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RESEARCH PAPER

The effect of epidural injection speed on epidural pressure and distribution of solution in anesthetized dogs

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Abstract

Objective To determine the effect of injection speed on epidural pressure (EP), injection pressure (IP), epidural distribution (ED) of solution, and extent of sensory blockade (SB) during lumbosacral epidural anesthesia in dogs.

Study design Prospective experimental trial.

Animals Ten healthy adult Beagle dogs weighing 8.7 ± 1.6 kg.

Methods General anesthesia was induced with propofol administered intravenously and maintained with isoflurane. Keeping the dogs in sternal recumbency, two spinal needles connected to electrical pressure transducers were inserted into the L6-L7 and the L7-S1 intervertebral epidural spaces for EP and IP measurements, respectively. Bupivacaine 0.5% diluted in iohexol was administered epidurally to each dog via spinal needle at L7-S1 intervertebral space, at two rates of injection (1 and 2 mL minute^{-1} groups), with a 1-week washout period. Epidural distribution was verified with computed tomography, and SB was evaluated after arousal by pinching the skin with a mosquito hemostatic forceps over the vertebral dermatomes. The results were analyzed according to each injection speed, using paired *t*- and Wilcoxon signed-rank tests.

Results Mean ± SD of baseline EP and IP values were 2.1 ± 6.1 and 2.6 ± 7.1 mmHg, respectively. Significant differences were observed between 1 and 2 mL minute^{-1} groups for peak EP (23.1 ± 8.5 and 35.0 ± 14.5 mmHg, $p = 0.047$) and peak IP (68.5 ± 10.7 and 144.7 ± 32.6 mmHg, $p < 0.001$). However, the median (range) of the ED, 11.5 (4–22) and 12 (5–21) vertebrae, and SB, 3.5 (0–20) and 1 (0–20) dermatomes, values of the two groups were not related to injection speed.

Conclusions and clinical relevance The EP profile during injection was measured by separating the injection and pressure monitoring lines. The increase in epidural injection speed increased the EP, but not the ED or the SB in dogs.

Keywords dog, epidural, injection, pressure, speed.

Introduction

Epidural anesthesia has been commonly used as a part of a balanced anesthetic protocol, for postoperative pain management in surgical cases, and to treat non-surgical pain in small animal practice (Skarda & Tranquilli 2007; Muir et al. 2013). Unfortunately, however, inadequate analgesia was sometimes experienced including insufficient range of pain relief and sensory blockade (SB) deviating from target spinal segment, and these unexpected results have motivated research to determine the influencing factors. The factors can be divided into three main groups including physical characteristics, technical factors, and epidural anatomical and physiological factors (Lee et al. 2001, 2004).

Among them, epidural pressure (EP) has been suggested as one of the epidural physiological factors since 1960s (Usubiaga et al. 1967b). In humans, several studies reported the effects of EP on epidural distribution (ED) and the extent of SB, but there have been some disagreements between authors about its significant relationship (Usubiaga et al. 1967b; Husemeyer & White 1980; Paul & Wildsmith 1989; Hirabayashi et al. 1990; Cardoso & Carvalho 1998).

The pressure in the epidural space becomes positive as fluid enters the space (Rocco et al. 1997), and increased EP is a possible cause of complications related to epidural anesthesia in human studies (Usubiaga et al. 1967a; de Jong 1981; Shah 1994). Therefore, it is necessary to determine the factors influencing EP increases in order to reduce potential complications. A human study reported that injection speed significantly correlated with peak EP (Cardoso & Carvalho 1998), but a previous study had determined no such relationship (Husemeyer & White 1980). In a recent study of dogs, Iff et al. (2007) identified that the EP increase was not related to the duration of the injection.

Consequently, additional study is needed to solve the controversy related to the change in the EP during epidural injection that involves differences in experimental conditions, individual variations in epidural anatomy, and the resistance generated by injection force in the pressure measuring system. Therefore, this study was performed to evaluate the effect of injection speed on the change in the EP in dogs, and to examine the effect of the EP on the ED and SB.

Materials and methods

Animals

All experimental procedures were approved by the Institutional Animal Care and Use Committee of Seoul National University (SNU-120222-2). The data were obtained from clinically healthy Beagles (five males and five females). Body condition score (BCS) was assessed on a 9-point scale based on previously described methods (Mawby et al. 2004). Mean ± SD body weight was 8.7 ± 1.6 kg, and the median BCS was 5, ranging from 3 to 7.

Anesthesia and positioning

Food was withheld for 12 hours before the experiment, but water was provided *ad libitum*. Following premedication with acepromazine (Sedaject; Samu Median, Korea) intravenously (IV), general anesthesia was induced with propofol (4 and 2 mg kg^{-1} increments; Provive 1%; Claris, India) until endotracheal intubation was possible, and maintained with a 1.0 minimal alveolar concentration of isoflurane (Ifrane; Hana Pharm., Korea) in oxygen using a circle system. Dogs were allowed to breathe spontaneously. Hartmann's solution (H/S; Daihan Pharmaceutical Co. Ltd., Korea) was administered at a rate of 10 mL kg^{-1} $hour^{-1}$ IV during anesthesia.

The dorsal pedal artery was catheterized with a 22-gauge over-the-needle catheter (0.9 × 25 mm; Sewoon Medical Co. Ltd., Korea) for measurement of arterial blood pressures. The electrocardiogram, hemoglobin oxygen saturation by pulse oximetry, respiratory rate by capnometry, end-tidal carbon dioxide concentration, and arterial blood pressure were continuously monitored (Datex-Ohmeda S/5; GE Healthcare, Finland) and recorded every ten seconds throughout the procedure on a laptop computer with a S5 data recorder (Datex-Ohmeda S/5 Collet version 4.0; GE Healthcare).

Each dog was positioned in sternal recumbency, with the pelvic limbs extended cranially along the abdomen and chest to increase the interspace between the sixth and seventh lumbar vertebrae (L6-L7), and between the seventh lumbar and first sacral vertebrae (L7-S1) (Di Concetto et al. 2012). The head was placed on 5 cm thick foam padding with the neck extended in a straight line. The height of the occipital bone was parallel with that of the highest point of the vertebral column to minimize the effect of head position. The dog was maintained in this position on a sliding computed tomography (CT) table throughout the experiment.

Epidural injection and the pressure measuring system

Bupivacaine (Bupivacaine hydrochloride; Sigma-Aldrich, MO, USA) 0.5% solution diluted in iohexol (Omnipaque 350 I mL^{-1}; GE Healthcare, Ireland) was prepared at 0.2 mL kg^{-1} dose as an epidural solution for injection into the epidural space. The lumbosacral area was aseptically prepared for epidural injection. Two spinal needles (22-gauge 38 mm; Tae-chang, Korea) were connected to an electrical pressure transducer (Auto Transducer; Acemedical, Korea) via a fluid-filled and non-distensible pressure line before epidural puncture.

