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Validation of the accuracy of needle placement as used in diagnostic local analgesia of the maxillary nerve for investigation of trigeminally mediated headshaking in horses

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Keywords: trigeminal neuropathy, posterior ethmoidal nerve, infraorbital nerve, horse

Summary

Objectives: Diagnostic local anaesthesia of the maxillary nerve is a valuable aid in the diagnosis of trigeminally mediated headshaking in horses. Our objective is to validate the accuracy of needle placement in this procedure and to identify any correlation between accuracy of the technique and operator experience.

Methods: Using a small volume of contrast medium, the procedure was performed bilaterally on 30 horse cadaver heads by three groups with different levels of experience with the technique. The location of deposition was then identified using computed tomography (CT).

Results: Contrast medium was deposited around the target site in 53.3% (32/60) of injections. An experienced operator succeeded in deposition around the target area significantly ($p<0.05$) more often (80%, 16/20) than did the less and non-experienced performers (40%, 16/40).

Conclusions: A negative response to diagnostic local anaesthesia of the maxillary nerve does not disprove facial dysaesthesia as the cause of headshaking in that horse as a false negative response could arise due to failure to deposit local anaesthetic around the target area. Increased experience in performing the procedure decreases the probability of false negative results.

Introduction

Headshaking in horses is commonly a clinical sign of a facial dysaesthesia (abnormal sensation), suspected to be due to a neuropathy of the maxillary branch of the trigeminal nerve (Newton and others 2000; Roberts 2011; Roberts and others 2013; Pickles and others 2014). A diagnosis of facial dysaesthesia can be made by observing a marked decrease in headshaking in response to local anaesthesia of the innervating sensory nerves (Roberts and others 2013; Pickles and others 2014).

Where no cause of this facial dysaesthesia can be identified on endoscopy, imaging of the head, ophthalmologic and dental examination the dysaesthesia is likely to be neuropathic (Newton and others 2000; Roberts and others 2013).

The maxillary nerve exits the brain via the round foramen, runs cranially and enters the maxillary foramen into the infraorbital canal to become the infraorbital nerve. The infraorbital nerve innervates the upper check teeth and the skin of the muzzle. The caudal nasal nerve (CNN) branches off the maxillary nerve just proximal to the maxillary foramen and enters the caudal nasal foramen before running towards the dorsal meatus of the nasal cavity to innervate the nasal mucosa (Dyce and others 2002). In previous articles the CNN has been called the ‘posterior ethmoidal nerve’ (Newton and others 2000; Roberts and others 2013), but due to possible confusion with the ethmoidal nerve which branches of the ophthalmic nerve rather than the maxillary nerve we will refrain from using this term.

Local anaesthesia of the infraorbital nerve as it leaves the infraorbital canal resulted in a decrease in headshaking in 3/19 (16%) horses only (Mair 1999). However, local anaesthesia applied around the maxillary nerve at the location of the maxillary foramen resulted in a marked decrease in headshaking in 11 of 17 (65%) and 23 of 27 (85%) of presumed idiopathic headshakers (Newton and others 2000; Roberts and others 2013). It is suspected there was a false negative result in at least some of the horses, as 3/4 horses which did not respond to diagnostic local analgesia responded well to caudal compression surgery which itself carries a 49% success rate (Roberts and others 2013).

The intended site of deposition of the local analgesic is around the maxillary and CNN, (Newton and others 2000; Roberts and others 2013) but accuracy of needle deposition at this location using the approach described by Newton et al (2000) has never been confirmed. Deposition in different locations could explain some of the false negative responses.

The objective of this study was to verify the exact location of injection when performing local anaesthesia of the maxillary and CNN and also to determine whether increased operator experience would result in a more accurate placement of the local analgesic.

Materials and Methods

Thirty horse cadaver heads with no known clinical abnormalities were obtained from an abattoir. No selection for breed, age or sex had been made. Decapitation had been performed at the atlanto-occipital joint. All procedures were performed within 3 hours of decapitation.

