**Approaches to endocrinopathic laminitis in the field: Results of a survey of veterinary practitioners in North America**

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**Abstract**

 Endocrinopathic laminitis is the most common cause of laminitis in the field. Insulin has recently been implicated as a key factor in development of endocrinopathic laminitis; however, it is unclear whether diagnostic and treatment approaches reflect insights derived from recent research. This study sought to evaluate North American veterinary practitioners’ approach to endocrinopathic laminitis in the field. Demographic information, approach to diagnosis, management, and prognosis of endocrinopathic laminitis, as well as factors influencing changes in approach to laminitis were collected. To compare regional differences in approach to laminitis, results were compared to a recently published study from the United Kingdom. Findings of the present study suggest that North American practitioners have changed their approach to laminitis to more readily incorporate diagnostic testing for endocrine disease.

**Keywords**

Insulin; Pituitary pars intermedia dysfunction; Adrenocorticotropin; Equine metabolic syndrome; Evidence-based veterinary medicine

1. **Introduction**

Laminitis is a painful, often debilitating condition affecting the distal phalanx of the equine foot. Systemic inflammation, increased weight bearing in a limb, or endocrinopathy may all cause laminitis. To date, most laminitis research has been focused on uncovering the pathologies leading to inflammatory laminitis, although it is now recognized that endocrinopathic laminitis is the most common cause of laminitis in the field [1, 2].

Endocrinopathic laminitis encompasses laminitis associated with pituitary pars intermedia dysfunction (PPID), equine metabolic syndrome (EMS) or insulin-dysregulation (ID), and exogenous administration of steroids [3]. Insulin appears to play a central role in the development of laminitis, regardless of the underlying endocrine disorder [1]. In a field study, pasture-associated laminitis in ponies was positively associated with plasma insulin concentrations [4]. In a subsequent landmark study, Asplin et al [5] demonstrated that hyperinsulinemia can induce laminitis in ponies. Similar findings were also documented in horses [6]. In one study of horses with PPID, only those horses with laminitis had hyperinsulinemia, while those without laminitis had normal serum insulin concentrations [7]. Furthermore, laminitis severity correlated with serum insulin concentrations in horses with PPID [8]. Horses and ponies with concurrent endocrinopathies (i.e., both EMS and PPID) have more marked hyperinsulinemia than those with a single endocrinopathy [9]. Finally, hyperinsulinemia and previous episodes of laminitis were risk factors for recurrence [10]. Taken together, these findings support the importance of diagnosing and treating insulin dysregulation in resolving laminitis and preventing future episodes.

 Incorporation of research findings into practice is a cornerstone of evidence-based veterinary medicine (EBVM) [11]. Much of the research surrounding endocrinopathic laminitis has been published in the last 15 years; thus, this is an area of clinical practice with a relatively new expansion of knowledge regarding diagnosis and treatment. Generating survey data from practitioners is key to developing understanding of how this research is being translated into equine clinical practice. The objectives of this study were to 1) evaluate how practitioners in North America were integrating testing and treatment for endocrinopathies into their approach to laminitis 2) identify which factors influenced any changes over time in approach to laminitis, and 3) assess the impact of diagnosis of endocrinopathy on management and case outcome. Finally, comparisons were made between practitioners in North America and the United Kingdom [12], to evaluate regional differences in approach to endocrinopathic laminitis.

**2. Materials and Methods:**

The study was exempted from full ethical review by Louisiana State University’s Institutional Review Board (IRB#E12236).

*2.1 Questionnaire Design*

The self-administered online questionnaire was designed using Kwiksurveys ([www.kwiksurveys.com](http://www.kwiksurveys.com)). Participants were asked to provide informed consent at the start of the survey, with the survey designed to prevent submission of any responses without respondents having ticked the box consenting to use of the data they provided for scientific research and publication. Following a short introduction section which included the aim and inclusion criteria of the study, the survey asked four questions about the participant (year of graduation; whether they graduated with their veterinary degree in North America, a European country or country in another region; type of work undertaken in current role; and country in which their current role was based) and 14 questions regarding their approach to laminitis in cases presenting with a clinical suspicion of laminitis but no signs of systemic illness (including fever), and perceptions regarding case management and outcome in endocrinopathic laminitis. Most questions were closed ended. Some questions had an “other” option. When “other” was selected, veterinarians were asked to provide additional description. To gather explanations on how respondents’ diagnostic approach to laminitis had changed since graduation, an open text format question was used.

