

Sedation and anaesthesia

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7.1

Sedatives and anaesthesia

There are now many safe, effective sedative drugs available and licensed which allow for less use of physical restraint. Assess the local markets to determine what is available.

Sedatives and tranquillisers alter mood, helping to calm the animal and make it less sensitive to external stimuli such as noise. The use of sedative or tranquillising drugs can also help animals to cope with fear or anxiety. This results in greater safety when carrying out examinations and treatment. These drugs are never a substitute for sympathetic handling (Section 2.3), correct usage of analgesia (Section 5.4) and local/general anaesthesia (Sections 7.2 and 7.3) where appropriate.

Considerations when using chemical restraint

Sedation of equids allows longer, more complex or painful treatment to be carried out and is often combined with local anaesthetic techniques or opioids for an enhanced effect. If performing any procedure where handling an animal is proving difficult due to its levels of pain and fear, sedation is required.

Consider sedation prior to attempting treatment, as this will decrease the dosage required and improve the animal's response to sedation.

Considerations which will influence the choice and efficacy of sedation

- Available personnel and their ability to help
- Animal's temperament
- Type of procedure (length of time, pain level involved)
- Concurrent conditions/illness of the animal
- Behavioural factors – equids are flight animals and may panic when they feel the onset of ataxia or muscle weakness

Always respect a sedated animal as they can quickly be aroused and respond adversely – a safe, quiet environment is essential.

Drugs commonly used for sedating equids

Phenothiazines

Commonly used agents (see Table 7.1.1)

- Acepromazine (ACP) 10%
- Chlorpromazine (There is very little information on its use in equids; use ACP as first choice.)

Onset and duration of action

- Effects of sedation are slow, seen after 30–40 minutes, regardless of administration route. Increasing the dose will only increase the duration of the effect, not the level of sedation itself.

Effect

- When used alone, ACP will act as a tranquiliser to calm the animal. It has **no analgesic or pain relief properties** so it is often used in conjunction with an opioid or NSAID.

Key considerations

- Profound hypotensive properties Do not use in animals suffering from colic or haemorrhage.
- Retractor penis muscle relaxation Useful if examination of the penis is required. Prolonged exposure can result in trauma or paralysis, therefore use with caution in breeding stallions particularly if they are sick or debilitated; actual reported cases in the field are very low (< 1 in 10,000 cases), but do exist (Driessen et al. 2011).
- Convulsions ACP lowers the threshold for seizure activity and, although epilepsy is rarely diagnosed in equids, this is still a consideration.
- Return to work The cardiovascular effects last for up to 4–6 hours, long after any sedative effect has worn off. Warn owners not to work the animal for at least 4 hours after administration.

Route	Horse – dose	Donkey – dose	Mule – dose
IV	0.01–0.05 mg/kg (0.1–0.5 ml/100kg)	0.04–0.1 mg/kg	0.04 mg/kg IV (May require double dose compared with horses)
IM	0.03–0.1 mg/kg (0.3–1 ml/100kg)	0.03–0.1 mg/kg	*
PO	0.1–0.25 mg/kg	0.1–0.2 mg/kg	*

(Mathews et al. 1997, Carmona et al. 2007. *Information not available in the literature.)

Table 7.1.1 Reported dose rates and routes of administration for acepromazine in horses, donkeys and mules.

Alpha2-adrenoreceptor agonists (alpha2-agonists)

Commonly used agents (see Table 7.1.2)

- Xylazine
- Detomidine
- Romifidine

Onset and duration of action

- Maximal effect is usually within 5–10 minutes; however, **adrenaline overrides the effect** so the rate of onset may be slower or not occur at all if the animal is in a noisy environment, is very nervous, or has just stopped work.

Effect

- Level of sedation is dose-dependent (Lizarrago and Beths 2012). Predictable sedation occurs with the use of these drugs alone, although more often they are used with an opioid drug for an enhanced effect (see neuroleptanalgesia later).

Key considerations

- Analgesia **These drugs provide reasonable analgesia** for half to two-thirds of the time the animal is sedated, especially visceral analgesia, e.g. colic.
- Decreased GIT Motility Advise owners not to feed animals for a few hours after sedation with alpha2-adrenoreceptor agonists as there is a risk of choke.

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- **Pregnancy** Use with caution during pregnancy due to the effect of increased intra-uterine pressure (Schatzmann et al. 1994). Only administer if necessary, especially in the last trimester (check the data sheet).
- **IV sulphonamide antibiotics** Never use at the same time as these drugs as it can cause fatal cardiac arrhythmias (see Section 5.3).
- **Ataxia** Romifidine is preferred in many cases as it gives less ataxia and has the longest duration of action of the three; however, it cannot be given IM and is not available in all countries.
- **Bradycardia** is a common result of using these drugs. However, this is reversible with atipamezole at a dose of 0.1–0.2 mg/kg (Muir 1998) by slow IV/IM. Atipamezole may also be used if the sedation is prolonged or problematic; remember this will also reverse the analgesia effects.

Donkeys and mules

There are reports that donkeys are more resistant to alpha2-agonists and need higher doses for profound sedation; however, a study by Lizarrago and Beths (2012) concluded that various doses of xylazine (0.5–1.1 mg/kg) produced the same hypoaesthetic effect in both horses and donkeys suggesting similar dose rates.

Studies of mules report that doses of 50% more drug are required compared with horses and donkeys (Mathews et al. 1997).

Drug	Horse – dose	Donkey – dose	Mule – dose
Xylazine	0.6–1 mg/ml	0.5–1.0 mg/kg IV 2.2–3 mg/kg IM (single dose)	1.1–1.6 mg/kg IV Mules require a 50% higher dose than horses or donkeys, and may even require up to double the dose compared with horses.
Detomidine	0.01–0.02 mg/kg – lower doses may be effective especially in young, old, debilitated or at-risk animals IM – dose 1.5/2 times greater than IV dose.	0.02–0.04 mg/kg IV or IM	0.03 mg/kg IV As for donkey, or 50% higher dose
Romifidine	0.04–0.12 mg/kg – onset of action 1–2 minutes Light sedation: 0.04 mg/kg Deep sedation: 0.08 mg/kg Deeper/prolonged sedation: 0.12 mg/kg	0.04 mg/kg IV	0.04–0.12 mg/kg IV or 0.12 mg/kg IM Note: Signs of sedation similar to other equids, but intensity less with same dose. IM route may be most efficient.

