Full thickness endotracheal tube defect resulting in an anaesthetic circuit leak

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Running head: Endotracheal tube circuit leak

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Summary

Background: Loss of endotracheal tube (ETT) integrity secondary to dental damage is reported in the human literature

Objective: To describe this problem in equine anaesthesia

Study design: Case report

Clinical summary: An 18-year-old standardbred gelding presented out of hours with colic signs. Findings on clinical examination and pain refractory to analgesia meant that exploratory

laparotomy was elected for. Prior to general anaesthesia (GA) leak testing of the anaesthetic machine was performed and the pilot balloon of the endotracheal tube (ETT) was inflated to confirm cuff integrity. Intermittent positive pressure ventilation (IPPV) was initiated immediately following placement in dorsal recumbency and connection to the anaesthetic machine. During the inspiratory phase of IPPV, a loud gas leak was audible from the oropharynx and minimal thoracic excursion was observed, with repeated inflations of the ETT cuff unsuccessful at abolishing the leak. Due to suspicion of a defect within the silicone ETT itself, a support arm was used to abolish curvature of the ETT, maintaining it in a straighter plane. This intervention abolished the leak allowing effective IPPV. After completion of GA, close inspection of the ETT revealed a full thickness laceration, thought to be a result of dental damage at an earlier date.

Main limitations: A single case is described

Conclusions: This report emphasises the importance of thorough inspection of the ETT prior to use to effectively secure the airway and enable IPPV provision in critical cases.

1. Introduction

Loss of endotracheal tube (ETT) integrity secondary to dental damage is reported in the human literature, risking the inability to mechanically ventilate the lungs and consequent hypoxaemia.[1,2] In this report we document a similar incident in a horse undergoing general anaesthesia (GA) for exploratory laparotomy, whereby suspected dental damage to the silicone tubing of the ETT initially impaired the ability to provide effective intermittent positive pressure ventilation (IPPV). In a study by Hovda et al. (2021), horses requiring emergency general anaesthesia (GA) for exploratory laparotomy had over six times the incidence of hypoxaemia when compared to horses undergoing GA for elective procedures.[3] Although no definite association between hypoxaemia and morbidity in anaesthetised horses has been identified, neurological impairment, skeletal muscle injury and impaired wound healing have all previously been attributed to hypoxia.[4-6] While ventilation strategies to improve the arterial partial pressure of oxygen (PaO2) are well described in the veterinary literature, this remains dependent on ETT

integrity.[7] In this reported case the full thickness defect to the silicone tubing of the ETT was not identified prior to use, necessitating temporary apposition of the lacerated edges intraoperatively to permit effective IPPV provision.

2. Case Report

An 18-year-old Standardbred gelding weighing 440 kg presented out of hours with acute onset colic signs of six hours duration. On presentation the horse had a heart rate of 80 beats per minute, respiratory rate of 32 breaths per minute, absent gut sounds on the right-hand side, and reduced gut sounds on the left-hand side. Abdominal palpation per rectum revealed caecal distension and tight caecal taeniae. Due to severe pain refractory to xylazine, flunixin and morphine administration, alongside abnormal clinical examination findings, surgical exploration was indicated.

Following induction of GA with 2.5 mg/kg ketamine and 0.05 mg/kg diazepam intravenously, the trachea was intubated with a size 28 mm internal diameter cuffed silicone ETT (Kruuse Ltd, Denmark) without complication. Following inflation of the ETT cuff with 30 ml of air the horse was hoisted into theatre and positioned into dorsal recumbency. The horse was connected to a large animal circle breathing system (Tafonius; Vetronic Services, UK), and GA was maintained with sevoflurane vaporised in oxygen. Prior to use, the anaesthetic machine had been thoroughly checked ensuring no leak. Mechanical ventilation of the lungs using volume control ventilation was immediately commenced, with tidal volume (VT) set at 5.0 litres and respiratory rate set at eight breaths per minute (bpm). On initiation of mechanical ventilation, a loud gas leak was audible on inspiration, with minimal thoracic excursion observed. Additional inflations of the ETT cuff were ineffective in eliminating the leak, with maintained inflation of the pilot balloon suggesting that loss of ETT integrity was due to another cause. The aboral aspect of the ETT was sprayed with a soapy solution but no air bubbles suggestive of a gas leakage were visualised. The horse spontaneously breathed at four bpm, during which time no leak was audible. However, a fresh gas flow (FGF) of 10 litres/minute was required to allow sufficient filling of the cylinder between breaths and ensure VT requirement was met.

Following a 20-minute period of spontaneous respiration, an arterial blood gas sample showed severe hypoxaemia [Arterial partial pressure of oxygen (PaO2) of 40 mmHg]. Due to ongoing suspicion of an ETT defect, a breathing circuit support arm was used to prevent the weight of the breathing system transferring to the ET tube. This intervention abolished curvature of the ETT, maintaining a straight plane. Consequently, it became possible to mechanically ventilate the lungs effectively for the remainder of GA, with no audible gas leakage and a VT of 6.0 litres resulting in a maximum peak inspiratory pressure of 30 mmHg. Furthermore, the FGF required for the remainder of the GA was significantly reduced at 3 litres/minute. Following repositioning of the ETT, commencement of mechanical ventilation, and treatment with aerosolised salbutamol (2 μg/kg), PaO2 increased to 221 mmHg over a 25-minute period. Exploratory laparotomy revealed a strangulating lipoma which had caused a 40 cm length of necrotic small colon. Due to the poor prognosis, alongside the owner not wanting to persevere with surgery if resection was required, the horse was euthanised. Following confirmation of death, the trachea was extubated, and the ETT inspected for damage. An 8 mm long full thickness defect running perpendicular to the length of the ETT was appreciated. The defect was positioned 16cm from the point of intersection between the silicone ETT and the blue rubber connector where the ETT attaches to the breathing system (Fig 1). Further partial thickness defects were also apparent on inspection of the ETT (Fig 1).

3. Discussion

In this case straightening of the ETT abolished the circuit leak, most likely due apposition of the laceration edges getting pushed together which closed the hole that was causing the leak. Although the cuff integrity was checked prior to intubation a close visual inspection was not performed, therefore it would be easy to overlook this defect. We hypothesise that, given the size and position of the ETT defect identified, damage arose from a tooth penetration of the ETT during a previous GA. Typically, as was the case in the described report, orotracheal intubation is performed using a PVC gag placed between the incisors. Should the gag become dislodged, contact of the ETT with incisor or canine teeth may result in damage. Alternatively, should the tube be manipulated via the interdental space without use of a gag, it is possible that the ETT

could contact the occlusal surface of premolars or molars, where sharp hooks may be present. When a horse is at risk of airway obstruction, recovery from GA with the ETT in situ may be required, whereby there is the risk of the horse biting on the tubing and creating a defect. At this institution, silicone ETTs are re-used following cleaning and disinfection, meaning damage to the ETT is likely to have occurred at an earlier date.

Reports of human patients inadvertently biting on ETTs *in situ* and causing partial circumferential damage has resulted in hypoxaemia and impairment of mechanical ventilation.[1,2] Temporary resolution of ETT defects identified in situ have been achieved through digital occlusion, use of cyanoacrylate glue or passage of an ETT of a narrower diameter through the lumen of the damaged one.[1,2,8]

While reintubation of the trachea may be possible, this is dependent on patient positioning and the risk of aspiration of gastric contents. In the case described here reintubation was not attempted due to the difficulty of replacing an ETT while a horse is in dorsal recumbency. This case demonstrates the importance of thorough inspection of ETTs prior to use, particularly in veterinary practice, where their re-use is commonplace.

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