Peer reviewed

Literature review

Shoulder lesions in sows: A review of their causes, prevention, and treatment

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Summary

Severe shoulder lesions in sows are manifested as ulcers comparable to pressure ulcers in humans. In sows, shoulder lesions appear on the skin overlying the bony prominence of the scapula, and are most commonly observed in the first weeks of lactation. Shoulder ulcers arise due to prolonged compression of blood vessels around the tuber of the scapular spine when the sow is lying, leading to insufficient blood circulation, necrosis, and subsequent ulceration. Due to the nature of shoulder lesions and their estimated occurrence (5%-50% of breeding sows worldwide), they represent an obvious welfare concern. There is also an economic impact due to labor time for treatment, medication, and premature culling of sows. While multiple factors contribute to ulcer development, maintaining optimum body condition in sows appears to be a key factor in prevention. This review summarizes the literature on sow shoulder ulcers, including the causes, prevention, and treatment. Regular monitoring of lesions is recommended, as this will help to identify individual farm causes and prevention measures. While much is known about shoulder ulcers, we conclude that there are significant gaps in the scientific literature regarding the mechanisms of development and healing, pain caused, and effective means for treatment and prevention.

Keywords: swine, sows, shoulder lesions, review, welfare

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Resumen – Lesiones de hombro en hembras: Una revisión de sus causas, prevención, y tratamiento

Las lesiones severas de hombro en hembras se manifiestan como úlceras comparables a las úlceras de presión en humanos. En las hembras, las lesiones de hombro aparecen en la piel sobre la prominencia de hueso de la escápula, y se observan más comúnmente en las primeras semanas de lactancia. Las úlceras de hombro surgen debido a la compresión prolongada de vasos sanguíneos alrededor del tubérculo de la espina escapular cuando la hembra está acostada, llevando a una circulación de sangre insuficiente, necrosis, y la ulceración subsecuente. Debido a la naturaleza de las lesiones de hombro y su ocurrencia estimada (5%-50% de las hembras de cría en todo el mundo), estas representan una obvia preocupación de bienestar. Hay también un impacto económico debido al tiempo de trabajo utilizado para su tratamiento, medicación, y el desecho prematuro de hembras. Si bien, múltiples factores contribuyen al desarrollo de la úlcera, mantener una condición corporal óptima de las hembras parece ser un factor clave en su prevención. Esta revisión resume la literatura de las úlceras de hombro en hembras, incluyendo las causas, prevención y tratamiento. Se recomienda el monitoreo regular de las lesiones ya que esto ayudará a identificar las causas individuales en la granja y las medidas de prevención. Aunque se sabe mucho de las úlceras de hombro, concluimos que hay una falta significativa de datos en la literatura científica sobre los mecanismos de desarrollo y curación, dolor causado, y medios efectivos de tratamiento y prevención.

Résumé – Lésions aux épaules chez les truies: Revue des causes, de la prévention et du traitement

Les lésions sévères aux épaules chez les truies se manifestent comme des ulcères comparables aux ulcères de décubitus chez les humains. Chez les truies, les lésions aux épaules apparaissent sur la peau recouvrant la proéminence osseuse de l'omoplate, et sont le plus fréquemment observées durant la première semaine de lactation. Les ulcères de l'épaule surviennent suite à la compression prolongée des vaisseaux sanguins autour de la tubérosité de l'épine scapulaire lorsque la truie est couchée, entrainant une circulation sanguine insuffisante, de la nécrose, et une ulcération subséquente. Étant donné la nature des lésions aux épaules et leur fréquence estimée (5%-50% des truies reproductrices mondialement), elles représentent un souci évident relativement au bien-être. Il y a également un impact économique étant donné le temps passé pour traiter, la médication, et la réforme prématurée des truies. Bien que de multiples facteurs contribuent au développement des ulcères, le maintien de la condition corporelle optimale des truies semble être un facteur clé dans la prévention. Cette revue résume la littérature sur les ulcères de l'épaule chez les truies, incluant les causes, la prévention et le traitement. Une surveillance régulière des lésions est recommandée étant donné que ceci aidera à identifier les causes dans les élevages de manière individuelle et les mesures de prévention. Bien que plusieurs choses soient connues sur les ulcères de l'épaule, nous avons conclu qu'il y a des lacunes importantes dans la littérature scientifique en ce qui concerne les mécanismes de développement et la guérison, la douleur causée et des moyens efficaces de traitement et de prévention.