(Mathews et al. 1997, Alves et al. 1999, Portier et al. 2009, Carmona et al. 2007).

Table 7.1.2 Reported dose rates and routes of administration of alpha2-adrenoreceptor agonists for horses, donkeys and mules.

Benzodiazepines

Commonly used medications (See Table 7.1.3)

- Diazepam

Note: Diazepam is not licensed for use in equids. The main use in adults is for induction of general anaesthesia in combination with ketamine. In foals diazepam is used for sedation and anti-seizure medication.

Onset and duration of action

- Rapid onset after IV administration due to high lipid solubility. Effects are short-lasting in adults (10–15 minutes). In foals the sedative effect is longer.

Effect

- Very mild sedation/sleepiness and muscle relaxation/ataxia in adult horses; more profound sedation in foals. Also used as an anti-convulsant.

Key considerations

■ Foals – Sole agent for sedation and restraint of young foals; however, will provide no pain relief when used alone.

- Induction of general anaesthesia Used in combination with ketamine as a general anaesthetic induction protocol in adult animals.
- Reactions Diazepam reacts with plastics, so never leave drawn up in a syringe – always use straight away.
- Pain relief None

Drug	Horse – dose	Foal – dose	Donkey – dose	Mule – dose
Diazepam	0.04–0.15 mg/kg	0.01–0.4 mg/kg slow IV	0.033–0.4 mg/kg slow IV	0.033 mg/kg IV

(Taylor 1985, Robertson 1997b, Mathews et al. 2005, Michou and Leece 2012a)

Table 7.1.3 Reported dose rates and routes of administration of diazepam in horses, foals, donkeys and mules.

Opioid analgesics

Opioid analgesics give **short-term pain control**. All drugs in this group are derived from the opium poppy, and have a similar effect by acting on μ (mu), κ (kappa) and δ (delta) receptors distributed widely within the CNS and periphery.

Commonly used medications (see Table 7.1.4)

- Butorphanol
- Buprenorphine
- Morphine
- Pethidine

Onset and duration of effect

- When used alone, the analgesic effects have been reported to last 30–90 minutes (Love et al. 2009). However, when used in combination with other sedative drugs the effects last

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longer and the negative side-effects are lessened (see neuroleptanalgesia below), for example buprenorphine and alpha2-agonist can provide analgesia for up to 12 hours (Michou and Leece 2012).

- As a result of the short duration of action they are not normally suitable for long term analgesia.

Uses

- Sedation and pain relief in combination with other drugs and short-term provision of analgesia

Drug	Horse – dose	Foal – dose	Donkey – dose	Mule – dose
Butorphanol	0.02–0.05 mg/kg IV (for sedation in conjunction with an alpha2-agonist – gives limited analgesia) 0.05–0.1 mg/kg IV (for improved analgesia)	0.02–0.05 mg/kg IV (0.1–0.2 mg/kg IM)	0.025–0.5 mg/kg IV (in combination with alpha2-agonist)	0.033–0.044 mg/kg IV (in combination with alpha2-agonist)
Buprenorphine	0.005–0.01 mg/kg IV/IM (IV in conjunction with an alpha2-agonist)	-	-	-
Morphine	0.1–0.2 mg/kg IV/IM (4–6 hours of good analgesia)	0.1 mg/kg IV	-	-
Pethidine (IM only)	1–3 mg/kg IM	-	2 mg/kg IM	-

(Mathews et al. 1992, Robertson 1997b, Mathews et al. 2005, Robert et al. 2008, Svendsen 2008, Davis et al. 2012, Michou and Leece 2012) - where literature on opioids in some species is lacking.)

Table 7.1.4 Reported dose rates and routes of administration for opioids in horses, foals, donkeys and mules.

Key consideration

- Side effects – The negative effect of the wide distribution of opioid receptors throughout the body is a wide range of potential side effects including excitement, manic behaviour and reduced gastrointestinal motility.

- Excitable behaviour is a widely reported side effect of some opioids, but is very rare with appropriate dose rates. The benefits of use in pain control far outweigh the small potential for side effects.

- Use in combination with sedatives (see neuroleptanalgesia below). Intra-muscular administration further reduces the chance of excitation.
- Opioids are controlled drugs. They may have legal restrictions (e.g. a register to be kept of each purchase and use) and they should always be stored in a secure place.
- Sourcing of opioids Every effort should be made to keep at least one type of opioid in stock at the clinic at all times. Human pharmacists/hospitals may be valuable sources of opioids in areas where they are not available through veterinary suppliers. Check the local laws and regulations regarding the use of opioids locally.

Neuroleptanalgesia

Neuroleptanalgesia is the name given to a combination of sedative (usually an alpha2-adrenoreceptor agonist) and analgesic (opioid) which work together to give profound sedation and effective pain control.

If there is any doubt about whether an examination, procedure or surgery may cause pain or fear to an animal, neuroleptanalgesia (opioid + alpha2-agonist) should be used to minimise distress and maximise safety of people and the animal.

Commonly used medications (see Table 7.1.5)

- Butorphanol + alpha2-adrenoceptor agonist

Onset and duration of effect

- The onset is 5–10 minutes if given IV (may take longer if it is administered IM). Most combinations last between 20 and 60 minutes; however, as with all sedative effects, individual animals may vary in their response.

Key considerations

- Combination with local or regional anaesthetic This gives increased duration and effect of neuroleptanalgesia. For example, use with local anaesthetic for wound repair, or palmar digital nerve block for a foot abscess (see Section 7.2 of this chapter and Section 14.2 for details of the technique). This provides the best analgesia for the animal and the safest working environment for clinicians and handlers.
- Other locally available drugs This is not a complete list. Explore locally available options and consult the manufacturer or textbooks for appropriate dose rates where available.

When is the best time to use neuroleptanalgesia drug combination?

Neuroleptanalgesia should be used for all painful procedures to minimise distress and maximise safety for all.

Examples include:

- cleaning, debriding and suturing wounds (see Section 15.1)
- examination of eye problems
- painful farriery or dental procedures
- minor (standing) surgery
- premedication before general anaesthesia (other options available see Section 7.3 of this chapter)

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- any procedure carrying a risk of being kicked. The addition of an opioid to sedation with an alpha2-adrenoreceptor agonist greatly reduces this risk.

