LAMINITIS IN PRACTICE: Causes, Risk Factors, Treatment and Prevention

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Laminitis in dairy cattle was first described in the 1960s (9), while in horses laminitis has been described as a difficult problem for thousands of years. Nevertheless, there are many similarities in the anatomy of the hoof and in the development of laminitis in the two species. One important difference is, however, the fact that the cow has two claws on each foot, which makes treatments less difficult as the lesions are most often restricted to one of the claws. On the other hand, in the dairy cow, there is an association between laminitis and many specific hoof-horn diseases due to the intensive dairy production.

- Laminitis is the cause of the most important hoof-horn diseases, which have a great influence on the dairy cow's performance and well being.
- Hemorrhages on the sole horn show that a cow has suffered a laminitis period, although lameness or other symptoms typical of acute laminitis may not necessarily be evident at the moment, i.e. subclinical laminitis.
- Laminitis-related hoof disorders are more prevalent in cows in confined free-stall systems than in tethered animals, due to more walking on concrete floors and tougher social interactions between animals.
- Hoof trimming is the most important measure to treat laminitis and to reduce further damage of the hoof.
- Dairy producers can prevent laminitis and hoof-horn lesions by slowly adjusting cattle to new management systems and diets before calving; encouraging diets and feeding routines that establish a stable rumen pH; and where possible, using rubber mats where cattle stand.
- Improved design and more cattle-friendly management systems may reduce laminitis-related problems in the future.

Complicated background to laminitis

Laminitis is an inflammation of the hoof corium, which is very painful and therefore causes lameness. Laminitis can be related to metabolic disturbances, of which the pathways are not fully understood. One hypothesis refers to endotoxins (toxin released by bacteria) produced and absorbed in the gastro-intestinal system. Endotoxin is the most potent toxin produced within the body. Large quantities of endotoxin can be released from E. coli bacteria if the animals are improperly fed and the metabolism is disturbed. The toxins can be absorbed into the blood circulation if the walls of the stomachs and intestines are weak or damaged. In the blood, the toxins start a chain reaction resulting in trombs that obstruct the small blood vessels (capillaries). The blood circulation deteriorates locally and causes a " heart attack" of the feet. The decreased oxygen and nutrient supply damages the horn-producing cells of the corium.

Foot inflammation causes redness, swelling, heat and pain, resulting in lameness. The swelling inside the rigid hoof capsule causes considerable pain. You may compare this to an inflammation under your own nails after a hit by a hammer!

Changes inside will be visible outside

The primary inflammation affects the cells in the laminar corium, which attach the claw bone to the wall. It weakens the connection between the corium and horn layers. Medically, laminitis is diagnosed when the laminar corium is separated from the horn lamellae of the wall. Due to the severity of the inflammation, loading and biomechanics, the claw bone sinks and/or rotates more or less permanently inside the horn capsule (10). If the natural position (Figure 1) of the bone inside the capsule changes, the prominent parts of the bone (toe, rear and outer ridge) contuse the adjacent corium (Figure 2). The contusion or pinching of the corium causes a secondary inflammation of the sole corium with hemorrhaging and

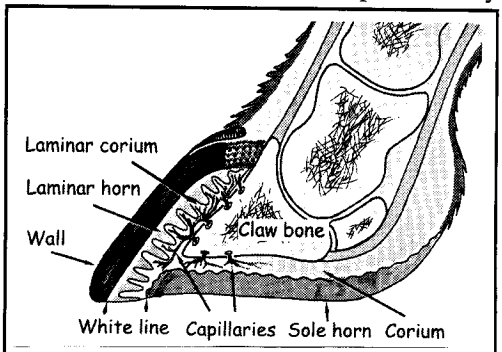


Figure 1. Schematic drawing of a section of a normal hoof with the attachment between bone-wall enlarged.

