Indicators of 'critical' outcomes in 941 horses seen 'out-of-hours' for abdominal pain (colic).

Key words: horse, equine, equids, out-of-hours, after hours, colic, abdominal pain, critical, outcomes

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Abstract

Background: This study aimed to describe the presentation and outcomes of horses with signs of colic (abdominal pain) seen 'out-of-hours' in equine practice.

Methods: This was a retrospective study of horses seen 'out-of-hours' with colic by two equine veterinary practices between 2011-2013. Case outcomes were categorised as 'critical' or 'not critical'. A critical outcome was defined as requiring medical or surgical hospital treatment, or resulting in euthanasia or death. A non-critical outcome was defined as resolving with simple medical treatment. A hierarchical generalised linear model was used to identify 'red flag' parameters (aspects of signalment, history and presenting clinical signs) associated with critical outcomes.

Results: Data were retrieved from 941 cases that presented with colic; 23.9% (n=225/941) were critical. Variables significantly associated with the likelihood of a critical outcome in the final multivariable mode were: increased heart rate (p<0.001), age of the horse (p=0.013) and abnormal mucous membrane colour (p<0.001). Overall 18% of cases (n=168/941) were euthanased.

Conclusions: This study highlights the mortality associated with colic. The 'red flag' parameters identified should be considered an essential component of the primary assessment of horses with colic.

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Introduction

Colic (clinical signs of abdominal pain) is the most common reason for emergency call outs for veterinary surgeons. It accounts for over a third of the cases seen 'out-of-hours' in equine veterinary practice (1). Clinical signs of colic are frequently resolved with simple medical management and analgesia (2-6). However, a proportion of equine colic cases are critical, with a more complex or severe underlying pathological process. Prognosis of critical cases of equine colic is influenced by early, accurate diagnosis as the duration and degree of pathology are negatively correlated with a successful outcome (7-9). The majority of current studies on colic are based within referral centres, and there are limited data about the primary assessment of colic (2-4). A recent study collected data from a large number of practices across the UK, however one of the study limitations was the potential for selection bias by participating practitioners (5). It reported that 19% of cases (n=195/1016) were critical (required hospitalisation for medical or surgical treatment, euthanasia or died), and 84% of these critical cases were euthanased or died (n=164/195); this was a higher proportion than had been reported previously (2-4). This study also identified clinical

changes present on the primary assessment by the veterinary surgeon which were significantly associated with critical cases (5), but further studies are needed to compare and validate these findings.

The aim of this study was to describe the primary assessment, treatment and outcomes of horses with colic (abdominal pain) that presented 'out-of-hours' in first opinion equine practice.

The objectives of the study were:

- To describe the history, signalment and physical examination findings of horses presented for primary (first opinion) assessment of colic 'out-of-hours' at two equine veterinary practices in the United Kingdom.
- To categorise the different types of colic occurring in horses presented for primary assessment 'out-of-hours' at two equine veterinary practices.
- To document the diagnostic approach, treatments administered and outcomes for horses presented for primary assessment of colic 'out-of-hours'.
- To determine the 'red flag' parameters (aspects of the initial clinical assessment) that can be used to differentiate critical and non-critical outcomes for cases presenting 'out-of-hours' with colic.

Methods

Study design and data collection: The study was a retrospective case series of horses seen as emergency visits 'out-of-hours' at two equine veterinary practices over three years (1st January 2011-31st December 2013). 'Out-of-hours' was defined as horses attended by veterinary surgeons outside of normal working hours. Cases of colic seen as emergencies within normal working hours were not included, as these could not be reliably identified within the practice records. The study design and data collection methods have been

previously described (1). The sample population for this study was the subset of horses attended for primary assessment 'out-of-hours' with colic. Colic was defined as 'any incidence of abdominal pain as assessed by the veterinary surgeon in attendance', and seven days without signs of colic was required for a case to be considered unrelated to a previous episode.

