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CASE REPORT

Food/farmed animals

Premature recovery from general anaesthesia in an adult Limousin bull

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Abstract

This case report describes the premature and unanticipated recovery of a bull from general anaesthesia for penile surgery. Retrospective review revealed: (i) the elements of case management that contributed to this critical event; and (ii) other measures that allowed prompt control, thus minimising risk to the subject and personnel. The case highlights the challenges of monitoring depth of anaesthesia in large ruminants and illustrates that non-surgical stimuli such as hoisting can be equally, if not more, stimulating than surgery itself. Finally, practical recommendations are made to: (i) reduce the likelihood of this problem recurring; and (ii) limit the risk of harm to patient or personnel if it does.

KEYWORDS
adverse event, anaesthesia, cattle, clinical practice, ruminants

BACKGROUND

Although undertaking procedures using local or regional anaesthetic techniques is popular in large ruminants, general anaesthesia may be preferred under specific conditions; for example, as a result of the site and complexity of the planned procedure. General anaesthesia for a surgical procedure aims to produce unconsciousness (and amnesia), immobility, and reduced or absent nociception. It can also contribute to providing safe conditions for attendant personnel. However, the techniques employed to produce general anaesthesia may (transiently) increase the risk of harm to animal subject and personnel, particularly during the induction and recovery phases. This is particularly true in the case of large ruminants, where size alone increases these risks and is often exacerbated by limited habituation to handling. Combined with these patient-specific factors, there may well be limitations imposed by environmental factors such as the available facilities and equipment. Depending on the setting, the irregularity with which procedures such as these are carried out may also limit the familiarity and expertise of the personnel involved.

It is therefore imperative that these risks are acknowledged and steps taken to reduce or eliminate them as far as possible. This case report describes an adverse event associated with the recovery from general anaesthesia of an adult bull. It highlights the challenges of monitoring depth of anaesthesia in large ruminants and illustrates that non-surgical stimuli such as hoisting can be equally, if not more, stimulating than surgery itself. Consideration of the various contributory factors leads to practical recommendations to reduce the likelihood of an event such as that described occurring in future and, if it does, to limit the risk of harm to the animal or attendant personnel.

CASE PRESENTATION

An 18-month-old Limousin bull (estimated body mass 1000 kg) was presented for surgical removal of penile fibropapillomata. Clinical examination found no abnormalities except for multiple verrucose lesions on the penile glans and shaft. Similar lesions had been surgically removed

under general anaesthesia 8 months previously, but had subsequently recurred and were compromising the animal's breeding potential.

TREATMENT

Pre-operative preparation comprised 16 hours of food deprivation and 4 hours of water deprivation. Sedation for venous cannulation was achieved with xylazine (0.03 mg/kg; Nerfasin 100 mg/mL, Dechra Veterinary Products) and butorphanol (0.04 mg/kg; Butador 10 mg/mL, Chanelle Pharma) injected into the gluteal muscle. The mild sedation produced was adequate for the cannulation of the left marginal auricular vein using a 20 SWG, 32 mm winged cannula (Biovalve Safe, Vygon), which was subsequently sutured in place (Monocryl, 2 Ph. Eur., Ethicon, Johnson&Johnson Surgical Technologies). The cannula was connected via a 150-cm long narrow-bore extension tube (V-green extension, Vygon) to a three-way tap (Discofix, B. Braun); both were primed with 0.9% sodium chloride solution (Aqupharm 1, Animalcare). This assembly was arrayed in the cervical midline, with the three-way tap located between the scapulae and secured in place with adhesive tape (Leukoplast Sleek 2.5 cm, Essity).

There was a 3-hour delay after cannula placement (arising from scheduling difficulties) meaning the sedative effects of the initial xylazine/butorphanol combination had waned. Therefore, a second dose of xylazine (0.05 mg/kg) was administered intravenously (IV) immediately before the animal was loaded onto a trailer for transport (approximately 200 m) to the anaesthesia induction and recovery box. Here, additional xylazine (0.02 mg/kg IV) was administered in an attempt to enhance sedation and produce recumbency. When recumbency had not occurred after 10 minutes, a decision to proceed with the induction of anaesthesia was made. Anaesthesia was induced with ketamine (4.5 mg/kg IV; Ketamidor 100 mg/mL, Chanelle Pharma); this produced recumbency smoothly and without physical assistance. A halter and a second lead rope attached to the nose ring were in place, but the bull did not require physical head restraint.

