with one fluid bolus in two dogs, while the third dog also needed a noradrenaline infusion (0.05–0.15 μg kg^{-1} $minute^{-1}$). The occurrence of bradycardia was significantly different between groups ($p < 0.0169$): one bolus of 20 μg kg^{-1} of atropine was administered in six of 15 dogs in group CNT but none in group ROPI. No further perioperative complications were recorded.

Discussion

Results of the present study suggest that the addition of a unilateral $ESPB_L$ with a volume of 0.4 mL kg^{-1} of ropivacaine 0.5% provided better intraoperative analgesia in these dogs than in those receiving the same block with saline solution. The use of the $ESPB_L$ block thus reduced the $FENT_{tot}$ and the occurrence of intraoperative bradycardia, in comparison with dogs which received methadone alone for premedication. Unilateral $ESPB_L$ ensured a long-lasting postoperative analgesic effect, reducing postoperative methadone requirement and pain scores.

The intraoperative analgesic efficacy of a unilateral $ESPB_L$ in our study was supported by the significantly lower FEN_{tot} administered in group ROPI in comparison with group CNT. All dogs in group CNT required at least one rescue fentanyl bolus followed by an infusion in eight of 15, while only seven of 15 dogs in group ROPI needed rescue boluses. These findings

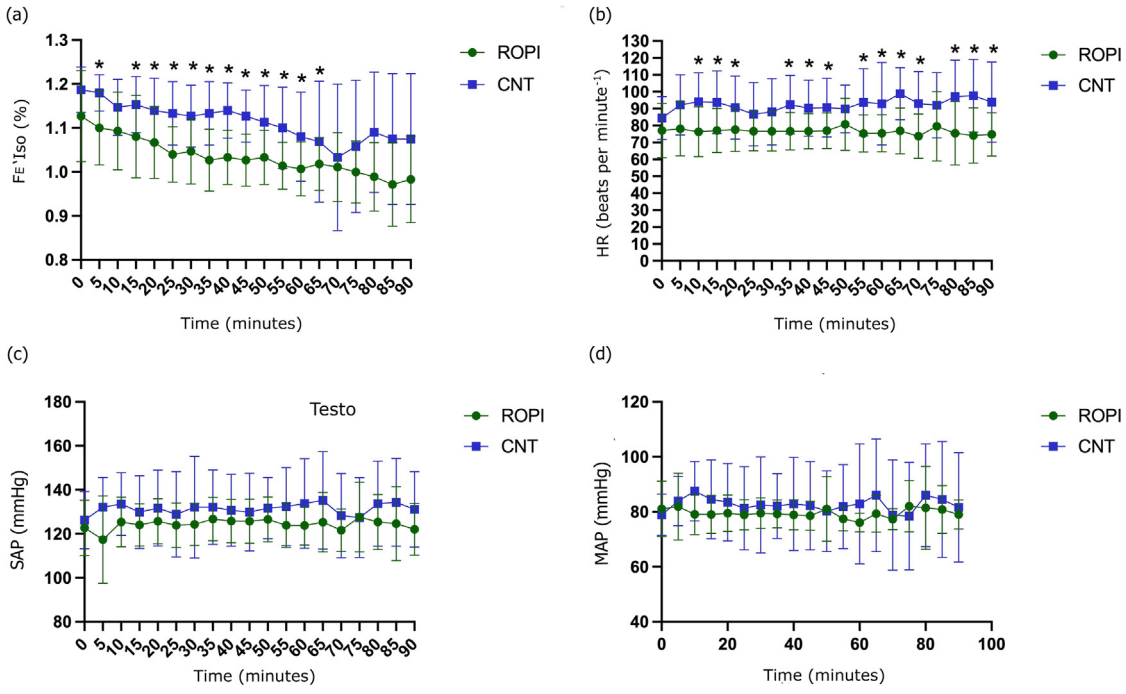

Figure 1 (a) Intraoperative end-tidal concentration of isoflurane (FE'Iso); (b) intraoperative heart rate (HR); (c) intraoperative systolic blood pressure; and (d) intraoperative mean arterial blood pressure measured in the 30 dogs enrolled in the study. Dogs were allocated to one of two groups: group CNT, receiving the lumbar erector spinae block ($ESPB_L$) with saline solution; group ROPI, receiving $ESPB_L$ with ropivacaine 0.5%. CNT, control; MAP, mean arterial blood pressure; ROPI, ropivacaine; SAP, systolic arterial blood pressure. *Significant difference between the two groups ($p < 0.05$). Data are shown as mean and standard deviation.

Table 3 Number of dogs receiving fentanyl bolus at relevant time points during surgery. Dogs were allocated to one of two groups: group CNT, receiving the lumbar erector spinae block ($ESPB_L$) with saline solution ($n = 15$); group ROPI, receiving $ESPB_L$ with ropivacaine 0.5% ($n = 15$). S_1, skin, subcutaneous, and fascial tissue incision; S_2, elevation of musculature from the vertebral laminae; S_3, removal of the articular process; S_4, drill of the vertebral laminae and pedicle; S_5, decompression of the spinal cord; S_6, fascial plane suturing; S_7, subcutaneous tissue and skin suturing. CNT, control; ROPI, ropivacaine.

