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CASE REPORT

Horses and other equids

Insufficient effect of sedation followed by difficulties inducing a colicking Shetland pony

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Abstract

A Shetland pony suspected of large intestinal displacement was presented for exploratory laparotomy. The pony was extremely agitated with refractory pain despite repeated intravenous administration of detomidine and morphine. As the pony became unmanageable and recumbent, it was decided to induce general anaesthesia as soon as possible to prevent further harm. However, it subsequently proved impossible to obtain adequate anaesthetic depth despite intravenous administration of ketamine/midazolam, propofol and thiopental. Only after endotracheal intubation and administration of isoflurane was a surgical plane of anaesthesia achieved. An anaesthetist may be faced with an unexpected lack of effect of administered anaesthetic drugs, which in equine anaesthesia may lead to dangerous situations for patients and personnel. Possible explanations for the observed events and recommendations for prevention are offered.

BACKGROUND

Induction of anaesthesia is a routine procedure in equine (referral) practice; however, hardly any literature addresses what to do in the event of an inability to achieve adequate sedative or anaesthetic depth. Although (near) failure to sedate and/or induce is likely to be multifactorial, a stepwise discussion of possible contributing factors and recommendations for prevention of such a potentially dangerous scenario may help anaesthetists facing a similar emergency situation.

CASE PRESENTATION

An 8-year-old female Shetland pony (bodyweight 147 kg, body condition score 6/9) was presented to the Utrecht University Equine Clinic with a 12-h history of acute colic, which was refractory to N-butyl scopolamine and flunixin meglumine administered by the referring veterinarian. The pony had delivered a healthy term foal 6 weeks before. The pony was not used to being away from home or travelling in a horse trailer. On presentation, the pony was continuously weight shifting with both hind legs and could barely stand still. Respiratory rate was not recorded, but heart rate was elevated at 72 bpm. Capillary refill time was prolonged (>2 s) and mucous membranes were slightly red and tacky.

INVESTIGATIONS

A nasogastric tube was passed with no appreciable amount of reflux retrieved. Rectal examination of the abdomen was difficult due to the small size of the patient, but no obvious abnormalities were noted. A 14-G catheter (Mila International) was placed lege artis in the left jugular vein and 25 μg/kg detomidine (Domosedan 10 mg/mL; Orion Pharma) and 0.05 mg/kg morphine (Morfine HCL 10 mg/mL, Centrafarm) were administered intravenously (IV) to treat ongoing refractory pain and agitation. A jugular venous sample was obtained for complete blood count, chemistry panel and venous blood gas, which revealed a mild metabolic acidaemia, hypocalcaemia and severe hyperlactataemia. The comprehensive results are presented in Table 1.

Hereafter, the mare and foal were placed in a quiet padded stable for close observation. Over the next 30 min, the administered sedatives and analgesics showed no appreciable effect. A further 25 μg/kg detomidine (from the same vial) was administered IV, which did not result in any apparent effect in the next 15 min. No further drugs were administered at this point.

DIFFERENTIAL DIAGNOSIS

Based on history (acute onset severe colic, recent foaling), clinical examination, blood results and ongoing refractory

pain, the pony was suspected to have a large intestinal displacement, and colonic torsion could not be ruled out. Hence, emergency exploratory laparotomy was advised and the owner consented to surgery.

