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Sole ulcers in dairy cattle: avoidance and treatment

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Lameness is a serious problem affecting all areas of the cattle industry, but dairy cows are particularly affected. It strikes large numbers of cattle and causes severe economic losses. Furthermore, given the public awareness of animal welfare, veterinarians should be at the forefront of a movement to reduce lameness in cattle. The aim of this edition of *Large Animal Veterinary Rounds* is to summarise the current understanding of the development, prevention, and treatment of one of the most common and costly foot lesions, the sole ulcer.

The size of the problem

The true magnitude of lameness has only been measured in the dairy industry. A recent British survey of 38 dairy farms over three years found the incidence of lameness to be 55 individual cases of lameness per 100 cows per year (a single cow may become lame more than once).[1] The cost of lameness in a dairy herd is really quite staggering. Using information from the DAISY system (Dairy Information System, a network providing production data from dairy farms across the UK), it is estimated that the cost of the average case of lameness is $540.[2] The reason this figure is so high is because it takes into account all the losses incurred by the farmer, including:

- reduced fertility
- reduced milk production
- milk withdrawal following antibiotic usage
- culling of cows with severe or chronic lameness
- the farmer's time spent dealing with a lame cow.

One must also consider the welfare aspects of the disease. A recent paper[3] demonstrated that lame cows had a significantly lower nociceptive threshold, so they suffer not only as a result of their lameness, but also because they are greatly affected by all painful stimuli.

The most costly cause of lameness is the sole ulcer, estimated to cost the farmer as much as $960 per case.[2] The reason for the high cost is the extremely severe complications that often follow such a lesion. They are also extremely common, accounting for 28% of lameness in the British survey.[1]

The sole ulcer

A sole ulcer (Figure 1) has been described as "a specific lesion located in the region of the sole-bulb junction, usually nearer the axial than the abaxial margin. Damage to the dermis is associated with a circumscribed zone of localized hemorrhage and necrosis."[4]

Clinical signs

The condition is often bilateral and most commonly affects the lateral hind claws. The degree of lameness is quite variable and depends on the severity of the lesion and the extent of any secondary infection. In the early stages of the disease, the animal attempts to minimize weight bearing on the affected region. The limb is typically held in an abducted position with the weight borne on the medial claw. The natural overgrowth of the lateral hind claw (which may predispose to this con-

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Figure 1: **The left hind foot of a 4-year-old Holstein cow. There is a severe sole ulcer in the lateral claw complicated by deep sepsis, with infection spreading to the deep digital flexor tendon and the heel bulb. The claw was amputated. (Reproduced with permission of the author.)**

dition), also results in external rotation of the toe and the cow adopts a "cow-hocked" stance. With increasing severity, the cow will attempt to reduce weight bearing on the affected claw by constantly shifting her weight, and may lie down for long periods of time. In extremely severe cases, cellulitis of the distal limb may develop with heat and swelling. If left untreated, the infection may result in rupture of the deep digital flexor tendon and a "cocked-up" toe appearance (see below).

Superficial examination of the foot may not reveal any signs. However, the presence of heat or swelling and a reaction to pressure by a hoof-tester in the central region of the claw, are all highly suggestive of the presence of a sole ulcer. In some cases, there may be a thick wedge of horn extending over the axial wall that must be trimmed to expose the lesion. As the sole horn is trimmed, the presence of chronic hemorrhage, typically a focal red dot approximately 5 mm in diameter, may be seen within the horn. In more severe cases or with further trimming, a defect may be found in the sole horn that exposes the corium or a mound of protruding granulation tissue. Stimulation of the exposed corium will elicit a pain response. The loss of the sole horn in this area allows infection to involve the deeper structures of the foot, most notably, the navicular bursa, the distal inter-phalangeal joint, the heel bulb, and the deep digital flexor tendon. A number of subtle signs aid in determining if infection is already present in these structures (see *Treatment of sole ulcers* below).

Pathogenesis

The pathogenesis of this condition is not fully understood. Consideration of the role of internal and external factors is a good approach:

External factors largely relate to the way that the cow bears weight on her claws. The lateral claw is subjected to greater forces than the medial claw.[5] It is postulated that this increase in force stimulates hyperplasia of the keratogenic layer and more rapid growth of horn. The end result is a thicker sole on the lateral claw that increases the weight borne by this claw and a self-perpetuating circle develops where the lateral claw becomes increasingly overburdened.[5]

Weight is also not borne evenly across the sole of the claw. Normally, the abaxial wall, the toe, and the heel carry weight. The only portion of the axial wall bearing weight is a small region adjacent to the toe. Therefore, in the normal claw, the central portion of the axial wall and the sole are essentially non-weight bearing.[4] However, as the horn grows and is worn away by contact with the ground, this central region may also overgrow and become weight bearing.

