Case Report

Shockwave therapy for treatment of a burn injury in a horse

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Summary

This article describes a horse that sustained burn injury wounds over the back extending from the withers to the tail head as a result of a fire in a trailer. The extensive nature of the burn prompted investigation into treatment options which may stimulate healing. Based on current applications in human medicine, shockwave therapy was administered. This horse recovered from a substantial burn injury. Shockwave therapy may be a viable supplemental option for treating burn injuries in the horse, with no noted adverse effects.

Introduction

Barn fires typically result in burn wounds over the dorsal aspect of the horse. Fortunately these injuries occur infrequently, but they can be quite severe. Horses that survive the initial fire can have short-term complications such as smoke inhalation, pulmonary injury and burn shock (Geiser and Walker 1985; Provost 1999; Hanson 2005a,b; Norman *et al.* 2005). The local response includes inflammation, vasospasm, oedema, and possible electrolyte shifts depending on the extent of the burn (Provost 1999). The systemic response may include hypovolaemia, fluid and electrolyte loss, protein loss, pulmonary oedema, increased caloric requirements and depressed immune responses (Provost 1999).

These horses often have prolonged periods of healing until the wounds are completely re-epithelialised. In some cases, complications of wound healing in the latter terms including burn induced neoplasia, sarcoids and keloid-like proliferations, may occur (Schumacher *et al.* 1986; Hanson 2005b). Treating burns in horses presents logistical problems including control of the environment to keep the burned area clean and protecting the burned area from self-mutilation. The wounds can be managed by the closed technique with occlusive bandages, a semiopen technique with continuous wet dressings or an open technique with exposed eschar formation (Provost 1999; Hanson 2005b). The most commonly employed method for managing thermal injuries in the horse is the open method, leaving the eschar intact to act as a natural bandage. The wound is cleaned and devitalised tissue is debrided 2–3 times daily and topical antimicrobials are applied to the wound.

Whatever method is used to treat the burn injury, it must be continued until complete re-epithelialisation occurs. Wound contraction on the trunk is faster and continues longer than distal limb wounds (Wilmink *et al.* 1999) however, these types of burn wounds tend to be quite large. A number of mechanisms have been evaluated to stimulate re-epithelialisation of distal limb wounds in the horse. Silver sulphadiazine is often used on burn wounds for its broad spectrum antimicrobial effect (Provost 1999; Hanson 2005b). A 1% silver sulphadiazine cream did result in a faster rate of epithelialisation in an equine wound study (Berry and Sullins 2003). Other medications, including antimicrobial drugs, (Berry and Sullins 2003) corticosteroids (Bertone 1989), and various dressings (Bigbie *et al.* 1991; Schumacher *et al.* 1992; Gomez *et al.* 2004) have shown little benefit to wound healing.

A recent case report of a human with a burn injury showed potential for application of shockwave therapy (SWT) to decrease time to re-epithelialisation of deep, partial-thickness burns of human beings (Meirer *et al.* 2005a; Schaden *et al.* 2007). When the effects of SWT on the healing of partial-thickness wounds of pigs were evaluated, researchers found that the effect of SWT on the speed of epithelialisation occurred in a dose related fashion (Haupt and Chvapil 1990). The amount of avascular necrosis of epigastric skin flaps of rats was shown to be decreased by the application of SWT (Huemer *et al.* 2005; Meirer *et al.* 2005b, 2007). SWT-treated flaps developed an area of necrosis of only 2.5%, whereas 17% of the area of flaps that did not receive SWT was necrotic

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(Meirer *et al.* 2005a). In the horse, distal limb wounds healed 14 days faster with SWT than untreated controls (Morgan *et al.* 2009). This Case Report details a large burn injury in a horse in which SWT was included in the treatment protocol.

