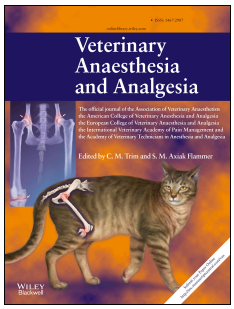
Accepted Manuscript



Ultrasound-guided thoracic paravertebral block: Cadaveric study in foxes (Vulpes vulpes)

Paolo Monticelli, Ian Jones, Jaime Viscasillas

PII: S1467-2987(17)30143-5

DOI: 10.1016/j.vaa.2016.06.007

Reference: VAA 131

To appear in: *Veterinary Anaesthesia and Analgesia*

Received Date: 5 February 2016

Revised Date: 17 May 2016

Accepted Date: 28 June 2016

Please cite this article as: Monticelli P, Jones I, Viscasillas J, Ultrasound-guided thoracic paravertebral block: Cadaveric study in foxes (Vulpes vulpes), *Veterinary Anaesthesia and Analgesia* (2017), doi: 10.1016/j.vaa.2016.06.007.

SHORT COMMUNICATION

Ultrasound-guided thoracic paravertebral block: Cadaveric study in foxes (Vulpes vulpes)

Paolo Monticelli[*], Ian Jones[+] & Jaime Viscasillas[*]

[*] Anaesthesia Department, Veterinary Clinical Science, The Royal Veterinary College, Hatfield, UK

[+]Diagnostic Imaging Department, Veterinary Clinical Science, The Royal Veterinary College, Hatfield, UK

Corresponding author: Paolo Monticelli, Anaesthesia Department, Veterinary Clinical Science, The Royal Veterinary College, Hawkshead Lane, Hatfield, AL9 7AL, UK. Email: pmonticelli@rvc.ac.uk

Running head: US-guided thoracic paravertebral block

Abstract

Objective To describe an ultrasound guided thoracic paravertebral block in canidae.

Study design Prospective experimental cadaveric study.

Animals Twelve thawed fox cadavers

Material and methods A 15 MHz linear transducer was used to visualise the paravertebral space at the level of the fifth thoracic vertebrae. Iohexol (300 mg mL^{-1}) at 0.2 mL Kg^{-1} was injected into the right and left paravertebral spaces under ultrasound guidance using a Tuohy needle. The needle was advanced in a lateral to medial direction using an in-plane technique. Injections were performed by two operators, each performing twelve injections in six fox cadavers. A thoracic computed tomography was then performed and evaluated by a single operator. The following features were recorded; paravertebral contrast location (yes/no), length of contrast column (number of intercostal spaces), location of contrast relative to the fifth thoracic vertebrae (cranial/caudal/mixed), epidural contrast contamination (yes/no), pleural contrast contamination (yes/no) and mediastinal contrast contamination (yes/no).

Results All the injections resulted in paravertebral contrast distribution (24/24). The mean length of the contrast column was five intercostal spaces. Contrast spread was caudal to the injection site in 54% (7/24), cranial in 29% (4/24) and mixed in 17% (3/24). Pleural contamination was observed in 50% (12/24) on injections; respectively 42% (10/24) and 4% (1/24) of the injections resulted in mediastinal and epidural contamination.

Conclusions and clinical relevance Injection of the paravertebral space in canidae is possible using the technique described. Possible complications include epidural, pleural and mediastinal contamination. To establish clinical efficacy and safety of this technique, further studies are required.

Keywords block, local anaesthesia, paravertebral, thoracic, ultrasound

Introduction

The thoracic paravertebral space (TPVS) is a wedge shaped space located on either side of the vertebral column. The TPVS is filled with adipose tissue that contains the intercostal nerve, intercostal vessels and the sympathetic trunk (Krediet et al. 2015). The parietal pleura forms the anterolateral boundary. The vertebral body, the intervertebral disc and the intervertebral foramen form the base. The transverse process and the superior costotransverse ligament form the posterior boundary. The endothoracic fascia lies between the parietal pleura anteriorly and the superior costotransverse ligament posteriorly and is attached to the periostium of the vertebral body (Karmakar & Ho 2007).