Drug dose (mg/kg)	Horse	Donkey	Mule
Butorphanol	0.02–0.05 mg/kg IV	0.025–0.05 mg/kg IV	0.033–0.044 mg/kg IV
Combined with one of the following			
Xylazine	0.5–1.0 mg/kg IV	1.0 mg/kg IV	1.1–1.6 mg/kg IV
Detomidine	0.01–0.02 mg/kg IV	0.01–0.02 mg/kg IV	0.03 mg/kg IV
Romifidine	0.04–0.12mg/kg IV	0.08–0.12 mg/kg IV	0.04–0.12 mg/kg IV (higher dose gives more effective sedation)
ACP	0.02–0.05 mg/kg IM/IV	0.04 mg/kg IV	0.04 mg/kg IV

(Mathews et al. 1992, Mathews et al. 1997, Alves et al. 1999, Mathews et al. 2005, Michou and Leece 2012)

Table 7.1.5 Neuroleptanalgesia dose rates for horses, donkeys and mules.

Intramuscular administration of sedation

As discussed, sedation is very useful when examining a stressed or scared animal, or one in pain, as it improves the animal's mental state and improves the safety of the staff and owners who are dealing with the case. However, finding a vein in a stressed, frightened, possibly dangerous animal can be difficult.

A neuroleptanalgesia drug combination is a very useful IM alternative to IV sedation. The individual drug dose rates should be strictly adhered to (refer to drug data sheets):

- Butorphanol + Detomidine + ACP
- Mix together in the same syringe and inject into the muscle.

Despite this neuroleptanalgesia drug combination being easy to administer, it is not to be used routinely as a substitute for finding a vein.

Being IM, it takes a lot longer to have effect, and the animal requires a very quiet environment for the medication to be effective. The addition of the ACP makes the hypotensive effects even more pronounced, so try to avoid this neuroleptanalgesia drug combination in animals with shock, haemorrhage, dehydration or any other condition in which a low blood volume or pressure is suspected.

Local anaesthetics (LA) remove all sensation in the area of administration (pain, touch, pressure and tension) whilst the animal remains conscious.

LA work by blocking conduction along sensory neurones by reducing sodium ion (Na⁺) influx via Na⁺ channels (Harkins et al. 1999) thus preventing action potentials and subsequently sensitisation or pain.

Commonly used medications (see Table 7.2.1)

- Lignocaine hydrochloride
- Bupivacaine hydrochloride
- Mepivacaine hydrochloride
- Proxymetacaine/oxybuprocaine (see Chapter 9 Ophthalmology)

Onset and duration of effect

- Most local anaesthetics take around 5–10 minutes to work (bupivacaine hydrochloride and mepivacaine hydrochloride take the longest at > 10 minutes).

Always check the area to be desensitised with a needle/blunt-ended scissors to ensure the tissues are desensitised before commencing any procedure.

The duration can be from 30 minutes to 8 hours depending on the drug and procedure. Adrenaline prolongs the effect due to vasoconstrictive properties, thus preventing the LA dispersing from the area. Bupivacaine hydrochloride is four times as potent as mepivacaine (Harkins et al. 1999). Mepivacaine hydrochloride is less toxic than bupivacaine hydrochloride and produces less local tissue oedema, hence it is very popular for diagnostic analgesia of the limbs (Baller and Hendrickson 2002).

Uses

- Management of any painful procedure: eye examination (see Chapter 9), wound debridement/suturing (see Chapter 15)
- Peripheral nerve blocks
- Diagnostic tool, for example nerve blocks for lameness examination (see Chapter 14)
- Epidural anaesthesia
- Adjunct to sedation, neuroleptanalgesia and general anaesthesia for optimal pain control and to reduce the amount of sedation needed

Side effects and toxicity

LA solutions are mildly irritant to tissues, especially with compounds containing adrenaline. LA can cause sloughing of wound edges and delay healing. Excessive volumes may be absorbed systemically and lead to toxicity which is manifested by muscle tremors, seizures, and then coma. In some situations it may lead to respiratory arrest and coma.

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LA agent	Duration of action (minutes)	Dose (mg/kg)
Lignocaine hydrochloride	30–120	10–40 mg per site (for diagnostic limb analgesia: Harkins et al. 1998); highest safe dose rate is 4 mg/kg (Baller and Hendrickson 2002)
Bupivacaine hydrochloride	30–90 (reported up to 8 hours)	1–2 mg/kg (Baller and Hendrickson 2002), or 0.5–2 mg per site
Mepivacaine hydrochloride	60–120	30 mg per site (Midwell et al. 2004)

Table 7.2.1 The duration of action and dose rates of local anaesthetics.

Local or regional anaesthetic techniques for use in equids

See individual chapters for the LA techniques for specific areas: for the eye see Chapter 9, for face and teeth see Chapter 10 and for limbs see Chapter 14.

Topical – solutions without adrenaline

- Apply to mucous membranes for urinary catheterisation, examination and cleaning of wounds on gums and vulva.
- Proxymetacaine eye drops give corneal anaesthesia for 15–20 minutes. Use for eye examination, corneal ulcer debridement, washing or removal of foreign bodies (see Chapter 9).

Local infiltration

Local infiltration is a useful technique in equids.

However, it must be used carefully due to the potential for systemic toxicity if used over large areas or with large volumes of LA.

The tissue irritation and delayed healing effects must also be taken into account.

- Inject subcutaneously close to a wound edge for skin suturing. Inject into one area and then perform further infiltrations through the previously anaesthetised area in a step-wise manner. This means the animal will only feel the first injection and is less likely to become fractious. Caution: Large volumes cause swelling and may impair healing.
- Inject 0.5–1 ml subcutaneously before placement of an IV cannula.
- Inject subcutaneously, into the body of the testicles and into the spermatic cord for castration.

Possible complications

- Always draw back on the syringe to ensure that the LA is not injected inadvertently into a blood vessel. It can cause a decrease in cardiac electrical activity and contractility which may lead to cardiac arrest (Baller and Hendrickson 2002).

Nerve blocks (perineural anaesthesia)

Prepare all sites for nerve blocks in a sterile way to avoid the risk of possible infection post-injection (Section 4.6).

