Comparison of epidural versus intrathecal anaesthesia in dogs undergoing pelvic limb orthopaedic surgery

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Abstract and Keywords

Objective: To compare the procedural failure rate (PFR), intraoperative rescue analgesia (iRA) probability and postoperative duration of motor block after epidural and intrathecal anaesthesia in dogs undergoing pelvic limb orthopaedic surgery.

Study design: Prospective, randomized clinical trial.

Animals: 92 client-owned dogs.

Methods: Dogs were assigned randomly to receive either lumbosacral epidural anaesthesia (EA), injected through a Tuohy needle (0.1 mg kg^{-1} bupivacaine 0.5% and 0.1 mg kg^{-1} morphine 1%), or intrathecal anaesthesia with the same drugs in a hyperbaric solution (HIA) injected through a Quincke needle at the L5-L6 level, with dosage based on body mass and spinal cord length. Inaccurate positioning of the Tuohy needle, assessed by radiographic imaging, and lack of cerebral spinal fluid outflow were considered procedural failures (PFs) of EA and HIA, respectively. Fentanyl (1 μg kg^{-1} IV) was provided for intraoperative rescue analgesia. Its use was recorded as a sign of intraoperative analgesic failure. Fentanyl was administered when either the heart rate or the mean arterial pressure increased by 30% above the pre-stimulation value. The motor block resolution was postoperatively evaluated.

Results: The PFRs in the EA and HIA groups were 15/47 (32%) and 3/45 (7%), respectively (p=0.003). Differences in iRA were analysed in 26 and 30 subjects in the EA and HIA groups respectively, using Kaplan-Meier survival analysis. The iRA probability within the first 80 minutes of needle injection (NI) was higher in the EA group (p= 0.045). The incidence of dogs walking within 3 hours of NI was significantly higher in the HIA group (8/20, 40%) than in the EA group (0/17) (p = 0.004).

Conclusions and Clinical Relevance: HIA was found to have lower PF, lower intraoperative analgesic failure and faster motor block resolution. In this study HIA was shown to provide some advantages over EA in dogs undergoing commonly performed pelvic limb orthopaedic surgery in a day-hospital regime.

Keywords: dogs, epidural anaesthesia, orthopaedic surgery, spinal anaesthesia.

Main text

Introduction

Single injection epidural anaesthesia (EA) is the most performed neuraxial technique in dogs undergoing common orthopaedic pelvic limb surgery and its use is supported by abundant veterinary literature (Troncy et al. 2002; Valverde 2008; Campoy et al. 2012; Caniglia et al. 2012). Some studies have shown that EA can decrease postoperative pain and rescue analgesic requirements (Hendrix et al. 1996; Kona-Boun et al. 2006). In contrast, intrathecal anaesthesia is usually the preferred neuraxial technique in humans undergoing pelvic limb surgery in a day-surgery regime (Korhonen 2006). The feasibility, incidence of side effects and quality of intrathecal nervous block in dogs undergoing anaesthesia for pelvic limb orthopaedic surgery have been recently reported (Sarotti et al. 2011, 2013); however, studies that compare these two neuraxial techniques in a clinical setting, allowing for an evidence-based choice, are still lacking. Ideally, regional anaesthesia should be able to achieve intraoperative muscle relaxation, a prolonged sensitive block in order to limit systemic drugs administration, and rapid postoperative motor function recovery.

The aim of this study was to prospectively compare the use of epidural and intrathecal anaesthesia using bupivacaine and morphine. The procedural failure rate (PFR), intraoperative rescue analgesia (iRA) requirement and time to postoperative motor block resolution was evaluated in dogs anaesthetized for pelvic limb orthopaedic surgery.

Materials and methods

This study was approved by the Ethical Committee of the University of Padua (Prot. N. 49574) and all owners gave their informed consent.

Animals and inclusion criteria

Dogs, older than 6 months presenting to the Centro Veterinario Fossanese, from January 2011 to January 2013, for various scheduled surgical procedures involving the pelvic limbs were enrolled in this prospective study. All animals underwent a preoperative physical examination. Blood test analyses, such as packed cell volume, plasma total protein, urea, creatinine and electrolyte concentrations, were performed for all the animals. Dogs were fasted 8 hours prior to surgery, while water was freely available.

