



# Lack of association between arterial oxygen tensions in horses during exploratory coeliotomy and post-operative incisional complications: A retrospective study



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## ABSTRACT

The aim of this retrospective study was to determine if there was an association between the lowest arterial blood oxygen tensions (PaO<sub>2</sub>) measured during anaesthesia and post-operative incisional complications in horses. Clinical records of 278 horses undergoing ventral midline coeliotomy from 1 January 2010 to 31 December 2013 were examined.

The frequency of incisional complications was 32.0% ( $n = 89$ ). In a multivariable model, intra-operative arterial blood oxygen tensions (PaO<sub>2</sub>) were not significantly associated with development of an incisional complication ( $P = 0.351$ ). Using hypertonic (7.2%) saline ( $P = 0.028$ , OR 3.167, 95% CI 1.132–8.861), increasing total plasma protein concentration (TP) ( $P = 0.002$ , OR 1.061 per g/L, 95% CI 1.021–1.102), an intestinal resection ( $P < 0.001$ , OR 4.056, 95% CI 2.231–9.323), increasing body mass ( $P = 0.004$ , OR 1.004 per kg, 95% CI 1.001–1.006) and the use of penicillin alone compared with penicillin and gentamicin pre-operatively ( $P = 0.009$ , OR 4.145, 95% CI 1.568–10.958) increased the risk of incisional complications. The study was unable to demonstrate a link between low intra-operative PaO<sub>2</sub> and increased risk of post-operative incisional complications.

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## Introduction

The survival of horses undergoing emergency abdominal surgery has improved in recent decades (Freeman et al., 2000). Post-operative complications at the incision site, such as drainage or oedema, are still common (Phillips and Walmsley, 1993; Mair and Smith, 2005; Freeman et al., 2012). In a previous study in this hospital, 16% of horses undergoing emergency abdominal surgery developed an incisional complication (Proudman et al., 2002); other reported rates of incisional complication range from 7.4% to 42.2% (Freeman et al., 2000; Mair and Smith, 2005; Torfs et al., 2010; Durward-Akhurst et al., 2013).

Risk factors associated with an increased likelihood of incisional complications include increasing heart rate on admission (French et al., 2002), increasing body mass and increasing age (Wilson et al., 1995), performing an enterotomy (Honnas and Cohen, 1997), use of polyglactin 910 to suture the linea alba (Honnas and Cohen, 1997), using staples rather than suture material for skin closure (Torfs et al., 2010), anaesthetic duration > 110 min (Smith et al., 2007) and poor anaesthetic recovery (Freeman et al., 2012). Factors thought to reduce the incidence of incisional complications include using two rather

than three layers of sutures to close the abdomen (Colbath et al., 2014) and using a stent (Tnibar et al., 2013) or an abdominal bandage to cover the incision (Smith et al., 2007).

In a study by Costa-Farre et al. (2014), horses with intra-operative arterial blood oxygen tensions (PaO<sub>2</sub>) < 80 mmHg (10.6 kPa) were significantly more likely to develop post-operative incisional complications than those with PaO<sub>2</sub> ≥ 80 mmHg (10.6 kPa). A direct correlation has also been found between arterial and subcutaneous partial pressures of O<sub>2</sub> and incisional infection rates in human patients undergoing colorectal surgery (Greif et al., 2000). Higher rates of wound infection have been demonstrated in rabbits exposed to hypoxic conditions (14% inspired oxygen) for 21 days postoperatively, compared with normoxic conditions (21% inspired oxygen) (Hunt et al., 1975). We hypothesised that PaO<sub>2</sub> measured during anaesthesia would be associated with the development of post-operative incisional complications in horses.

## Materials and methods

### Inclusion criteria

Clinical records of horses admitted to the Philip Leverhulme Equine Hospital for investigation of colic from 1 January 2010 to 31 December 2013 were examined. Cases were included if they had undergone ventral midline coeliotomy for correction of gastrointestinal pathology and survived for at least 7 days post surgery. Any horses that underwent repeat coeliotomy, midline coeliotomy for a cause not related to the gastrointestinal tract, or where anaesthetic records did not include PaO<sub>2</sub> values,

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were excluded. Anaesthetic, surgical and post-operative management varied between cases and was determined by the anaesthetist and surgeon involved.

