

## Anesthetic management of a pregnant broodmare with gastrointestinal colic

### *Anesthesie van een drachtige fokmerrie met gastro-intestinale koliek*

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## ABSTRACT

Gastrointestinal colic in mares during early pregnancy may require general anesthesia for surgical correction. There is a scarcity of literature identifying anesthetic risk factors associated with negative outcome in the pregnant mare. In this case report, a seven-year-old Thoroughbred broodmare, presenting for the investigation and treatment of colic in the fifth month of pregnancy, underwent surgery for the correction of right dorsal displacement of the large colon. Intraoperatively, interventions for maternal hypoxemia and hypotension were necessary. The mare recovered well from general anesthesia and was discharged from the hospital eleven days postoperatively. In this case report, the successful anesthetic management of a pregnant broodmare is described, and all aspects that may improve the outcome for both mare and fetus are considered, with emphasis on the prevention of cardiovascular and respiratory disturbances.

## SAMENVATTING

Voor gastro-intestinale koliek bij merries vroeg in de dracht kan algemene anesthesie voor chirurgische correctie vereist zijn. Er is weinig literatuur beschikbaar waarin de risicofactoren van anesthesie met negatieve gevolgen voor de drachtige merrie beschreven worden. In de voorliggende casuïstiek worden het onderzoek en de behandeling van koliek beschreven bij een zevenjarige volbloed fokmerrie in de vijfde maand van haar draagtijd. De merrie onderging een chirurgische ingreep voor de correctie van een rechter dorsale verplaatsing van de dikke darm. Intraoperatief waren er interventies noodzakelijk voor maternale hypoxemie en hypotensie. De merrie herstelde goed van de algemene anesthesie en werd elf dagen postoperatief ontslagen uit de dierenkliniek. In deze gevalstudie wordt het succesvolle anesthesiebeheer bij een drachtige fokmerrie beschreven. Verder worden alle aspecten overwogen die de prognose voor zowel de merrie als de foetus kunnen verbeteren, met nadruk op de preventie van cardiovasculaire- en ademhalingsstoornissen.

## INTRODUCTION

Causes of colic in mares during early stage pregnancy are typically related to the gastrointestinal system, whereas uterine tears or torsions more commonly occur in late gestation (Southwood, 2013). Broodmares suffering from gastrointestinal related colic in early pregnancy are frequently diagnosed with impaction, displacement or torsion of the large colon (Boening and Leendertse, 1993; Steel and Gibson, 2001), and may require surgical treatment. In a retrospective analysis by Chenier and Whitehead (2001) of

pregnant mares with colic, it has been shown that the incidence of a negative pregnancy outcome was 3.5 times greater for horses undergoing surgery compared to medical management alone. Although surgery is sometimes unavoidable, it is necessary to consider the potential risks of general anesthesia (GA) to both the mare and developing fetus.

In a retrospective study by Drumm et al. (2013) with 228 Thoroughbred pregnant mares undergoing colic surgery, it has been identified that a young age (mares  $\leq 15$  years old) and a later stage of gestation ( $\geq 40$  days long) were factors that resulted in an improved

prognosis for a live foal. In other studies, additional risk factors during GA have been demonstrated. Firstly, hypoxic mares under GA during the last sixty days of gestation all aborted or birthed non-viable foals (Santschi et al., 1991); prior to this period, intraoperative hypoxia did not affect pregnancy outcome. In addition, intraoperative hypotension and duration of GA (> 3 hours) are considered to be significant risk factors for negative pregnancy outcome (Chenier and Whitehead, 2001).

The potential for GA to induce and exacerbate pre-existing cardiovascular and respiratory disturbances may be particularly relevant in pregnancy when the mare's physiological status has already been altered to support foetal development. The existing evidence suggests that the fetus may be particularly sensitive to compromised perfusion secondary to maternal hypotension (Chenier and Whitehead, 2001), in addition to incidences of maternal hypoxia occurring during late gestation (Santschi et al., 1991). When GA of the pregnant broodmare is unavoidable, consideration should be given to the potential impact of altered maternal hemodynamics and blood gas variables on the fetus. Anesthetics and analgesics undergoing placental transfer can additionally result in direct physiological effects on the fetus (Luukkanen et al., 1997).

