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Mepivacaine local anaesthetic duration in equine palmar digital nerve blocks

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Summary

***Reasons for performing study*: Perineural analgesics are used for lameness diagnosis but the duration of effect, knowledge of which would provide valuable information when performing subsequent blocks, is unknown.**

***Objective*: To evaluate the duration of a palmar digital nerve block using force plate measurements.**

***Methods*: Ten horses diagnosed with unilateral navicular syndrome were trotted at range of 3 ± 0.15 m/sec over a force plate to record ground reaction forces for 5 trials of each forelimb. Data were recorded before nerve block, and then at 15 mins, 1, 2 and 24 h post nerve block.**

***Results*: Before nerve block, peak vertical force (mean ± s.e.) was significantly higher in the contralateral forelimb (CL = 5345 ± 188 N) than in the lame forelimb (L = 4256 ± 204 N; P<0.05). At 15 mins post nerve block there was no significant difference between the 2 forelimbs (CL = 5140 ± 184 N; L = 5126 ± 129 N), and this remained the case for 1 h. By 2 h, the mean score for the lame leg had decreased (L = 4642 ± 182 N) but was still greater than preblock. By 24 h, vertical forces had returned to preblock values.**

***Conclusions*: The palmar digital nerve block was fully effective between 15 mins and 1 h. The analgesic effect began to subside between 1 and 2 h but sufficient analgesia persisted to affect gait characteristics beyond 2 h.**

***Potential relevance*: When using a palmar digital nerve block, it is important to perform lameness evaluations between 15 mins and 1 h to be sure of effective nerve blockade.**

Introduction

Mepivacaine hydrochloride produces conduction blockade in sensory neurons by slowing sodium influx into cells (Altman *et al.* 1985). The resulting local anaesthetic effect has a rapid onset of action, which is advantageous when perineural analgesia is used as an adjunct in lameness diagnosis (Harkins *et al.* 1999). A palmar digital nerve block is a useful tool to assess and localise lameness to the palmar aspect of the foot. Decrease in lameness after a block at this location may be used to support a diagnosis of navicular syndrome (Derksen 1980; Stashak 2002). When it is difficult to determine the origin of lameness, serial blocks may be performed, often beginning with a palmar digital nerve block and moving up the limb until resolution of the lameness is achieved (Wright 1993). Structures desensitised by a palmar digital nerve block can include the navicular bone, podotrochlear bursa, distal sesamoidean ligaments, distal parts of the deep and superficial flexor tendons and their sheaths, digital cushion, corium of the frog, sole and palmar aspects of the distal phalanx and proximal and distal interphalangeal joints. There is variability in the desensitisation of some of these structures related to dose and placement of anaesthetic (Anderson and Turner 1993). Ideally, the block should be placed at the proximal border of the lateral cartilages of the distal phalanx to reduce the chance of blocking the dorsal and intermediate branches of the palmar digital nerves (Wheat and Jones 1981).

Local anaesthetic duration of procaine, tetracaine, lidocaine, mepivacaine and bupivacaine have been compared in studies involving rat sciatic nerve blocking procedures (Leblanc 1990; Dyhre *et al.* 1997) and in human studies (Moore *et al.* 1970). Previous reports have examined the effects and duration of mepivacaine in equine intra-articular spaces (Dyson and Kidd 1993; Andreen *et al.* 1994; Gough *et al.* 2002), the epidural space (Skarda *et al.* 1984) and systemically (Harkins *et al.* 1999). Knowledge of the duration of effect would provide valuable information when performing subsequent, additional blocks, especially if performed on different limbs. To evaluate the effects and duration of the anaesthetic, previous studies have used observation (Pleasant *et al.* 1997), motion analysis (Keegan *et al.* 1997), superficial and deep muscular pinprick stimulations (Skarda and Muir 1982), or serum (Skarda *et al.* 1984) and urine (Harkins *et al.* 1999) mepivacaine concentrations. Lameness and the effectiveness of a nerve block are difficult to evaluate objectively by observation (Keegan *et al.* 1998). A force plate offers an objective means of measuring forces induced during weightbearing and is an effective method of detecting biomechanical asymmetry that is known to exist with lameness between contralateral limb pairs (Khumsap *et al.* 2003). The objective of this study was to determine the duration of a mepivacaine nerve block over the palmar digital nerves in horses with navicular syndrome. Additionally, the usefulness of a cutaneous pinprick test to evaluate the effectiveness of a perineural anaesthetic block was evaluated.

