**Original Article**

**Retrospective analysis of post-mortem findings in Thoroughbreds aged from birth to 18 months presented to a UK pathology laboratory**

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# Abstract

Enhanced understanding of reasons for, and timings of, mortality in Thoroughbreds prior to entering race training is warranted to provide insight into this population’s  health status. The aims of this study were to describe pathologies diagnosed at post-mortem (PM) examination in Thoroughbreds aged from birth to 18 months and investigate associations between age and pathology. Reports from a  pathology laboratory in Newmarket, UK, were used to identify eligible cases examined between January 2006 and December 2020. Reported pathologies were extracted and categorised where appropriate. Comorbidities and pathogens identified were reported where available. Associations between age and selected pathologies were assessed using logistic regression. Of 144 eligible Thoroughbreds presented for PM, 137 had an available report and pathologist’s diagnosis. Congenital defects were most commonly reported (20%; n =28/137; 95%CI 15–29), 69% of which (n =19/28; 95%CI 49–82) were conformational manifestations of developmental orthopedic disease (DOD). Pneumonia was an important pathology (14%; n =20/137; 95%CI 36–53) during the pre-weaning period, where Rhodococcus equi was identified in 50% (n =10/20; 95% CI 29–70) of cases. Odds of congenital defects (OR 56.6; 95%CI 7.0–460.0; P <0.001) were significantly greater in horses aged 0–2 days compared to 4–18 months at PM. Odds of pneumonia (OR 4.3; 95%CI 1.1–1.7; P =0.04) were significantly greater in horses ages 1–4  months compared to 0–2  days at PM. This study shows that conformational manifestations of DOD are an important contributor to perinatal mortality, and that pathologies reported at PM vary with age in young Thoroughbreds.

*Keywords:* Disease; Equine; Mortality; Pathology; Thoroughbred. Introduction

A recently published analysis of stud book authorities’ outcomes of the 2014 and 2015 United Kingdom (UK) and Ireland (IRE) Thoroughbred foal crops (Arango-Sabogal JC et al., 2021) estimated that 2.1% of individuals had died by 1 year of age and a further 0.7% between 1 and 2 years of age. However, of the 53% of individuals reported not to have entered training by 3 years of age a significant proportion (35%, 5,049/11,403) had no recorded fate (death, export or sales transaction). A recent Australian survey to the owners of Thoroughbreds which failed to enter training reported a mortality rate of 38% (239/633) in this population (Flash et al., 2020), suggesting likely underreporting of mortality in industry level figures.

Current industry priorities include improving transparency and traceability of Thoroughbreds prior to entering training (Horse Welfare Board, 2020), but there is a paucity of up-to-date information describing causes and timings of losses, in particular beyond the neonatal period, in the UK.

Retrospective analyses of post-mortem (PM) reports of Thoroughbreds have been used to enhance understanding of the reasons for losses occurring on racetracks (Lyle et al., 2011; DeLay, 2017) and to understand causes of abortion, stillbirth and neonatal death (Smith et al., 2003; Roach et al., 2020). Similar retrospective analyses of PM data have been used to describe causes of death in other equid populations (Baker and Ellis, 1981; Morrow et al., 2011). The analysis of such data can provide insight into the relative distribution of causes of death and disease in a population.

The aims of this study were to describe causes of death in Thoroughbreds aged from birth to 18 months and investigate associations between age and cause of death. This work will up-date understanding of timings and causes of loss in the UK Thoroughbred breeding industry to inform future research priorities.

# Materials and methods

## Ethical approval

Ethical approval was granted by the Royal Veterinary College’s Clinical Research Ethical Review Board (URN: 2018 1843-2).

## Study design and period

A retrospective cross-sectional study was conducted, using PM records of Thoroughbreds examined between January 2006 and December 2020, at a pathology laboratory in Newmarket, UK.

## Selection of cases

Cases were identified from the laboratory’s practice management software (Eclipse PMS, Eclipse Veterinary Software Ltd) by searching PM procedure codes and a manual search of all recorded submissions by year. All eligible records were read by one author (RM) to identify cases meeting the inclusion criteria of (i) being Thoroughbred and (ii) aged between birth and18 months at PM.

