

SUGGESTIONS FOR ANAESTHESIA & ANALGESIA IN SHEEP

Problems and complications associated with general anaesthesia in sheep:

- Difficult intubation
- Regurgitation & aspiration of rumen content
- Bloat/rumen distension
- Hypoxaemia
- Hypoventilation
- Hypotension/poor perfusion
- Hypothermia

The following protocols are aimed at minimising complications and problems.

1. Pre-anaesthetic preparation

In sheep food should be withheld for 24 hours and water for 8-12 hours depending on environmental temperatures and animals' state of health.

Ideally body weight should be obtained as sheep can vary in weight from 35-65 kg depending on breed, sex, and health status. A physical examination including assessment of temperature, cardiac function, pulmonary ventilation, and hydration status including assessment mucous membrane colour and pulse quality should be performed. If indicated blood samples collected from the jugular vein should be analysed to assist in determining health status or to provide pre-operative base values.

2. Pre-anaesthetic sedation & induction

Sedation: Diazepam 0.2-0.3 mg/kg IV

Induction: a. Diazepam 0.2-0.3 mg/kg IV followed by Ketamine 2-5 mg/kg IV **or**
b. Alfaxan CD 1-2 mg/kg IV

Note: Following sedation a 16 gauge 3 ¼ or 5 ¼ inch percutaneous jugular catheter should be placed and secured to allow for administration of induction agents, supplemental parenteral anaesthetics and analgesics, and IV fluids. When using Ketamine for induction diazepam may have to be readministered following catheterisation and before ketamine administration. Sheep should be placed in sternal recumbency and the head supported in elevated position before administering induction agents.

Other peripheral veins can be catheterised but in our experience the jugular vein is most suitable for catheter placement and for catheter maintenance.

A variety of premedication/induction protocol for general anaesthesia in sheep have been described, but we use the above protocol most commonly and find it provides good and safe condition for intubation without undue cardiopulmonary depression of the patient. **IV Butorphanol 0.2 mg/kg or buprenorphine 0.01 mg/kg can be administered as part of premedication.**

3. Endotracheal intubation

With the sheep placed in sternal recumbency a tie (soft rope or similar) is placed around each the upper and lower jaw to facilitate opening the mouth and holding the head and neck elevated and extended. Using a laryngoscope the larynx is visualised and approximately 2 ml of lignocaine 20% is dripped on to the larynx using a syringe with 5 ¼ inch catheter without stylet (alternatively local anaesthetic spray can be used). The endotracheal tube (ET) is inserted, secured and the cuff inflated. At this point the head can be lowered and the sheep positioned for surgery.

Note: ET sizes for adult sheep may vary from 7.5 – 9.0 mm internal diameter. ETs need to have a cuff and cuffs need to be checked for leaks beforehand. A guide or stylet can be used to facilitate intubation. A guide can either be placed in the lumen of the ET for reinforcement or introduced into the trachea and the ET subsequently fed over it. In the latter procedure the guide has to be at least twice the length of the ET. Once the sheep is positioned for surgery the cuff pressure should be checked by compressing the rebreathing bag and only leave enough air/pressure in the cuff to provide an airtight seal.

4. Maintenance of anaesthesia

Any of the commonly used inhalation anaesthetics in veterinary practice including halothane, isoflurane, and sevoflurane are suitable for maintenance of anaesthesia. Parenteral protocols including alfaxolone, propofol, and propofol with ketamine administered in increments when needed or given as a constant infusion have been used. We found parenteral maintenance not to have significant advantages if used instead of inhalation maintenance. Parenteral maintenance can be suitable if of advantage for special circumstances but unless the duration of anaesthesia is short (< 30 min) can be much more costly compared to halothane and isoflurane maintenance. It is our experience that when using parenteral maintenance of anaesthesia patient monitoring had to be intense as individual patients have different anaesthetic dose requirements which if not adjusted has the potential for disaster. Also parenteral anaesthesia does not eliminate the necessity of endotracheal intubation as sheep regurgitate regardless of the maintenance agent. Inhalation anaesthesia has the advantage of the sheep breathing an oxygen rich gas mixture, which minimises the common intraoperative complication of hypoxaemia in this species. In our experience we find recovery in sheep from both inhalation and parenteral anaesthesia to be comparable i.e. good. Parenteral anaesthesia can however carry the risk of prolonged recovery.