Materials and methods

The study included 10 client-owned horses, age range 5–12 years, weight 473–558 kg and of American Quarter Horse, Paint Horse

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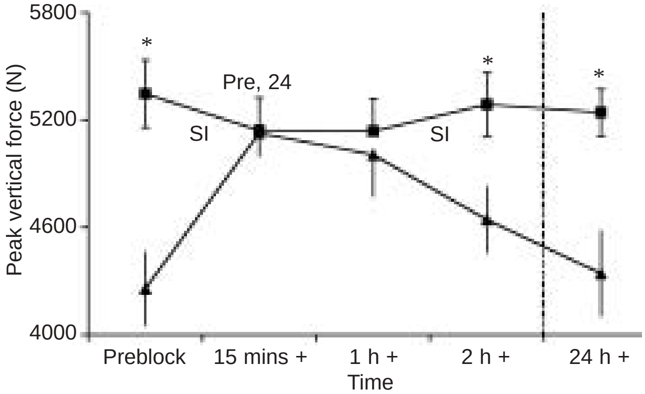

Fig 1: Peak vertical forces (mean ± s.e) of the control limb (CL; ■) and lame limb (L; ▲) for 10 horses diagnosed with navicular syndrome trotting at 3 ± 0.15 m/sec prior to palmar digital nerve block in the lame limb, and at 15 mins, and 1, 2 and 24 h post block. Statistically significant (P<0.05): difference between CL and L (*); difference between limbs combined at 15 mins vs. preblock (Pre) and at 15 mins vs. 24 h (24); interaction between limbs and preceding to succeeding time period (SI).

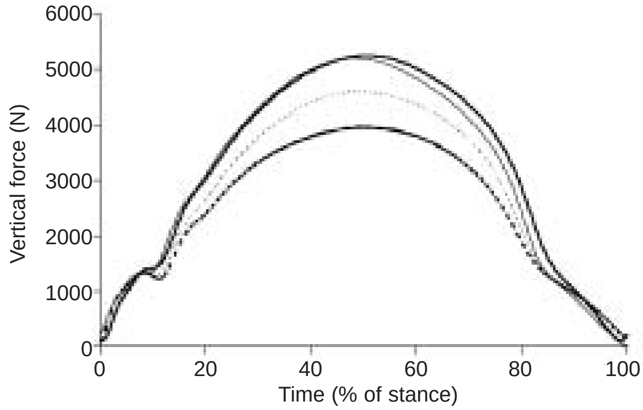

Fig 2: Peak vertical forces of the control limb (solid lines) and lame limb (dashed lines) for one horse diagnosed with navicular syndrome trotting at 3 m/sec pre- (thick lines) and 15 mins post (thin lines) palmar digital nerve block.

and Thoroughbred breeding. The horses were selected from clinical cases presented to the veterinary teaching hospital at Michigan State University. All horses showed clinical signs and radiographic changes consistent with navicular syndrome affecting one forelimb only. A criterion for inclusion was that the lameness was blocked out with a palmar digital nerve block as judged subjectively by lameness examination and objectively by force plate measurements. Six additional horses were excluded from the study, as the palmar digital nerve block was ineffective. This study was approved by the Animal Use and Care Committee of Michigan State University.

