Evaluation of the local analgesic effect of ketamine in the palmar digital nerve block at the base of the proximal sesamoid (abaxial sesamoid block) in horses

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Objective—To evaluate the local analgesic effect of ketamine in a palmar digital nerve block at the base of the proximal sesamoid (abaxial sesamoid block) in horses.

Animals—36 mature healthy Andalusian horses.

Procedure—Horses were randomly assigned to 4 groups of 9 horses each and received an abaxial sesamoid block in a randomly chosen forelimb with 1 of the following: saline (0.9% NaCl) solution, 1% ketamine solution, 2% ketamine solution, or 3% ketamine solution. To determine analgesia, the radiant heat lamp-hoof withdrawal model was used as a noxious thermal stimulus. Before each nerve block, baseline hoof withdrawal reflex latency (HWRL, time between lamp illumination and withdrawal of the hoof) was determined; after the nerve block, local analgesic effects were determined by measuring HWRL at 2 and 5 minutes after injection and then every 5 minutes for a total period of 1 hour.

Results—Significant differences in HWRL were found between baseline values and values at 2 to 15 minutes following a nerve block with ketamine. Significant differences were found between HWRL values at every time point from 2 to 10 minutes following a nerve block with saline solution, compared with 1 or 2% ketamine solution. Similarly, significant differences were found between HWRL values at every time point from 2 to 15 minutes following a nerve block with saline solution, compared with 3% ketamine solution.

Conclusions and Clinical Relevance—Abaxial sesamoid block with ketamine ensures adequate analgesia in horses with an onset of action of 2 minutes and a maximal duration of action of 15 minutes. (*Am J Vet Res* 2003;64:475–478)

Many diagnostic and surgical procedures are performed safely in horses, combining local anesthetic techniques with physical restraint, sedation, or both. Peripheral nerve blocks are used to provide intra- and postoperative anesthesia to a surgery site and as an aid in accurate diagnosis of lameness in horses.[1] Diagnostic nerve blocks are performed first on the most distal branches of nerve trunks and proceed proximally by use of a systematic approach.

Since the first published report[2] of the clinical use of ketamine in humans, ketamine has been the only agent that serves as an anesthetic, sedative, amnestic, and analgesic. Clinically, ketamine has been reported to produce not only general but also local anesthesia. It interacts with N-methyl-D-aspartate, opioid, mono aminergic, and muscarinic receptors and voltage sensitive Ca^{2+} channels.[3]

Ketamine is a dissociative anesthetic agent widely used in veterinary practice. In horses, ketamine is used as an induction agent,[4,5] and hypnotic agent during IV anesthesia,[4,5] and it has also been used epidurally to produce perineal analgesia.[6] The purpose of the study reported here was to evaluate the local analgesic effect of ketamine in the palmar digital nerve block at the base of the proximal sesamoid (abaxial sesamoid block) in horses.

Materials and Methods

Horses—The Complutense University Animal Care and Use Committee approved our study. A total of 36 mature and healthy Andalusian horses with a mean (± SD) age of 12 ± 4 years (range, 7 to 18 years) and a mean weigh of 490.3 ± 59.0 kg (range, 413 to 584 kg) were used. A routine physical examination was performed on all selected horses to ensure that all horses were healthy and free of lameness.

Experimental design—Two weeks before each experiment, a forelimb was randomly selected on each horse. The limb was prepared by clipping the hair on the dorsal and lateral sides of the proximal interphalangeal (pastern) joint region and blackening the skin with stamp pad ink.[a] An abaxial sesamoid block with 5 mL of 2% mepivacaine chlorohydrate[b] was performed as a positive control to rule out aberrant nerve supplies in the distal limb of the horses.

On the day of study, horses were transferred to a room with an ambient temperature of 21°C. Horses were then randomly assigned to the following 4 groups: 9 horses (control group) received an abaxial sesamoid block with 5 mL of saline (0.9% NaCl) solution, 9 horses (KET 1% group) received an abaxial sesamoid block with 5 mL of 1% ketamine hydrochloride[c] solution (ie, 50 mg of ketamine diluted in saline solution to a volume of 5 mL), 9 horses (KET 2% group) received an abaxial sesamoid block with 5 mL of 2% ketamine solution (ie, 100 mg of ketamine diluted in saline solution to a volume of 5 mL), and 9 horses (KET 3% group) received an abaxial sesamoid block with 5 mL of 3% ketamine solution (ie, 150 mg of ketamine diluted in saline solution to a volume of 5 mL).

Local anesthetic effect of ketamine was determined with a heat projection lamp adapted from that described by

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Kamerling et al.[7] This model uses a focused radiant light-heat as a noxious stimulus and was directed onto the pastern joint region to elicit the classic flexion-withdrawal reflex.

After covering the horse's eyes immediately before each experiment, the **hoof withdrawal reflex latency (HWRL)** was determined by use of a heat lamp. The heat lamp rapidly increased the temperature of the superficial skin layers of the pastern joint region to approximately 90°C in 4 to 6 seconds, at which point the horse sharply withdrew its hoof. Hoof withdrawal reflex latency is defined as the time between lamp illumination and withdrawal of the hoof.[8] The HWRL was measured at 30 and 15 minutes before and immediately before local infiltration of ketamine. The mean time of these 3 HWRL measurements was used to establish a baseline value (0 minute) for HWRL in each horse.