Dogs were excluded from the study when, based on clinical and laboratory examination, the American Society of Anesthesiologists (ASA) Physical Status class of assignment was III or superior and when there were reasons to consider neuraxial anaesthesia as being either absolutely (infection of the puncture site, uncorrected hypovolemia, bleeding disorders, degenerative central or peripheral diseases, anatomical abnormality of the lumbosacral region, the disapproval of the owner) or relatively (bacteremia and neurologic disorders) contraindicated. Dogs undergoing surgical procedures distal to the knee joint were excluded from iRA and postoperative evaluation. Motor block resolution was not evaluated in dogs that were unable to walk before surgery or that had postoperative bandaging of the leg.

Randomization

The estimated sample size to detect a difference in the primary endpoint (rate of iRA probability at 60 minutes) with a power of 80% and an alpha error of 5% using a two group study design has been performed with an effect size (w) of 0.61. It resulted in a minimum number of subjects of 21 in each group. The effect size (w) was calculated with a hypothesis of iRA probability in the HIA group of 10% and in the EA group of 40%. The dogs were assigned to one of the two treatment groups according to a computer-generated randomization sequence: epidural anaesthesia (EA) group or hyperbaric intrathecal anaesthesia (HIA) group, using a stratified randomization for type of surgery in order to obtain homogenous groups. All anaesthetic procedures were performed by the same experienced operator (DS), who was not blinded to the assigned technique.

Anaesthesia

All the dogs received a fentanyl bolus ranging from 1 to 3 $\mu g\ kg^{-1}$ intravenously (IV) two minutes before anaesthesia induction through a previously inserted catheter. The dosing of fentanyl was decided by the anaesthetist, based on the dog's temperament, in order to achieve stress-free anaesthesia induction. General anaesthesia (GA) was induced by administering propofol to effect and was maintained using a variable rate of propofol titrated to maintain a sluggish palpebral reflex. All patients were allowed to breathe spontaneously during anaesthesia, unless end-tidal CO_2 (P_E'CO_2) exceeded 6 kPa, in which case intermittent positive pressure ventilation (Alpha-Delta, Siare, Italy) was imposed to restore and maintain normocapnia. Lactated Ringer's solution (Ringer Lattato; Fresenius Kabi, Italy) was administered IV at 10 mL kg^{-1} $hour^{-1}$ during anaesthesia in all of the dogs. The oscillometric technique (Viridia C26, HP, Germany) was used to measure systemic arterial blood pressure every 2-3 minutes using an appropriately sized cuff placed on the distal third of the left forelimb, while the fraction of inspired oxygen (FiO_2), P_E'CO_2, electrocardiogram, arterial oxygen saturation, heart rate (HR), respiratory rate and oesophageal temperature were monitored continuously (Viridia C26, HP, Germany). In order to perform the regional technique, anaesthetized dogs were positioned in lateral recumbency and the skin over the L_3-S_1 vertebrae was aseptically prepared with chlorhexidine (4%) and alcohol (70%), after clipping the hair. The body temperature was maintained above 35ºC during the perioperative period using an active heating system (Bair Hugger Warmer Model 505, Augustine Biomedical Design, MN, USA). Thirty minutes before the end of surgery, all dogs received 0.2 mg kg^{-1} of meloxicam (Metacam 0.5%; Boehringer Ingelheim, Spain) subcutaneously (SC). At the end of surgery, the urinary bladder was manually voided. Two different experienced operators evaluated postoperative pain 30 minutes after extubation and then every 2 hours until discharge using the short form of the Glasgow composite pain scale (Reid et al. 2007). If Glasgow composite pain scale score was 6 methadone 0.1 mg Kg^{-1} was administered IM as a test dose, when it was > than 6 methadone 0.2 mg kg^{-1} was administered, as rescue analgesia..