TREATMENT

Antibiotics (11.000 IU/kg benzylpenicillin; Eurovet and 6.5 mg/kg gentamicin 5%; Dechra) were administered IV, and the pony was separated from the foal and walked to the quiet induction room, displaying severe ataxia. As the pony was still very excited (not able to stand still and very responsive to the surroundings), a further 35 μg/kg detomidine (from a different vial) and another 0.05 mg/kg morphine were administered IV, again without appreciable effect on sedation depth (T = 0 min, see Figure 1 for a timeline of events). At this point, the authors questioned the patency of the IV catheter. Although successful aspiration of blood confirmed appropriate positioning. A further 35 μg/kg detomidine was administered IV in a final attempt to reduce excitation (T = 10 min). Sedation depth did not improve visibly, yet 2 min later, the pony went down with signs of colic. The pony was agitated and eyes open, and although she was initially flailing, she progressed to rolling in less than a minute. As the IV catheter was now visibly dislodged, a new 16-G catheter was quickly placed in the right jugular vein and 2.2 mg/kg ketamine (Narketan 100 mg/mL; Vétoquinol) and 0.06 mg/kg midazolam (Midazolam 5 mg/mL; Actavis) were administered IV for rapid induction of general anaesthesia to prevent self-damage (T = 16 min). The pony's movements became less frantic, yet she was still rolling on the floor. The patency of the new IV catheter was checked in a similar fashion; this time, it was difficult to aspirate blood, and therefore, a third 14-G catheter was placed in the same (right) jugular vein. A 500-mL hypertonic saline (NaCl 75 mg/mL; Braun) IV fluid bolus was started to improve circulation. A further 1.4 mg/kg ketamine and 0.03 mg/kg midazolam was administered IV, which resulted in cessation of spontaneous movement (T = 20 min). Although the pony still exhibited nystagmus, it was now possible to lift the pony onto the surgery table (T = 27 min). Once positioned, the pony demonstrated spontaneous movement again and 3.5 mg/kg propofol (Propofol 1%; Fresenius Kabi) was administered IV (T = 28 min). Spontaneous movement was still present and the patency of the IV catheter was checked again by aspirating blood and flushing the catheter with saline, both of which were easily possible. A total dose of 6.8 mg/kg thiopental (Thiopental 500 mg; Rotexmedica) was administered IV (T = 33 min). This reduced spontaneous movement somewhat, but the pony still demonstrated slow limb movements. Although jaw tone was not relaxed and the pony was actively swallowing, it was possible to place a mouth gag and perform endotracheal intubation with a silicone 14 mm internal diameter endotracheal tube, cuffed to a pressure of 200 mmHg (T = 38 min). The pony was attached to a circle system and connected to the anaesthetic machine (Sfinx; Veterinary Technics). The isoflurane vaporiser was set to deliver 5% isoflurane at a fresh gas flow of 5 L/min to speed up delivery of the inhalant agent (Isoflo; Zoetis). Volume-controlled intermittent positive pressure ventilation was started at a tidal volume of 1.5 L and 7 breaths/min to further expedite anaesthetic wash-in (T = 43 min). At this time, anaesthetic depth deepened and became adequate for surgery (no spontaneous movement, no palpebral reflex, no nystagmus, no swallowing and reduced jaw tone). Arterial oxygen saturation, end-tidal isoflurane concentration, fraction of inspired oxygen and invasive arterial blood pressure were continuously measured with a multiparameter monitor (Datex Ohmeda S/5; Datex Ohmeda). Throughout the procedure, end-tidal isoflurane concentration was titrated to maintain constant anaesthetic depth and could be kept at 1.2%. Tidal volume and respiratory rates were adjusted to maintain an arterial partial pressure of carbon dioxide of 35–45 mmHg. Crystalloid fluid therapy (Ringer Fresenius; Fresenius Kabi) was provided at free flow (estimated rate of 25 mL/kg/h) and anaesthesia supplemented with a constant-rate infusion (CRI) of 50 μg/kg/min lidocaine (Lidocaine 20 mg/mL; Braun) and 0.5 mg/kg/h ketamine. A CRI of 0.25 μg/kg/min dobutamine (Dobutamine 5 mg/mL; Hameln Pharma) and two IV boluses of 1 μg/kg phenylephrine (phenylephrine hydrochloride 25 mg/mL; Bausch and Lomb) were administered to maintain a mean arterial pressure of more than 60 mmHg. The results of sequential arterial blood gas analysis are presented in Table 1. Thirty minutes after the start of surgery (T = 90 min), a rupture was found in the mesocolon ascending to the dorsal roof of the abdomen, from which rapid haemorrhage was actively occurring. This rupture or any haemorrhage had not been identified at initial opening of the abdomen, and no other tentative causes for the severe colic symptoms were found. As it proved impossible to stop the bleeding or repair the rupture, with owner consent the pony was euthanased by an IV overdose of 50 mg/kg pentobarbital (Euthasol 40%; AST Farma).

LEARNING POINTS/TAKE HOME MESSAGES

- Lack of observed effect of anaesthetic premedication is likely multifactorial but should always prompt investigation for potential drug error and intravenous access issues.
- Poor or absent sedative effects may be due to extreme agitation or pain and, regardless of the cause, can greatly increase subsequent anaesthetic requirements in individual patients.
- Anaesthetists should be prepared to use higher dosages as well as different anaesthetic induction agents to handle the potentially dangerous and stressful situation where an equine patient presented for emergency surgery is not amenable to sedative agents and/or becomes recumbent prior to induction.
- Good situational awareness is necessary to prevent medical errors and ensure staff and patient safety.

OUTCOME AND FOLLOW-UP

Postmortem examination revealed a subacute to chronic lymphocytic–plasmacytic enteritis, which could not explain the acute onset or severity of colic symptoms. Necropsy failed to identify an underlying cause for the mesocolonic rupture and acute haemorrhage, nor did it reveal any other cause for

TABLE 1 Preoperative blood analysis and arterial blood gas analysis.

