Introduction

Endotracheal intubation is commonly performed in horses undergoing general anaesthesia to provide oxygen, inhalation anaesthetic agents and other drugs. Moreover, an adequate seal must be obtained to provide mechanical ventilation and avoid fluid aspiration or environmental pollution with inhalant anaesthetics. Oedema and haemorrhage of the laryngeal and tracheal mucosa, and tracheal stenosis and perforation have been reported secondary to orotracheal intubation in horses (Heath et al. 1989, Touzot-Jourde et al. 2005, Saulez et al. 2013, Wylie et al. 2015). Consequences of these may be fatal (Rainger et al. 2006, Wylie et al. 2015). In one study, 95% and 85% of orotracheally intubated horses showed damage of the tracheal and laryngeal mucosa, respectively; but these lesions were classified as mild and resolved without treatment within 24 hours after extubation (Heath et al. 1989).

This case report describes successful treatment of a horse with laryngeal and tracheal trauma secondary to intubation during myelography and underscores the importance of monitoring carefully these horses for development of pneumonia.

Case history

A 10-year-old Warmblood mare weighing 608kg was admitted to the Royal Veterinary College hospital for investigation of poor performance and suspected intermittent hindlimb ataxia. A neurologic examination performed at the time of admission identified mild hypermetria in all 4 limbs but was otherwise unremarkable. No ataxia was observed. The orthopaedic exam was unremarkable.

Due to concerns over reports of intermittent ataxia and the implications for rider safety, the owner elected for the mare to undergo head and cervical spine computed tomography (CT) and myelography under general anaesthesia. The pre-anaesthetic evaluation showed that the mare was bright and alert, in a good body condition score (6/9) with normal thoracic auscultation, respiratory rate, heart rate and rectal temperature. Premedication consisted of acepromazine (Tranquinervin)[1] 0.02 mg/kg intramuscularly and flunixin meglumine (Pyroflam)[2] 1.1 mg/kg intravenously one hour and a half before the procedure. Then, the horse was premedicated with romifidine (Sedivet)[3] 0.08 mg/kg intravenously. At this point, the mouth was rinsed with water

[1]Le Vet. Beheer B.V, Dordrecht, The Neederlands
[2] Norbrook Laboratories Limited, Northern, Ireland.
[3] Boehringer Ingelheim Ltd, Bracknell, Berkshire, UK.

until clean. General anaesthesia was induced with ketamine (Ketamidor)[4] 2.5 mg/kg and midazolam (Dormazolam)[5] 0.05 mg/kg intravenously. Once recumbent, the mare was intubated with a lubricated 30 mm silicone tube and the cuff was inflated with a 30 ml syringe until the indicator balloon felt firm to palpation. Then the horse was hoisted onto the CT table, placed in left lateral recumbency, connected to a large animal anaesthetic machine, and inhalational anaesthesia with isoflurane in oxygen and medical air was initiated. At this point, a large persistent leak was identified despite attempts to inflate the endotracheal tube cuff. The mare was extubated and reintubated with a lubricated 26mm endotracheal tube. The initial endotracheal tube used showed a torn cuff. The mare was hoisted and repositioned several times until satisfactory position for the CT scan was obtained meanwhile it was kept connected to the anaesthetic machine. The horse was monitored with electrocardiogram, invasive blood pressure, end tidal carbon dioxide, end tidal isoflurane concentration, inspired fraction of oxygen, arterial blood gas analysis and airway pressures. Arterial blood gas analysis revealed inadequate partial pressure of Oxygen [PaO_2 79 mmHg (FiO_2 72%)] which was successfully corrected with a stepwise alveolar recruitment manoeuvre and 100 micrograms salbutamol (Ventolin)[6] inhaled via the Y-piece salbutamol port. Dobutamine[7] was used to maintain mean arterial blood pressure above 60 mmHg. Following completion of the CT scan and myelography, flexed and extended radiographs of the neck were obtained. The mare was then hoisted into the recovery box, where the endotracheal tube cuff was deflated. Once nystagmus appeared, romifidine (Sedivet)[3] 0.02 mg/mg intravenously was administered. The mare was extubated when swallowing reflex was present. Recovery occurred uneventfully.

CT showed bilateral enlargement of the articular process joints of C4-C5, C5-C6 and C6-C7, with mild osteophyte formation and sclerosis of the subchondral bone. Mild enlargement of the articular process joints of C2-C3 and C3-C4 was also noted. There was no evidence of spinal cord compression. Figure 1 shows the position of the endotracheal tube cuff during CT scan.

