COLEGIUL MEDICILOR VETERINARI DIN ROMÂNIA

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ACTUALITATI IN ANESTEZIA EPIDURALA LA BOVINE

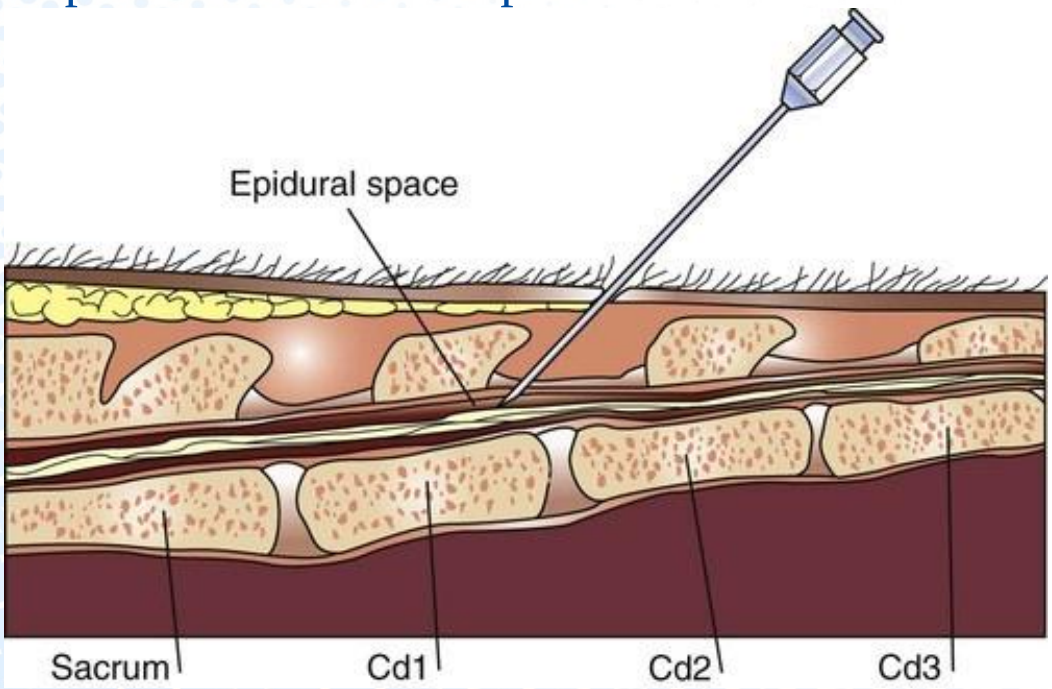
Lect.univ.dr. Lescai Daniel FMV Spiru Haret

- Rumegatoarele sunt candidati nepotriviti pentru anestezia generala ca urmare a posibilelor riscuri de complicatii precum regurgitarea, timpanismul, degenerarea musculara. De aceea este preferata realizarea inerventiilor chirurgicale in pozitie patrupodala si cu anestezie locala. Cele mai comune modalitati de a realiza anestezie locala sunt blocurile paravertebrale (proximal, distal, L), infiltrarea locala sau pe linia de incizie, infuzia intravenoasa la nivelul membrelor si anestezia epidurala.

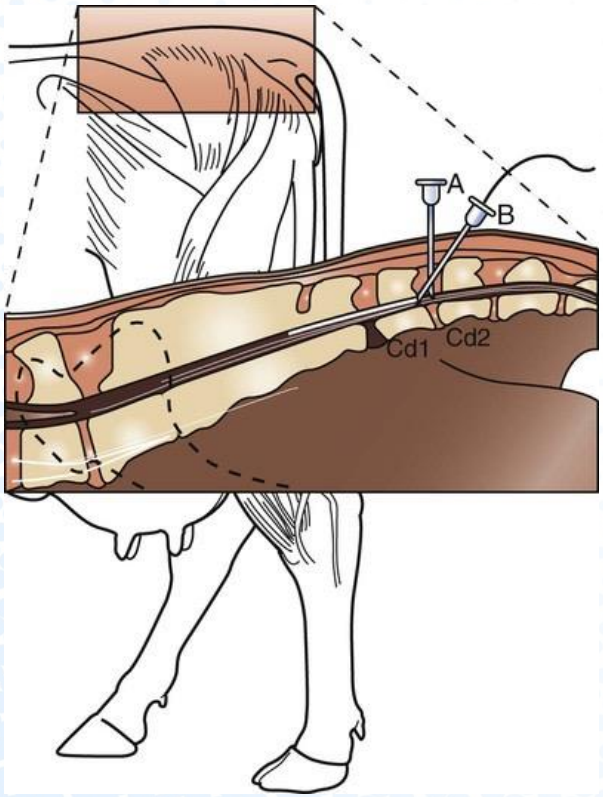
- Numeroase interventii obstetricale, proceduri la nivelul anusului, perineului, ugerului caudal, scrot se realizeaza sub ***anestezie epidurala***. Chiar si controlul tenesmelor poate fi realizat prin anestezie epidurala.

Tehnica administrarii epidurale si clasificari

- La animalele mari, cele mai comune locuri de administrare a agentilor anestezici sunt **primul spatiu vertebral intercoccigian** (Co1-Co2) si spatiul vertebral **sacrococcigian** (S5-Co1). Tehnica este considerata una simpla la animalele mari, se poate realiza in statiune patrupodala si nu necesita, in acest caz, echipament special cu exceptia plasarii de catetere epidurale.

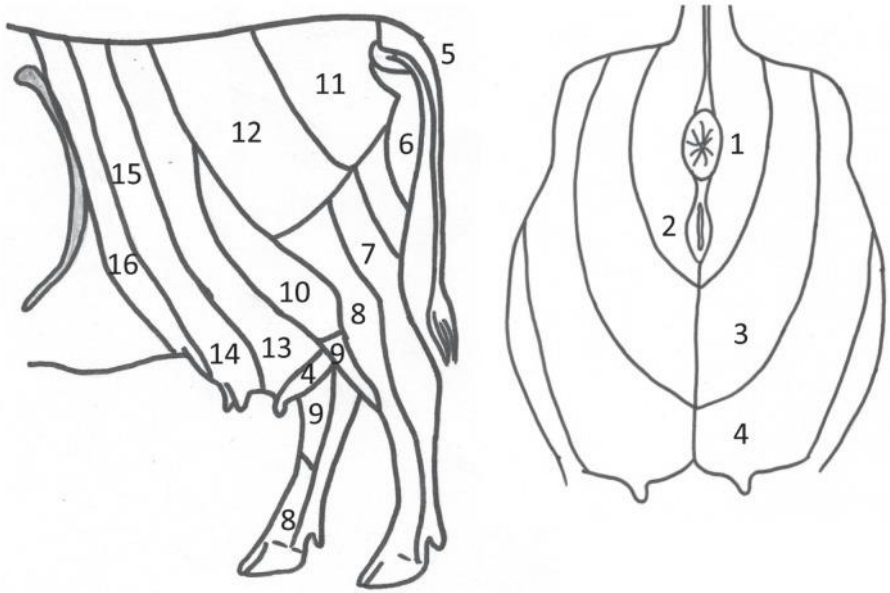


- Locul administrarii poate fi identificat prin miscarea in sus si in jos a cozii, sub forma miscarilor de pompa, iar spatiul intervertebral cel mai proximal identificat este accesat. Locul se pregateste chirurgical, prin tundere si asepsie locala. Se pot folosi ace de 18G, acul patrunzand usor inclinat cranial cu viteza redusa.



- Exista doua tehnici de verificare a penetrarii spatiului epidural: **metoda picaturii aspirate si metoda pierderii rezistentei la injectare**.
- Ambele metode se bazeaza pe accesarea spatiului epidural care este cu o diferenta de presiune fata de mediul extern si care nu opune rezistenta la instilarea solutiei. Mai mult, inainte de a instila prima parte a solutiei este recomandata aspirarea usoara pentru a nu exista **sange** sau alte produse tisulare. In acest caz acul este retras si se reia procedura. Chiar si in cazul in care se aspira lichid spinal-LCR este indicata reluarea procedurii sau adaptarea dozelor (accesare a spatiului suharahnoidian)!!!

- In functie de volumul de solutie instilat, anestezia epidurala poate fi ***caudala*** (doza mica) sau ***craniala*** (doza mare-volum mare).
- Epidurala caudala este mai des folosita si realizeaza desensibilizarea nervilor sacrali caudali si nu afecteaza functia motorie. Se obtine desensibilizarea cozii, vagin, vulva, anus, rect, preput caudal, scrot si uretra si foloseste in general pentru controlul tenesmelor si contractiilor din timpul interventiilor din prolapsul rectal sau prolapsul vaginal, repozitionare de uter sau distocie.