After induction, the halter was removed and two Drinkwater gags were placed within the premolar tables. Oro-tracheal intubation with a 26 mm internal diameter, cuffed, silicone, endotracheal tube (Jørgen Kruuse) was achieved, with the bull in lateral recumbency and using direct palpation of the larynx.

Hobbles were attached to all four limbs, proximal to the carpi and tarsi, and the bull hoisted onto a padded surgical table and positioned in dorsal recumbency. Anaesthesia was maintained with isoflurane in oxygen, delivered from a Tafonius large animal anaesthetic machine with integrated ventilator (Vetronic Services). The lungs were mechanically ventilated in volume-control mode with a tidal volume of 6 L. Respiratory rate was adjusted between 8 and 12 breaths per minute, maintaining end-tidal carbon dioxide ($E'CO_2$) partial pressure between 35 and 50 mmHg. Peak inspiratory pressure ranged from 22 to 26 cmH_2O. Additional physiological monitoring was achieved using an S5 Compact multi-parameter monitor (GE Datex-Ohmeda) to measure inspired and expired gases (oxygen, CO_2, isoflurane), pulse oximetry, electrocardiography and invasive blood pressure. Direct arterial blood pressure was monitored using a 20 SWG cannula inserted in the auricular artery. Physiological variables were recorded on a standard anaesthetic record every 5 minutes. Depth of anaesthesia was monitored by observation of the eye position, periodic assessment of the palpebral reflex (stimulated by medial canthus brushing), noting presence or absence of spontaneous breathing effort and any cardiovascular response to surgical stimulation. Hartmann's electrolyte solution (Aqupharm 11, Animalcare) was administered IV at approximately 3 mL/kg/h. Meloxicam (0.5 mg/kg; Inflacam 20 mg/mL, Virbac) was administered subcutaneously at the onset of surgery in an attempt to limit post-operative inflammation and pain.

LEARNING POINTS/TAKE-HOME MESSAGES

- Assessing depth of anaesthesia is challenging in large ruminant patients.
- Hoisting animals may stimulate and promote recovery from anaesthesia.
- Ensure sedative/anaesthetic immobilising drugs are drawn up and ready to inject at all times and maintain secure intravenous access (including short extension for remote access) at least until both animal and personnel are safe.
- Review of adverse incidents allows consideration of the many, often indirect, factors that may have contributed to their occurrence and institution of, often simple, preventative measures in the future.

The calibrated vaporiser (Vaportec Series 3 Isoflurane Vaporiser, Burtons Medical Equipment) was initially set to deliver 3% isoflurane, achieving an end-tidal isoflurane concentration (E'Iso) of 1.2% at the start of surgery. The invasive blood pressure readings at this time suggested that profound hypotension was present (mean arterial pressure [MAP] 42–45 mmHg). The vaporiser setting was therefore reduced to 2%, causing E'Iso to decrease to 0.9%–1%. The option to administer additional intravenous crystalloid was considered, but ultimately not pursued. Concurrently, alternative reasons for the apparent hypotension were examined; the arterial line was flushed and transducer height checked. The latter was found to be considerably higher than the estimated level of the right atrium, and after correction (lowering to the level of the point of the scapula) the recorded MAP increased to 60 mmHg. As the bull was unresponsive to ongoing surgical stimulation, an attempt to improve the still marginal blood pressure was made by maintaining E'Iso at 0.9% for the remainder of the procedure. This resulted in no change in physiological variables or the perceived depth of anaesthesia.

Surgery consisted of the use of a harmonic scalpel (Harmonic, Ethicon, Johnson&Johnson Surgical Technologies) to resect the multiple papillomatous lesions around the tip of the penis. Some incisions were closed with simple interrupted sutures of polydioxanone (PDS-II, 3 Ph. Eur., Ethicon, Johnson&Johnson Surgical Technologies); those around the urethral orifice were left unsutured to heal by second intention. Surgery lasted 25 minutes, and on completion, 50 minutes after induction, depth of anaesthesia was assessed in preparation for moving the bull into the recovery box. This assessment revealed no changes in cranial nerve activity from the assessments made during surgery. The bull was