The endothoracic fascia divides the TPVS into two compartments: an anterior compartment (or extrapleural) and a posterior compartment (also called subendothoracic). The sympathetic ganglion is contained in the anterior compartment. The spinal nerve is positioned in the posterior compartment. The spinal nerves are segmented into small bundles within the TPVS which make them accessible to local anaesthetic solution injected into the TPVS. Thoracic paravertebral (TPVB) involves injecting local anaesthetic alongside the thoracic vertebra close to where the spinal nerves emerge from the intervertebral foramen (Karmakar & Ho 2007). Ipsilateral somatic and sympathetic nerve blockade are achieved with the TPVB. In human medicine the main indications for TPVB include breast, thoracic surgery and pain management following thoracic trauma and thoracotomies (Karmakar & Ho 2007). The ultrasound-guided TPVB is a well validated technique in human medicine (Krediet et at 2015) while it has not previously described in veterinary patients.

The aim of this descriptive study was to investigate the ultrasound anatomy and a technique to approach to the in canidae patients, define the distribution of the contrast within the TPVS and recognise potential complications.

Materials and Methods

Twelve thawed fox (vulpes vulpes) cadavers were included in the study. Cadaver foxes were donated by an independent, pest eradication company in accordance with local RVC Ethical approval, (URN 2015 1417).

Cadavers were 5.0 ± 1.4 kg with a body condition score between 3 and 4 out of 9 on the World Small Animal Veterinary Association Global Nutrition Committee scale. The TPVBs were performed using a S9v Sonoscape ultrasound machine with a 15MHz linear transducer (Sonoscape, China). Injections were performed by two operators (PM, JV), each operator performing twelve injections in six cadavers.

Cadavers were positioned in lateral recumbency with the targeted paravertebral space positioned uppermost. The thoracic region was clipped and ultrasonographic gel (Blue ultrasound gel; Henleys Medical, UK) was applied to the skin. The transducer was placed in a transverse orientation adjacent to the dorsal spinous process of the fifth thoracic vertebrae. The transverse process and rib of the fifth thoracic vertebrae were identified and the transducer moved caudally in order to locate the TPVS. The transducer was then positioned parallel to the neck of the rib, oblique to the TPVS (Fig. 1). The TPVS appeared as a wedge-shaped hypoechoic area with hyperechoic boudaries dorsally (intercostal membrane) and ventrally (pleural membrane) (Fig. 1). An epidural 20-gauge, 50 mm Tuohy needle (Pebax catheter, Vygon France) was used for the injections. The needle was advanced into the TPVS in a lateral to medial direction using an in-plane technique. The bevel of the needle was orientated away from the pleura. A decrease in resistance was felt as the needle penetrated the internal intercostal membrane, passing into the TPVS. This was often accompanied by a popping sensation. In order to simulate the antemortem technique, aspiration was performed to help avoid intravascular injection. Ioexol (300 mg mL^{-1}) at 0.2 mL Kg-1(Omnipaque 300, GE Healthcare, Germany) was injected into the right and left paravertebral spaces at the level of the fifth thoracic vertebrae over a 30 second period. Visualization of movement of the

pleural membrane during injection was recorded for each subject (yes/no). After rotating the cadaver onto the other side, the technique was repeated on the contralateral side. A thoracic computed tomography (CT) scan was then performed with the cadaver in sternal recumbency. All scans were obtained using a 16-slice MDCT scanner (MX 8000 IDT, Philips Medical Systems, Cleveland, USA). The CT settings were: helical acquisition, slice thickness 3mm, image reconstruction interval 1.5mm, helical pitch 0.688, tube rotation time 0.75s, x-ray tube current 150 mAs, x-ray tube potential 120kVp, matrix 512x512 and medium frequency ('soft tissue') reconstruction algorithm. Scans were performed in a cranial to caudal direction. Images were evaluated using "Bone" windowing (window level 300 window width 1500). The CT scans were reviewed by a single operator (IJ). The following features were recorded; paravertebral contrast location (yes/no), length of contrast column (number of intercostal segments), location of contrast relative to the fifth thoracic vertebrae (cranial/caudal/mixed), pattern of contrast spread (linear/intercostal/cloud) epidural contrast contamination (yes/no), pleural contrast contamination (yes/no), mediastinal contrast contamination (yes/no), contrast contamination of other areas (yes/no).

Data was analysed with IBM SPSS Statistic for Windows 21.0 (IBM Corp., NY, USA). Normality was assessed using the Shapiro-Wilk test. Descriptive statistics were used. Means and standard deviations are reported for parametric data.

Results

Movement of the pleural membrane was observed during 100% (24/24) of injections. All injections (24/24) resulted in identification of contrast within the paravertebral space. Linear spread was observed in all subjects (24/24). In 42% (10/24) of subjects, spread was considered to be both linear and intercostal.