The heads were randomly assigned to one of three groups, with ten heads to be injected by an experienced operator (VR) who has used local anaesthesia of the maxillary and CNN routinely on clinical cases (eight years' experience with headshakers consisting 2% of caseload, total more than 100 cases on which this procedure has been performed). Another 10 heads were injected by a less experienced (learning) operator (SW), who had been trained by the first operator and had performed the procedure in four clinical cases before this study. The last ten heads were injected by ten final year veterinary students with no experience in performing the procedure. Prior to performing the procedure all of the students were given access to the literature available to veterinary practitioners on the technique. This included the guidelines as described by Newton *et al.*

(2000), a video on placement of the injection which is included in a commercially available iPhone app (Equine Techniques)[c], anatomy books and an equine skull, but no further explanation was offered and no communication with other performers was allowed. All twelve performers were right hand dominant. The heads were positioned horizontally (ventral part of mandible resting on the table) on the CT machine [a] scanning table. Injection around the maxillary and CNN was then performed bilaterally using the contrast medium amidotrizoate (Urografin 150®, Bayer)[b] and all performers used the approach as first described by Newton *et al*. (2000) (technique shown in figure 1); A 19 gauge 90 mm spinal needle was inserted on the ventral border of the zygomatic process of the temporal bone at the narrowest point of the zygomatic arch and directed rostromedially in the direction of the contralateral upper sixth cheek tooth. The needle was inserted to its full length or until contact with bone was made. Aspiration was attempted before contrast injection and the stylet was replaced before needle withdrawal in an attempt to keep the contrast localised. To ensure good accuracy of measurements, only a 0.1ml volume of a mixture of contrast medium was injected (Bardell and others 2010).

Immediately following bilateral injection, CT images were obtained using a 4th generation helical CT scanner [a]. All heads were scanned from cranial to caudal using a 1.5mm diameter slice thickness with a pitch of 0.9. Settings were kV of 130, mAs 190 (effective – Siemens CareDose 4D protocol) and a rotation time of 1 second. Reconstructions were obtained at a thickness of 1.2mm to ensure that there was sufficient slice detail for multi-planar reconstructions. All images were then reviewed using commercially available DICOM viewing software [d]. Images were initially reviewed in the transverse plane to locate the contrast material. Dorsal images were then reconstructed with the plane aligned with the hard palate using multiplanar reconstruction. The location of the contrast injected was then noted and the distance from the target site. In some images, due to the 3 dimensional nature of the skull, thick slice reconstructions were required to bring the location of the contrast injection into the same plane as the caudal nasal foramen. In order to assess placement zones correctly, the images were then reconfigured as thin slice images and rotated around the axis of the caudal nasal foramen to align the foramen and contrast injection site. All measurements were taken at the closest point of the visible contrast media to the caudal nasal foramen.

The position of the injected contrast medium was divided into 4 zones depending on its position to determine the accuracy of the injection (Figure 2). Zone 1 represented contrast around the CNN nerve within and including at the entrance of the caudal nasal foramen where the CNN nerve branches off of the maxillary nerve. Zone 2 and 3 lie between zone 1 and a line drawn between the hamulus of the pterygoid bone and the caudal lateral tip of the caudal maxillary sinus. This region was then divided into equal portions based on the distance along the maxillary tuber to give zones 2 and 3 (see figure 2). Zone 4 was all regions outside this area which included the orbit and represents a failure to place the contrast near the maxillary nerve. Designation to the zones were made and recorded by a single independent observer (CWS) blinded to the identity of the performer of the injection.

Data are presented descriptively and a Kruskal Wallis test was performed to examine the relationship between accuracy and the three groups of performers, followed by a Mann Whitney U test to examine significance in difference between each pair of groups. When it was then found appropriate to combine groups, a Fisher's exact test was used to examine if the experienced performer did inject around the maxillary nerve (zone 1, 2 and 3) more often than the other performers did. A Wilcoxon Signed Rank test was used to determine the relationship between deposition zone and left or right side of the head. Statistical analysis was performed using SPSS Statistics for Windows version 19 [e)]. Significance was taken as $p<0.05$.

Results

The position of the contrast deposition was recorded for each head and the results for each zone, side of head and group are displayed in table 1. Contrast is deposited around the maxillary nerve (zone 1, 2 and 3) in 53.3% (32/60) of injections.

The Kruskal Wallis test showed a significant difference in accuracy amongst the 3 groups (H(2) = 12.148, $P = 0.002$) with a mean rank of 33.50 for non-experienced, 37.60 for learning and 20.40 for the experienced performer. The Mann Whitney U test showed no significant difference in accuracy between the non-experienced and learning performers ($P = 0.478$), but a significant difference between non-experienced and experienced performers ($P = 0.018$) and also between the learning and experienced performers ($P = 0.001$). Fig 3 shows the distribution over the zones where contrast was deposited by the experienced performer versus the other 2 groups combined.