Group	Number of dogs that received fentanyl boluses during surgery						
Surgery times	**S_1**	**S_2**	**S_3**	**S_4**	**S_5**	**S_6**	**S_7**
ROPI	2	—	—	—	4	2	1
CNT	5	7	7	5	8	1	7

Table 4 Number of dogs per group receiving a fentanyl infusion at relevant time points during surgery. Dogs were allocated to one of two groups: group CNT, receiving the lumbar erector spinae block ($ESPB_L$) with saline solution ($n = 15$); group ROPI, receiving $ESPB_L$ with ropivacaine 0.5% ($n = 15$). S_1, skin, subcutaneous, and fascial tissue incision; S_2, elevation of musculature from the vertebral laminae; S_3, removal of the articular process; S_4, drill of the vertebral laminae and pedicle; S_5, decompression of the spinal cord; S_6, fascial plane suturing; S_7, subcutaneous tissue and skin suturing. CNT, control; ROPI, ropivacaine.

Group	Number of dogs that received a fentanyl infusion during surgery						
Surgery times	**S_1**	**S_2**	**S_3**	**S_4**	**S_5**	**S_6**	**S_7**
ROPI	—	—	—	—	—	—	—
CNT	3	2	2	5	5	4	3

are in line with previous studies (Portela et al. 2021; Viilmann et al. 2022) in which the $ESPB_T$ was associated with a reduction of the requirements of intraoperative rescue opioids. In addition, in this study, both HR and FE'Iso were significantly lower in group ROPI than in group CNT. These data are well reported in veterinary literature and confirm the advantages of locoregional anaesthesia, such as the sparing effect on inhalant anaesthetic drugs and a more stable anaesthetic plane during surgery, in comparison with a group receiving systemic analgesia (Grubb & Lobprise 2020; Tayari et al. 2022).

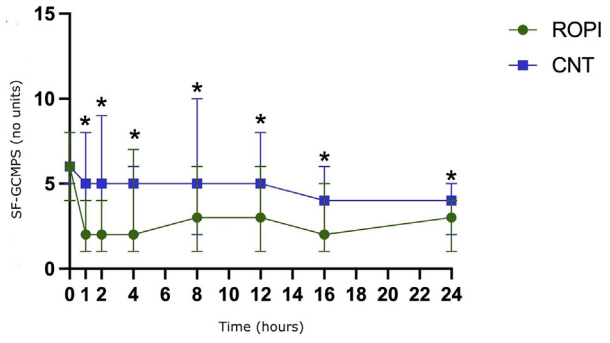

Figure 2 Preoperative (0 hour) and postoperative pain scores using the short-form Glasgow Composite Measure Pain Scale (SF-GCMPS) at 1, 2, 4, 8, 12, 16, 20 and 24 hours after extubation in the dogs enrolled in the study. Dogs were allocated to one of two groups: group CNT, receiving the lumbar erector spinae block ($ESPB_L$) with saline solution; group ROPI, receiving $ESPB_L$ with ropivacaine 0.5%. CNT, control; ROPI, ropivacaine. * Significant difference between the two groups ($p < 0.05$). Data are shown as median and range.

