Hypobaric intrathecal anaesthesia for partial hemipelvectomy in a dog

L. Novello1,2, B. Carobbii, N. J. Bacon1, R. A. S. White1
1Dick White Referrals, Six Mile Bottom, Newmarket, Suffolk, UK
2Department of Anaesthesia, the Queen’s Veterinary School Hospital, Cambridge, UK

Summary

Objective: To report the intrathecal use of a hypobaric anaesthetic solution for partial hemipelvectomy in a nine-year-old, neutered female, Golden Retriever dog, weighing 34 kg. Methods: Under inhalational anaesthesia, with the dog lying in lateral recumbency and the surgical side uppermost, 1.9 ml of a hypobaric solution containing 3.42 mg of bupivacaine and 0.66 mg of morphine were administered in the subarachnoid space at L5–L6 level 30 minutes before surgery. Following the intrathecal injection the dog was maintained for five minutes in a 10° head-down position, then for three minutes in a 10° head-up position. Results: Apart from a transient increase in heart and respiratory rates during resection of the sartorius muscle, which was treated with a plasma Target Controlled Infusion (TCI) of fentanyl, spinal anaesthesia provided cardiovascular stability and excellent relaxation of the surgical site. Neither motor blockade nor proprioceptive deficit were apparent in the contra-lateral hind limb at recovery, 200 minutes after injection. Postoperatively, rescue analgesia was not required in the 48 hours following surgery. Clinical significance: In dogs, the use of intrathecal hypobaric bupivacaine and morphine as a part of a balanced anaesthetic protocol should be considered during unilateral major orthopaedic surgeries of the pelvis and hind limb, as it allowed a reduction in the dose administered compared to isobaric solutions, providing selective spinal anaesthesia, excellent long-lasting analgesia, and rapid recovery of ambulation.

Keywords

Spinal anaesthesia, selective spinal anaesthesia, analgesia, intrathecal, hypobaric, regional anaesthesia, SSA

Introduction

Spinal anaesthesia consists of the administration of a local anaesthetic solution into the cerebrospinal fluid (CSF) in order to provide effective anaesthesia at the site of surgery. In humans it has been widely and successfully used for over 100 years, especially for procedures involving the lower abdomen, perineum, and the legs. In the last 20 years a better understanding of mechanisms involved in spinal anaesthesia has led to the investigation of the use of minimal doses of intrathecal agents to provide satisfactory surgical conditions, earlier discharge times compared to conventional approaches, and a decreased incidence of adverse effects (1–3).

The weight of the anaesthetic solution injected in relation to the weight of CSF, the dose of the anaesthetic solution, and the position of the patient at the time of injection and for some time thereafter are the most important factors in determining the spread of an intrathecally injected anaesthetic solution (4, 5). Low-dose hypobaric local anaesthetics can provide a predominantly unilateral spinal block (6), and the adjunct of analgesic additives to local anaesthetics provides better and longer lasting sensory blockade (7–9), without increasing the intensity and duration of motor block or delaying recovery of voluntary urination or the ability to walk (10).

Although the successful use of low-dose local anaesthetic-opioid combination for spinal anaesthesia has already been reported (11, 12), to authors’ knowledge there have not been any reports about the clinical use of hypobaric anaesthetic solutions for selective spinal anaesthesia (SSA) in small animals.

In this study, we report on a SSA with low-dose hypobaric bupivacaine and morphine in a dog undergoing partial hemipelvectomy.

Clinical report

A nine-year-old, neutered female, Golden Retriever dog, weighing 34 kg, was referred for investigation and management of a grade 1 soft tissue sarcoma of the left thigh. At presentation the left thigh was swollen on the proximal medial aspect, although the dog was not lame and it was not painful to palpate. A magnetic resonance imaging (MRI) scan of both hind limbs and the pelvis revealed a poorly defined and infiltrative soft tissue mass in the intermuscular space of the left thigh, encroaching on the ventral aspect of the coxo-femoral joint and extending caudally and laterally around the femur. According to these findings, the dog was scheduled for left partial hemipelvectomy.

