Disease and pharmacologic risk factors for first and subsequent episodes of equine laminitis: A cohort study of free-text electronic medical records

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ABSTRACT

Electronic medical records from first opinion equine veterinary practice may represent a unique resource for epidemiologic research. The appropriateness of this resource for risk factor analyses was explored as part of an investigation into clinical and pharmacologic risk factors for laminitis. Amalgamated medical records from seven UK practices were subjected to text mining to identify laminitis episodes, systemic or intra-synovial corticosteroid prescription, diseases known to affect laminitis risk and clinical signs or syndromes likely to lead to corticosteroid use. Cox proportional hazard models and Prentice, Williams, Peterson models for repeated events were used to estimate associations with time to first, or subsequent laminitis episodes, respectively. Over seventy percent of horses that were diagnosed with laminitis suffered at least one recurrence. Risk factors for first and subsequent laminitis episodes were found to vary. Corticosteroid use (prednisolone only) was only significantly associated with subsequent, and not initial laminitis episodes. Electronic medical record use for such analyses is plausible and offers important advantages over more traditional data sources. It does, however, pose challenges and limitations that must be taken into account, and requires a conceptual change to disease diagnosis which should be considered carefully.

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1. Introduction

Laminitis is a painful, prevalent, multifactorial condition of ungulates. In the domestic horse, compromised welfare due to the pain and immobility associated with laminitis often leads to euthanasia (Slater, 2014; Wylie et al., 2013a,b). Many studies have identified significant risk factors for laminitis, but have not always been in agreement (Hunt, 1993; Polzer and Slater, 1997; Slater et al., 1995; Wylie et al., 2013a,b). Administration of certain systemic corticosteroids has been presumed to pose a risk of laminitis, but this potentially putative risk factor has not been well studied in the general horse population (Bailey and Elliott, 2007; Bailey, 2010; French et al., 2000; Katz and Bailey, 2012; McCluskey and Kavenagh, 2004). Given financial constraints and ethical implications, previous stud-

ies have often been of limited sample size, thus reducing the power of the analyses to detect significant relationships of small effect size. In addition, the recurrent nature of laminitis has not been fully taken into account. It is possible that the initial case of laminitis is associated with different risk factors compared to subsequent episodes.

The use of electronic medical records (EMR) in first-opinion equine veterinary medicine in the UK is widespread. Although amalgamation of records between practices for epidemiologic research purposes is somewhat rare at present, sharing of such data will become more common in future (Johns and Adams, 2015; Wylie et al., 2014). This resource can offer huge sample sizes, and could be more easily extrapolated to the general horse population compared with other study types. It may, however, suffer from problems not usually encountered in prospective studies, due to record accuracy and completeness, for example. In first-opinion practice, diagnoses and case management decisions are often informed by less than the full battery of gold-standard tests available for each condition. Indeed, veterinarians in practice are often required to treat horses according to tentative diagnoses reached by pattern recognition alone, or with minimal investiga-

Table 1
Description of the convenience sample of first-opinion equine veterinary practices throughout the UK that contributed data to the current study between 1987 and 2013.

Practice	Number of full time veterinarians	Location	Cover own out-of-hours	RCVS Accredited[a]	Species seen	Number of branches	Number of records
1	11	Scotland	Yes	Yes	Mixed	2	2893
2	21	Central England	Yes	Yes	Equine only	1	38705
3	17	Northern England	Yes	Yes	Mixed	5	1442
4	14	Central England	Yes	No	Mixed	4	14339
5	11	Southern England	Yes	No	Equine only	1	5565
6	4	Northern England	Yes	Yes	Large species	1	5052
7	8	Northern England	Yes	No	Mixed	2	2485

[a] Accreditation of the practice by the Royal College of Veterinary Surgeons, URL: http://www.rcvs.org.uk/practice-standards-scheme/.

tion, due to financial, time, or practical constraints. In addition, free-text medical records vary greatly in verbosity between individuals, cases and practices. EMR offer a true historical account of the decisions made in the treatment of individual animals, whether those decisions were well-founded or otherwise. As such, EMR are a very different data-type compared with experimental data, where exhaustive exclusion criteria can be universally applied. EMR likely contain a wealth of useful, accurate information, but may require a lower sensitivity of case identification to be of used.

The aims of this study were to use a large database of first-opinion electronic medical records to analyse the relationships between known medical risk factors for the first, and subsequent episodes of laminitis. Our hypotheses were that (a) systemic corticosteroid administration is significantly and independently associated with laminitis risk, and (b) significant risk factors for initial and subsequent laminitis episodes will vary.