The following perioperative events were recorded: bradycardia (HR<60 beats $minute^{-1}$), hypotension (mean arterial pressure (MAP) < 60 mmHg for at least 5 min or any MAP value lower than 55 mmHg), vomiting, pruritus and neurologic deficit. Hypotension was treated by reducing the administration of general anaesthetic and by giving a bolus of fluids (Lactate's Ringer) at 3 mL kg^{-1} IV. If MAP increased after the first bolus, an additional 2 mL kg^{-1} of fluid was administered. If the hypotension persisted, the dogs were treated with a bolus of ephedrine (50-100 µg kg^{-1}) and/or norepinephrine CRI (0.05-0.3 µg kg^{-1} min^{-1}). Urinary retention was defined as the inability to spontaneously void in the presence of bladder over-distension. Bladder over-distention was evaluated by abdominal palpation and ultrasonography in all patients that did not spontaneously urinate within 12 hours after discharge from the veterinary clinic. Owners were instructed to monitor their dog's micturition and to report episodes of prolonged sedation and marked lameness. If the owner noted that the dog had not urinated for at least 12 hours, he or she was asked to return the dog to the veterinary practice. Inaccurate positioning of the Tuohy needle, as assessed by radiographic imaging (Manchikanti et al. 2004) and lack of cerebral spinal fluid (CSF) outflow were considered procedural failures, respectively, of EA and HIA. An iRA (fentanyl 1 µg kg^{-1} IV) was administered when HR or/and MAP was raised by more than 30% of the pre-incisional value, which was defined as the mean value of the parameter during the 5 minutes prior to skin incision. One µg kg^{-1} of fentanyl IV was repeated every two minutes until HR and MAP were below 30% of the pre-incisional value. The ability to walk was tested by the same operator (DS). If necessary, dogs could be helped to get up, but they had to walk on their own. Recovery of ambulation was tested at 3, 4, 5 and 8 hours after performing the neuraxial technique, unless the dog had already been sent home because it was able to walk.

EA Group

An epidural injection was administered with a Tuohy needle (Perican 22, 20 or 18 G; B. Braun, Brazil), with the dogs in lateral recumbency, using a median approach at the level of the lumbosacral intervertebral space (L_7-S_1). The needle was advanced perpendicularly into the skin until an increase in resistance was felt, indicating the *ligamentum flavum*. The epidural space was then identified using the following clinical signs: 1) loss of resistance (LOR), assessed using an air-filled LOR syringe (Perifix, B. Braun; Germany) and 2) sudden LOR to needle advancing. The correct positioning of the needle was confirmed by a radiograph, with the animal in lateral recumbency. If the radiograph showed incorrect positioning, a further two radiographically assessed attempts were made to reach the epidural space. An isobaric solution of bupivacaine 0.5% (Bupivacaina Angelini 5 mg mL^{-1}; Angelini, Italy) at 1 mg kg^{-1} (maximum dose allowed 30 mg, 6 mL) and morphine 1% (Morfina Cloridrato; Molteni, Italy) at 0.1 mg kg^{-1} was administered over at least 20 seconds. Surgery started between 25 and 50 minutes after the epidural injection.

HIA Group

The intrathecal injection was administered using a paramedian approach at the level of the intervertebral space between L_5 and L_6. Three attempts were allowed to reach the subarachnoid space. A 75-mm-long 25 G Quincke needle (Aghi spinali; Pic, Italy) was used to administer all the intrathecal injections reported in this study. Once the CSF outflow became visible in the hub of the needle, the intrathecal solution was injected over 20-40 seconds. The needle bevel always faced cranially during administration of the intrathecal solution. Once the injection was complete, dogs were maintained in lateral recumbency with the pelvic limb to be operated lowermost for at least 12 minutes (Hocking & Wildsmith 2004).

The bupivacaine (Bupisen iperbarica 0.5%; Galenica Senese, Italy) dose calculations were based on body mass (BM) and spinal cord length (SCL). SCL was determined as being the distance between the caudal part of the L7 spinal process and the occipital bone in accordance with the following equation (Sarotti et al. 2013).

Bupivacaine 0.5% (mg): 0.21 BM (kg) + 0.035 SCL (cm)

The formula used to calculate the bupivacaine dose resulted in a dosing regimen 30% less than that suggested by Sarotti et al. (2013). The 1% morphine dose was 0.3 mg in dogs less than 10 kg, 0.5 mg in dogs between 11 and 20 kg, and 1 mg in dogs over 20 kg.