The inclusion criteria for horses were a recorded case history with at least one of the following:

- a presenting complaint of colic (clinical signs of abdominal pain)
- a definitive diagnosis of colic (all underlying pathologies)
- clinical signs of abdominal pain noted on presentation/clinical examination

Cases were excluded if a non-gastrointestinal cause of abdominal pain was identified, or if the final outcome could not be determined.

Colic cases were identified for both practices and the data were pooled in Microsoft Excel (2013). The rationale for pooling the data was due to the similarities identified in the analysis of the dataset as a whole (1): there were no significant differences identified between the data from the different practices. Cases were categorised by year and month to allow for analysis of seasonality, although dates of visits were not included. Case outcomes within the pooled colic dataset were subject to binary retrospective classification of 'critical' or 'not critical'. Critical outcomes were defined as cases which were fatal (death or euthanasia), or required critical care for resolution of the condition (hospitalisation for intensive medical treatment or surgery). Conversely, 'non-critical' cases outcomes had clinical signs of abdominal pain which resolved with simple medical treatment and no requirement for referral or hospitalisation (5).

The data were subject to descriptive statistical analysis: analysis of continuous variables included mean, mode, median and range, whilst percentage frequencies were calculated for all categorical data. Data were then entered into a statistical software package (SPSS Statistics Version 24, IBM Corporation, 2012) for further analysis. Individual variables, including biologically plausible interaction terms, were evaluated for effect on a "critical"

outcome with those showing evidence of association ($p<0.2$) used for build a multivariable model using a simple univariable binary logistic regression on pooled data from both practices. Data were further analysed using a generalised linear model which allowed for hierarchical modelling to assess the effects of predictive variables by practice. This was performed using a manual forwards stepwise process with individual assessment of the log likelihood parameter as well as Akaike Information Criterion (AIC) was used to assess goodness of fit. Variables were retained if there was a significant likelihood ratio test-statistic ($p<0.05$) between iterations. A Wald Chi-Square test was used to reflect the overall effect of each parameter on the final model.

Results

Study population.

During the period from 1st January 2011 to 31st December 2013 inclusive, 941 horses had primary evaluations for abdominal pain outside of normal working hours (628 cases from Practice 1, 313 cases from Practice 2). The mean age of horses was 14 years (SD $\pm$ 8.4, range three months to 44 years). Gender was recorded in 86% (n=806/941) of case records, and the study population consisted of 54% (n=436/806) geldings, 42% (n=340/806) mares/fillies and 4% (n=30/806) stallions/colts. There were 66 breeds/types of horse described, which were categorised into eight main breed types (Supplementary Item 1).

Clinical history and presentation, diagnostic tests and treatments administered.

Of the colic case population, 13% (n=126/941) had a history of at least one episode of colic in the 12 months preceding the 'out-of-hours' examination. The majority (76%, n=712/941) of cases had no definitive diagnosis recorded; 87% (n=619/712) of these responded to medical treatment. In cases where there was a definitive diagnosis (24%, n=227/941), there were 31 different problems/lesions described as causing the abdominal pain (Figure 1). The

most commonly diagnosed problems were spasmodic colic (30%, n=67/227), pelvic flexure impaction (18%, n=40/227), small intestinal strangulation (12%, n= 27/227), and right dorsal displacement of the large colon (7%, n=16/227). There was no obvious seasonality of colic cases, with no consistent trends.

A change of demeanour was recorded in 32% (n=299/941) of the case records, which was most commonly noted as restless and agitated (38%, n=113/299), or dull and depressed behaviour (29%, n=88/299) which was considered abnormal for the individual animal.