	1 h prior to induction	33 min after start induction	1 h after start induction	Reference (arterial)
Venous/arterial	**Venous**	**Arterial**	**Arterial**	
pH	7.308	7.187	7.175	7.25–7.35
pCO_2	37.43	38.8	46.0	35–45 mmHg
pO_2	29.02	112.1	135.4	>90 mmHg
HCO_3^- act	17.6	14.4	16.6	20–28 mmol/L
HCO_3^- std		14.5	15.5	20–28 mmol/L
BE (B)	−7.2	−13.1	−11.7	−3 to +3 mmol/L
Saturation		97.1	98.0	>95%
Hct	0.39			0.3–0.43 L/L
Urea	14.7			<8 mmol/L
Ammonia	28			<30 mmol/L
CK	2077			<280 U/L
GGT	22			<35 U/L
Na^+	137	141.7	141.5	135–150 mmol/L
K^+	3.6	2.9	3.22	3.0–5.9 mmol/L
Cl^-	97	108	106	96–107 mmol/L
Ca^{++}	0.47	0.55	0.56	1.4–1.7 mmol/L
Leukocytes	13.0			$4.7–10.0 \times 10^9$/L
Glucose	15.9	18.8	19.0	3.9–5.6 mmol/L
Lactate	6.2	12.66	12.03	0.7–1.2 mmol/L
FiO_2	0.21	0.95	0.95	

Abbreviations: act, actual; B, blood; CK, creatine kinase; FiO_2, fraction of inspired oxygen; GGT, gamma-glutamyltransferase; Hct, haematocrit; pCO_2, partial pressure of carbon dioxide; pO_2, partial pressure of oxygen; std, standardised.

the acute severe colic symptoms. Due to administrative error, no detailed examination of the jugular veins was performed.

The 6-week-old foal survived and was doing well at 4 months of age.

DISCUSSION

While anaesthetic induction is considered a high-risk event in equine anaesthesia,[1] reports of difficulties inducing anaesthesia are rare in equine literature. One retrospective survey of anaesthesia in horses with colic did not, other than one fatality, mention any problems with induction.[2] In human medicine, scientific literature on failure to induce general anaesthesia is likewise scarce; however, a limited body of evidence exists on accidental awareness during the induction phase of general anaesthesia.[3] Surprisingly, in one meta-analysis on consciousness during different anaesthetic regimens in humans, an astonishing one-fifth of patients remained conscious during anaesthetic induction, with consciousness measured by the isolated forearm technique.[4] Half of the reports of accidental awareness in human medicine in fact involved the induction and theatre transfer phase, with the vast majority (81%) occurring during anaesthetic induction itself.[3] In these induction events, elective and emergency cases were equally represented.[3]

The reasons for not achieving adequate anaesthetic depth in an individual patient are, as highlighted by this case, sometimes difficult to assess and likely to be multifactorial. Factors that can be involved in difficult induction include difficulties in assessing anaesthetic depth, drug errors, failure of IV drug delivery (vascular access and catheter/vessel patency issues), failure of the drug to reach the brain (cardiac output issues) and increased anaesthetic requirement.

Assessing loss of consciousness

Assessing actual loss of consciousness can be difficult and clinically relies on the absence of response to stimulation. In humans, this is often assessed as lack of response to verbal command; in animals, loss of consciousness is assumed to coincide with loss of righting reflex. The lack of response (swallowing or coughing) to airway manipulation is usually used as an indicator of sufficient depth of anaesthesia to perform endotracheal intubation. The jaw tone of the patient in this case report was not reduced and the pony was actively swallowing on intubation, indicating insufficient depth of anaesthesia to perform endotracheal intubation. In this case, given the emergency setting and severe presentation, it was decided to proceed with endotracheal intubation, as discontinuing the procedure would return the pony to a state of refractory pain and potential intestinal rupture with resultant euthanasia.

Drug error

An important potential cause of lack of effect of IV-administered anaesthetic drugs is a drug error. Drug administration errors (i.e., administration of the wrong drug, wrong drug dosage or wrong route of administration)

