Practical Understanding of Claw Lesions

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Introduction

Successful control and management of lameness in commercial swine operations should include the following: Early detection of lameness problems on an individual and herd basis. This can be achieved by: 1) Close observation of individual animals for signs of lameness and/or lesions (See flow chart); 2) Lesion identification and record keeping; 3) Knowledge of the causes and corrective actions necessary for each of the different lesions.

Visible lesions of the foot without swelling or lameness do not penetrate through the full thickness of the horn (wall, sole, heel or white line) and as a result cause no pain and require no immediate action. However, it is important that lesions are identified and the prevalence recorded. High prevalence rates warrant investigation as to the possible cause in order to institute corrective actions. For example, vertical wall cracks may indicate poor horn quality and keratinization and may point to nutritional imbalances or deficiencies. Lesions that penetrate though the full thickness of the horn cause pain due to penetration into the corium (the underlying soft tissue layer) which is highly innervated with pain receptors. Trauma and infection of the exposed corium lead to inflammation and swelling resulting in more pain and inflammation. Progression from partial to full thickness horn lesions develops over time but is also dependant on other factors such as flooring and housing. Hard floors increase concussion on individual claws and dissipation of tension forces through the claw created by weight bearing becomes less efficient. This may not only lead to progression of existing lesions but can lead to mechanical trauma of the soft tissues within the claw which will result in further pain and inflammation. This applies particularly to the outer claw of the back leg which carries more weight compared to the inner claw. Overgrowth of the outer claw may further predispose the claw to mechanical trauma. In unpigmented claws inflammatory changes can be seen as red discoloration below the horn surface. Swelling at and above the coronary band, particularly in the presence of a discharging tract, are signs of deep sepsis of the foot often accompanied by osteomyelitis. Such lesions are serious and usually unresponsive to treatment.

Lameness in the absence of visible lesions may indicate problems in the upper leg such as osteochondrosis or osteoarthritis. Osteoarthritis may follow osteochondrosis and is commonly seen in the elbow joint of older pigs.

Structure of the foot

The *foot* includes the limb below the fetlock joint. It is comprised of two digits each of which has a horn-covered claw. The term "*claw*" is preferable to hoof. When referring to an area nearest the longitudinal axis (i.e. toward the center) it is designated as *axial*, whereas structures away from the center are designated as *abaxial*.

Each digit of the foot consists of: phalanx 1 (P_1), phalanx 2 (P_2), phalanx 3 (P_3), and navicular bone; and 2 joints: proximal interphalangeal (PIP) and distal interphalangeal (DIP). P_3 is completely enclosed within the claw horn capsule.The deep flexor tendon is attached to the flexor tuberosity at the back P_3.The navicular bone is attached to P_3 and also to P_2. The navicular bursa is situated between the navicular bone and the deep flexor tendon and permits movement of the deep flexor tendon over the surface of the navicular bone during extension and flexion of the claw. P_3, the DIP joint, navicular bone and navicular bursa are within the claw horn capsule.

The claws

The purpose of the claw horn capsule is to protect the underlying sensitive tissues of the corium and dissipate the concussion forces that occur when the digits impact the ground. It consists of the wall, which can be divided into the abaxial (outside) and the axial (inside). The abaxial wall is further subdivided into the dorsal (or front/toe) and lateral (abaxial) aspects. The wall is demarcated from the heel on the abaxial side of the claw by the abaxial groove. Perioplic horn is the softer horn lying just below the skin-horn junction. At the back of the foot the periople gradually widens and eventually becomes the horn of the heel. Coronary horn, the hardest horn within the claw capsule makes up the bulk of the horn of the wall. The wall has faint ridges or rugae, which run horizontally and parallel to each other. Toward the heel these ridges diverge reflecting a more rapid rate of growth in the heel region due to faster rates of wear. In mature sows the normal toe length is 45 to 50mm.

