SOLE ULCERS AND WHITE LINE DISEASE: PRIMARY CAUSES OF LAMENESS IN DAIRY CATTLE

[1]J.K. Shearer DVM, MS.
Dairy Extension Veterinarian

[2]S.R. Van Amstel BVSc, Dip Med Vet, Mmed Vet (Med)
Diplomate: IPC Dairy Training Centre, Friesland
Associate Professor

[1]Department of Large Animal Clinical Sciences
College of Veterinary Medicine, University of Florida
Gainesville, FL 32610-0136, USA

[2]Department of Large Animal Clinical Sciences
College of Veterinary Medicine
University of Tennessee
Knoxville, TN 37901-1071, USA

Introduction

Bovine lameness is a health disorder of considerable significance throughout the world. In problem herds where incidence is high, lameness accounts for tremendous economic loss. Claw disorders (sole ulcers and white line disease) associated with housing conditions and chronic subclinical laminitis are primary causes of lameness in most herds, followed by digital dermatitis, interdigital dermatitis and foot rot. Early detection and proper treatment of lameness minimizes losses, improves outcome, and reduces animal suffering. Neglect not only increases losses, but raises important animal welfare concerns.

Weight-Bearing in Cattle: Anatomical and Bio-mechanical Factors

Over 90% of lameness in dairy cattle involves the foot, and of that, more than 90% involves the rear feet, with the majority of disorders affecting the outside claw. Clearly, more than just nutrition and feeding management errors are responsible for lameness disorders, because if all lameness were simply a function of conditions that predisposed to rumen acidosis, then risk and incidence of disease should be similar for all claws of each foot. Indeed, the unique pattern of lameness in cattle suggests to us that it is much more complex.

Anatomical Considerations - There are important anatomical differences between the lateral and medial claws of rear feet and these have significant implications for weight-bearing and subsequent hoof overgrowth. Both the heel bulb and axial wall are less developed in medial claws as compared with lateral claws. As a consequence, the sole of the inner claw of rear feet in cattle slopes toward the axial side of the claw (in other words, it slopes toward the inter-

digital space). This differs from the outer claw which tends to be flatter and more stable during weight-bearing. Thus, when the cow steps forward and places her foot down, weight shifts (or rolls over) from the inside claw to the outside claw. The result is greater weight-bearing on the outside claw, that over time (particularly on hard surfaces) leads to irritation of the corium and accelerated hoof horn formation on the outside claw.

The hind legs of cattle are connected to the pelvis through a ball-and-socket joint. This creates a fairly rigid skeletal structure for support of the rear quarters and legs of the cow. When viewed from the rear in an animal standing squarely on its feet, one can visualize weight distribution as being essentially equal over all 4 claws of the rear feet. However, during movement the distribution of weight within and between claws changes. Studies by Toussaint Raven show these changes in the distribution of weight to be greatest for outside claws. Despite movement, load-bearing on the inside claws is more even (more stable). Outside claws automatically and continuously correct for ever-changing weight load. This circumstance of ever-changing weight distribution is believed to be a major reason for irritation of the corium that results in accelerated hoof growth and a higher incidence of claw disorders involving the outside claw.

The situation for front feet is different. There appears to be greater flexibility in the anatomical arrangement of the skeleton and soft tissues of the shoulder. Front legs are not connected to the upper body through a ball-and-socket joint. Instead, front legs are connected to the torso by tendons and ligaments that tend to cushion the effects of variable weight distribution between the claws. As a result the bio-mechanical forces associated with variable weight distribution are less pronounced in front feet and disorders leading to lameness less frequent. However, when lesions do occur they are more commonly associated with the inside claw.