*2.2 Survey Administration*

The study population included veterinary practitioners within North America with a scope of practice that included equids. A link to the survey was distributed via the American Association of Equine Practitioners “Spur of the Moment” newsletter three times between April and June (April 13, May 11, June 22, 2020). It was posted on social media sites (Facebook and Twitter), including LSU SVM’s social media pages, between May and July. The survey was also emailed to LSU SVM alumni two times during the same period.

*2.3 Data Analysis*

Statistical analyses were performed using commercially available statistical software (SPSS version 25). Open-ended question responses were categorized for analysis. Data were reported as medians with interquartile ranges (IQR) for continuous data and proportions for categorical data. Pearson Chi-square or Fisher’s exact tests were used to evaluate associations between categorical variables. Differences in number of years since graduation and change in diagnostic approach to laminitis cases since graduation (binary; yes or no) was compared using a Mann Whitney U test. To assess potential regional differences in approaches to laminitis, responses were also compared between North American respondents and United Kingdom respondents [12] using a Mann Whitney U test, Pearson Chi-square or Fisher’s exact test, as indicated. Results were considered significant at p<0.05.

**3. Results**

*3.1 Study population*

Responses were submitted online between April 13-July 13, 2020, and 234 questionnaires were returned. Of these, 20 partially completed questionnaires (where respondents completed only the section about veterinary training and current role, but no response to any questions about diagnostic approach to laminitis) were excluded from analysis. There was no difference between included and excluded survey responses in years since graduation (p=0.23), region from which they graduated with their veterinary degree (p=0.19) or current role (p=0.88). For a small number of questions, there were missing data; therefore, the denominator for all results was 214 unless otherwise stated.

Respondents had received their veterinary degree a median of 9 years previously (IQR 4.0 – 16.4 years; range 0 – 53 years) (Figure 1). Most respondents had graduated from a veterinary school within North America (92.5%; n=198), with a further 4.7% of respondents (n=10) having undertaken their veterinary degree within a European country, and 2.8% (n=6) having undertaken their veterinary degree in another region.

When examining employment, most respondents reported being in a solely equine clinical veterinary role (66.8%; n=143) (Table 1). Ninety-two percent of respondents (n=197) were currently working within the United States of America, while the remaining 7.9% of respondents (n=17) were based in Canada.

*3.2 Current approach to laminitis cases*

Respondents were asked to estimate the average number of cases of laminitis evaluated each week during the time in which they observed the highest frequency of laminitis. Fifty-five percent of respondents (n=118/213) estimated that they evaluated <1 laminitis case per week, 28.2% (n=60/213) estimated that they evaluated approximately 1 laminitis case per week, and the remaining 16.4% of respondents (n=35) estimated that they evaluated >1 laminitis case per week.

Respondents were asked to indicate how often they would perform select diagnostic tests, both at initial examination and upon re-examination(s) of cases of laminitis without signs of systemic disease (Table 2). Seventy-nine percent of respondents reported performing ≥1 endocrine test. Measurement of basal adrenocorticotropin (ACTH) was performed more frequently than basal insulin (Table 2). Dynamic tests of ACTH or insulin were performed more frequently at re-examination compared to first examination. When combining initial and subsequent examinations, 92.5% of respondents performed endocrine testing for some laminitis cases, including 92.5% of respondents testing for ACTH (basal or dynamic tests), and 87.4% of respondents testing for insulin (basal or dynamic tests).

Other diagnostic tests/procedures performed by respondents in some or all suspected laminitis cases at either first or re-examination included venography (n=10); measurement of serum amyloid A (n=4), leptin (n=4), T4/unspecified thyroid test (n=3), glucose (n=1) or iron (n=1); fecal PCR (n=1), abdominal ultrasonography (n=1), nerve blocks (n=1), and evaluation of response to treatment (n=1).