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Introduction

Several terms are used to describe skin sores in the shoulder region of sows. These include (but are not limited to) shoulder lesions, shoulder ulcers, decubital shoulder ulcers (stemming from the Latin word "decumbre" meaning to lie down),[1] shoulder sores, and abrasions. The terms "shoulder lesions" and "shoulder ulcers" are often used, erroneously, as synonyms. Jensen[2] rightfully pointed out that when considering skin sores in the shoulder region of sows, it is essential to differentiate between shoulder ulcerations and non-ulcerating shoulder lesions. Shoulder lesions can take any form, from mild with intact epithelium or simple abrasions, to severe. Shoulder ulcers are a more severe subset of shoulder lesions where there is necrosis of epidermis, loss of basement membrane, and effacement of superficial adnexal structures, manifested and commonly referred to as "open sores."[3] Decubital shoulder ulcers in sows are comparable with pressure ulcers in humans (bed sores).

In sows, shoulder ulcers often appear over the underlying bony prominences, in which the amount of soft tissue (eg, muscular and [or] adipose tissue) between the skin and bone is insufficient to distribute external pressure.[4] The reduced body condition of sows during lactation, combined with the prolonged recumbency during nursing, increases the incidence of shoulder ulcers.[5] However, the precise mechanism behind the development of shoulder lesions is not well understood. There remain several opinions as to how and why pressure leads to tissue breakdown.[6] It is thought that the ischemia (restriction of blood flow) results in insufficient blood circulation, causing necrosis and subsequent ulceration. Severity depends on the force and duration of the pressure, but is also influenced by the robustness of the skin.[4] Prospective and cross-sectional studies have determined that these wounds typically develop in the first week after farrowing.[7,8] It is estimated that the majority of shoulder lesions are present for at least 2 to 3 weeks and that some lesions will develop into ulcers during this period.[6] The severity of shoulder lesions can vary greatly, ranging from superficial lesions to deep subcutaneous ulcers.

For this review, the term "shoulder lesion" will be used to broadly refer to abnormal structure of skin, and "shoulder ulcer" will be used to specifically identify a wound with loss of overlying epithelium.

The occurrence of shoulder lesions as established by cross-sectional studies on-farm and in abattoirs reveals a large between-herd variation in lesion prevalence, from 4.6%[9] to 50%.[5] Where studies have taken repeated data from herds, a large range of within-herd prevalence has also been found (eg, Cleveland-Nielsen et al 2004[10]), which reflects sow management decisions. A summary of studies recording the prevalence of shoulder lesions is presented in Table 1. These studies cover a variety of housing types, genotypes, and stages of gestation, and include both ante- and post-mortem observations, which must be considered alongside results. Regardless, the large between-herd variation in prevalence highlights the influence of farm facilities and sow management on the development of lesions. Surveys may underestimate the prevalence of shoulder ulcers because sows with severe ulcers may be euthanized, and thus not recorded. On the other hand, survey summaries may overestimate the prevalence of shoulder ulcers because lesions (eg, abrasions) that are not ulcerated may be included in the definition. While this research suggests that shoulder lesions likely have an economic impact on pork production, there is currently no information on the overall cost of this problem, or the cost-benefit of treatment options.

The degree of pain caused by shoulder lesions is poorly understood, however human patients with pressure ulcers self-report pain.[19,20] On the basis of human literature, sows may also experience varying degrees of pain at different stages of severity.[21] Presently, no pain relief is typically given for the treatment of shoulder lesions or shoulder ulcers. Ulcers also provide a portal of entry for pathogens that may cause local or systemic infection.[4]

Materials and methods

The objective of this review was to collect and review the literature related to sow shoulder lesions from a range of sources, to explore the major causes leading to their development, treatment, and prevention, and to identify potential areas for future research. The information presented is excerpted from a comprehensive report that was funded by the National Pork Board. This review is targeted towards pork producers, veterinarians, researchers, and students.

The main databases used were AGRICOLA, CAB International, Scopus, and Science Direct. Because of the limited literature available, both peer-reviewed and non-peer-reviewed resources were evaluated for inclusion. The non-peer-reviewed information was largely published by industry or academics (eg, National Pork Board, British Pork Executive, or conference abstracts). They were still based on science, but did not go through the same rigorous process as a peer-reviewed journal article. Very old studies, > 30 years old, were unlikely to be relevant due to the changing nature of the swine industry (eg, heavier animals, larger litters). After the initial collection of material, the literature selection was refined to remove older studies. References from as early as the 1980s were included if they provided useful information that is relevant to present-day sow management.

Causes of shoulder lesions

Anatomy of the sow shoulder

The scapula or shoulder blade of the pig is a large, flat bone located over the rib cage with muscle attachment by *M infraspinatus, M supraspinatus*, and *M deltoidius*. From the cranial aspect (front), a ridge or spine is present on the side of the scapula that terminates dorsally in a large bump, known as the prominent tuber. When the sow lies laterally, the anatomy and location of the prominent tuber results in pressure being exerted on the overlying tissue, and predisposes this area to pressure ulcers.