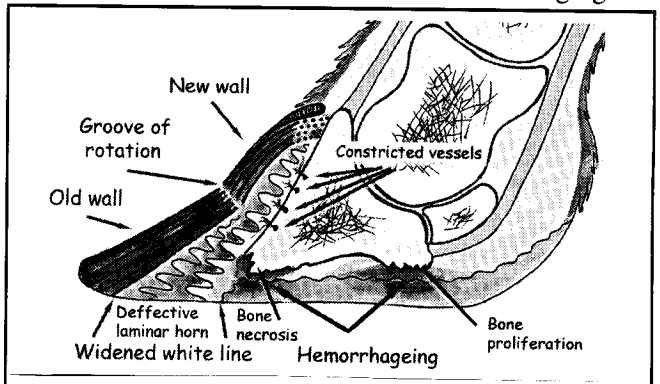
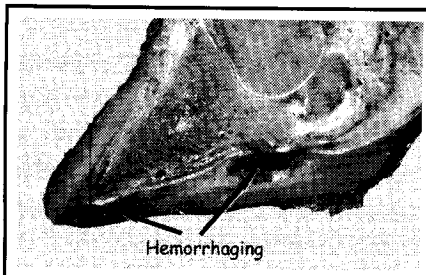


Figure 2. Schematic drawing of a section of a laminitic claw with rotation of the claw bone. The most prominent points causing sole lesions are shown.

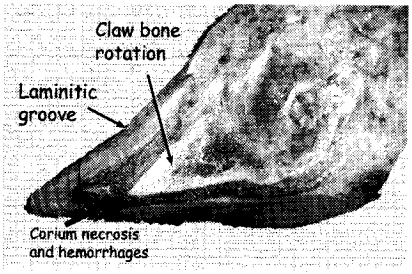
edema, and sometimes tissue death or necrosis (Pictures 1 and 2). The hemorrhages from the corium (Picture 3) will be incorporated into the growing horn and will be visible at trimming (Picture 4). The lesions on the sole can be compared to a print of the bone where it hits the sole. The most commonly affected region is the rear part of the claw bone, resulting in lesions of the central, rear third of the sole or the "typical" sole-ulcer site (Picture 5).

The time lapse from the initial insult until the hemorrhage can be detected depends on the growth rate of the sole and the sole thickness. Due to the time lapse between the acute laminitis and when the hoof lesions are visible, the close relationship between laminitis and hoof lesions has not always been well understood. Sometimes sole hemorrhages are misinterpreted as a stone bruise!

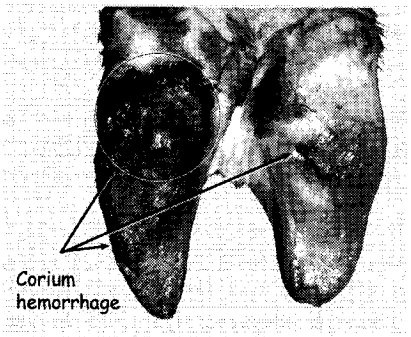
A horizontal break point of the wall, also known as a hardship groove or laminitic ring, can be seen after each disruption of cell growth. Changes of the bone position also affect the grooving wall. The newly produced wall horn of the upper part follows the new position of the bone while the lower part of the wall, beneath the groove, reflects the position of the bone before the period of laminitis (Figure 2). Thus, the rotated bone inside the capsule is reflected as a concavity of the wall outside. The difference of the toe angle between upper and lower wall is equal to the degree of rotation.



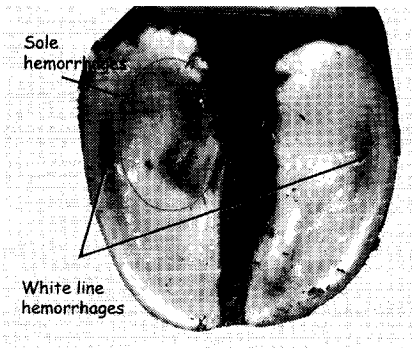
Picture 1. Section of a claw with sinking of the claw bone that developed early sole hemorrhages and poor horn formation at the rear and the toe of the bone.



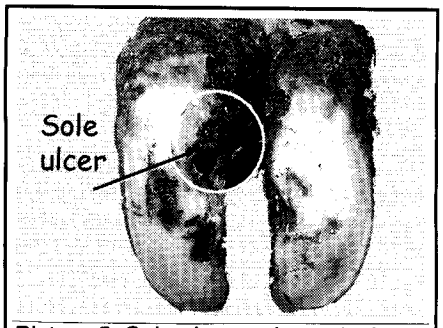
Picture 2. Section of a claw with recent claw bone rotation. Shows poor horn formation, sole hemorrhaging and necrotic tissue at the toe.