The pre-anaesthetic physical examination revealed an overweight patient, with an estimated lean body mass (LBM) of 28 kg and a measured crown-rump length of 76 cm. A history of drug sensitivity or bleeding was not reported, and the dog had been on oral tepoxalin (250 mg) and enrofloxacin (200 mg) once a day for the previous 16 days. Thoracic and abdominal survey radiographs, and abdominal survey ultrasound were normal, and problems were not reported during anaesthesia for the MRI scan three days previously. Pre-anaesthetic haematological examination, serum biochemical profile, and electrolytes were within the normal reference ranges. The physical condition of the dog was scored ASA II according to the preoperative assessment scale of

a Zubrin, Schering-Plough Veterinary, Welwyn Garden City, Hertfordshire, UK
b Baytril, Bayer HealthCare, Kiel, Germany.
the American Society of Anesthesiologists. The examination of radiographs and MRI images did not reveal any contraindication to lumbar puncture; however anatomical landmarks were not easily palpated. According to the surgical site, the expected extension and duration of surgery, and the need for a rapid recovery of ambulation, a hypobaric spinal anaesthesia was planned.

**Anaesthetic technique**

Diluted (0.1 mg ml\(^{-1}\) in water for injection) medetomidine\(^c\) (0.07 mg) was administered intramuscularly as a pre-anaesthetic medication. Thirty minutes later, a 0.9 mm (20 gauge) catheter (Jelco, Medex Medical Ltd, Rossendale, UK) was placed in the left cephalic vein, and an infusion of lactated Ringer’s solution (Isolec, Ivex Pharmaceuticals, Larne, UK) was started. General anaesthesia was induced with midazolam\(^d\) (5 mg IV) followed by propofol\(^e\) (80 mg IV) and maintained with isoflurane\(^f\) in oxygen with spontaneous ventilation. During the procedure, the isoflurane concentration delivered ranged from 1.8 to 2.1% (vaporizer setting), using a fresh gas flow (FGF) of 0.8 L min\(^{-1}\) in a small animal circle breathing system.

Ketamine\(^g\) (14 mg IV over five minutes) was administered 10 minutes before the first incision, and then every 60 minutes until the end of surgery. After induction of anaesthesia, a 0.7 mm (22 gauge) catheter (Jelco, Medex Medical Ltd, Rossendale, UK) was placed in the right dorsal pedal artery and direct arterial blood pressure was measured continuously using a pre-calibrated transducer connected to a monitor. Inspiratory and end tidal carbon dioxide, electrocardiogram, pulse oximetry, heart and respiratory rates, temperature and blood losses were monitored continuously throughout the procedure.

The dog was placed in right lateral recumbency with the surgical side uppermost, and the dural puncture was performed under fully aseptic conditions at L5-L6 interspace using a spinal needle (SpinoCan; 22G 88 mm; B.Braun, Melsungen, Germany). Once a free flow of clear CSF was obtained, 1.9 ml of a solution containing 3.42 mg of 0.18% bupivacaine and 0.66 mg of preservative-free morphine (made up with 0.5% bupivacaine\(^h\) 0.9 ml + 1% morphine\(^i\) 0.087 ml + sterile distilled water\(^j\) to 2.5 ml) was injected in the subarachnoid space. Before injection the solution was heated to 39°C. Finally, a 6 Fr Foley urinary catheter was aseptically placed, and a purse-string suture around the anal sphincter followed. Immediately after the intrathecal injection the dog was maintained for five minutes in a 10° head-down position (10° Trendelenburg position), then for three minutes in a 10° head-up position (10° reverse Trendelenburg position), then in a 5° Trendelenburg position for the rest of the procedure.

Surgery started 30 minutes after subarachnoid injection. A left-sided partial hemipelvectomy was performed with osteotomies through the mid ilium, and the cranial and caudal pubic bones of the left obturator foramen. An active suction drain was placed before closure. The heart rate (HR) ranged from 104 to 121 beats min\(^{-1}\), the respiratory rate (RR) from 15 to 22 breaths min\(^{-1}\) (bpm), the mean arterial blood pressure (MAP) from 74 to 79 mmHg, and the end-tidal carbon dioxide from 6.0 to 7.0 kPa. Before resection, major nerves were blocked using perineural 0.25% bupivacaine\(^k\) (2 ml in total).

Although neither purposeful movements nor sympathetic response to surgical stimulation were observed, a mild increase in heart and respiratory rates (HR 133, RR 26) was noticed during resection of the sartorius muscle. A fentanyl infusion was immediately started using a TCI system (Computer Control Infusion Pump, Department of Anaesthesia and Intensive Care, The Chinese University of Hong Kong, Hong Kong) set at 0.5 ng ml\(^{-1}\) plasma concentration according to drug kinetic in dogs (13), decreased to 0.3 ng ml\(^{-1}\) 12 minutes later, and stopped 13 minutes later. No cardiorespiratory instability was noticed during the remaining 90 minutes of surgery. According to blood losses (700 ml), 900 ml of lactated Ringer’s solution and 150 ml of Hetastarch were infused to restore circulating volume, and 450 ml of fresh blood was administered at end of surgery on recovery.