The mean length of the contrast column was 5.0 ± 1.5 intercostal segments. Contrast spread was caudal to the fifth thoracic vertebrae in 54% (13/24), cranial in 29% (7/24) and mixed in 17% (4/24). Half of the injections (12/24) resulted in pleural contamination, 42% (10/24) in

mediastinal contamination and 8% (2/24) in epidural contamination. Contamination of other areas was found following 8 % (2/24) of injections, namely the cranial vena cava and right atrium.

Discussion

Various techniques (blind, neurostimulation or ultrasound guided) have been described for TPVB in human anaesthesia (Naja et al. 2004; Cowie et al. 2010; Marhofer et al. 2013). A neurostimulator-guided TPVB has been described in dogs where needle placement was verified by twitching of the intercostal muscles (Portela et al. 2012). This technique was successful in 75% of subjects (Portela et al. 2012). Contrast was identified within the TPVS in 100% of foxes using the ultrasound guided technique described here; therefore we suggest that US guided TPVB may be a superior technique.

The in-plane technique described allows direct visualization of the needle during its advancement. This is essential as penetration of the intervertebral foramen is a possible complication. The choice of needle is an important consideration. Tuohy needles provide more resistance and thus enhanced perception of tissue firmness. Fifty millimetre needles were most suitable for the foxes used in this study. Short needles may not reach the target while long needles increase the risk of damaging deeper tissues and are more difficult to use. Linear spread was observed after all injections but in 42% of the cases, it was also associated with an intercostal one. A linear pattern of spread may be related to distribution of contrast in the anterior compartment of the TVPS. This would result in blockade of the sympathetic ganglion only. An intercostal spread may be related to distribution of contrast within the posterior compartment. However, we cannot confirm this and further studies are required to investigate the clinical significance of different patterns of distribution (Naja et al. 2004). Previous investigators (Portela et al. 2012) obtained different results. They observed mostly cloud-like rather than linear spread. This difference may have resulted from the technique used to assess the correct position of the needle. Portela and others (2012) identified the

TPVS using electro-location and it is plausible to hypothesise that their injections were performed after stimulating the intercostal nerve that is located in the posterior compartment. This is supported by other researchers (Naja et al. 2004), who observed that injections into the posterior compartment were more likely to result in a cloud-like type of spread.

The length of the contrast column within the TPVS was 5.0 ± 1.5 intercostal spaces. This is comparable to previous reports in humans (Cowie et al. 2010; Marhofer et al. 2013). Our findings also support the large variation in the distribution of the contrast found in human patients. (Karmakar & Ho 2007; Marhofer et al. 2013). However, it is difficult to predict the relationship between regional spreading of contrast in vitro and the clinical efficacy of injectate in vivo. In most humans, regional local anaesthesia extends beyond the anatomical distribution of the contrast (Marhofer et al. 2013). Therefore, it is not possible to predict potential clinical efficacy based on the regional contrast distribution in cadavers.

Contamination of structures other than the TPVS was common using the technique described. Mediastinal contamination occurred following 42% of injections. In humans, mediastinal contamination has never been reported using the technique described. Mediastinal contamination may have occurred because of the close anatomical relationship between the TPVS, the mediastinum and unavoidable post mortem tissue degeneration.

Pleural contamination occurred following 50% of injections, which is much higher than that reported in humans (Karmakar & Ho 2007). Tearing of the pleural membrane may lead to leakage of contrast into the pleural space, potentially reducing the efficacy of the injected pharmaceutical (Komatsu et al. 2015). We oriented the bevel of the Tuohy needle tip away from the pleura in an attempt to reduce the risk of penetration (Komatsu et al. 2015). Penetration of the pleural membrane was not observed during any injection using the technique described. As cadaver specimens were used, it is also possible that pleural contamination may have occurred secondary to post mortem change. When the pleura is