disconnected from the anaesthetic breathing system and hoisted into the recovery box, a process requiring approximately 60 seconds. Shortly after the bull was laid into right lateral recumbency in the recovery box, determined limb and neck movements—suggestive of conscious attempts to stand—were encountered. These movements occurred while the animal remained hobbled and connected to (but not suspended by) the hoist. During the struggle, the endotracheal tube (with cuff still inflated) and gags was expelled by forced expiration. After this, attempts to move into sternal recumbency became stronger and more violent, raising fears of impending major injury to the bull and attending personnel. The hobbles effectively precluded successful attempts to achieve sternal recumbency and/or stand, and so facilitated rapid situation assessment and control. The lead rope attached to the nose ring had been retained and allowed an element of head control. Pre-prepared ketamine (0.5 mg/kg IV) was administered via the three-way tap extension assembly and achieved rapid sedation in less than 30 seconds. This allowed the hobbles and hoist to be removed and a halter to be placed. Thereafter, the animal recovered well, without struggling or uncoordinated attempts to change position. The bull achieved sternal recumbency 13 minutes after the last ketamine injection and stood, on the second attempt, a further 5 minutes later.

The bull was confined in the recovery box for a further 30 minutes until able to stand and walk without significant ataxia. It was then transported to its pen where food and water were made available.

OUTCOME AND FOLLOW-UP

The bull was discharged from the hospital the following day without further complications. It was put to cows 1 month after discharge, with the first calf born 11 months later. A report describing the incident was submitted to the Institution's Clinical Audit Group, describing the event and detailing several recommendations to reduce the likelihood of a repeat occurrence. In addition to those described in 'Take-Home Points' above, the recommendations included:

- Assessment of anaesthetic depth and administration of additional sedative/anaesthetic agents (if required) immediately before and after hoisting.
- Ensuring effective means to cut hobbles from the patient are easily available.
- Ensuring that halters, lead ropes, and so forth are maintained throughout the procedure (being mindful of the risk of compression or reduced perfusion that could lead to iatrogenic myopathy or neuropathy) or replaced at the earliest opportunity.

DISCUSSION

The reported case illustrates the challenges faced by veterinary anaesthetists when dealing with large, physically powerful domestic animals undergoing noxious surgery, despite the availability of suitable handling and movement facilities, appropriate anaesthetic drugs and equipment, and trained personnel. In this case, the rapid and unanticipated recovery of the bull while still hobbled and connected to the hoist required prompt and appropriate responses and, with the goal of avoiding future episodes of a similar nature, warrants critical analysis.

Different approaches can be used to conduct adverse event analysis, including root cause analysis, producing an Ishikawa (fishbone) diagram or working through an incident decision tree.[1] Irrespective of the selected process, a common theme persists; namely, that critical problems usually arise from a combination of several independently inconsequential changes or events.

> *We need to stop thinking of an error as a single event, but as an 'incident'. Viewing an error as an incident moves away from the idea that it is a single, spontaneously occurring event and moves toward the view that it is the manifestation of a series of events and latent conditions that have evolved over time under a set of circumstances in a specific environment.*
>
> J. W. Ludders and M. McMillan, 2017

The following discussion seeks to present an 'error narrative' of the incident in order to consider the series of events and latent conditions that led to its occurrence.

Of major concern is the rapid change of anaesthetic depth from surgical adequacy to conscious righting attempts in under 5 minutes. Approximately 2 minutes before hoisting, the bull was undergoing penile surgery under what was adjudged to be, given the absence of any nociceptive responses, an appropriate surgical plane of anaesthesia. This premature recovery posed immediate risks to animal welfare and personnel safety. Evidently, the depth of anaesthesia was insufficient at the time of disconnection from the anaesthetic machine and the onset of hoisting, despite anaesthetic depth assessment suggesting otherwise. A combination of factors probably contributed to this.

First, the bull was thought to be profoundly hypotensive at the onset of surgery, prompting a reduction in the delivered concentration of isoflurane. Isoflurane causes hypotension predominantly by decreasing systemic vascular resistance.[2] An appropriate component of treating hypotension during maintenance of general anaesthesia with volatile agents is, therefore, to reduce inhaled concentrations to the minimum effective dose, using 'balanced' (also referred to as multimodal) anaesthetic techniques if needed.[3] This can include the administration of drugs such as ketamine, xylazine, morphine and lidocaine by continuous infusion.[4] As well as potentially allowing a reduction in volatile agent administration and concomitant improvement in cardiovascular variables, such strategies are attractive because of the additional analgesia they may provide. Potential disadvantages, particularly in large ruminants, include the possibility of prolonging recovery and depressant effects on gastrointestinal motility. However, conclusive evidence of both benefits and risks of these approaches is lacking in cattle.[4] There may also be jurisdiction-dependent licensing and withdrawal considerations in food-producing animals.