When the inexperienced group was combined with the less experienced performer into one group, and zones 1, 2 and 3 were combine into a result 'hit', a Fisher's exact test could be used to compare the two groups. This confirmed that the experienced performer placed the injection around the maxillary nerve (zone 1, 2 and 3 combined) significantly ($P = 0.006$) more frequently (80% (16/20 injections)) than the other performers (40% (16/40 injections)).

There was significant difference in accuracy between injections placed on the left or right side of the head, as determined by the Wilcoxon Signed Rank test ($P = 0.046$), with greater accuracy on the right as the median of the zones hit on the right hand side was lower than on the left (zone 3 and 4 respectively). The injection was placed around the maxillary nerve in 43.3% of injections on the left side, and in 63.3% of injections on the right side of the head. (Table 1)

Discussion

This study shows that contrast is deposited around the maxillary nerve (zone 1, 2 and 3) in 53.3% (32/60) of injections, and we found that accuracy is significantly greater when the procedure is performed by the very experienced performer. There was no significant difference in accuracy between those with little or no experience in placing the injection in this study.

The use of one operator per category is not ideal and represents a limitation of the paper. However, given the limited number of experienced operators available it was not possible to include more operators in the experienced or learning group.

Injection did not always occur around the maxillary nerve as intended. Thus, a negative response to the local anaesthesia of the maxillary nerve in horses could result from failure to deposit local anaesthetic around the nerve. In clinical cases, accurate placement of the local anaesthetic can be confirmed to some extent by assessing sensitivity of the facial skin and nasal passage, which may help to distinguish a true negative from a false negative response.

Injections placed on the right side of the head were significantly more accurate than injections placed on the left side of the head. All performers were right hand dominant. In clinical cases a false negative response to bilateral local anaesthesia of the maxillary nerve and CNN would be more likely for remaining left-sided facial dysaesthesia. Signs of facial dysaesthesia in headshaking horses are usually bilateral (Aleman and others 2013). Therefore unilateral application of the local anaesthesia has not been attempted by the authors in clinical cases.

When performing local anaesthesia of the maxillary nerve and CNN in horses, a greater volume of local anaesthetic (5ml) is used than the volume of contrast medium in this study (Newton and others 2000). Previous to this study, an attempt was made by the authors to analyse the location of deposition of 5ml contrast medium, but description of anatomical structures involved proved difficult, complicating ensuing statistical analysis had this larger volume been used in the study. The use of a small volume of contrast medium and imaging modalities rather than dye and dissection techniques enabled us to accurately locate into which zone the injection had been placed. The larger volume used in clinical cases will result in analgesia of a much larger area as the anaesthetic will diffuse along tissues, including more branches of the maxillary nerve than could be visualised in this study. Therefore in clinical cases success rate of anaesthetising the maxillary and CNN will be greater than reported in this study. The use of zones rather than absolute distances enabled us to overcome the variation in head size by standardising each head to itself and helped verify the accuracy of placement, although the distance of diffusion could not be accounted for.

However even when using a larger volume, deposition of local anaesthetic in zone 4 is unlikely to result in desensitization of the maxillary nerve and will not lead to a decrease in headshaking even if this is due to facial dysaesthesia. This occurred in 24/40 (60%) of injections by the non-experienced or less experienced performers, and in 4/20 (20%) of the injections performed by the experienced performer, suggesting experience is essential when performing local anaesthesia of the maxillary nerve and CNN.

Possible complications of inaccurate injection of local anaesthesia around the maxillary nerve that have been observed by the authors in clinical cases include temporary loss of sight when the anaesthetic diffuses to or is deposited around the optic nerve, swelling of the retrobulbar fossa when disruption of an artery or vein results in a haematoma, or sudden distress when the needle touches the nerve. These side effects do resolve with time (Tremaine 2007).

We consider it to be good practice to perform diagnostic local anaesthesia around the maxillary nerve and CNN on presumed idiopathic headshakers (Roberts and others 2013). A marked decrease in headshaking in response to application of diagnostic local anaesthesia around the maxillary nerve and CNN without other pathology in the innervated area will support the diagnosis of trigeminal (maxillary) neuropathy to the veterinarian, the owner of the horse, and may also be used as proof for insurers. However, the possibility of a false negative outcome must be considered and preferably explained to the client before performing the diagnostic local anaesthesia around the maxillary nerve and CNN.