Statistical Analysis

Categorical variables were reported as frequencies and percentages and differences between groups were analysed using exact fisher's test. Continuous variables were checked for normal distribution with visual inspection of bar graphs, histograms and using the Shapiro–Wilk test. Data not normally distributed were reported as the median and the range (minimum–maximum) and differences analized with Mann-Whitney test. The significance level was set at 5% for all statistical methods. The intraoperative time-to-event probability of iRA was analysed using Kaplan-Meier survival analysis. The survival curves were analysed using the log-rank test and Hazard ratio statistic (MedCalc Softwere for Windows version 12.5 Belgium).

Results

The types of pelvic limb orthopaedic surgery and the demographic data are listed, respectively, in Tables 1 and 2. Procedural data concerning the local anaesthetic (LA) dose related to BM and SCL, the morphine dose related to BM, the fentanyl induction bolus, the propofol induction bolus, the median propofol dose consumption in the first hour, the time between the intrathecal injection and the beginning of surgery and between the intrathecal injection and the end of surgery are reported in Table 3. Intermittent positive pressure ventilation was provided to 24/26 (92%) dogs in the EA group and 25/30 (83%) in the HIA group.

Epidural and intrathecal anaesthesia were attempted on 92 dogs, with an overall PFR of 15/47 (32%) and 3/45 (7%), respectively ($p = 0.003$). The Tuohy needle was correctly repositioned and an epidural injection administered in eight out of the 15 cases in the EA group, using radiographic imaging to redirect the needle. Considering that 14 dogs were excluded because they had surgery distal to the knee joint in the EA group and 12 were excluded using the same criteria in the HIA group, a total of 26 and 30 anaesthetic periods, respectively, were analysed for intraoperative and postoperative evaluation. A CONSORT diagram is shown in Figure 1.

Procedural data concerning the local anaesthetic (LA) dose related to BM and SCL, the morphine dose related to BM, the fentanyl induction bolus, the propofol induction bolus, the median propofol dose consumption in the first hour, the time between the intrathecal injection and the beginning of surgery and between the intrathecal injection and the end of surgery are reported in Table 3.

The iRA survival probability at 60 minutes after needle injection (NI) was 64% (16/25) and 90% (26/29), respectively, in the EA and HIA groups, and 52% (11/21) and 68% (13/19), respectively, in the EA and HIA groups 80 minutes after NI. The iRA probability during surgical stimulation within the first 80 minutes of NI was higher in the EA group (P=0.045 log-rank test, Hazard Ratio 0.355, 95% CI 0.127 to 0.991) (Fig. 2). The occurrence of iRA was not related to the LA or morphine dose, BM, SCL, age or type of surgery ($p > 0.05$). There was no difference in the incidence of perioperative side effects between the groups ($p > 0.05$). The incidence of hypotension was 6/26 (23%) and 7/30 (23%), while bradycardia was found in 1/26 (4%) and 2/30 (7%) cases, respectively, in the EA and HIA groups. Two cases in the EA group and five in the HIA group needed norepinephrine CRI to maintain normotension. In the HIA group, one case of postoperative pruritus, focused in the back area, was recorded 3 hours after the intrathecal injection and was treated with a bolus of propofol (1 mg kg^{-1} IV) followed by 30 minutes of CRI (10 mg kg^{-1} h^{-1}). One case of urinary retention was recorded in the EA group and was treated by urinary catheterization 20 hours after the local injection. No nervous deficit or sign of paraesthesia was recorded 24 hours after the loco-regional technique in any patient. All patients included in this study scored less than six on the Glasgow composite pain scale, during the postoperative observation period (at least 5 hours after NI) and did not receive postoperative rescue analgesia. The return of ambulation at 3 hours and at 4 hours after NI was significantly higher in the HIA group ($p = 0.004$ and $p = 0.045$, respectively). There was not a statistical difference in the motor block resolution at 5 and 8 hours ($p > 0.05$), (see Table 4).