Ethical approval was granted from Veterinary Research Ethics Committee University of Liverpool, UK, on 15 October 2013, approval number VREC155.

#### Definitions

An incisional complication was defined as positive bacterial culture from an incision site swab and/or the presence of the following clinical signs: marked oedema at the incision site, purulent discharge from the incision site and hypoechoic areas around the incision site on ultrasonographic examination, with accompanying pyrexia.

#### Data collected

The following data were recorded from each case: age, body mass, breed, sex, heart rate (HR), packed cell volume (PCV) and total plasma protein concentration (TP) at admission, clinical signs of systemic inflammatory response syndrome (SIRS) at admission (defined as HR > 50 beats per min (bpm) and PCV > 0.5 L/L), American Society of Anesthesiologists (ASA) grade, pre-anaesthetic medication, anaesthetic induction and maintenance agents and peri-operative administration of antimicrobial agents. Intra-operative data included use of vasopressors and inotropes, fluid therapy, analgesic infusions, dexamethasone administration, mean arterial blood pressure (MAP), highest arterial partial pressure of carbon dioxide (PaCO<sub>2</sub>), lowest pH, lowest PaO<sub>2</sub> and duration of anaesthesia. Recovery score, anaesthetist, surgeon, whether surgery was performed out of hours, type of pathology, whether an intestinal resection and/or enterotomy was performed, suture materials for abdominal closure, presence of an incisional complication before discharge from the hospital and how this was defined were also recorded.

#### Anaesthetic and surgical technique

Anaesthetic protocol varied and was determined by the anaesthetist involved. After induction of anaesthesia, all horses had an orotracheal tube placed, were hoisted onto a padded operating table, positioned in dorsal recumbency and the endotracheal tube connected to a large animal circle breathing system. Inhalational anaesthetic agents were vaporised in 100% oxygen and all horses were mechanically ventilated throughout.

In all cases, the surgical site was clipped and prepared aseptically with chlorhexidine, followed by surgical spirit, and an adhesive drape was placed over the incision site. The pattern of abdominal closure and the suture material used to close the abdomen was determined by the surgeon involved; however, in all cases, suture material rather than staples were used to close the skin. All horses had an adhesive dressing and an abdominal bandage for recovery.

At the end of surgery, horses were disconnected from the anaesthetic breathing system, hoisted into a padded recovery box and positioned in right lateral recumbency. Oxygen was provided via a demand valve until extubation and subsequently at 15 L/min via a nasal tube. This was continued until horse head movement dislodged the tubing.

Until discharge from the hospital, incision sites were examined at least once daily. In horses showing clinical signs of infection, the decision to swab the incision site for bacterial culture and sensitivity was determined by the attending clinician.

#### Blood gas analysis

During anaesthesia, arterial blood samples were taken through a cannula placed in the mandibular branch of the facial artery, which also permitted invasive arterial blood pressure monitoring. Samples were collected anaerobically into heparinised syringes (PICO50; Radiometer) following withdrawal of approximately 1 mL of blood that was discarded, and analysed immediately using a bench top blood gas analyser (ABL77; Radiometer). The timing and frequency of blood gas analysis were not standardised, and the lowest recorded PaO<sub>2</sub> from each horse was used for data analysis.

#### Statistical analysis

Statistical analyses were performed using Minitab 16 (Minitab) and Stata 13 (StataCorp). Data were tested for normality using a Ryan–Joiner test. Parametric data are presented as means ± standard deviations (SDs); non-parametric data are presented as medians with interquartile ranges (IQR). Univariable analysis was performed with Pearson's  $\chi^2$  analysis for categorical variables and binary logistic regression for continuous variables. Variables with  $P < 0.2$  were offered to a multivariable logistic regression model, using both forwards and backwards stepwise entry, with a  $P$  value of 0.20 for entry and 0.21 for removal, although the final model chosen by both procedures was the same. The possible effect of the interaction of anaesthetic duration and PaO<sub>2</sub> was tested by forcing it into the final model. The statistical significance of entering terms into regression models was assessed by changes in the Likelihood Ratio and the Wald Statistic used to obtain the  $P$  value of coefficients in the model, together with their confidence intervals (CIs). A  $P$  value < 0.05 was considered to be significant.