## Data collection

Case reference number, date of birth, date of death, date of PM examination and sex were extracted, entered and stored anonymously in a custom-designed Access database. Post-mortem reports, ranging from full pathologists’ reports to clinicians’ letters to owners describing cause of death, were manually retrieved. Cases where no report was available were excluded from further analysis.

Examining pathologist/reporting clinician and whether the animal was euthanased, died (sudden/unexpected death) or died under veterinary treatment were noted. Cause(s) of death as described by the pathologist/clinician was recorded along with any further details of co-morbidities, infectious agents, anatomical location and descriptions of pathological lesions. Cases of stillbirth and cases where cause of death could not be established were excluded from further analysis.

## Data processing

Using the World Health Organisations’ (2011) Methodology for classification of cause of mortality data, the underlying cause of death, defined as ‘*the disease or injury which initiated the train of morbid events leading directly to death*’, was established for each case.

Data were initially categorised into infectious or non-infectious pathologies, within which (where n ≥3) more detailed categories were created using definitions and key descriptive terms from available literature (Supplementary Table 1). Infectious pathologies were categorised into: pneumonia, enteritis/colitis, abdominal abscesses, intestinal rupture/obstruction, hepatitis, septic arthritis, osteomyelitis, omphalitis and sepsis. Within these categories, cases were further described by infectious agent identified. Agents were described by genus and species where available. Non-infectious pathologies were categorised into: congenital defects, fractures, gastrointestinal rupture/obstruction, enteritis/colitis, developmental orthopaedic disease (DOD), perinatal asphyxia syndrome (PAS) and neonatal isoerythrolysis, and where appropriate described by anatomical location.

## Statistical analysis

Analysis was carried out using Stata (Release 16, StataCorp LP). Age at time of PM was calculated using date of birth and PM examination date. Time from death to PM examination was calculated where data available.

Descriptive frequencies of the study population characteristics were calculated. Histograms were visually inspected for normality and median and interquartile range (IQR) reported for non-normally distributed data. Proportions and 95% confidence intervals (CI) were calculated for categories within infectious and non-infectious cases of death. Descriptive statistics by pathogen and anatomical location were derived where appropriate.

Kruskal-Wallis tests were used to identify differences in the distributions of age at PM (as a continuous variable) between groups. Age at PM was divided into quartiles, within which proportions and 95% CI of categories of cause of death were calculated. Univariable logistic regression was used to quantify the strength of association between age group and the outcomes ‘non-infectious pathology’ and ‘congenital deformity’, respectively. Statistical significance was set at *P*<0.05.

**Results**

## Cases presented for post-mortem examination

Overall, 144 individuals met the case inclusion criteria; 85 (59%) colts, 55 (38%) fillies and 4 (2%) with no sex recorded. Median age at PM examination was 21 days (IQR 2-118, range 0-533, n=144). Figure 1 displays the distribution of age at PM examination. Median time from death to PM examination was 0 days (IQR 0-0, range 0-2 days, n=143).

Five individuals (3%, 5/144) had no PM report available and were excluded from further analysis.

Sixty-three (45%, 63/139) individuals underwent a full PM examination and 74 (55%, 74/139) were recorded as having undergone a limited, gross or “for interest purposes” PM examination. Sixty percent of individuals (83/139, 95%CI 51-67) were reported to have been euthanased, 20% (28/139, 95%CI 14-27) to have died and 20% (28/139, 95%CI 14-27) to have died under veterinary treatment.

## Causes of death

No cause of death could be established for 2 cases, resulting in 137 cases for further analysis.

## Non-infectious causes

Non-infectious pathologies accounted for 56% (76/137, 95% CI 47-63) of causes of death. Table 1 provides a summary of non-infectious causes of death, including anatomical locations and comorbidities, where identified.

Congenital defects were the most commonly reported non-infectious cause of death (37% (28/76, 95% CI 27-48). Cases were mainly reported to have been euthanased (82%, 23/28, 95% CI 64-92), with the majority (86%, 24/28, 95% CI 68-94) presenting during the perinatal period (median age at PM: 0 days, IQR 0-1, range 0-187). The musculoskeletal system was most commonly affected (75%, 21/28, 95% CI 57-87), in particular by flexural deformities of carpi and fetlocks (71%, 15/21, 95% CI 50-86). Table 2 presents a summary of congenital defects affecting the musculoskeletal system.