The heart rate was recorded in 96% (n=900/941) of cases, of which 43% (n=387/900) had tachycardia (Figure 2). Respiratory rate was recorded for 64% (n=601/941) of cases, with 57% (n=341/601) reported as having an elevated respiratory rate on initial clinical examination (Figure 3). Rectal temperature was recorded in 56% of clinical records (n=523/941), with 9% (n=46/523) considered pyrexic. 'Normal' ranges used in the analysis were either determined by the values referenced by the attending veterinary surgeons, or defined as heart rates 28-44 beats per minute, respiratory rates 8-16 breath per minute, and rectal temperatures of 37.3-38.3^{o}C (consistent with the values used by the practices). Where recorded, mucous membranes were an abnormal colour in 24% (115/482) of cases, described as pale (61%, 70/115), congested (14%, 16/115), or toxic (13%, 15/115), whilst capillary refill time was prolonged (> 2 seconds) in 8% (n=26/341) of cases. Details of abdominal auscultation findings were recorded in 91% (n=858/941)of cases . Normal borborygmi were present in 16% (n=139/858) of these cases, 32% (n=273/858) had hypermotile or increased borborygmi and 36% (n=306/858) had hypomotile or reduced borborygmi. Borborygmi were absent in at least 1 abdominal quadrant in 11% (n=96/858) of cases and the clinical notes of the remaining 5% (n=44/858) of cases contained information relating to acoustic details rather than motility.

The common diagnostic procedures recorded as performed at the primary assessment included rectal examination (73%; n=685/941), nasogastric intubation (22%; n=204/941), blood sampling (5%; n=51/941) and abdominal paracentesis (5%; n=48/941). Treatments were recorded in 94% (n=887/941) of cases. The most common treatment was analgesic drug administration, given in 92% (n=861/941) of cases. Spasmolytic drugs containing

hyoscine either alone or combination (Buscopan-20 or Buscopan Compositum) were used in 71% (n=663/941) of horses with colic. It was not possible in the retrospective analysis to accurately determine what percentages of each drug were administered. Oral fluids were given in 11% (n=107/941) of cases; most frequently this was a water and electrolyte combination (76%, n=81/107). The most common treatments (Supplementary Item 2) included administration of a nonsteroidal anti-inflammatory agent (NSAID) and spasmolytic agent concurrently (64%, n=571/887) or an NSAID alone (18%, n=159/887).

Case outcomes.

The majority (62%, n=583/941) of equine patients attended 'out-of-hours' required a single treatment for resolution of the condition, whilst a further 18% (n=174/941) needed multiple treatments. Of the study population, 5% (n=45/941) of animals were hospitalised for intensive care / treatment. It was recorded that abdominal surgery was recommended in 7% (n=65/941) of cases and was performed in 4% (n=41/941). Euthanasia was performed prior to any treatment in 4% (n=33/941) of cases. A total of 19% of the animals did not survive the episode of colic; 18% (n=168/941) were euthanased and 0.7% (n=7/941) died. The remainder of the horses within the study either had no obvious outcome in their case record (0.7%, n=7/941), or the colic resolved without veterinary treatment (0.2%, n=2/941).

The inclusion criteria for a critical outcome of colic were those that were fatal (euthanased on humane grounds or died as a consequence of colic) or were hospitalised to receive intensive medical treatment or surgical intervention. There were 225 cases (24% of colic cases) that were categorised as having a critical outcome. Of the 225 critical outcomes, 145 (64%) were fatal (141 were euthanased, four died) without attempting intensive medical treatment or surgical intervention (Figure 4). Thirty nine animals (17%) were hospitalised for intensive medical treatment; ten were euthanased after treatment failed, one died before it could be euthanased, and 28 recovered following treatment (Figure 4). The duration of hospitalisation ranged from 2-52 days. Surgical intervention was undertaken in 41 animals (18%). Twenty two animals (10% of the critical outcomes, n=22/225) that underwent surgery survived until discharge. It was not possible to determine the long term survival based upon

case records. Two horses died prior to surgery (one during transit to a referral hospital, and the other during induction of anaesthesia), whilst 17 were euthanased; two prior to surgery, six during surgery after identification of the underlying pathology and three due to post-surgical complications (Figure 4). The reason/timing of euthanasia was not identifiable in the case records for six animals.