Case details

History

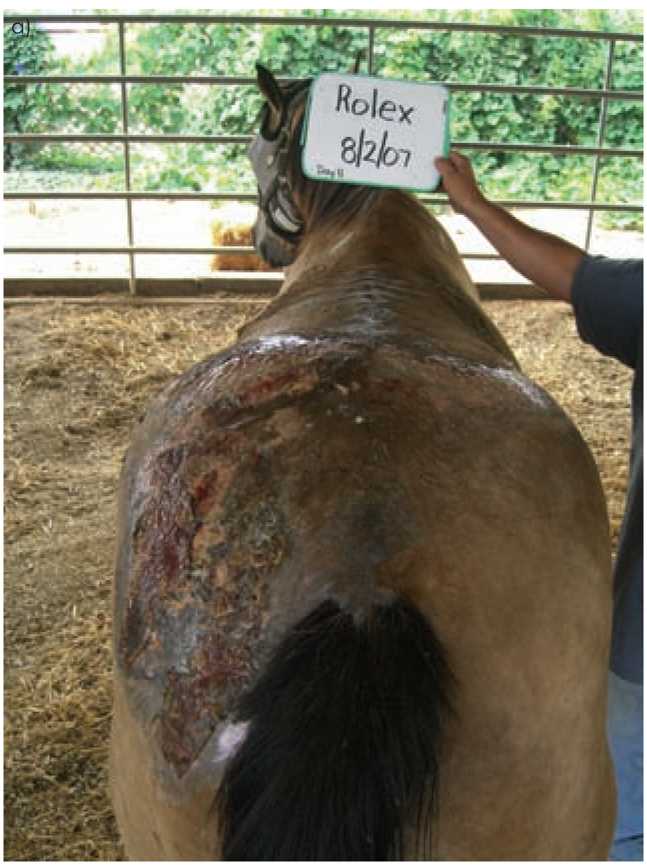
A 12-year-old Quarter Horse gelding was being transported in a horse trailer when a generator in the rear tack room ignited the blankets and fire spread to the fibreglass roof of the trailer. The fibreglass roof melted and fell onto the dorsal aspect of the horse. After the fire, the owner cleaned the burned area and applied a topical nonprescription corticosteroid cream daily. No other medications were administered.

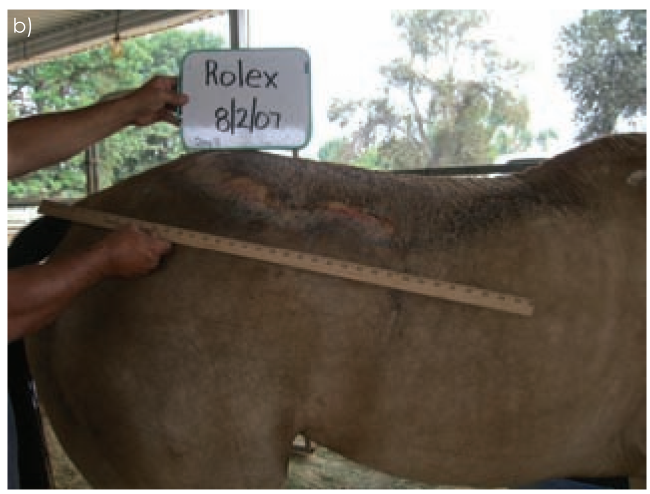
Clinical findings

The horse was taken to the primary veterinarian 3 days after having sustained the burns. Initial examination indicated the horse was bright, alert, and without overt signs of pain. Temperature, pulse and respiration were within normal limits and there were no indications of short-term complications. The horse had at least deep second degree burns (Provost 1999) from the withers to the tail head, extending ventrally from the dorsal midline approximately 32 cm on the left side and 29 cm on the right side. The left lumbar and gluteal region was extensively burned with deep second degree and third degree burns. It was estimated that 25% of the horse's body sustained second and third degree burns. The horse was hospitalised for wound management.

Treatment

The burned area was cleaned twice daily with warm saline solution. Silver sulphadiazine cream[1] was applied to the burned area after the evening cleaning and nystatin-neomycin sulphate-thiostrepton-triamcinolone acetonide cream[2] was applied after the morning cleaning. The horse was administered trimethoprim-sulphadiazine (80 mg/kg bwt, *per os*, q. 24 h)[3] and phenylbutazone (4.4 mg/kg bwt, *per os*, q. 12 h)[4]. Four days after admission, the horse became pruritic and received one injection of dexamethasone sodium phosphate (20 mg, i.v.)[5].