Confinement on concrete or other hard surfaces enhances the physical effects of load-bearing on feet, whereas housing on earthen surfaces tends to reduce these effects. The practical significance of which is the observation of cattle (especially heifers) that when moved from pasture to confinement may experience lameness due to a physical/mechanical form of laminitis. These physical effects are further complicated by the fact that the unyielding nature of hard-flooring surfaces tends to irritate the corium and accelerate hoof growth. Excessive hoof growth (particularly of the outside claw of rear feet) leads to overgrowth and eventually overloading of the affected claws. The end result is a greater likelihood of developing claw disease.

It is important to recognize that confinement on hard surfaces alone is sufficient to cause hoof overgrowth and overloading of the claw that can lead to claw disease. However, add to this complications incurred from metabolic or systemic disease that may predispose to laminitis and the potential for claw disease escalates significantly.

Normal Gait in Cattle

The cow's stride consists of the stance (standing position) and swing phase (movement from, and back to, the standing position). The swing phase is further subdivided into a retraction (contraction or shortening) and protraction (extension or lengthening) phase. The retraction phase of the stride begins with cow in standing position. Body weight shifts to the weight-bearing surface of the claw which also provides traction as the cow moves forward. The claw is retracted or lifted toward the body as the heels leave the ground, thus ending the retraction phase. As the claw is extended forward it enters the protraction phase of the stride. The heels strike the ground first with the soles resuming a normal weight-bearing position as the cow completes the protraction phase and reaches the standing position. In a sense, the rear legs propel the cow's body forward while the front legs act more or less like props or supports for the body weight.

Laminitis and its Relationship to Claw Disease

The pathogenesis of laminitis is believed to be associated with a disturbance in the micro-circulation of blood in the corium (quick of the foot) which leads to breakdown of the dermal-epidermal junction between the hoof and pedal bone. Rumen acidosis is considered to be a major predisposing cause of laminitis and presumably mediates its destructive effects through the release of various substances which act directly on blood vessel walls. These substances initiate a cascade of events in blood vessels of the corium including increased blood flow, thrombosis (clotting of blood within the blood stream), ischemia (complete blockage or loss of blood flow), hypoxia (low oxygen), and arterio-venous shunting which directs the flow of blood directly from artery to vein. The end result is swelling, hemorrhage, and death of corium tissues. By virtue of its anatomical location between the hoof shoe and the 3rd phalanx (P_3) the corium is particularly vulnerable to inflammatory insult. Any increase in size of the corium due to fluid accumulation (blood and lymph) increases pressure, pain, and tissue damage. Bound on one side by the hoof wall and the other by P_3 inflammation of corium tissues often leads to swelling at the coronary band.

Destruction of the dermal-epidermal junction has particular consequences to the individual claws as it leads to laminar separation. As the laminae separate P_3 begins to "sink" within the hoof horn shoe. The result is compression of the corium between P_3 and the sole which sets the stage for development of sole ulcers. In some cases this "P_3 sinking phenomenon" involves severe rotation of the toe of P_3 downward toward the sole. If compression of the corium by the toe is severe enough a toe ulcer may develop. If, on the other hand, sinking of P_3 is such that the rear portion sinks furthest, compression and thus sole ulcer development will most likely develop in the area of the heel-sole junction (known by some as the "typical site" or the site most commonly associated with the development of sole ulcers).

Sole Ulcers

A sole ulcer is described as a circumscribed loss of the horny sole which exposes the corium. Sole ulcers tend to be one of the most debilitating of lameness conditions affecting dairy cattle. Appearance of the lesion will vary according to it's maturity. Early ulcers may appear as nothing more than a circumscribed area of fresh tissue that may be uncovered in the process of hoof trimming. More mature or long-standing sole ulcers may be covered initially by rough, irregular horn tissue that when pared away exposes granulation tissue which bleeds freely if damaged with the knife.

As indicated previously, laminitis is thought to be a major predisposing cause of sole ulcers. The combination of excessive hoof horn formation, displacement of P_3, the production of softer solar horn, and the accelerated growth of hoof horn on the anterior (front) and abaxial (outside) hoof walls predispose the lateral claw to excessive loading, wear, and weight-bearing at the "typical site". The additional strain and pressure applied to the heel/sole region exacerbates pinching and dysfunction of the underlying corium and leads to development of the lesion. Treatment requires corrective trimming to remove the necrotic (dead or decaying) horn tissue followed by elevation of the affected claw with a foot-block attached to the unaffected claw. All healthy horn tissue should be left in place.