Sow-related risk factors

Numerous pig-related risk factors have been identified as contributing to the development of shoulder lesions, including (but not limited to) body condition post farrowing,[14,22] parity,[18,23] health status (underlying disease),[18] lameness,[11,23] previous history of shoulder lesions,[24] weaning weight of the litter,[18] lactation length,[25] sow behavior (unrelieved pressure),[6] breed,[18] and genetics.[5,26] Studies have found that sows with a body condition score (BCS) < 3 at weaning,[17] or ≤ 2 during gestation,[18] have a three-fold greater likelihood of developing shoulder lesions than do those with BCS ≥ 3. A low BCS reduces the cushion of fat covering the tuber of the scapula,[17] increasing the likelihood of lesion development.

Anil et al[11] studied 162 sows from four US farms and reported that longer lactation periods presented a risk for increased likelihood of lesion development. Similarly, a

Table 1: Studies reporting on the prevalence of shoulder lesions in sows including study location and key findings or associations*

Authors	Year	Country	No. of sows in study	% of sows observed with lesions	Method: Post mortem/ante mortem	Findings/association with lesion prevalence
Anil et al[11]	2006	United States (USA)	162	33%, of which 19% bilateral lesions	On-farm (4 herds), before weaning	↑ Longer lactation length ↑BCS ≤ 2 ↑ Lameness ↔ Parity ↔ Farrowing performance
Bausted and Fredriksen[12]	2006	Norway	3048	10%	Post mortem (4 abattoirs)	↓ BCS ↑ Body size
Cleveland-Nielsen et al[10]	2004	Denmark	23,794	0% to 40% within herd prevalence	Post mortem (207 herds, sampled in 4 abattoirs)	Large within and between herd prevalence: indicates varying management and farm factors
Davies et al[7]	1996	USA	1916	8%, of which 4% bilateral	On-farm, (one herd)	↓ BCS
Davies et al[8]	1997	USA	147	16% to 48%	On-farm (prospective study)	↑Parity ↓ Scapular tuber depth significantly associated with ulcers and ulcer size
Deen[13]	2010	USA	157	33%	On-farm	↓ Increased backfat at 109 days gestation ↑ Cast iron slats ↓ Rubber mats ↔ Lameness ↔ Time in lateral recumbency
Havn and Poulsen[14]	2004	Denmark	429	14% to 37%	On-farm	↑ In farrowing area ↓BCS ↑ Parity
KilBride et al[15]	2009	United Kingdom	344	10%	On-farm (4 lactating sows from 86 herds)	↓ Outdoor housed sows ↑ Fully slatted floors ↓ > 20 cm between tail and back of crate
Knauer et al[16]	2007	USA	3146	18%	Post mortem	↓ BCS
Dahl-Pederson et al[17]	2013	Denmark	2733	5%	On-farm (37 herds)	↔ Condition of concrete floors in farrowing pen ↓ BCS
Ritter et al[9]	1999	USA	1751	5%	Post mortem	↓BCS
Zurbrigg[18]	2006	Canada	312	34%	On-farm	↓BCS ↑ Flank-to-flank at weaning, breed, parity, farrowing room section, weaning weight of litter

* Arrows denote the relationship between risk factor and development of shoulder lesions: ↑ = positive association; ↓ = negative association; ↔ = no relationship.

BCS = body condition score.

heavier litter weaning weight was identified as a significant risk factor[18] on one Canadian farm, and Ocepek et al[27] identified purebred maternal sow lines, and high-producing first-parity sows in particular, as being at greater risk. These studies link shoulder lesions to high maternal investment by the sow.[5] Ultimately, these factors can be mitigated by appropriate management of the sow during the lactation period. Therefore, competent management of high-producing sows during lactation, or lack thereof, may have the greatest impact on lesion development. Three conditions that create inappetence in the sow, namely, disease, injury, and climatic extremes,[18] create challenges to maintaining sow condition, especially during lactation. Furthermore, these factors can also influence sow activity and lying patterns, which may further increase the risk of lesion development. Hence, rapid identification of the cause of inappetence and prompt interventions to rectify are keys to reducing the risk of lesion development.

Sow behavior

Sow behavior can impact the occurrence of shoulder lesions. Factors within the environment influence the behavior of the sow, including the floor surface, the environmental temperature, and the health and comfort of the sow. However, individual sow characteristics also influence sow behavior. The duration of lateral recumbency has been identified as a major contributing cause of shoulder lesion development. Lateral recumbency is the predominant posture of post-parturient sows and is necessary for nursing piglets. Shoulder ulcers are also more common in diseased or lame sows,[7] which may be linked to increased lateral recumbency (as reported in sows in which lameness was induced).[1,25] A Danish study by Larsen et al[28] compared the behavior of 19 sows with shoulder ulcers and 19 sows without ulcers. They found that sows with shoulder ulcers spent less time lying and nursing, and more time standing still. Affected sows performed a greater amount of shoulder rubbing and tended to perform a greater number of postural changes than did sows with no ulcers,[28] which may indicate discomfort. There is little research on the relationship between sow behavior and development of shoulder lesions. However, research to identify relationships between sow lying postures and duration, movement in relation to shoulder ulcer development, and correlations with other sow and management factors, would provide a better understanding of the problem.