In this case, both xylazine and ketamine had been administered as bolus doses only, shortly before and to induce general

anaesthesia, respectively. Each has been shown to exert a minimum alveolar concentration (MAC) 'sparing' effect in horses, allowing the inhalant anaesthetic concentration to be reduced.[5] However, to the authors' knowledge, this effect has not yet been conclusively demonstrated in cattle.

Hypotension may also be countered by increasing the circulating blood volume with crystalloid or colloid fluids and/or using drugs to increase cardiac output and/or increase systemic vascular resistance. Vascular access was initially limited to a 20 SWG auricular venous cannula, which was inadequate for the effective and prompt provision of suitable volumes of intravenous fluids (maximum flow for the cannula used in this case is reported as 60 mL/min).[6] Given the animal's size, cannulation of the jugular vein(s) with one or more wide-bore cannula should have been considered to administer the necessary volumes of fluid (5–10 L) in an appropriate timeframe (10–15 minutes). However, even with the presence of multiple wide-bore cannulae, administration of large volumes of fluid IV can be challenging to achieve without large volume pressure bags and multiple mechanical infusion controllers, neither of which were available. Both appropriate venous access and the necessary equipment to enable rapid administration of large fluid volumes should be available to those carrying out general anaesthesia of large ruminants.

Several pharmacological agents can be used to increase cardiac output and/or systemic vascular resistance.[7] Unfortunately, legislation covering drug administration to food-producing animals in the United Kingdom at the time precluded the administration of vasopressor drugs such as dopamine, dobutamine, phenylephrine and ephedrine to cattle.[8] The use of epinephrine (adrenaline) is permitted but, due to its potent adrenergic effects, requires careful titration. Furthermore, there are limited data regarding its use in the management of hypotension in ruminants.[9] Administration of an antimuscarinic agent, such as atropine, to increase heart rate and consequentially cardiac output, was not considered as the bull's heart rate at the time of concern was not considered to be haemodynamically significant (heart rate was 52–58 beats per minute). As such, the primary focus of restoring normotension in this case was a reduction in the concentration of volatile agent being inhaled.

In the end, it transpired that the initial concerns over hypotension were partly unwarranted: the blood pressure transducer was mis-positioned, and should have been set at the level of the right atrium.[10] An excessively elevated transducer will artefactually lower blood pressure readings by 7.5 mmHg for every 10 cm elevation over datum. Accurately estimating the position of the right atrium in a one-tonne bull in dorsal recumbency is challenging, and evidence-based recommendations are scant. Following repositioning of the transducer, MAP remained at approximately 60 mmHg, a common 'trigger threshold' for hypotension management in veterinary anaesthetic practice,[11,12] but substantially less than the MAP that has been reported for anaesthetised cattle.[13] The site of arterial cannulation can also affect blood pressure measurement and, while use of the auricular artery has been reported in cattle,[14] using this locus in anaesthetised dogs gives lower readings for systolic, mean and diastolic pressures compared with readings recorded from other sites.[15] Having obtained an 'acceptable' MAP and with the lack of response to surgical stimulation supporting the conclusion that anaesthetic depth was adequate, the inspired isoflurane concentration was not increased for fear of aggravating vasodilatation and hypotension.

Monitoring depth of anaesthesia in large ruminants is more challenging than in other species, especially when they are positioned in dorsal recumbency. Assessment of jaw tone is arguably futile given the collective bulk of the muscles of mastication and mandibles in large adult ruminants. Furthermore, the frequent presence of mouth-gags will greatly limit the range of mandibular movement, complicating any subjective assessment of tone. Palpebral reflexes are lost at very light planes of anaesthesia in ruminants, and therefore cannot be considered useful indicators of depth.[16] It is stated that the globe rotates ventrally until the pupil becomes completely obscured by the lower eyelid when surgical planes of anaesthesia are achieved.[16] However, evaluating this end-point is difficult in many animals positioned in dorsal recumbency, because peri-orbital soft tissue becomes distorted and, in extreme cases, may obscure ocular orientation altogether. Overall, the evidence base for readily identified and unequivocal features of cranial nerve reflex function, allowing reliable anaesthetic depth assessment, is scant or absent. Objective techniques, such as the bispectral index, are considered by some to represent a standard of care for monitoring anaesthetic depth in humans. However, the necessary equipment is not routinely available in veterinary clinical practice, and there are limited data to support its ability to discriminate anaesthetic depth in cattle.[17–19]