- In cazul anesteziei epidurale cu **doza mare** volumul injectat este mai mare si de aceea se obtine difuzie craniala. Se poate intercepta chiar si activitatea diafragmului, caz in care pot fi observate tulburari cardio-respiratorii. Suplimentar, functia motorie va fi afectata la nivelul membrelor posterioare si se poate obtine **decubitul**. Este o tehnica mai rar folosita si poate fi intalnita in cazul viteilor cu hernie ombilicala.

- **Substante active si combinatii**

- Cele mai des folosite substante sunt ***lidocaina, bupivacaina, ropivacaina, xylazina, medetomidina, romifidina, ketamina, tramadol si neostigmina***.

- Cele mai utilizate combinatii sunt ***lidocaina-xilazina, lidocaina-tramadol, lidocaina-ketamina, lidocaina-sulfat de magneziu, ketamina-medetomidina, xilazina-bupivacaina, medetomidina-bupivacaina.***

Table-1: Anesthetic drugs, dosages, analgesic effects and side effects used in cattle, camels, and buffalos for epidural analgesia.

Drugs	Dosages	Technique	Species	Findings/side effects	References
Bupivacaine (mg/kg)	0.125	Co1-Co2	Buffalo calves	Mild to moderate analgesia Mild to moderate ataxia	[15]
Ropivacaine (mg/kg)	0.11	Co1-Co2	Adult cows	Variable analgesia with minimal ataxia	[16]
Lidocaine (mg/kg)	0.22	S5-Co1Co1-Co2	Buffalo calves; adult buffalo; camel calves; cattle calves	Adequate analgesia of the mild to moderate ataxia	[6,9,11,23]
Lidocaine (mg/kg)	0.5	Co1-Co2	Cattle calves	Mild to moderate analgesia	[13]
Neostigmine (µg/kg)	10	S5-Co1	Buffalo calves	Adequate analgesia of the mild or moderate ataxia	[23]
Xylazine (mg/kg)	0.05	S5-Co1 Co1-Co2	Buffalo	Analgesia ascended to thoracic segments Mild to moderate ataxia	[6,15,17]
Tramadol (mg/kg)	1.0	Co1-Co2	Adult Holstein cows	Combine with lidocaine is recommended	[8]
		S5-Co1	Buffalo calves	Adequate analgesia in combination with lidocaine	[11]
Medetomidine (µg/kg)	15	Co1-Co2	Buffalo calves	Adequate analgesia of the mild ataxia	[15]
Ketamine (mg/kg)	0.3, 0.5, 0.7, 2.5	L6-S1 Co1-Co2	Buffalo calves Adult cattle	Complete analgesia of the flank region Mild to moderate ataxia	[17,21]
Romifidine (µg/kg)	30, 40, 50	Co1-Co2	Adult cattle	Dose-dependent analgesia and sedation	[20]

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Table-2: Combinations, dosages, analgesic effects and side effects of anesthetic drugs used in cattle, camels, and buffalos for epidural analgesia.

Drugs	Dosages	Technique	Species	Findings/side effects	References
Lidocaine-Xylazine (mg/kg)	0.22 and 0.05	S5-Co1	Adult buffalo	Adequate analgesia Mild to moderate ataxia	[6]
Lidocaine-tramadol (mg/kg)	0.22 and 1	Co1-Co2	Camel calves	Adequate analgesia Mild to moderate sedation and severe ataxia	[10]
Lidocaine-tramadol (mg/kg)	0.11 and 0.5	Co1-Co2 S5-Co1	Adult Holstein cows Buffalo calves	Adequate analgesia Mild ataxia in buffalo	[8,11]
Lidocaine-ketamine (mg/kg)	0.22 and 1	Co1-Co2	Camel calves	Adequate analgesia Mild ataxia	[9]
Lidocaine (mg/kg) -$MgSO_4$(10%)	0.22 and 1 ml	S5-Co1	Adult Holstein cows	Adequate analgesia	[7,8,13]
Lidocaine-ketamine (mg/kg)	0.5 and 2	Co1-Co2	Young calves	Adequate analgesia Moderate ataxia	[13]
Xylazine-ketamine (mg/kg)	0.05 and 2.5	L6-S1	Buffalo calves	Adequate analgesia Severe ataxia	[17]
Ketamine-xylazine (mg/kg)	2.5 and 0.17	Co1-Co2	Adult camels	Adequate analgesia Mild ataxia and moderate sedation	[18]
Ketamine (mg/kg)-medetomidine (µg/kg)	2.5 and 10		Adult camels	Long duration of analgesia Mild ataxia and moderate sedation	[18]
Xylazine-bupivacaine (mg/kg)	0.05 and 0.125	Co1-Co2	Buffalo Calves	Adequate analgesia Mild to moderate ataxia	[15]
Medetomidine (µg/kg)-bupivacaine (mg/kg)	15 and 0.125	Co1-Co2	Buffalo calves	Adequate analgesia Mild to moderate ataxia sedation	[15]

$MgSO_4$= Magnesium sulfate

because its action is not specific to the sensory tracts, it also blocks motor and sympathetic fibers

Bupivacaine

Bupivacaine is a potent amino-amine local anes-

- **Lidocaina** este un anestezic local din grupa amidelor, actionand prin blocarea canalelor de sodiu de la nivelul membranei neuronale. Totusi, actiunea este neselectiva si afecteaza si functia motorie si poate duce uneori, la anumite doze, la decubit. Nu este potrivita pentru interventii de durata si de aceea este folosita adeseori in combinatie cu opioide si alfa-2 adrenoceptori agonisti pentru o activitate mai potenta si mai intinsa in timp.
- Doza este variabila si exista descrieri de la 0.11 pana la 0.22 mg/kg, 2%. Cele mai multe animale au necesitat cca 5-6 ml de solutie pentru o activitate corespunzatoare. Intra in actiune dupa 3-5 minute si dureaza pana la maximum 150 de minute.
- Epiduralele cu doza mare folosesc 2-8 mg/kg, 8 fiind maximul admis. Cele mai des intalnite cazuri de ataxie si decubit se intalnesc la combinatia lidocainei cu ketamina.

- **Bupivacaina** este un agent local din aceeasi clasa cu lidocaina dar de aproximativ patru ori mai puternic, cel mai des gasita in concentratie de 0.5%. Efectul acesteia de tip analgezic este facilitat de xilazina si mai putin de medetomidina.

- **Xilazina si medetomidina** sunt agenti cu actiune atat sedativa dar si anelgezica prin stimularea receptorilor alfa-2 adr. din cornul dorsal al maduvei. **Xilazina** este al doilea cel mai utilizat produs in epidurala la bovine, atat singura cat si in combinatie cu lidocaina. Singura este folosita la o doza de 0.05 mg/kg (2%) diluata pana la un volum de 5 ml de ser fiziologic cu initierea efectului in decurs de 10 minute si mentinerea efectului pentru 3-4 ore. Durata se extinde in combinatie cu lidocaina. Efectele secundare sunt de sedare si ataxie minora, risc de bradicardie si scadere a motilitatii ruminale.

- **Tramadol** este un analog de codeina si impiedica recupereraea serotoninei. Nu este utilizat singur ci in combinatie cu lidocaina. Aceasta combinatie este indicata mai ales in cazul interventiilor obstetricale, la o doza de 2-3 mg/kg, fara a se observa efecte generale cardiovasculare.

- **Ketamina** este un antagonist noncompetitiv al receptorilor NMDA, actioneaza asupra canalelor de sodiu si interactioneaza si cu receptori opioizi si muscarinici cat si cu canalele de calciu. Se poate folosi si singura dar mai ales in combinatie cu lidocaia cand se asociaza cu ataxie de intensitate mica.

- Un studiu din **2015** (Ronaldo Pagliosa) evalueaza eficienta administrarii epidurale a lidocaine, xilazinei sau xilazinei cu hialuronidaza in cazul electroejacularii la tauri. Acest studiu concluzioneaza, dupa ce a luat in calcul frecventa cardiaca, cea respiratorie si tensiunea arteriala ca administrarea epidurala de ***xilazina sau xilazina-hialuronidaza a determinat un confort mai bun decat simpla administrare de lidocaina***.

