COMPARISON OF THE EFFICIENCY OF ANATOMICAL AND ULTRASOUND-GUIDED METHOD FOR THE Th₄ – Th₇ INTERCOSTAL NERVE BLOCK IN DOGS

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Abstract

The aim of this study was the assessment of the usefulness of the ultrasound-guided method during injections into the Th₂–Th₇ intercostal nerve area in dogs, as well as comparison of the liquid deposition precision obtained using anatomical and ultrasound-guided methods. The study has been performed on fresh cadavers of 20 dogs. A mixture of black ink and iodinated contrast medium was injected. The procedure was performed by anatomical method at the right side and ultrasound-guided at the left side. Subsequently, thoracic radiograph in dorsal recumbency and post-mortem examination were performed. A spread of the contrast media mixture was assessed on radiographs and during post-mortem examinations. Eighty injections were done in 20 dogs with the use of each method. The assessment method of the accurate placement of the contrast medium mixture in the area of the intercostal nerve, based on X-ray examination, was consistent with necropsy findings. Probability of the precise liquid placement was two times greater in case of ultrasound-guided method than in case of anatomical one. These differences were statistically significant. Ultrasound viewing improved considerably the precision of injection of the contrast medium mixture in the area of intercostal nerves. This technique is simple and easy to master and it increases effectiveness and safety of performed procedures. The comparison of both methods on cadavers enables a choice of an appropriate anaesthesia technique in living animals.

Key words: dog, intercostal nerve block, ultrasound-guided anaesthesia.

Local anaesthesia of intercostal nerves enables keeping under control pain resulted from injuries and surgeries on chest. In order to reach analgesia of a given area one should anaesthetise at least each two intercostal nerves before and after a place of injury (13, 18, 19). The most frequently used method of anaesthesia in case of small animals is anatomical one, that is applied after localisation of characteristic reference points (caudal edge of the rib angle). Complications that can occur after blockage application are: lack of anaesthesia or insufficient one, pneumothorax, laceration of the intercostal vessels, injury of the intrathoracic organs (11, 19), and total spinal anaesthesia (10).

Performing peripheral nerves blockade with ultrasonography utilisation increases its efficiency and reduces a number of complications. Ultrasound viewing enables observation of the anaesthetised structures, a needle and local anaesthetic spread at real time (1, 2, 4-6, 9, 13, 14). So far, ultrasound-guided local anaesthesia of the brachial plexus (1), brachial plexus, sciatic and femoral nerves (4), sciatic and saphenous nerves (6), and sciatic and femoral nerves in dogs (9) have been described in veterinary literature. Utilisation of ultrasound viewing for intercostal nerves blockade in dogs has not been described in available literature till now.

The aim of this study was the assessment of the usefulness of the ultrasound-guided method during performing injections in the Th₂–Th₇ intercostal nerves area in dogs, as well as comparison of the precision of a liquid deposition obtained using anatomical and ultrasound-guided methods.

Material and Methods

The study was performed on fresh cadavers of 20 dogs (7 males and 13 females), 1-16-year-old, weighing 8-26 kg, subjected to euthanasia or dead from other reasons than diseases or injuries of thorax. The animals represented seven races: Mongrel-12, Dachshund-3, English bulldog-1, Dalmatian-1, Labrador retriever-1, Poodle-1, and Shar-pei-1.

All procedures were performed in the same way as in case of live animals. After preparing the cadavers to the procedure (shaving of thorax and skin washing with 70% ethanol), they were placed in lateral recumbency, free hind limb was stretched out to front, the Vth rib (counting from last) was located and its
position was marked on skin by marker. Instead of local anaesthetic, a mixture (1:1) of black ink and iodinated contrast medium (Omnipaque 350; Amersham Health, Norway) at dose of 0.15 ml/kg b.w./nerve was injected into the Th5-Th8 intercostal nerves area. The liquid was injected by disposable syringes and Ø 0.7 mm needles. A level of the needle was directed parallelly to parietal pleura. The procedure was performed by anatomical method (18, 19) at the right side and ultrasound-guided method at the left side. Electronic linear probe of 7.5 MHz frequency and footprint length 40 mm (L 40, Teson, Poland) connected to stationary ultrasonic scanner (Integra, Teson, Poland) was used for imaging. The probe was placed vertically to ribs at the area of their angle. During the examination, an appropriate intercostal space was located, and external and internal intercostal muscles as well as parietal pleura were identified. The needle was inserted vertically to ultrasound beam (in a short axis of the probe). The liquid was injected close behind the rib, between internal intercostal muscle and parietal pleura. During the procedure needle’s position and a spread of injected liquid were constantly monitored. An injection, after which injected liquid moved away parietal pleura from a rib, was regarded as the correct one (Fig. 1).