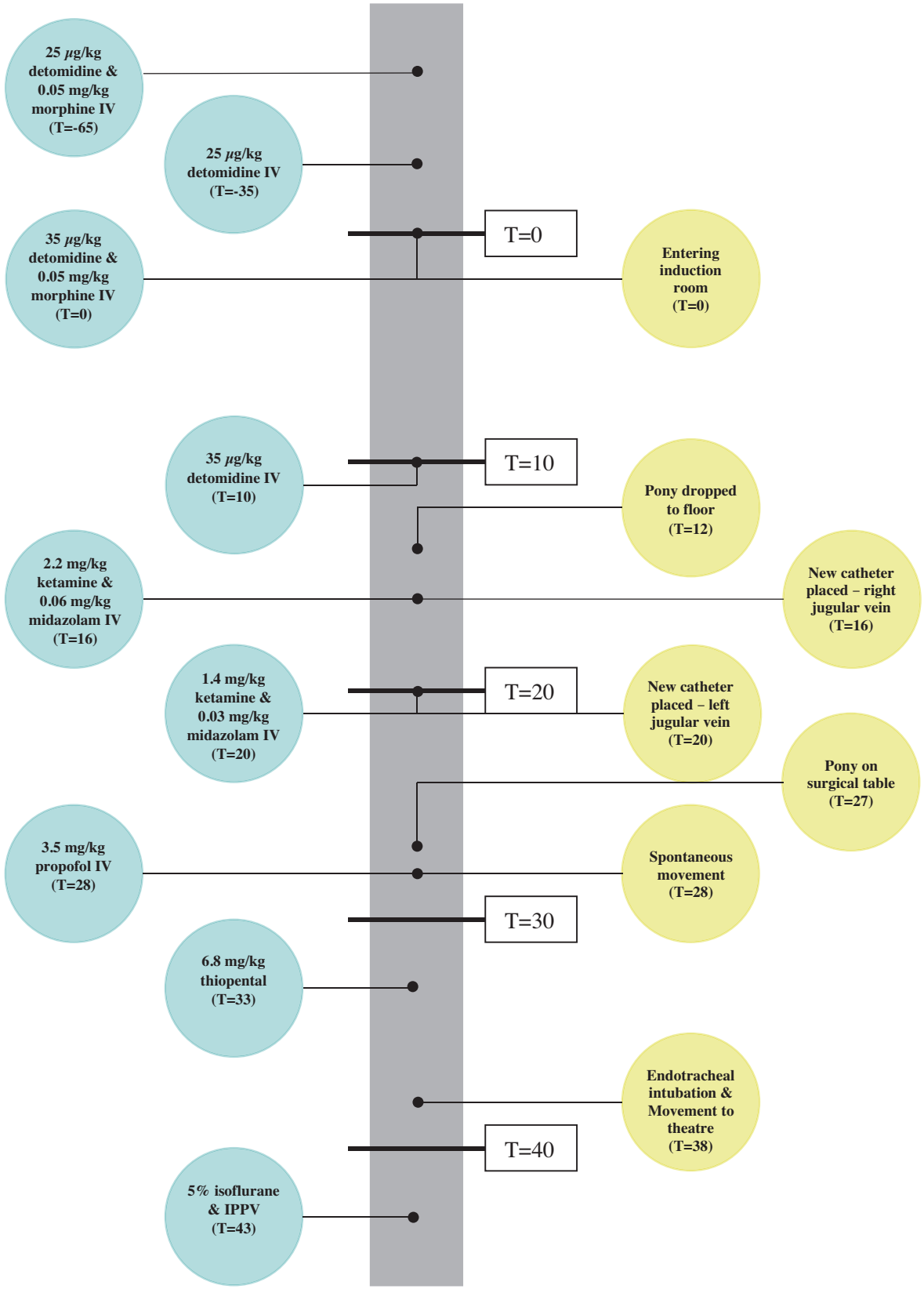

FIGURE 1 Timeline of events. $T = 0$ represents the time when the pony entered the induction room. $T = x$ represents the time in x minutes after the pony entered the induction room. IPPV, intermittent positive pressure ventilation; IV, intravenous.

are in fact relatively common, and should never be disregarded as a potential cause for lack of the predicted effect of an administered sedative or anaesthetic drug. Recent human studies report a rate of drug error of one in every 140 anaesthetics[3] or even as high as one drug error in every 25 perioperative drug administrations, with more than a third of these leading to an adverse drug reaction.[5] In veterinary anaesthesia, in contrast to human medicine, drawing up and administering anaesthetic drugs is usually performed by only one professional (i.e., nobody witnesses), which likely leads to an even higher potential drug error rate. In the case reported here, drug errors cannot be excluded as the cause of failure

to induce. However, it would appear extremely unlikely that consecutive drug errors occurred with administration of every different induction agent used.

Improper drug choice or drug dosages may lead to insufficient depth of anaesthesia. In the pony of this case report, adequate anaesthetic depth was not achieved despite the use of several anaesthetic drugs administered at regular clinical dosages. We feel the observed difficulty obtaining adequate sedative depth after premedication to be the most important reason for the observed difficulty inducing anaesthesia in this case. Lack of effective sedation increases the dose requirement of induction agents beyond normal dose ranges. Therefore, it is possible that the dose of each induction agent was in fact not high enough to achieve adequate anaesthetic depth in this case. While we expected the cumulative dosages of induction agents used within the short timeframe to achieve adequate anaesthetic depth, in hindsight, it may have been better to dose the induction agent(s) to effect, rather than sticking to set routine dosages of individual agents. In an attempt to improve sedative and anaesthetic effects, sequential drug choices represented a range of drug classes (alpha-2 agonist agents, opioids, benzodiazepines, dissociative anaesthetics, non-barbiturate and barbiturate hypnotic agents), each targeting different receptors.