FULL PAPER *Theriogenology*

Efficacy of caudal epidural injection of lidocaine, xylazine and xylazine plus hyaluronidase in reducing discomfort produced by electroejaculation in bulls

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ABSTRACT. To test the hypothesis that epidural administration of lidocaine, xylazine or xylazine plus hyaluronidase provides reduced pain and stress during electroejaculation in bulls, eight 30-month-old Nellore bulls received saline solution (control), 2% lidocaine, 2% xylazine or 2% xylazine plus hyaluronidase injected into the first intercoccygeal (Co1–Co2) epidural space in randomized order. Heart rate, respiratory rate, mean arterial pressure, analgesia, animal behavior and motor blockade were evaluated before treatment and at predetermined intervals during and after treatment. Pain and stress were scored subjectively, and semen quality was evaluated. The onset of anesthetic action was significantly faster with lidocaine (3.0 ± 1.2 min) than with xylazine or xylazine plus hyaluronidase (8.9 ± 1.5 and 5.5 ± 2.6 min, P=0.021 and P=0.012, respectively), and the onset of anesthesia with xylazine plus hyaluronidase was significantly faster than that with xylazine alone (P=0.032). Treatment with xylazine or xylazine plus hyaluronidase resulted in less discomfort than treatment with lidocaine, as indicated by animal behavior. Changes in heart rate, respiratory rate and arterial pressure were within acceptable limits. Penile protrusion and semen emission occurred in all animals during all four treatments. Our results suggest that xylazine plus hyaluronidase reduced discomfort during electroejaculation more effectively than xylazine or lidocaine alone. Further experiments are necessary to determine whether electroejaculation with xylazine plus hyaluronidase is feasible for obtaining semen from Nellore bulls unaccustomed to being handled or restrained.

KEY WORDS: bull, electroejaculation, epidural analgesia, hyaluronidase, xylazine

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Among the various techniques used for collection of semen from animals, electroejaculation (EEJ) remains the most common method used for bulls (for breeding soundness evaluation, for example) and is particularly useful in animals that are not accustomed to the procedures in a breeding soundness exam. However, although EEJ is very effective in inducing semen emission, it is now considered to be painful and stressful to bulls and has been banned in several European countries [17, 19] owing to concerns about animal welfare (defined in terms of the "five freedoms," as cited by Mench [16]). Studies have been conducted for the purpose of measuring and decreasing pain associated with this necessary procedure [14, 15, 17, 19].

In men with normal sensation in the pelvic area, general or epidural anesthesia is used before EEJ [18], and the use of caudal epidural anesthesia in animals to reduce pain and stress due to EEJ has been studied. Serum cortisol and progesterone concentrations and heart rate (HR) tend to be lower in bulls that receive caudal epidural anesthesia; however, anesthesia does not significantly reduce the stress response to EEJ [15]. Lidocaine is a local anesthetic that is routinely used for caudal epidural anesthesia in cattle during various reproductive procedures [14, 15, 17]. Other drugs, such as xylazine [17] and ketamine [12], are also used for this purpose. Caudal epidural xylazine might reduce the pain caused by rectal smooth muscle spasms or intrapelvic nerve stimulation [17], but this drug has the disadvantage of exhibiting delayed onset of analgesia [6, 7]. Hyaluronidase is hypothesized to hasten the onset of the block by enhancing the spread of local anesthesia [10, 25].

The purpose of this study was to evaluate the effectiveness of caudal epidural lidocaine, xylazine and xylazine plus hyaluronidase for reducing discomfort due to EEJ; caudal epidural saline solution was used as a control. HR, respiratory rate (RR) and mean arterial pressure (MAP) were used for evaluating systemic effects, and stress was evaluated by means of a subjective scale of behavioral responses. The degree of motor blockade was determined, and the effects of the anesthetics on penile protrusion, semen emission and semen quality were evaluated.

MATERIALS AND METHODS

Experimental animals: The experimental protocol of the present study was approved by the Ethics Committee for Animal Use of the Federal University of Mato Grosso do

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- **Un articol publicat in 2013** de David Anderson propune o serie de solutii pentru administrarea epidurala inclusiv de **opioide** pentru interventii paralombare dar, in acelasi timp, trece in revista si plasarea de **catetere epidurale**. Utilizabile mai ales in cazul afectarii cronice de tip prolaps rectal, vaginal dar si alte situatii de instalare a durerii cronice. Pot fi utlizate metadona, ketamina, bupivacaina cu instilare continua pe o perioada de mai multe zile, saptamani.

sacral nerves S2, S3, S4, and S5. The low caudal epidural at the first coccygeal space (Co1–Co2) desensitizes sacral nerves S3, S4, and S5; as the anesthetic dose increases, nerves cranial to S2 may also become affected.[50] If possible, the hair should be clipped and the skin scrubbed and disinfected. Standing alongside the cow, the tail should be moved up and down to locate the fossa between the last sacral vertebra and the first coccygeal vertebra or between the first and second coccygeal

Table 3
Usage of epidural anesthesia for standing paralumbar analgesia or laparotomy in cattle

Drug	Dosage	Onset of Analgesia (min)	Duration of Analgesia
Lidocaine 2%	0.2 mg/kg (5 mL)	5	10–115 min
Xylazine	0.05 mg/kg (5 mL in saline)	20–40	2–3 h
Clonidine	2–3 μg/kg diluted to 8 mL in saline	2 μg dose: 19 3 μg dose: 9	2 μg dose: 192 min 3 μg dose: 311 min Peak effect during 60–180 min
Ketamine 5%	5 mL (250 mg) 10 mL (500 mg) 20 mL (1000 mg)	5 mL: 6.5 10 mL: 5 20 mL: 5	5 mL: 17 min 10 mL: 34 min 20 mL: 62 min
Procaine HCl 5%	300 mg (6 mL)	8–20	45–127 min Mean, 83 min
Medetomidine	15 μg/kg (5 mL)	5	412 min
Detomidine	40 μg/kg	—	—
Romifidine + morphine	Romifidine: 50 μg/kg Morphine: 0.1 mg/kg	—	12 h maximum

Much of the pain research that has been performed has shown benefits of preemptive analgesia. There is a less marked effect of the administration of analgesic medication after the noxious stimulus has become established. In a study in which flunixin meglumine was administered before laparotomy for correction of abomasal displacement, cows receiving flunixin (2.2 mg/kg IV) had significantly greater rumen contracts during the first 24 hours after surgery compared with control cows.[27] This administration of flunixin may not represent preemptive analgesia because of the prior abomasal displacement. Another study was designed to investigate the effect of preoperative and 24-hour postoperative administration of flunixin meglumine (1.25 g IV) on postoperative recovery of cows having surgical correction of left displaced abomasum.[28] In that study, cows receiving flunixin meglumine immediately before and 24 hours after surgery had significantly better appetite, defecation, and milk production compared with cows that were not given flunixin. A risk-benefit analysis should be done on a case-by-case basis to determine whether an NSAID should be administerd.[29] Meloxicam has been used recently for pain management in cattle for a variety of conditions. This NSAID has been shown to be effective in mitigating the pain of castration and dehorning and the pharmacokinetics suggest that meloxicam should be effective for perioperative pain management as well.[30] Clinical experience has been positive with this drug when (0.5–1 mg/kg body weight) given orally, every 24 to 48 hours. Future research is needed to more fully elucidate the clinical indication for the use of meloxicam. Based on AMDUCA guidelines, the authors only use meloxicam when sustained effect is needed (>3 days), because the more selective COX-2 inhibition should be safe for prolonged administration compared with flunixin. In cases of severe, prolonged pain when a pathologic pain state has become established, gabapentin can be administered as a complimentary drug to meloxicam as a multimodal therapy.[31] The use of gabapentin (10 mg/kg, orally, every 12 hours) has been useful in cases of deep digital sepsis and septic arthritis as a tool to dampen the exaggerated central nervous response to the limb pain.

OPIOIDS

Opioids are useful in a wide variety of settings because there are limited cardiovascular side effects (**Table 2**). Economic constraints have limited the use of these drugs in ruminant practice.[1,2,26] The most common narcotic drug used in cattle is butorphanol tartrate (0.02–0.04 mg/kg, IV or subcutaneous [SC] every 4–6 hours). Morphine (0.05–0.1 mg/kg, SC every 4–12 hours) and buprenorphine (0.005–0.01 mg/kg, SC

Table 2
Opioids used for analgesia during surgery in ruminants

Drug	Dose	Route	Frequency
Morphine	0.5–1 mg/kg 0.05–0.1 mg/kg	IV Epidural	Every 12 h Every 24 h
Fentanyl	0.05–0.5 μg/kg	Transdermal patch	Every 72 h
Meperidine	3.3–4.4 mg/kg	SC or IM	—
Buprenorphine	0.005–0.01 mg/kg (sheep and goats)	IM	Every 6–12 h
Butorphanol	0.02–0.05 mg/kg	IV SC	Every 2–4 h Every 6–8 h

None of these drugs are approved for use in cattle in the United States. Meat and milk withholding times must be cautiously estimated.
Data from Refs.[1,2,63]

- **Tot in 2013**, Nasser Vesal investigheaza lidocaina, bupivacaina sau combinatia lor pentru administrare epidurala. Aceasta este o dilema in acest moment, daca combinatia celor doua ofera ceea ce e mai bun din acestea, adica initierea rapida a efectului dar si lungimea in timp a acestuia. Autorii studiului ajung la concluzia ca administrarea nu produce efecte generale de tip cardiovascular iar ca asocierea lidocaine cu bupivacaina (la o doza ceva mai scazuta-notati relativitatea) chiar **intra in actiune mai repede si asigura o activitate anelgezica mai indelungata**.

coccygeal epidural administration in standing cows.