Typical vaporiser setting for maintenance with halothane is and isoflurane is 1-2%. In general there is a tendency when anaesthetising sheep to run the vaporiser setting to high. Premedication may further reduce the anaesthetic requirement.

For administration of inhalation anaesthesia standard human rebreathing circle type breathing systems with a soda lime container of 1-2 litres and a 2-3 litre rebreathing bag can be used.

5. Supportive care and monitoring

Supportive care:

Positioning and padding: padding of 3-5 cm thick foam mattress or similar, neck area should be elevated by placing rolled up towel under neck/shoulder to allow for drainage of saliva & rumenal content

Temperature maintenance: despite the fleece sheep become hypothermic during anaesthesia and measures similar to those commonly used in small animal anaesthesia should be used i.e. heat lamps, insulating blankets, heat pads. Hypothermia decreases metabolism resulting in decreased anaesthetic requirement

Fluid therapy: Polyionic fluids containing an alkalinizing agent are ideal (Hartmanns, Plasmalyte 148) and are generally administered at a rate of 10 ml/kg/hr.

Monitoring:

Depth of anaesthesia:

Physical signs: The most reliable indicator of anaesthetic depth is spontaneous movement or chewing motions upon painful stimulation, which indicate inadequate anaesthetic depth. Active regurgitation evident as peristaltic movements of oesophagus in the neck at times accompanied by swallowing movements is another reliable sign of light level of anaesthesia. Passive regurgitation characterised by a continuous flow of rumen fluid may indicate deep anaesthesia.

During light anaesthesia the eyes may be positioned dorso-laterally and muscle tone in the eyelid and palpebral reflex may be present. A centrally positioned eye with dilated pupil, relaxed eyelid and absent palpebral reflex may indicate deep anaesthesia.

Note: Determination of anaesthetic depth in sheep using physical signs is relatively difficult and if uncertain the level of anaesthesia should be reduced until signs of light anaesthesia are evident at which time the anaesthetic level can be increased if required.

Cardiopulmonary parameters: During inhalation anaesthesia both blood pressure and pulmonary ventilation will decrease with increasing anaesthetic depth. Mean arterial blood pressure should be above 60 mmHg in order to maintain adequate tissue perfusion. As a general rule if blood pressure in a major artery is not palpable the mean blood pressure may be less than 60. Pulmonary ventilation, the product of tidal volume and respiratory rate is decreased during inhalation anaesthesia, mostly due to reduced tidal volume. Normal respiratory rate and tidal volume in awake sheep is around 40 breaths/min and 7 – 10 ml/kg respectively and remain similar during inhalation

anaesthesia. Shallow breathing as gauged by movements of rebreathing bag can indicate deep anaesthesia. Ideally capnography and or arterial blood gas analysis should be performed to assess ventilation objectively, particularly during prolonged anaesthesia.

Blood pressure/tissue perfusion

Blood pressure: The auricular artery on the abaural surface of the ear, the saphenous artery, and the digital artery can be palpated for pulse pressure. Manual palpation of blood pressure is only a subjective assessment of blood pressure and more advanced techniques should be used for anaesthetics of longer duration. The Doppler technique with the probe placed on the ventral surface of the distal carpus and the cuff proximal to that around the carpus provides a means of assessment of systolic pressure. As a rough guideline if systolic pressure is less than 80 mmHg hypotension is severe enough to result in inadequate tissue perfusion. Systolic, diastolic and mean arterial blood pressure can be measured from a percutaneous catheter placed in the auricular artery and connected to an electronic pressure gauge which will continuously display systolic, diastolic and mean arterial pressure. Catheterisation of the auricular artery is easily achieved and can even be done in awake sheep. Mean pressure in anaesthetised sheep should be above 60 mmHg.