In this case report, the successful anesthetic management of a pregnant broodmare requiring surgery for large colon displacement is described. Additionally, the potential peri-anesthetic risks that the mare and fetus may be exposed to and the appropriate interventions that may be made in the event of their occurrence are considered.

## CASE

A seven-year-old Thoroughbred broodmare weighing 555 kg was referred to The Royal (Dick) Equine Hospital, The University of Edinburgh, following acute onset of colic signs of approximately one-and-a-half-hours' duration, including brief periods of recumbency. The mare presented out of hours and was five months in foal, while also accompanied by its healthy four-month-old Thoroughbred filly at foot. Despite receiving 1.1 mg kg<sup>-1</sup> flunixin meglumine (Flunixin Injection 50 mg mL<sup>-1</sup>, Norbrook, Newry, UK) intravenously by the referring veterinary surgeon, on arrival, the mare continued to exhibit clinical signs of colic. Clinical examination revealed a heart rate of 44 beats minute<sup>-1</sup> (bpm) with matching pulses of moderate strength and a respiratory rate (RR) of 20 respirations minute<sup>-1</sup> (rpm). Mucus membranes were pink and tacky, with a capillary refill time of < 2 seconds. Cardiopulmonary auscultation revealed no abnormalities, although abdominal auscultation identified absence of gastrointestinal borborygmi in all four quadrants. Rectal temperature was 37.3°C. The results from venous blood sample collection revealed a

packed cell volume (PCV) of 46%, total protein (TP) of 78 g L<sup>-1</sup> and systemic lactate of 1.1 mmol L<sup>-1</sup>.

Following the placement of an intravenous catheter in the left jugular vein, the mare was administered 0.3 mg kg<sup>-1</sup> hyoscine N-butylbromide (Buscopan Compositum 20 mg mL<sup>-1</sup>, Boehringer Ingelheim, Berkshire, UK). Consecutive administration of 0.6 mg kg<sup>-1</sup> xylazine (Chanazine 100 mg mL<sup>-1</sup>, Chanelle Pharma, Berkshire, UK) intravenously facilitated diagnostic procedures. Findings made on abdominal ultrasound and per rectal palpation resulted in a diagnosis of right dorsal displacement of the large colon with tympanic distension and impaction. Initial lunging of the mare resulted in moderate improvement of gastrointestinal sounds and the mare was placed in the intensive care unit (ICU) for close monitoring, with administration of a 30 ml kg<sup>-1</sup> lactated Ringer's (Aquapharm No.11, Animalcare, York, UK) bolus. Despite an initial attempt to manage the case medically, the mare continued to display clinical signs of severe colic, including ongoing periods of recumbency, and the decision to perform an exploratory abdominal celiotomy was made. Procaine penicillin (Depocillin 300 mg mL<sup>-1</sup>, MSD Animal Health, Milton Keynes, UK) was administered intramuscularly at a dose of 22,000 IU kg<sup>-1</sup> and 6.6 mg kg<sup>-1</sup> gentamicin (Genta-Equine 100 mg mL<sup>-1</sup>, Dechra Veterinary Products, Shropshire, UK) was administered intravenously via the jugular catheter.