*3.3 Change in diagnostic approach to laminitis cases*

Overall, 66.4% of respondents (n=142) reported a change in diagnostic approach to laminitis since graduation. One hundred thirty respondents who reported a change in diagnostic approach to laminitis volunteered a free text explanation of how their approach had altered; however, 11 of these responses pertained solely to changes in treatment rather than diagnosis, and a further three responses were broad statements that did not describe a specific change in approach. Four additional respondents reported a greater focus on identifying the underlying cause (n=3) or changes to diagnostic tests (n=1) without mention of any endocrine or metabolic condition(s). The most commonly reported change in diagnostic approach was increased use or awareness of endocrine testing for PPID and/or EMS (77.5%; n=86/111). Changes in approach to radiography were the next most frequently reported (28.8%; n=32/111), including increased use of radiography in laminitis cases, followed by increased use of, or changes to use of, venography (11.7%; n=13/111). Six percent of respondents (n=7/111) mentioned consideration of cost or restricted client finances as a factor involved in their change in diagnostic approach.

Respondents who reported changing their diagnostic approach had been a veterinarian for a median of 12 years (IQR 7 – 23.3 years) compared to a median of 3.5 years (IQR 2 – 8 years) for those who reported no change in approach (p<0.001). Region from which respondents received their veterinary degree (North America; European country or non-EU country) (p=0.53), current role (p=0.58), country in which current role was based (Canada versus United States; p=0.80), and the estimated number of laminitis cases attended per week during the month(s) of highest laminitis frequency in the respondents’ current role were not associated with change in approach to laminitis (p=1.0).

Respondents were asked to select factors or activities that had influenced their change in diagnostic approach to laminitis from a provided list. The most frequently reported influencing factors were personal experience (88.7%), Continuing Education (CE) activities/events (77.5%) and research or EBVM (73.9%) (Table 3).

*3.4 Management of endocrinopathic laminitis*

The majority of respondents (85.2%; n=156/183) considered that diagnosing an underlying endocrinopathy makes it easier to advise horse owners about laminitis management, treatment and prognosis, while 7.7% of respondents (n=14/183) reported it makes little/no difference to how they advise owners of laminitis cases. A further 7.1% of respondents (n=13/183) considered that diagnosing an endocrinopathy makes it more difficult to advise owners about laminitis management, treatment and prognosis. Treatment for PPID was generally considered to decrease time to clinical improvement of laminitis (62.5%; n=115/184; Figure 2) and considered moderately or highly effective in reducing laminitis recurrence (78.7% of respondents; n= 144/183; Figure 3), while treatment for EMS/ID was generally considered to decrease time to clinical improvement of laminitis (71.6%; n=131/183; Figure 2) and considered moderately or highly effective in reducing laminitis recurrence (86.9% of respondents; n= 158/183; Figure 3). Diagnosis of PPID or EMS guided management to some extent or to a great extent for >97% of respondents (Figure 4).

Compared to managing cases of laminitis without identifying any underlying cause(s), respondents considered diagnosing an endocrinopathy improves (45.9%; n=84/183) or greatly improves (12.6%; n=23/183) overall case outcome (including factors such as return to soundness, return to previous level of exercise, and case mortality rate). Nine percent of respondents (n=17/183) considered there to be little or no difference in overall case outcome where an underlying endocrinopathy is diagnosed, while 29.0% of respondents (n=53/183) considered case outcome to be poorer, with a further 3.3% (n=6/183) considering outcome to be much poorer in cases where an endocrinopathy is diagnosed.

*3.5 Comparisons between North American and United Kingdom respondents*

Respondents from North America generally evaluated fewer laminitis cases per week compared to respondents from the United Kingdom (p<0.001). When comparing responses between North America and the United Kingdom, at initial examination, North American veterinarians performed ACTH testing less frequently (p=0.01), and insulin testing more frequently (p=0.003) compared to United Kingdom veterinarians (Table 2). At re-examination, North American respondents performed both tests of ACTH (p=0.003) and insulin (p=0.01) less frequently compared to United Kingdom respondents. Veterinarians in North America were less likely to change their approach since graduation (66.4% compared to 83.6%, p<0.001). North American practitioners were influenced by personal experience more (p=0.001) and disease awareness initiatives less (p<0.001), compared to practitioners from the United Kingdom (Table 3). Reliance on expert opinion approached significance (p=0.07), with North American practitioners relying on expert opinion less (p=0.07). Although there were no differences between groups with respect to impact of treatment for EMS (p=0.10) or PPID (p=0.74) on improvement in acute laminitis, practitioners from North America were generally less likely to perceive a positive impact of treatment for PPID (p<0.001) or EMS (p<0.001) on prevention of future laminitis and were more likely to consider a diagnosis of an underlying endocrine disorder a factor which made client communication more difficult (p=0.03). Diagnosis of PPID (p<0.001) or EMS (p=0.01) were less likely to influence management for veterinarians from North America, compared to veterinarians from the United Kingdom. Finally, compared to practitioners from the United Kingdom, practitioners from North America generally viewed the impact of diagnosis of an endocrinopathy on case outcome less favourably (p<0.001).