Clinical findings

[4] Richter Pharma AG, Wels, Austria.
[5] Le Vet. Beheer B.V, Dordrecht, The Neederlands.
[6] Glaxo Wellcome Production, Evreux, France.
[7] Hameln pharma ltd, Gloucester, UK

Approximately 24 hours after general anaesthesia a persistent cough was noted, whilst the vital parameters were unremarkable. Thoracic ultrasound identified an increased number of comet tails and mild consolidation in both cranioventral lung fields consistent with pneumonia. Upper airway endoscopy was performed, showing laryngitis with moderate to marked inflammation and erosions extending caudally into the trachea for approximately five cartilage rings. These lesions were symmetrical and localised at 8 o'clock to 10 o'clock and the 3 o'clock to 5 o'clock position.

Diagnosis

Laryngitis and moderative to severe erosive tracheitis with secondary pneumonia.

Treatment

The mare was treated with flunixin meglumine 1.1 mg/kg (Pyroflam)[2] intravenously every 24 hours, doxycycline[8] 10 mg/kg orally every 12 hours for five days and a single dose of dexamethasone (Colvasone)[9] 0.1 mg/kg intravenously. The following day, flunixin meglumine (Pyroflam)[2] was discontinued and phenylbutazone (Equipalazone)[10] 2.2mg/kg orally every 12 hours was started.

Outcome

The mare remained bright and normothermic over the following 72 hours. Upper airway endoscopy and thoracic ultrasonography showed a marked improvement of the laryngeal and tracheal inflammation with resolution of the previously identified consolidation in the cranioventral lung fields. The mare was discharged from the hospital four days after general anaesthesia, at which time the cough had resolved.

Discussion

The most common cause of pneumonia in adult horses is aspiration of microorganisms inhabiting the nasopharynx or oral cavity. However opportunistic bacteria can colonize the lungs when pulmonary defence mechanisms are compromised, by, for example, general anaesthesia (Reuss and Giguere, 2015). Moreover, intubation results in enhanced capacity of gram-negative bacteria to bind tracheobronchial cells, favouring colonization and pneumonia. Injured airway creates binding sites for bacteria in the

[8] Bova Compounding, Caringbah, Australia.
[9] Norbrook Laboratories Ltd, Corby, UK.
[10] Dechra Limited, Skipton, UK

bronchial tree and mucus production creates potential sites for bacterial adherence (Levine 1991, Raidal 1995, Rainger et al. 2006).

Laryngeal trauma is common after orotracheal intubation. In one study laryngeal trauma occurred in 35 out of 38 intubated horses (Heath et al. 1989). Of those horses, 92% had mild to moderate focal mucosal ecchymosis but these lesions improved 24 hours after extubation without intervention. The case presented by the authors had to be reintubated because a persistent leak was identified. Likely, the endotracheal tube cuff was ripped by the teeth during intubation. Although no studies have evaluated the consequences of reintubation, the degree of difficulty placing the tube has not been associated with increased laryngeal and tracheal damage (Heath et al. 1989). Therefore, we considered less likely that re-intubation was the cause of the extensive lesions found in the laryngeal and tracheal mucosa.

Tracheal damage after intubation is reported in horses (Touzot-Jourde et al. 2005, Saulez et al. 2013, Wylie 2015, Miller and Auckburally 2018). Tracheal necrosis is related to a reduction of the capillary blood flow in the tracheal mucosa and has been associated with fatality due to secondary tracheal stenosis and infection (Wylie et al. 2015) and pleuropneumonia (Rainger et al. 2006). There are several causes for tracheal damage including use of large endotracheal tubes, over-inflation of the endotracheal cuff, positioning of the endotracheal cuff near the thoracic inlet, changes in the position of the horse's neck with the endotracheal cuff inflated and chemically induced injuries (Burns 2019). In this case report, movement of the endotracheal tube was considered as the most likely cause of the tracheal damage due to the extension, location and symmetry of the lesions. However, cuff inflation or overinflation could have also played a role. In humans, movement of the endotracheal tube during patient head and neck positioning is described (Yap et al. 1994, Tailleur et al. 2016). In one study, a 30 degrees flexion from neutral position moved the tip of the endotracheal tube an average of 5.5 mm closer to the carina, while a 30 degrees extension moved the endotracheal tube an average of 6.3 mm away from the carina (Yap et al 1994). One study in dogs found that flexion and hyperextension of the neck leads to movement of the endotracheal tube within the trachea up to four vertebral spaces (Quandt et al. 1993). Moreover, extension of the neck causes an increase of length of the trachea and a decrease of the cross-sectional axis, increasing the appositional forces between the tracheal mucosa and cuff wall (Burns 2019). Additionally, in dogs, movement of the endotracheal tube can also lead to endobronchial intubation, and laryngeal and tracheal