Fractures, PAS and gastrointestinal (GI) ruptures or obstructions were the next most frequently described non-infectious causes of death. Cases of fracture were euthanased apart from 4 cases of rib fracture which either died (n=3) or died under treatment (n=1) as a result of secondary lacerations of the lung, spleen and heart.

All cases of PAS died or were euthanased within the first 4 days of life (mean age at PM: 2 days, SD 1.4, range 0-4). A history of either dystocia or premature placental separation was reported in 44% (4/9, 95% CI 19-73). Cases of GI rupture (n=5) or obstruction (n=4) had a median age at PM of 21 days (IQR 6-145, range 3-281).

## Infectious causes

Infectious pathologies were reported as the cause of death in 44% (61/137, 95% CI 36-53) of cases. All but 3 cases (of gross intestinal parasite infestations) had further diagnostics performed for agent identification. A summary of infectious causes of death including agents, where identified, is given in Table 3.

Pneumonia was the most commonly reported category of infectious pathology, where cases presented at a median age of 53 days (IQR 10-117, range 2-453 days) with the majority (85%, 17/20, 95% CI 64-95) reported to have been euthanased (*n*=11) or died under veterinary treatment (*n*=6). Agents were identified in 90% (18/20, 95% CI 70-97) of pneumonia cases, 50% of which were *Rhodococcus equi* (10/20, 95% CI 29-70).

Enteritis/colitis was the second most frequently reported infectious category. Cases presented at a median age of 90 days (IQR 22-173, range 2-331), with the majority (92%, 11/12, 95%CI 64-98) having been euthanased (*n*=6) or died under veterinary treatment (n=5).

Overall, agents were identified in 75% (46/61, 95% CI 63-85) of infectious causes of death cases, 85% (39/46, 95%CI 72-92) being bacteria; 9% (4/46, 95% CI 3-20) parasites and 6% (3/46, 95% CI 2-17) viruses. *Rhodoccocus equi* was the most commonly reported agent (30%, 14/46, 95% CI 19-45), with cause of death reported as pneumonia (72%, 10/14, 95% CI 45-88), abdominal abscesses (21%, 3/14, 95%CI 8-48) or osteomyelitis (7%, 1/14 95%CI 1-31) and a median age of 61 days (IQR 43-120, range 10-137).

## Causes of death by categories of age at PM examination

The most common causes of death, by age group at PM examination, are presented in Table 4.

The distribution of age at PM varied significantly (*P*<0.001) between infectious and non-infectious pathologies. The cause of death was more likely to be a non-infectious pathology in cases presented for PM examination in the first 2 days of life as compared to those presented between 4 and 18 months of age (OR 4.2, 95% CI 1.5-11.8, *P*=0.001).

The distribution of age at PM examination varied significantly between categories of cause of death within both infectious (*P*=0.03) and non-infectious (*P*<0.001) pathologies. Within non-infectious pathologies, congenital deformities were more likely to be reported as the cause of death in neonates (the first 2 days of life) than in those aged between 4 and 18 months at PM examination (OR 56.6, 95%CI 7.0-460.0, P<0.001).

**Discussion**

This study provides insight into the relative distribution of causes of death and disease in UK Thoroughbreds aged from birth to 18 months. Causes of death varied significantly by age at presentation. Congenital deformities, in particular conformational manifestations of DOD, were an important cause of death in the neonatal period and *Rhodococcus equi* was found to be an important pathogen, particularly in cases of pneumonia in the pre-weaning period.

Risk of death in Thoroughbred populations has consistently been reported to be highest in the neonatal period and decline thereafter. Galvin and Corley (2010) reported that 67% of 17 deaths observed in a cohort of 338 foals born in Ireland between birth and 1 year of age occurred by 30 days and 82% by 6 months of age. A similar pattern of age distribution was observed in a survey by Morley and Townsend (1997) of the outcomes of 805 foals of the 1989 Canadian foal crop, where 45% of 87 reported deaths occurred in the first 14 days of life. The distribution of age at PM examination in the current study (50% by 21 days) is similar to those described above in population level studies suggesting that the cases presented for PM examination are representative of the source population in terms of age distribution.