Multivariable models of variables associated with critical cases of colic.

Results of the univariable analysis (Supplementary Item 3) were used as the basis for the multivariable model. There were three variables significantly associated with the likelihood of an outcome being classified as 'critical' (Table 1), all of which had an evidence of effect in both practices. Two continuous variables, age of the animal and heart rate at presentation were associated with an increased likelihood of a case being "critical". The presence of abnormal mucous membrane colour, which was not further categorised based on the data available in the clinical records, was also associated with "critical" cases. Each variable nested within practice had a significant individual effect on the model (heart rate: $p<0.001$; age: $p=0.013$; abnormal mucous membrane colour: $p<0.001$). Akaike's Information Criterion demonstrated an optimised model using these three parameters (AIC 167).

Table 1: Multivariable model for clinical variables (history, signalment and clinical presentation) from 941 horses that were attended for primary assessment outside of normal working hours for clinical signs of abdominal pain at two practices over a three year period (2011-2013). Cases were categorised as critical or not critical on the basis of outcome. B is the coefficient for the variable in the logistic regression model, and is the log of the Odds Ratio [exp(B)].

Variable	**B**	**Odds ratio**	**95% CI**	**p value**
Intercept	-6.00	0.00	0.00-0.02	<0.001
Heart rate (practice A)	0.08	1.08	1.00-1.14	<0.001
Heart rate (practice B)	0.05	1.05	1.01-1.09	0.01
Age (practice A)	0.07	1.07	1.01-1.14	0.02

Age (practice B)	0.08	1.08	1.00-1.17	0.04
Abnormal mucous membrane colour (practice A)	1.89	6.68	1.34-50.5	0.03
Abnormal mucous membrane colour (practice B)	3.10	22.3	5.23-115	<0.001

CI = Confidence Interval

Discussion

This study describes the primary presentation, treatment and outcomes of horses seen outside of normal working hours for abdominal pain in two equine practices in the UK. During the three year study period, 941 horses were examined at primary assessment for colic. The majority (76%) of these cases had no definitive diagnosis of the cause underlying the colic episode, and 87% responded to simple medical treatment. Edwards (10) reported that six to ten percent of horses with colic had obstructions which required surgery. In the present study, intensive medical treatment or surgical intervention was only performed in 9% of the study population. A total 24% of the study population were defined as having a critical outcome (cases that required intensive medical or surgical management, were euthanased or died), with the majority of critical cases being euthanased. It is likely that this euthanased subset of cases also included cases where surgery may have been a possible treatment. Age of the horse was significantly associated with a critical outcome, which may either reflect a higher incidence of critical conditions (such as pedunculated lipoma or neoplasia), or that the age of the horse affects the choices made by the owner. Currently, the majority of published research is based upon data from horses that have arrived at referral centres. This study only represents data from two UK veterinary practices, and there is a need for further studies to expand this evidence. It does however highlight that the number of horses referred represent a small proportion of the total cases seen. There is a need for more research on first opinion cases, and the large number of cases with critical

outcomes seen in equine practice. The clinical changes that were present at the primary examination and significantly associated with a critical outcome are in agreement with a previous study (5)and strengthen the current evidence for these as 'red flag' indicators of a critical outcome.

Early recognition of critical cases is essential (regardless of whether treatment or euthanasia is the elected option), as they represent a significant welfare concern. Multivariable modelling identified an increased heart rate and an abnormal mucous membrane colour as potential early indicators or 'red flags' for critical outcomes of colic. The importance of cardiovascular parameters and markers of hypovolaemia as prognostic indicators were identified previously from referral hospital data (11-13). There has been one other study (5) which has reported on the primary assessment of colic cases; this found that increased heart rate, hypovolaemic markers and absence of borborygmi were significantly associated with critical outcomes, which is consistent with this study. The current study also found that age of the horse was significantly associated with a critical outcome. There are a number of potential reasons for this – some clinical conditions, such as pedunculated lipomas and neoplasias are more common in older horses (14, 15). This significant association may however also be due to owners' decision-making. Older horses are less likely to be insured (16), have a lower financial value, and may have a number of other co-morbidities (17). All these factors may make owners more likely to opt for euthanasia rather than treatment in an older horse, however further research is needed to explore this and understand decision-making in critical cases.