Materials and methods

Thirty-seven 3–3.5-year-old, non-pregnant cows from a large commercial dairy herd in Shiraz, Iran (longitude 052°36′E and latitude 29°33′N) were used in this study. Cows were housed in a free-stall barn. All cows, whilst in a standing position, underwent reproductive examination (28–35 days post-parturition) and intrauterine (IU) infusion of oxytetracycline. This clinical study was approved by the Institutional Animal Care and Use Committee.

Cows were assigned randomly to one of four groups and received one of the following treatments:
- Group LID, 0.2 mg kg^{-1} (1 mL 100 kg) of 2% lidocaine HCl (Pasteure Institute, Iran).
- Group LID-BUP, 0.1 mg kg^{-1} of 2% lidocaine HCl in combination with 0.025 mg kg^{-1} of 0.5% bupivacaine HCl (final volume:1 mL 100 kg; Merk Company, France).
- Group BUP-LD (bupivacaine lower dose), 0.05 mg kg^{-1} of 0.5% bupivacaine HCl (1 mL 100 kg).
- Group BUP-HD (bupivacaine higher dose), 0.06 mg kg^{-1} bupivacaine HCl (1.2 mL 100 kg).

Lidocaine-bupivacaine mixture was freshly prepared immediately before use by adding 2% lidocaine to 0.5% bupivacaine in a 1:1 ratio. Each cow received only one treatment.

evaluated each minute until no reaction occurred at the perineal area and then at 10-minute intervals until a response occurred. The degree of vulval and vaginal relaxation and anal and rectal contractibility were assessed during reproductive manipulations. The onset of tail paralysis was also recorded. The same investigator assessed the anti-nociception in all cases and was unaware of the treatment given.

Data were tested for normal distribution using the Kolgomorov–Smirnov test. A one-way ANOVA followed by Duncan's test was used to compare the onset and duration of tail paralysis and of anti-nociception. Overall frequency of complete block was compared using χ^2 analysis. Statistical analysis was undertaken using SPSS Version 10 for Windows (SPSS, MicroMaster, Richboro, Pennsylvania) and $p \leq 0.05$ was considered significant. All data are presented as mean ± SD.

Results

There were no significant differences in body weight between the four groups of cows (Table 1). No difficulty was encountered in locating the proper site for injection of the local anaesthetic. With the exception of one case, the procedure was well tolerated by all animals.

No significant difference ($p > 0.05$) was noted for time of onset of tail paralysis and perineal

- **In 2010**, Habibian stabilieste in studiul sau ca administrarea unei combinatii de **lidocaina cu tramadol** asigura o mai buna analgezie si o instalare rapida fata de utilizarea singulara a celor doua substante.

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Caudal epidural injection of lidocaine, tramadol, and lidocaine–tramadol for epidural anesthesia in cattle

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Bigham, A. S., Habibian, S., Ghasemian, F., Layeghi, S. Caudal epidural injection of lidocaine, tramadol, and lidocaine–tramadol for epidural anesthesia in Cattle. *J. vet. Pharmacol. Therap.* **33**, 439–443.

Caudal epidural anesthesia is commonly utilized in veterinary medicine to allow diagnostic, obstetrical, and surgical intervention, in the perineal region of large animal. The aim of this study is to directly compare the time of onset and duration of analgesia produced by a tramadol and lidocaine–tramadol combination with that produced by lidocaine administration in the epidural space of Cattle. Five healthy adult Holstein dairy cows were selected to this study. Epidural anesthesia was produced in all cows by lidocaine, with 2 weeks intervals repeated by a combination of lidocaine–tramadol and tramadol. Time to onset and duration of analgesia were recorded. Heart rate, respiratory rate and body temperature were recorded at 0 min and at 5, 10, 15, 30, 60, and 75 min after the epidural administrations of each treatments. The tramadol produced a significant ($P < 0.05$) longer duration of analgesia (306.8 ± 8.58 min) than lidocaine (69.40 ± 8.96 min) alone and lidocaine–tramadol combination (174 ± 4.84 min). Also, lidocaine–tramadol combination produced a significant ($P < 0.05$) longer duration of analgesia than lidocaine alone. Complete analgesia began at 14.10 ± 1.57 min in the tramadol treatment, being more delayed than in the treatments with lidocaine–tramadol (4.84 ± 0.68 min) and lidocaine (3.90 ± 0.89 min). Body temperatures, heart rates, and respiratory rates were not significantly different in comparison with baseline values throughout the study in the all treatments. The combination of lidocaine–tramadol produced anesthesia of longer duration than lidocaine and the onset time was approximately same as for the lidocaine group. Utilizing this combination, long duration of anesthesia could commence relatively soon after epidural injection and might be used without re-administration of anesthetic agent in long-duration obstetrical and surgical procedures.

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INTRODUCTION

Ruminants generally are not considered good subjects for general anesthesia mainly because of hazards of regurgitation and inhalation of ruminal contents or saliva into the lung if the airway is left unprotected (Trim, 1981; Hall *et al.*, 2001). Thus, regional anesthesia produced by the perineural or epidural injections of anesthetic agents is often employed in these species. Caudal epidural anesthesia is commonly utilized in veterinary medicine to allow diagnostic, obstetrical, and surgical intervention, in the perineal region of large animal (Elmore, 1980; Skarda, 1996). The most frequently used epidural anesthetic is lidocaine; mepivacaine, bupivacaine, and procaine are also used (Day & Skarda, 1991). With the exception of bupivacaine, this group of agents provides analgesia of relatively short duration and may necessitate re-administration of the agent to allow completion of the procedure. In addition, local anesthetic agents indiscriminately block motor, sensory, sympathetic fibers (Day & Skarda, 1991) that cause vasodilation (due mainly to the inhibition of action potentials via sodium channel blocking in vasoconstrictor sympathetic nerves) (Newton *et al.*, 2007), ataxia, hind limb weakness, and occasionally recumbency. Epidural and intrathecal administration of agents with greater duration of action may be more appropriate for procedures requiring long-duration analgesia. These agents include opioids and alpha-2 adrenergic agonists that selectively block sensory

- **Tot in 2010**, Rafael DeRossi studiaza administrarea epidurala prin catetere cu porturi multiple la nivel dorsolombar a ***ketaminei, lidocainei*** sau a combinatiei dintre acestea. Deloc surpinzator se stabileste **ca utilizarea combinatiei dintre cele doua este mai eficienta decat utilizarea singulara a fiecareia** dintre cele doua dar cu efecte cardiovasculare, cu toate ca sunt specificate a fi minore.

Veterinary Anaesthesia and Analgesia
Formerly the Journal of Veterinary Anaesthesia
Veterinary Anaesthesia and Analgesia, 2010, 37, 451–459 doi:10.1111/j.1467-2995.2010.00559.x

RESEARCH PAPER

Segmental dorsolumbar epidural analgesia via the caudal approach using multiple port catheters with ketamine or lidocaine or in combination in cattle

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Abstract

Objective To determine the analgesic and systemic effects of epidural administration of ketamine, lidocaine or a combination of ketamine/lidocaine in standing cattle.

Study design Prospective, randomized, experimental trial.

Animals Six healthy male cattle weighing between 335 and 373 kg.

Methods The animals received 0.5 mg kg^{-1} of ketamine (K), 0.2 mg kg^{-1} of 2% lidocaine (L) or 0.25 mg kg^{-1} ketamine plus 0.1 mg kg^{-1} lidocaine (KL). All the drugs were injected into the dorsolumbar epidural space via a caudal approach through a non-styletted multiple-port catheter. Each animal received each treatment at random. Evaluations of analgesia, sedation, ataxia, heart rate, arterial pressure, respiratory rate, skin temperature and rectal temperature were obtained at 0 (basal), 5, 10, 15, 30, 45, 60, 75, 90 minutes after epidural injection, and then at 30-minute intervals until loss of analgesia occurred. Skin temperature was taken at these intervals up to 60 minutes. All the animals received a standard noxious stimulus; a 4-point scale was used to score the response. A second scale was used to score ataxia and a third for sedation.