In a study where horses with abdominal pain received 40 μg/kg detomidine IV, analgesia and sedation were rated as highly satisfactory (74% and 73%, respectively) or satisfactory (21% and 27%, respectively).[6] In the pony in this case report, 35 μg/kg detomidine was administered twice in the induction room (where a usual dose would be 10–20 μg/kg); therefore, the dosage of detomidine given is considered high rather than low. Speculatively, it is possible that the 'ceiling effect' of detomidine was reached, meaning higher dosages would only increase the length of sedation but not depth of sedation, which has been described in horses and dogs.[7,8] Importantly, the pony in this case report is likely to have had very high circulating endogenous catecholamine levels, which would have decreased the sedative effect of detomidine.[9] No alternative alpha-2 agonist was used to improve the sedative effect in this pony. However, the authors did use two different bottles (negating the possibility of unexpected issues with vial contents).

It was attempted to deepen sedation and improve analgesia by addition of an opioid. Opioids can produce increased locomotor activity[10,11] and/or excitation[12] in horses, but these adverse effects are not normally seen in painful[12] or sedated horses. An excessively high dose of morphine would theoretically have been able to cause the observed spontaneous movements, but the 0.1 mg/kg morphine administered (total amount) is well within the therapeutic dose range for anaesthetic premedication and is not normally associated with locomotor stimulation. As the side effects of opioids may closely mimic the effect of insufficient analgesia, in fact, the dosage of morphine given in premedication (0.05 mg/kg, repeated once) may well have been too low to effectively curb this pony's pain, which may have contributed to failure to sedate effectively. Hence, opioid side effects would seem an unlikely cause for the events seen at the time of induction.

It is possible that due to a drug error (see above), the pony in this case report only received ketamine or only midazolam, in which case the desired muscle relaxation and deeper plane of anaesthesia would not be achieved. Paradoxical excitation in horses receiving only midazolam has been reported.[13] Inadvertent administration of ketamine alone can cause poor quality of induction[14] with excitation and muscle rigidity. In this case, however, the excitation, rolling and myoclonus occurred before the administration of any midazolam or ketamine; in fact, induction of general anaesthesia with ketamine–midazolam was performed in an attempt to stop excitation and prevent self-trauma or trauma to attending staff.

The choice to administer propofol before thiopental was made because of three considerations. First, time was of the essence, as the pony rolling on the floor caused a potentially dangerous, uncontrolled situation. Although the induction time for thiopental is significantly shorter compared to propofol and ketamine,[15,16] the administration of thiopental requires dissolving powder into a solution for IV injection, which is time consuming. Second, due to the relatively low weight of the pony, the amount of propofol needed represented a feasible injection volume. Last, at this point there were concerns about catheter patency and/or vessel quality, which is important because the inadvertent perivascular administration of thiopental can cause serious tissue necrosis.[17]

In the patient in this case report, despite the administration of ketamine/midazolam, propofol and thiopental, it proved difficult to achieve adequate anaesthetic depth, while it was finally possible to increase anaesthetic depth to a surgical plane with isoflurane. Inhalational induction via face mask was not considered due to concerns over room pollution and staff exposure; also, inhalational induction has been shown to cause increased mortality in horses compared to IV induction techniques.[18]

Failure of IV drug delivery (vascular access and catheter/vessel issues)

Whenever depth of sedation and anaesthesia are assessed by experienced staff and the correct sedative or anaesthetic drug at routine dosages have been administered IV without sufficient apparent effect, one should question whether the administered drug actually reached the systemic circulation. In the current case, the apparent lack of effect of premedication drugs prompted investigation of catheter position and patency; detomidine and morphine premedication were administered via a jugular catheter that appeared in situ based on ability to aspirate blood and flush. In hindsight, when repeated top-up doses failed to achieve the desired sedative effect, a new IV catheter should have been placed regardless, preferably in a different vein. After the administration of the first dose of induction agents (midazolam/ketamine), only a mild sedative effect of the anaesthetic agents was seen. The patency of this (replacement) IV catheter was checked at this point, and it seemed that the catheter was not (or never was) in the jugular vein. In human medicine, it is reported that 7% of the accidental awareness cases during the induction phase occurred when the induction agent went back up the IV line or when the IV catheter was displaced extravascularly.[3] It is well possible that the first dose of induction agents was in fact injected perivascularly in this case. Besides extravascular position of the catheter, it is theoretically also possible that a previous jugular thrombophlebitis compromised local blood flow, leading to a poor connection to the venous circulation.[19] Theoretically, this may have led to a situation in which

aspirating blood and flushing the catheter was easily possible, yet the injection of a drug did not lead to a significant amount reaching the jugular vein and then systemic circulation in a timely fashion. In absence of detailed pathology examination, it is considered very unlikely that both jugular veins would have an anomalous connection to the systemic circulation. In human patients, disruption of IV access is common during transfer of patients[3] and these events will further delay the administration of additional anaesthetic agents. In equine anaesthesia, such a delay can be disastrous, as potentially dangerous arousal can occur in this time frame, rendering any further attempts at re-establishing IV access far too risky. In the current case, the first IV catheter appeared to have been functioning, but it was lost during accidental recumbency. While the second jugular catheter, which had been placed in a rush to allow rapid induction, did not appear to be intravascular when checked after drug administration, the third catheter was checked and found to be in working order after hoisting the pony onto the table.