Uses

- Painful procedures Extremely useful for analgesia of painful procedures, e.g. paring out foot abscesses or suturing muzzle or lower limb wounds. Wherever possible, use as an adjunct to sedation, neuroleptanalgesia or general anaesthesia to maximise pain control and reduce the amount of other drugs needed.
- Lameness diagnosis Useful for lameness diagnosis when performing nerve blocks from distal to proximal in a logical manner to pinpoint the site of pain (see Section 14.2 for details of palmar/plantar digital nerve block and abaxial sesamoid nerve block techniques).
- Eye For thorough examination of the eye and eyelids LA of the auriculopalpebral nerve block can be carried out (see Chapter 9 Ophthalmology for techniques). This nerve block blocks the motor function of the upper eyelid. This stops blinking. However, the surface of the eye is not desensitised, therefore ensure that topical ophthalmic LA is applied if required (sensory block). The sensory innervation to the medial (nasal) two-thirds of the upper eyelid can be eliminated by a supraorbital (frontal) nerve block. For examinations, suturing injuries of the eye and enucleations, administer the lacrimal, zygomatic and infratrochlear block leading to complete desensitisation of the eye and eyelids. (Full descriptions in Chapter 9.)
- Distal face, jaw and lips For examination and treatment of injuries of the distal face, jaw and lips, e.g. a suspected fractured mandible or mouth trauma, apply the mental nerve block (see Section 10.8 for full details of the technique). Further desensitisation of the upper lip and nose is provided by the infraorbital nerve block.

Caudal epidural anaesthesia

Caudal epidural anaesthesia provides analgesia of the perineum, rectum, vulva and vagina and can be useful in cases of dystocia as it helps with uterine relaxation. This technique allows surgical intervention in the standing animal without the risks and costs of general anaesthesia (Salmon et al. 1995).

Clipping and sterile preparation is mandatory for equine epidurals, unlike those performed on cattle.

The aim is to produce regional anaesthesia without losing motor function to the hindlegs.

1. Sedate the animal, and clip and aseptically prepare the area cranial to the tail.
2. Ensure operator safety at all times – even with sedation, the animal can still react to the needle insertion so do not stand directly behind it.

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3. With the animal standing square, locate the first inter-coccygeal space (Co1–Co2). This is the first obvious midline depression caudal to the sacrum, about 2½ inches (6–7 mm) cranial to the origin of the first tail hairs. Pumping/moving the tail up and down can assist in locating the depression. Place a bleb of local anaesthetic under the skin in this area (Figure 7.2.1).
4. Use a 2-inch, 19G needle. Before injecting into the space, place a few drops of sterile saline into the hub, for use as an indicator that the needle is in the right place (see next step).
5. Angling the needle perpendicular to the skin, direct it into the midline depression facing cranially. As the needle enters the right space, the saline in the hub will be sucked in quickly – the ‘hanging drop’ technique. Correct placement is also ensured by lack of resistance when injecting 5 ml of air. Always draw back before injecting to ensure a vein has not been inadvertently penetrated.
6. Inject – a combination of local anaesthetic and an alpha2-agonist is the most frequently used permutation of drugs for epidurals as this combination extends the period of action of epidural anaesthesia/analgesia: e.g. lidocaine 0.2 mg/kg and xylazine 0.17 mg/kg.



Figure 7.2.1 Site for caudal epidural anaesthesia (left) and placement of a needle (right). (Images provided by Avice O'Connor, University of Cambridge, UK.)

General anaesthesia in the field

7.3

Choice of anaesthetic agents

The choice is between:

- (1) inhalants/volatile gases, such as halothane and isoflurane
- (2) intravenous agents, such as thiopentone and ketamine.

Field general anaesthesia (GA) is limited to procedures that can be done under short timescales.

It is also limited in the types of agents that can be used due to a lack of equipment for inhalant anaesthesia, which is expensive and impractical for the field (Robertson 1997a). Here only intravenous anaesthesia is described.

Intravenous agents can be given as:

- a single bolus for short duration procedures such as wound repair, tissue removal or castration. For example, a single dose of ketamine can give 10–27 minutes of GA time (Fisher 1984).
- repeated boluses administered when a longer GA time is required; the induction and anaesthetic agents are re-administered at intervals to maintain GA. However, it is difficult to maintain a steady plasma concentration of agents in the required therapeutic range, with peaks and troughs occurring (Robertson 1997a).
- a constant rate infusion. This is the ideal as the plasma drug rate will be constant within the therapeutic range. However, it does require extra equipment to administer the drugs: from higher technical computer-driven pumps to simple standard fluid-giving sets attached to a jugular catheter (Beths 2007).

Total Intravenous Anaesthesia

There have been advances in Total Intravenous Anaesthesia (TIVA) techniques in recent years based on the combination of two or three different drug types, usually involving a muscle relaxant, a sedative and an anaesthetic agent, without the need for inhalant anaesthetic facilities.

Recent advances in the use of sedative combinations and local anaesthesia techniques also facilitate standing surgical procedures.

However, TIVA may still be necessary in some instances for short surgical interventions, painful diagnostic procedures and minor procedures in animals where pain or fear cannot be controlled by standing techniques.

Field anaesthesia always carries some degree of risk, including fatality, which varies with the health of the animal and the skill and technique of the veterinarian.

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The type of GA most applicable to working equine veterinarians is TIVA where equipment required is minimal and inexpensive.

Advantages of TIVA

- Applicable for the field situation
- Physiologically superior to gaseous anaesthetic agents: reports state that TIVA is less noxious than inhalant anaesthetic gasses and results in less cardiorespiratory depression (Robertson 1997a, Stanway 2001)
- Combinations of lower doses of several drugs reduce side effects of each individual drug (Muir and Scicluna 1998)

Disadvantages of TIVA

- Oxygen not always available
- Not suitable for lengthy procedures (greater than 90 minutes) as prolonged recoveries are then seen (Stanway 2001)
- Cannot remove any drug once administered (inhalant levels can more easily be adjusted)
- Anaesthetic depth harder to monitor, especially with ketamine as the usual signs of GA are not shown: the eye remains active with palpebral movements (nystagmus) and swallowing may also occur (Robertson 1997a)

Ideally, airways should be maintained with an endotracheal tube, and oxygen should be available from an oxygen cylinder (size E) and a demand valve (Brouwer 1985).

Welfare cost versus benefit of GA

Animal welfare is paramount when considering GA.

Preparation for GA

Preparation must include a method of humane euthanasia close at hand in case the surgery fails or the animal injures itself severely during anaesthesia or recovery. Veterinarians must decide in advance the 'cut-off points' for failure of the procedure/irreparable injury and agree to destroy the animal humanely immediately if this occurs. This requires advance consent from owners for surgery and euthanasia if it becomes necessary. The field anaesthetic techniques described below are only suitable for short procedures. Some anaesthetic combinations can be maintained by 'top-up' doses or drip infusions.