On arrival to the induction box with the accompanying foal, sedation of the mare was achieved with 0.01 mg kg<sup>-1</sup> detomidine (Medesedan 10 mg mL<sup>-1</sup>, Virbac, Suffolk, UK) and 0.11 mg kg<sup>-1</sup> morphine (Morphine sulphate 30 mg mL<sup>-1</sup>, Martindale Pharma, Buckinghamshire, UK) intravenously, resulting in mild ataxia. The accompanying foal was administered 0.01 mg kg<sup>-1</sup> detomidine (Medesedan 10 mg mL<sup>-1</sup>, Virbac, Suffolk, UK) intravenously prior to being returned to the ICU box. Following the onset of adequate sedation, the mare was positioned against one wall of a padded induction box and restrained with a swing gate. Ten minutes following sedation, GA was induced with the combined intravenous administration of 2.4 mg kg<sup>-1</sup> ketamine (Ketamidol 100 mg mL<sup>-1</sup>, Chanelle Pharma, Berkshire, UK) and 0.06 mg kg<sup>-1</sup> diazepam (Diazepam injection 5 mg mL<sup>-1</sup>, Hameln Pharmaceuticals, Gloucester, UK). Once in right lateral recumbency, the trachea was intubated with a cuffed 26 mm endotracheal tube and the mare was subsequently hoisted into theatre, being positioned in dorsal recumbency onto a padded surgical table. General anesthesia was maintained with sevoflurane vaporized in oxygen, delivered via a circle breathing system (Tafonius, Vetronic Services, Devon, UK), with end tidal sevoflurane concentration between 2.2% and 2.5% throughout anesthesia.

Intermittent positive pressure ventilation (IPPV) was started immediately and GA maintained for 140 minutes, with an initial RR set at 8 rpm and tidal vol-

ume (VT) of five litres and peak inspiratory pressures ranging between 18 - 25 cmH<sub>2</sub>O. Lactated Ringer's solution (Aquapharm No.11, Animalcare, York, UK) was administered intravenously at a rate of 15 ml kg<sup>-1</sup> hour<sup>-1</sup> and an indwelling urinary catheter was placed, with a total volume of ten litres urine collected during GA. Anesthetic monitoring consisted of end tidal inhalational agent, fraction of inspired oxygen (F<sub>I</sub>O<sub>2</sub>), capnography, pulse oximetry, electrocardiogram and invasive arterial blood pressure measurements from the transverse facial artery.

Immediately following the positioning of the mare into dorsal recumbency, blood gas analysis revealed a moderately low partial pressure of arterial oxygen (PaO<sub>2</sub>) of 86 mmHg (11.5 kPa) (Table 1, Sample A). As part of the ventilation strategy, RR was increased to 12 rpm and VT to six litres, resulting in an increase of PaO<sub>2</sub> to 155 mmHg (20.7 kPa) over a thirty-minute period and prior to commencing surgery (Table 1, Sample B). Hemoglobin oxygen saturation (SaO<sub>2</sub>), which had previously been 94% at the start of GA, increased and was subsequently maintained at 97-98% (Table 1, Samples B and C). Over the initial thirty minutes of GA, during surgical preparation time, mean arterial pressure (MAP) reduced from 90 mmHg to 65mmHg. Intravenous administration of dobutamine (Dobutamine concentrate 12.5 mg, Hameln Pharmaceuticals, UK) as a continuous rate infusion (CRI) was commenced at rates of between 0.3 - 0.4 mcg kg minute<sup>-1</sup> and this was administered for the duration of GA, maintaining MAP values between 60 - 80 mmHg (Table 1).

Exploratory abdominal celiotomy confirmed right dorsal displacement of the large colon, which was observed to be edematous and immotile. Following careful exteriorization of the caudal portion of the large colon, enterotomy was performed at the pelvic flexure to allow evacuation of impacted content within the large colon. Following the closure of the abdominal incision, a stent was placed to protect the incision wound. At the end of surgery, the mare was observed to have developed significant edema of the ocular and nasal mucous membranes. Ten minutes prior to moving the mare to recovery, a total volume of 10 ml phenylephrine 1 mg mL<sup>-1</sup> (Minims phenyl-

ephrine hydrochloride, Bausch & Lomb, Surrey, UK) was administered intranasally bilaterally using an atomizer device. At this timepoint, an additional bolus of 0.11 mg kg<sup>-1</sup> morphine was also administered intravenously.

After weaning off the ventilator, achieved by a reduction in RR, and confirming resumption of spontaneous ventilation, the mare was hoisted to a padded recovery box and positioned into left lateral recumbency. Oxygen was supplied at 15 L minute<sup>-1</sup>, initially via the endotracheal tube and continued after ten minutes via the ventral meatus, following tracheal extubation. Recovery was assisted using head and tail ropes, with the mare making an initial attempt to stand after 45 minutes, although becoming recumbent again due to moderate ataxia. The mare was successful on the second attempt to stand, at which point the mare was reintroduced to the foal within the recovery box before returning to the ICU unit for postoperative monitoring.