Regular hoof trimming is an important factor in lowering the incidence of sole ulcers. Periodic trimming maintains appropriate weight-bearing on all claws by removal of overgrown hoof horn. This aids in reducing the potential for excessive claw-loading and sole ulcer development.

White Line Disease (Sole Abscesses)

Areas of hemorrhage of the corium are often most noticeable and severe in the white line region of the sole. This corresponds to the primary weight-bearing region of the claw. Because it is an active area of hoof formation it is highly vascular, and a frequent site for hemorrhage during bouts of laminitis. These areas of hemorrhage are not visible during the acute stage of laminitis. Instead, they gradually rise to the surface of the sole over a period of 6-8 weeks. At this point they become visible and useful as indicators of disease of the corium most commonly associated with subclinical laminitis.

Another outcome of veterinary significance associated with laminar necrosis is the formation of subsolar abscesses. Some of these abscesses are sterile but nonetheless troublesome as they cause acute lameness in affected animals. However, abscesses tend to occur at higher incidences in animals suffering laminitis via another mechanism - penetration of the white line by foreign material from the environment. There are a couple of reasons for this: 1) white line separation and distorted claw growth which results in weight-bearing disparities and widening of the white line, and 2) hoof horn formed by the diseased corium is softer and thus more subject to wear and penetration by

foreign material from the environment. As a consequence, the incidence of white line disease increases in herds suffering laminitis.

Regardless of how the abscess develops, it is treated by the paring away of all loose and damaged horn and drainage of the abscess. For abscesses which develop as a result of penetration through the white line or sole, establishing drainage is necessary. The site of entry can usually be visualized as a dark area packed with extraneous debris on the surface of the sole (usually in the abaxial white line heel area). Visibility of these is often improved following cleaning and/or paring away of the superficial layers of the solar horn. Once the entry site is located, careful paring out of the tract and adjacent hoof wall leading to the abscess is required until drainage is accomplished. Removal of the wall adjacent to white line disease abscesses reduces weight-bearing and thus discomfort associated with the lesion. Care should be taken to remove necrotic hoof horn and establish drainage, however minimize peripheral damage. Many animals will show immediate improvement, whereas others in which abscessation was more extensive may take several days to improve. There is no need for antibiotic therapy unless the infection extends to deeper tissues of the foot as evidenced by swelling and severe lameness.

Sole abscesses are extremely painful. For severe cases, pain can be alleviated through the application of a foot block to the unaffected claw of the affected foot as described for treatment of sole ulcers. Elevation of the damaged claw suspends weight-bearing, reduces discomfort, and promotes recovery. Blocks will eventually fall off (or wear off) after a period of several days to a couple of weeks.

In Summary,

Disproportionate weight-bearing on claws leads to hoof overgrowth. This is particularly significant for the outside claw of rear feet and the inside claw of front feet. The inside claw of the rear foot is particularly unstable by virtue of its underdeveloped axial wall. This results in a sloping of the sole toward the interdigital space and a tendency for weight to be shifted to the outside claw. The natural shifting of weight through the pelvis also results in a greater distribution of weight to the outside claw. Despite movement weight-bearing on inside claws of the rear feet is more stable. On concrete, effects of these weight-bearing dynamics have significant implications for foot health in cattle. Laminitis increases the risk of claw disorders because of its effect on the displacement of P_3 and the integrity of white line hoof horn. Separation, poor horn quality and widening of the white line are important predisposing causes of white line disease associated with laminitis. Corrective trimming and the use of foot blocks on healthy claws to relieve weight-bearing in diseased claws are essential treatment procedures for affected animals.

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