Overall, congenital deformities were the most common cause of death in this study (20% all cases), notably during the perinatal period (63% cases aged 0-2 days at PM). The majority of deformities were reported to affect the musculoskeletal system, in particular flexural deformities resulting in contracture of the joints of the forelimbs. These findings are in keeping with those of previous population-level studies. Galvin and Corley (2010) showed that congenital abnormalities, including flexural deformities, accounted for 45% (5/11) of all cases of mortality by 30 days of age. Morley and Townsend (1997), surveying owners of a cohort of 805 Thoroughbreds born in Canada, reported a case fatality rate of 25% between birth and 14 days of age in individuals with contracted tendons whilst Platt (1973), in a survey of 2,209 births over 5 breeding seasons on UK Thoroughbred farms, described congenital abnormalities to account for 68% of 66 cases of mortality up to 8 weeks of age. Thoroughbreds are primarily bred for racing and athletic purposes (Parkin and Rossdale, 2006). It is likely that musculoskeletal congenital defects may render an individual unsuitable for athletic performance, resulting in euthanasia even when the defect may not be incompatible with survival, which may serve to explain why such lesions are such an important cause of death in this population.

Flexural deformities are one manifestation of DOD, a term used to describe a range of conditions affecting the joints of growing horses (McIlwraith, 2004). It is reasonable to assume that cases presented at PM examination represent the most extreme presentations of the syndrome (Adams, 2000) and could therefore be the ‘tip of the iceberg’ in terms of the disease at the population level. O'Donohue et al. (1992) detected signs of DOD in 68% of 248 foals between birth and 18 months of age on 17 farms in Ireland and estimated that up to 10% of yearlings produced annually were not suitable for sale due to the condition. Morley and Townsend (1997) described manifestations of DOD as not only a significant cause of death in their most severe presentation, but also the most common reason for individuals being deemed unsuitable for racing at 1 year of age. In work by Whittaker et al. (2012), conformational musculoskeletal defects were reported to have affected 18% of 399 foals, on 1 farm over 3 seasons in the UK, in the first 30 days of life. Despite being a significant cause of morbidity and mortality the precise aetiology of many of the manifestations of DOD remains unclear. Olstad et al. (2007) demonstrated the presence of osteochondral lesions in foals as young as 12 days of age, and experimental studies support a growing body of evidence that DOD may be associated with in-utero exposures (Allen et al., 2004; Peugnet et al., 2016). In humans, the influence of in-utero exposures on health and susceptibility to disease in offspring is well established (Barker, 2007). Results from this work highlight the need to investigate associations with in utero exposures by adding to the weight of evidence to support the congenital nature of many of the lesions of this syndrome, which is so prevalent within the industry.

*Rhodococcus equi* was the most common infectious agent in this study, identified in a third of all reported infectious pathologies and half of all cases of pneumonia. *R. equi* is considered one of the most significant pathogens in the equine breeding industry and has a worldwide distribution (Takai, 1997), presenting primarily as chronic bronchopneumonia with abscessation in foals between 1 and 6 months of age (Muscatello et al., 2007). A more acute form of interstitial pneumonia with diffuse miliary pyogranulomatous lesions has also been reported in foals showing signs of respiratory distress and dying within hours or days (Martens et al., 1982). It could be hypothesised that the foals in this study reported to have died may have suffered this more acute form of the disease whereas those which were euthanased or died under veterinary treatment the more common, chronic form. Unfortunately, the variety in pathological detail in the reports did not enable such comparisons. Less commonly, enteritis, arthritis, osteomyelitis and abscessation have been reported in foals with and without concurrent respiratory disease (Muscatello et al., 2007). In this study, along with pneumonia, *R. equi* was also isolated from cases with abdominal abscesses and osteomyelitis. There is currently no effective prevention for *R. equi* (Arnold-Lehna et al., 2020) and this study highlights the continued importance of this agent as a cause of death within the UK breeding industry. Further work to gain greater understanding of early life exposures which may predispose individuals to *R. equi* infection are required if there is to be any reduction of its impact.

The decision to present an individual for PM examination will be based on various factors, and is likely to differ between farms and between individuals within farms. As such, a cohort presented for PM examination may not be entirely representative of the population as a whole, which should be taken into account when interpreting results. Clinical information was not available for individuals in this study and it is therefore possible that veterinary treatment and management of some cases may have allowed them to survive for a period of time before succumbing to the disease, in particular with infectious pathologies. This also means that age at death or PM is not necessarily a proxy for when an individual was first affected by a particular condition. There was also considerable variation in the type, extent and detail of both reports and examinations performed. Therefore, the focus of this study was to describe broader categories of causes of death rather than provide pathological description or detail, as this was not available for a significant proportion of cases. Where limited or gross examinations are performed there is the potential for conditions, which could have contributed to the cause of death, to be missed. Most notably for individuals who are electively euthanased, the point at which that decision is made may affect the findings at PM examination, and hence the cause of death stated in a report. Such biases may be more likely to occur with limited types of examinations and/or reports such as some of those included in this study.