In all cases the risk of side-effects increases with the duration of anaesthesia.

The risk of fatality increases markedly after 1.5–2 hours.

Preparation is vital before any general anaesthetic procedure because situations can change rapidly and become dangerous to both the animal's welfare and that of the staff. All necessary equipment must be ready at hand, including spare equipment and a back-up plan in place if the first procedure fails or takes longer than anticipated. At least two experienced veterinarians should be present, of whom one must be responsible for anaesthesia at all times (not involved in surgery), and at least one trained assistant.

Recumbent anaesthetised horses are anatomically, physiologically and pharmacologically susceptible to cardiorespiratory depression during anaesthesia leading to arterial hypoxaemia (low blood oxygen), hypercapnia (high blood CO₂), and hypotension (low blood pressure), which ultimately can produce skeletal muscle ischaemia and postanaesthetic myopathy.

The risks should be fully explained to the owner, and GA should only be undertaken if there is sufficient time, resources and personnel to provide care for the procedure itself and for the post-op and recovery period.

Close consideration should be given to pre-, during and post-GA care to ensure that the animal's welfare is respected.

List of equipment for GA

- Anaesthetic consent form, signed after informed consent from the owner
- Head collar (with padding) and long lead ropes
- IV catheters
- Sedation and induction drugs and top-ups
- Ophthalmic lubricating ointment
- Towels

Pre-operative examination

The risk of a healthy equid dying under GA is approximately 1 in 100 (Stanway 2001).

This figure will rise dramatically if the animal is dehydrated, anaemic, in shock, has other cardiovascular compromise or any other sickness, due to the effects of anaesthetic drugs on the cardiovascular system. The importance of client communication and informed consent cannot be overstressed – always fill in a consent form for both anaesthesia and euthanasia.

Take a history and perform a thorough clinical examination, paying close attention to the heart (Figure 7.3.1) and respiratory rates, mucous membrane colour, capillary refill time (CRT) and lung auscultation – any signs of respiratory or cardiovascular distress should be taken seriously. Take the temperature.

It is absolutely essential that an accurate weight is obtained prior to GA so that drug doses can be calculated accurately.

Information on estimating bodyweight can be found in the References (Section 7.4. of this chapter) and in Chapters 5 and 11.



Figure 7.3.1 Perform a thorough pre-general anaesthetic clinical examination.

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Unsuitable conditions for GA

- Pyrexia
- Severe respiratory disease
- Diarrhoea
- Anaemia
- Cachexic or animals with BCS < 1.5 (on a scale of 1 = very thin, to 5 = very fat; see Section 11.1)
- Pregnancy (can be undertaken if essential, but should be avoided)

The environment for GA

Sedation and general anaesthesia requires a quiet environment to be effective.

The ideal casting area is flat, dry and clean, free of other animals and unnecessary observers. The animal will need good grip to get up, so a grassy area is ideal (Figure 7.3.2).

Venous catheterisation

Always required – enables drugs to be administered IV rapidly and easily in the case of an emergency and it eliminates the risk of injecting into the carotid artery or extravascularly if the animal is lying down.

Phases of GA

There are four phases of GA:

1. Pre-anaesthetic
2. Induction
3. Maintenance
4. Recovery

Pre-anaesthetic

The aim of this phase is to produce an animal that is calm, sedated, free from pain and relaxed.

A pre-anaesthetic, or pre-medication, agent is a drug given before starting the GA to sedate the animal. Besides inducing muscle relaxation essential for a smooth induction, it reduces the total amount of each drug required. Certain combinations can also provide peri-operative analgesia.

Premedication drugs include acepromazine (ACP), alpha₂-adrenoceptor agonists, opioids and NSAIDs, all of which have been discussed in Section 7.1. of this chapter and Chapter 5.

Do not be deterred by the combination of several drugs: this is safer and better for the animal than using only one anaesthetic agent.



Figure 7.3.2 A good location for performing a general anaesthetic.

Induction of GA

The aim of induction is to get the animal from a standing to a recumbent position as smoothly, quietly and safely as possible for all involved.

It is essential that the animal is restrained quietly for induction and is not disturbed by noise or sudden movement as this can lead to a violent induction. The animal should be kept steady and not allowed to move around. It is not advisable to push an animal backwards as it will tend to push against the restraint and fall forward. With firm controlled restraint, the animal should buckle at the knees, thereafter sink back into sternal recumbency and then into lateral recumbency in a slow and controlled manner. Trained personnel can aid the animal into lateral recumbency by keeping the head low and one hand on the front of the shoulder to guide the animal to the ground. Large equids may require two handlers, one either side of the head facing the shoulders with one hand on a lead rope either side and the other hand on the point of the shoulder; smaller equids can be controlled by a single person.

Easy, safe induction is only possible with a calm animal that is well sedated – do not inject ketamine unless the animal is deeply sedated – top up with the same alpha₂-adrenoreceptor agonist if necessary.

Maintenance of GA

The aims of this phase are to maintain a state of unconsciousness, analgesia and muscle relaxation, whilst minimising the physiological effects of the surgery. There are three planes of anaesthesia described by Geudel (1937): light, medium and deep.

Planes of GA

1. Light Decreased reflexes with no involuntary muscle movements. Palpebral, corneal reflexes and lacrimation are still maintained; swallowing reflex depends on GA agent used (absent with inhalants, present with TIVA).
2. Medium Ideal for most surgical interventions: absence of pain and palpebral reflexes, pupils dilated and corneal reflexes present. Local anaesthetic techniques required for ocular surgery (see Chapter 9).
3. Deep Signs of early overdose are seen. Respiration is depressed, bradycardia is present, all reflexes are absent.

Beyond this, cardiovascular and respiratory function cease and death will ensue.

Recovery from GA

This is often the most crucial and yet forgotten stage of the GA.

The risks for the animal are increased. The aim is for a quiet, controlled transition from recumbency to standing. See later for more details.

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Injectable agents

Ketamine

Ketamine is a dissociative anaesthetic agent that produces a trance-like loss of consciousness whilst maintaining skeletal muscle tone and cranial nerve reflexes. The result is an animal with intact muscle tone, swallowing and ocular reflexes (blinking, nystagmus), which can be unnerving for the surgeon, and make anaesthetic monitoring difficult.