After the abaxial sesamoid block, HWRL values were determined by use of the heat lamp at 2 and 5 minutes after the injection and then every 5 minutes during a total period of 1 hour. To prevent undue tissue damage, thermal stimulus experiments were routinely finished after 10 seconds of exposure.

Statistical analysis—Analysis of data was performed by use of computer software.[d,e] All data were grouped and summarized as mean (± SD) values. Results were further analyzed by use of a Shapiro-Wilk normality test, and then a 2-way ANOVA for repeated measures. A Fisher test for multiple comparisons was also used. Values of $P < 0.05$ were considered significant.

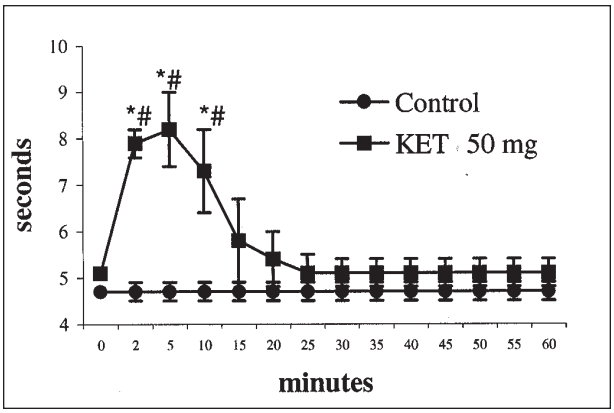

Figure 1—Mean (± SD) hoof withdrawal reflex latency (HWRL) at baseline (0 minutes) and 2, 5, and every 5 minutes during a total period of 1 hour after palmar digital nerve block at the base of the proximal sesamoid (abaxial sesamoid block) with 50 mg of ketamine (KET). *Significantly ($P < 0.05$) different with respect to 0 minutes (baseline). #Significantly ($P < 0.05$) different with respect to control values.

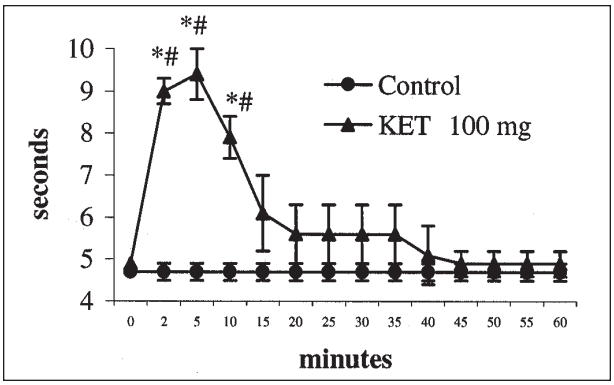

Figure 2—Mean (± SD) (HWRL) at baseline (0 minutes) and 2, 5, and every 5 minutes during a total period of 1 hour after abaxial sesamoid block with 100 mg of KET. *See* Figure 1 for remainder of key.

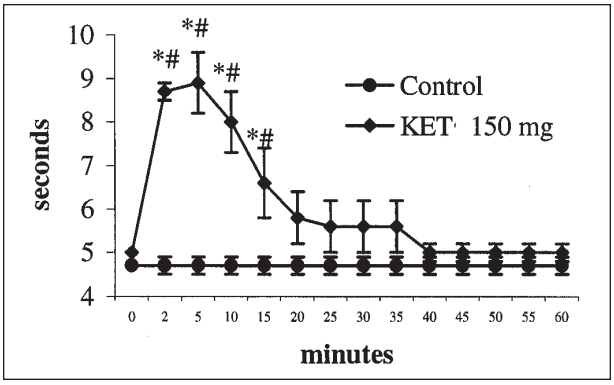

Figure 3—Mean (± SD) (HWRL) at baseline (0 minutes) and 2, 5, and every 5 minutes during a total period of 1 hour after abaxial sesamoid block with 150 mg of KET. *See* Figure 1 for remainder of key.

Results

In KET 1% and KET 2% group horses, significant differences in HWRL were found between baseline values and values at 2 to 10 minutes following an abaxial sesamoid block (**Fig 1 and 2**). In KET 3% group horses, significant differences in HWRL were found between baseline values and values at 2 to 15 minutes following an abaxial sesamoid block (**Fig 3**). Additionally, significant differences were found between control group horses and KET 1% and 2% group horses in HWRL values at every time point from 2 to 10 minutes following an abaxial sesamoid block. Similarly, significant differences were found between control group horses and KET 3% group horses in HWRL values at every time point from 2 to 15 minutes following an abaxial sesamoid block. Anesthesia did not result in any control group horses following saline solution injection. In KET 1%, KET 2%, KET 3% group horses, no significant differences in HWRL values were found at any time point following an abaxial sesamoid block.

Of the 9 KET 1% group horses, 4 had an abaxial sesamoid block that was unsuccessful (negative result). Nevertheless, all KET 2% and 3% group horses had an abaxial sesamoid block that was successful (positive result).