The F_{Iso} was recorded as 0.9% immediately before disconnecting the anaesthetic machine and hoisting. The MAC of isoflurane in (female, Holstein-Friesian) cattle, obtained using the noxious stimulus of 'a tail clamp…applied to full rachet lock and the tail moved vigorously for 60 seconds', is reported to be 1.14%.[14] This study determined the mean time to sternal recumbency after discontinuation of inhalant to be 4.6 minutes (±0.58 minutes, standard error of the mean). In the current case, ketamine and xylazine had been administered 50 and 60–70 minutes, respectively, before ending anaesthesia. As stated earlier, these will likely have exerted a 'MAC-sparing' effect, allowing maintenance of general anaesthesia using lower F_{Iso}. Indeed, xylazine (0.05 mg/kg IV) and ketamine (2 mg/kg IV) alone will provide anaesthesia for approximately 15 minutes.[20] In this case, the bull received twice this dose of ketamine at induction, which one might simplistically assume would provide anaesthesia for around twice this period (i.e., 30–45 minutes). Therefore, it is likely that the end of isoflurane administration in this case coincided with the waning of ketamine- and xylazine-induced effects. Consideration could have been given to administering additional sedation (e.g., xylazine) before recovery, as is commonly practised with horses. However, prolonging recumbency in large ruminants unnecessarily is undesirable, as it will increase the risk of complications such as ruminal tympany and myopathy.

Intuitively, surgery is considered the most stimulating element of procedures conducted under general anaesthesia. Some practitioners will decrease the amount of volatile agent being administered on conclusion of surgical stimulation, in preparation for recovery. The case described suggests that non-surgical procedures, such as hoisting, may themselves provide a level of stimulus sufficient to cause clinically relevant arousal. To the authors' knowledge, the stimulation caused by

hoisting large animals has not been evaluated. It is not unreasonable to assume that suspending heavy (one-tonne) animals by their limbs might be at least as stimulatory, even nociceptive, as surgical incision. The activation of (presumably hitherto unencountered) vestibulo-cochlear and proprioceptive reflexes along with Aδ and C nerve fibre nocistimulation from skeletomuscular and synovial structures may, under conditions of apparently adequate planes of surgical anaesthesia, promote levels of arousal that overwhelm unconsciousness.

Hoisting may also promote recovery from general anaesthesia in other ways. In horses, hoisting impairs arterial oxygenation,[21] presumably because the spinal flexion that occurs when the four limbs are pulled together at a single hoist point reduces the functional residual capacity. This will diminish the end-tidal oxygen reserve within the lungs and also increase the rate of elimination of isoflurane from the alveolar space once isoflurane delivery is discontinued.[22] This, in turn, would accelerate the recovery from general anaesthesia, and may have been important in the case described here. Taken together, the effects of hoisting might merit a deliberate increase in F'_{iso}, or administration of additional IV xylazine and/or ketamine, before it is commenced.

The complications described would not have occurred had surgical conditions been achieved without general anaesthesia. The recommended treatment for penile fibropapilloma, a common occurrence in young bulls, is surgical excision, but this can be carried out, with appropriate restraint, under local or regional anaesthesia.[23] In this case, general anaesthesia was chosen for several reasons, namely, safety of the surgical team and provision of optimal surgical conditions. The latter was prioritised given the only temporary success of the previous surgery and concerns with maintaining urethral patency. Use of general anaesthesia does not preclude the use of a loco-regional technique; however, a local anaesthetic technique was not employed in this case. A dorsal penile nerve block is described and was considered.[24] However, the licensed product available in the practice at the time of the procedure (Pronestesic 40 mg/mL, FATRO SpA) contains an unambiguous statement within its datasheet: 'Do not use to anaesthetise regions with terminal circulation (ears, tail, penis, etc.), owing to the risk of tissue necrosis following complete circulatory arrest, due to the presence of epinephrine (substance with a vasoconstrictor action)'. Interestingly, a comparable licensed product (Adrenacaine, Norbrook Laboratories) does not have any such restrictions about where it can be used. Alternatives to local infiltration of local anaesthetic that could have been considered include epidural anaesthesia or a pudendal nerve block.[24] However, these are undertaken in the standing animal, and appropriate handling and restraint facilities were not available adjacent to the operating theatre.