Failure of the drug to reach the brain (cardiac output issues)

Another potential contributor to difficulty achieving an adequate anaesthetic plane can lie in low cardiac output. Cardiac output has a significant yet dichotomous influence on the onset time of anaesthetic drugs. Notably, low cardiac output will increase the onset time of IV-administered drugs, while the volume of distribution may be reduced due to centralised circulation leading to higher initial plasma concentrations. With inhalant agents, the effect of cardiac output is different: in a low cardiac output state, the inhalant agent is carried away from the alveoli more slowly, which helps to increase the rate of rise of the inhalant agent alveolar concentration, resulting in a faster induction.[20] Given the cardiovascular and haematologic parameters at presentation, it is possible that a low cardiac output state in this pony contributed to difficulties in induction by injectable anaesthetics, while it hastened the onset of effect of isoflurane administration.

Anaesthetic requirement

Even if anaesthetic drugs reach the target site in adequate concentrations to induce general anaesthesia in the majority of the population, many intrinsic and external factors are known to influence individual anaesthetic requirements. In terms of intrinsic factors, patient sex, age and genetic background have all been shown to dictate anaesthetic requirements.[21] Extrinsic factors that can cause reduced effect of sedative and anaesthetic drugs include significant pre-induction stress, pain or anxiety,[22] as well as noisy surroundings.[23] Realistically, factors that will have been of influence in this case are severe patient anxiety and pain. Apart from the acute abdominal pain, there were several reasons for increased anxiety in this pony: it was not used to being away from home or being transported and she had not been separated from her foal before. Although the stable and induction rooms were quiet, they still represented an unfamiliar environment. In human medicine, a clear correlation exists between preoperative anxiety and anaesthetic requirements, with anxious people requiring more propofol for induction.[24] In cats, however, this relationship could not be established.[25] In general, pain and anxiety cause the release of endogenous catecholamines, which increase the individual's anaesthetic requirement, possibly by desensitisation of alpha-2-adrenoreceptors.[26,27] As the pony of this report showed intractable pain and agitation, these factors definitely will have contributed to the reduced response to sedatives and anaesthetics, and in hindsight should have prompted an increase in anaesthetic agent dose, with drugs administered to effect rather than to standard dosage recommendations.

Human factors

The practice of anaesthesia requires constant vigilance in a multitasked setting where a small error can have large consequences within a very short time frame. In human medicine, key cognitive errors appear to be present in more than 50% of simulated emergencies.[28] The occurrence of cognitive errors in equine anaesthesia is recognised, but there is no quantitative evidence of its incidence.[29] A good example is that mortality in equine anaesthesia is higher in emergencies and during out-of-hours procedures requiring general anaesthesia.[18] The higher anaesthetic risk in out-of-hours procedures is attributed to the emergency nature of these procedures but also attributed to cognitive errors due to sleep deprivation, circadian rhythm disturbance and fatigue.[30] One common problem affecting situational awareness is plan continuation error (also known as fixation error), which describes the situation in which an anaesthetist is not able to consider different options and persists in carrying out the initial plan, despite new information coming in that should alter interpretation of the situation and prompt adjustment of the plan to be carried out.[31] The anaesthetist in this case report, faced with a recumbent agitated pony, quickly decided to induce anaesthesia and then switched to different induction agents after difficulties obtaining the expected effect of a repeated administration of ketamine/midazolam. However, the anaesthetist's choice to use only standard dosages of IV anaesthetic agents (recommended for premedicated patients), despite the fact that the pony had clearly shown insufficient sedation following much higher than usual dosages of alpha-2 agonist, represents a type of plan continuation error. Also, before the pony became recumbent, it would have been prudent to consider why the IV anaesthetics did not have the expected effect and attempt to place a catheter in another body vein as well as to improve cardiac output (which was in fact attempted with hypertonic saline infusion).

The unexpected problems during premedication and subsequent induction in this Shetland pony required situational awareness to prevent patient and personnel harm. This case report highlights the importance of anaesthetists' awareness of their own decision-making processes and the use of an analytic approach instead of intuitive reasoning to handle unanticipated emergent situations.

Staff safety

In veterinary medical literature, surprisingly little remains known about the risk of equine anaesthesia for the staff involved. A German study found that of all work-related

TABLE 2 Factors to consider with (near) failure to induce a patient.

