

Effect of a static magnetic field on blood flow to the metacarpus in horses

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Objective-To determine the effect of a static magnetic field on relative blood flow to the metacarpus of horses.

Design-Randomized controlled clinical trial.

Animals-6 healthy adult horses.

Procedure-Red blood cells were radiolabeled in vivo by administration of technetium Tc 99m (pyro- and trimeta-) phosphates, and scintigraphic images were obtained 30 minutes later. A magnetic wrap that emitted a static magnetic field was applied to 1 metacarpus and a control wrap was applied to the contralateral metacarpus. Forty-eight hours later, the wraps were removed, and scintigraphy was repeated. Relative perfusion ratios were calculated by dividing mean count per pixel for the portion of the metacarpus under the wrap by mean count per pixel for a portion of the distal aspect of the antebrachium that was not in the magnetic field.

Results-The difference between the relative perfusion ratio prior to application of the wrap and the ratio after application of the wrap for limbs that received the magnetic wrap was not significantly different from the difference in ratio for limbs that received the control wrap.

Conclusions and Clinical Relevance -Results suggest that in horses, the static magnetic field associated with application of commercially available magnetic wraps for 48 hours does not increase blood flow to the portion of the metacarpus underneath the wrap. (*J Am Vet Med Assoc* 2000; 217:874-877)

The use of electromagnetic fields in the healing arts dates back as far as the fifteenth century, although the magnetic effects of "lodestone" were first described by the shepherd Magnes circa 1000 BCE in the region known today as Turkey¹. In the 18th century, Mesmer began treating hysteria and other disorders (today recognized to be psychosomatic in origin) with lodestones. He also claimed that nonmagnetic substances such as paper, wool, silk, and stones had similar healing properties.¹ Mesmer was later declared a charlatan, and interest in magnetic field therapy subsequently waned. Recently, however, interest in magnetic field therapy has revived, and a variety of products are available for treatment of humans and horses.

Devices employing pulsed or static magnetic fields have been proposed to have beneficial effects in a variety of applications. The mechanism of action whereby

such effects might be attained remains elusive, but one hypothesis is that there is an increase in blood flow in areas influenced by the magnetic field. Pulsed magnetic fields have been used to treat various conditions, such as inflammation,² osteoarthritis,^{3,4} soft-tissue injuries,⁵ chronic pelvic pain,⁶ and tendonitis,⁷ and have been reported to be useful for nerve regeneration,⁸⁻⁹ healing of osseous defects,¹⁰ bone grafts,¹¹ and fractures,^{12,13} and prevention of osteoporosis.¹⁴ On the other hand, pulsed magnetic fields have not been found to have any significant effects on soft-tissue wound healing in rats¹⁵ or on blood flow in the brains of mice.¹⁶ Static magnetic field therapy has been shown to result in significant pain relief in post-polio patients.¹⁷ However, static magnetic fields have been shown to have no significant effect on blood flow to the thumb or forearm of humans,¹⁸ maxillary buccal mucosal blood flow in humans,¹⁹ soft tissue healing in rats,¹⁵ blood flow to the skin of rats,²⁰ or relief of heel pain in humans.²¹

Uses of pulsed and static magnetic field therapies in horses have also been studied. For instance, in horses, pulsed magnetic field therapy was found to have a significant positive effect on healing of cancellous bone grafts,²² but had little to no effect on tendon repair²³ and healing of osteotomies of the third metacarpal bone²⁴ and did not increase uptake of technetium Tc 99m medronate in clinically normal horses²⁵ or skin temperature or blood flow in horses.²⁶

In a previous study,²⁷ a static magnetic field was shown to increase uptake of technetium Tc 99m medronate in the third metacarpal bone of horses, and the authors concluded that the increased uptake was a result of increased blood flow. However, uptake can be affected by factors other than blood flow, such as amount of osteoblastic activity, and in our experience, it is not uncommon to find asymmetric uptake between the right and left limbs of horses during bone scintigraphy. In addition, in our experience, evaluation of relative uptake (ie, the ratio of uptake in the target area versus uptake in a nontarget area) is a more accurate method of determining radiopharmaceutical uptake than is evaluation of absolute uptake. Therefore, the purpose of the study reported here was to determine the effect of a static magnetic field on relative blood flow, determined by means of scintigraphy using radiolabeled RBC, to the metacarpus of horses.

