Digital Dermatitis: New Ideas on an Old Disease

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Abstract

Approximately 42 years ago Drs. Cheli and Mortellaro published an article describing the disease of digital dermatitis (DD). To this day, despite millions of dollars spent on research of this disease, it remains a major cause of lameness in dairy and beef cattle throughout the world. Our research team at Iowa State University has centered much of its attention on the developmental aspects of DD, with specific emphasis on the etiology and epidemiology of the disease, in hopes of finding better methods of treatment, control and prevention. Early studies were designed to monitor the progression of DD lesions from the earliest to the mature lesion stages. Despite our attempts to use the popular "M" system of lesion scoring, it failed to properly differentiate the various morphologic variants of early stage lesions observed in our studies. Therefore, we developed and validated (using a variety of techniques) a lesion staging system that classified early lesions as: Type A (1 and 2) lesions described as small focal ulcerated lesions and Type B lesions (1 and 2) which are diffuse encrusted acantholytic lesions. "Classic lesions" were categorized as Stage 3 (an easily visible ulcerated lesion) or Stage 4 (thickened chronic lesion with or without filiform outgrowths of epithelium). Using metagenomics to assess the microbial populations in each stage of the lesions we have demonstrated an abundance of Treponema spp. in mature (Stage 3 and 4) lesions. However, we found that early stage lesions have only minor populations of Treponemes and are characterized by a much more diverse population of organisms. This suggests that non-Treponemal species may be responsible for initiating lesion development, with Treponemes representing secondary invasion later in the disease process. Based upon careful monitoring of DD lesions in cows over a 3 year period, it was observed that the progression of lesions from an early to mature lesion state occurred over a mean of 147 days (range 37 to 522 days). This is corroborated by our clinical observation of DD in feedlot cattle in North America, whereby most cattle enter the feedlot free of DD; but develop mature lesions by 3 to 4 months after their arrival. Treatment of DD is normally accomplished on farms in the US by a one-time topical application of tetracycline under a loose wrap. Despite the popularity of the treatment approach our research suggests that single time-point treatment with tetracycline has a high level of recrudescence. Of 44 classic lesions topically treated with tetracycline, all but 6 lesions recrudesced. In addition to our studies of the disease and its treatment in cattle, we have also tried to determine possible reservoirs of the disease in the dairy farm environment. In total, 204 different samples were collected from a single DD positive dairy farm, and an additional nine samples were collected from alley flush water or manure lagoons of other farms known to have DD. Treponema positive samples were typically found in higher numbers and in a larger prevalence from animal associated samples and hoof trimming

equipment, although samples derived from animal bedding, equipment and the farm worker environments were also positive.

Digital Dermatitis in Dairy and Beef Cattle

Digital dermatitis (DD) is considered to be the most common infectious disease affecting housed dairy cattle world-wide. It is estimated to affect nearly 100% of dairy herds and up to 20% of all dairy cattle. A study published in 2000 of cull dairy and beef cattle in the southeastern United States also found a higher prevalence of digital dermatitis in dairy compared with beef cattle. Researchers examined the left hind foot for lesions of digital dermatitis in a total of 815 cattle during 4 visits to a slaughterhouse. Twenty-two of 76 (29%) dairy cattle and 29 of 739 (4%) beef cattle were observed to have lesions of digital dermatitis. Male beef cattle were more likely to have lesions compared with beef females. Results of this study confirm that although prevalence is lower, DD does occur in cow/calf operations as well.

Although Italian researchers Cheli and Mortellaro are credited with being the first to describe digital dermatitis, there's evidence that a veterinarian from the US could have justified similar fame. In 1974, a veterinary practitioner from Vicksburg, Mississippi, reported observing papillomas (warts) occurring on the feet of a mature Angus bull. Lesions were described as beginning on the pastern and coronet of the rear feet and gradually spread upward to the dewclaws and fetlock. Attempts to isolate viruses from the lesions were unsuccessful and despite multiple attempts at therapy the disease was refractory to treatment. Of interest, none of the treatment approaches involved topical antibiotics. It's unknown whether the condition described here was actually DD, however considering its similarities to digital dermatitis, one might wonder if topical antimicrobial treatment might have proved beneficial based on the poor response to therapy.