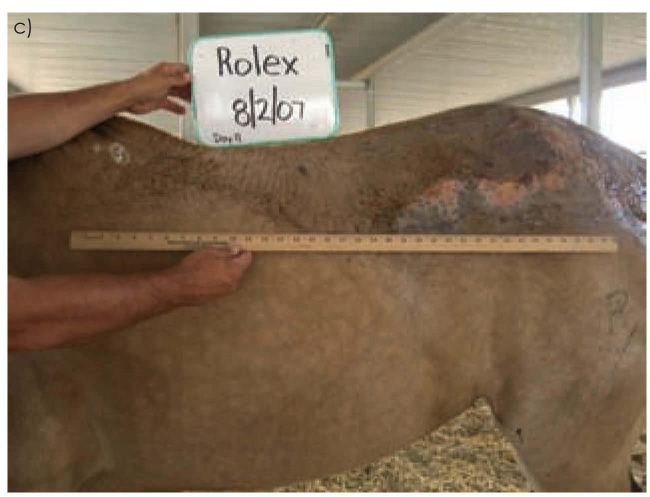


***Fig 1:** The dorsal (1a), right (1b) and left (1c) sides of the horse 11 days after the burn. The dessicated skin over the dorsum forms part of the eschar. The second and third degree burns on the left hip are devoid of eschar.*

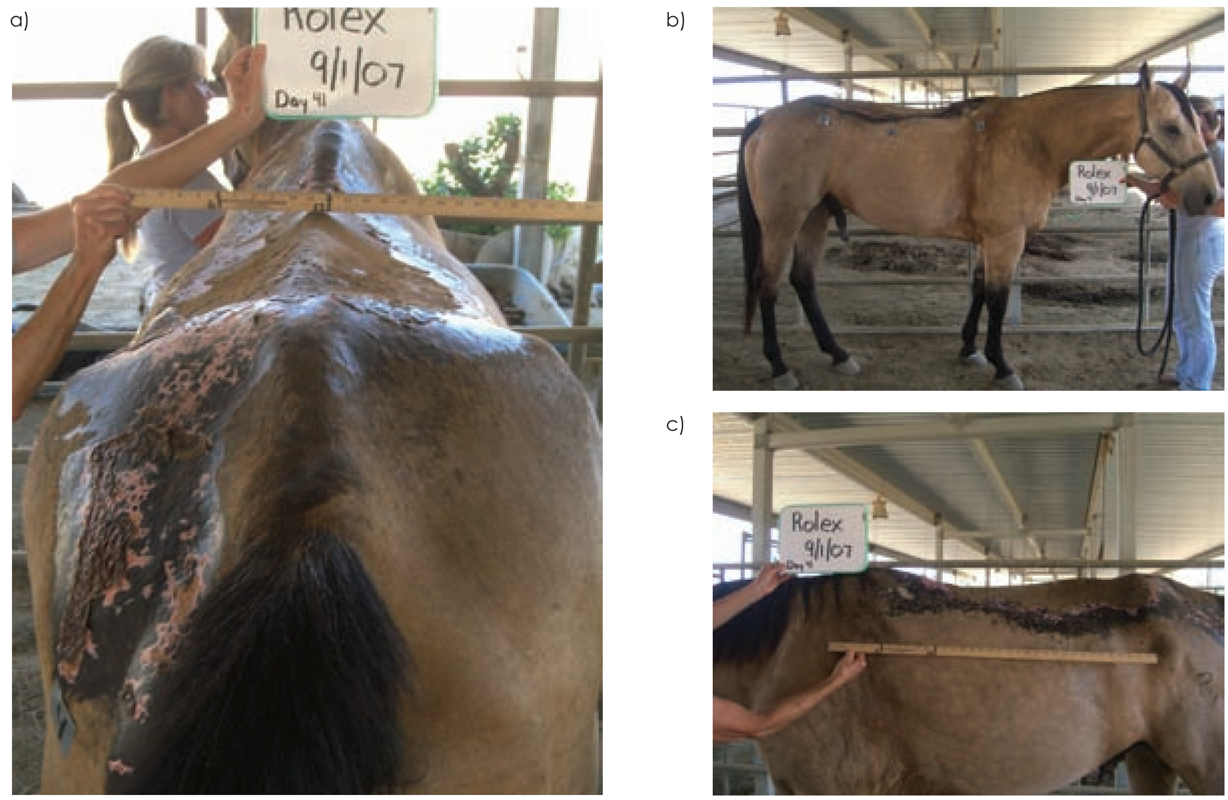


***Fig 2:** The dorsal (2a), right (2b) and left (2c) sides of the horse 41 days after the burn injury show that part of the dessicated skin remains in place. The margins are filling with pigmented and nonpigmented epithelium and the deeper burns on the left hip remain as open wounds.*