Innervation of epaxial muscles, vertebral laminae and facet joints in dogs is provided by the medial branches of the DRSN (Forsythe & Ghoshal 1984; Evans & de Lahunta 2013). Rescue fentanyl was not required in group ROPI during S_2, S_3 and S_4. In group CNT instead fentanyl boluses and/or an infusion were administered in a greater number of dogs (Tables 3 and 4). Therefore, unilateral $ESPB_L$ performed with ropivacaine provided satisfactory analgesia during the most invasive and painful parts of the surgery (Cavalcanti et al. 2022). These results agree with previous cadaver studies, in which $ESPB_L$ was found effective in staining the medial branches of the DRSN (Medina-Serra et al 2021; Cavalcanti et al. 2022).

Innervation of intervertebral disc, dorsal longitudinal ligament and meninges in humans is provided by the meningeal branches of the spinal nerves (MBSN) (Bridge 1959; Groen et al. 1988). Cadaver and immunohistochemical studies conducted in dogs have demonstrated the presence of innervation to these structures (Waber-Wenger et al. 2014). However, there is controversy regarding the factual existence of the MBSN and the exact branching pattern of these nerve fibres remains unclear in dogs (Forsythe & Ghoshal 1984). Notably, only four of 15 dogs needed rescue fentanyl in group ROPI during S_5, while eight of 15 required boluses and five of 15 dogs required an infusion in group CNT. Our results agree with a previous study (Viilmann et al. 2022), in which 64/93

(68.8%) of dogs receiving $ESPB_T$ did not require rescue analgesia during the removal of herniated disc material. This effect could be as a result of the migration of LA into the epidural space, even if this finding was only rarely described in a cadaver study (Medina-Serra et al. 2021). The discrepancy between these findings and the clinical effect reported in our study could be as a result of the different biophysical properties of cadaver tissues in comparison with living ones. These differences include alterations in fascial permeability and intracompartmental pressures, as described in human medicine (Chin & El-Boghdadly 2021).

Innervation of the skin and fascial planes of the dorsolateral aspect of the trunk is mainly supplied by the lateral branches of the DRSN (Forsythe & Ghoshal 1984; Evans & de Lahunta 2013). S_1, S_6 and S_7 elicited nociception in five of 15 dogs in group ROPI. Notably, IVDE in these dogs was localized between T13 and L2, where, according to Cavalcanti et al. (2022), the $ESPB_L$ resulted in less effective staining of the lateral branches of the DRSN. In the authors' opinion, this finding could explain the poor analgesic effect during surgical manipulation of the skin and superficial tissue planes. However, skin can also be innervated by fibres from the contralateral side (Capek et al. 2015). Therefore, nociception could have been prevented by performing a bilateral $ESPB_L$ block.

Unilateral $ESPB_L$ in group ROPI provided a long-lasting postoperative analgesia, reducing pain scores and MET_{tot} during the first 24 postoperative hours. Furthermore, nine of 15 dogs in group ROPI did not receive any rescue methadone. Even though different LA, volumes and approaches were used in our study, the results support the findings previously reported by Portela et al. (2021) and Viilmann et al. (2022). In our study, two of seven French Bulldogs in group CNT did not require any rescue methadone in the postoperative period. Although individual variability and influence of other postoperative treatment cannot be excluded, pain assessment might be influenced by the breed. Despite the lack of scientific evidence regarding breed differences in pain sensitivity, results from a recent survey demonstrated that Bulldogs are ranked as a low pain sensitivity breed by veterinarians and owners (Gruen et al. 2020).