While it is possible that the sudden and violent recovery observed in this case may have been exacerbated by a degree of pain sensation following the regaining of consciousness, it is difficult to conclude this with any certainty. The absence of any physiological nociceptive response to the surgery itself, despite low concentrations of inhalant anaesthetic, and the fact that multi-modal analgesia had been provided by the earlier administration of meloxicam, ketamine and xylazine, argue against pain being a significant contributory factor.

Consideration should also be given to features of the case that prevented a worse, potentially catastrophic, outcome. The maintenance of secure intravenous access, with the auricular cannula sutured to the skin, is central to this. The use of a narrow-bore extension and three-way tap facilitated rapid, remote IV access, enabling safe drug administration despite violent head movement and without the administrator positioning themselves in harm's way. Further, having a syringe containing an appropriate dose of ketamine already prepared meant that a dangerous situation was rapidly brought under control.

In conclusion, this case demonstrates that the frequent and close clinical appraisal of anaesthetic depth indicators, along with the continuous and advanced monitoring of physiological variables, does not prevent misinterpretation of the depth of anaesthesia in large ruminants. The case further demonstrates the need for awareness of the various durations of action of all anaesthetic and sedative agents administered. While acknowledging that clinical monitoring of anaesthetic depth may be difficult and sometimes unreliable, it remains important to regularly assess depth of anaesthesia before moving to, and on arrival in, the recovery area. Handling procedures such as hoisting may be equally, if not more, stimulating than surgical stimuli. It may even be necessary to intentionally deepen the plane of anaesthesia before hoisting, to allow sufficient time for this part of the procedure to be completed and for attendant personnel to retreat to a place of safety, given that unanticipated recovery from anaesthesia of large ruminants poses notable risks to animal and personnel welfare. It is critical to maintain secure (ideally remote) venous access until both animal and humans are safe, to allow rapid administration of pre-prepared immobilising agents in situations where unanticipated recovery from anaesthesia may incur significant risks.

AUTHOR CONTRIBUTIONS

Stephen Nicholas Greenhalgh, Paul Wood and Hannah Leigh were responsible for case management. Stephen Nicholas Greenhalgh and Richard Eddie Clutton conceived and planned the case report. All authors were involved in drafting and reviewing the manuscript, and approved the final version.

CONFLICT OF INTEREST STATEMENT

The authors declare they have no conflicts of interest.

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ETHICS STATEMENT

The authors confirm that the ethical policies of the journal, as noted on the journal's author guidelines page, have been adhered to. No institutional ethical approval was required as this is a retrospective report of a clinical case that was undertaken with informed owner consent.

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MULTIPLE-CHOICE QUESTION

Which of the following is unlikely to prevent premature recovery from anaesthesia during hoisting of a large ruminant?

POSSIBLE ANSWERS TO MULTIPLE-CHOICE QUESTION

(a) Carrying out the procedure under standing sedation rather than general anaesthesia.

(b) Deepening the plane of anaesthesia by increasing the inhaled concentration of isoflurane 5 minutes before hoisting.

(c) Administering a low dose of ketamine intravenously before hoisting.

(d) Assessing anaesthetic depth immediately before hoisting.

(e) Keeping the halter in place throughout the procedure.

CORRECT ANSWER

(e) Keeping the halter in place throughout the procedure.

Keeping the halter in place is unlikely to prevent premature recovery, but will facilitate safe patient handling should it occur. Conversely, undertaking the procedure using standing sedation instead of general anaesthesia will remove the need for hoisting. Assessing anaesthetic depth before hoisting, although challenging in large ruminants, should reduce the risk of premature recovery, although it will not prevent it. Similarly, deepening the plane of anaesthesia through administration of an increased concentration of volatile anaesthetic or intravenous injection of ketamine will also reduce the risk of recovery during hoisting.