One day postoperatively, tachycardia (HR 52 bpm) with a concurrent mild hemoconcentration (PCV 44 %) and a significant hypoproteinemia (TP 46 g L<sup>-1</sup>) on a venous blood sample was identified and abdominal ultrasonography showed marked edema of the large colon. Commencement of fluid therapy, consisting of 4 ml kg<sup>-1</sup> 6% hydroxyethyl starch (Voluven, Fresenius Kabi, Cheshire, UK) BID and 4 ml kg<sup>-1</sup> hour<sup>-1</sup> lactated Ringer's solution (Aquapharm No.11, Animalcare, York, UK), in combination with 1.1 mg kg<sup>-1</sup> flunixin (Flunixin Injection 50 mg mL<sup>-1</sup>, Norbrook, Newry, UK) intravenously resulted in resolution of the observed clinical signs and reduction in large colon edema. During ultrasonographic assessment, the fetus was identified to have an elevated heart rate of approximately 200 bpm, suggestive of fetal stress, although this reduced to within normal limits over the following four days. During hospitalization, the mare received 0.05 mg kg<sup>-1</sup> altrenogest (Regumate Equine 2.2 mg mL<sup>-1</sup>, MSD Animal Health, Buckinghamshire, UK) per os SID, a continuation of a course of medication started prior to presentation. Procaine penicillin 22,000 IU kg<sup>-1</sup> intramuscularly BID and 6.6 mg kg<sup>-1</sup> gentamicin SID were continued for four days postoperatively, with a subsequent change to a ten-day oral

**Table 1. Arterial blood gas results displaying an improvement in partial pressure of arterial oxygen (PaO<sub>2</sub>) values following an increase in minute volume settings during intermittent positive pressure ventilation (IPPV). Abbreviations: pH, arterial; PaCO<sub>2</sub>, partial pressure of arterial carbon dioxide; PaO<sub>2</sub>, partial pressure of arterial oxygen; BE, base excess; SaO<sub>2</sub>, hemoglobin oxygen saturation; HCO<sub>3</sub><sup>-</sup>, bicarbonate.**

Sample	Time sample taken from anesthetic induction (minutes)	Arterial/Venous	pH	PaCO <sub>2</sub> (mmHg)	PaO <sub>2</sub> (mmHg)	BE (mmol L <sup>-1</sup> )	SaO <sub>2</sub> (%)	HCO <sub>3</sub> <sup>-</sup> (mmol L <sup>-1</sup> )
A	10	Arterial	7.29	66	86	2.8	94	31.3
B	32	Arterial	7.33	61	155	4.3	98	31.8
C	75	Arterial	7.29	64	114	2.3	97	30.5

course of 50g trimethoprim potentiated sulfadiazine (Trimediazine Plain, Vetoquinol, UK) BID on day 5. Slow reintroduction of feeding was started from 24 hours postoperatively, increasing from quarter to full forage rations over a five-day period. Throughout hospitalization, the mare continued to successfully nurse the foal and both were discharged eleven days postoperatively. Two weeks following discharge, the mare was euthanized due to recurrence of severe colic signs unresponsive to analgesia, with the owner declining further diagnostic investigation.

## DISCUSSION

In the present case report, the importance of considering the pharmacological effects of sedative and anesthetic agents on the pregnant mare and their potential consequences for the fetus is highlighted. In addition, the occurrence of common anesthetic complications, such as hypoxemia and hypotension, have the potential to negatively impact the fetus. The predominant aim of peri-anesthetic management in this case was to try and prevent exposure of both mare and fetus to pathophysiological disturbances.

The tolerance of the equine fetus, at the varying stages of development, to both maternal cardiovascular and respiratory disturbances has not been ascertained. Only the existing veterinary evidence on risk factors for negative pregnancy outcome in the pregnant mare may provide some guidance to manage anesthesia in the broodmare (Santschi et al., 1991; Chenier and Whitehead, 2001; Drumm et al., 2013). Additional considerations in this case were the stressors associated with recent transportation, an unfamiliar environment and separation from companions (Schulman et al., 2014), including the mare's foal in this case, as well as the side effects of an effective sedation (alpha-2 agonist-based) as an essential component of anesthetic management.