171 punctured, current guidelines are to change intercostal space and repeat the block (Komatsu et
172 al. 2015).
173 Contamination of the epidural space following TPVB has been reported in both dogs and
174 humans (Purcell-Jones et al. 1989; Cowie et al. 2010; Portela et al. 2012). The previously
175 described techniques resulted in epidural contamination following 15% of injections (Portela
176 et al. 2012). In humans, the incidence of epidural contamination may be as high as 70%
177 (Purcell-Jones et al. 1989; Cowie et al. 2010). Only 8% of injections resulted in epidural
178 contamination using the technique described. The use of ultrasound to guide needle placement
179 may have reduced the incidence of epidural spreading.
180 Contamination of the caudal vena cava occurred following 8% of injections using the
181 technique described. . Contamination of the systemic venous system has been reported in
182 humans (Purcell-Jones et al. 1989). The internal vertebral venous plexus lies adjacent to the
183 paravertebral space. Blood passes from the internal vertebral venous plexus to the azygos vein
184 and finally into the right atrium (Specchi et al. 2014). Injection of contrast into the internal
185 vertebral venous plexus may have resulted in contamination of the cranial vena cava and right
186 atrium. This finding could represent a major concern because of the intravenous toxicity of
187 local anaesthetics. We were not able to prevent intravascular injection of contrast in our
188 cadaver specimens. In live animals we would recommend aspirating prior to injection of local
189 anaesthetic to check for possible intravascular needle placement. The technique was
190 performed by two operators which may have introduces methodological bias as the study was
191 not designed to evaluate differences between operators.
192 Injections were performed on both sides in each subject prior to CT examination. It was
193 therefore impossible to evaluate potential contralateral spreading of the contrast column
194 (Karmakar & Ho 2007). The technique described here was performed in foxes. Domestic
195 dogs (Canis lupus familiaris) and foxes (Vulpus vulpes) are of the same Family (Canidae). To
196 the authors' knowledge, no comparative anatomical studies addressing differences between

the fox and dog have been performed. The authors are aware that this limitation may limit the potential application of the technique in dogs. However, we suggest that the gross anatomy and ultrasonographic appearance of the TPVS is similar in foxes and dogs and therefore further studies are justified to evaluated the use of this technique in dogs.

Conclusion

Ultrasound-guided TPVB is possible in canidae. The described technique may be suitable for use in the domestic dog. Further studies are needed to evaluate this technique in clinical situations.

Acknowledgements

The authors declare no conflict of interest

Authors' contributions

PM and JV: performed the US-guided thoracic paravertebral blocks; IJ: performed the CT scans and interpreted the images. All the authors contributed to the elaboration of the manuscript.

References

Cowie B, McGlade D, Ivanusic J et al. (2010) Ultrasound-guided thoracic paravertebral blockade: A cadaveric study. Anesth Analg 110, 1735-1739.

Karmakar MK, Kwok WH, Kew J (2000) Thoracic paravertebral block: radiological evidence of contralateral spread anterior to the vertebral bodies. Br J Anaesth. 84, 263-265.

Karmakar MK, Ho AM (2007) Thoracic & lumbar paravertebral block. In: Textbook of Regional anaesthesia and acute pain management, Admir Hadzic (ed.) Ed. Mc Graw Hill Medical pp. 583-597.

Komatsu T, Sowa T, Kino A et al. (2015) The importance of pleural integrity for effective and safe thoracic paravertebral block: a retrospective comparative study on

postoperative pain control by paravertebral block. Interact Cardiovasc Thorac Surg 20, 296-299.

Krediet AC, Moayeri N, van Geffen G et al. (2015) Different approaches to ultrasound-guided thoracic paravertebral block. Anesthesiology 123, 459-474.

Marhofer D, Marhofer P, Kettner SC et al. (2013) Magnetic resonance imaging analysis of the spread of local anesthetic solution after ultrasound-guided lateral thoracic paravertebral blockade: a volunteer study. Anesthesiology 118, 1106-1112.

Naja MZ, Ziade MF, Rajab ME et al. (2004) Varying anatomical injection points within the thoracic paravertebral space: effect on spread of solution and nerve blockade. Anaesthesia 59, 459-463.

Portela DA, Otero PE, Sclocco M et al. (2012) Anatomical and radiological study of the thoracic paravertebral space in dogs: iohexol distribution pattern and use of the nerve stimulator. Vet Anaesth Analg 39, 398-408.

Purcell-Jones G, Pither CE, Justins DM (1989) Paravertebral somatic nerve block: A clinical, radiographic, and computed tomographic study in chronic pain patients. Anesth Analg 68, 32-39.

Specchi S, D'Anjou MA, Carmel E.N et al. (2014) Computed tomographic characteristics of collateral venous pathways in dogs with caudal vena cava obstruction. Vet Radiol Ultrasound 55, 531-538.

241 **Figure 1** This picture represents a fox cavader **A.** Ultrasonographic appearance of the thoracic
242 paravertebral space (TPVS). **B.** Ultrasonographic landmarks for the TPVS block. Cr, Cranial;
243 Cd, Caudal; 1, pleura; 2, transverse process of the fifth vertebra; 3, costotransverse ligament;
244 4, fifth rib; 5, internal intercostal membrane; 6, paravertebral space; 7, spine. The picture on
245 the right side represents the fox in lateral recumbency with the positioning of the ultrasound
246 transducer.
247