Ethical approval for this study was granted by the Research Ethics Committee, School of Veterinary Medicine, University of Glasgow.

2. Materials and methods

2.1. Data source

EMR from a convenience sample of seven first-opinion equine veterinary practices around the UK were collected and amalgamated into a single anonymised dataset (Table 1). These data spanned twenty-six years (1987–2013, n = 70481 records), and contained the following database; unique numeric identifier per horse, date of birth, date of entry into the system (date of veterinary record), breed and sex. Free-text notes detailing the reason for the consultation, clinical findings, presumptive or definitive diagnosis, treatment, and prescription information were available for each record. Age was calculated as the date of record minus the date of birth, and ages less than 0 or greater than 40 years (due to erroneous date records in 16% of records) were removed. Age was subsequently categorised as follows: under 1 year, 1–4 years, 4–8 years, 8–13 years and above 13 years. Sex was converted in to three categories: female, male, and unknown sex. Breeds were converted initially into ten categories; Arab/Arab cross, Cob/Cob cross, Draught/Draught cross, Native/Native cross, pony/pony cross, Thoroughbred/Thoroughbred cross, Warmblood/Warmblood cross, Welsh/Welsh cross, unknown and other breed. Horses were followed from their first record in the dataset, to their first or subsequent laminitis episodes, or until they died, were lost from follow up or the study period ended. Censoring was assumed to be uninformative. All analyses were conducted in R statistical environment (R Core Team, 2015). Statistical significance was set at 0.05 and all testing was two-tailed.

2.2. Text mining

Text mining was employed to convert free text records into numeric variables. Commercially available text mining software

Table 2
Examples of the words and phrases used to categorise electronic medical records (EMR) from a convenience-sampled UK horse cohort between 1987 and 2013. Where possible common negations were excluded, and all terms were validated through assessment of the term in context.

Category	Examples of words/phrases used for case detection (excluding misspellings)
Laminitis	Laminitis, founder, laminitic
Triamcinolone	Adcortyl, Triamcinolone, Kenalog, Vetalog
Recurrent Airway Obstruction (RAO)	RAO, heaves, Chronic Obstructive Pulmonary Disease (COPD)
Respiratory	Bronchospasm, bronchoconstriction, cough, dyspnoea, pneumonia, wheeze
Dermatologic	Abrasion, alopecia, blepharitis, bursitis, cellulitis, Chorioptes, dermatitis, eczema, folliculitis, furunculosis, lymphangitis, pyoderma, sweet itch, thrombophlebitis
Equine Metabolic Syndrome (EMS)	EMS, metabolic syndrome, peripheral Cushing's
Pituitary Pars Intermedia Dysfunction (PPID)	Cushing's disease, PPID, hyperadrenocorticism, Pergolide, Prascend
Prednisolone	Prednicare, Prednidale, Prednisolone, Preds
Methylprednisolone	Depomedrone, Methylprednisolone
Dexamethasone	Colvasone, Dexamethasone, Dexadresson, Dexafort, Duphacort
Gastrointestinal	Colic, colitis, diarrhoea, enteritis, enterocolitis, scour
Systemic	Abortion, allergy, anaphylaxis, autoimmune, bacteraemia, dystocia, endometritis, endotoxaemia, hepatitis, mastitis, Pemphigus, peritonitis, placentitis, pyelonephritis, pyrexia, sepsis, toxaemia, urticaria, vasculitis
Orthopaedic	Osteoarthritis, epiphysitis, kissing spines, osteomyelitis, sesamoiditis, spavin, spondylosis, tendonitis
Neurological	Ataxia, encephalopathy, hemiplegia, meningitis, Wobblers syndrome

(SimStat and WordStat, Provalis Research Ltd., Canada) was used to construct dictionaries of words or phrases designed to mine free text records for instances of systemic or intra-synovial corticosteroid administration (triamcinolone acetonide, dexamethasone, prednisolone and methylprednisolone) and laminitis, and for records of syndromes known to be related to laminitis, or known to be a common indication for systemic or intra-synovial corticosteroid use (Table 2). These syndromes were decided upon *a priori* after discussion with experienced equine veterinarians, and examination of a proportion of EMR containing corticosteroid administration. The iterative mining process used was similar to that published in Lam et al., 2007; and validated for use in veterinary data by Anholt et al. (Anholt et al., 2014a,b; Lam et al., 2007). Negated terms were excluded where possible (e.g. 'not Cushing's disease'). A 'case' of laminitis or disease was thereby defined