An additional finding of the study by Curtis and others (5) was a significant increased pain/behaviour score. Behavioural scoring was not possible in this study due to the retrospective methodology. The limitations of the methodology have been previously discussed (1). The majority (76%) of cases of colic were treated without a definitive diagnosis of the underlying cause/pathology, consistent with findings from other studies (2, 3). Reasons may include a lack of an obvious anatomical abnormality, limitations in diagnostic approaches/techniques available or client preference/finance (18). The major impact of this study is that clinical parameters associated with a critical outcome were identified on the

very first assessment of these horses, and therefore can be used as part of early decision-making in colic cases. It also highlights the need for early recognition and a rapid response by horse owners to horses showing signs of colic.

This retrospective study provides novel information on the type of data entered into clinical records for 'out-of-hours' cases. Heat rates were the most commonly recorded clinical parameter (95.6% of cases), possibly due to the relationship between cardiovascular status and predicting surgical lesions, and prognosis (11, 12, 19, 20). Abdominal auscultation to determine the presence and nature of borborygmi was recorded in 93.2% of cases, unsurprising as it is a marker for gastrointestinal function, and most cases of colic have an underlying gastrointestinal cause (21-25). Respiratory rate (63.9%) and rectal temperature (55.6%) were frequently recorded, which was expected given that these parameters, combined with heart rate, are the three components that form the basis of a routine clinical examination (26). Surprisingly, assessment of markers of hypovolaemia were not commonly recorded. Hypovolaemic markers including capillary refill time are integral to assessing the peripheral perfusion status of the animal and are 'red flags' for critical cases of colic (5). It is likely that the assessment of such clinical parameters is conducted but not recorded, highlighting a possible flaw with the study methodology. Retrospective case series often have missing and variable data recording, an inherent problem of collecting data from case records.

The diagnostic tests that were most frequently used were rectal examination (72.8% of cases) and nasogastric intubation (21.7% of cases) which is consistent with two other studies of primary care colic cases (5, 18). It is important to recognise that nasogastric intubation may be adjunctive therapy to deliver oral fluids rather than being purely diagnostic in its use (27). Diagnostic testing is dependent on individual circumstances with certain diagnostic tests not considered at the first examination, not required for diagnosis or not possible due to the demeanour of the horse, due to concerns by owner or vet of risk to horse, or the lack of facilities available at the point of care (18, 28, 29). Furthermore, injury to equine vets in particular has been an area of increased investigation in recent years, and perhaps equine

veterinary surgeons are less inclined to put themselves at risk to perform diagnostic tests when the animal or environment are not suitable (30-32).

The most commonly administered pharmacological treatments were NSAIDs, which were administered either alone (16.9% of cases), or in combination with other therapies (74.6% of cases). The types of NSAID given were consistent with other studies of colic in horses and were appropriate for management of the condition (33-37). The use of spasmolytic agents may have been to facilitate rectal examination (38, 39) or as a therapy as they are licensed and indicated for use in colic with certain underlying causes (40). The efficacy of different treatments is unknown and cannot be surmised, especially given the multiplicity and diversity of underlying causes of abdominal pain in horses. Finally, the retrospective study design meant it was not possible to determine how diagnostic and treatment decisions affected the outcome of individual cases.