Tissue perfusion: Mucous membrane colour is used as an indicator of tissue perfusion, although the method is subjective. Pulse oximetry is a non invasive method of detecting blood flow and haemoglobin saturation with oxygen. The clothe pin like probe can be placed on the tongue and the pulse oximeter displays a continuous pulse signal and haemoglobin saturation value (S_pO_2). As a general rule efforts should be made to maintain S_pO_2 above 90%. Due to profuse salivation in anaesthetised sheep the tongue may be slippery and the pulse oximeter probe may not stay in place. Placing one or two layers of a gauze swab between the tongue and probe may overcome this problem.

Capnography

Capnography is a non-invasive method of measuring CO_2 in the air exhaled by the patient and provides a continuous measure of pulmonary ventilation. The end expiratory CO_2 is an estimate of arterial PCO_2 . In anaesthetised sheep the difference between arterial and alveolar CO_2 can be up to 10 mmHg and therefore capnography should ideally be used in conjunction with arterial blood gas analysis i.e. at least one arterial blood sample should be analysed in order to determine the accuracy of capnography in a particular patient. In awake sheep normal arterial PCO_2 is around 35 mmHg and during inhalation anaesthesia can increase considerably. PCO_2 values above 80 mmHg will lead to cerebral oedema and patients remain unconscious long after termination of anaesthesia. Effort should be made to maintain PCO_2 below 55 mmHg, and when using capnography efforts should be made to avoid any increase from values obtained in the early phase of anaesthesia.

6. Recovery from anaesthesia

As soon as possible sheep should be repositioned in sternal recumbency or near sternal recumbency to allow for rumenal gas to escape. **The ET with the cuff inflated should be left in place until the sheep are swallowing spontaneously and can be seen to make chewing motions. The ET is then removed with the cuff inflated. Ensure that patient can breathe i.e. move air.** Keep patient positioned in sternal recumbency and support if necessary.

Efforts should be directed towards warming the animal using insulating materials like blankets or external heat sources such as heat lamps for example.

7. Pain management and analgesia

- Pain and painful stimulation causes physical discomfort and stress which result in altered homeostasis including cardiopulmonary, endocrine, metabolic and thermoregulatory abnormalities and behavioural changes.
- Assessment of pain in sheep and ruminants generally is difficult. Painful animals may exhibit physical signs including tachypnea, tachycardia, elevated blood pressure and body temperature. Interpretation of behaviour as an indicator of pain is difficult and generally sheep being herd animals and animals of prey do not display overt signs of pain. Behaviour indicating pain may include abnormal gait or stance, vacant stare, teeth grinding, exaggerated avoidance behaviour, repetitive motor activity, guarding of painful limb, reluctance to stand, inappetence, and separation from flock and lagging behind.
- Ideally an analgesia protocol should be designed considering the type and duration of painful procedure and aiming at critical evaluation of the effectiveness of the protocol.
- Ideally analgesia should be administered preemptively.
- Analgesic drugs used in sheep include opioids, α_2 -adrenergic agonists, NSAIDs, and local anaesthetics.
- The effectiveness of opioids for analgesia in sheep is controversial. Most information on opioid analgesia in sheep is based on experimental data and should be applied to clinical conditions with care. In general opioids in sheep are less useful for treatment of pain compared to dogs and cats. μ -agonists such as morphine and fentanyl are poorly effective in sheep when administered epidurally or spinally.
- α_2 -adrenergic agonists produce analgesia and sedation in sheep both when administered systemically and epidurally. Sedation generally outlasts analgesia. α_2 -adrenergic agonists can cause cardiopulmonary changes and hypoxaemia. In sheep analgesia is more likely to be achieved with α_2 -adrenergic agonists than with opioids.
- NSAIDs provide analgesia through their antiinflammatory effects peripherally but in sheep seem to also have centrally mediated analgesic properties. Compared to opioids and α_2 -adrenergic agonists NSAIDs are longer acting. NSAIDs may be useful for treatment of orthopaedic and visceral pain. NSAIDs can induce gastro intestinal ulcerations. Due to the longer duration of action and absence of sedative and behaviour modifying effects NSAIDs are particularly suitable for preemptive administration.