Heritability of shoulder lesions

Several researchers have estimated the heritability of shoulder lesions[5,26,29] or have observed breed differences in the prevalence of shoulder lesions.[18,27] Lundeheim et al[26] reported that shoulder ulcers are a heritable trait, specifically, the heritability was estimated at 0.13, which was based on a population of Swedish Yorkshire sows (including 4336 farrowings in 2634 sows). Hedebro Velander et al[29] reported a similar figure for heritability of shoulder ulcers ($h^2 = 0.18$) and also calculated the heritability of the size of ulcers ($h^2 = 0.09$) in Landrace × Yorkshire crossbred sows. Lundgren et al[5] estimated the heritability of shoulder ulcers and the genetic correlations between shoulder ulcers, mean piglet weight, and sow body condition. Data were extracted from the Norwegian litter recording scheme, and the genetic analysis included 5549 Norwegian Landrace sows (7614 lactations) in 45 herds. Their results estimated the heritability of shoulder ulcers to be 0.25. Lundgren et al[5] also found a genetic correlation between shoulder ulcers and mean piglet weight. The correlation was low but positive ($r^2 = 0.23$), indicating that the sow's ability to raise heavy piglets is associated with a higher risk of shoulder ulcers. The authors concluded that high-producing sows are at greater risk of developing shoulder lesions than are low-producing sows. This conclusion is supported by recent work by Ocepek and colleagues,[27] who compared productivity and prevalence of shoulder lesions in sows from purebred maternal (Norsvin Landrace) and crossbred (Norsvin Landrace and Swedish Yorkshire) lines. Shoulder lesions were most common in first-parity sows from purebred maternal lines ($P < .001$), and were associated with higher litter weights at birth ($P = .003$) and weaning ($P = .05$), and greater weight loss during lactation ($P = .016$). Zurbrigg[18] compared Duroc, Landrace, and Yorkshire sows in a commercial herd in Ontario, Canada, and found that Landrace and Duroc sows were 3 and 4.6 times (respectively) more likely to develop shoulder lesions than Yorkshire sows ($P < .05$).

It can be concluded the propensity for a sow to develop shoulder ulcers is heritable, at least in so far as greater prevalence can be found in specific lines. On this basis, it should be possible to reduce their prevalence using appropriate selection and breeding programs. However, the heritability of ulcers is likely to be linked to selection for other production traits, as indicated by the findings of Lundgren et al,[5] which may hinder the ability to reduce their prevalence through selection.

Environmental risk factors

Several environmental risk factors have been identified as contributing to the occurrence of shoulder lesions, including flooring type,[23,30] pen location,[18] temperature and humidity,[31,32] type of sow housing,[33] and friction properties of the floor.[34]

Environmental risk factors can be described at both individual sow and herd level. In farrowing pens (crates), flooring type has been associated with the risk of developing limb and body lesions.[30] Metal slatted flooring is a risk factor for having more sows with shoulder lesions when compared with those housed on solid concrete, because slatted floors support the sow's body weight over a smaller surface area.[17] KilBride et al[15] found there was an increased risk for body lesions when the lying surface was either damaged or soiled when compared to clean, dry, and (or) undamaged floors.

Farrowing crate floors should provide a comfortable surface for lying, sufficient space for comfortable nursing, a non-slip surface for rising and standing, and separation from excreta, and must be sufficiently robust for the sow's size and weight.[15] In the human medical literature it is believed that kinetic friction forces rubbing the skin, possibly in combination with increased skin moisture, contribute to the development of pressure ulcers.[34] Friction, along with other flooring properties, such as abrasiveness, hardness, surface profile, and thermal properties,[35] may all contribute to the development of shoulder lesions in sows and should be explored further.

The location of sows within a farrowing room can also contribute to the development of shoulder lesions because of variation in climatic conditions associated with room temperature fluctuation, location of ventilation units, and the use of drip coolers. No data are currently available regarding the direct effect of temperature on the prevalence of shoulder ulcers in sows.[4] Sow movement is likely reduced at higher temperatures, and could thus be a contributing factor in the development of shoulder ulcers. Citations from human medical literature often conclude that moisture, humidity, and temperature are likely to play a role in the development of bed sores.[34,36,37]

There is an increasing global trend to reduce close confinement management of sows. Many countries have placed a ban or partial ban on the use of gestation stalls, and alternate indoor farrowing systems are being explored, from farrowing pens to group lactation systems.35,38 The greater freedom of movement provided to sows in these systems may increase muscle tone and encourage more frequent postural changes, which may help to reduce the incidence of shoulder lesion development in sows. The use of bedding or alternative flooring types (ie, solid flooring, rubber-coated flooring) in these systems may also influence the development of shoulder lesions. Assumptions driving these changes in system design and their outcomes on sow welfare and longevity are worthy of investigation.