Results The duration of analgesia in the upper and lower flanks in cattle was 140 ± 15, 50 ± 14 and 80 ± 22 minutes (mean ± SD) after dorsolumbar epidural KL, K or L, respectively. The cardiovascular changes were within acceptable limits in these clinically healthy cattle.

Conclusions Dorsolumbar epidural administration of KL to cattle resulted in longer duration of analgesia of the upper and lower flanks in standing conscious cattle, than the administration of K or L alone.

Clinical relevance Further research is necessary to determine whether this combination using this technique provides sufficient analgesia for flank surgery in standing cattle.

Keywords analgesia, cattle, dorsolumbar epidural, ketamine, lidocaine, multiple port catheter.

Introduction

Some surgical procedures in cattle are more easily achieved in standing animals, such as omentopexy, flank cesarean, ruminotomy or ruminostomy.

- **In 2009,** Melrose Condino evalueaza admnistrarea subarahnoidina a xilazinei cu lidocaina la vitei deja sedati cu xilazina. ***Administrarea subarahnoidina*** a fost la o doza de 0.025 mg/kg si lidocaina 0.1 mg/kg si a fost mai eficienta decat admnistrarea epidurala, in cazul viteilor sedati deja cu xilazina.

Veterinary Anaesthesia and Analgesia
Formerly the Journal of Veterinary Anaesthesia

Veterinary Anaesthesia and Analgesia, 2010, **37**, 70–78 doi:10.1111/j.1467-2995.2009.00494.x

RESEARCH PAPER

Antinociceptive, sedative and cardiopulmonary effects of subarachnoid and epidural xylazine-lidocaine in xylazine-sedated calves

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Abstract

Objective To evaluate the antinociceptive, sedative and cardiopulmonary effects of subarachnoid and epidural administration of xylazine-lidocaine in xylazine-sedated calves.

Study design Prospective, crossover study.

Animals Six clinically healthy Holstein calves.

Materials The calves were allocated randomly to receive two treatments, subarachnoid or epidural xylazine (0.025 mg kg^{-1})–lidocaine (0.1 mg kg^{-1}) diluted to a total volume of 5 mL with physiological saline. Prior to either epidural or subarachnoid injection, sedation was induced in all calves by intravenous administration of 0.1 mg kg^{-1} xylazine. The quality and duration of antinociception and sedation were monitored. Areas of the cranial abdomen, umbilicus, and caudal abdomen were evaluated for antinociception using pinprick tests with a scoring system of 0–3 (0, none; 1, mild; 2, moderate; 3, complete). Sedation was assessed by using a 4-point scale (0, none; 1, mild; 2, moderate; 3, deep). The following cardiopulmonary variables were monitored: heart rate (HR), respiratory rate (f_R), mean arterial pressure (MAP), blood pH, arterial partial pressure of oxygen (PaO_2), partial pressure of carbon dioxide ($PaCO_2$), bicarbonate (HCO_3), base excess (BE), and oxygen saturation (SaO_2).

Results Xylazine sedation and subarachnoid xylazine-lidocaine resulted in significantly higher nociceptive block than the epidural technique. Moreover, subarachnoid xylazine-lidocaine induced a significantly longer duration of complete antinociception (median [IQR]) in the cranial abdomen (15.0 [15.0–30.0] *versus* 7.5 [1.3–10.0] minutes; $p < 0.05$) and umbilicus (45.0 [32.5–57.5] *versus* 10.0 [6.3–17.5] minutes; $p < 0.05$) compared with epidural xylazine-lidocaine. There was moderate sedation with both techniques. In both treatments, blood pH, MAP and PaO_2 decreased significantly, and $PaCO_2$ increased significantly during anaesthesia. No change was evident in HR, f_R, HCO_3, BE, or SaO_2.

Conclusion and clinical relevance The subarachnoid injection provided better quality and longer duration of antinociception than epidural administration of the same doses of xylazine-lidocaine in xylazine-sedated calves, while cardiopulmonary depressant effects were observed with both regimens.

Keywords antinociception, epidural, sedation, subarachnoid, xylazine-lidocaine.

- **Totusi, Davide Zani aduce in prim plan si o complicatie frecventa a administrarii epidurale: abcesul spinal.**

Veterinary Surgery
37:801–808, 2008

Spinal Epidural Abscess in Two Calves

DAVIDE D. ZANI, DVM, PhD, LAURA ROMANÒ, DVM, MASSIMILIANO SCANDELLA, DVM, PhD, MARCO RONDENA, DVM, PhD, PIETRO RICCABONI, DVM, PhD, NICOLA MORANDI, DVM, ROCCO LOMBARDO, DVM, PhD, Diplomate ACVIM (Neurology), Diplomate ECVN, MAURO DI GIANCAMILLO, DVM, ANGELO G. BELLOLI, DVM, and DAVIDE PRAVETTONI, DVM, PhD

Objective—To report clinical signs, diagnostic and surgical or necropsy findings, and outcome in 2 calves with spinal epidural abscess (SEA).
Study Design—Clinical report.
Animals—Calves (n = 2).
Methods—Calves had neurologic examination, analysis and antimicrobial culture of cerebrospinal fluid (CSF), vertebral column radiographs, myelography, and in 1 calf, magnetic resonance imaging (MRI). A definitive diagnosis of SEA was confirmed by necropsy in 1 calf and during surgery and histologic examination of vertebral canal tissue in 1 calf.
Results—Clinical signs were difficulty in rising, ataxia, fever, apparent spinal pain, hypoesthesia, and paresis/plegia which appeared 15 days before admission. Calf 1 had pelvic limb weakness and difficulty standing and calf 2 had severe ataxia involving both thoracic and pelvic limbs. Extradural spinal cord compression was identified by myelography. SEA suspected in calf 1 with discospondylitis was confirmed at necropsy whereas calf 2 had MRI identification of the lesion and was successfully decompressed by laminectomy and SEA excision. Both calves had peripheral neutrophilia and calf 2 had neutrophilic pleocytosis in CSF. Bacteria were not isolated from CSF, from the surgical site or during necropsy. Calf 2 improved neurologically and had a good long-term outcome.
Conclusion—Good outcome in a calf with SEA was obtained after adequate surgical decompression and antibiotic administration.
Clinical Relevance—SEA should be included in the list of possible causes of fever, apparent spinal pain, and signs of myelopathy in calves.

INTRODUCTION

INFECTIONS INVOLVING the epidural space are rare, however, they represent a devastating neurosurgical emergency.[1–3] In humans, spinal epidural abscess (SEA) or spinal epidural empyema (SEE) occurs in 0.2–1.3 per 10,000 hospital admissions and typically affects immunosuppressed patients.[1,3,4] Clinical presentation and course of SEA vary from subtle to dramatic. Clinical findings depend on the position and extension of the abscess or empyema. Despite a significant improvement in outcomes, there is still a 15% mortality rate, and 38% of human patients have persistent neurologic dysfunction.[5] Treatment usually involves surgical decompression with or without drainage of the abscess, followed by prolonged antimicrobial therapy. If the abscess extends over many segments, or extends in a panspinal fashion, surgical treatment can involve multilevel destabilizing laminectomy that requires stabilization of the spinal column.[3,6]

SEA and SEE have been described in dogs, which like humans have a poor prognosis despite appropriate therapy. This is often because the delay in diagnosis can result in progression of clinical signs.[7–10] In dogs, SEE is suspected by neurologic examination and spinal diagnostic imaging, but definitive diagnosis is made during surgery and by histopathology or necropsy.[7] The most common

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- **Mai recent, in 2018,** S.T.L. Ting apreciaza ca **ketoprofenul** are o actiune mai buna postoperator decat anestezia locala sau epidurala si ca cea mai slaba actiune este la castrarile taurilor doar cu anestezie locala, fara epidurala sau ketoprofen, generand un raspuns adaptativ din partea organismului.