Materials and Methods

Animals-Six healthy young-adult mixed-breed horses were used in the study. Horses did not have any history of recent lameness or visible swellings or blemishes of the metacarpus. The study protocol was approved by the Colorado State university animal care and use committee.

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Table 1 Relative perfusion ratios* of the metacarpi in 6 horses before and after application for 48 hours of a magnetic wrap that emitted a static magnetic field to 1 forelimb and a control wrap to the contra lateral forelimb.

Horse No.	Magnetic wrap			Control wrap		
	Before treatment	After treatment	Difference	Before treatment	After treatment	Difference
1	0.74	0.88	-0.14	0.76	0.86	-0.10
2	0.74	0.81	-0.07	0.81	0.79	0.02
3	0.87	0.78	0.09	0.89	0.82	0.07
4	0.99	1.24	-0.25	0.98	1.24	-0.26
5	0.73	0.73	0.00	0.84	0.76	0.08
6	0.70	0.77	-0.07	0.74	0.98	-0.24

*Red blood cells were radiolabeled in vivo by administration of technetium Tc 99m (pyro- and trimeta-) phosphates, and scintigraphic images were obtained 30 minutes later; relative perfusion ratio was calculated by dividing mean count per pixel for the portion of the metacarpus under the wrap by mean count per pixel for a portion of the distal aspect of the antebrachium that was not in the magnetic field.

Magnetic wraps-Commercially available magnetic wraps were used to create the static magnetic fields. Two magnetic wraps were purchased from the manufacturer^a and sent to one of the authors (JLK). Both wraps were disassembled, and the magnets were scanned with a Hall probe to confirm that they were magnetized in alternating patterns, as stated by the manufacturer, and the strength of the magnetic field was measured at the surface of and 7 mm away from the surface of the magnets. One magnetic wrap was reassembled to its original condition (treatment wrap). For the other wrap (control wrap), the magnet was replaced with a polytetrafluoroethylene sheet of identical size and weight and the wrap was reassembled so that it was identical to the other wrap. The wraps were then labeled "A" and "B" and shipped to the remaining authors for use in the study. Authors involved in performing and interpreting the results of scintigraphy did not know which wrap was the treatment wrap and which was the control wrap until the end of the study. These authors avoided handling the wraps near any ferromagnetic materials throughout the study, so that identity of the wraps would not inadvertently be revealed too early.

Study protocol-Red blood cells were radiolabeled in vivo by administering 75 mCi of technetium Tc 99m (pyro- and trimeta-) phosphates^b and allowing 30 minutes for radiolabeled RBC to equilibrate in the body.²⁸ Sixty-second dorsal images of both metacarpi were then acquired with a gamma camera. Lead shielding was placed behind the limb to eliminate scatter from the other limbs, and the gamma camera was kept as equidistant as possible from the dorsum of each limb. Images were stored on a disk for later processing.

One wrap was then applied to each metacarpus. In each horse, the treatment wrap was placed on 1 front limb, and the control wrap was placed on the other front limb; whether the treatment wrap was placed on the left or right limb was randomly chosen.

The wraps were left in place for 48 hours, as per the manufacturer's recommendations. After 48 hours, RBC were again radiolabeled and scintigraphy was repeated, as described.

Processing of scintigraphic images-For each of the scintigraphic images, a region of interest (ROI) involving the portion of the metacarpus that was under the wrap was identified, being sure not to include any pixels with zero counts, and mean count per pixel in this ROI was recorded. Similarly, a ROI involving the distal aspect of the antebrachium (ie, a region that was not in the magnetic field) was identified, and mean count per pixel in this ROI was recorded. Relative perfusion ratio of the metacarpus was then calculated by dividing mean counts per pixel for the target ROI (metacarpus) by mean counts per pixel for the nontarget ROI (antebrachium).

Statistical analyses-The difference between the relative perfusion ratio prior to application of the wrap and the ratio after application of the wrap was compared between limbs that received the treatment wrap and limbs that received the control wrap by use of the Mann-Whitney test. A value of $P < 0.05$ was considered significant.