Picture 3. Hemorrhages of the sole corium from an exungulated claw with acute laminitis.



Picture 4. Sole and white-line hemorrhages appear at hoof trimming two to three months after the initial phase of laminitis.



Picture 5. Sole ulcer at the typical site, corresponding to the rear central part of the claw bone.

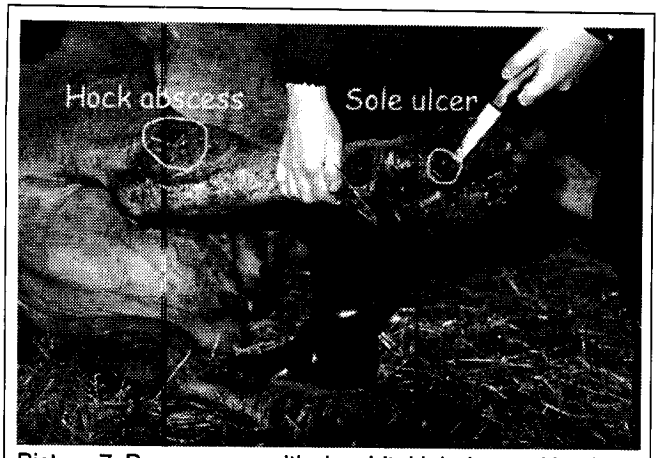
Laminitis results in serious hoof horn lesions

The laminitic lesions of the corium and of the horn-producing tissue result in sole lesions and impaired horn quality. The severity and the extension of the lesions depend on the individual animal and its hoof status, its behavior, and the environment where the animal is housed. The relationship between acute clinical laminitis and sole lesions has been described in several studies.

A United Kingdom study showed a correlation between clinical laminitis at calving and a high incidence of *sole ulcers* two months later. In a Swedish study, 11 herds with a history of laminitis problems were compared to 11 healthy herds that were similar in other respects. The laminitic herds had a higher prevalence of *sole hemorrhages* and *sole ulcers*. The lesions were more common in the rear than in front feet, and in first-calving heifers than in older cows.

Too thin soles from excessive trimming or too much wear can even provoke laminitis and sole lesions, or so called *traumatic* laminitis. With regular, correct hoof trimming; comfortable stalls and floors; and taking advantage of pasture; minor sole hemorrhages usually recover spontaneously without complications. However, if hoof trimming is neglected and traumatic influence from the environment is evident, the impact can be too large and the lesions progress. A common severe consequence of laminitis is sole ulceration.

Sole ulcer is the most prevalent lesion causing lameness and thus has a great economic impact on dairy production all over the world. Other common lesions associated with laminitis are: *hemorrhages*, *fissures* and *abscesses of the white line*, *sole hemorrhages* and *double soles*, *toe ulcers* and *toe abscesses*, and *under-running of the heels*. These lesions are recognized at regular hoof trimming or as acute cases, and the hoof trimmer, farmer or veterinary practitioner has to treat them promptly to avoid involuntary culling. If not correctly managed, the sole lesions can develop into serious problems with secondary infections, leading to joint and tendon infections, abscesses of the heart, lungs and kidneys, and finally death (Picture 7). Raised body temperature and loss of appetite are early signs of a general affection of the animal. A comfortable and hygienic environment is important to avoid such complications.



Picture 7. Downer cow with decubital injuries and hock abscesses due to sole ulcers.

Risk factors for laminitis

Sole hemorrhages and yellowish horn (due to blood serum exudation, i.e. edema), are often called *subclinical laminitis* (5), because the cow is often not clinically lame when these symptoms are observed. Nevertheless, cows with sole hemorrhages are good indicators of laminitis. Records of sole lesions have been used as a research method to study different risk factors and their impact on laminitis. Also lameness scoring has been used in studies of laminitis, but is less specific. Since several factors contribute to laminitis, and consequently the related hoof disorders, laminitis is called a *multifactorial* disease.