Fig. 1. The ultrasound scan of the Vth intercostal space of a mongrel dog, male, 1-year-old, and 9 kg b.w., before and after injection of the liquid between internal intercostal muscle and parietal pleura. „After” injected liquid moved away parietal pleura from a rib (dog’s head on the left). Legend: rib Vth, VIth (5, 6), parietal pleura (red arrows), injected liquid (blue arrow).

Subsequently thoracic radiograph in dorsal recumbency and post-mortem examination were performed. A spread of the contrast medium mixture was assessed on radiographs and during post-mortem examinations. The presence of the liquid in intercostal space and under parietal pleura at the area of intercostal nerves was regarded as the correct one. After incorrect injections, the liquid was found outside intercostal space.

The obtained results were subjected to statistical analysis using PASW statistics programme (SPSS, Poland). Conformity of the methods’ precision, defining the liquid injection, was assessed by $\kappa$ factor calculation. Probability of the precise liquid placement at the area of intercostal nerves was calculated for anatomical method as well as for ultrasound-guided method. The comparison of the probabilities was done by “$u$” test (16), at relevance level $\alpha=0.05$.

**Results**

It was difficult to identify proximal parts of the IVth and Vth ribs when anatomical method was used. Separate ribs, intercostal muscles, parietal pleura, a needle and injected liquid were identified using ultrasound-guided method. In none of the cases intercostal nerves were visible.

Application of the contrast medium mixture made the injected liquid visible during X-ray and post-mortem examinations. The assessment of the liquid spread was possible in all of the cases.

Eighty injections were done in 20 dogs using each of the methods. When anatomical method was applied, 38 (47.5%) injections were found precise, while 42 (52.5%) were found imprecise. The largest number of mistakes was observed in the area of the IVth and Vth intercostal spaces. Among ultrasound-guided injections, 76 (95%) of them were found precise and four (5%) were found imprecise. All mistakes occurred during injections into the IVth intercostal space. In one of the cases, the liquid was placed in the IIIth intercostal space (Figs 2, 3, 4), while in remaining cases it was placed in pleural cavity. Results of the contrast medium mixture injections for individual intercostal nerves are presented in Table 1.

**Table 1**

<table>
<thead>
<tr>
<th>Intercostal nerve</th>
<th>Anatomical method</th>
<th>Ultrasound-guided</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>right</td>
<td>wrong</td>
</tr>
<tr>
<td>IV</td>
<td>3</td>
<td>17</td>
</tr>
<tr>
<td>V</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>VI</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>VII</td>
<td>15</td>
<td>5</td>
</tr>
</tbody>
</table>

The assessment method of the accurate placement of the contrast medium mixture in the area of the intercostal nerve, based on x-ray examination was consistent with post-mortem examination ($\kappa=1.0$). Probability of the precise liquid placement in the area of intercostal nerve was two times greater in case of ultrasound-guided method than in case of the anatomical one. These differences were statistically significant ($\mu_{emp}=6.597; \alpha=0.05$) (Table 2).
Fig. 2. Vento-dorsal thoracic radiograph of a mongrel dog, male, 10-year-old, and 8 kg b.w., made after injection of mixture of the contrast medium. On the right, the contrast medium is outside the intercostal spaces (green arrows). On the left, contrast medium is in the intercostal spaces IIIrd and Vth-VIIth (red arrows).

Fig. 3. Photograph of internal part of the right thoracic wall made during post-mortem examination of a mongrel dog, male, 10-year-old, and 8 kg b.w. Lack of the mixture of contrast medium in intercostal spaces IVth-VIIth and under parietal pleura at the area of the Th5-Th7 intercostal nerves (black tint). The point of the needle is close behind the Th5 intercostal nerve (dog’s head on the right, spine at the bottom).