1. **Discussion**

 In the present study, we sought to evaluate the approach of North American veterinary practitioners to diagnosis and treatment of laminitis. Key findings included that the majority of practitioners who reported changing their approach since graduation had increased their use of endocrine testing. This was primarily influenced by personal experience, continuing education, and evidence-based medicine. Diagnosis of endocrinopathy was reported to be important to outcomes and treatment strategies, and improved discussions with owners about management and prognosis. When compared to practitioners in the United Kingdom, over 90% of practitioners from North America undertook some form of endocrine testing (including basal and dynamic tests for ACTH, insulin, or both) for some laminitis cases at initial and/or subsequent examinations, but differed in which testing approaches to diagnosis of laminitis were used. Similarly, the majority of practitioners from North America considered that diagnosing an underlying endocrinopathy improved client communication and case outcomes, but the number of respondents who responded favourably was lower than reported from the UK.

 Over the past 15 years, there have been substantial changes to understanding of the underlying etiologies of laminitis, including recognition of endocrinopathic laminitis as the most common form identified in the field [1, 2, 13]. The identification of a change in approach to laminitis since graduation among respondents, with a majority indicating an increase in endocrine testing, suggests that practitioners are incorporating new evidence from the past 15 years into practice. As expected, this finding was influenced by time since graduation, with more recent graduates being less likely to implement changes compared to veterinarians who have been in practice longer. This may indicate that new graduates have received increased exposure to diagnosis and management of endocrinopathic laminitis within their veterinary curricula. Importantly, although endocrine testing has increased, respondents reported testing for ACTH more frequently than testing for insulin, indicating that practitioners may benefit from improved awareness of the central role of insulin in endocrinopathic laminitis. The inconsistent translation of insulin testing from research to practice might be a due to confusion between endocrine disorders (EMS versus PPID) in underlying etiology of laminitis. It is crucial to continue to emphasize the importance of testing for insulin in communication about endocrinopathic laminitis, whether in scientific publications, disease awareness initiatives, or continuing education events.

When examining sources of influence leading to a change in approach to laminitis, personal experience (88.7%), continuing education (77.5%) and evidence-based medicine or research (73.9%) were most frequently reported factors. Thus, personal experience was still the primary factor driving change in approach. Recently, there has been a shift towards enhancing the practice of EBVM [14], including considerations for continuing professional development [15]. Developing strategies to increase integration of EBVM in practice may improve outcomes [16].

When comparing results of the present study to results from the survey undertaken in the United Kingdom, there were several differences identified with respect to diagnostic and management approach. Practitioners from North America implemented insulin testing more and ACTH testing less on initial exam compared to practitioners from the United Kingdom. Both groups increased use of endocrine testing at re-examination, although United Kingdom veterinarians reported more use of endocrine testing than North American practitioners at this time point.

Despite the majority of practitioners from North America reporting a change in approach to diagnosis of laminitis, this was lower than that reported from the UK. For those that reported a change in practice, compared to practitioners in the UK, fewer practitioners from North America reported being influenced by disease awareness initiatives and more practitioners from North America reported being influenced by personal experience. In 2012, a nationwide laminitis awareness initiative was launched in the United Kingdom [17], which offered free ACTH testing for cases of laminitis. This initiative likely increased awareness of endocrinopathic laminitis among practitioners from the United Kingdom, and may have contributed to increased use of ACTH testing at first examination and endocrine testing at re-examination. In North America, free testing for PPID was offered but was not linked directly to laminitis. The trend towards a decreased reliance on expert opinion by practitioners in North America, compared to the United Kingdom, suggests a difference in perspective regarding the role of the specialist in laminitis diagnosis and care. Although both groups generally considered diagnosis of an endocrine disease to have a favourable impact on case management and outcomes, veterinarians from North American had a less favourable view, compared to practitioners from the United Kingdom. The reason for this is unclear, but may be related to perceived differences in treatment or management successes. As the focus of the survey was on diagnostic approaches, questions about the specific management or treatment strategies for endocrine disorders were not included.