Mortality in the Thoroughbred breeding industry is of both economic and welfare concern (Parkin and Rossdale, 2006). With the industry prioritising efforts to better understand the health and fate of Thoroughbreds both before and after their racing careers, work such as this to describe causes and timings of deaths can aid in directing future strategies and interventions.

**Conclusions**

This study provides current knowledge on the timings and causes of death in the UK Thoroughbred breeding industry. Congenital deformities, in particular conformational manifestations of DOD, are an important cause of perinatal death, highlighting a need for further understanding of in utero exposures which may be involved in in their etiology. *Rhodococcus equi*, particularly manifesting as pneumonia, was an important infectious cause of death, confirming the necessity of efforts towards its control and prevention.

**Conflict of interest statement**

The authors declare no competing interests.

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Preliminary results from this work have been accepted for presentation at the British Equine Veterinary Associations annual congress in September 2021

**Appendix: Supplementary material**

Supplementary data associated with this article can be found, in the online version, at https://

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**Table 1**

Non-infectious causes of death and, where identified, associated comorbidities amongst 137 Thoroughbreds presented for post-mortem examination between birth and 18 months of age to a pathology laboratory in Newmarket, UK, between 2006 and 2020. Proportions and 95% Confidence Intervals (CI) given of the population as a whole.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Cause of mortality** |  | **Comorbidity** | **N** | **%** | **95% CI** |
| **Non-infectious**  | **All** |  | **76** | **56.3** | **47.9-64.2** |
|  |  |  |  |  |  |
| **Congenital defect** | **All** |  | **28** | **20.4** | **14.5-27.9** |
|  | Musculoskeletal  | PAS (n=3) | 21 | 15.3 | 10.2-22.3 |
|  | Lung/diaphragm |  | 2 | 1.5 | 0.04-5.2 |
|  | Meninges |  | 1 | 0.7 | 0.01-4.0 |
|  | Heart |  | 1 | 0.7 | 0.01-4.0 |
|  | Jejunum | Jejunal rupture | 1 | 0.7 | 0.01-4.0 |
|  | Eye |  | 1 | 0.7 | 0.01-4.0 |
|  | Bone marrow |  | 1 | 0.7 | 0.01-4.0 |
|  |  |  |  |  |  |
| **Fracture** | **All** |  | **9** | **6.7** | **3.5-12.2** |
|  | Rib  | Internal haemorrhage | 4 | 2.9 | 1.1-7.3 |
|  | Skull |  | 2 | 1.5 | 0.04-5.2 |
|  | Pelvis |  | 1 | 0.7 | 0.01-4.0 |
|  | Carpus |  | 1 | 0.7 | 0.01-4.0 |
|  | Fetlock |  | 1 | 0.7 | 0.01-4.0 |
|  | Humerus |  | 1 | 0.7 | 0.01-4.0 |
|  |  |  |  |  |  |
| **PAS** | **All** |  | **9** | **6.6** | **3.5-12.0** |
|  |  |  |  |  |  |
| **GI rupture/** | **All** |  | **9** | **6.6** | **3.5-12.0** |
| **obstruction** | Jejunum |  | 4 | 0.7 | 0.01-4.0 |
|  | Stomach | Ulceration (n=1) | 2 | 1.5 | 0.04-5.2 |
|  | Duodenum | Ulceration | 1 | 0.7 | 0.01-4.0 |
|  | Illeum |  | 1 | 0.7 | 0.01-4.0 |
|  | Rectum | Impaction | 1 | 0.7 | 0.01-4.0 |
|  |  |  |  |  |  |
| **DOD** | **All** |  | **3** | **2.2** | **0.7-6.2** |
|  | OCD |  | 1 | 0.7 | 0.01-4.0 |
|  | CVM |  | 1 | 0.7 | 0.01-4.0 |
|  | Subchondral Cyst |  | 1 | 0.7 | 0.01-4.0 |
|  |  |  |  |  |  |
| **Enteritis/colitis** | **All** |  | **3** | **2.2** | **0.7-6.2** |
|  | Drug induced |  | 2 | 1.5 | 0.04-5.2 |
|  |  |  |  |  |  |
| **Other causes\*** | **All** |  | **15** |  |  |

PAS = Perinatal asphyxia syndrome, GI= Gastrointestinal, DOD = Developmental orthopedic disease, OCD = Osteochondrosis dissecans, CVM = Cervical vertebral malformation.