Effect of ketoprofen, lidocaine local anesthesia, and combined xylazine and lidocaine caudal epidural anesthesia during castration of beef cattle on stress responses, immunity, growth, and behavior[1]

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*Teagasc, Grange Research Centre, Dunsany, Co. Meath, Ireland, and †Faculty of Veterinary Medicine, and ‡Conway Institute, University College Dublin, Belfield, Dublin 4, Ireland

ABSTRACT: To determine the effects of burdizzo castration alone or in combination with ketoprofen (K), local anesthesia (LA), or caudal epidural anesthesia (EPI) on plasma cortisol, acute-phase proteins, interferon-γ production, growth, and behavior of beef cattle, 50 Holstein × Friesian bulls (13 mo old, 307 ± 5.3 kg) were assigned to (n = 10/treatment): 1) control (handled; C); 2) burdizzo castration (B); 3) B following K (3 mg/kg of BW i.v.; BK); 4) B following LA (8 mL into each testis and 3 mL s.c. along the line where the jaws of the burdizzo were applied with 2% lidocaine HCl; BLA); and 5) B following EPI (0.05 mg/kg of BW of xylazine HCl and 0.4 mg/kg of BW of lidocaine HCl as caudal epidural; BEPI). The area under the cortisol curve against time was lower ($P < 0.05$) in BK than in B, BLA, or BEPI animals. On d 1 after treatment, plasma haptoglobin concentrations were higher ($P < 0.05$) in B, BLA, and BEPI than in BK animals. On d 3, haptoglobin and plasma fibrinogen concentrations were higher ($P < 0.05$) in all castration groups than in C. On d 7, haptoglobin and fibrinogen concentrations remained higher ($P < 0.05$) in BLA than in B and C animals. On d 1, concanavalin A-induced interferon-γ production was lower ($P < 0.05$) in B, BLA, and BEPI than in C, but there was no difference between BK and C animals. From d −1 to 35, ADG was lower ($P < 0.05$) in B, BLA, and BEPI animals, but not in BK compared with C animals. Overall, there was a higher ($P < 0.05$) incidence of combined abnormal postures in B than in C, BK and BEPI animals. Although the use of K and EPI decreased ($P < 0.05$) these postures compared with B alone or B with LA, there was no difference between the K and EPI treatment. In conclusion, burdizzo castration increased plasma cortisol and acute-phase proteins, and suppressed immune function and growth rates. Local anesthesia prolonged the increase in acute-phase proteins. Ketoprofen was more effective than LA or EPI in decreasing cortisol and partially reversed the reduction in ADG following castration. The use of K or EPI was more effective than LA in decreasing pain-associated behavioral responses observed during the first 6 h after treatment. Systemic analgesia with ketoprofen, a nonsteroidal antiinflammatory drug, was more effective in reducing inflammatory responses associated with castration than LA or EPI.

Key Words: Bulls, Castration, Epidural Anesthesia, Interferon-γ, Ketoprofen, Stress

 J. Anim. Sci. 2003. 81:1281–1293

Introduction

The castration of postpubertal male cattle intended for beef production is a routine practice in many countries. There is a legal requirement in Ireland to provide anesthesia for the surgical/burdizzo castration of cattle older than 6 mo (Protection of Animals [Amendment] Act, 1965). The administration of lidocaine local anesthesia (**LA**) for castration (Jones, 1997) is a standard procedure employed by veterinary practitioners. However, LA is not effective in reducing the overall stress (cortisol) response associated with castration (Fisher et al., 1996). In contrast, ketoprofen (**K**), a nonsteroidal antiinflammatory drug (**NSAID**), was found to be more effective than LA in reducing the stress of castration in calves (Earley and Crowe, 2002). The use of caudal

[1]This study was supported by a Teagasc Walsh Fellowship Research Fund to S. T. L. Ting. The authors acknowledge Merial Animal Health Ltd., Harlow, U.K., for the supply of Ketofen. The authors thank G. Claffey, V. P. Gath, and N. Hynes (Faculty of Veterinary Medicine, University College Dublin; UCD), graduate students at Teagasc Grange and UCD, for their invaluable help during the study. The authors also acknowledge the skilled technical assistance of the staff at Teagasc Grange: F. Collier, J. A. Farrell, J. Larkin, M. Munnelly, M. Murray, and D. Prendiville. Many thanks to P. Reid (Teagasc, Dublin) and S. Hanrahan (Teagasc, Athenry) for their invaluable advice on statistical analyses. The help of the foreman, G. Santry, and the farm staff, B. Duffy and S. Fagan, for care and management of the animals is gratefully acknowledged.

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- **In 2013**, Eva Rioja evalueaza efectele anlgezice si motorii ale administrarii de volum mare de solutie la nivel epidural folosind **concentratii de 0.125 % si 0.0625 %.** Concluzia a fost ca utilizarea concentratiei mai mici dar cu volum mare a dus la **o analgezie incompleta** dar poate produce deficit motor mediu spre mare ajungandu-se la decubit.

Article

Analgesic and motor effects of a high-volume intercoccygeal epidural injection of 0.125% or 0.0625% bupivacaine in adult cows

Eva Rioja, Luis M. Rubio-Martínez, Gabrielle Monteith, Carolyn L. Kerr

Abstract

The objectives of this study were to determine the analgesic and motor effects of a high-volume intercoccygeal epidural injection of bupivacaine at 2 concentrations in cows. A prospective, randomized, blinded, crossover trial was conducted on 6 adult cows. An indwelling epidural catheter was placed in the first intercoccygeal space and advanced 10 cm cranially. All the cows received 3 treatments with a washout period of 48 h: saline (control), 0.125% bupivacaine (high dose), or 0.0625% bupivacaine (low dose), at a final volume of 0.15 mL per kilogram of body weight, infused manually into the epidural space over a period of 15 min. The anal and tail tone and motor deficits of the pelvic limbs were evaluated in 5 of the cows with use of a numerical rating scale and a visual analogue scale (VAS). Sensory block was assessed in 4 of the cows by the response to needle pricks in different regions with the use of a VAS. Measurements were obtained before and at different time points after injection, up to 360 min. Analysis of variance for repeated measures and post-hoc Tukey's and Dunnett's tests were used. Differences were considered significant when the *P*-value was ≤ 0.05. One cow became recumbent 6 h after injection. Anal and tail tones were significantly decreased and motor deficits of the pelvic limbs were significantly increased after bupivacaine treatment compared with control treatment. The overall mean VASpain scores ± standard deviation were 66 ± 8 after control treatment, 52 ± 5 after low-dose bupivacaine treatment, and 43 ± 5 after high-dose bupivacaine treatment. The pain scores were significantly lower in caudal regions up to the saphenous nerve after high-dose bupivacaine treatment compared with control treatment and significantly lower in the anus, vulva, and tail after low-dose bupivacaine treatment compared with control treatment. Thus, analgesia with moderate motor deficits of the pelvic limbs may be obtained with 0.125% bupivacaine administered epidurally.

Résumé

Les objectifs de la présente étude étaient de déterminer chez la vache les effets analgésiques et moteurs d'une injection épidurale inter-coccygienne d'un volume important de bupivacaïne à deux concentrations. Une étude croisée prospective, randomisée, et à l'aveugle a été réalisée chez 6 vaches adultes. Un cathéter épidural à demeure a été placé dans le premier espace inter-coccygien et avancé cranialement de 10 cm. Toutes les vaches ont reçu 3 traitements avec une période d'évacuation de 48 h : saline (témoin), 0,125 % de bupivacaïne (dose élevée) ou 0,0625 % de bupivacaïne (faible dose), à un volume final de 0,15 mL par kilo de poids corporel, infusé manuellement dans l'espace épidural sur une période de 15 min. Le tonus anal et de la queue ainsi que les déficits moteurs des membres pelviens ont été évalués chez 5 des vaches au moyen d'une échelle numérique de pointage et une échelle analogue visuelle (VAS). Le bloc sensitif a été évalué chez 4 des vaches par la réponse à des piqûres d'aiguille dans différentes régions avec l'utilisation d'une VAS. Les mesures ont été obtenues avant et à différents temps après l'injection, jusqu'à 360 min. Une analyse de variance pour mesures répétées et les tests post-hoc de Tukey et de Dunnett ont été utilisés. Les différences étaient considérées significatives lorsque la valeur de P *était ≤ 0,05. Une vache est demeurée couchée 6 h après l'injection. Le tonus anal et de la queue était réduit de manière significative et les déficits moteurs des membres pelviens étaient significativement augmentés après le traitement à la bupivacaïne comparativement au traitement témoin avec la saline. Dans l'ensemble les scores moyens ± l'écart-type de VASdouleur étaient 66 ± 8 après le traitement témoin, 52 ± 5 après le traitement à faible dose de bupivacaïne, et 43 ± 5 après le traitement avec la dose élevée de bupivacaïne. Les scores de douleur étaient significativement plus faibles dans les régions caudales jusqu'au nerf saphène après le traitement avec les doses élevées de bupivacaïne comparativement au traitement témoin et significativement plus faibles au niveau de l'anus, la vulve et la queue après le traitement avec les faibles doses de bupivacaïne comparativement au traitement témoin. Ainsi, une analgésie avec des déficits moteurs modérés des membres pelviens peut être obtenue avec de la bupivacaïne à 0,125 % administrée par voie épidurale.*

(Traduit par Docteur Serge Messier)

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- **Comparativ, la animalele mici, nivelul de cercetare este relativ mai mare dar se pot desprinde cateva actuale combinatii mai utilizate si usor accesibile.**

frontiers in Veterinary Science

REVIEW
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An Update on Drugs Used for Lumbosacral Epidural Anesthesia and Analgesia in Dogs

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This review aims to report an update on drugs administered into the epidural space for anesthesia and analgesia in dogs, describing their potential advantages and disadvantages in the clinical setting. Databases searched include Pubmed, Google scholar, and CAB abstracts. Benefits of administering local anesthetics, opioids, and alpha$_2$ agonists into the epidural space include the use of lower doses of general anesthetics (anesthetic "sparing" effect), perioperative analgesia, and reduced side effects associated with systemic administration of drugs. However, the potential for cardiorespiratory compromise, neurotoxicity, and other adverse effects should be considered when using the epidural route of administration. When these variables are considered, the epidural technique is useful as a complementary method of anesthesia for preventive and postoperative analgesia and/or as part of a balanced anesthesia technique.