Diet and feeding management

United Kingdom studies found the diet has an influence on the prevalence of sole lesions and lameness (7). In a test group with restricted forage in the diet, 64 percent of the group developed *sole ulcers* compared to eight percent in a group with free access to forage. In a series of other United Kingdom studies (8), a higher concentrates-forage ratio, a high concentrate amount, and a high dietary protein intake resulted in more lameness problems. Dutch studies (11) have also concluded that a higher ratio of concentrates results in more *sole ulcers*.

Not only the composition of the diet, but also the way it is fed and the feeding behavior of the animals are important risk factors for laminitis. In a Swedish study (1) of tie-stall herds with separate concentrate feeding, there was no significant correlation between sole hemorrhage scores and the diets fed. On the other hand, high sole-hemorrhage scores were associated with feeding concentrates less than four times daily, less access to feed at the manger and feeding concentrates before roughage. These factors could be related to the rumen metabolism. A concentrate fed without enough functional fibers from the roughage results in less chewing, so less buffering saliva is produced. It may result in a drop of the rumen pH and the ingesta passing through the alimentary tract faster. Some people argue that *rumen acidosis* is involved in laminitis etiology (the cause of).

Feeding a total mixed ration (TMR) can improve rumen digestion. A Dutch study initially indicated that a TMR diet resulted in less *sole ulcers* compared to separate feeding of the same concentrate-forage ratio.

The animals' behavior when being fed can also influence the development of laminitis. In an Irish experiment, the animals were scored for their interaction behavior when the feed space at the manger was reduced. The sole-hemorrhage scores were significantly higher in the animals with a high interaction score than in those with low interactions. The study concluded that competing for food at the manger could provoke interactions between animals resulting in sole hemorrhages.

Changes around calving

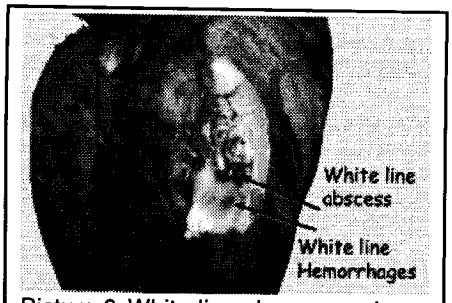
In a Swedish experiment, 60 heifers in early pregnancy were tied on either concrete floors or on rubber mats and were challenged with high-concentrate diets. Sole-hemorrhage scores were generally low and no differences were found between groups. The same animals were grazed during the summer, regrouped, and in the fall housed on concrete floors or rubber mats, and were allocated to either a high- or a low-concentrate diet (2). All hooves were scored for sole hemorrhages at trimming two weeks before and again 14 weeks after calving. The animals on the concrete floors had significantly higher scores than those on rubber mats. The combination of high-concentrate feeding and concrete floors resulted in significantly more sole hemorrhages than the low-concentrate diet and rubber mats. It was concluded from the two experiments that calving per se, and environmental and management changes before calving were the main contributing factors for subclinical laminitis.

In the same series of experiments, another group of heifers was tied up on concrete floors during the winter before calving in spring. The presence of sole hemorrhages was compared to the sole-hemorrhage scores of heifers calving on concrete floors the previous autumn. The spring-calvers had higher scores than the autumn-calvers before calving, but significantly lower scores after calving. The results were interpreted to mean that spring-calving heifers have a longer adaptation period to concrete floors before calving, compared to the autumn-calving animals, which come from pasture just a few weeks before calving. Consequently the autumn-calvers passed the sensitive period around calving with less severe sole lesions.

Floors

As revealed in the experiments above, hard floors increase the risk of subclinical laminitis. Also in a field study, animals on concrete floors had higher sole-hemorrhage scores than those tied on rubber mats. When cows tied on rubber mats were compared to cows in free stalls with rubber mats and concrete slatted floors, significantly more *white-line hemorrhages* were found in the latter group. These findings are in accordance with the observations made in tied animals, that white-line lesions and trauma of the wall are seen more seldom in tied than in free moving cattle on hard floors. A tearing of the hemorrhagic weakened wall, as when the animal turns around, can cause a fissure between wall and sole in the white line and a white-line abscess (Picture 6). Danish studies came to the same conclusion that tied animals on

rubber mats had less hoof lesions than those in loose housing system (12).



