Retrospective study of lameness cases in growing pigs associated with joint and leg submissions to a veterinary diagnostic laboratory

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Abstract
Objective: The objective of this study was to categorize and quantify the most common causes of joint- or leg-associated lameness by summarizing available information from cases presented to the Iowa State University Veterinary Diagnostic Laboratory (ISU VDL) between 2010 and 2015.

Materials and methods: All cases of lameness or locomotor dysfunction in 7- to 40-week-old pigs submitted to the ISU VDL between May 1, 2010 and April 30, 2015 were retrieved. After removing cases that did not meet the inclusion criteria, the remaining cases were individually reviewed and assigned a primary and secondary diagnosis.

Results: Of the 1847 cases retrieved, 464 met the inclusion criteria. The 4 most common primary diagnosis categories were *Mycoplasma hyosynoviae* (93 cases; 20%), metabolic bone disease (86 cases; 18.5%), infectious arthritis due to non-*Mycoplasma* bacterial infection (81 cases; 17.5%), and lameness with inconclusive findings (101 cases; 21.8%). There were 23.3% of the cases (108 of 464 cases) that had a secondary diagnosis with metabolic bone disease (28.7%; 31 of 108 cases) identified as the most common secondary diagnosis.

Implications: This study reinforces the importance of careful clinical examination, proper sampling, and confirming causes with appropriate diagnostic testing for accurate diagnosis of lameness.

Keywords
swine, *Mycoplasma hyosynoviae*, lameness, arthritis, case series

Disciplines
Large or Food Animal and Equine Medicine | Veterinary Preventive Medicine, Epidemiology, and Public Health

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Summary

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Keywords: swine, Mycoplasma hyosynoviae, lameness, arthritis, case series

Accepted: November 6, 2018

Resumen – Estudio retrospectivo de casos de cojera en cerdos de crecimiento asociados con el envío de articulaciones y piernas a un laboratorio de diagnóstico

Objetivo: El objetivo de este estudio fue categorizar y cuantificar las causas más comunes de cojera asociada con la articulación o la pierna resumiendo la información disponible de los casos enviados al Laboratorio de Diagnóstico Veterinario de la Universidad del Estado de Iowa (ISU VDL por sus siglas en inglés) entre 2010 y 2015.

Materiales y métodos: Se recuperaron todos los casos de cojera o disfunción locomotora en cerdos de 7 a 40 semanas de edad enviados al ISU VDL entre el 1 de mayo de 2010 y el 30 de abril de 2015. Después de eliminar los casos que no cumplieran con los criterios de inclusión, los casos restantes se revisaron individualmente y se les asignó un diagnóstico primario y uno secundario.

Resultados: De los 1847 casos recuperados, 464 cumplieron con los criterios de inclusión. Las 4 categorías de diagnóstico primario más comunes fueron Mycoplasma hyosynoviae (93 casos; 20%), enfermedad metabólica ósea (28.7%; 31 de 108 casos), artritis infecciosa debida a infección bacteriana no relacionada con Mycoplasma (81 casos; 17.5%) y cojera sin hallazgos concluyentes (101 casos; 21.8%). Un 23.3% de casos (108 de 464 casos) tuvieron un diagnóstico secundario relacionado con enfermedad metabólica ósea (28.7%; 31 de 108 casos), identificado como el diagnóstico secundario más frecuente.

Implicaciones: Este estudio refuerza la importancia de un examen clínico cuidadoso, un muestreo adecuado y la confirmación de las causas con pruebas de diagnóstico apropiadas para un diagnóstico preciso de la cojera.

Résumé – Étude rétrospective des cas de boiterie chez des porcs en croissance associée à la soumission d’articulations et de pattes à un laboratoire de diagnostic vétérinaire

Objectif: L’objectif de la présente étude était de catégoriser et quantifier les causes les plus fréquentes de boiteries associées aux articulations ou aux pattes en résumant les informations disponibles des cas présentés au Iowa State University Veterinary Diagnostic Laboratory (ISU VDL) entre 2010 et 2015.