Detomidine was the selected alpha-2 agonist. Apart from their cardiopulmonary effects, this group of drugs might have an effect in the reproductive system, specifically altering uterine tone. Intravenous administration of both xylazine and detomidine have been demonstrated to increase myometrial activity in the non-pregnant mare (Gibbs and Troedsson, 1995). Contractions of the myometrium during pregnancy are a concern as they increase intrauterine pressure and reduce uterine perfusion, potentially compromising fetal viability (LeBlanc et al., 1984). In non-pregnant mares, intravenous administration of 1.1 mg kg<sup>-1</sup> xylazine, 40 mcg kg<sup>-1</sup> detomidine and 80 mcg kg<sup>-1</sup> romifidine demonstrated increases in intrauterine pressure of 74.1%, 48.1% and 39.8%, respectively (Schatzmann et al., 1994). While no evidence exists to support the safety of alpha-2 agonist administration during pregnancy, detomidine was selected in this reported case. In a study by Luukkanen et al. (1997), intravenous administration of 15 mcg kg<sup>-1</sup> detomidine

at three-week intervals to mares in their final trimester of pregnancy induced both maternal and fetal bradycardia, although this did not result in detrimental effects on pregnancy outcome. Furthermore, in a study by Jedruch et al. (1989), intravenous doses of detomidine ranging from 20 - 40 mcg kg<sup>-1</sup> had no association with abortion in mares during the final trimester of pregnancy.

In order to provide analgesia through a multimodal approach, morphine was administered in combination with detomidine in the present case. Although the low molecular weight and lipid solubility of opioids permit their passage across the placenta, fetotoxic effects in domestic animals have not been reported (Taylor, 1997) and their short-term use is unlikely to be detrimental (Mathews, 2008). The developing fetus has a reduced and immature hepatic metabolism, meaning opioid elimination is reliant on diffusion of the drug back into maternal circulation (Taylor, 1997). In human medicine, the use of lower but more frequently administered doses of opioids during pregnancy has been suggested to limit placental transfer of drug through a reduction in the maternal fetal opioid concentration gradient (Phillips et al., 2017), a concept that may be implemented in veterinary medicine through administration of the lowest effective dose of any given agent.

Although its use was initially considered, lidocaine was not included as part of the multimodal analgesic plan in the present case. Reported benefits of administration of this local anesthetic in colic surgery include anti-inflammatory, prokinetic and anesthetic sparing effects (Dzikiti et al., 2003; Torfs et al., 2009; Peiro et al., 2010). Lidocaine is only moderately protein bound and while increases in free systemic drug have been detected during pregnancy in humans, hepatic clearance is high and hence elimination should be unaffected (Fragneto et al., 1994; Lin, 1995). Currently however, no veterinary evidence to determine the safety of fetal exposure to lidocaine is available and care should be taken to avoid fetal hypoxia, as consequential reductions in pH may cause accumulation of this weak base within the fetus through the process of ion trapping (Griffiths and Campbell, 2015). In this case, lidocaine was not used mainly due to the potential detrimental effects of lidocaine constant rate infusions on equine recoveries. Although discontinuing its administration thirty minutes prior to recovery can avoid poor quality, ataxic recoveries (Valverde et al., 2005), this side effect of lidocaine might be exacerbated in pregnant mares (Maney and Quandt, 2012; Nannarone et al., 2015).