damage due to the shearing forces between the tracheal mucosa and cuff wall (Quandt et al. 1993). Movement of the endotracheal tube in the adult horse is unlikely to cause endobronchial intubation due to relative length of endotracheal tube compared to tracheal length. One case report described tracheal lesions and pleuropneumonia leading to fatality after myelography in a horse (Rainger et al. 2006). The authors also postulated that the extension and flexion of the neck during myelography were the cause of the tracheal damage. Differences exist with our case report as our diagnosis was performed antemortem based on diagnostic findings and clinical signs, location and distribution of the tracheal damage and clinical outcome. The use of endotracheal tubes has been linked to tracheal damage when cuffs are inflated until a seal is obtained during mechanical ventilation or even when low cuff inflation pressures have been used (Heath et al. 1989, Touzot-Jourde et al. 2005). Therefore, we cannot conclude if cuff movement or cuff inflation, or a combination of both, were the main cause of the tracheal damage.

One study evaluated the effect of two different endotracheal tubes on tracheal trauma (Heath et al. 1989). The majority of the horses (95%) intubated with a cuffed endotracheal tube showed tracheal lesions. These lesions were mainly from 1 to 1.5 cm^2 in the ventral tracheal wall, while lesions in dorsal and lateral tracheal wall were rarely reported (Heath et al. 1989). Larger lesions, 10 to 15 cm, were found at the level of the endotracheal tube cuff. The use of cuffless endotracheal tubes, was also associated to the presence of tracheal (83%) and laryngeal (100%) damage. In the case presented here, lesions were found caudal to the larynx in a symmetric shape, being compatible with the endotracheal tube cuff position and shape.

In the author's institution silicone tubes are used. These endotracheal tube cuffs are classified as low volume-high pressure. In this type of cuffs measurement of the endotracheal tube cuff pressure does not equal the tracheal wall pressure, and devices used to measure intracuff pressure are not useful to estimate the tracheal wall pressure (Muir and Hubbell 2009). One study that used similar silicone tubes than in this case report evaluated the relationship between tracheal damage and intra-cuff pressures, reported mild epithelial attenuation and erosion as the most common lesion in the trachea of horses in which the endotracheal tube cuff was inflated to seal a leak with cuff pressures varying between 80-100 cm H_2O, and more severe damage with intra-cuff pressures of 120 cm H_20 (Touzot-Jourde et al. 2005). Therefore, we consider unlikely that cuff over-inflation caused the extensive and severe tracheal damage, as the

cuff was inflated, in the second intubation, until a leak was sealed to allow mechanical ventilation. Moreover, both endotracheal tubes were checked prior to induction of general anaesthesia and no abnormalities were detected in the cuff inflation or shape.

As routine protocol in our institution, the endotracheal tube is cuffed after intubation until the pilot balloon feels firm. The cuff is further inflated if a leak is detected during mechanical ventilation. Once general anaesthesia is finished, horses are hoisted to the recovery box with the cuff inflated to avoid aspiration of gastrointestinal content. Once in the recovery box, the cuff is deflated. It has been shown that pilot balloon palpation is an inaccurate way of assessing the cuff inflation in dogs, and monitoring cuff pressures with a manometer is recommended (Briganti et al. 2012).

In order to avoid the tracheal damage induced by movement of the cuffed endotracheal tube, the animal could have been disconnected from the anaesthetic machine and the cuff deflated for hoisting or neck flexion and extension. During this period of time, total intravenous anaesthesia could have been used to maintain general anaesthesia.

Pneumonia was diagnosed based on clinical signs and thoracic ultrasonography. Whilst tracheal wash and culture is recommended, it was not performed in this case as the horse improved following empirical administration of doxycycline. Doxycycline was selected as it has good penetration and concentration in lung tissue and has broad spectrum activity against respiratory pathogens (Womble et al., 2007). Anti-inflammatory drugs are also recommended for the treatment of pneumonia (Wilkins and Lascola, 2015). In this case, phenylbutazone was administered due to its anti-inflammatory, analgesic and antipyretic properties. A single dose of dexamethasone was given to suppress tracheal inflammation and ameliorate the cough.

Conclusions:

Orotracheal intubation is recommended and commonly performed in horses. Tracheal and laryngeal trauma is not uncommon and this may lead to pneumonia. Horses should be monitored closely for signs of tracheal and laryngeal trauma after general anaesthesia for myelography.

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