Interventions and treatment

The primary intervention for sows with shoulder ulcers is to move them into pens with softer flooring. Deep straw bedding provides the correct properties for improving comfort by providing wider distribution of pressure for lying sows. However, in many modern pig production facilities, the use of straw is not feasible because of incompatibility with liquid manure disposal systems.[39,40] In Denmark, a pathoanatomical scale from 0 to 4 is used to grade shoulder ulcers, where grade 0 is no lesion and grade 4 is a lesion (ulcer) involving all three layers of the skin and underlying bone. On Danish farms, sows with grade 3 or 4 lesions must be kept loose and have access to soft bedding.[40] Rubber mats can provide a means for increasing the comfort of flooring in unbedded systems.[41]

For established lesions, there is evidence that rubber mats can be beneficial. In the study by Zurbrigg, sows provided with a mat had shorter healing times (25 days) than did sows housed in a conventional farrowing crate (32 days to heal), or those provided with solid stainless steel plates under the shoulder region.[18]

Few commercially available products exist for the topical treatment of shoulder lesions. A study testing AluShield Aerosol Bandage (Neogen, Lexington, Kentucky), a food-animal labelled product specifically for the treatment of wounds, was found to be ineffective. There was no difference in the reduction of lesion size between control and treatment groups (reductions of 66% and 60% respectively), nor a difference in the change of lesion diameter or time to lesion healing between the control and treatment groups.[41,42]

A study by Kaiser et al[42] compared the effectiveness of a combination treatment of rubber mats and zinc ointment (25% zinc oxide) with a local antibiotic treatment (chlortetracycline spray) on healing of shoulder ulcers in three sow herds. Sows were paired according to the grade of their ulcer (Danish pathoanatomical scale: 0 to 4) on the first observation and were randomly divided into treatment groups: mats and zinc ointment (Apotekets Baby Zinksalve, Denmark), or antibiotic spray (Cyclo Spray Vet, Eurovet Animal Health B.V., Netherlands). The rubber mat plus zinc oxide treatment had a statistically significant effect, reducing the size of the ulcer on days 14 and 21 of treatment compared to antibiotic spray. For lean sows provided with rubber mats and zinc oxide, the average shoulder ulcer size on day 14 was 3.8 cm^2, versus 9.5 cm^2 when antibiotic spray was used. This treatment appeared to be equally effective in all three herds studied. Therefore, the authors recommended rubber mats as a means to reduce the number of sows that needed to be euthanized, culled, or weaned early due to this type of lesion, and suggested that rubber mats be used preventatively for sows at risk.[42]

As an alternative to providing a rubber mat, some Danish producers use a padded shoulder protector (eg, Maxi Pork, designed by Danish company Unitron Scandinavia A/S). The device consists of two layers of foam rubber coated with nylon netting, and straps which allow it to be fastened to the sow. This device is best for treating sows in the early stages of lesion development, before the ulcer has formed, and not for treating the open wound. Producers install the pads on sows as soon as they observe any redness of the skin on the shoulder.

In general, products used to treat decubital ulcers on sows are few and have not been well-evaluated.[42] Nevertheless, individual farms should implement procedures for identification, surveillance, and treatment of shoulder ulcers. Future research should focus more on preventative management of sows, as this is a far more effective approach. Traumatic neuromas found in healed ulcerations suggests that sows continue to experience discomfort after ulcer healing;[41] however, robust strategies to deal with shoulder ulcers must also be developed, as ulcers will persist until effective means of prevention can be implemented.

Prevention

Maintaining an optimum BCS is a critical factor in the prevention of shoulder lesions. Sows need sufficient backfat at farrowing (ideally BCS 3 on a 1 to 5 scale) to maintain sufficient levels throughout lactation. In a study investigating the effect of softer flooring in the farrowing crate on subsequent sow performance,[43] fifty-two of 140 sows developed shoulder ulcers (17 were from farrowing crates with rubber mat floors and 35 from farrowing crates without rubber mats). Analysis revealed that lower backfat thickness at day 109 of gestation was associated with increased likelihood of having shoulder ulcers at weaning. Backfat thickness is affected by a combination of sow genetics and diet. Maximizing feed intake during lactation may be hindered by a variety of factors, including hot temperatures in summer[11] or the onset of illness.[43] Regular, objective assessment of body condition can assist stockpersons to identify low BCS in individual sows and take appropriate action. New technologies for individual sow feeding during gestation and lactation, which provide feed on demand rather than all at once, may also help to optimize sow body condition. The cause of decreased feed intake needs to be identified promptly to avoid a reduction in body condition. Earlier management interventions to rectify problems will go a long way to preventing development of shoulder lesions and ulcers.