Discussion

This study demonstrates that a single HIA injection provides a lower PFR, a higher intraoperative analgesia efficacy and faster motor block resolution compared with a single EA injection in dogs undergoing pelvic limb orthopaedic surgery. According to our results LOR technique to identify epidural space can be inaccurate, even when executed by an expert operator in about one-third of cases. In this study, the PFR in the HIA group was five times lower than in the EA group (p = 0.003).

One reason to explain this finding may simply be the different end point for needle positioning between the two techniques. While correct positioning of the needle during IA can be ascertained by CSF outflow, the LOR technique is prone to operator subjectivity and experience. The PFR found in the EA group, using the LOR technique to identify the epidural space, was higher than previously reported for dogs (Iff & Moens 2010). In the veterinary literature, to the authors' best knowledge, this is the first work that has studied the PFR, as determined by radiographic assessment, of EA performed using the LOR technique in dogs. To evaluate procedural failure by just clinically assessing the presence of nervous block can be misleading for at least three reasons. First, the needle can correctly reach the epidural space through a different spinal segment than planned; second, as reported in the literature, the LA can, though correctly injected into the epidural space, not produce a consistent nervous block (Curatolo et al. 1995); and, third, the tip of the needle can be positioned paravertebrally next to the lumbar plexus, thus producing a nervous block of the posterior limb. Other techniques have been proposed to monitor the correct positioning of the needle in the epidural space, such as electrical stimulation, ultrasonography, fluoroscopy and detection of pressure changes on entering the epidural space (Read 2005; Iff et al. 2007; Naganobu & Hagio 2007; Carvalho 2008) but unfortunately they add to the complexity of the procedure and often require expensive equipment.

In this study, dogs undergoing EA had a significantly higher iRA probability. This finding is in accordance with what is well established for humans. Inadequate surgical analgesia, after spinal anaesthesia, has been reported as being less than 1% (Fettes et al. 2009) while it ranges between 9 and 15% after epidural anaesthesia (Curatolo et al. 1995; Kinsella 2008). In contrast to the subjective experience of many anaesthetists, failure of epidural anaesthesia is a frequent clinical problem in humans: a recent heterogeneous cohort review of 2140 surgical patients undergoing lumbar epidural anaesthesia reported a failure rate as high as 27% (Hermanides et al. 2012). However, it is difficult to meaningfully compare our data with those presented for humans for many reasons, not least because single-injection epidural anaesthesia is rarely used in daily practice in adult subjects. The use of this technique, which does not allow top-up dosing, could result in a higher incidence of inadequate control of surgical stimulation. One of the reasons that can explain the difference in efficacy between the neuraxial techniques discussed in this study arises from anatomical differences relative to the site of injection of the LA. Intrathecal anaesthesia provides a dense block due to the deposit of LA and morphine next to the spinal nerve roots, while during an epidural block the solution is injected into the extra-meningeal layer, which produces a less dense nervous block. The higher morphine concentration, around the spinal cord, produced by intrathecal injection could also have produced a faster onset time and more intense analgesic effect in the HIA group.

Another reason to explain the poorer efficacy of EA could be incorrect dosing of the LA used to perform the epidural block. The use of BM as the only predictive variable of the LA dosing might not be adequate in all canine subjects. In the authors' clinical experience and as suggested by a recent study (Otero et al. 2009) a linear correlation does not exist between the appropriate LA dosage and BM. The use of a fixed ratio between the volume of LA and BM can increase the risk of underdosing in small subjects and overdosing in heavier ones, even though the use of 6 mL as a maximum volume can limit this problem. In the HIA group, the LA dose was calculated by including the SCL in the formula along with BM. In a recent study the SCL was found to be a predictive variable of LA to control cardiovascular response in dogs undergoing pelvic limb surgery (Sarotti et al. 2011).

Inadequate surgical analgesia in the HIA group started to become apparent 80 minutes after the subdural injection, as shown by the Kapler-Meier curve, probably due to the offset of the nervous block. A similar characteristic of intrathecal nervous block in dogs has been previously reported in veterinary literature (Sarotti et al. 2013). Hyperbaric bupivacaine solution was used to perform intrathecal anaesthesia. Baricity refers to the density of a substance compared with the density of CSF. A local anaesthetic is commonly made hyperbaric by adding dextrose to the mixture, such solutions will flow in the direction of gravity and settle in the most dependent areas of the intrathecal space. The main advantage of using hyperbaric solutions is to produce a profound unilateral spinal block with a reduced haemodynamic impact (Di Cianni et al. 2008).