The study protocol involved placing a palmar digital nerve block, using 1.5 ml 2% mepivacaine[1] injected subcutaneously over the medial and lateral palmar digital nerves of the lame limb. These injections were placed approximately midpastern at the proximal border of the lateral cartilage of the distal phalanx. The same clinician performed the nerve blocks and evaluations on all patients. A pinprick test was used on the skin over the heel bulbs prior to each data collection on the force plate to compare cutaneous sensation with force measurements. Response from the horse by moving or elevating the limb tested was considered a positive response to pinprick. A standardised pain/sensation rating scale to grade the horse's reaction was not used. Horses were trotted at range of 3 ± 0.15 m/sec over a 60 x 120 cm force plate[2] embedded in a rubber runway to record ground reaction forces (GRFs) at 1200 Hz using Realtime 3.2 software[3]. Five trials of the lame and contralateral forelimbs were recorded at each period. Approximately 10–15 mins was required to capture the trials. Baseline force measurements were recorded immediately before administering the nerve block and then at 15 mins, 1, 2 and 24 h after.

Peak vertical GRF was chosen as the variable representative of the weightbearing function of the limb, as it is a sensitive indicator of lameness (Morris and Seeherman 1987). Data analysis was performed in MATLAB[4] using custom-written code, where the data were smoothed at 40 Hz using a 4th order Butterworth low-pass filter. Stance duration was normalised to 101 data points using a cubic spline interpolation. The data were evaluated statistically in SPSS[5] and were normally distributed (Shapiro-Wilks, P>0.05). Peak vertical forces were compared between the lame and contralateral limbs and over time using 2-way repeated measures ANOVA. *Post hoc* analysis involved simple main effects for interaction and least significant differences for main effects. Data are presented as means ± s.e.

Results

A statistically significant interaction (SI) for limb by time was found between pre-nerve block and 15 mins and between 1 and 2 h post block (indicated with SI in Figure 1). At pre-nerve block evaluation, the peak vertical force exerted by the contralateral forelimb (CL = 5345 ± 188 N) was significantly greater than that of the lame forelimb (L = 4256 ± 204 N; P<0.05). At 15 mins (CL = 5140 ± 181 N, L = 5126 ± 129 N) and 1 h (CL = 5137 ± 181 N; L = 5005 ± 231 N) post nerve block, no significant difference existed between the 2 forelimbs. At 2 h the peak vertical force in the lame limb (L = 4642 ± 182 N) was still higher than during the preblock evaluation, but this difference was not significant (P = 0.06). Peak vertical force in the lame limb returned to preblock level by 24 h post block (L = 4341 ± 237 N). As well as all trials falling within the 2.85–3.15 m/sec speed range, no statistically significant differences existed in the speeds between limbs and between time periods (P>0.05), thereby excluding any speed variation from explaining the results observed.

At preblock, mean difference in the peak vertical force between the forelimbs was 1089 N and at 15 mins post block this was reduced to 14 N. In all 10 horses, the preblock value was less for the lame limb than the contralateral limb. Peak vertical force increased in the lame limb after nerve block in all horses. Peak vertical force in the contralateral limb reduced significantly after the block (P<0.05), although the statistics masked 3 horses where the force had slightly increased. In 5 horses at 15 mins after block, peak vertical force in the lame limb became greater than in the contralateral limb. The pattern in Figure 2 illustrates findings in half of the horses in peak vertical forces of lame and sound limbs before and after palmar digital nerve block.

Pinprick evaluation of cutaneous reaction showed that all were sensitive before and 24 h after the nerve block. There was no response in any of the horses between 15 mins and 1 h post block. In 2 of the horses sensation was present in a single heel bulb at

60 mins, but analgesia did not completely resolve within 2 h. However, none of the horses had a complete return of cutaneous sensation within the 2 h testing period. Consequently, skin sensation did not correspond with the force measurements.

Discussion

Due to variability associated with observation when evaluating lameness (Keegan *et al.* 1998), the force plate acted as an objective quantitative measure of differences in gait before and after nerve blocks (McGuigan and Wilson 2001). The data from this study indicates that a palmar digital nerve block is fully effective between 15 mins and 1 h, and that the analgesic effects begin to subside between 1 and 2 h. At 2 h after administration the block is no longer completely effective, but sufficient analgesia may persist and continue to affect gait characteristics. When performing subsequent blocks on other limbs, it is important to consider the duration of the previous block.