Regular monitoring of early signs of skin insults, such as redness, abrasion, or irritation, are paramount, since early detection and intervention are important and effective in prevention of sow suffering. Lesions may be as subtle as slight redness; the observation of flies on the shoulder crest can be an early indication of an incipient shoulder lesion.[42] If these early signs are observed, the floor surface should be checked for roughness. It would be appropriate to place a pad over the affected area of the sow's shoulder to relieve pressure, or to move the affected sow to a comfort pen with a softer lying surface, such as a rubber mat or deep bedding.[40] Lesions should be cleaned and treated with an antiseptic (according to veterinary advice and farm health protocols).

One reason that sows may be reluctant to stand or change position during lactation is locomotor problems. In evaluation of sow lesions at slaughter, Stalder and Karriker[44] reported that open shoulder lesions were significantly and positively associated with rear foot abscesses. This suggests sow-herd leg and foot health should be evaluated

in combination with the goal of reducing shoulder lesions. Uninterrupted lying bouts increase the risk of developing shoulder lesions;[23] therefore, the authors suggest that it may be beneficial to stimulate sow activity by making them stand or move about on a daily basis, particularly in the first weeks post farrowing.

Flooring is an important risk factor. The common use of fully slatted floors increases pressure due to the distribution of body weight over a smaller surface area.[9,45] The odds of a sow housed on a slatted floor developing shoulder ulcers during lactation was three times higher in sows not provided with rubber mats than in those with rubber mats extending to their hind limbs.[4,13] The use of alternative flooring in the farrowing pen may benefit the sow by reducing occurrences of a painful condition, while benefiting the producer by subsequent productivity improvement.[45] Regardless of treatment and prevention options, in severe cases sows should be culled or euthanized.

Future research

Numerous gaps exist in our knowledge of shoulder lesions and ulcers, providing a basis for future research, summarized as follows:

- Pathogenesis: Identify the mechanisms by which shoulder lesions and ulcers develop and heal. A better understanding of lesion pathogenesis will help towards identifying effective prevention measures.
- Feeding practices, nutrition, and body condition: Investigation of feed quality, feed delivery, and feeding management (eg, automated or on-demand lactation feeders) for lactating sows and the occurrence of shoulder lesions and ulcers.
- Housing and use of alternate flooring: Studies on alternative flooring for farrowing crates are warranted, with consideration for sow comfort and pressure-relieving properties, while maintaining drainage and cleaning properties. Rubber matting has shown promise, but further evaluation of the physical characteristics, durability, and effectiveness for lesion prevention is required.
- Lying behavior and time in recumbency: Identify whether changes in sow behavior (eg, lying posture and duration) are predictive of lesion development and can be used as risk indicators.
- Sow productivity: Identify the contribution of increasing litter size, milking ability, and duration of lactation on the development of shoulder lesions and related management strategies to reduce the risk of ulcer development.
- Cost and financial analysis: Quantify the economic cost of shoulder ulcers to the swine industry, considering prevalence, reductions in performance, treatment costs, and sow retention.
- Impact on animal welfare: Quantify the level of pain experienced by sows during the development, presence, and healing of shoulder lesions and ulcers. Identify appropriate wound treatment and pain mitigation strategies for shoulder ulcers. Identify the time when pain control provision is most beneficial and whether this influences recovery time or production outcomes.
- Environmental temperature and humidity: While higher temperatures are believed to influence occurrence of shoulder lesions, no data are available regarding the effects of temperature and possible interaction with humidity on the occurrence of shoulder ulcers.[3]

Perhaps just as important as these research topics is the need for greater on-farm monitoring of this condition. The old maxim, "you can only manage what you measure" surely applies to shoulder lesions and ulcers. Lesions can easily be recorded on-farm, either during lactation or as sows exit from farrowing. The increasing use of computerized and automated systems for data collection will make this a simpler task in the future, and can provide an important first step towards increasing recognition of the problem and identification of appropriate treatments.

Conclusions

Estimates of prevalence of shoulder lesions, including ulcers, are reported at 5% to 50% in breeding sows; however, the true incidence of shoulder lesions and (or) shoulder ulcers is not known. Lesions in sows are a painful condition, represent a welfare concern, and benefit from timely interventions. Treatment success of sow shoulder lesions is enhanced by early recognition and intervention.