Keywords: epidural, canine, analgesia, anesthesia, opioids, local anesthetics, pain

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INTRODUCTION

Epidural administration of drugs for pain management has been widely used in veterinary medicine (1–3). The advantage of this route is its proximity to the spinal cord receptors involved in the modulation and transmission of the nociceptive signal. The terms epidural and extradural refer to the space outside the dura mater. The terms intrathecal, subarachnoid, and spinal refer to the space between the pia mater and arachnoid membrane. *Epidural anesthesia* refers to the sensory, motor, and autonomic blockade produced by epidural administration of local anesthetics while *epidural analgesia* refers to epidural administration of analgesics, such as opioids.

The use of this technique may provide preemptive analgesia by inhibiting central sensitization and modulating afferent signals to the dorsal horn, reducing pain and inhalant, and/or analgesic requirements during the perioperative period (4–6). In addition, epidural anesthesia suppresses the markers of stress response as represented by decreases in serum concentrations of cortisol and norepinephrine for up to 48 h after administration (7–9).

Absolute contraindications to epidural anesthesia include untreated hypovolemia, coagulation disorders, septicemia, bacteremia, skin trauma, neoplasia, and/or infection at the lumbosacral region (2, 10). Some neurological diseases, spinal cord trauma, low-dose heparin therapy, and anatomical changes including trauma of the pelvic area and obesity resulting in difficulty locating the lumbosacral space are considered relative contraindications (2). The use of ultrasonography to locate the epidural space may circumvent this latter issue (11).

TABLE 1 | Commonly used and recommended epidural anesthetics and analgesics in dogs.

Drug	Dose (mg kg^{-1})	Final volume (mL kg^{-1}) injected into the LS epidural space	Onset time (min)	Duration of analgesia (h)	Comments	Reference
Local anesthetics						
2% Lidocaine with 1:200,000 epinephrine	5.0	0.25	4–6	1	Duration of motor blockade 60–120 min	(46, 60, 66, 68)
0.5% Bupivacaine	0.5–1.0	0.2–0.25	5–15	>2	Duration of complete motor blockade and ataxia was 65 and 240 min, respectively. May be prolonged with 0.75% bupivacaine. Complete motor blockade may not be observed at 0.25%	
0.5% Levobupivacaine	0.5–1.0	0.2	5–15	1–1.5	Duration of complete motor blockade and ataxia was 30 and 180 min, respectively. Complete motor blockade may not be observed at 0.25%	
0.75% Ropivacaine	1.65	0.22	7–15	1.5–2.5	Duration of motor blockade 90–150 min	
Opioids						
Morphine PF	0.1	0.1 for abdominal and pelvic procedures; 0.25 for thoracic procedures	45–90	12–24 for pelvic limb and abdominal procedures at 0.1 mL kg^{-1}; 5–6 for thoracotomy procedures at 0.25 mL kg^{-1}	Reduced minimum alveolar concentration (MAC) by 30% and minimized CV depression from inhalant. Potential for urinary retention and pruritus	(4, 25, 80)
Buprenorphine	0.004	0.2	<60	Up to or greater than 24	Reduced risk for urinary retention	(83)
Local anesthetics and opioids						
Morphine PF and 0.5% bupivacaine	0.1 and 0.5–1.0	0.22	<15	Up to 24	67% return to normal motor function within 8 h. Potential for urinary retention	(125, 126)
Oxymorphone and 0.75% bupivacaine	0.1 and 1.0	0.2	<15	Up to 24	Decreases in heart rate. Transient hypotension. Systemic absorption of epidural oxymorphone is high	(24, 88)
Buprenorphine and 0.5% bupivacaine	0.004 and 1.0	0.2	<30	Up to 24	Low incidence of urinary retention	(130)
Alpha$_2$-Adrenoreceptor agonists						
Dexmedetomidine	0.003–0.006	0.25	<15	Up to 4.5	Dose-dependent MAC reduction up to 4.5 h. Bradycardia and elevated blood pressure may occur. Minimal effects on motor function	(110, 111)
Alpha$_2$-Adrenoreceptor agonists and local anesthetics						
Dexmedetomidine and 0.5% bupivacaine	0.004 and 1.0	0.22	<15	Up to 24	Less urinary retention when compared to opioid epidurals Prolonged motor blockade compared to local anesthetic and opioid epidurals	(126)

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Review

Epidural anesthesia and analgesia in small animal practice: An update

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Epidural anesthesia
Epidural neurostimulation
Small animal anesthesia

ABSTRACT

Epidural anesthesia is a commonly performed technique in both human and veterinary medicine. The technique is relatively simple following appropriate training and provides anesthesia and analgesia for acute and chronic pain. Several drug combinations have been administered by this route with variable success and duration. Multiple techniques to guide or confirm correct epidural needle placement are discussed in this article, as well as anatomical features of the epidural space, effect of drug volume and concentration, and adverse effects of the technique in small animal practice. This article is not an exhaustive review of the literature, but an update of some new findings over the last decade.

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Introduction

Epidural deposition of anesthetic and analgesic drugs is commonly performed in small animal medicine and is an effective means of providing anesthesia and/or analgesia (Jones, 2001; Valverde, 2008; Sarotti et al., 2015). The lumbosacral epidural space is the most utilized site for injection in small animal veterinary medicine. Considered by some to be the gold-standard for pre-emptive analgesia, epidural anesthesia decreases central sensitization, intraoperative inhalant and opioid requirements, the use of postoperative rescue analgesia and plasma concentrations of stress response biomarkers during surgery (Romano et al., 2016; Steagall et al., 2017). It is a relatively cheap and easy technique to perform and has a relatively low degree of complications (Gurney and Leece, 2014).

This manuscript does not intend to serve as a review of all the literature available on this technique, but as an update of the last 10 years of research and published literature.

Updates on technique and methods to confirm epidural needle and catheter placement

In small animals, the lumbosacral space is most commonly used for epidural injections, administered with the animal in either sternal or lateral recumbency. A study demonstrated that extending the hind limbs cranially yielded an increase of close to 100% on the cranial-caudal distance from the dorsal facets of the lumbosacral space, as well as the L_6-L_7 space in dogs in sternal recumbency; the dorsal facet distance at the lumbosacral space was found to range from 3 to 10 mm with the pelvic limbs in neutral position and from 7 to 16 mm when the limbs were extended cranially (Di Concetto et al., 2012).

The sacrococcygeal intervertebral space may also be used for epidural delivery of drugs, which is beneficial, especially in cats in which the dural sac may extend as caudally as the lumbosacral intervertebral space, therefore avoiding inadvertent access to the subarachnoid space (O'Hearn and Wright, 2011). At this site, lower volumes can be used to anesthetize the pudendal, pelvic and caudal nerves, thus desensitizing the anus, distal colon, perineum, vulva or penis.

Identification of correct needle placement in the epidural space varies with the experience of the operator (Garcia-Pereira et al., 2010). Among the several methods reported to assist in epidural space identification, the two most commonly used are the "hanging drop" and loss of resistance (LOR) (Valverde, 2008) (Fig. 1). There are, however, controversies regarding the specificity and sensitivity of these methods (Adami and Gendron, 2017).

Another method, using a constant infusion of fluid was primarily described in humans by Baraka (Baraka, 1972) (Fig. 2). In a study comparing the hanging drop with the Baraka method in dogs in sternal and lateral recumbency, both techniques could successfully identify the lumbosacral epidural space. However, the same study found two factors to delay identification of the epidural space; the hanging drop method, as it required more attempts per subject; and positioning, lateral recumbency taking longer than sternal recumbency. Lastly, the authors also suggested that the hanging drop method is more reliable if animals are positioned in sternal recumbency (Martinez-Taboada and Redondo, 2017).