\*Other non-infectious causes of mortality where case numbers did not allow further categorisation included neonatal isoerythrolysis, hepatopathy, ischaemia/infarction, pulmonary oedema, acquired megaoesophagus, aspiration pneumonia (drowning), immune mediated synovitis, neoplasia, ethmoidal thrombus, tracheal rupture and cerebral trauma.

**Table 2**

Congenital defects affecting the musculoskeletal system, reported as the cause of death amongst 137 Thoroughbreds aged between birth and 18 months presented for post-mortem examination to a pathology laboratory in Newmarket, UK, between 2006 and 2020. Proportions and 95% confidence intervals (CI) given of total cases where congenital defects were reported as the case of death.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Congenital defect** | **Anatomical location** | **n** | **%** | **95%CI** |
| **All** |  | 21 |  |  |
|  |  |  |  |  |
| **Contracture** | All | 11 | 52.4 | 32.4-71.7 |
|  | Carpus | 7 | 33.3 | 17.2-54.6 |
|  | Carpus and fetlock | 4 | 19.0 | 7.7-40.0 |
|  |  |  |  |  |
| **Contracture and scoliosis** | All | 3 | 14.3 | 5.0-34.6 |
|  | Vertebrae and carpus | 2 | 9.5 | 2.6-28.9 |
|  | Vertebrae and fetlock | 1 | 4.8 | 0.01-22.7 |
|  |  |  |  |  |
| **Angular deformity** | All | 3 | 14.3 | 5.0-34.6 |
|  | Carpus | 2 | 9.5 | 2.6-28.9 |
|  | Tarsus | 1 | 4.8 | 0.01-22.7 |
|  |  |  |  |  |
| **Hyperextension** | Fetlock | 1 | 4.8 | 0.01-22.7 |
|  |  |  |  |  |
| **Scoliosis** | Vertebrae | 1 | 4.8 | 0.01-22.7 |
|  |  |  |  |  |
| **Kyphosis** | Vertebrae | 1 | 4.8 | 0.01-22.7 |
|  |  |  |  |  |
| **Incomplete ossification** | Tarsus | 1 | 4.8 | 0.01-22.7 |

**Table 3**

Infectious causes of death and, where identified, associated infectious agents amongst 137 Thoroughbreds presented for post-mortem examination between birth and 18 months of age to a pathology laboratory in Newmarket, UK, between 2006 and 2020. Proportions and 95% Confidence Intervals (CI) given of the population as a whole