Although no statistically significant differences were found regarding intraoperative values of SAP and MAP between groups, hypotension was only apparent in group CNT. This finding agrees with the study of Portela et al. (2021), in which this complication occurred more frequently in dogs receiving systemic analgesia. Hypotension is one of the most commonly described perioperative complications in dogs admitted for hemilaminectomy (Bruniges & Rioja 2019). In our study, higher FE'Iso was recorded in group CNT. Isoflurane causes dose-dependent reductions in systemic vascular resistance, and myocardial contractility (Steffey et al. 2017), thus we speculate that the sparing effect of unilateral $ESPB_L$ on isoflurane prevented the occurrence of hypotension in group ROPI.

Bradycardia was only recorded in group CNT, where six of 15 dogs required atropine. This complication is well documented in dogs undergoing hemilaminectomy (Posner et al. 2014; Bruniges & Rioja 2019; Portela et al. 2021) and could be partially as a result of the high parasympathetic tone in breeds predisposed to IVDE (Harrison et al. 2012). In the authors' opinion, bradycardia was more likely to occur in group CNT because of higher $FENT_{tot}$ administered in this group. These results support the hypothesis that unilateral $ESPB_L$ guarantees a more stable anaesthetic and analgesic plane, reducing cardiovascular complications (Portela et al. 2021).

Even though efforts were made to standardize the study design, there are some limitations which should be mentioned. First, based on ethical grounds, all dogs in our study received methadone for premedication. Therefore, we cannot exclude the impact methadone had on the analgesic effect of the unilateral $ESPB_L$ seen in this study. Second, the hemilaminectomy procedure was performed by different ECVS residents and this may have produced some variation in our results. Nevertheless, all surgeries were performed following a standardized technique, under direct supervision of the same board-certified surgeon. Third, the hemilaminectomies were performed between T11 and L2 in 15/30 dogs and caudal to L2 in 15/30 dogs. However, the $ESPB_L$ was performed using the same approach (Medina-Serra et al. 2021) in both thoracolumbar and lumbar hemilaminectomies, as suggested by previous studies (Cavalcanti et al. 2022). Fourth, the MFS score was 5/5 in two of the 30 dogs included in this study, one per group. Absence of deep pain perception could affect the overall evaluation of pain, according to other authors (Portela et al. 2021; Viilmann et al. 2022). However, in our clinical experience these dogs still experience pain in the anatomical area around the IVDE, while the absence of pain perception is usually evaluated by application of a noxious stimulus to the pelvic limbs and tail (Lewis et al. 2020). For that reason, we decided not to exclude these dogs from the study. Finally, final year students and interns assessed pain in the postoperative period. Even though they had received previous training and the SF-GCPS is routinely used in our hospital, lack of experience could have altered results regarding the postoperative analgesic effect of unilateral $ESPB_L$.

Conclusions

The unilateral $ESPB_L$ performed with ropivacaine in dogs undergoing thoracolumbar or lumbar hemilaminectomy provided superior intraoperative, prolonged postoperative analgesia and reduced total opioid consumption in the

perioperative period, in comparison with dogs which received only methadone for premedication. Our results also showed that the unilateral $ESPB_L$ provided a more stable anaesthetic plane and decreased the occurrence of intraoperative bradycardia.

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Author contributions

MD: study design, data analysis and writing of the manuscript. AB: study design, data analysis and review of the manuscript. JD, AT, PP, GB, CS: data analysis and review of the manuscript.

Conflict of interest statement

The authors declare no conflict of interest.

Institutional review board statement

The study was conducted and approved by the Institutional Ethics Committee of the University of Liege (protocol code 25/2020).

Informed consent statement

By signing the informed consent, owner agreed to enrol the dog in the study.

Data availability statement

The data presented in this study are available on request from the corresponding author.

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Appendix A. Supplementary data

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