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RESEARCH PAPER

A sonographic investigation for the development of ultrasound-guided paravertebral brachial plexus block in dogs: cadaveric study

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Abstract

Objective To describe a novel in-plane ultrasound (US)-guided approach to the sixth (C6), seventh (C7), eighth (C8) cervical and to the first thoracic (T1) spinal nerves.

Study design Prospective, descriptive, experimental anatomic study.

Animals A total of seven canine Beagle cadavers.

Methods Phase 1: One cadaver was used to define bony landmarks for the C6-T1 spinal nerves using computed tomography (CT) and magnetic resonance imaging. A US transducer was positioned lateral to the C6 vertebra. Methylene blue (0.05 mL kg^{-1}) was injected cranial and caudal to the transverse process of C6. The probe was moved caudally to identify the cranial costal fovea of T1 and 0.1 mL kg^{-1} of methylene blue was injected. Full cadaver dissection was performed to assess the staining of the spinal nerves.
Phase 2: The technique was repeated using a 50:50 mixture of iohexol and methylene blue in six dogs. CT verified the proximity of contrast to C6, C7, C8 and T1 nerves. Mediastinal, epidural, intravascular and pleural contamination was recorded. Methylene blue staining of the phrenic nerve was assessed by dissection.

Results Phase1: The identified bony landmarks were the lamina ventralis of C6, the transverse process of C6 and C7, T1 vertebra and the first rib. Phase 2: At all the 12 sites, the C6, C7 and C8 nerves were in contact with contrast material. Contrast was demonstrated in close proximity to the anatomical location of the T1 nerve in 11/12 sites. Mediastinal, epidural and intravascular contamination was observed in six, four and two cadavers, respectively. Pleural contamination was not observed. The phrenic nerve was stained on 2/12 of sides.

Conclusions and clinical relevance In-plane US-guided blockade of the spinal roots is a feasible technique. However, because of the undesirable spreads of contrast, further research is needed to diminish the occurrence of contaminations of noble structures.

Introduction

The canine brachial plexus is formed by the ventral branches of the sixth (C6), seventh (C7) and eighth (C8) cervical and the first thoracic (T1) spinal nerve. Occasional contributions from the fifth cervical (C5) and the second thoracic (T2) spinal nerves can be present (Lemke & Creighton 2008).

The brachial plexus block is a well-validated technique to provide sensory and motor blockade of the forelimb (Campoy & Read 2013); however, a paravertebral approach is required for procedures involving the shoulder and brachium (Lemke & Creighton 2008; Campoy & Read 2013). Various techniques have been developed, such as the blind technique with the use of anatomical landmarks, the electrolocation technique (Lemke & Creighton 2008)

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and the ultrasound (US)-guided technique (Bagshaw et al., 2009; Rioja et al., 2012). Encountered complications include unilateral blockade of the phrenic nerve, intravascular injection (Lemke & Creighton 2008), pneumothorax (Bhalla & Leece 2015), Horner's syndrome (Viscasillas et al., 2013) and ventricular arrhythmias when electrolocation is used (Adami & Studer 2015).

Owing to the experienced difficulties in its execution and possible side effects, the paravertebral brachial plexus block is considered as an advanced level technique (Campoy & Read 2013). Therefore, in order to decrease the complications and improve the outcome, the development of a reproducible, easy-to-perform technique has been advocated.

When the use of US was introduced to human anaesthesia, both the reproducibility and safety of the brachial plexus block increased (Chan et al., 2007). Even if the sonographic appearance of the canine brachial plexus has been fully described elsewhere (Guilherme & Benigni 2008), previous research with the use of US guidance failed to improve the feasibility of the block (Rioja et al., 2012).

The aims of this study were threefold: 1) to describe the US landmarks for a new paravertebral approach to the brachial plexus; 2) to demonstrate the feasibility of the technique; and 3) to elucidate possible complications when applied to live animals.

Material and methods

Ethical approval for this study was obtained from the Royal Veterinary College (URN 2016 1506). The study was structured into two phases.

Phase 1

For the first part of the study, one Beagle cadaver (9 kg) was used to develop the technique. Magnetic resonance imaging (MRI) and computed tomography (CT) examinations were performed to clearly identify the path of the C6-T1 spinal nerves and their anatomical relationship to bony landmarks. The cadaver was positioned in dorsal recumbency with the limbs retracted caudally to acquire MRI and CT images. MRI was performed using a 1.5 tesla scanner (Intera 1.5 T; Philips Healthcare, The Netherlands). Dorsal and transverse T1- and T2-weighted fast spin echo and thin slice gradient echo images were acquired of the cervical spine. Helical CT scan of the same region was obtained using a 16-slice fourth generation CT scanner (Mx8000 IDT; Philips Healthcare). The CT settings were 120 kVp, 150 mA, 16 × 1.5 mm collimation, pitch 1, tube rotation time of 0.5 seconds and 2 mm reconstruction slice thickness. Images were reconstructed using medium- and high-frequency algorithms. Following CT, the first US examination of this region was performed using a 10 MHz linear array transducer (S9v; Sonoscape, China) with the cadaver positioned both in dorsal and lateral recumbency to identify the most suitable approach for the test injections. Although the specific bony landmarks for the C6, C7, C8 and T1 nerves were identified in both positions, a closer proximity to the vascular structures was encountered with the cadaver in dorsal recumbency. Therefore, the authors considered the lateral position as more suitable for the subsequent evaluations.

Using the bony landmarks, a test injection was performed at each site with the cadaver positioned in lateral recumbency and the non-dependent forelimb pulled caudally for the ease of access to the caudal cervical region. An 18 gauge, 38 mm Quincke spinal needle (Becton Dickinson SA, Spain) connected to a syringe and primed with methylene blue (Methylthionium Chloride Injection 1% w/v; Martindale Pharmaceuticals Ltd, UK) was utilized for the injections.

The in-plane US-guided technique used in both the study phases was as follows

C6 and C7 spinal nerves. The transducer was positioned in a transverse plane on the ventral neck, laterally displacing the trachea and oesophagus to identify the ventral border of the C6 vertebral body. The probe was moved laterally to visualize the ventral aspect of the plate-like expansion of the C6 transverse process called the lamina ventralis. Further laterally, the dorsal portion of the transverse process of C6 was identified. With the dorsal and ventral aspects of the C6 transverse process in view, the transducer was advanced 2−3 mm cranially until the concave surface ridge of the lamina ventralis disappeared (Fig 1a). This was the first injection site used to block the C6 spinal nerve. Aligned with the transducer, the needle was introduced in a dorsolateral to ventromedial direction. Under US guidance, the needle was advanced to contact bone. A volume of 0.05 mL kg^{-1} of methylene blue was injected. The transducer was then moved 2−3 mm caudal to the concave ridge of the lamina ventralis until the latter disappeared (Fig 1a). This was the second injection site used to block the C7 spinal

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