The overall mortality rate of horses seen 'out-of-hours' with abdominal pain in this study was 19%. Euthanasia was performed in 18% of the horses affected by colic in the study population: 15% without receiving intensive medical treatment or surgical intervention, 1% after failure of medical treatment, and 2% after unsuccessful surgery or associated complications. Mortality rates in other colic studies have varied, they were reported to be lower (between 6 and 11%) in more historic studies (3, 4, 41); population age was not reported in these studies making it difficult to draw comparisons. This study however had a similar mortality rate to the study by Curtis and colleagues where 16% of colic cases resulted in death or euthanasia (either before or after referral). The discrepancy could be due to the differences between referral and primary care populations of horses with colic, whilst an alternative hypothesis is due to changes in decision making in equine colic that have occurred over time. Decision making is multifactorial and there are many aspects to consider including the horse's signalment, clinical status and its prognosis, the owner's personal and financial position and possibly the insurance status (33, 42, 43). The number of critical cases of colic (24% of study population) was higher than the fatality rate because of successful medical and surgical treatment of underlying conditions. The success rate of horses that underwent surgery and survived to discharge was 54% (n=22/41), which is similar to that

reported in other studies (8, 9, 44-47). It is important to note that if there had been more unsuccessful surgeries or intensive medical treatments, the fatality rate would have been higher.

Colic remains an important condition in the first opinion setting, where the majority of cases are treated without a definitive diagnosis, animals may require referral for surgery or intensive medical treatment and it is a frequent cause of mortality. This study highlights the importance of primary assessment of colic, where the majority of animals are treated. Most critical cases of colic were fatal, and many of these were euthanased prior to referral, which was in agreement with a previous study (5). Further investigation into the reasons for euthanasia is required, to determine why treatment was not an option for these cases. Age of the horse was one of the factors associated with a critical outcome, and this requires further investigation to determine whether this is due to older horses being more likely to have critical conditions, or that owners are more likely to choose euthanasia instead of treatment in older horses. The population of horses that died, although a small number, represents a significant welfare concern, particularly as the reason for death was often not clear or recorded. The key finding from this study was the identification of key 'red flag' indicators for critical outcomes: increased heart rate, and abnormal mucous membranes. This is in agreement with a previous study (5), and adds to the strength of evidence for these as critical indicators. These clinical parameters should be considered essential components of the assessment and monitoring of horses with acute abdominal pain.

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Figure legends:

Figure 1: The conditions attributed to clinical signs of colic in 941 horses that were attended for primary assessment outside of normal working hours at two practices over a three year period (2011-2013). *Expressed as a percentage of the 941 horses that were attended for abdominal pain.

Figure 2: The frequency distribution of heart rates of 900 horses with abdominal pain that were attended for primary assessment outside of normal working hours at two practices over a three year period (2011-2013). The red highlighted area depicts the normal reference range (28-40 beats per minute).

Figure 3: The frequency distribution of respiratory rates of 601 horses with abdominal pain that were attended for primary assessment outside of normal working hours at two practices over a three year period (2011-2013). The red highlighted area depicts the normal reference range (8-16 breaths per minute).

Figure 4: The outcomes of 80 critical cases of abdominal pain in horses that were attended for primary assessment outside of normal working hours and received intensive treatment at two practices over a three year period (2011-2013).

References

1. Bowden A, Boynova PB, England GCW, Brennan ML, S. MT, Furness W, et al. Retrospective case series of 2,602 'out-of-hours' first opinion emergencies seen by equine veterinary practitioners. Veterinary Record. 2020;submitted January 2020.
2. Proudman CJ. A two year, prospective survey of equine colic in general practice. Equine Veterinary Journal. 1992;24(2):90-3.
3. Tinker MK, White NA, Lessard P, Thatcher CD, Pelzer KD, Davis B. Prospective study of equine colic incidence and mortality. Equine Veterinary Journal. 1997;29(6):448-53.