In this reported case, 1.1 mg kg<sup>-1</sup> flunixin meglumine was administered five hours prior to GA, which was continued once daily for five days postoperatively. While administered for its anti-inflammatory effects, a previously suggested advantage of flunixin meglumine is the inhibition of endotoxin induced production of endometrial prostaglandin F<sub>2</sub> alpha, preventing the lysis of progesterone secreting corpus lu-

**Table 2. Equation for calculation of oxygen delivery (adapted from Hubbell and Muir, 2015). Abbreviations: DO<sub>2</sub>, oxygen delivery (ml minute<sup>-1</sup>); CO, Cardiac output (L minute<sup>-1</sup>); 1.36, oxygen carrying capacity of hemoglobin (ml O<sub>2</sub> g<sup>-1</sup> Hb); [Hb], hemoglobin concentration (g 100 ml<sup>-1</sup> blood); SaO<sub>2</sub>, hemoglobin oxygen saturation (%); PaO<sub>2</sub>, arterial partial pressure of oxygen (mmHg); 0.003, ml of O<sub>2</sub> dissolved per 100 ml plasma).**

$$DO_2 = CO + ((1.36 \times [Hb] \times SaO_2) + (PaO_2 \times 0.003))$$

teum (Santschi et al., 1991; Boening and Leendertse, 1993). Although Santschi et al. (1991) identified endotoxemia as being a risk factor for negative pregnancy outcome, Chenier and Whitehead (2001) did not find any association between mares treated with flunixin meglumine and pregnancy outcome. Other drugs suggested to aid in the maintenance of pregnancy include exogenous progesterone (altrenogest in this report), although similarly to flunixin meglumine, supplementation does not alter foaling rate (Chenier and Whitehead, 2001). While some evidence exists to support altrenogest administration in cases of suspected progesterone deficiency secondary to endotoxemia and placentitis (Daels et al., 1991; Bailey et al., 2010), prescription of altrenogest in this reported case was on a prophylactic basis following the mare's initial exhibition of colic signs prior to referral.

Hypotension is a predominant concern during colic surgery, with the presence of distended gastrointestinal tract risking aortocaval compression following positioning into dorsal recumbency, a clinical scenario, which is worsened in the pregnant mare with a gravid uterus. Pressure of abdominal contents on the vena cava limits venous return with a consequent reduction in stroke volume and cardiac output (CO), resulting in hypotension. Slow decompression of any distended bowel as soon as feasibly possible may improve blood pressure (Santschi, 2017). Advice to slightly tilt the dorsally recumbent pregnant patient to the left in order to relieve some pressure off the vena cava should not be performed in Equidae (Doherty and Valverde, 2006; Duke et al., 2006; Santschi, 2017). The predominant aim during positioning should be to ensure equal distribution of weight over a well-padded surface, as otherwise compromises in microcirculation within the most dependent muscles risks ischemia and consequent myopathy (Young, 2005; Schauvliege and Gasthuys, 2013).

Moderate hypotension was also present in this case, with a MAP of 65 mmHg prompting treatment with a CRI of dobutamine. The use of positive inotropic drugs to treat hypotension has previously been recommended in horses over the use of those with vasoconstrictive effects in order to maintain peripheral perfusion (Schauvliege and Gasthuys, 2013). Dobutamine increases gastrointestinal microperfusion in anesthetized horses, while both dopamine and phenylephrine administration conversely results in reductions in perfusion (Dancker et al., 2018). In a study by Dugdale, et al. (2007), no differences in intra- or postoperative survival were found in horses undergo-

ing colic surgery and receiving either dobutamine or phenylephrine for treatment of hypotension. Currently, there is no consensus on the most appropriate pharmaceutical agent to treat hypotension during equine pregnancy. In pregnant sheep with epidural induced hypotension, ephedrine better maintains uterine and placental perfusion than phenylephrine (Erkinaro et al., 2004).