Discussion

Results of our study indicate that an abaxial sesamoid block with ketamine ensures adequate analgesia in horses with an onset of action of 2 minutes and a maximal duration of action of 15 minutes. Traditionally, local anesthetics such as procaine, lidocaine, mepivacaine, and bupivacaine have been used for abaxial sesamoid blocks[8-10]; however, other drugs such as fentanyl[11] and a distillate of the pitcher plant[12] have been tried recently, but resulted in no local anesthetic efficacy.

Clinically, ketamine has been reported[3] to produce not only general but also local anesthesia. Epidurally, ketamine is capable of inducing perineal analgesia in horses[6] and others species.[13-15] High concentrations of

ketamine possess local anesthetic properties similar to lidocaine and procaine[16-18]; results of a study by Durrani et al[19] revealed that ketamine can produce adequate regional anesthesia in humans following IV administration.

Following an abaxial sesamoid block in horses with 5 mL of 1, 2, and 3% ketamine solution, we observed an onset of local anesthesia at 2 minutes and a duration of action that ranged from 10 to 15 minutes. Successful injections of 5 mL of ketamine SC at the base of the proximal sesamoid desensitized the entire foot distal to the injection.

A correlation exists between the degree of lipid solubility and inherent anesthetic potency. However, duration of action is primarily a function of the extent of protein binding and vasoactivity of the local anesthetic. Five milliliters of 2% procaine solution, injected SC over the palmar and metacarpal nerves, produces analgesia within 10 minutes, and mepivacaine analgesia, when compared with procaine analgesia, is achieved earlier (5 minutes).[7] The duration of action of commonly used local anesthetics is long (ie, 60 to 90 minutes for procaine, 90 to 180 minutes for lidocaine, 120 to 180 minutes for mepivacaine, and 180 minutes for bupivacaine).[20]

It has been shown that SC infiltration with 0.3% ketamine solution produces a local anesthetic effect with a duration ranging from 10 to 20 minutes in humans,[21] and that infiltration with 0.5% ketamine solution causes a loss of thermal and pain sensation for 8 to 10 minutes in human volunteers.[17] Subcutaneous infiltration with ketamine has local analgesic effects in healthy and hyperalgesic skin.[18] Additionally, it is reported[21-23] that the addition of ketamine to locally administered anesthetics can enhance the duration of regional anesthesia and postoperative analgesia, which cannot be explained by a central action of ketamine and is most likely the result of a peripheral mechanism.[21]

Results of studies by Dowdy et al[16] and Shrivastav[24] reveal that high doses of ketamine possess local anesthetic properties by blocking Na^+ channels; subsequently, Weber et al[17] suggested a stabilization of peripheral nerve membranes as a possible mechanism for local anesthesia by ketamine. Later it was discovered that ketamine not only blocks Na^+ channels, but also K^+ channels,[25,26] stabilizing cellular membranes and obstructing nerve transmission, verifying that the mechanism of action is the same as that for other local anesthetics.[25] Ketamine has central effects that are mediated primarily by the interaction of ketamine with N-methyl-D-aspartate receptors[3]; however, it has recently been reported[18,27,28] that N-methyl-D-aspartate receptors are present on peripheral sensory axons.

Pain perception in horses has been measured with difficulty. Most clinical studies use subjective measures of pain, which include hoof compression, needle probing, digital pressure, and scored clinical signs.[7] In our study, local analgesic effect of ketamine was determined by use of the radiant heat lamp-hoof withdrawal model of Kamerling et al.[7] This model has been used in previous studies[7,8,11,12] on local effects of various agents in horses. The lamp-hoof withdrawal model detects the local anesthetic effects of submilligram doses of potent local anesthetics[11,12] by use of a focused radiant light-heat as a noxious thermal stimulus.

In our study, 4 of the 9 KET 1% group horses had an abaxial sesamoid block that was unsuccessful (negative result). Nevertheless, all KET 2% and 3% group horses had an abaxial sesamoid block that was successful (positive result). The failure or partial failure of a local block may occur for several reasons. The most common reasons are aberrant nerve supplies, incorrect anatomic deposition, inadequate anesthetic volume, dilution or hemodilution of anesthetic agent, and presence of fibrous connective tissue inhibiting diffusion of anesthetic agents.[29] Two weeks before the start of our study, horses were selected on the basis of positive results to an abaxial sesamoid block with mepivacaine. This was done to eliminate horses with possible aberrant nerve supplies and fibrous connective tissue from our study. The absence of analgesia observed in horses treated with 1% ketamine solution could be attributable to the concentration used in this group.

[a]Tinta negra hidrosoluble, JOVI, Barcelona, Spain.
[b]Scandinibsa 2%, Inibsa, S.A. Laboratorios, Barcelona, Spain.
[c]Ketamine 10%, Alfasan Woerden-Holland, Woerden, The Netherlands.
[d]Statview 4.0, Abacus Concepts Inc, Berkeley, Calif.
[e]SPSS 8.0.1S, SPSS Inc, Chicago.

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