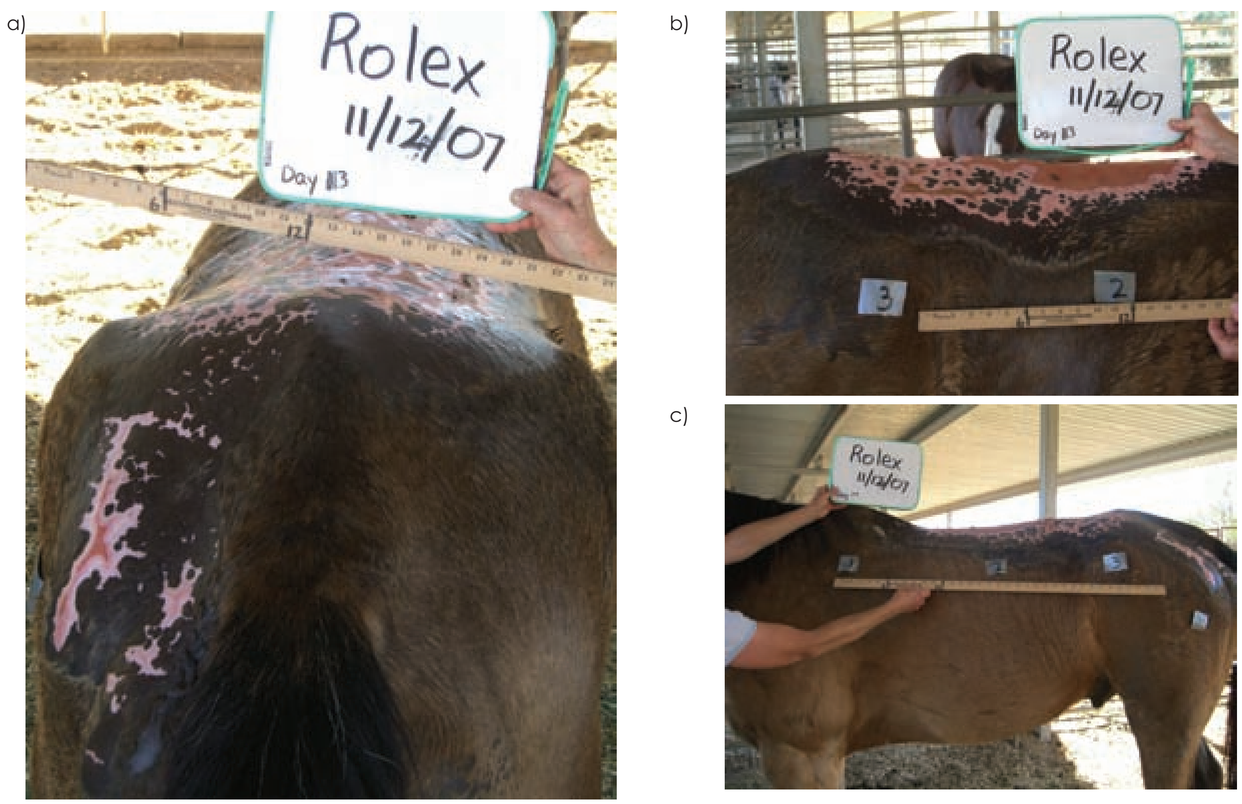


***Fig 3:** The dorsal (3a), right (3b) and left (3c) sides of the horse 113 days after the burn. All of the eschar has sloughed. The wounds over the dorsal aspect are nearly covered with epithelium. The second and third degree burns on the left hip have nearly healed. The shape and size of the epithelialisation on the left hip wound indicate much of the wound healing at that location was the result of wound contraction.*

Eleven days after the initial burn consulting veterinarians (J.E.J. and S.R.M.) were asked to consider the potential of shockwave therapy for treating the injury. At this time, the burned area consisted of a large area over the thoracic vertebrae consisting of dessicated devitalised skin, and multiple areas of deep second and third degree burns and over the left haunch (**Fig 1**). There was a foul odour and purulent exudate under the sloughing skin and around the eschar. The horse was sensitive to palpation and moved stiffly, apparently as a result of tight dessicated skin on the haunches.

The horse was sedated (7.5 mg, detomidine HCl, i.v.)[3] and the affected area cleaned with warm saline, then ultrasound gel was applied to the entire burn area. Shockwave therapy was performed with a focused electrohydraulic shockwave machine[6] with a 5 mm probe at an energy flux density of 0.11 mJ/mm^2. A total of 4500 pulses were administered with 2500 on the left side and 2000 impulses on the right side. The shockwaves were distributed over the burned area, including over the eschar and devitalised skin, but the highest concentration of impulses were given at the junction of the burned and normal skin. The same treatment protocol was used for all subsequent treatments.