Has anaesthetic depth been assessed accurately?
Is there a possibility of a drug error? (wrong drug, wrong dosage, wrong route of administration)
Is the anaesthetic drug reaching the circulation? (vascular access and vessel patency issues)
Is the anaesthetic drug reaching the brain? (cardiac output)
Could this patient have increased anaesthetic requirement?

accidents in veterinary medicine, two-thirds could be attributed to scratches, bites or kicks from animals,[32] and in another study conducted in veterinary teaching hospitals, higher rates of injury were reported for treating horses (0.4/1000 cases) compared to other species (0.074–0.1/1000 cases).[33] The pony in this case report suddenly dropped to the floor and started rolling, making the situation dangerous to attending staff. The rolling on the floor probably displaced the IV catheter and a new IV catheter had to be placed while the pony was recumbent and moving. Due to the small size of this pony, it was relatively safe to restrain the pony and place a new IV catheter. However, if this had not been a pony but an adult horse, the situation would have been very different. Whenever IV administration of anaesthetic drugs is not possible due to staff safety concerns, another anaesthetic drug administration route should be considered, even if this may not be ideal from the patient's perspective.

Conclusion

An anaesthetist may be faced with an unexpected lack of effect of administered sedative and anaesthetic agents. It is paramount that effective sedation is achieved prior to any attempt to induce an equid, and any lack of observed effect should prompt investigation of potential drug error or IV access issues. In the event a horse becomes recumbent prior to effective sedation having been reached, rapid induction of anaesthesia may be indicated, and the anaesthetist should bear in mind that higher than normal dosages titrated to effect may be needed to achieve a stable plane of anaesthesia in such cases. Underlying factors involved in difficulty to achieve adequate anaesthetic depth in an equine patient are summarised in Table 2. In systematically addressing these factors, the anaesthetist should keep not only patient outcome but also staff safety in mind.

AUTHOR CONTRIBUTIONS

Iris Veen and Janny de Grauw conceived and designed the project. Iris Veen acquired the data. Iris Veen and Janny de Grauw analysed and interpreted the data and wrote the paper.

CONFLICT OF INTEREST STATEMENT

The authors declare they have no conflicts of interest.

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ETHICS STATEMENT

The pony described in this case report is a client-owned animal, in which the treatment described was performed to the highest possible standard of veterinary care. Informed client consent was obtained.

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REFERENCES

1. Taylor PM, Clarke KW. Handbook of equine anaesthesia. 2nd ed. Saunders; 2006. p. 123.
2. Trim CM, Adams JG, Cowgill LM, Ward SL. A retrospective survey of anaesthesia in horses with colic. Equine Vet J Suppl. 1989;7:84–90. https://doi.org/10.1111/j.2042-3306.1989.tb05663.x
3. Pandit JJ, Cook TM. Accidental awareness during general anaesthesia in the United Kingdom and Ireland—5th National Audit Project of the Royal College of Anaesthetists and the Association of Anaesthetist of Great Britain and Ireland. September 2014. Available from: https://www.nationalauditprojects.org.uk/NAP5report
4. Linassi F, Zanatta P, Tellaroli P, Ori C, Carron M. Isolated forearm technique: a meta-analysis of connected consciousness during different general anaesthesia regimens. Br J Anaesth. 2018;121:198–209. https://doi.org/10.1016/j.bja.2018.02.019
5. Nanji KC, Patel A, Shaikh S, Seger DL, Bates DW. Evaluation of perioperative medication errors and adverse drug events. Anesthesiology. 2016;124:25–34.
6. Jochle W, Moore JN, Brown J, Baker GJ, Lowe JE, Fubini S, et al. Comparison of detomidine, butorphanol, flunixin meglumine and xylazine in clinical cases of equine colic. Equine Vet J Suppl. 1989;7:111–6. https://doi.org/10.1111/j.2042-3306.1989.tb05668.x
7. Grimsrud KN, Ait-Oudhia S, Durbin-Johnson BP, Rocke DM, Mama KR, Rezende ML, et al. Pharmacokinetic and pharmacodynamic analysis comparing diverse effects of detomidine, medetomidine, and dexmedetomidine in the horse: a population analysis. J Vet Pharmacol Therap. 2014;38:24–34.
8. Kuusela E, Raekallio M, Antilla M, Falck I, Mölsä S, Vainio O. Clinical effects and pharmacokinetics of medetomidine and its enantiomers in dogs. J Vet Pharmacol Therap. 2000;23:15–20.
9. Raekallio M, Leino A, Vainio O, Scheinin M. Sympatho-adrenal activity and the clinical sedative effect of detomidine in horses. Equine Vet J Suppl. 1992;11:66–8. https://doi.org/10.1111/j.2042-3306.1992.tb04777.x
10. Harkins JD, Queiroz-Neto A, Mundy GD, West D, Tobin T. Development and characterization of an equine behaviour chamber and the effects of amitraz and detomidine on spontaneous locomotor activity. J Vet Pharmacol Therap. 1997;20:396–401.
11. Mama KR, Pascoe PJ, Steffey EP. Evaluation of the interaction of mu and kappa opioid agonists on locomotor behavior in the horse. Can J Vet Res. 1992;57:106–9.
12. Valverde A, Gunkel CI. Pain management in horses and farm animals. J Vet Emerg Crit Care. 2005;15:295–307. https://doi.org/10.1111/j.1476-4431.2005.00168.x
13. Hubbel JAE, Kelly EM, Aarnes TK, Bednarski RM, Lerche P, Liu Z, et al. Pharmacokinetics of midazolam after intravenous administration to horses. Equine Vet J. 2013;45:721–5. https://doi.org/10.1111/evj.12049
14. Allison A, Robinson R, Jolliffe C, Taylor PM. Evaluation of the use of midazolam as a co-induction agent with ketamine for anaesthesia in sedated ponies undergoing field castration. Equine Vet J. 2018;50:321–6. https://doi.org/10.1111/evj.12759
15. Wakuno A, Aoki M, Kushiro A, Mae N, Kodaira K, Maeda T, et al. Comparison of alfaxalone, ketamine and thiopental for anaesthetic induction and recovery in Thoroughbred horses premedicated with medetomidine and midazolam. Equine Vet J. 2017;49:94–8. https://doi.org/10.1111/evj.12548
16. Ferreira TH, Brosnan RJ, Shilo-Benjamini Y, Moore SB, Hollingsworth SR. Effects of ketamine, propofol, or thiopental administration on intraocular pressure and qualities of induction of and recovery from anesthesia in horses. Am J Vet Res. 2013;74:1070–7.
17. Shibata Y, Yokooji T, Itamura R, Sagara Y, Taogoshi T, Ogawa K, et al. Injury due to extravasation of thiopental and propofol: risks/effects of local cooling/warming in rats. Biochem Biophys Rep. 2016;8:207–11. https://doi.org/10.1016/j.bbrep.2016.09.005