Manufacturers' details

a) Siemens Somatom Emotion, Erlanger, Germany.

b) Bayer plc, Newbury, Berkshire, UK.

c) Veterinary advances ltd, Ireland.

d) Osirix, Pixmeo, Switzerland

e) IBM Corporation, New York, United States.

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List of figure legends

Fig 1: Location of intended placement location of 19 Gauge 19mm spinal needle demonstrated in a horse skull and a clinical case.

Fig 2: Dorsal view of an equine head at the level of the maxillary foramen, with the location of zones used in this study. The caudal part of the infraorbital nerve and the caudal nasal nerve are highlighted in red. Zone 1 represented contrast around the CNN nerve within and including at the entrance of the caudal nasal foramen where the CNN nerve branches off of the maxillary nerve. Zone 2 and 3 lie between zone 1 and a line drawn between the hamulus of the pterygoid bone and the caudal lateral tip of the caudal maxillary sinus. This region was then divided into equal portions based on the distance along the maxillary tuber to give zones 2 and 3 (see figure 2). Zone 4 was all regions outside this area which included the orbit and represents a failure to place the contrast near the maxillary nerve.

Fig 2b: Dorsal view of an equine head at the level of the maxillary foramen, with yellow circles highlighting the contrast medium in zone 1 (left) and zone 2 (right).

Fig 3: The distribution over the zones where contrast was deposited by the experienced performer versus the other 2 groups combined.

Tables

		Zone 1	Zone 2	Zone 3	Zone 4	Zone 1+2+3	Total
Left	Non-experienced	0 (0%)	2 (20%)	1 (10%)	7 (70%)	3 (30%)	10
	Learning	0 (0%)	1 (10%)	2 (20%)	7 (70%)	3 (30%)	10
	Experienced	0 (0%)	6 (60%)	1 (10%)	3 (30%)	7 (70%)	10
	Non-exp + learning	0 (0%)	3 (15%)	3 (15%)	14 (70%)	6 (30%)	20
	All performers[§]	0 (0%)	9 (30%)	4 (13.3%)	17 (56.7%)	13 (43.3%)	30
Right	Non-experienced	1 (10%)	2 (20%)	3 (30%)	4 (40%)	6 (60%)	10
	Learning	1 (10%)	0 (0%)	3 (30%)	6 (60%)	4 (40%)	10
	Experienced	2 (20%)	5 (50%)	2 (20%)	1 (10%)	9 (90%)	10
	Non-exp + learning	2 (10%)	2 (10%)	6 (30%)	10 (50%)	10 (50%)	20
	All performers[§§]	4 (13.3%)	7 (23.3%)	8 (26.7%)	11 (36.7%)	19 (63.3%)	30
Both sides	Non-experienced[*]	1 (5%)	4 (20%)	4 (20%)	11 (55%)	9 (45%)	20
	Learning[*]	1 (5%)	1 (5%)	5 (25%)	13 (65%)	7 (35%)	20
	Experienced[**]	2 (10%)	11 (55%)	3 (15%)	4 (20%)	16 (80%)[ł]	20
	Non-exp + learning	2 (5%)	5 (12.5%)	9 (22.5%)	24 (60%)	16 (40%)[łł]	40
	All performers	4 (6.7%)	16 (26.7%)	12 (20%)	28 (46.7%)	32 (53.3%)	60

TABLE 1: Number of times contrast was located in each zone at each side of the head for each group of performers.

Zone 1 represented contrast around the CNN nerve within and including at the entrance of the caudal nasal foramen where the CNN nerve branches of from the maxillary nerve. Zone 2 and 3 lay between zone 1 and a line drawn between the hamulus of the pterygoid bone and the caudal lateral tip of the caudal maxillary sinus. This region was then divided into equal portions based on the distance along the maxillary tuber to give zones 2 and 3 (see figure 2). Zone 4 was all regions outside this area which included the orbit and represents a failure to place the contrast near the maxillary nerve.

The *, § and ł symbols indicate which groups were compared with each other, where an equal number of symbols represents no significant difference and an different number of the same symbols represent a significant difference.

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