One day after the first shockwave treatment, the primary veterinarian reported that small blood vessels were visible at the wound margins, the odour and purulent discharge had decreased, sensitivity to palpation was decreased, and the periphery of the burned area was more pink. Four days after shockwave therapy (15 days post burn), the wound was contracting and the dessicated skin in the saddle area had started to slough.

The horse continued to have a good appetite and remained bright and alert with the temperature, pulse and respiration within normal limits. He became pruritic again 6 days after the shockwave treatment and was administered dexamethasone as before. Both times the horse became pruritic, the dexamethsone decreased the pruritis before the horse created additional trauma to the wounds. Prior to the second shockwave treatment 8 days after the first treatment (19 days post burn), the burned area appeared to have less inflammation and had minimal discharge and odour. The wound edges were free of necrotic tissue and the area under the dessicated skin appeared to be epithelialised with some hair present. The area over the left haunch was contracting and had healthy margins.

The third shockwave therapy was administered 7 days after the second shockwave therapy treatment (26 days post burn). The horse continued to have an excellent appetite and was bright and alert, but had lost considerable muscle mass over the back, lumbar area, and haunches. A vitamin and mineral supplement[7] was added to the diet. Haematology and fibrinogen results were within normal limits so the trimethoprim-sulphadiazine was discontinued. There were ulcerations on the mucous membranes and lips so the phenylbutazone was discontinued and the horse was administered an oral antacid[8] (30 ml, *per os*, q. 12 h) for 21 days and omeprazole (GastroGard)[9] (4 mg/kg bwt *per os* q. 24 h) for 14 days. The burned area was healing well. The area under the saddle had lost 50% of the burned skin and the area now had new skin that was pink and black and had a mix of skin and hair. The wound and eschar over the left haunch continued to re-epithelialise and contract.

A fourth shockwave therapy was performed 15 days after the 3rd treatment (41 days post burn) (**Fig 2**). The horse, while still bright and alert with an excellent appetite, had lost a considerable amount of muscle mass. The horse was reported to have collapsed one time when the primary veterinarian lifted the horse's head to evaluate the oral mucous membranes. The cause of the collapse was unknown. The wound continued to contract and re-epithelialise well. The wound continued to be cleaned and treated twice daily.

Outcome

Evaluation at 4 months post burn revealed that the majority of the devitalised skin had sloughed and had been replaced with both pink and black skin and patchy areas of hair (**Fig 3**). The general body condition of the horse was poor due to significant muscle loss over the back and rump. The horse had a good attitude and appetite throughout the convalescent period. The horse left the region and was not seen for 8 months. At 12 months, an area of approximately 10 cm^2 remains as an open wound over the withers. Another shockwave treatment was administered and the wound has decreased in size. The remainder of the previously burned area has healed with a mix of pink and black skin and a mottled hair pattern. The horse has regained weight and muscle mass to preburn levels.

Discussion

On initial presentation, the horse's prognosis for life was guarded. Using the rule of nine as an estimate for % area of skin affected in the burn injury (Provost 1999; Hanson 2005b), approximately 25% of the horse's body was affected by the thermal injury. At 4 months post burn, the horse's prognosis for life was excellent and it may be possible for the horse to carry a saddle. This horse did not suffer from the typical systemic effects of a burn (Hanson 2005b; Norman *et al.* 2005), perhaps due to the short exposure to smoke and heat. Hot fibreglass fell on the horse, but as he was quickly removed from the trailer; there was not much smoke inhaled. The horse was administered prophylactic systemic antimicrobials because of the potential for pneumonia following smoke inhalation. The horse developed notable muscle atropy in the convalescent period. This may have been secondary to an increased metabolic rate that can be seen in burned horses (Geiser and Walker 1985) that resulted in increased caloric needs that were not met combined with 4 months of confinement in an enclosure with minimal exercise. To date, the horse has not developed any tumour-like lesions (Schumacher *et al.* 1986; Baird and Frelier 1991). However, this could take years to occur.

The purpose of this report is to present shockwave therapy as a potential option in the treatment of thermal injury in the horse. As with any case report it is a single case with no control. The authors considered treating only one side of the horse; however, due to the severity of the injury and the potential benefits of the treatment, the entire wound was treated. While there is no control for comparison of healing rate, it is the opinion of the veterinarians involved that the burn injury presented in this case healed faster and with much less discomfort to the horse than if only conventional methods had been used.