18. Johnston GM, Eastment JK, Wood JNL, Taylor PM. The confidential enquiry into perioperative equine fatalities (CEPEF): mortality results of phases 1 and 2. Vet Anaesth Analg. 2002;29:159–70.
19. Schoster A. Complications of intravenous catheterization in horses. Schweiz Arch Tierheilkd. 2017;159:477–85. https://doi.org/10.17236/sat00126
20. Khan KS, Hayes I, Buggy DJ. Pharmacology of anaesthetic agents II: inhalation anaesthetic agents. Contin Educ Anaesth Crit Care Pain. 2014;14:106–11. https://doi.org/10.1093/bjaceaccp/mkt038
21. Liem EB, Lin C, Suleman M, Doufas AG, Gregg RG, Veauthier JM, et al. Anesthetic requirement is increased in redheads. Anesthesiology. 2004;101:279–83.
22. Chen YK, Soens MA, Kovacheva VP. Less stress, better success: a scoping review on the effects of anxiety on anesthetic and analgesic consumption. J Anesth. 2002;36:532–53. https://doi.org/10.1007/s00540-022-03081-4
23. Katz JD. Noise in the operating room. Anesthesiology. 2014;121:894–8. https://doi.org/10.1097/ALN.0000000000000319
24. Maranets I, Kain ZN. Preoperative anxiety and intraoperative anesthetic requirements. Anesth Analg. 1999;89:1346–51.
25. Shimizu Y, Kanda T. Effects of pre-anesthesia anxiety on propofol induction dose in cats. Animals. 2021;11:2126. https://doi.org/10.3390/ani11072126
26. Deighton NM, Hamilton CA, Howie CA, Reid JL. Effects of short-term exposure to noradrenaline and adrenaline on adrenoceptor responses. Eur J Pharmacol. 1989;169:95–101.
27. Murrel JC. Adrenergic agents. In: Grimm KA, Lamont LA, Tranquilli WJ, Greene SA, Robertson SA, editors. Veterinary anaesthesia and analgesia—the fifth edition of lumb and jones. Wiley Blackwell; 2015. p. 185.
28. Stiegler MP, Neelankavil JP, Canales C, Dhillon A. Cognitive errors detected in anaesthesiology: a literature review and pilot study. Br J Anaesth. 2012;108:229–35. https://doi.org/10.1093/bja/aer387
29. Hartnack S, Bettschart-Wolfensberger R, Driessen B, Pang D, Wohlfender F. Critical incidence reporting systems—an option in equine anaesthesia? Results from a panel meeting. Vet Anaesth Analg. 2013;40:e3–8.
30. Dugdale AHA, Taylor PM. Equine anaesthesia-associated mortality: where are we now? Vet Anaesth Analg. 2016;43:242–55.
31. Eisen LA, Savel RH. What went right—lessons for the intensivist from the crew of US airways flight 1549. Chest. 2009;136:910–7.
32. Nienhaus A, Skudlik C, Seidler A. Work-related accidents and occupational diseases in veterinarians and their staff. Int Arch Occup Environ Health. 2005;78:230–8.
33. Whittem T, Woodward AP, Hoppach M. A survey of injuries that occurred in veterinary teaching hospitals during 2017. J Vet Med Educ. 2021;48:401–16. https://doi.org/10.3138/jvme-2019-0152

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