The horn of the claw does not grow in an even manner. Typically, the horn of the toe grows faster than the heel, resulting in an elongated toe. This has the effect of tipping the claw backwards and increasing the weight borne by the caudal region of the sole.[5] Finally, erosion of the heel can occur from standing in unsanitary conditions and may cause the claw to tip back even further. This also greatly increases the forces borne by the caudal portion of the sole.[6] The final result is that very large forces are borne by the caudal portion of the sole, especially on the lateral hind claw, an area of the sole that in the normal cow does not bear weight.

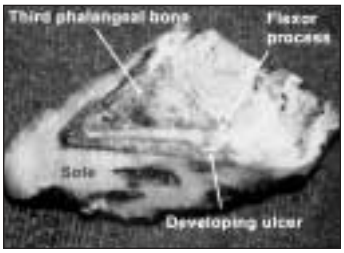
Internal factors affecting the development of a sole ulcer fall into two categories; the first category is anatomical. The ventral surface of the third phalanx is not a smooth flat surface; rather, it is slightly concave with a small process on the caudo-medial aspect where the deep digital flexor tendon attaches. This is termed the flexor process of the third phalanx. The flexor process does not normally bear any weight because the natural shape of the sole prevents weight bearing by the central portion of the axial wall and the sole.[7] However, (as discussed above), if the claw becomes overgrown, increasingly large amounts of weight are transferred to this area.

Secondly, the third phalanx is actually suspended within the hoof capsule by the laminae. If these attachments start to weaken or break down, then the third phalanx will "sink" within the hoof capsule, increasing the weight being borne in the region of the flexor process. This process is postulated to occur in cases of laminitis.[8]

As the weight borne by the region of the flexor process increases, the horn-forming corium below the process becomes compressed between the bone and the horn of the sole. Initially, this trauma to the corium results in hemorrhage into the horn as it is formed. There may also be white-yellow discolouration and the horn may be weaker than normal. In severe cases, the corium may undergo ischemic necrosis, resulting in a complete failure of horn production at this site (Figure 2).[4]

Over the course of approximately two months (the sole horn will be approximately 10 mm thick; horn is estimated to grow at 5 mm/month), this defect in the sole grows out toward the surface until all the overlying horn is worn away and the internal structures of the claw are exposed. This

Figure 2: **Cross-section through the lateral hind claw of a Holstein cow showing a developing sole ulcer. There is severe overgrowth of the sole and erosion of the heel. Ischemic necrosis and failure of normal horn production are apparent below the flexor process of the third phalanx. (Reproduced with permission of the author.)**



allows infection to penetrate the sole. Meanwhile, the lesion attempts to heal from the periphery by the production of granulation tissue.

Treatment of sole ulcers

Before starting treatment, it is especially important look for any signs of deep sepsis of the claw. Infection of the deep digital flexor tendon may be inferred by swelling along the course of the tendon. In severe cases, the tendon may rupture, resulting in a cocked-up toe (since all weight bearing is on the heel, and the toe is no longer in contact with the ground). Septic arthritis of the distal interphalangeal joint should be suspected when swelling is present above the coronary band on the cranio-abaxial aspect of the claw (radiographs are necessary to confirm this diagnosis). In severe cases, the joint may rupture at this point and drain. Infection of the heel bulb manifests as severe swelling in the heel region (Figure 1). All of these conditions carry a poor prognosis, and treatment is likely to be expensive and time-consuming.

Assuming that the sole ulcer is uncomplicated by secondary infection, the single most important treatment is corrective trimming of the foot. This should achieve two goals. First, all the under-run and necrotic horn should be removed in order to facilitate healing. Secondly, and of greater importance, trimming the feet should normalize weight bearing and remove one of the most important causes inciting the sole ulcer.

Corrective bovine claw trimming

The best way to ensure correct foot trimming is to use the method developed in the Netherlands.[5] This very simple technique is universally applicable to all forms of lameness and is easy to learn. The aims of the method are to balance weight bearing between the lateral and medial claws, and to remove weight bearing from the central portion of the axial wall.

The following description is for a hind foot where the procedure starts with the medial claw which bears less weight. In the foreclaw, the technique is similar, but starts with the lateral claw. The steps in the corrective trimming of the bovine hind foot are:

- The toe is cut perpendicularly with nippers, 75 mm from the coronary band.
- Excess abaxial wall is removed.
- The sole is trimmed flat using a hoof knife.
- The sole is trimmed until it is approximately 8 mm thick.
- The lateral claw is trimmed to match the medial claw.
- The central portion of the axial wall is trimmed away to prevent weight bearing at the site of the sole ulcer.