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Cause of mortality** | **Pathogen+** | **n** | **%** | **95% CI** |
|  |  |  |  |  |
| **Infectious**  | **All** | **61** | **44.5** | **36.4-52.9** |
|  |  |  |  |  |
| **Pneumonia** | **All** | **20** | **14.6** | **9.6-21.5** |
|  | *Rhodococcus equi* | 10 | 7.3 | 4.0-12.9 |
|  | *Streptococcus* spp. | 4 | 2.9 | 1.1-7.3 |
|  | Escherichia *coli* | 2 | 1.5 | 0.04-5.2 |
|  | Equine Herpes Virus 4 | 1 | 0.7 | 0.01-4.0 |
|  | *Actinobacillus* *equuli* | 1 | 0.7 | 0.01-4.0 |
|  |  |  |  |  |
| **Enteritis/colitis** | **All** | **12** | **8.1** | **4.6-14.0** |
|  | *Clostriduim perfringens* | 2 | 1.5 | 0.04-5.2 |
|  | Escherichia *coli* | 1 | 0.7 | 0.01-4.0 |
|  | *Lawsonia* intracellularis | 1 | 0.7 | 0.01-4.0 |
|  | *Salmonella* spp. | 1 | 0.7 | 0.01-4.0 |
|  | *Eimeria* spp. | 1 | 0.7 | 0.01-4.0 |
|  |  |  |  |  |
| **Sepsis** | **All** | **7** | **5.1** | **2.5-10.2** |
|  | Beta Haemolytic *Streptococcus spp.* | 2 | 1.5 | 0.04-5.2 |
|  | Equine Herpes Virus 1 | 2 | 1.5 | 0.04-5.2 |
|  | Escherichia *coli* | 1 | 0.7 | 0.01-4.0 |
|  | *Actinobacillus* spp. | 1 | 0.7 | 0.01-4.0 |
|  |  |  |  |  |
| **Omphalitis** | **All** | **4** | **2.9** | **1.1-7.3** |
|  | Escherichia *coli* | 2 | 1.5 | 0.04-5.2 |
|  |  |  |  |  |
| **Abdominal abscess** | **All** | **3** | **2.2** | **0.7-6.2** |
|  | *Rhodococcus equi* | 3 | 2.2 | 0.7-6.2 |
|  |  |  |  |  |
| **Hepatitis** | **All** | **3** | **2.2** | **0.7-6.2** |
|  | *Listeria monocytogenes* | 1 | 0.7 | 0.01-4.0 |
|  |  |  |  |  |
| **Gastrointestinal rupture/** | **All** | **3** | **2.2** | **0.7-6.2** |
| **obstruction** | Tapeworm spp. | 2 | 1.5 | 0.04-5.2 |
|  | *Ascarid* sp. | 1 | 0.7 | 0.01-4.0 |
|  |  |  |  |  |
| **Osteomyelitis** | **All** | **3** | **2.2** | **0.7-6.2** |
|  | *Rhodococcus equi* | 1 | 0.7 | 0.01-4.0 |
|  | *Staphylococcus aureus* | 1 | 0.7 | 0.01-4.0 |
|  |  |  |  |  |
| **Arthritis** | **All** | **3** | **2.2** | **0.7-6.2** |
|  | *Staphylococcus aureus* | 1 | 0.7 | 0.01-4.0 |
|  | Beta Haemolytic *Streptococcus spp.* | 1 | 0.7 | 0.01-4.0 |
|  |  |  |  |  |
| **Other causes\*** | **All** | **3** | **2.2** | **0.7-6.2** |

\*Other infectious causes of death were reported as nephritis, myositis and vasculitis. +Pathogen species given where information available otherwise genus described

**Table 4**

Most common categories of cause of death by group (quartile) of age at examination for 137 Thoroughbreds aged between birth and 18 months presented for post-mortem (PM) examination to a pathology laboratory in Newmarket, UK, between 2006 and 2020. Proportions and 95% confidence intervals (CI) given of total case numbers (n) in each age group.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Age at PM (days)** | **Cause of mortality** |  | **n** | **%** | **95%CI** |
| **0-2**  | Congenital defect |  | 24 | 63.1 | 47.3-76.2 |
| (n=38) |  | *Limb contracture* | *14* | *36.8* | *23.4-52.7* |
|  | PAS |  | 4 | 10.5 | 4.2-24.1 |
|  |  |  |  |  |  |
| **3-22**  | PAS |  | 5 | 16.1 | 7.1-32.6 |
| (n=31) | GI Rupture/obstruction |  | 5 | 16.1 | 7.1-32.6 |
|  | Pneumonia |  | 3 | 9.7 | 3.3-24.9 |
|  |  |  |  |  |  |
| **23-115**  | Pneumonia |  | 9 | 26.5 | 14.6-43.1 |
| (n=34) |  | *Rhodococcus equi* | *7* | *20.6* | *10.3-36.8* |
|  | Enteritis/colitis |  | 5 | 14.7 | 6.4-30.1 |
|  |  |  |  |  |  |
| **116-540**  | Pneumonia |  | 5 | 14.7 | 6.4-30.1 |
| (n=34) | GI Rupture/obstruction |  | 5 | 14.7 | 6.4-30.1 |
|  | Enteritis/colitis |  | 4 | 11.8 | 4.7-26.6 |

PAS = Perinatal Asphyxia syndrome, GI= Gastrointestinal, CI= Confidence interval

**Figure legends**

Fig. 1. Distribution of cases presented for post-mortem (PM) examination by age (days) at time of examination, of 144 Thoroughbreds presented to a pathology laboratory in Newmarket, UK, between 2006 and 2020.