Equine clinicians regularly perform perineural blocks as a diagnostic tool (Stashak 2002) and, based on desensitisation of the skin over the blocked nerve, may attempt to evaluate the effects within 5–10 mins of administration. Local anaesthetics block nerve fibre activity by affecting the sensations in the order of pain, cold, warmth, touch, joint distension and then pressure. Sensation returns in reverse order as the anaesthetic wears off (Butterworth and Stichartz 1990; Steffey and Booth 1995). In the nerve trunks of the limb, proximal sensory nerve fibres are located superficially and distal sensory nerve fibres are located centrally (Gokin *et al.* 2001). Local anaesthetic infiltrated around a large nerve could affect sensation first proximally and, as the anaesthetic diffuses into the centre of the nerve trunk, then distally. Therefore, it is not surprising that the pinprick test does not correlate directly with the effectiveness of the block in the navicular region.

In half of the horses, the pattern illustrated in Figure 2 was observed. This is consistent with previous reports of horses with navicular syndrome, who were significantly different from clinically sound horses in vertical and longitudinal GRFs at the beginning and end of the stance phase (Williams 2001). After administration of a palmar digital nerve block, the navicular horses were significantly different from the clinically sound horses only at the beginning of stance phase, suggesting only partial improvement (Williams 2001). Incomplete block that does not completely alleviate lameness may occur because the block was not fully administered, or because lameness has resulted in neural degradation and muscle wasting. This degradation and wastage may arise from changes in limb motion in horses with navicular syndrome where, after a palmar digital nerve block, significant kinematic increases have been found in the extension of the metacarpophalangeal joint during stance phase and flexion of the carpal joint during swing phase (Keegan *et al.* 1997).

In the remaining 5 horses, lameness was found to switch sides so that the blocked lame limb experienced greater peak vertical force than the contralateral limb. This finding suggests that there was a mild lameness in the contralateral limb, which was masked at the preblock evaluation. In an effort to protect an injured limb, the body centre of mass shifts to the sound contralateral limb (Buchner *et al.* 2001). In addition, as the peak vertical force was statistically significantly higher in the contralateral limb pre- than post block ($P<0.05$), this evidence of lameness compensation supports the proposal that a secondary lameness could develop in the contralateral limb (Stashak 2002). This statistically significant compensation masked 3 horses, one lame unilaterally and 2 bilaterally, where the peak vertical force of the contralateral limbs increased from pre- to post nerve block. Consequently, the compensatory mechanisms for lameness were varied and not consistent within the unilaterally and probably bilaterally lame horses in this study.

Six horses that demonstrated evidence of lameness or inflammation in the distal limb were excluded from the study because their lameness did not resolve with a palmar digital nerve block. This result can occur frequently in lameness diagnostics. These horses may have navicular syndrome, but in disease processes tissues surrounding nerves can be inflamed, producing an acidic environment. Local anaesthetics are most effective in the ionised form in a pH of 7.35–7.45; therefore, uptake is slower and less effective in the acidic environment of inflamed tissues (Altman *et al.* 1985). This may explain why some lamenesses are difficult or impossible to block with perineural anaesthesia.

The palmar digital nerve block is an important tool in lameness evaluation. Understanding the duration of the block should provide useful information to clinicians who perform multiple nerve blocks. Since analgesia persists for 1 h, subsequent blocks on multiple limbs should be performed during that period or initial blocks should be repeated to minimise confounding effects from limbs that are no longer completely desensitised.

Acknowledgements

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Manufacturers' addresses

[1]Pharmacia & Upjohn Company, Kalamazoo, Michigan, USA.
[2]AMTI, Watertown, Massachusetts, USA.
[3]Motion Analysis Corporation, Santa Rosa, California, USA.
[4]MathWorks Inc, Natick, Massachusetts, USA.
[5]SPSS Inc, Chicago, Illinois, USA.

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