Materials and methods

Laboratory diagnostic submissions from the ISU VDL were used for this study, so no Institutional Animal Care and Use Committee approval was needed. All cases of lameness or locomotor dysfunction submitted to the ISU VDL between May 1, 2010 and April 30, 2015 were retrieved for review using the ISU VDL laboratory information management system (LIMS). Each individual laboratory accession was considered a single case irrespective of number of samples submitted. Inclusion criteria were selected with the aid of VDL diagnosticians and information technology specialists. All cases were individually reviewed to ensure each met the inclusion criteria: species (porcine), age or weight (7-40 weeks or >16 kg), case type (field case), histopathology performed, and at least one diagnostic code assigned by a diagnostic pathologist. The 23 diagnostic codes and diagnostic assays that were used to search the LIMS for lameness cases are presented in Table 1. If the age or weight was not present in the data output from LIMS, the case remained in the database and the original submission sheet was reviewed for any information that referenced age or weight. If no age or weight data was included on the submission sheet, the case was removed. Cases must have included joint tissue for histology to be included in this study. Cases involving serum, oral fluids, or swabs only were excluded.

For each qualifying accession, the submission form and laboratory report were reviewed and relevant information extracted into a spreadsheet. Information extracted from the LIMS included accession number, submission date, pig age, diagnostic code, diagnostician, histopathology observations, and all tests performed with results. The clinic and bill party information were used to remove those cases that were not diagnostic investigations of field cases, such as research and teaching accounts. Client name, submitting veterinarian, and premises identification were not extracted from the database to maintain confidentiality and anonymity.

To confirm that all qualifying cases did involve lameness or locomotion dysfunction, additional information from the submission sheet and final report was entered into the spreadsheet manually. The history, submission notes, and the final diagnosis and comments from the diagnostician on the final report were entered and evaluated. Specifically, the case had to include terms involving lameness or locomotion in the history and the completed diagnostic testing had to be relevant to locomotion dysfunction, lameness, or joint disease. For example, a case may have Mycoplasma hyorhinis (MHR) septicemia as a diagnostic code, but if the history did not report any information related to lameness and legs or joints were not submitted with the case, then the case was excluded.

Assigning primary and secondary diagnosis

After confirming that all cases remaining in the database involved locomotion dysfunction and met the inclusion criteria, the cases were individually reviewed and assigned a primary diagnosis and, when diagnostic criteria for more than one category was present, a secondary diagnosis. Specific criteria were created for each diagnosis and applied uniformly to the cases (Table 2). Unless designated as “if available” in Table 2, all criteria listed for a given category must have been satisfied for the diagnosis to be assigned to a case. Criteria for each diagnosis were determined by peer-reviewed literature and consultation with an

Joint- and leg-associated lameness in growing pigs is a common diagnostic and therapeutic challenge for swine veterinarians. A diagnostic investigation usually starts when the caretaker identifies lameness in a group of pigs and notifies a veterinarian. The veterinarian will perform an assessment, which may involve submission of samples to a veterinary diagnostic laboratory (VDL). In recent years, there has been a great interest in Mycoplasma hyorhinis (MHS) septicemia as a diagnostic code, but if the history did not report any information related to lameness and legs or joints were not submitted with the case, then the case was excluded.

Inconclusive diagnostic testing increases uncertainty of diagnosis and decreases confidence in specific recommendations for therapy. Sample submissions that do not generate actionable information or support a specific etiology for the lameness are reported by practitioners, but the frequency of these cases from VDL submission databases has not been quantified and reported in the peer-reviewed literature.

Increasing regulation and oversight of antimicrobial use in swine reinforces the value of an accurate diagnosis to support treatment decisions and prudent antimicrobial use. While diagnostic laboratory data is not equivalent to field prevalence, it is helpful for swine practitioners to be aware of the spectrum and relative frequency of lameness causes as reported by a Midwestern VDL. Insight into capabilities and expectations of laboratory testing can assist veterinarians in proper sampling, test selection, interpretation of results, and provide insights into the relative importance of specific lameness etiologies for future research priorities. Specifically, insights from a study of submission trends and diagnostic approaches for cases of acute MHS synovitis may inform improvements in sampling and testing for this common etiology of growing pig lameness. Beyond general recommendations in swine texts, there is limited published information on submission practices for joint-associated lameness cases.

The primary objective of this study was to categorize and quantify the most common causes of joint- or leg-associated lameness by summarizing available information from cases presented to the Iowa State University (ISU) VDL between 2010 and 2015. The second objective of this study was to summarize submission trends and features of those cases with an MHS diagnosis.
Description of submission characteristics for *Mycoplasma hyosynoviae* cases

Cases that were assigned MHS as the primary diagnosis were then further reviewed to summarize case attributes related to submission habits. Specifically, the following data were collected and summarized: submission year, inclusion of a history on submission sheet (yes or no), inclusion of differential diagnosis in history (yes or no), number of differential diagnoses included in history, type and number of specimens submitted, number of MHS polymerase chain reaction (PCR) assays performed per case, number of animals from which the submitted specimens were procured, number of diagnostic tests requested, types of diagnostic tests requested, results from non-MHS related tests performed, and secondary diagnosis.