Garcia-Pereira et al. (2010) used neurostimulation and LOR to identify the lumbosacral epidural space in dogs. An electric nerve locator was useful in predicting correct epidural needle placement

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Fig. 3. Use of a backpressure equipment (Compuflo) to find the epidural space (arrow indicating the sudden drop in pressure). This continuous pressure monitor uses a slow continuous infusion to measure backpressure in different tissues while the needle is advanced, showing the changes in pressure as the needle is introduced into the epidural space.

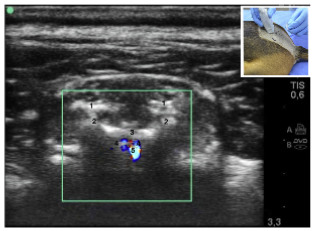


Fig. 4. Ultrasonographic image of the canine lumbosacral intervertebral space depicting colour flow doppler of the local anesthetic being injected into the epidural space. 1, Caudal articular processes of L_7; 2, Cranial articular surface of S_1; 3, Interarcuate ligament; 4, epidural space; 5, Local anesthetic flowing into the epidural space. Photo kindly provided by Dr. Pablo Otero.

respectively (Zhang et al., 2013). After administration of 0.2 mL/kg of contrast medium at a rate of 0.01 mL/s, epidurography revealed that the spread in number of vertebrae after 30 min was similar in both groups. (20.25 segments for the thoracic group and 21.5 for the lumbar group). The cranial-caudal spread was different between the two groups, with thoracic injections equally distributed, whereas the lumbar group diffused more cranially than caudally. In cats, similar results were found when methylene blue was injected (0.1–0.4 mL/kg) epidurally at the level of the lumbosacral intervertebral space (Lee et al., 2004). Of importance in the study of Zhang et al. (2013) is that 30 min following administration, contrast medium was seen at the level of the fifth cervical vertebra, when animals were positioned in sternal recumbency, consequently, innervation of intercostal muscles, as well as the phrenic nerves (at C_5-C_6 level) may be desensitized, leading to respiratory failure, and rendering mechanical ventilation obligatory. Another study in sternally recumbent anesthetized dogs found cranial spread between L_2 to C_6 after lumbosacral epidural administration of 0.2 mL/kg of contrast medium at the rate of 1 mL/min (Son et al., 2011). A potential explanation for the pronounced cranial distribution is the variation in injection velocity by manual delivery, which was also reported by Freire et al. (2010). A positive correlation between speed of injection and epidural pressure, with no change in distribution, was reported when contrast was injected by a syringe pump at a constant rate into canine lumbosacral epidural space (Son et al., 2014). Therefore, manual delivery can create large pressure waves, increasing cranial spread of the drugs in the epidural space.

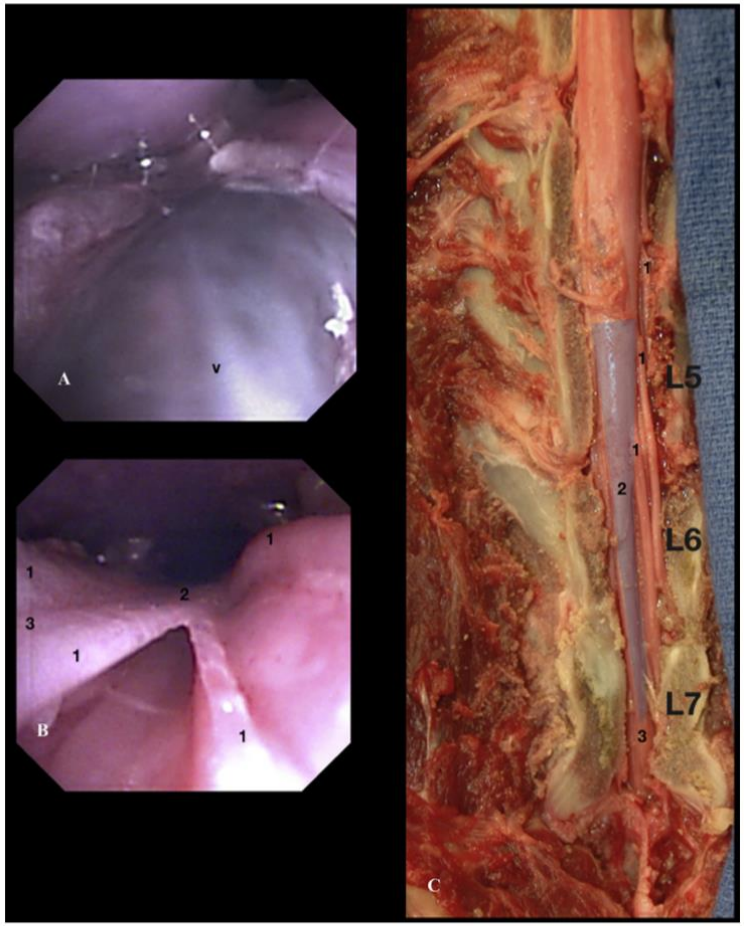
Iseri et al. (2010) compared the use of saline versus air for the LOR test in the canine lumbosacral epidural space, followed by administration of contrast medium. CT images showed that the use of air decreased cranial spread of the contrast, created air pockets in several areas and compression of the spinal cord. The authors subsequently recommended the exclusive use of saline for testing LOR. A similar study using the same volume of contrast medium (0.2 mL/kg) in sternally recumbent dogs, injected manually at the lumbosacral space over 30 s, found that cranial spread after injection reached the thoracolumbar junction in only 80% of their subjects (Kawalilak et al., 2015). This more limited distribution may be the result of CT images being captured immediately after injection, and only sagittal images being used, which could underestimate the extent of cranial spread.

Distribution after epidural administration is not always bilaterally homogeneous, even after single injection (Son et al., 2015). Changes in distribution have also been reported after long-term epidural catheter placement in dogs (Sasauchi et al., 2016). The catheters were advanced from the lumbosacral epidural space to the level of L_6 in six beagle dogs and tested weekly by contrast CT imaging (using 1.5 mL of contrast medium after 2 mL of lidocaine (2%)) on two different occasions. Contrast medium distribution and duration of motor blockade changed with time and by the 5th week no cranial spread past L_5 was observed, and the duration of motor blockade in the pelvic limbs was reduced by over 50% compared to first administration. Histological examination of the lumbar epidural space (L_5-L_7) from the 3rd and 5th weeks showed granulation tissue around the tip of the catheter, which probably limited the cranial spread of contrast medium and local anesthetic.

Commonly administered drugs and drug combinations

Local anesthetics cause increasing degrees of reversible nerve conduction blockade in different nerve fiber types depending on dose, concentration and volume used (Lyons et al., 2007; Almeida et al., 2010; Ozcan et al., 2014; Fenten et al., 2015). The mechanism of action is mainly by blockade of various sodium channels present on the neural cell membrane, although some of these drugs have additional sites of action (Hahnenkamp et al., 2006; Toda et al., 2011; Brenneis et al., 2014). Local anesthetics provide anesthesia and analgesia for surgical procedures, postoperative and chronic pain. They are classified as either amides or esters and have variable durations of action depending upon their lipid solubility and receptor affinity (Maheshwari and Naguib, 2015; Steagall et al., 2017; Wick et al., 2017).

A recent study administered lidocaine (6 mg/kg) into the epidural space of dogs alone or in combination with tramadol (1 mg/kg) or morphine (0.1 mg/kg). Sensation and motor activity in the pelvic limbs returned after approximately 120 min independent of the addition of opioids. Furthermore, this study suggested that epidural lidocaine provides sufficient anesthesia and analgesia during canine orchiectomy. Most importantly, the majority of animals (35/36) were conscious and calm during the surgical procedure. However, lidocaine's brief duration of action resulted in the group receiving the drug alone to have higher composite pain scale scores and to require more rescue analgesia 4 h after epidural



p left counterclockwise, (A) Epiduroscopy view of the floor of the epidural space. (B) Epiduroscopy view of lumbosacral epidu
umbar spinal cord (Cauda equina highlighted). 1, Nerve roots; 2, Dural Sac; 3, Cauda equina; v, Venous plexus.

n, Horner's syndrome, discospondylitis and
d bowel dysfunction (Bosmans et al., 2009;
, 2011; Song et al., 2011; Threlfall et al., 2012;
o et al., 2014).

nistration of drugs is a relatively simple
echnique is performed with care, taking into
elevant anatomy of the epidural space and the
ation, minimal adverse effects have been

Conflict of interest statement

None of the authors of this paper have a f
relationship with other people or organi
inappropriately influence or bias the content

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