Recovery from anaesthesia was unremarkable, and the dog was extubated 200 minutes after subarachnoid injection. At that time the predicted fentanyl plasma concentration was 0.06 ng ml\(^{-1}\). Postoperatively, pain was assessed at two-hour intervals during the first 24 hours, and at six-hour intervals thereafter using the Mathews Pain Scale (a descriptive scale with score ranging from 0 to 10) (14) with the indication to administer analgesics if the pain score was 3 or higher.

Ten minutes after extubation the dog was in sternal recumbency, fully awake and responsive, breathing normally, and haemoglobin oxygen saturation was 97%, measured with a pulse oxymeter (SpO\(_2\)) while the dog was breathing room air. At this stage neither motor blockade nor proprioceptive deficit were noticed in the remaining hind limb. Patellar and tibial reflexes, and proprioception were normal. The dog was able to move the leg normally and stand, although muscle strength was weak. However, it was encouraged to lie in sternal recumbency until the blood transfusion was terminated. According to pain scores rescue analgesia was not required for the next 48 hours. With the dog breathing room air, clinical evidence of respiratory depression was investigated assessing respiratory rate and pattern, chest expansion, sedation and pulse oximetry monitoring at six, eight and 10 hours after subarachnoid injection, as described elsewhere (15). A respiratory rate lower than 8 bpm, inadequate respiratory effort, and SpO\(_2\) lower than 94% were not detected at any relevant time. The dog ate a small meal two hours after recovery from anaesthesia. The urinary catheter was removed after 24 hours, and urination was observed to be normal thereafter. Swelling of the wound fol-
lowed drain removal two days after surgery, and buprenorphine (0.3 mg IM every eight hours) was started 48 hours after subarachnoid injection because the pain score increased to 3. Buprenorphine was discontinued the next day. Neither complications nor neurological sequelae of spinal puncture were noticed until discharge.

Discussion

Spinal anaesthesia has a rapid onset, and compared with epidural anaesthesia, provides equivalent levels of sensory analgesia with a lower dose, resulting in the plasma levels of the drugs being too low to have direct systemic effects. It also provides better modulation of both intra- and post-operative endocrine and metabolic responses to surgical trauma, compared to general anaesthesia. In humans, major indications to spinal anaesthesia are surgical procedures involving the rectum, the lower urinary tract, lower limbs, and the lower abdomen. The same considerations should also apply to small animals.

The authors have attempted to produce selective spinal anaesthesia with minimal motor block on the contra-lateral side in order to facilitate patient comfort immediately after surgery, because a prolonged motor block or a proprioceptive deficit would decrease the ability to use the remaining hind limb, and an early return to walking and activity after amputation typically results in shorter hospitalization time and complications.

Baricity is the ratio between the density of an anaesthetic solution and the density of the CSF: if the baricity of a solution is 1.0, it is by definition isobaric; if greater than 1.0 it is hyperbaric; if less than 1.0 it is hypobaric. Because density is inversely related to temperature it must be measured at the same temperature, preferably at normal body temperature, when it is involved in the calculation of baricity. We used 0.18% bupivacaine, obtained by diluting 0.5% bupivacaine in sterile water at 39°C. The calculated density of this solution is 0.997 g ml⁻¹ at 25°C, while the median density of canine CSF has been reported to be 1.010 (1.005–1.017) (16). The solution used therefore meets all of the criteria to be considered hypobaric in all patients.

The injection of non-isobaric anaesthetic solutions in a patient lying in the same position for 10–30 minutes may result in a preferential distribution of anaesthesia (17), although it has been reported that a spread of the block can still occur after 20 minutes even if a very low dose of hypobaric local anaesthetic is used (6). Non-isobaric anaesthetic solutions will move within the CSF according to their density, then baricity can be used to move the anaesthetic solution within the CSF along the cord, not only to achieve a unilateral block.

In the case reported herein, lateral recumbency with the affected leg uppermost was used to achieve a preferential unilateral block. The Trendelenburg position was initially used to achieve a more dense caudal block, then the reverse Trendelenburg position was used to extend the cranial spread of the solution. The low-dose hypobaric solution was used in an attempt to achieve a selective spinal anaesthesia of the surgical site.