Results

Primary and secondary diagnosis for all lameness cases

The results of each step of the case database creation process are presented in Figure 1. The primary and secondary diagnosis associated with each of the 464 lameness cases is summarized in Table 3. The four most common primary diagnoses were almost equally represented: MHS (93 cases; 20%), metabolic bone disease (86 cases; 18.5%), infectious arthritis due to non-*Mycoplasma* bacterial infection (81 cases; 17.5%), and lameness with inconclusive findings (101 cases; 21.8%). Of the 23.3% of cases that had a secondary diagnosis (108 of 464 cases), metabolic bone disease was identified as the most common (28.7%; 31 of 108 cases).

Summary of submission characteristics for *Mycoplasma hyosynoviae* cases

The number of MHS diagnosed cases per full calendar year ranged from 7 cases in 2011 to 34 cases in 2013. A review of case characteristics revealed that the mean age of pigs diagnosed with MHS was 18.3 weeks (range, 10-32 weeks). A mean of 2.4 MHS PCR assays were conducted per MHS case (range, 1-26 assays). The cycle threshold values for MHS PCR ranged from 20.3 to > 44. Cycle threshold values > 44 were considered negative for MHS at the ISU VDL. For cases requesting 3 or more MHS PCR tests (n = 29), the mean percentage of MHS-positive PCRs was 54.7%.

Seventy-one percent (66 of 93) of cases listed differential diagnoses with their submission form and of these, 80.3% (53 of 66 cases) listed multiple possible differential diagnoses. Nine cases (9.7%) listed MHS as the sole differential. Of the 53 cases that listed more than one differential, the most common differentials were MHS (71.7%; 31 of 44 cases), septic arthritis (41.5%; 22 cases), and lameness with inconclusive findings (35.8%; 19 cases). Metabolic bone disease, osteochondrosis (OCD), and trauma were listed 19 (35.8%) times cumulatively.

The majority (68.8%; 64 of 93) of submitting veterinarians selected diagnostic testing to be at the discretion of the VDL diagnostician, while 15.1% (14 of 93 veterinarians)
### Table 2: Diagnostic criteria for each diagnostic category applied to cases associated with joint or leg lameness

<table>
<thead>
<tr>
<th>Diagnostic category</th>
<th>Criteria for diagnostic category inclusion</th>
</tr>
</thead>
</table>
| **Lameness with inconclusive findings (abnormal diagnostic testing results with inconclusive findings)** | Lameness reported by practitioner or diagnostician  
Histology of joint revealed mild non-specific changes to the synovial tissue  
Additional testing not performed, or results of additional testing were inconclusive or not significant  
Description of inconclusive or nonspecific joint changes included in final report by pathologist [*if available*] |
| MHS | Specimens submitted from animals with clinical lameness, joint swelling, or both  
At least one positive MHS PCR result on joint fluid or joint tissue  
Histology lesions consistent with MHS as per diagnostician comments in histology report or published histology findings associated with experimental and field MHS cases¹,³,⁴ |
| Metabolic bone disease | Abnormal results on any calcium, phosphorus, bone histopathology, vitamin D assay, or bone ash/density tests. Not all assays listed had to be performed to be included in the metabolic bone disease category  
Diagnostician comments that abnormality is contributing to locomotion issues |
| Infectious arthritis (bacterial, non-*Mycoplasma* species) | Histology on synovium indicative of infectious (non-*Mycoplasma*) process  
Significant findings on culture †  
Gross description of fluid indicative of infection, ie, purulent, serosanguinous [*if available*]  
Positive PCR results on molecular testing for *Erysipelothrix* species or *Haemophilus parasuis* from joint specimens [*if available*] |
| Lameness: no abnormal findings | Lameness reported by practitioner or diagnostician  
Culture with no significant findings †  
MHS PCR negative  
Histology of joint revealed no changes to synovial tissue |
| Osteochondrosis | Gross or histologically observed cartilage defects in articular cartilage |
| MHR | MHR PCR positive or MHR culture positive on joint fluid or joint tissue  
Histological changes to the synovium consistent with MHR  
Systemic gross and histological lesions from other tissues submitted indicative of systemic MHR cases [*if available*]  
Serosanguinous synovial fluid or fibrin in synovial fluid [*if available*] |
| Trauma | Fractures unrelated to abnormal bone histology indicative of metabolic bone disease  
OR  
Bursitis related to physical contact with slats, as associated in diagnostician comments |
| Osteomyelitis | Bacterial infection of the bone as per gross or histological assessment of the bone  
Significant findings on culture [*if available*] |