To reduce the excitement reactions which occur with ketamine induction it is vital the animal is well sedated with an alpha2-adrenoreceptor agonist.

Many veterinarians combine ketamine with diazepam in the same syringe for induction to improve muscle relaxation. See Table 7.3.1 for protocols.

After injection of ketamine, lateral recumbency is usually achieved in 40–100 seconds; recumbency time is reported from 10 to 27 minutes, with 5–15 minutes surgery time (Muir 2010, Fisher 1984).

Thiopentone

This barbiturate anaesthetic is typically presented in 5-g vials, and is mixed with 100 ml sterile water for 5% solutions. It is a lot faster acting than Ketamine, often giving less than 10–15 minutes of surgical anaesthesia.

The disadvantages of thiopentone use is that, like all barbiturates, it has a cumulative effect and is generally not suitable for multiple top-up injections as this tends to cause prolonged, difficult recoveries with a higher risk of injury.

It is not suitable for use as a sole anaesthetic agent and premedication is vital.

Rapid IV injections cause hypotension and respiratory depression. It is also an extreme irritant perivascularly, so do not use without an IV catheter. See Table 7.3.2 for protocols.

Recumbency is achieved 25–30 seconds after injection. Correct dosage is essential as under-dosage can lead to excitement on induction.

Drugs and doses for GA

Tables 7.3.1 and 7.3.2. show reported doses for pre-anaesthesia sedation and induction of GA. Always ensure that additional analgesia is given in the form of NSAIDs or opioids, as the analgesic effects of sedatives and induction agents are short-lived.

Species (references)	Horse (Fisher 1984, Taylor 1995, Moens et al. 2003, Beths 2007, Muir 2010)	Donkey (Mathews et al. 1994, Mathews et al. 2005)	Mules (Mathews et al. 1992, Mathews et al. 2005)
Surgical/recumbency time	5–15 minutes of surgical GA	15–30 minutes of surgical GA	5–20 minutes of recumbency time
Protocol	<p>Sedate with (optional): ACP 0.04 mg/kg IM/ IV (care with sick, dehydrated animals and entire males).</p> <p>Wait 30–40 minutes if possible and then sedate with: Alpha2-agonist, e.g. xylazine 1–1.1 mg/kg IV or romifidine 0.08 mg/kg IV (+/- butorphanol 0.02 mg/kg IV).</p> <p>Wait 2–5 minutes (or to sedation effect) and then induce with: Ketamine 2.2 mg/kg (+/- diazepam 0.04–0.1 mg/kg IV).</p>	<p>Sedate with: ACP 0.04 mg/kg IV.</p> <p>Wait 30–40 minutes if possible and then sedate with: Xylazine 1–1.1 mg/kg IV (+/- butorphanol 0.025–0.05 mg/kg IV).</p> <p>Wait 5 minutes then induce with: Ketamine 2.2 mg/kg IV (+/- diazepam 0.02–0.1 mg/kg IV).</p>	<p>Sedate with: Xylazine 1.6 mg/kg IV (Mules require 50% increased dose of xylazine and detomidine compared with horses and donkeys.) +/- butorphanol 0.044 mg/kg IV.</p> <p>Wait 3–5 minutes then induce with: Ketamine 2.2 mg/kg IV (Ketamine is cleared more quickly from the body of donkeys, followed by mules, then horses.) +/- diazepam 0.033 mg/kg IV.</p>
Options	<p>Depending on drug availability and patient, variations include:</p> <ul style="list-style-type: none"> ■ Step 1 – Leave out ACP. ■ Step 2 – Leave out butorphanol and substitute romifidine or xylazine with detomidine 0.015–0.02 mg/kg. ■ Step 3 – Leave out diazepam and just use ketamine at 2.2 mg/kg. 	<p>Depending on drug availability, variations include:</p> <ul style="list-style-type: none"> ■ Step 1 – Leave out ACP. ■ Step 2 – Instead of xylazine, sedate with detomidine 0.01–0.02 mg/kg, or romifidine 0.12 mg/kg IV; leave out butorphanol. ■ Step 3 – Leave out diazepam and just use ketamine at 2.2 mg/kg. 	<p>Options:</p> <ul style="list-style-type: none"> ■ Step 1 – Detomidine 0.03 mg/kg IV +/- butorphanol 0.033–0.044 mg/kg IV ■ Step 2 – Leave out diazepam. ■ Mules following the protocol of xylazine/butorphanol/ketamine had smoother inductions, longer GA time, better analgesia, and better recoveries than those on xylazine/ketamine only.

Table 7.3.1 Reported protocols for ketamine induction in horses, donkeys and mules.

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Species (references)	Horse (Muir and Scicluna 1998, Stanway 2001)	Donkey (Mathews et al. 2005, Emami et al. 2006, Al-Heani 2010)	Mule (Grint et al. 2011)
Surgical time	-	17–24 minutes	-
Protocol	<p>ACP 0.04 mg/kg IM/IV (Caution! – see above)</p> <p>Wait 30–40 minutes then sedate with:</p> <p>Detomidine 0.015–0.02 mg/kg IV, or romifidine 0.01 mg/kg IV, or xylazine 0.1 mg/kg IV.</p> <p>Wait 2–5 minutes (or to sedation effect) and then induce with:</p> <p>Thiopentone 4–10 mg/kg IV (+/- diazepam 0.04–0.1 mg/kg IV).</p>	<p>Romifidine 0.12 mg/kg IV</p> <p>Wait 5 minutes then induce with:</p> <p>Thiopentone 4–10 mg/kg.</p>	<p>ACP 0.03 mg/kg IV</p> <p>Wait 30–90 minutes then induce with:</p> <p>Thiopentone 10 mg/kg IV.</p>
Options	<p>Options:</p> <ul style="list-style-type: none"> ■ Step 1 – Leave out ACP. ■ Step 2 – Select a more readily available or familiar sedative. ■ Step 3 – Leave out the diazepam. 	<p>Depending on drug availability, variations include:</p> <ul style="list-style-type: none"> ■ Step 1 – Instead of romifidine, sedate with xylazine 1 mg/kg or detomidine 0.02 mg/kg. ■ Pre-step 1 – Administer atropine and ACP, then use xylazine sedation followed by thiopentone 7 mg/kg, maintained for up to 100 minutes with thiopentone 8 mg/kg in 500 ml normal saline. 	-

Table 7.3.2 Reported protocols for anaesthetic induction with thiopentone in horses, donkeys and mules.