Step 1

The toe of the medial claw is removed with hoof nippers so that it is 75 mm long. A cut is made at this point perpendicular to the sole (Figure 3a). The length of the toe may be estimated using a small piece of wood cut to the correct length. Alternatively, experienced foot trimmers learn to estimate the length of the toe using the width of their palm as a guide. The hoof nippers are then used to shape the abaxial aspect of the toe (Figure 3b).

Next, using a hoof knife, the sole of the hoof is trimmed from the toe towards the heel to give a completely flat sole that is perpendicular to the axis of the limb. Great care should be taken to avoid excessive trimming at the heel. The horn of the sole is not uniform, and the horn of the wall is much tougher than that of the sole. There is a natural tendency for the trimmer to trim the sole rather than the wall, resulting in a concave sole; this temptation should be avoided.

The sole should be trimmed until the sole is approximately 8 mm thick (Figure 3c). The thickness of the sole may be estimated from the cut end at the toe. In addition, the trimmer should periodically stop trimming and apply pressure to the sole with their thumb. If any give is felt, it is likely that the sole is less than 5 mm thick and trimming should stop.

Step 2

Using the trimmed medial claw as a model, the lateral claw is trimmed to match it as closely as possible. Particular care is required to ensure that the toe is trimmed to the same length and that the depth of the sole is similar. The final result should be that the soles of the two claws can be held together giving a completely even weight bearing surface.

Step 3

The aim of this step is to remove weight bearing from the central portion of the axial wall, in order to approximate the normal weight bearing seen in nature. The middle third of the axial wall is removed. This is done with a hoof knife

Figure 3: **Stages in the trimming of a bovine claw. (Reproduced with permission from *Cattle Claw Care*, by C. Clarke. Vet Visions Inc, Saskatoon, 2000.)**

a. **The toe is cut perpendicularly, 75 mm from the coronary band.**

b. **The overgrown wall is removed from the toe and abaxial wall with the hoof nippers to approximate the shape of a normal toe.**

c. **Sole is removed with the hoof knife until the depth measured at the toe is 8 mm.**

held at an angle of approximately 30° to produce a semi-circular depression in the sole that extends approximately 1/3 of the way across the sole. Now that the weight bearing of the foot is returned to normal, the final two steps are designed to aid in healing the sole ulcer.

Step 4

The caudal two-thirds of the sole on the affected claw is trimmed further. This reduces the amount of sole in contact with the ground and transfers the weight bearing to the sound claw. This rests the affected claw and gives it a chance to heal.

Step 5

All loose and under-run horn is removed. It is particularly important to use the hook at the end of the hoof knife to remove any under-run edges around the sole ulcer and expose the diseased corium. This prevents debris from becoming impacted and encourages healing.

There is a desirable final tidying step, where a rasp is used to remove any of the sharp edges from the horn. This gives a more pleasant look to the foot, and also ensures that there are no sharp edges on the horn to injure the teats when the cow rises.

Additional therapies for the sole ulcer

Bandaging

The use of dressings to treat sole ulcers is controversial. Potential benefits of bandaging are protection of the lesion and the topical application of medication. However, the bandages have a tendency to absorb moisture and the topical application of either antibiotics or copper sulfate appears to be of little use. The only clinical trial using bandages for the treatment of hoof lesions in cattle found that lesions healed better when left uncovered.[9]

Blocking

A number of prosthetic blocks are commercially available for the treatment of lame cows and can be extremely useful. The principle of the treatment is that the block is applied to the uninjured claw, thereby elevating the affected claw from the ground, removing weight bearing and giving it a chance to heal.

The two most commonly used blocks are Technovit,™ a wooden block that is applied to the sole. The other type is the Cowslip,™ a plastic shoe that is applied to the sole and the wall of the claw. The Cowslip is designed to fit most dairy cows, but it is not quite as versatile as the Technovit block. The advantage of the Cowslip is its ease of application; it can be applied single-handedly and is also self shedding, falling off in approximately 6 weeks.

Whichever form of block is used, it is vital to ensure that the block is placed well back on the claw to give support to the heel and allow the approximately 5 mm of additional space needed for the cranial migration of the block as the claw grows. The block should not impinge on the injured claw.

