Shock-Wave Therapy: How It Has Shocked or Bored Us

Shock-wave therapy was first used in horses to treat musculoskeletal injuries about 10 years ago. During the past decade, there have been proclamations of wonder and disgusted claims of quackery regarding this form of treatment. Fortunately, the reality lies somewhere in between. The development of this modality in human and veterinary medicine in the past 10 years has resulted in a fairly dynamic knowledge base.

A colleague and I described the physical generation of shock waves in Compendium 6 years ago. All true shock-wave generators use parabolic designs to focus the shock waves. Some people have proposed generating “unfocused shock waves” (shock waves that simply do not converge to a focal point) to treat superficial and skin wounds.

Shock Waves Versus Radial Pressure Waves
There are striking differences between shock waves and radial pressure waves. Although these two waveforms are quite different, they continue to be confused and incorrectly grouped together. Some facts regarding shock waves and radial pressure waves deserve a specific mention:

- These different waveforms have different energy levels and abilities to penetrate tissue.
- It is inappropriate to assume that results obtained using one waveform will be similar to those obtained using the other.
- According to the literature, both modalities have yielded positive and negative outcomes.

This column focuses on shock-wave therapy.

The Underlying Mechanisms
Although positive results have been obtained in several studies on shock-wave therapy, the mechanisms underlying the response to this therapy remain somewhat of a mystery. One of the most commonly reported responses to shock-wave therapy is neovascularization, which has been demonstrated in tissues as diverse as bone and myocardium. Similarly, other studies have demonstrated that shock-wave therapy results in increased expression of cytokine genes in different tissues. It is hoped that the results of ongoing studies will identify the mechanisms that initiate the responses to pressure waves at a cellular level.

When the mechanisms underlying the responses to shock-wave therapy have been identified, it should be possible to “fine tune” the shock waves to maximize their beneficial effects and minimize unwanted effects. Because high-pressure waves are followed by the negative pressure component of the shock wave, they can cause cavitation, which is the production and collapse of bubbles within the fluid media or tissue. Collapse of the cavitation bubbles increases the pressure and temperature in the area. Although maximizing cavitation is beneficial during lithotripsy because it improves the effectiveness of stone fragmentation, it has been suggested that cavitation creates unwanted effects in soft tissues and may be responsible for initiating the pain associated with the treatment. If cavitation is not required for the desired effects in other applications, shock-wave generators can be made to minimize cavitation. Additionally, identification of the mechanisms responsible for the effects of shock-wave therapy would permit the operator to control the energy levels, waveforms, and number of pulses needed to yield the desired outcome.
The fulness of shock-wave therapy has become available for horses with suspensory desmitis. The results of two controlled studies using a collagenase-induced desmitis model of this disease indicated that lesion size was decreased in limbs treated with shock-wave therapy compared with untreated controls and that there was histologic evidence of more new collagen fibrils and increased proteoglycan deposition in the treated limbs. These findings are similar to those in clinical practice, and the results of a prospective study of horses with naturally occurring suspensory desmitis in the forelimbs or hindlimbs indicated that a combination of shock-wave therapy and controlled exercise compared favorably with results obtained previously with other treatments.

**Damaged Tendons and Ligaments**

The efficacy of shock-wave therapy in horses with damaged tendons and ligaments is much less clear, primarily because controlled exercise, NSAIDs, heat and cold therapy, and pressure wraps are all routinely used in conjunction with shock-wave therapy. There are even more difficult questions to address concerning the concurrent use of shock-wave therapy and biologics such as ACell Vet (ACell Inc., Jessup, MD) or stem cells in treating horses with tendon or ligament damage. The concept of providing a scaffold with ACell Vet or stem cells and then stimulating neo-vascularization with shock-wave therapy makes sense, and the efficacy of this approach appears to be borne out in a limited number of clinical cases. However, there is a concern that shock-wave therapy administered shortly after injection of the cells may reduce their effectiveness. Thus, the protocol would be to administer the first of three shock-wave treatments, inject the biologic product, and then follow up with the last two shock-wave treatments at 3-week intervals.

**Musculoskeletal Disorders**

The first application of shock-wave therapy for musculoskeletal disorders in humans and horses was to treat diseases that affect bone. Subsequent, large retrospective studies in humans have resulted in refinement of the treatment protocols to yield the expected response. New applications of shock-wave therapy, including treatment of osteonecrosis of the femoral neck, are showing promise. However, in horses, shock-wave therapy for bone disorders has not been pursued as aggressively as it has in humans. This may be related to differences in case management: in equine patients, complete fractures are often inaccessible because of the application of casts. The responses of incomplete fractures, such as dorsal cortical fractures, to shock-wave therapy are moderate at best. A better outcome would be expected based on two studies that demonstrated a positive stimulatory effect of shock-wave therapy on bone formation in the metacarpus. The first study was a pilot study involving two horses in which application of shock-wave therapy to the dorsal cortex of the metacarpus resulted in more new bone deposition than in the untreated control metacarpus. In the other study, application of shock-wave therapy to the proximal palmar aspect of the metacarpus resulted in a local increase in osteoblasts. Lower cellularity, thickness of the dorsal metacarpal cortex, and related distance to vasculature could be why some stress fractures of the metacarpus fail to respond as well as expected. The energy of the shock waves that are commonly used in practice may also be a factor. Stimulation of bone formation in the equine dorsal cortex may require a higher energy flux density than is routinely used (i.e., at or approaching the level [0.89 mJ/mm²] that was used in the pilot study).

**Inflammation**

Veterinarians in clinical practice and in research have noticed a rapid decrease in the clinical signs of inflammation in some horses after shock-wave therapy. For example, shock-wave therapy in horses with collagenase-induced tendonitis resulted in a reduction in swelling on the palmar aspect of treated limbs. Similarly, shock-wave therapy in horses with experimentally induced osteochondral fragments resulted in less severe lameness and a lower protein concentration in the synovial fluid on day 28 of the study, when lameness and synovial protein concentration were maximal in the control group. These findings are particularly interesting considering that many people would expect shock-wave therapy to result in increased inflammation. These findings also seem to dispel the opinion that shock-wave therapy is simply an “internal blister.”

**Soft Tissue Disorders**

The use of shock-wave therapy for treating soft tissue disorders has increased in human medi-
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A purported effect of shock-wave therapy is analgesia. In one study conducted on horses and sheep, there was evidence of local cutaneous analgesia for 72 hours after shock-wave therapy. In a study that evaluated the duration of analgesia associated with shock-wave therapy in horses with naturally occurring lameness, serial force-plate analyses were conducted before and after treatment. The results, which were based on decreased lameness demonstrated by force-plate analysis, indicated that a significant analgesic effect was present from 8 hours through 48 hours after shock-wave therapy. After 48 hours, the lameness returned to the pretreatment level. As a result, racing jurisdictions in the United States as well as the Fédération Equestre Internationale require a 5- to 7-day withdrawal period after shock-wave therapy before a horse is allowed to perform.

Critical Point

While the exact mechanisms responsible for the effects of shock-wave therapy have not been identified, neovascularization is a consistent histologic outcome.
References