Although the baricity and the dose of the local anaesthetic, and the position of the patient at the time of injection and for some time thereafter determine the spread of the solution within the CSF (4, 5), the local anaesthetic selected and the dose administered affect both the quality of anaesthesia provided and the time to recovery of voluntary urination and ambulation (5, 18).

Selective spinal anaesthesia (SSA) has been defined (19) as ‘the practice of employing minimal doses of intrathecal agents so that only the nerve roots supplying a specific area and only the modalities that require to be anesthetized are affected’. This implies that an effective spinal anaesthesia providing an excellent and long lasting sensory block does not necessarily require a profound or prolonged motor block. Moreover, it has been emphasized that since light touch and proprioception may be present after selective spinal anaesthesia, patients may be aware of certain stimuli: they do not feel any pain with any surgical stimulus, however they may need reassurance or sedation (9).

In order to achieve an adequate level of blockade for hemipelvectomy, L2-S2 dermatomes need to be anaesthetised. Although in this case the authors used a very low dose of bupivacaine (0.12 mg kg⁻¹ LBM or 0.045 mg cm⁻³) and morphine (0.023 mg kg⁻¹ LBM) compared to the dose that is usually suggested for intrathecal administration in dogs (bupivacaine 0.5–0.6 mg kg⁻¹ or 0.25–0.3 mg cm⁻³, morphine 0.05–0.18 mg kg⁻¹) (20), the sensory block appeared to be adequate for the procedure. Whilst a sudden increase in heart and respiratory rates, but not in arterial pressure, in response to a surgical stimulus involving the L2 and L3 dermatomes suggested the administration of fentanyl for a short period of time, it should be considered that the target plasma concentration achieved is more likely to relieve discomfort than pain (21). Furthermore, the very low predicted plasma concentration at the time of recovery from anaesthesia rules out any fentanyl contribution to postoperative analgesia. In humans, the use of fentanyl to relieve discomfort and anxiety during regional anaesthesia is well documented.

In humans the intrathecal administration of a low-dose hypobaric bupivacaine has been shown to provide a predominantly unilateral block, with a mean duration of anaesthesia estimated by patients of 210 minutes (6). Interestingly, in the same study a very low incidence of hypotension and absence of urinary retention have also been noticed. The patient described here was cardiovascularly stable throughout the procedure, and did not experience hypotension or bradycardia at any time. Mean blood pressure decreased about 9 mmHg and heart rate about 15 beats min⁻¹ in the five minutes following intrathecal injection, and remained unchanged thereafter. This seems to agree with human data suggesting that non-isobaric local anaesthetics exert very little cardiovascular effects (17, 6).

Intrathecal opioids selectively decrease nociceptive afferent input from A-delta and C fibres, thus enhancing antinociceptive effects of bupivacaine, without affecting sympathetic efferent pathways (7). However, they also produce several adverse effects.
including sedation, nausea and vomiting, bradycardia, and respiratory depression in a dose-dependent fashion. Clinically, the addition of analgesics to intrathecal local anaesthetics has been shown to produce enhancement and increased duration of sensory analgesia, without increasing the intensity of motor block or prolonging recovery of ambulation and bladder function (10, 22).

Although intrathecal morphine provides long lasting analgesia distant to the site of injection (23), it has a slow onset of action and carries an increased risk of delayed respiratory depression compared to lipophilic opioids (5). It has been suggested that decreasing the dose administered may minimise the incidence of side effects without significantly affecting analgesia (8, 24). In small animals the intentional subarachnoid administration of opioids is uncommon, although subarachnoid fentanyl administration during elective spinal anaesthesia has already been reported (11, 12, 25). In a dog, the preoperative intrathecal administration of a morphine dose as low as 0.03 mg kg⁻¹ provided excellent long lasting analgesia without any adverse effects (15).

In our patient, analgesia was excellent for 48 hours postoperatively, then buprenorphine was administered to relieve discomfort probably related to soro-haemorrhagic fluid accumulation in the wound dead space. The next day the fluid was drained and buprenorphine administration was discontinued.

Based on respiratory rate, respiratory effort, sedation and pulse oximetry monitoring, there was no evidence of a clinically significant respiratory depression at six, eight and 10 hours after spinal injection. Se-
dation was not detected at any time after recovery from anaesthesia.