The sole is connected to the wall by means of the white line. The white line courses forward from the area of the heel on the abaxial side of the claw, around the tip of the toe and about 1/3 of the way back on the axial side of the claw's weight bearing surface. The white line is a unique and important structure. It is the softest horn within the claw capsule. This permits it to provide a flexible junction between the harder horn of the wall and the softer horn of the sole. On the other hand, because of its softer nature it also represents a

weak area on the weight-bearing surface that is vulnerable to damage. The epidermal layer overlying the corium produces horn cells in the form of tubules (tubular horn). Cells within the tubules are arranged in a steep spiral around the center axis. Tubules differ in size, number and shape in various parts of the claw and are round near the inside of the wall and oval near the surface. There are approximately 80 tubules per mm^2 in the wall and $20/mm^2$ in the sole and heel. Intertubular horn interconnects the tubular horn. Intertubular horn consists of sheets of elongated horn cells arranged parallel with the bearing surface. Since tubular horn is what imparts structural strength to the horn capsule, it follows that the horn of the wall is structurally the strongest followed by the sole and the heel.

Horn quality and physical properties

Horn quality is dependent on a number of internal as well as external factors. Internal factors would include blood and nutrient supply whereas external factors relate to environmental influences. Horn production requires good vascular supply. Any compromise in blood flow will have a negative effect on horn production. Horn production is also dependent on the supply of nutrients which include adequate levels of protein, energy, lipids, vitamins A, D and E, calcium and phosphorous. Micronutrients such as the sulfur containing amino acids like cysteine and methionine are essential for cross-linking of keratin filaments. Trace minerals particularly zinc, copper and the vitamin biotin have very important roles in the keratinization of horn cells and integrity of the intercellular cementing substance of claw horn.

Biomechanics of weight bearing

Observation of slaughter house specimens and claw measurements have shown that weight bearing between front claws is relatively evenly distributed while there is a significant difference in claw size between the outer and inner claws of the back leg. The outer claw has a larger surface area and carries more weight. As a result the heel of the outer claw overgrows and as such is more predisposed to mechanical injury particularly on hard walking surfaces. In some instances it appears as if the inner claw of the back leg is almost non-weight bearing and under-goes disuse atrophy. A genetic base for this difference in claw size needs to be investigated.

Pathogenesis of lameness

Lameness is an indication of the presence of pain. The corium is highly innervated with pain nerve endings. Inflammatory changes cause the release of cytokines and neurotransmitters which activates pain fibers resulting in transmission of pain signals to the brain. Pain is highly catabolic and results in significant weight loss despite maintenance of normal food intake. The basal cellular metabolic rate is elevated. Endogenous steroid (cortisol) release results in gluconeogenesis (break down of body protein to glucose), and activates hormone sensitive lipase, an enzyme which converts body fat (triglycerides) to fatty acids for transport to the liver where it is used for energy. Cortisol also causes insulin resistance which makes it more difficult for blood glucose to enter cells which in turn will induce further breakdown of body reserves.

Horn lesions

The claw consists of structurally different types of horn which on biometric strength (hardness) ranks as follows (hard to most soft): wall; sole; heel; coronary band and white line. Lesions in the different areas are the following:

Wall: Horizontal and vertical wall fissures; Wall crack at the wall/heel junction; wall hemorrhages; overgrowth

Sole: Fissures/cracks and sole crack at the heel/sole junction

Heel: Erosion and cracks

Coronary band: Hemorrhage; discharging tract and swelling

White line: Hemorrhage; separation which is often continuous with separation at the wall/heel junction and/or heel/sole junction.

Vertical wall fissures

Vertical wall fissures occur mainly on the abaxial wall in one or multiple claws. The fissure may start at the coronary band or the bearing surface and may involve part or full length of the wall. Cracks start in the intertubular horn and progress along the intercellular cement substance which connect horn cells together (like the cement in a brick wall). Intercellular cementing substance consists of long chain fatty acids. Biotin is important in the production and elongation of these fatty acids and supplementation of biotin can reduce the prevalence of vertical cracks in problem herds. Other causes of vertical wall cracks include trauma. Some pigs will constantly rub the abaxial wall of the

outer claw of the back foot in contact with flooring surface when they are lying down. This will result in thinning and weakening of the wall with subsequent development of a vertical wall crack.

Full thickness cracks will cause severe irritation of the corium with lameness. This is exacerbated by secondary infection and inflammation. Cracks starting at the coronary band can lead to deeper infection of the foot with severe swelling. Infection may spread to the bone (usually P_2).

Not all vertical wall cracks will cause lameness and careful examination for the presence of other problems such as inflammation of the corium of systemic origin has to be carried out. This can be recognized as red discoloration on the inside of the wall on multiple feet.