Results

The magnetic field at the surface of the magnets was 270 gauss. Seven millimeters from the surface of the magnets the magnetic field was ≤ 0.5 gauss (ie, \leq the magnetic field of the earth). For limbs that received the treatment wrap, the difference between the relative perfusion ratio prior to application of the wrap and the ratio after application of the wrap ranged from -0.25 to 0.09 (mean, -0.07; median, -0.07; **Table 1**). For limbs that received the control wrap, the difference between the relative perfusion ratio prior to application of the wrap and the ratio after application of the wrap ranged from -0.26 to 0.08 (mean, -0.07; median, -0.04). These values were not significantly different from each other.

Discussion

Results of the present study suggest that in horses, the static magnetic field associated with application of these commercially available wraps for 48 hours does not increase blood flow to the portion of the metacarpus underneath the wrap. Results of the present study do not allow us to conclude that these magnetic wraps do not have any potential advantages, but rather suggest that any effects of these magnetic wraps are not a result of increased local blood flow.

It has been suggested that static magnetic fields have a stimulatory effect on regional blood flow to the extremities in horses and that this enhances healing of musculoskeletal injuries. Kobluk et al²⁷ reported that a static magnetic field significantly increased blood flow and metabolic activity in the metacarpus of horses. However, baseline scintigraphic images were not obtained prior to application of the magnetic wrap or the modified Robert Jones bandage that was used as the control in that study. In addition, technetium Tc 99m medronate, a bone-seeking radiopharmaceutical, was used to evaluate blood flow. In our experience, it is common to detect uptake of technetium Tc 99m medronate by bone 10 minutes after injection, and for this reason, we believe that acquiring images 20 minutes after administration of this radiopharmaceutical is

not the best technique for studying tissue perfusion. Finally, Kobluk et al used the absolute (ie, total) number of counts in the ROI for their statistical analyses, rather than the relative ratio. However, various factors can affect absolute counts. For instance, the distance between the gamma camera and the limb will affect the absolute count because of the inverse square law.²⁹ In our clinical experience, it is common to find individual variations in uptake among limbs. For instance, it is not unusual in our experience to find differences as high as 50% in uptake of medronate among limbs of a horse during a single scintigraphic study. The cause of this asymmetrical uptake among limbs is, to our knowledge, not known. Absolute count in a ROI may also be affected by the amount of radiopharmaceutical administered. Inevitably, a certain amount of radiopharmaceutical will remain in the syringe, needle, and intravenous catheter, if one is used, and the amount of radiopharmaceutical lost for this reason is unpredictable. Finally, absolute count in a ROI will be affected by the amount of time after administration of the pharmaceutical that images are obtained, and by the interaction between the half-life of the radionuclide (technetium Tc 99m) and the half-life of the pharmaceutical part (medronate) of the drug. Only approximately 50% of the injected dose of technetium Tc 99m medronate is taken up by the calcium hydroxyapatite molecules in bone; the other 50% is excreted by the kidneys.

For all of these reasons, we elected to use radiolabeled RBC to evaluate blood flow in the present study. We believe that use of radiolabeled RBC provides a more accurate representation of blood flow.

The use of quantitative scintigraphy in veterinary nuclear medicine has increased in recent years, because relative counts provide more accurate results than do absolute counts.³⁰⁻³³ Relative uptake ratios, calculated by dividing mean counts per pixel for the target ROI by mean counts per pixel for a reference ROI on the same image, account for discrepancies in amount of radiopharmaceutical administered, distance of the gamma camera from the limb, effective half-life, asymmetrical limb uptake, and other factors that may affect absolute counts.

The failure in the present study to detect an increase in blood flow to the treated limb may be understandable in light of the weak magnetic field applied. The magnets used in these wraps are flexible magnets with an alternate pole arrangement, typical of common household magnets. The alternating pole arrangement allows for an increased magnetic gradient, which increases the ability of the magnet to stick to a ferromagnetic surface. This also decreases the distance that a measurable magnetic field can be detected from the surface of the magnet, as the poles tend to cancel each other out. In the case of the magnets used in the magnetic wraps in the present study, no measurable magnetic field greater than that of the earth-itself (0.5 gauss) was detected at a distance of 7 mm from the surface of the magnet. Given that these magnetic wraps do not fit exactly to the surface of the limb and that the limb is covered with hair, it is unlikely that the underlying blood vessels were exposed to a magnetic field of any clinically important strength.

^aNorfield's Magnetic Therapy Products, Los Angeles, Calif
^bPyrolite, Du Pont Merck Pharmaceutical, Billerica, Mass.

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