In feedlot cattle DD occurs sporadically in some locations of the country and in near epidemic proportions in others. Although there are no published data on incidence, clinical observation suggests incidence rates as high as 50% or more in pens of affected cattle. One of the troubling features of DD is that lameness is often

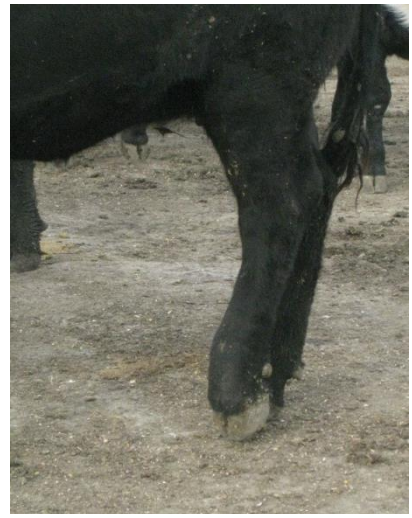

Figure 1.Typical posture of a steer with digital dermatitis affecting the plantar interdigital cleft.

inconsistent. Less than half of affected cattle may demonstrate obvious signs of lameness. Observations from a large study at Iowa State University

over a 3 year period of time strongly suggest that nearly all early lesions and a significant percentage of advanced lesions fail to result in visually detectable lameness (i.e. a locomotion score greater than 3 on a 5-point scale). In our study only a portion of the cows with clinical lesions had lameness. Similar results were observed by Frankena and co-workers where only 39% of the cows with severe DD lesions had lameness. These observations suggest that lameness is not a good means of identifying the prevalence of cows with DD lesions. It simply misses too many.

Detection is often based on direct observation of lesions or a finding of variable degrees of lameness amongst cattle within a pen. Cattle with lesions on rear feet often exhibit a characteristic posture whereby they will shift weight to the less severely affected foot and place weight on the painful foot onto the toe thereby placing less stress on the skin on the plantar surface (See Figure 1).

Characteristic Appearance of DD Lesions

Lesions of DD are typically observed in one of 3 locations of the foot: 1) on the skin of the plantar aspect of the rear foot adjacent to the interdigital cleft, 2) on the interdigital skin and 3) at the skin-horn junction of the heel bulbs. Less frequently, lesions may be observed near or above the dewclaws. From our research work at Iowa State University, we have found that it helps to categorize lesions into two major groups, pre-clinical and clinical. Pre-clinical lesions are the early stages of lesion development that are easier to treat and generally do not cause clinical lameness. Clinical lesions are those that have a deeper seated infection making them more difficult to treat and are capable of causing clinical lameness.

For research purposes we subdivide these stages into additional classifications to better understand lesion development and treatment responses; however that level of complexity is not generally necessary for making clinical decisions. For example, in our staging system "pre-clinical" stages of developing lesions (A Type) are usually observed on the plantar interdigital cleft and subdivided into A and B type lesions. A-type lesions are a spreading non-proliferative lesion, whereas B-type lesions are more of a focal or multifocal crust with acanthosis. Classic (i.e. mature)

lesions are generally red, circular or oval with a raw ulcerated surface that frequently border the interdigital cleft (Figure 2); however they may be found anywhere on the foot from the dewclaws on down to the coronet (skin-horn junction) . As lesions

Figure 2.A lesion of digital dermatitis in an atypical location on the lateral side rear foot.

mature they develop a granular appearing surface similar to that of a wart. The borders of mature lesions are often clearly demarcated by the presence of hypertrophied hairs.

Chronic lesions are characterized by a thick bed of granulation tissue and in some cases epithelial outgrowths that appear as long hairs extending from the surface of the granulation tissue bed, thus the common name – hairy heel wart. Digital dermatitis lesions are extremely sensitive and very painful when touched or disturbed.

Lesions also have a characteristic odor believed to be caused by the breakdown of keratin and the presence of secondary bacterial infection. Finally, mature and particularly chronic lesions are accompanied by significant erosion of the heel horn. The heel erosion may be diffuse, in the form of fissures, or in the shape of a "V". In some cases the erosion may result in significant undermining of heel horn.

Pain is a key feature of DD lesions, so animals will naturally learn to adjust posture and walk in a manner that avoids discomfort. Hoof trimmers know to carefully examine a foot with an abnormally long heel or toe; because the shape of a hoof is an important indicator of foot problems. In the case of chronic DD lesions, animals will adjust their posture and gait to avoid contact with flooring surfaces. For example, when lesions occur on the plantar surface of the foot animals will shift their weight to the toe as shown in Figure 1. This causes greater wear at the toe and less at the heel permitting the heel to become abnormally long. Lesions occurring on the front of the foot will cause the animal to shift its weight to the heel resulting in a longer toe and shorter heel. Therefore, claw conformation can be a very useful diagnostic indicator of DD lesions in cattle.