4. Hillyer MH, Taylor FGR, French NP. A cross-sectional study of colic in horses on Thoroughbred training premises in the British Isles in 1997. Equine Veterinary Journal. 2001;33(4):380-5.
5. Curtis L, Burford JH, Thomas JSM, Curran ML, Bayes TC, England GCW, et al. Prospective study of the primary evaluation of 1016 horses with clinical signs of abdominal pain by veterinary practitioners, and the differentiation of critical and non-critical cases. Acta Veterinaria Scandinavica. 2015;57(1):69.
6. Proudman CJ, Edwards GB, Barnes J, French NP. Modelling long-term survival of horses following surgery for large intestinal disease. Equine Veterinary Journal. 2005;37(4):366-70.
7. Fischer AT. Advances in diagnostic techniques for horses with colic. Veterinary Clinics of North America, Equine Practice. 1997;13(2):203-19.
8. Proudman CJ, Smith JE, Edwards GB, French NP. Long-term survival of equine surgical colic cases. Part 1: Patterns of mortality and morbidity. Equine Veterinary Journal. 2002;34(5):432-7.
9. Proudman CJ, Smith JE, Edwards GB, French NP. Long-term survival of equine surgical colic cases. Part 2. Modelling postoperative survival. Equine Veterinary Journal. 2002;34(5):438-43.
10. Edwards GB. Equine colic - the decision for surgery. Equine Veterinary Education. 1992;3(1):19-23.
11. Furr MO, White NA. Prognosis for acute abdominal diseases. Current Practice of Equine Surgery. 1990(ref):390-4.
12. Proudman CJ, French NP, Smith J, Edwards GB, editors. Survival analysis of post-operative equine surgical colic cases. Society for Veterinary Epidemiology and Preventive Medicine 2001; Golden Tulip Conference Centre, Leeuwenhorst, Noordwijkerhout, The Netherlands
13. Sutton GA, Ertzman-Ginsburg R, Steinman A, Milgram J. Initial investigation of mortality rates and prognostic indicators in horses with colic in Israel: a retrospective study. Equine Veterinary Journal. 2009;41(5):482-6.
14. Edwards GB, Proudman CJ. An analysis of 75 cases of intestinal obstruction caused by pedunculated lipomas. Equine Vet J. 1994;26(1):18-21.
15. Knowles EJ, Tremaine WH, Pearson GR, Mair TS. A database survey of equine tumours in the United Kingdom. Equine Vet J. 2016;48(3):280-4.
16. Barker I, Freeman SL. Assessment of costs and insurance policies for referral treatment of equine colic. The Veterinary record. 2019;185(16):508.
17. Ireland JL, Clegg PD, McGowan CM, McKane SA, Chandler KJ, Pinchbeck GL. Disease prevalence in geriatric horses in the United Kingdom: veterinary clinical assessment of 200 cases. Equine Vet J. 2012;44(1):101-6.
18. Curtis L, Trewin I, England GCW, Burford JH, Freeman SL. Veterinary practitioners' selection of diagnostic tests for the primary evaluation of colic in the horse. Veterinary Record Open. 2015;2(2).
19. Nielsen JV. Colic in horses: prognostic factors and indicators for referral. Dansk Veterinaertidsskrift. 2007;90(13):22-9.
20. Dukti S, White N. Prognosticating Equine Colic Veterinary Clinics of North America, Equine Practice. 2009;25(3):543-4.
21. Cohen ND. Epidemiology of colic [in horses]. Veterinary Clinics of North America, Equine Practice. 1997;13(2):191-201.
22. Cohen ND. The John Hickman memorial lecture: colic by numbers. (Special Issue: evidence-based medicine). Equine Veterinary Journal. 2003;35(4):343-9.
23. Cook VL. Colic in the horse - aetiology and diagnosis. Pferdeheilkunde. 2009;25(4):367-8.
24. Reeves MJ. What really causes colic in horses? Epidemiology's role in elucidating the ultimate multi-factorial disease. Equine Veterinary Journal. 1997;29(6):413-4.
25. White NA. Epidemiology and etiology of colic. Philadelphia, PA 19106-4198: Lea & Febiger; 1990.
26. Coomer R. Colic Part 2: Physical evaluation. UK Vet: Companion Animal. 2007;12(3):5-12.