Shockwave therapy has been shown to produce a short term period of analgesia (McClure *et al.* 2005; Dahlberg *et al.* 2006). The horse was noted to be much less sensitive the day after treatment. In this case, pruritis was evident and treated on 2 occasions with corticosteroids. It would have been educational to have performed a shockwave treatment when pruritis was first noted to determine if the shockwave therapy could reduce the pruritis. Analgesia associated with treatment could be a potential benefit in addition to the stimulation of wound healing.

The odour and purulent discharge decreased after treatment was started. This may have been due to the wound nearing the end of the normal debridement phase. The physical aspect of running the probe over the burn may have disrupted the eschar and allowed for drainage and for air to penetrate resulting in a cleaner appearance of the wound. It is unlikely any therapeutic effect other than analagesia can occur that quickly.

Shockwave therapy has been successfully used to treat human burn injuries and wounds (Meirer *et al.* 2005a; Schaden *et al.* 2007) as well as open distal limb wounds in the horse (Morgan *et al.* 2009). Due to the severity and extent of the burn and the limited availability of consistently successful treatment for thermal injuries in the horse (Geiser and Walker 1985; Fox *et al.* 1988; Hanson 2005b) it was decided to treat the horse with shockwave therapy. The energy setting selected was similar to that used in human and horse wounds (Meirer *et al.* 2005a; Schaden *et al.* 2007; Morgan *et al.* 2009). The treatments were started later (Day 11) than the previous publications where they started on Day 1 because of the time to initial examination, referral, and treatment plan development. The plan to treat the horse weekly was based on the wound study in horses (Morgan *et al.* 2009). There have been no studies to date to identify the optimum treatment protocol and protocols have been developed based on clinical outcomes.

The suggested mechanisms of action of shock waves on a burn wound include stimulation of neovascularisation at the wound edges, an anti-inflammatory effect, and an anti-bacterial effect as well as providing some transient analgesia (Steinberg *et al.* 2006). In other tissues, treatment with shockwave therapy increases the production of growth factors and the in growth of new blood vessels (Wang *et al.* 2002; Kersh *et al.* 2006; Meirer *et al.* 2007). It stimulates the early expression of angiogenesis-related growth factors, including endothelial nitric oxide synthase, vessel endothelial growth factor and proliferating cell nuclear antigen (Park *et al.* 2002; Wang *et al.* 2006). Shockwaves also have an antibacterial effect on clusters of bacteria (Gerdesmeyer *et al.* 2005). It is likely that these factors working together accelerate healing and prevent bacterial overgrowth.

The topical antimicrobial applied after the wound was cleaned in the morning contained triamcinolone. Steroids have been implicated to decrease the rate and quality of wound healing. They decrease the inflammatory phase so fibroblast proliferation and capillary budding are slowed (Lloyd 1999). It may not have been the best selection to utilise in this horse. Alternatively, the decrease of the inflammation at the wound margins may have decreased some of the pain and pruruitis associated with the wound.

In this case, SWT was used to treat an extensive burn wound over the dorsum of a horse. The horse treated in this case responded well to shockwave therapy and progressed through the healing process relatively quickly. This horse healed with few complications, and no complications were seen associated with the therapy. It is unlikely that a large blinded controlled thermal injury study will be conducted in horses. With this case of thermal injury, cases and studies from wounds and thermal injury in other species, and in a model of distal limb wounds in horses (Morgan *et al.* 2009), this treatment option holds promise as an adjunct to the conventional treatments for burn injuries in the horse. Equine practitioners will need to interpret the data from other species and other types of wounds and apply the therapy as they feel appropriate.

Manufacturers' addresses

[1]Marion Laboratories, Kansas City, Missouri, USA.
[2]Pharmaderm, Mellville, New York, USA.
[3]Pfizer, Exton, Pennsylvania, USA.
[4]Phoenix Pharmaceutical Inc., St. Joseph, Missouri, USA.
[5]Bimeda Inc, Le Sueur Minnesota, USA.
[6]Sanuwave, Alpharetta, Georgia, USA.
[7]Platinum Performance, Santa Ynez, California, USA.
[8]Novartis, Parsippany New Jersey, USA.
[9]Merial Ltd, Duluth, Georgia, USA.

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Continued from page 64

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