Fig. 4. Photograph of internal part of the left thoracic wall made during post-mortem examination of a mongrel dog, male, 10-year-old, and 8 kg b.w. The presence of the liquid in intercostal spaces and under parietal pleura at the area of the Th3, Th5-Th7 intercostal nerves (black tint). The point of the needle is close behind the Th5 intercostal nerve (dog’s head on the left, spine at the bottom).

Table 2
Comparison of the efficiency of anatomical and ultrasound-guided methods used during injection into the Th4-Th7 intercostal nerves (n=160)

<table>
<thead>
<tr>
<th>Method of injection</th>
<th>Injection right</th>
<th>Injection wrong</th>
<th>Total</th>
<th>Probability of the right injection</th>
</tr>
</thead>
<tbody>
<tr>
<td>anatomical</td>
<td>38</td>
<td>42</td>
<td>80</td>
<td>0.475</td>
</tr>
<tr>
<td>ultrasound-guided</td>
<td>76</td>
<td>4</td>
<td>80</td>
<td>0.950</td>
</tr>
</tbody>
</table>

Discussion

The most frequently performed surgery on dogs’ chest is thoracotomy in the Vth intercostal space (17). The local control of the postoperative pain requests anaesthesia of the Th4-Th7 intercostal nerves. Effectiveness of peripheral blockade depends on quantity of applied local anaesthetic and on precision of its injection. During our studies, a dose of 0.15 ml/kg b.w./nerve of the contrast medium mixture was injected, which corresponded to a volume of 0.5% bupivacaine solution, used in a clinical practice. This quantity of bupivacaine does not exceed a safe dose in a dog amounting to 3 mg/kg b.w. (18, 19) at anaesthesia of four intercostal nerves. In order to achieve the best anaesthetic effect, a local anaesthetic should surround a trunk of the nerve (1, 2, 4, 6, 9, 13-15). Costa-Farre et al. (6) performed ultrasound-guided anaesthesia of sciatic and saphenous nerves in dogs. During injections, they observed an entire surrounding (doughnut sign) of trunk of the saphenous nerves and a partial surrounding of the sciatic nerves by local anaesthetic. During clinical
examination they found an entire blockade of saphenous nerves and a partial blockade of sciatic ones.

Forty two (52.5%) incorrect injections were done when anatomical method was used. The mistakes consisted of too superficial liquid injection, which did not reach a respective intercostal nerve. A needle was introduced too flat due to concern about uncontrolled puncture of the intrathoracic structures. The greatest number of mistakes happened during liquid injection into the IVth and Vth intercostal spaces (17 and 15 times, respectively). It resulted from difficulties in localisation of characteristic anatomical points. Proximal parts of the IVth and Vth ribs are located close to the caudal margin of the scapula and they are covered by well-developed muscles. As it results from our experience, an angle of the needle insertion should be greater in case of the IVth and Vth than in case of other intercostal spaces (unpublished data). More useful technique applied during thoracotomy is a sight guided anaesthesia of respective intercostal nerves (done from the parietal pleura side) or a finger guided percutaneous local anaesthesia (8, 18). These methods cannot be used in animals, which are not subjected to a surgery. They also did not enable a preemptive analgesia i.e. a control of pain before its occurrence. The preemptive analgesia is a postoperative pain treatment method with recognised effectiveness. Its application enables to delay pain occurrence, as well as reduces its intensity. A serious complication of intraoperative intercostal nerves anaesthesia, that has been described in humans, was erroneous injection of local anaesthetic into a sheath or trunk of the spinal nerve. The injected anaesthetic migrated to subarachnoid space of the spinal cord causing a total spinal anaesthesia. A serious respiratory arrest, bradycardia, and hypotension were observed in patients. The choice of improper places for local anaesthetic injection was the reason of the complications. The places of injections were located much closer to the vertebral column than acceptable in the anatomical method (10).