In human medicine, a consensus has not been reached regarding the most appropriate method of respiratory monitoring for patients who have been treated with neuraxial opioids (26), although respiratory rate is the most commonly used. Neuraxial opioid-induced respiratory depression develops slowly and progressively, and is generally preceded by nausea, vomiting and increased sedation. Therefore, vigilant nursing observation, documentation of inadequate respiratory effort, slow respiratory rate, or unusual somnolence represent the best form of monitoring. Compared to respiratory rate, pulse oximetry has been considered to be a more sensitive indicator of respiratory depression (27). Although pulse oximetry does not detect hypercarbia, hypoventilation may decrease arterial oxygen partial pressure (paO₂) and cause life-threatening hypoxemia. Interestingly, moderate and severe hypoxaemia have been related to sedation, to perioperative systemic opioid administration on top of spinal analgesia, and to postoperative patient-controlled analgesia systems (27, 28).

We were unable to assess urinary retention because the dog had a urinary catheter in place for 24 hours postoperatively. Although in small animals the inability to urinate in the postoperative period has been associated with both pelvic surgery as neuroaxial anaesthesia, it has been suggested that dogs that are able to stand and walk are also able to void urine voluntarily (29).

In summary, we have provided a detailed description of the execution of a selective spinal anaesthesia as a part of a balanced anaesthetic protocol using hypobaric bupivacaine and morphine, discussing advantages and disadvantages. Intraoperative anaesthesia was good, and postoperative analgesia excellent and long lasting. Further studies on a larger scale are warranted to standardize the technique and to further assess drugs and doses to be used in dogs and cats.

Acknowledgements
The authors gratefully thank all of the staff and interns, radiologists, and nurses at Dick White Referrals, Suffolk, UK, for their cooperation and assistance.

*Presented as a poster at the ECVS Meeting, Dublin, Republic of Ireland, June 28–30, 2007.

References

Hypobaric intrathecal anaesthesia for partial hemipelvectomy


Correspondence to:
Lorenzo Novello, Med Vet, Diplomate ESRA, MRCVS
c/o ISVRA–Italian Society of Veterinary Regional Anaesthesia and Pain Medicine
via Meucci 13, 30016 Jesolo (Venice), Italy
Phone: +39 346 0683855
E-mail: novello@isvra.org

BOOKREVIEWS

Feline Orthopedics
H. Scott, R. McLaughlin
384 pp, Hardcover
Blackwell Publishing, 2006

The book is divided into 13 chapters. The first five chapters are dedicated to the principles of orthopaedic diagnostics, classification, decision making and instrumentation. Chapter 1 provides a valuable introduction to feline orthopaedics, with a brief comparison to dogs, followed by emphasis on features specific to the feline patient and their significance. Chapter 3 provides a relatively complete and valuable review of the management of the feline trauma patient. Fracture fixation methods and implants appropriate to cats are comprehensively outlined in Chapters 5 and 6. The often overlooked topic of feline arthrology, which is presented in Chapter 7, is particularly interesting in that it provides a discussion of joint diseases shared by dogs and cats, but more importantly details the disorders and features that are unique to the feline patient. Chapters 8 through 11 detail the management of specific fractures in the traditional fashion of division of chapters by anatomical location. Of particular value are chapters 11 and 12 which discuss fractures and disorders of the spine and neuromuscular disorders in cats. These sections include helpful tables on lesion localization and extensive differential diagnoses. The final chapter contains sections on metabolic and nutritional disorders, neoplasia, infection and congenital abnormalities.

Overall, the content of this book is comprehensive and well illustrated. The pictures and radiograph reproduction are of excellent quality. The illustrations are clear and their style and quality are consistent throughout the book. The illustration style is quite familiar in format to other popular surgery textbooks. Coloured tables are particularly useful for the highlighting of key information, such as normal values and differential diagnoses. The information is current and recent references have been used. Surgical techniques are briefly described with occasional illustrated approaches. A good general surgical knowledge of approaches and orthopaedic techniques is a prerequisite before attempting procedures because the descriptions provided are somewhat limited in scope. It is apparent that the purpose of this book is not to provide a step-by-step description of all feline orthopaedic surgical procedures. That being said, the book does provide a fairly comprehensive summary of the current literature and techniques commonly utilized. After reviewing this textbook, the only real criticism is a minor one, namely the format for referencing. All of the references are divided up by chapter, and are to be found at the end of the textbook, instead of at the more convenient end of the chapter.

In conclusion, I have enjoyed reviewing this book as well as having utilized it in clinical practice. It is a very good reference material and a tool for anyone involved in the diagnosis and treatment of musculoskeletal disorders of the cat. It represents a very good addition to the library of students, interns, residents and practitioners alike. This book will advance a species specific approach to diagnosis and treatment of feline orthopaedic disorders and as the introduction of the book states, ‘cats are not small dogs’.