In addition to hypotension, maternal hypoxemia under GA is another possible concern, with the gravid uterus further exacerbating any compression atelectasis resulting from gastrointestinal distension and dorsal recumbency (Nyman and Hedenstierna, 1989; Santschi, 2017). Oxygen delivery to the tissues (DO<sub>2</sub>) is dependent on CO and arterial oxygen content of the blood (CaO<sub>2</sub>), the latter factor determined predominantly by the SaO<sub>2</sub> (Table 2). In this case, the initial PaO<sub>2</sub> reading of 86 mmHg indicated a moderately low PaO<sub>2</sub>. An improvement was achieved by increasing the minute ventilation (VE), although an alveolar recruitment maneuver or application of positive end expiratory pressure are additional methods that may be utilized (Hubbell and Muir, 2015). In horses, an SaO<sub>2</sub> of > 90% should occur at PaO<sub>2</sub> values of approximately 53.1 mmHg under conditions of normal pH and temperature; slight declinations in PaO<sub>2</sub> below this value can result in rapid reductions in SaO<sub>2</sub>, as represented by the equine oxyhemoglobin dissociation curve (Clerbaux et al., 1993; Wagner, 1993). Hypoxemia in recovery is common, a timepoint when the transition from supplemental oxygen provision to room air results in reduced FIO<sub>2</sub> (Bardell et al., 2020). Intranasal phenylephrine was administered prior to recovery in this case to lessen the mucosal edema, as upper airway obstruction may additionally contribute to the development of hypoxemia (Lukasik et al., 1997). In recovery, oxygen was supplemented at 15 L minute<sup>-1</sup>, a flow rate that increases PaO<sub>2</sub> values when compared to horses breathing only room air (McMurphy and Cribb, 1989) (Table 2).

The degree of tolerance of the equine fetus to maternal hypoxemia is unknown (Boening and Leendertse, 1993), although PaO<sub>2</sub> values of < 80 mmHg during the last sixty days of pregnancy is a risk factor for negative pregnancy outcome (Santschi et al., 1991). As equine pregnancy progresses, the oxygen demand of uteroplacental tissue increases in order to enable placental transfer and synthesis of substances necessary for fetal survival (Hay, 1997; Fowden et al., 2000). In humans, increases in VE of up to 48% from baseline from the first trimester have been reported

to account for rises in basal metabolic rate and fetal oxygen consumption (LoMauro and Aliverti, 2015), encouraging methods to prevent or reduce maternal hypoxemia during all stages of gestation.

The advance planning for a calm, uneventful recovery from GA is essential. First, keeping MAP values > 70 mmHg during the maintenance phase of GA is a practice suggested to reduce myopathy incidence, the third most common cause of equine peri-anesthetic death (Johnston et al., 2004). In this case, dobutamine was administered intraoperatively to maintain normotension, and therefore adequate tissue and muscle perfusion (Duke et al., 2006). Second, efforts should be made to alleviate pain, avoiding premature attempts to stand and worse recoveries (Young and Taylor, 1993; Love et al., 2006; Clarke et al., 2008). In this reported case, 0.11 mg kg<sup>-1</sup> morphine was administered intravenously prior to recovery. Third, urinary catheter placement during surgery aimed to relieve any postoperative discomfort induced by a full bladder, therefore preventing premature efforts to stand, and reducing the risk of urination and subsequent loss of grip in the recovery box. Finally, recovery was assisted with the use of head and tail ropes, although the temperament of the individual broodmare must be considered as this approach may be unsuitable for infrequently handled animals of a nervous disposition (Niimura del Barrio et al., 2018; Arndt et al., 2020).

There are no studies in which recovery outcomes in broodmares have been specifically looked at, although complications have been reported (Rioja et al., 2012; Nannarone et al., 2015). Broodmares may represent a specific subset of the equine population more prone to fractures during recovery as a result of underlying osteoporosis in combination with colic induced fatigue (Dugdale et al., 2016). Interestingly, Glade (1993) identified that in lactating mares, full restoration of mechanical bone strength is not achieved until 24 weeks post parturition. Alternatively, in a retrospective study by Rioja, et al. (2012), post anesthetic myopathy as a result of skeletal muscle hypoperfusion was hypothesized to be a possible contributing factor to three pregnant mares undergoing caesarean section and sustaining fractures during recovery.

## CONCLUSION

Anesthesia of the pregnant broodmare demands careful planning. In this reported case, the risk factors for negative pregnancy outcomes and those associated with GA were identified. In the reported anesthetic protocol, the potential adverse effects in both the mare and the foal were considered and adequate analgesia, aiming to provide a quiet, uneventful recovery was provided. Ventilatory and pharmaceutical interventions were required to treat the hypoxemia and hypotension, which are sometimes unavoidable occurrences.

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