27. Hallowell GD. Retrospective study assessing efficacy of treatment of large colonic impactions. Equine Vet J. 2008;40(4):411-3.
28. Fehr JE. How to work up the referral colic - is it surgical? ; Gainesville: The North American Veterinary Conference; 2007.
29. Southwood LL, Fehr JE. Abdominal Palpation per Rectum. Practical Guide to Equine Colic: John Wiley & Sons, Inc.; 2012. p. 22-37.
30. Reijula K, Rasanen K, Hamalainen M, Juntunen K, Lindbohm ML, Taskinen H, et al. Work environment and occupational health of Finnish veterinarians. American journal of industrial medicine. 2003;44(1):46-57.
31. BEVA. Survey reveals high risk of injury to equine vets. Veterinary Record. 2014;175(11):263.
32. Everitt S. Clinical decision making in veterinary practice [PhD thesis]: University of Nottingham; 2011.
33. Archer DC. Decision making in the management of the colicky horse. In Practice. 2004;26(7):378-85.
34. Keegan KG, Messer NT, Reed SK, Wilson DA, Kramer J. Effectiveness of administration of phenylbutazone alone or concurrent administration of phenylbutazone and flunixin meglumine to alleviate lameness in horses. American journal of veterinary research. 2008;69(2):167-73.
35. Longo F, Autefage A, Bayle R, Keister M, Gool Fv. Efficacy of a non-steroidal anti-inflammatory, ketogen 10% (ketoprofen) in the treatment of colic in horses. Journal of Equine Veterinary Science. 1992;12(5):311-5.
36. Sanchez LC, Robertson SA. Pain control in horses: what do we really know? Equine Veterinary Journal. 2014;46(4):517-23.
37. Cook VL, Blikslager AT. The use of nonsteroidal anti-inflammatory drugs in critically ill horses. Journal of Veterinary Emergency and Critical Care. 2015;25(1):76-88.
38. Mair T, Edwards B. Medical treatment of equine colic. In Practice. 1998;20(10):578-84.
39. Mair TS, Mellor D, editors. BEVA evidence based medicine study of analgesia for colic: preliminary findings. . 8th International Colic Research Symposium; 2005; Quebec.
40. Boehringer Ingelheim Vetmedica. 2017 [Available from: http://www.bi-vetmedica.com/species/equine/products/buscopan.html.
41. Traub-Dargatz JL, Kopral CA, Seitzinger AH, Garber LP, Forde K, White NA. Estimate of the national incidence of and operation-level risk factors for colic among horses in the United States, spring 1998 to spring 1999. Journal of the American Veterinary Medicine Association. 2001;219(1):67-71.
42. Egenvall A, Penell J, Bonnett BN, Blix J, Pringle J. Demographics and costs of colic in Swedish horses. Journal of Veterinary Internal Medicine. 2008;22(4):1029-37.
43. Scantlebury CE, Perkins E, Pinchbeck GL, Archer DC, Christley RM. Could it be colic? Horse-owner decision making and practices in response to equine colic. BMC Veterinary Research. 2014;10(Suppl. 1).
44. Archer DC, Pinchbeck GL, Proudman CJ. Factors associated with survival of epiploic foramen entrapment colic: A multicentre, international study. Equine Veterinary Journal. 2011;43:56-62.
45. Archer DC, Proudman CJ, Pinchbeck G, Smith JE, French NP, Edwards GB. Entrapment of the small intestine in the epiploic foramen in horses: a retrospective analysis of 71 cases recorded between 1991 and 2001. Veterinary Record. 2004;155(ref):25, 793-7.
46. Mair TS, Smith LJ. Survival and complication rates in 300 horses undergoing surgical treatment of colic. Part 1: Short-term survival following a single laparotomy. Equine Veterinary Journal. 2005;37(4):296-302.
47. Southwood LL, Gassert T, Lindborg S. Colic in geriatric compared to mature nongeriatric horses. Part 2: Treatment, diagnosis and short-term survival. Equine Veterinary Journal. 2010;42(7):628-35.