Lesions typically develop in the weeks following farrowing, when sows spend the majority of their time lying and nursing. Other factors, such as low body condition score, hard or abrasive flooring, genetic predisposition, and a host of other environment and management factors increase sows' susceptibility to developing shoulder lesions.

Most of the literature on shoulder ulcers has been in surveys and is epidemiological in nature. The process of wound development and healing is poorly understood, hence research aimed to better understand the underlying causes, progression, effects of pain on productivity, and development of more effective treatment and preventative interventions is warranted.

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Conflict of interest

None reported.

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References

1. Kryczka T, Grieb P. Supportive treatment of pressure ulcers with dietary supplementation. *Clin Pharmacol Biopharm.* 2014;3.

2. Jensen HE. Investigation into the pathology of shoulder ulcerations in sows. *Vet Rec.* 2009;165:171–174.

3. Cheville NF. *Introduction to Veterinary Pathology*. 2nd ed. Ames, Iowa: Iowa State University Press; 1999.

4. Herskin MS, Bonde MK, Jørgensen E, Jensen KH. Decubital shoulder ulcers in sows: a review of classification, pain and welfare consequences. *Animal.* 2011;5:757–766.

5. Lundgren H, Zumbach B, Lundeheim N, Grandinson K, Vangen O, Olsen D, Rydhmer L. Heritability of shoulder ulcers and genetic correlations with mean piglet weight and sow body condition. *Animal.* 2012;6:1–8.

6. Rolansdotter E, Westin R, Algers B. Maximum lying bout duration affects the occurrence of shoulder lesions in sows. *Acta Vet Scand*. 2009;51:44.

7. Davies PR, Morrow WE, Miller DC, Deen J. Epidemiologic study of decubital ulcers in sows. *J Am Vet Med Assoc*. 1996;7:1058–1062.

8. Davies PR, Morrow WE, Rountree WG, Miller DC. Epidemiologic evaluation of decubital ulcers in farrowing sows. *J Am Vet Med Assoc*. 1997;210:1173–1178.

9. Ritter LA, Xue JL, Dial GD, Morrison RB, Marsh WE. Prevalence of lesions and body condition scores among female swine at slaughter. *J Am Vet Med Assoc.* 1999;214:525–528.

10. Cleveland-Nielsen A, Bækbo P, Ersbøll AK. Herd-related risk factors for decubital ulcers present at post-mortem meat-inspection of Danish sows. *Prev Vet Med*. 2004; 64:113–122.

*11. Anil SS, Anil L, Deen J. Factors associated with shoulder lesions in breeding sows. *Proc Allen D. Leman Swine Conference*. Minnesota; 2006.

*12. Bausted BM, Fredriksen B. Prevalence and prevention of decubital shoulder ulcers in Norwegian sows. *Proc IPVS.* Copenhagen, Denmark; 2006.

*13. Deen J. Effect of a softer floor surface in the farrowing crate on the expression of lameness and subsequent sow performance. *Pork Checkoff*. Final Report NPB#08-153. 2010.

*14.Havn KT, Poulsen HK. Risk factors for shoulder ulcers in sows in a danish breeding farm. *Proc IPVS.* Hamburg, Germany; 2004.

15. KilBride AM, Gillman CE, Green LE. A cross sectional study of the prevalence, risk factors and population attributable fractions for limb and body lesions in lactating sows on commercial farms in England. *BMC Vet Res.* 2009;5:30.

16. Knauer M, Stalder KJ, Karriker L, Baas TJ, Johnson C, Serenius T, Layman L, McKean JD. A descriptive survey of lesions from cull sows harvested at two Midwestern U.S. facilities. *Prev Vet Med.* 2007;82:198–212.

17. Dahl-Pedersen K, Bonde MK, Herskin MS, Jensen KH, Kaiser M, Jensen HE. Pathogenesis and pathology of shoulder ulcerations in sows with special reference to peripheral nerves and behavioural responses to palpitation. *Vet J.* 2013;198: 666–671.

18. Zurbrigg K. Sow shoulder lesions: Risk factors and treatment effects on an Ontario farm. *J Anim Sci.* 2006;84:2509–2514.

19. Gorecki C, Lamping DL, Brown JM, Madill A, Firth J, Nixon J. Development of a conceptual framework of health-related quality of life presure ulcers: A patient-focused approach. *Int J Nurs Stud*. 2010;47:1525–1534.

20. Rutherford KMD. Assessing pain in animals. *Anim Welf.* 2002;1:31–53.

21. Herskin MS, Bonde MK, Jørgensen E, Jensen KH. Decubital shoulder ulcers in sows: a review of classification, pain and welfare consequences. *Animal.* 2011;5:757–766.

22. Bonde M, Rousing T, Badsberg JH, Sørensen JT. Associations between lying-down behavior problems and body condition, limb disorders and skin lesions of lactating sows housed in farrowing crates in commercial sow herds. *Livest Prod Sci.* 2004; 87:179–187.