This study included dogs undergoing different orthopaedic procedures. As a consequence, surgical stimulation may have been variable in terms of intensity and nerves involved in the nociceptive transmission. In order to reduce this source of variability, dogs undergoing surgery below the knee joint were excluded from iRA and postoperative analysis. The vast majority of nociceptive nerves involved in the surgical stimulation on the distal part of the rear leg belong to the sciatic nerve.

The major study limitation of this work is that the operators collecting the data were aware of the group assignment of the dogs enrolled. This limitation may have influenced our findings. Subjects belonging to HIA group may have been involuntary kept at a deeper level of anaesthesia by the operators, introducing a bias in the study. The use of propofol, to maintain anaesthesia, may have led this error to be more frequent compared to the use of a volatile anaesthetic agent, due to the lack of monitoring of anaesthetic concentration.

No subjects enrolled in this study required rescue analgesia during the postoperative observation period (maximum 8 hours). The limited observation time of our study did not allow a true comparison between the analgesic properties of EA and HIA. The motor block resolution time was faster in the HIA group, with a significant difference at 3 hours ~~($p = 0.004$)~~ and 4 ~~hours ($p = 0.045$)~~ after the LA injection even if no difference was found at 5 hours. This finding is in accordance with what is reported in humans (Atef et al. 2010). Various factors influence the offset of motor block produced by neuraxial techniques. A possible explanation of the slower motor block recovery produced by EA can be the much higher dose of LA used in comparison with spinal anaesthesia and the persistence of the LA within the vertebral canal absorbed by the epidural fat, which acts as a reservoir for the drug (Reina et al. 2009). Hyperbaric intrathecal anaesthesia is the most commonly used neuraxial technique in day surgery procedures in human patients. It has been proven to provide recovery and discharge times comparable with short-acting general anaesthetics such as propofol, desflurane and sevoflurane (Ben-David et al. 2001; Lennox et al. 2002). Continuous, and not single-shot, epidural anaesthesia using short-acting LAs has also successfully been used in day surgery procedures; however, considering the technical difficulties, the longer preparation time and the onset time of the nerve block, this technique is not normally used (Michael et al. 2003).

There were no significant differences in perioperative side effects between the HIA and EA groups. Hypotension was the most frequent effect in both groups and was generally resolved by fluid bolus administration, a lighter plane of anaesthesia and, in some cases, the use of vasoactive drugs in both groups.

No sign of dural puncture was found in the over 40 epidural punctures successfully performed in this study. Iff and Moens (2010) reported an incidence of 4% of subarachnoid puncture over 98 epidural blocks. In two different papers by Bosmans and colleagues a fatality (Bosmans et al. 2011) and an incidence of Horner's syndrome (Bosmans et al. 2009) potentially caused by an accidental intrathecal injection were reported. In the authors' opinion, the use of a Quincke spinal needle to perform EA may play a role in increasing the risk of a dural puncture. The use of a Tuohy needle makes it easier to perceive a LOR to needle advancement and a dural puncture less probable due to its blunt curved cutting tip (Hadzic ~~1997~~2007).

This study shows that the use of HIA in dogs undergoing common pelvic limb surgeries provides a lower PFR, a lower risk of intraoperative cardiovascular response to surgical stimulation for at least 80 minutes, and earlier motor block resolution, with a similar incidence of side effects as the single-shot EA technique. Epidural and intrathecal anaesthesia have different characteristics and, consequently, different indications for use; however, in this study, HIA has been shown to provide some advantages over EA in dogs undergoing commonly performed pelvic limb orthopaedic surgery in a day-hospital regime.

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Figure legends

Fig. 1 The CONSORT diagram on patient recruitment, inclusion, and exclusion is shown. EA (Epidural anaesthesia), HIA (Hyperbaric intrathecal anaesthesia), iRA (intraoperative rescue analgesia).