Potential limitations of this study include recall and selection bias of practitioners who filled in the survey. This may have led to increased inclusion of those practitioners with an interest in laminitis who may be more likely to integrate new approaches to laminitis into their practice. Because of the use of social media, the extent of survey distribution is not known; thus, response rate is not known.

In the present study, diagnosis of endocrine disease was considered important to prognosis and management of laminitis, and was considered important with respect to advising clients on laminitis outcome and treatment strategies. Practitioners generally reported incorporating diagnostic testing for endocrine disease into their approach to laminitis. Continuing to raise awareness of the central role of insulin in development of endocrinopathic laminitis may improve diagnosis, treatment and management. Ultimately, integration of current research into practice may improve the welfare of equids affected by or at risk of laminitis.

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**Author Roles**

Conceptualization (HEB, JI)

Data curation (ER, HEB, JI)

Formal analysis (JI, MA)

Investigation (ER, HEB, CM, MA, JI)

Methodology (HEB, CM, JI)

Project Administration (HEB, JI)

Resources (HEB, JI)

Software (JI)

Supervision (HEB, CM, JI)

Validation (HEB, JI)

Visualization (ER, HEB, CM, MA, JI)

Roles/Writing – Original draft (ER, HEB, JI)

Writing – Review and editing (MA, CM)

**Tables**

**Table 1.** Employment role of respondents in an online survey of veterinarians undertaking equine work within North America.

|  |  |  |
| --- | --- | --- |
| **Description of current role (n=214)**  | **Frequency** | **Percent** |
| 100% equine – ambulatory/first opinion only | 91 | 42.5 |
| 100% equine - referral hospital +/- first opinion | 51 | 23.8 |
| Mixed practice | 58 | 27.1 |
| Other\* | 14 | 6.5 |

\*Other category includes academia/research (n=10); equine pharmaceutical/industry; 100% equine racetrack work; academia including 50% clinical work; and large animal residency (80% equine) (all n=1).

**Table 3.** Factors influencing changes in diagnostic approach to laminitis cases in separate online surveys of veterinarians undertaking equine work within North America and the United Kingdom.

|  |  |  |  |
| --- | --- | --- | --- |
| **Factor influencing change in diagnostic approach to laminitis since graduation**  | **North America (n=142)** **Frequency (%)** | **United Kingdom (n=117) Frequency (%)** | **P value** |
| Personal experience | 126 (88.7%) | 86 (73.5%) | 0.001 |
| Continuing education (CE)  | 110 (77.5%) | 80 (68.4%) | 0.10 |
| Research or evidence-based medicine | 105 (73.9 %) | 82 (70.1%) | 0.50 |
| Expert opinion  | 69 (48.6%) | 71 (60.7%) | 0.07 |
| Disease awareness initiatives (e.g. free laboratory testing schemes) or marketing | 52 (36.6%) | 67 (57.3%) | <0.001 |
| Practice policy  | 15 (10.6%) | 19 (16.2%) | 0.18 |
| Other\* | 2 (1.4%) | 0 (0%) | 0.60 |

#Other category includes extrapolation of human medical literature pertaining to endocrinology, Type II diabetes and nutrition to EMS, availability of portable digital radiography in addition to social media and client awareness (both n=1)

**Figure Legends**

**Figure 1.** Bar chart of distribution of time since graduating from their primary veterinary degree in an online survey of veterinarians undertaking equine work within North America.

**Figure 2.** Bar chart of perceived effect of concurrent treatment for endocrinopathy on time taken to achieve clinical improvement of acute laminitis.

**Figure 3.** Bar chart of perceived degree to which treatment of an endocrinopathy aids prevention of further laminitis episodes in affected animals.

**Figure 4.** Bar chart of perceived degree to which diagnosis of an endocrinopathy guides medium to long-term management of laminitis cases.

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