## Results

Of 278 horses that met the inclusion criteria from 1 January 2010 to 31 December 2013 (Fig. 1), 89 (32%) developed an incisional complication; swabs were taken from 64 of these and all were positive on bacterial culture.

#### Demographic data

The ages of horses ranged from 2 months to 30 years, with a mean ± SD of 12.2 ± 5.7 years, which was not significantly different between groups. Body mass ranged from 48 to 750 kg, with a median of 532 (466–600) kg. The most commonly represented breeds were Thoroughbreds ( $n = 35$ ; 12.6%) and Cobs ( $n = 35$ ; 12.6%), followed by Welsh ponies ( $n = 33$ ; 11.9%) and Warmbloods ( $n = 31$ ; 11.2%); the remaining 144 horses consisted of multiple different breeds. There were 154 (55.4%) neutered males, 112 (40.3%) entire females and 12 (4.3%) entire males; these proportions were not significantly different between groups. The median pre-operative HR was 48 (40–60) bpm, the median PCV was 0.39 (0.34–0.43) L/L and the median TP was 68 (62–72) g/L; overall 21/278 (7.6%) horses had clinical signs of SIRS on presentation.

#### Anaesthetic and surgical management

Horses were graded ASA 4 or 5 in 89/278 (32%) cases. The most common pre-anaesthetic medication was xylazine and morphine (211/278; 75.9%). In 233/278 (83.8%) cases, anaesthesia was induced with ketamine and diazepam or midazolam. Maintenance of anaesthesia was with isoflurane (150/278; 54.0%), sevoflurane (126/278; 45.3%) or desflurane (2/278; 0.7%); none of these variables were significantly different between groups.

Peri-operative penicillin was used in 199/278 (71.6%) cases, while 44/278 (15.8%) cases received penicillin and gentamicin. Most horses, (242/278; 87%) were treated with vasopressors and/or positive inotropes due to hypotension; the agent most frequently administered was dobutamine (210/278; 75.6%). Drugs used were not

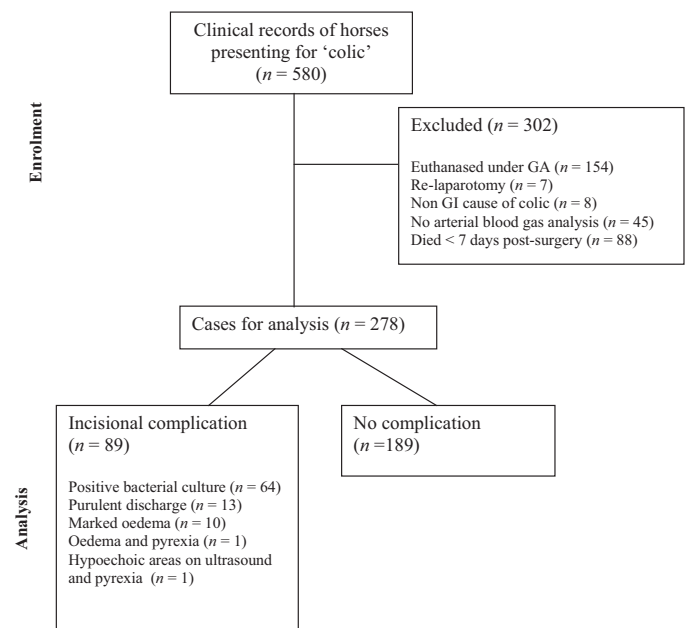


Fig. 1. Flow diagram of case enrolment and drop out. GA, general anaesthesia; GI, gastrointestinal.

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