* Indicates that for some cases, this information or specimen may not be available or that relevant tests for this diagnostic category may not have been performed.  
† Significant findings refer to growth of a bacterial species associated with arthritis as per the bacteriologist or published literature.  
MHS = *Mycoplasma hyosynoviae*; PCR = polymerase chain reaction; MHR = *Mycoplasma hyorhinis*. 
was aerobic culture and the mean number of pathogens other than *Mycoplasma* species was requested for secondary diagnosis. 26.7% (8 of 30 cases) being the most common specific diagnosis.

This does not include *Erysipelothrix* cultures. Erysipelas was commonly listed as a differential (35.8%; 19 of 53 cases) but none of the cases listed skin lesions as part of the history or gross lesion findings. Almost half (45 cases) of the 93 MHS cases had at least one *Erysipelothrix* culture or PCR performed, with a mean of 2.5 *Erysipelothrix* assays per case. Of these 45 cases, however, only 1 (2.2%) returned a positive result.

**Discussion**

This study summarizes the most frequently observed lameness diagnostic categories for case submissions involving joints and legs at the ISU VDL between 2010 and 2015. A similar study reported the frequency of diagnosis of arthritis, specifically MHS and MHR cases, between 2003 and 2010 at the ISU VDL. There were 431 clinical cases with infectious arthritis during that time period and MHS represented 17% of the arthritis cases. There were more MHR cases identified in that study than reported here, but that study included pigs < 7 weeks of age. Findings from the current study are also consistent with another summary of arthritis cases from 2003 to 2014 at the ISU VDL. This study found that 25% of the cases were idiopathic, 20% were MHS, 24% bacterial and 12% were MHR based on the diagnostic code alone. These results reinforce that many diagnostic investigations do not reveal a clear etiology of the lameness as a consequence of diagnostic testing alone.

Although these two studies are similar in topic to the current study, there are key distinctions between these papers and this retrospective review. For example, one study was a diagnostic note on cases between 2003 and 2010 and focused on recommendations for diagnosing *Mycoplasma*-associated arthritis. Since that timeframe there has been development of additional PCR tests for *Mycoplasma* species associated with arthritis available at ISU VDL and lameness in growing pigs, particularly MHS, has become an emerging issue within the swine industry. Thus, an updated retrospective review is warranted. Another publication on lameness submissions to ISU VDL reflected a more current timeframe but is a conference proceeding and not available publicly. Both of these articles do not provide information about how the relevant diagnostic lab data was procured from the lab information management system, include information about inclusion/exclusion criteria, or require histology as part of the case. These comparable studies provide pilot information about the number of lameness cases and the types of primary diagnosis found but do not apply a systematic diagnostic criterion consistently across cases. This study focused on cases for which sufficient testing (histology, for example) was performed to diagnose MHS and then described characteristics of that subset of submissions.

Studies aiming to summarize lameness etiologies have been performed in the context of field cases. One Danish study looked at the microbiological causes of lameness in pigs at slaughter in Denmark. *Erysipelothrix rhusiopathiae* and MHS each comprised about 10% of the cases, while 70% of joints

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**Figure 1:** Summary of case selection process from a retrospective survey of lameness cases from the Iowa State University Veterinary Diagnostic Laboratory between May 2010 and April 2015

<table>
<thead>
<tr>
<th>Description</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cases returned from database from initial search</td>
<td>1847</td>
</tr>
<tr>
<td>Number of cases meeting inclusion criteria related to age/weight of pigs, date, case type, and relevant diagnostic tests performed</td>
<td>1019</td>
</tr>
<tr>
<td>Number of cases involving locomotion dysfunction in growing pigs</td>
<td>464</td>
</tr>
<tr>
<td>Number of cases with <em>Mycoplasma hyosynoviae</em> as the main diagnosis</td>
<td>93</td>
</tr>
</tbody>
</table>
were sterile. Gross changes to the joints were observed with E rhusiopathiae and MHS associated arthritis but gross pathological changes in the sterile joints were non-specific. In another Danish slaughter pig study, MHS was isolated from 60% of the pigs with arthritis in three of the five herds. Claw lesions (22%) and severe OCD (10%) made up the second and third most common diagnosis across all herds.