Propofol

An alternative induction agent for GA is propofol. This has been used in foals (2–3 mg/kg IV) 5 minutes after xylazine sedation (0.5 mg/kg IV). However, it is very costly and this is generally prohibitive for adult equids due to the volumes needed. Respiratory depression has been reported in numerous cases (Robertson 1997a). For protocols using propofol refer to anaesthetic texts and the articles such as Robertson (1997b).

Guaifenesin

Guaifenesin is a centrally-acting muscle relaxant, causing no lack of consciousness or analgesia when used alone.

It should be used only in conjunction with anaesthetic agents for TIVA in horses (Robertson 1997a, Beths 2007); providing GA for up to 90 minutes (Stanway 2001). It is used in combination with alpha2-agonists and ketamine ('triple-drip' combinations): guaifenesin/ketamine/xylazine, guaifenesin/ketamine/detomidine (Robertson 1997a, Stanway 2001) and guaifenesin/ketamine/romifidine (Beths 2007). Infusion rates can be altered depending on the depth of GA obtained; remember there is a 60-second delay in response to the combination (Stanway 2001); these techniques require catheterisation for a constant infusion of the mixture of drugs.

Guaifenesin availability is limited in some countries. Refer to the referenced papers for reported dose rates and protocols for infusion techniques.

Chloral hydrate

This has been used historically as an injectable agent for GA, alone and in combination with thiopentone (Crispin 1981); however, doses are close to the lethal limit and it is best used in combination. Reported doses of 100–120 mg/kg IV followed by thiopentone (10 mg/kg IV) have been used to produce GA for 5–40 minutes. Chloral hydrate is very cheap and may be considered if the safer alternatives (ketamine or thiopentone) are not available and a GA is absolutely necessary. (See Chapter 8 for use of chloral hydrate in euthanasia.)

Other important considerations for the induction of GA

1. Padding around metal rings of the head collar to protect the bony prominences and nerves of the head will prevent traumatic complications such as facial nerve paralysis.
2. Cover eyes with a towel to protect the upside eye from sunlight and the downside eye from the ground in lateral recumbency. Protect the eyes from desiccation during anaesthesia by applying lubricating ophthalmic drops/ointment.
3. Place cotton wool in the ears to minimise environmental stimulation and increase anaesthesia time.
4. Remember that local anaesthesia of the surgical site also helps decrease the painful stimulus and maintenance of smooth GA.
5. Atropine sulphate has been used in older protocols (and other species) to reduce airway and intestinal secretions during anaesthesia.

Atropine can cause gut stasis and impaction in equids so it is not recommended.

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6. Dorsal recumbency is physiologically a very stressful position for an equid, as breathing and circulation will be compromised. Lateral recumbency is better, although this, too, will eventually compromise the down-side lung and reduce oxygen availability.

7. All equids undergoing anaesthesia or a surgical procedure should receive appropriate analgesia – ideally given before induction (i.e. before the procedure is performed).

Pre-emptive analgesia (pre-induction) has been shown to be more effective than analgesics given after the painful stimulus has occurred as the cumulative pain cycle is inhibited, minimising the wind-up of pain receptors and mediators. The use of butorphanol and an alpha2-agonist will not provide adequate analgesia; the addition of an NSAID will provide longer and more effective analgesia.

Positioning an equid during GA

- Ensure the ground underneath the animal is well padded and soft (Figure 7.3.3).
- Extend the head and neck to maintain an open airway (Brouwer 1985).
- When in lateral recumbency ensure that the dependent forelimb (lower/down-most) is pulled rostrally (forwards) to take the pressure off the muscles of the shoulder and minimise the risk of compromise and post-anaesthetic myopathy. It may also be possible to support the uppermost foreleg with a bag of straw or similar. Hindlegs can be similarly supported.



Figure 7.3.3 A sheet can be laid down to aid cleanliness of the operating site, and provide comfort for the animal.

Monitoring under TIVA

GA monitoring is difficult in field circumstances, especially if ketamine is being used because some ocular and motor reflexes are maintained which do not truly reflect the plane of anaesthesia (see earlier). It is important for the person monitoring the GA to record parameters and warn the surgeon of fluctuations in the plane of anaesthesia (see Table 7.3.3).

What if the animal has an adverse reaction or becomes unstable during TIVA?

This is the biggest problem with GA in the field. It is not possible to turn the anaesthetic down, turn the oxygen up, as with gaseous anaesthesia, or uninject medication that has already been administered. If there is a problem during anaesthesia warn the surgeon and monitor the animal. Prepare to administer reversal agents, if available. As the anaesthetic is metabolised the equid should become more stable.

This emphasises the importance of choosing GA candidates wisely and only undertaking GA if it is entirely necessary.

Parameter	GA too light	Surgical plane of GA (correct)	GA too deep
Respiratory pattern (Thiopentone may cause the animal to hold its breath for the first 2–3 minutes of anaesthesia – ‘induction dyspnoea’)	Change in respiratory pattern – a sudden, deeper breath may indicate the animal is lightening up. Equids do not increase their respiratory rate (RR) when lightening as do other species due to large respiratory reserves.	Strong and steady	Increasing periods of time between breaths
Pulse Palpate every 5 minutes. Mandibular (see Section 1.4), facial, metacarpal, metatarsal or digital pulses	The heart rate is not a good indicator of a lightening plane of anaesthesia due to the large cardiac reserve. However, use it to monitor overall cardiovascular system (CVS) function.	Strong and steady Mucous membranes pink with normal CRT (2 seconds)	Weak, irregular or slowing
Peripheral reflexes Corneal reflex and anal tone (Ketamine induction does not abolish cranial nerve reflexes – palpebral, gag and sometime skin twitch reflexes will remain making the monitoring of depth more difficult.)	Nystagmus Eye position is generally more unreliable in equids compared to other species.		A fixed, central, dry eye means the animal is too deep and may die.

Table 7.3.3 Anaesthetic monitoring parameters related to depth of GA.

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If a pre-operative check is not carried out there is an increased risk of anaesthetising an animal which is not fit enough to cope with a general anaesthetic. Remember the majority of working equids have at least one, if not more, factors which make them higher risk candidates for GA, as discussed earlier. The choice for GA should always be taken seriously.