Another common location for vertical wall crack is the wall/heel junction, also referred to as the abaxial groove. The cause of this lesion is associated with weight bearing on hard floor surfaces. The pathogenesis appears to be as follows: During weight bearing there is expansion of the heel towards the outside. This will cause the creation of tension forces which pass upwards through the heel/wall junction. Dissipation of such forces is less effective on a hard surface and may eventually lead to fracture.

Horizontal wall fissures

A horizontal wall fissure usually extends across both the abaxial and axial walls. They occur on multiple feet in the same animal and denote an interruption in horn growth due to vascular compromise in the corium. Several horizontal wall fissures may occur in the same claw indicating repeated episodes of interrupted horn growth. The vascular compromise is usually due to substances such as endotoxin which can be produced in the gastrointestinal tract or be associated with infections caused by gram negative organisms such as with mastitis or metritis. Endotoxin causes the release of vasoactive agents capable of producing changes in the microvasculature of the corium such as increased capillary pressure, edema, thrombosis and influx of cells associated with inflammation. Nutritionally induced laminitis has not been documented in swine. However microscopic changes of laminitis in the claw similar to those in other species have been reported.

Wall hemorrhages

Red discoloration beneath the wall is an indication of hemorrhage and/or inflammation. Wall hemorrhages are usually traumatic in origin and may be present in only one claw. Fracture of the wall may be present at the same

time. Severe inflammation on the other hand may involve multiple feet and is a sign of a systemic problem or disease.

Heel erosion and heel and heel/sole cracks

Heel erosion and heel cracks are the most common lesions found in the claw. The outer claw of the back leg is often the most severely affected due to the biomechanics of weight bearing. Heel horn is soft (has few horn tubules) and makes up the largest part of the weight bearing surface of the claw. This is unlike other cloven hoofed animals where the sole forms the largest part of the weight bearing surface. The sole has more tubules and is harder than the heel. Lesions of the heel vary from shallow erosion to deep cracks which often reach the underlying corium and results in pain and lameness. Cracks become infected with anaerobic bacteria which produce keratolytic enzymes that will lead to further destruction of heel horn and cause inflammation. Removal of some of the hyperkeratotic overgrowth and opening of deep fissures may be helpful to slow down the process. Thorough cleaning in addition to antibiotics and anti-inflammatory medication are indicated in the treatment of such cases. Attention to the abrasiveness of flooring surfaces, foot baths and social interaction in group housing may be useful in limiting the incidence of lameness as a result of heel erosion and heel cracks.

Heel/sole crack is another entity which may result in lameness. The heel becomes separated from the sole. This separation may progress to include the abaxial white line and sometimes the axial white line. In such cases the heel may almost become separated from the rest of the claw. Such lesions often extend into the corium resulting in lameness.

White line separation (disease)

The white line consists of soft flexible horn. As such it is very susceptible to the abrasive effect of concrete and the erosive effects of bacterial enzymes. Because of the soft horn cell turn-over is faster than in other parts of the claw with the result that more immature cells are in contact with the bearing surface. White line separation is also linked to the biomechanics of weight bearing. The abaxial white line is widest at its caudal abaxial border where it connects with the bottom of the heel/wall junction (abaxial groove). During weight bearing there is lateral expansion of the heel. The abaxial groove and white line is pushed sideways. This results in

widening of the white line and greater exposure of the soft flexible horn to the bearing surface resulting in increased wear. Abaxial white line separation is often continuous with heel/wall crack and/or heel sole crack. Dirt and bacteria gets trapped into the separated area and may form an abscess which may extend into the deeper tissues of the foot.

Dew claws

Overgrowth of the dew claws is common. The dew claws may become weight bearing and wear down to a sharp tip which may cause trauma. Overgrown dew claws are prone to mechanical injury and may fracture at the junction with the skin. Infection with swelling of the leg may follow. Complications may include joint infection or osteomyelitis. Such cases are usually unresponsive to systemic antibiotic therapy. Overgrown dew claws should be trimmed back to about 2 cm.

Long toes

Since the rate of growth usually exceeds the rate of wear, toes become progressively overgrown. Overgrowth is usually not in a straight line but often deviates to the inside. Overgrown toes may have the following effects: Normal joint angles are disturbed which over time may result in osteoarthritis. This is commonly seen in the elbows of older Vietnamese potbellied pigs; The weight bearing axis is moved further back which results in the flexor tendon becoming over stretched. Overgrown claws should be trimmed. A trimming method has been described.

Lameness in pigs flow chart