During ultrasound-guided peripheral blockade, two methods of the needle insertion are applied: in a long axis of the probe (in-plane) and in a short one (out-of-plane). A choice of one of them depends on the anatomical structure of a specific area and on preference of physician that performs the procedure. An entire needle can be exposed when in-plane technique is applied. Nevertheless, it requests the needle holding in “a field of vision” of the probe that is in area of 1 mm width. A track of the needle insertion is a long one. The needle presence in tissues causes arising of artefacts that hamper observation of structures located below. When out-of-plane technique is applied, a track of the needle insertion is a shorter one and in this case precise harmony of the needle and probe position is not required. As only a part of the needle passing ultrasound beam is visible during the procedure, constant monitoring of the needle point passing through tissues requests keeping a proper angle between the needle and the probe. According to Chapman et al. (5) and Marhofer (13, 14), an angle between the probe and the needle should decrease while the depth of the needle’s insertion increases. Bloc et al. (3) recommend application of the needle hydrolocalisation. It consists of injecting a small amount of liquid (0.5-1.0 ml) while the needle is passing through tissues. Owing to good liquid visibility in ultrasound viewing, as well as to tissue deformation caused by the liquid injection, the needle point position can be precisely defined. In our studies, the out-of-plane technique was used. The presence of the scapula in the area of the IVth and Vth rib angles made placing the probe parallel to ribs and in plane technique application impossible. Apart of it, artefacts arising during needle insertion could deteriorate visibility of small anatomical structures in intercostal spaces. During the procedure, the needle point position was constantly monitored and the probe position was corrected. Hydrolocalisation was not applied because injection of the contrast medium mixture at the moment of the needle passing through tissues could have had a negative influence on interpretation of radiological and post-mortem examinations.

Four (5%) ultrasound-guided injections were found incorrect. In one of the cases, erroneous injection in the IIIrd intercostal space occurred and in the remaining ones the needle point was inserted too deep and consequently liquid was injected into pleural cavity. It was connected with inaccurate localisation of the needle point. The visualisation of the IVth intercostal space requested pushing in the probe below the scapula. It hampered performance of the procedure in an unconstrained manner. Application of the probe with a smaller footprint possibly could allow avoiding mistakes. Acoustic shadow of rib does not allow visualisation of intercostal nerve. In this connection, visualisation of intercostal muscles, and parietal pleura in local anaesthesia is essential. According to Marhofer (13), the placement of the local anaesthetic within the limits of internal intercostal muscle or in the space between internal intercostal muscle and parietal pleura, enables anaesthesia of the trunk of the intercostal nerve in human beings. We had no problems with visualisation of intercostal muscles and parietal pleura during our studies. An injected liquid was visible, and the occurrence of parietal pleura withdrawal from the rib was observed after correctly executed procedure. The presence of the contrast medium surrounding intercostal nerve was found in these intercostal spaces during necropsy. It should be taken for granted that anesthesia of intercostal nerve would be achieved in alive dogs as well, after injection of local anesthetic between internal intercostal muscle and parietal pleura.

Precision of the liquid’s placement in the area of a specific intercostal nerve was assessed on the basis of radiological and post-mortem examinations of the thorax. Application of black ink and iodinated contrast medium mixture enabled liquid visualisation in both types of examinations. Regular shadings in particular intercostal spaces were observed on radiograph after correct injection of the liquid. Identical results were achieved by Crossley et al. (7) when they injected a mixture of local anaesthetic and radiological contrast medium to healthy volunteers. After correctly executed procedure, black tint of tissues under parietal pleura and
around trunk of the intercostal nerve were observed during post-mortem examination. Application of dye for assessment of spread of the liquid placed in the area of peripheral nerve is commonly used and the achieved findings are considered reliable (1, 2, 4, 9, 15). Black ink proved to be a cheap and available contrast medium. It was easily mixed with radiological contrast medium and it was visible in a place of injection.

In summary, ultrasound viewing considerably improves the precision of injection of the contrast medium mixture in the area of intercostal nerves in dogs. This technique is simple and easy to master and increases the effectiveness and safety of performed procedures. The obtained results of the comparison between the anatomical and ultrasound-guided methods on cadavers enables to choose an appropriate anaesthesia technique in living animals.

References