Maintenance and 'top-ups' of TIVA

Once anaesthesia has been induced GA can be maintained if necessary by further intravenous 'top-up' techniques. These are easy to perform, but unlike continuous gaseous anaesthesia, will result in an undulating plane of anaesthesia.

Ketamine is the drug of choice to top-up with, even if thiopentone has been used as an induction agent. Thiopentone is less suitable for repeat administration due to the previously mentioned cumulative effects (the total dose given should not exceed 5 mg/kg). Draw up two or three top-up doses of ketamine (or thiopentone) before commencing the general anaesthetic. Ensure the drawn-up drugs are labelled and kept in a safe location. A second competent veterinarian, in addition to the surgeon, should be present to administer 'top-up' anaesthetic medication and to monitor the patient. Total GA time maintained via top-ups should not be longer than 90 minutes due to prolonged recovery times (Stanway 2001).

Top-up protocols

1. Ketamine

Donkeys and mules Boluses of $\frac{1}{4}$ – $\frac{1}{2}$ the original dose can be administered (Mathews et al. 2005).

Horses Top-ups depend on the choice of alpha2-agonist used as pre-GA sedation (Stanway 2001), give boluses of either:

- xylazine 0.5 mg/kg + ketamine 1.1 mg/kg IV
- romifidine 0.025 mg/kg + ketamine 1.1 mg/kg IV
- detomidine 0.01 mg/kg + ketamine 1 mg/kg IV.

2. Thiopentone

Horses Repeated boluses of 1 mg/kg thiopentone can be given up to 5 times to maintain GA for a longer period (Stanway 2001).

Thiopentone works much faster than ketamine (which has a 60-second delay). If the animal is so light it starts moving, it is very useful to have a thiopentone 'top-up' drawn up. This agent will deepen the level of anaesthesia almost instantly.

Use thiopentone after a ketamine induction and ketamine after a thiopentone induction, or even administer a bolus of thiopentone to deepen a 'triple drip' GA – whichever is available and desired at the time.

Recovery after TIVA

Generally, recovery is smooth after TIVA, with less ataxia and fewer attempts to stand compared to gaseous anaesthesia.

A long line can be attached to the head collar to control the direction of the head upon standing, and caudal and downward pressure on the tail can also help with balance depending on the temperament of the animal.

Possible complications

- **Poor recovery** Animals may thrash or fall on recovery, causing injury which may be severe enough to require euthanasia. The risk is greater with thiopentone or if the animal is in pain as it recovers. When choosing a site for general anaesthesia, think ahead to the recovery and ensure a safe environment.

Depending on the length of the GA the pre-anaesthetic dose of analgesia may need re-administering before the animal wakes up to avoid an excessive pain response.

- **Myopathy or neuropathy** GA time (> 1 hour) or abnormal positioning during general anaesthesia increases the risk of damage to muscles and nerves. Place large pads (e.g. bags of straw) between the front and back legs and under the head to reduce the risk. Make sure any animal being anaesthetised is normo-volaemic throughout the procedure to avoid low blood pressure which can predispose to myopathy. If myopathy occurs treat symptomatically with analgesics, anti-inflammatory drugs, IV fluids, massage, support and good nursing. The prognosis for recovery is often poor for these cases so prevention is paramount.

During recovery the animal should be discouraged from standing too early while it is still ataxic. Therefore, noise should be kept to a minimum and it can be useful to cover the animal's head with a blanket to prevent it from being visually stimulated.

Post-operative colic may very occasionally occur, due to reduced gut motility caused by anaesthetic drugs. Treat symptomatically and the prognosis is usually good.

Standing surgery

Continuous Rate Infusion (CRI) sedation with xylazine – a possible alternative to GA in some cases

Standing sedation for a prolonged period of time, coupled with good analgesia and possibly local anaesthesia, can make standing surgery possible.

This CRI protocol involves xylazine (or romifidine) slowly administered by IV drip, resulting in prolonged standing sedation with a smoother level of sedation than that achieved by administering repeated boluses. Altering the drip rate gives a controlled sedative effect which may be feasible in the field for longer procedures in which a single injection of sedative may not be sufficient.

Maintain a constant plasma concentration of sedative drug which gives good sedation at the required level (the patient neither becoming ataxic nor moving unnecessarily). Nerve blocks are useful to reduce pain response during treatment which may lighten the level of sedation in the animal. Systemic NSAIDs and opioid analgesics are given to provide analgesia and reduce fluctuations in the sedation effect as a result of pain responses. Plan the procedure so that sedation can be increased during periods of more painful stimulation.

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A disadvantage is that CRI cannot be performed without a catheter and giving set, and the fluid bag cannot be reused. Dispose of unused fluid/drug mixture.

CRI should be approached the same way as a GA. Clinically assess the animal prior to anaesthesia and monitor carefully throughout and after the procedure.

If available, stocks and a head stand will support the animal and avoid the animal dropping its head excessively (due to the sedative) and stop the drug 'pooling' at the catheter site. If stocks are unavailable improvise to ensure that the animal is supported by using aspects of the environment and other objects, and by having experienced handlers. Always ensure the safety of the animal and handlers during this procedure. Doing this in the field will require the same supervision rate as a GA so be prepared to stay for an extended period of time whilst the animal recovers sufficiently.

Protocol for xylazine CRI sedation (Michou and Leece 2012)

1. Place IV catheter and administer analgesia.
2. Administer a loading dose of xylazine 0.5 mg/kg IV.
3. Connect fluid bag up to catheter and start infusion straight away xylazine 0.65 mg/kg IV (add 500 mg xylazine to a 500 ml bag 0.9% NaCl).
4. Administer at 325 ml/hour; titrate to the desired effect.

Close supervision of the drip rate and sedation depth is mandatory – if the gauge on the giving set slips the animal will be over-sedated.

Reports advise to start off slowly, and then gradually increase the dose rate to 2 drops/second (assuming 20 drop/ml giving set) in the first 10 minutes. Once the desired level of sedation has been reached the drip rate can be halved for the remainder of the procedure. The animal should be able to walk within 10–15 minutes of stopping the drip.

There have been various other protocols for CRI with xylazine (Ringer et al. 2012a) and other drugs including romifidine (Ringer et al. 2012b), detomidine, butorphanol and ketamine. However, xylazine CRIs tend to be favoured amongst equid practitioners for its rapid onset.

Consult the literature to develop appropriate CRI protocols.

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