This study supports that MHS is an important contributor to arthritis, but there are several other important known and unknown etiologies associated with lameness. In this study, four diagnostic categories (lameness with inconclusive findings, MHS, metabolic bone disease, and non-Mycoplasma bacterial infection) accounted for 77.8% of the cases and 23.3% of these cases had at least one other lameness-associated abnormality. This reinforces that lameness is often multifactorial, and that many swine lameness pathological processes may be cumulative contributing to the difficulty in assigning a single etiology causation. Additionally, the retrospective case review process involves subjective steps completed by the submitting veterinarian, laboratory technician, diagnostician, and case reviewer. For example, a diagnostician may interpret histopathologic findings differently depending on their experience, current or popular health priorities within the industry, areas of expertise, and information provided about the case by the submitting veterinarian.

This retrospective study generated information that can support clinicians when diagnosing lameness in the field and when submitting lameness cases to a VDL. For example, this study quantifies the number of investigations that did not reveal a clear diagnosis (lameness with inconclusive findings) which is important for veterinarians to understand when developing a diagnostic plan for lameness and when communicating that plan to producers. This study also did not include sows, boars, gilts, sucking, or nursery pigs; all of which contend with diverse lameness challenges. Additionally, the retrospective case review process involves subjective steps completed by the veterinarian, laboratory technician, diagnostician, and case reviewer. For example, a diagnostician may interpret histopathologic findings differently depending on their experience, current or popular health priorities within the industry, areas of expertise, and information provided about the case by the submitting veterinarian.

This retrospective study generated information that can support clinicians when diagnosing lameness in the field and when submitting lameness cases to a VDL. For example, this study quantifies the number of investigations that did not reveal a clear diagnosis (lameness with inconclusive findings) which is important for veterinarians to understand when developing a diagnostic plan for lameness and when communicating that plan to producers. This study also highlights that diverse etiologies contributed to the cause of lameness in the majority of cases. The role of infectious agents, such as MHS, have been heavily emphasized.

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Primary diagnosis</th>
<th>Secondary diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lameness with inconclusive findings</td>
<td>101 (21.8%)</td>
<td>27 (25.0%)</td>
</tr>
<tr>
<td>Mycoplasma hyosynoviae</td>
<td>93 (20.0%)</td>
<td>1 (0.9%)</td>
</tr>
<tr>
<td>Metabolic bone disease</td>
<td>86 (18.5%)</td>
<td>31 (28.7%)</td>
</tr>
<tr>
<td>Infectious (bacterial)</td>
<td>81 (17.5%)</td>
<td>18 (16.7%)</td>
</tr>
<tr>
<td>Lameness: no abnormal findings</td>
<td>43 (9.3%)</td>
<td>0 (0.0%)</td>
</tr>
<tr>
<td>Osteochondrosis</td>
<td>29 (6.3%)</td>
<td>18 (16.7%)</td>
</tr>
<tr>
<td>Mycoplasma hyorhinis</td>
<td>19 (4.1%)</td>
<td>4 (3.7%)</td>
</tr>
<tr>
<td>Trauma</td>
<td>10 (2.1%)</td>
<td>8 (7.4%)</td>
</tr>
<tr>
<td>Osteomyelitis</td>
<td>2 (0.4%)</td>
<td>1 (0.9%)</td>
</tr>
<tr>
<td>Total</td>
<td>464 (100%)</td>
<td>108 (100%)</td>
</tr>
</tbody>
</table>
in contributing to lameness, however this retrospective study suggests that for cases submitted to the laboratory, MHS was not found in a majority of cases. In terms of summarizing submission information for lameness cases, this study provides information on diagnostic submission habits that was previously not available. This information can serve as useful talking points when completing lameness submissions with a producer and outlines potential expectations for lameness diagnostic plans.

Implications
- In this study, the four diagnostic categories of lameness with inconclusive findings, MHS, metabolic bone disease, and bacterial infection comprised 77.8% of the cases.
- Examination of the submission sheet and diagnostic results for the MHS cases revealed varied approaches to MHS diagnosis with respect to the amount of information provided to the lab, number of tests requested, and number of specimens submitted for diagnostics.
- This study reinforces the importance of careful clinical examination, proper sampling, and confirming causes with appropriate diagnostic testing for accurate diagnosis of lameness.

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Conflict of Interest
None reported.

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References
* Non-refered references.