Fig. 2. The time-to-event probability of intraoperative rescue analgesia (iRA) was analysed using Kaplan-Meier survival analysis for epidural anaesthesia (EA) and hyperbaric intrathecal anaesthesia (HIA). The iRA survival probability was not significantly different between groups for the entire study period (p = 0.0536 log-rank test, Hazard ratio 0.418, 95% CI 0.168 to 1.041), but the EA group required more iRA during the first 80 minutes (P=0.045 log-rank test, Hazard ratio 0.355, 95% CI 0.127 to 0.991). "Censored" refers to subjects for which no events (iRA) were observed during surgery period.Censored data in the graph were marked with a small vertical line.

Table 1.

Types of surgical procedures and anaesthesia (EA: epidural anaesthesia and HIA: intrathecal anaesthesia with hyperbaric solution) included in the study. TPLO (Tibial Plate Levelling Osteotomy); ESCCL (Extracapsular Stabilization of Cranial Cruciate Ligament); DPO (Double Pelvic Osteotomy); FHNO (Femoral Head and Neck Ostectomy).

	EA (26)	HIA (30)
TPLO	10	9
ESCCL	5	7
FHNO	2	3
Luxating patella	4	3
DPO	2	2
Femoral fracture	1	2
Others	2	4

Table 2.

Demographic data of dogs that met the inclusion criteria for intraoperative and postoperative evaluation. EA (epidural anaesthesia) and HIA (intrathecal anaesthesia with hyperbaric solution); BM: body mass; SCL: spine cord length; ASA, American Society of Anesthesiologists.

	EA (n =26)	HIA (n =30)
Type of breed	Mongrel (16), Labrador (2), Yorkshire (2), Beagle (1), West Highland White Terrier (1), Collie (1) German Shorthaired Pointer (1), Scottish Shepard (1), Bernese Mountain Dog (1)	Mongrel (12), Labrador (5), Yorkshire (4), Cane Corso (2), American Staffordshire Bull Terrier (1), Poodle (2), Boxer (1), German Shepard (1), Italian Spitz (1), Neapolitan Mastiff (1)
Median (range) age (Years)	6 (0.5-13)	7 (0.6-14)
Median (range) BM (kg)	8.2 (4-33)	13 (1.8-56)
Median (range) SCL (cm)	45 (33-76)	47.5 (30-85)
ASA	ASA I (22) ASA II (4)	ASA I (26) ASA II (4)

Table 3.

Procedural data according to EA (epidural anaesthesia) or HIA (intrathecal anaesthesia with hyperbaric solution); BM: body mass; SCL: spine cord length; Ii, intrathecal injection.

	EA	HIA	*p*-value
Median (range) bupivacaine dose related to BM (mg kg^{-1})	1	0.35 (0.26-0.85)	
Median (range) bupivacaine dose related to SCL (mg cm^{-1})	0.21 (0.11-0.48)	0.1 (0.18-0.05)	
Median (range) morphine dose	0.1	0.04 (0.02-0.16)	
Median (range) fentanyl bolus (µg kg^{-1} IV)	2 (1-3)	2 (1-3)	$p > 0.05$
Median (range) propofol induction bolus (mg kg^{-1} IV)	5 (3-6)	5 (3-6)	$p > 0.05$
Median (range) propofol dose consumption in the first hour (mg kg^{-1} IV)	25 (15-38)	23 (15-35)	$p > 0.05$
Median time (range) between Ii and beginning of surgery (min)	30 (25-50)	27.5 (15-39)	$p > 0.05$
Median time (range) between Ii and end of surgery (minutes)	88 (50-140)	94 (50-150)	$p > 0.05$

Table 4.

Resolution time of motor block. At 3 and 4 hours after local anaesthetic injection there is a statistical difference in the motor block resolution between the EA (epidural anaesthesia) and HIA (intrathecal anaesthesia with hyperbaric solution) groups.

Dogs able to walk	EA (26)	HIA (30)	*p*-value
At 3 h	0/17	8/20 (40%)	$p = 0.004$
At 4 h	4/17 (24%)	12/20 (50%)	$p = 0.045$
At 5 h	11/17 (65%)	17/20 (85%)	$p > 0.05$
At 8 h	17/17 (100%)	20/20 (100%)	$p > 0.05$