*23. Rosendal T, Nielsen JP. Risk factors for the development of decubital ulcers over the scapula in sows. *Proc IPVS.* Hamburg, Germany; 2004.

*24. Thorup F. Backfat at farrowing affects the frequency of shoulder lesions. *Proc IPVS.* Copenhagen, Denmark. 2006;486.

25. Pairis-Garcia MD, Johnson AK, Stalder, KJ, Abell CA, Karriker LA, Coetzee JF, Millman ST. Behavioral evaluation of analgesic efficacy for pain mitigation in lame sows. *Anim Welf.* 2015;24:93–99.

26. Lundeheim N, Lundgren H, Rydhmer L. Shoulder ulcers in sows are genetically correlated to leanness of young pigs and to litter weight. *Acta Agric Scand, Sect A - Anim Sci.* 2014;64:67-72.

27. Ocepek M, Andersen-Ranberg I, Edwards SA, Fredriksen B, Framstad T, Andersen IL. Can a super sow be a robust sow? Consequences of litter investment in purebred and crossbred sows of different parities. *J Anim Sci.* 2016;94:3550–3560.

28. Larsen T, Kaiser M, Herskin MS. Does the presence of shoulder ulcers affect the behaviour of sows? *Res Vet Sci.* 2015;98:19–24.

*29. Hedebro Velander I, Nielsen B, Henryon MA. Genetic variation in shoulder ulcers in crossbred sows exists. *Proc European Federation of Animal Science.* Stavanger, Norway; 2011.

*30. Mattson B, Ivarsson E, Holmgren N, Lundeheim N. Shoulder ulcers in sows: causes of variation. *Proc European Federation of Animal Science*. Barcelona, Spain; 2009.

*31. Holmgren N, Lundeheim, N. Shoulder lesions in loose-housed lactating sows on partly slatted floors. *Proc IPVS.* Vancouver, Canada; 2010.

32. Kokate JY, Leland KJ, Held AM, Hansen GL, Kveen GL, Johnson BA, Wilke MS, Sparrow EM, Iaizzo PA. Temperature-modulated pressure ulcers: A porcine model. *Arch of Phys Med Rehabil.* 1995;76:666–673.

*33. Reese D, Straw W, Waddel JM. Shoulder ulcers in sows. *Nebraska Swine Reports* 2005;9:6–9.

34. Lahmann NA, Kottner J. Relation between pressure, friction and pressure ulcer categories: A secondary data analysis of hospital patients using CHAID methods. *Int J Nurs Stud*. 2011;48:1487–1494.

35. Ison SH, Wood CM, Baxter EM. Behaviour of pre-pubertal gilts and its relationship to farrowing behaviour in conventional farrowing crates and loose-housed pens. *Appl Anim Behav Sci.* 2015;170:26–33.

36. Leigh IH, Bennett G. Pressure ulcers: Prevalence, etiology, and treatment modalities: A review. *Am J Vet Surg.* 1994;167:S25–S30.

37. Parish LC, Witkowski JA. Controversies about the decubital ulcer. *Dermatol Clin.* 2004;22:87–91.

38. van Nieuwamerongen SE, Soede NM, van der Peet-Schwering CM, Kemp B, Bolhuis JE. Development of piglets raised in a new multi-litter housing system vs. conventional single-litter housing until 9 weeks of age. *J Anim Sci.* 2015;93:5442–5454.

39. Calderon Diaz JA , Boyle LA. Effect of rubber slat mats on the behaviour and welfare of group housed pregnant sows. *Appl Anim Behav Sci.* 2014;151:13–23.

40. Jensen HE. Grading of shoulder ulceration in sows by biopsies. *J Vet Diagn Invest.* 2014;26:291–296.

*41. Hazel A, Wayne S, Morrison R. Evaluation of a shoulder decubital ulcers treatment method in sows. *Proc AASV.* Dallas, Texas; 2014.

42. Kaiser M, Kristensen CS, Bækbo P, Alban L. Treatment of shoulder ulcers in sows - rubber mats and zinc ointment compared to chlortetracycline spray. *Acta Vet Scand.* 2013;55:12–20.

43. Cornou C, Vinther J, Kristensen AR. Automatic detection of oestrus and health disorders using data from electronic sow feeders. *Livest Sci.* 2008;118:262–271.

*44. Stalder K, Karriker L. Evaluation of sows at harvest to determine the incidence of abnormalities that could lead to culling of breeding herd females. Pork Checkoff NPB#04-127. 2006.

45. Tuyttens FAM, Wouters F, Struelens E, Sonck B, Duchateau L. Synthetic lying mats may improve lying comfort of gestating sows. *Appl Anim Behav Sci*. 2008;114:76-85.

* Non-refereed references.