Picture 6. White-line abscess and white-line hemorrhages in the posterior outer wall.

Cow comfort

With a comfortable environment, dairy cows are lying down 12 to 15 hours per 24 hours and most often when ruminating. Comfortable stalls mean soft bedding and enough space for rising and laying-down. In uncomfortable stalls, cows often stand half into the free stalls with their rear feet on the alley. A longer standing time increases the loading and exposure to unhygienic materials, particularly for the rear feet. An Irish study illustrated the effect of prolonged standing due to uncomfortable stalls. (6). Heifers were introduced either to comfortable free stalls equipped with rubber mats and open dividers, allowing better space for rising and laying-down; or to concrete-based cubicles without bedding, with dividers more closed on the sides, and without lunge space. Researchers assessed lying time and sole-hemorrhage scores before and after the cows had been introduced to the free stalls at calving. There was no difference in scores between the groups before calving. At calving, heifers were lying significantly longer in the more comfortable stalls. The sole-lesion scores increased in both groups, but there was still no difference between them. However, two months after calving, the animals in the uncomfortable stalls had significantly more *sole hemorrhages* even if the animals were lying longer in both types of stalls at this time. The sole hemorrhages thus reflected the longer standing time due to poor comfort that took place two months earlier.

Hoof trimming

Hoof trimming has proved to reduce lameness. In a United Kingdom study, trimming the feet before calving resulted in fewer lame cows than when the feet were not trimmed (8). Preliminary results from a Swedish study show twice as many sole ulcers in animals trimmed only once each year compared to those trimmed twice. German experiments (4) also show that when the distribution of weight between the claws is unequal, and the sole bears too much weight, there is a greater risk for sole lesions. When the feet are trimmed, the weight is more equally distributed between and within the claws. From the German study, researchers also concluded that it is more difficult to equalize the weight distribution in cows with excessive wear, i.e. cows in free stalls on abrasive concrete floors.

It is of the outmost importance that hoof trimming is performed correctly:

- Uniform distribution of weight bearing between outer and inner claws.
- Toe angle of at least 45 degrees, but not more than 60 degrees.
- Toe length averaging 7.5 cm (3 inches) in a mature cow.
- Shaping the sole to reduce pressure on the "typical" sole ulcer site.

Treating laminitis

Acute laminitis can be medically treated with anti-inflammatory and pain-reducing non-steroid anti-inflammatory drugs (NSAID). However, due to an often late-diagnosis of laminitis, hoof corium lesions are already evident inside the hoof capsule when laminitis is treated. Consequently, if laminitis is not detected in an early stage, medical treatments are less valuable. The treatment should then be concentrated on non-medical regimes.

The disease history and the time interval from calving are valuable tools in deciding treatment regimes for a laminitic cow. With a case history of weeks or more, in what is called *chronic laminitis*, sole lesions are rather a rule than an exception. The most important treatment in chronic laminitis is to relieve weight from the affected areas of the sole. Even with a rather short disease history, and before sole lesions are visible, weight relief is valuable as well.

Many lesions in dairy cows have a remarkable healing capacity. However, the lesions have to be detected before affecting vital structures. To relieve the load on the diseased claw, put a block or elevated shoe on the healthy claw. This procedure not only increases the chance of healing, but also improves mobility and reduces pain. Thus, the cow can go back to the herd quicker and does not have to lose too much condition and performance.

Treatment regimes for hoof lesions related to laminitis:

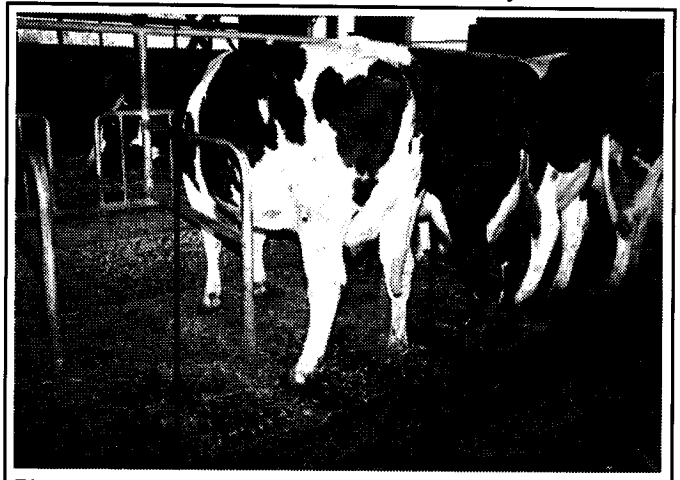
- Paring to re-establish equal weight distribution, so called *functional trimming*
- Paring away diseased and disconnected hoof horn
- Relieve the weight of a painful or badly injured claw by a block or elevated shoe.
- Topical treatment and wrapping if necessary.
- Gentle exercise to promote blood circulation and healing, and soft bedding to avoid secondary decubital injuries from too much lying.

Housing design with healthy feet in mind

There will be larger herd sizes, and breeding for higher yield will continue in the future. The need for comfortable stalls for healthy and high-producing animals is obvious. A main problem is the floors. Concrete is very practical from a hygienic and economical point of view, especially in larger herds. Increased walking distances and prolonged waiting for milking and feeding, reduces the time lying down and thus increases the load on the feet. Areas where the cows' hooves can rest from concrete would be beneficial for hoof health. Rubber mats have proved to be a durable material that reduces the risk of laminitis. Rubber mats are used more and more often in free-stall operations. Conveyor belts are practical to put on top of the concrete, but can be hard to clean if flush systems are not used.

To get a softer and more hygienic environment for the hooves, and thus to prevent hoof problems, a specific type of *feed stalls* (Picture 8) have been constructed in Swedish free-stall barns. The feed stalls are equipped with rubber

mats and the animals stand comfortably when eating. The individual feed stalls are 1.60 m long and on a 0.2 m elevated platform and use dividers between each cow (0.80 m distance). The manger is elevated 20-40 cm above the foot level to make eating more comfortable. The cow can stand with all four feet on the rubber mat and still deposit manure on the alley behind the platform. The slope of these feed stalls makes them self-cleaning and they can be used with any kind of alleys. Also, the alleys can be scraped or flushed more frequently without disturbing the animals when they are eating, unlike in traditional systems.



Picture 8. Feed stall equipped with rubber mat and divider between each cow protects the feet from concrete in a hygienic environment.

Feed stalls have been tested since 1992 in Swedish commercial dairy herds with satisfying results (3). The change in management systems from tie stalls to free stalls was studied according to health and function. In the year after the system change, the need for replacements in herds with feed stalls was 50 percent lower than in traditional free-stall systems. The cleaner and more comfortable foot-environment in herds with feed stalls reduced *sole ulcers* and *heel-horn erosions*. Feed stalls also gave low-ranking cows (first-calving heifers) better opportunities to feed without being displaced.

Preventing laminitis

Laminitis is often a herd problem. Management decisions are critical to reducing most laminitis risk factors. Laminitis prevention increases if the farmer or manager understands the close relationship between laminitis and sole horn. Remember that these lesions affect fertility and increase the risk for culling. A *sole ulcer* costs the herd owner about $550.

Keeping hoof-lesion records can help monitor herd problems and decision-making. Records can also help evaluate the effects of a preventative protocol.

Use the research results discussed here and practical experience to prevent laminitis on a herd basis. Still more research is needed to learn more about the causes of laminitis.

Measures to prevent laminitis and laminitis-related hoof lesions:

- Provide a long adjustment period to concrete floors, especially if the animals are moved from pasture or deep-pack bedding to harder floors.
- Use rubber mats for animals to stand upon when eating and at milking.
- Introduce the heifers to the dairy herd at least a month before calving or wait until after calving.
- Reduce stress and social interactions in the herd by improving cow traffic and give continuous access to food
- Use stalls with enough lunge space and soft bedding to favor lying comfort.
- Make a gradual adjustment to lactation diet.
- Use feeding routines that stimulate natural digestion.
- Feed well-balanced diets with enough functional fiber to promote rumination.
- Trim hooves to establish functional hoof shape before calving

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