Causes of DD

For the past 25 years researchers have consistently isolated bacterial spirochetes from DD lesions. The majority of these spirochetes have been

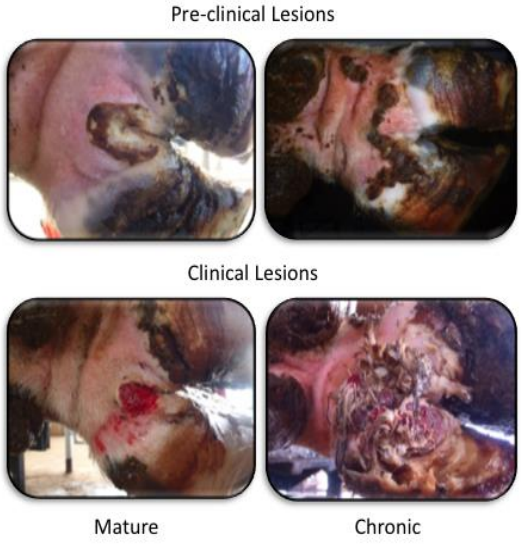

Figure 3: Typical appearance of different stages of Digital Dermatitis lesion development. The top pictures demonstrate the two pre-clinical lesion types. The bottom pictures show clinical lesions with the mature lesion on the left and a more chronic lesion on the right. (Note lesions are shown on dairy cattle with white feet to make the lesions easier to visualize)

identified as belonging to the genus Treponema sp. causing many to conclude that Treponemes are the most likely causative agent of DD. However, the bacterial flora of the foot includes a multitude of other bacteria, some capable of causing disease and some not. Nonetheless, questions remain as to whether DD is solely caused by Treponemal spirochetes, by other associated bacteria or is it a combination of both?

Studies by Krull et al, at Iowa State University suggest that more than Treponemes are likely involved. Evidence for this comes from several observations: 1) attempts to reproduce the disease by skin inoculation with pure cultures of these microorganisms have largely failed to cause disease, 2) vaccines prepared against spirochetes have not proven to be effective for control of DD, 3) a large number of different bacterial organisms can be identified in the lesions including multiple types of Treponemes, and 4) the lesions of DD respond favorably to antibiotics. At present the data suggest that the disease process is poly-microbial (i.e. poly-bacterial), meaning that multiple species of bacteria need to be present at the same time in order to induce disease. A very similar disease process associated with similar Treponeme species is human gingivitis where there is a large body of evidence that multiple bacterial species are required to induce disease. Not surprisingly, poly-bacterial diseases are much more complex to study and understand which likely explains the difficulty researchers have experienced in determining the cause of this disease.

Treatment of DD

Treatment of Individual Animals with an antibiotic compound such as oxytetracycline or tetracycline soluble powder with or without a bandage is the most common form of individual treatment on dairy farms. It is labor intensive and effectiveness depends upon the nature of the lesion with respect to chronicity (i.e. early, mature or chronic).

Our research group has been evaluating the clinical response to treatment with topical antibiotics. Several key factors have been confirmed. First, we have confirmed the results of other researchers that demonstrate that the majority of lesions that are treated a single time with topical tetracycline fail to completely heal. Treatment does often improve lameness and the lesions tend to improve and some will return to a pre-clinical stage; however over time most lesions persist or recrudesce (reoccur). Second, our data suggest that there is not a significant difference in lesion recrudescence between the mature and more chronic lesions. So, treatment of all observed clinical DD lesions is warranted. Finally, we have demonstrated that when lesions heal completely (i.e. return to normal skin) they are much less likely to recrudesce. This finding would suggest that more aggressive follow-up to topical treatment with retreatment until the skin completely heals may be warranted.

Topical antibiotic sprays

Have been shown to be very effective for treatment of DD. Although labor intensive, it offers a couple of

advantages over footbath treatment approaches. For one, this treatment method is not affected by freezing temperatures and secondly, DD lesions can be sprayed with full-strength solutions that haven't been subject to contamination and possible neutralization by organic matter. While this approach to treatment and control may seem too cumbersome, some argue that in feedlot situations spraying is easier than trying to construct and manage a footbath.

Walk-Through Footbaths

The use of a walk-through footbath is the most popular approach to treatment of DD in dairy cattle; but there is little information in the scientific literature to support its efficacy. Products or compounds suggested for use usually include copper sulfate, zinc sulfate, formalin, and various antibiotics. In feedlot conditions one of the first challenges is finding the best location for a footbath so that it can be properly used and maintained. The next issue is design of the footbath; if the footbath is too short animals will jump over it and if it is too narrow animals will step around it. Based on the dairy industry's experience longer (12 ft.) footbaths are likely to increase the number of foot immersions per trip through the bath.

Prospects for Vaccination to Control DD

History suggests that developing a vaccine may be difficult. Results from early studies of a Treponema bacterin for control of DD in cattle concluded that immunization could reduce clinical disease. However, commercial use proved otherwise and the vaccine was eventually removed from the market. The US experience with vaccination for DD was corroborated by German researchers who found no benefit from a vaccine containing herd-specific pathogens including Treponema sp. While interest in finding a vaccine continues to be the focus of many who research this disease, there are many questions to be answered in the process of finding permanent solutions through vaccination.

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