Treatment of complications of the sole ulcer

Treatment of any deep infection in the foot with antibiotics alone is rarely successful. The best prognosis is when only the heel bulb and digital cushion are affected. However, even in this case, it is necessary to ensure adequate drainage through the sole. The treatment of septic arthritis and septic tenosynovitis require special surgical procedures.[10,11]

The only other salvage option for the cow is to amputate the affected digit through the lower third of the first phalanx.[12] This is a relatively simple procedure with a good short-term prognosis. However, the long-term prognosis is poor; most experts agree that the majority of cows will be shipped within a year of amputation.[11]

There has been some recent research using regional perfusion of antibiotics for the treatment of deep sepsis; this may benefit selected cases.[13]

Avoiding sole ulcers

The best way to deal with sole ulcers is to prevent them from occurring. Prevention should involve avoiding the factors discussed above that are thought to be associated with the formation of sole ulcers. Preventing abnormal weight bearing by the claw is of primary importance. This may be achieved in a number of ways:

- Routine corrective trimming to restore normal weight bearing by the foot: Dairy cows should have their feet trimmed once a year, preferably when they are dried off. This means that only a few cows need to be trimmed every week by the farmer or veterinarian. During the dry period, cows are generally housed in a less intensive system and on a less carbohydrate-rich diet. This also encourages healing of sole lesions. Finally, the stresses associated with calving, the return to the milking herd and the dairy ration may all predispose cows to sole ulcer formation. Ensuring that the foot is well trimmed before calving helps prevent the development of sole ulcers.
- Weight bearing is thought to be a major factor in the formation of sole ulcers. Cows at pasture spend approximately half their time lying down. When cows are housed indoors, this amount of time falls to approximately one-third of their time.[14] Increased effort is needed to design cattle housing so that cows spend less time standing and more time recumbent when the feet can rest. Further details on housing design are available.[15]
- Erosion of the heel by exposure to slurry is a risk factor for the development of sole ulcers.[6] Efforts should be made to improve the hygiene within the housing facility. Attempts to improve resting areas will insure that cows are lying in clean areas and not standing in slurry.
- The role of laminitis in the development of sole ulcers has long been discussed.[16] Many of the proposed mechanisms for the pathogenesis of laminitis are related to feeding practices. It is therefore recommended that care be taken to ensure that the diet contains sufficient long fiber and that steps are taken to avoid excessive ingestion of carbohydrate or protein.[15]

Summary

Some farmers and veterinarians accept lameness as an unavoidable part of keeping cattle and little more than a nuisance. This is not the case, in fact, it is an extremely costly problem economically, and it adversely affects the welfare of the affected cattle. The sole ulcer is one of the most costly forms of lameness; however, often with only minimal effort, its incidence may be reduced.

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Abstracts of Interest

The influence of lesion type on the duration of hyperalgesia associated with hindlimb lameness in dairy cattle.

WHAY HR, WATERMAN AE, WEBSTER AJ, O'BRIEN JK.

The nociceptive threshold of 42 sound dairy cattle were compared with 53 animals displaying hind-claw lameness. All animals in the study were lameness scored and nociceptive threshold tested. Each animal then received a routine claw trim, while the lame cattle also had the cause of lameness determined and treated. Those cattle found to have a unilateral hind-claw lameness (n=42) were re-evaluated at 28 days after treatment. The lame cattle were found to have a significantly lower nociceptive threshold ($P<0.001$) as compared to the sound animals on day 1 and also at retesting on day 28 ($P<0.001$). The group which were retested on day 28 were subdivided by lesion type: sole ulcer, white line disease, and acute digital tissue infection. Each lesion type caused a decrease in nociceptive threshold at day 1. At re-evaluation on day 28 only the threshold of the acute digital tissue infection group were not significantly different from the sound group but thresholds in sole ulcer and white line disease cows were still depressed.
Vet J 1998;156:23-29.

Epidemiology of lameness in dairy cattle: description and analysis of foot lesions

MURRAY RD, DOWNHAM, DY, CLARKSON, MJ, ET AL.

Information from 37 dairy farms, in four regions of England and Wales provided data on 8991 lesions and the preventive trimming of 4837 cows' feet. Of the total of 13,828 forms returned, veterinary surgeons treated 32% and farmers or stockmen 46%. Of the 8645 lesions associated with episodes of lameness, lesions in the hindlimbs accounted for 92%, of which 65% were in the outer claw, 20% in the skin, and 14% in the inner claw. Sole ulcers (40%) and white line disease (29%) were the predominant diseases of the horn, and digital dermatitis (40%) was the most common disease of the skin. Subjective assessments showed that sandcrack, penetration of the sole by foreign bodies and interdigital necrobacillosis were associated with the most severe cases of lameness. There was a significant seasonal effect in the reporting of lesions.
Vet Rec 1996;138:586-591.

Popular Websites

www.usask.ca/wcvm/herdmed/specialstock
The Specialized Livestock Research and Development Program
Western College of Veterinary Medicine
University of Saskatchewan

http://www.cfia-acia.agr.ca/english/searece.shtml
The Canadian Food Inspection Agency search engine

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