The following may be useful when planning analgesic therapy:

a. Parenteral analgesia

- **Fentanyl** at a dose of 0.01 mg/kg IV provided analgesia of rapid onset but short duration (< 1hr) for painful mechanical and thermal stimuli. Fentanyl may precipitate abnormal behaviour. Transdermal fentanyl i.e. fentanyl patches (100 µg/60 kg) might be an option for prolonged, possibly up to 3 days, analgesia.
- **Buprenorphine** at a dose of 0.005-0.01 mg/kg IV, IM, SC can produce primarily cutaneous analgesia (thermal stimulus) for 3-4 hr duration. It can be readministered at 4-6 hr intervals by IM, SC route. Onset of action is slow and abnormal behaviour such as agitation is possible.
- **Butorphanol** doses range from 0.1-0.5 mg/kg IV, SC which decrease the responsiveness to thermal stimuli at lower doses and at higher doses produces sedation and decreased responsiveness to pinch stimuli at various sites and to nasopharyngeal stimulation. It is questionable whether butorphanol provides visceral analgesia. Butorphanol can cause ataxia and altered behaviour including agitation and vocalisation.
- **Xylazine** at a dose of 0.05 mg/kg IV can produce good analgesia for mechanical and thermal painful stimuli for approximately 45-60 min. Xylazine causes sedation and recumbency.
- **Detomidine**, 0.05 mg/kg IM has been used in sheep and found to be of longer analgesic duration than xylazine and less associated with hypoxaemia.
- **Medetomidine** 0.005 mg/kg produces analgesia and sedation for approximately 1 hr. Side effects are likely similar to other α_2 - adrenergic agonists.
- **Flunixin** (2.2 mg/kg IV) is an effective analgesic in sheep although less potent than α_2 - adrenergic agonists. Duration of action is approximately 3-6 hrs and re-administration of 2.3 mg/kg Q 12 hrs or 1.1 mg/kg Q 8 hrs has been recommended.
- **Phenylbutasone** IV or PO at a dose range of 2-6 mg/kg can be used in sheep and presumably similar to cattle readministered once daily.
- **Carprofen** has been studied in sheep and 4.0 mg/kg administered IV found to provide a therapeutic plasma levels for at least 72 hrs.

b. Local and regional anaesthesia/analgesia

Using local anaesthetics as an adjunct to general anaesthesia can greatly improve the quality of anaesthesia and early postoperative recovery without altering mentation.

Lignocaine and **bupivacaine** are the most commonly used local anaesthetics in veterinary practice. Lignocaine has a rapid onset of action (minutes) and short duration of action (60-90 min) while bupivacaine has a slow onset of action (15-20 min) and longer duration of action (4-6 hrs). The toxic dose of lignocaine if given IV is 3-7 mg/kg and 1-2 mg/kg for bupivacaine. Volumes for local infiltration should not exceed the toxic volume in order to minimise possible complications of toxicity. Local and regional anaesthesia/analgesia in combination with

sedation can be useful for procedures including castration and dehorning and disbudding.

Local anaesthetics can be used for analgesia in the forelimb, (brachial plexus nerve block), intraarticular analgesia, analgesia of lateral thoracotomy (intercostal nerve block), analgesia for midline sternotomy (intrapleural block 1.5 mg/kg bupivacaine)

c. Epidural and spinal anaesthesia/analgesia:

Epidural analgesia is achieved by depositing a local anaesthetic or analgesic into the spinal canal outside the meninges. Spinal or intrathecal analgesia refers to the injection of analgesic drugs into the subarachnoid space, which is smaller than the epidural space. In sheep the technique of spinal anaesthesia is most commonly practiced. The spinal needle is placed into the spinal canal at the lumbosacral junction, which results in penetration of the meninges, evident by CSF appearing in the needle. Injection of local anaesthetics will result in loss of sensory and motor function in the pelvic area including the hind limbs.

In sheep analgesics suitable for spinal analgesia include the local anaesthetics and α_2 - adrenergic agonists. **Xylazine** (20 mg/ml) at a dose of 0.05 mg/kg (\pm 2 mg in 1ml saline) or **detomidine** at a dose of 0.01 mg/kg (\pm 0.5 mg in 1 ml saline) can be injected into the CSF (subarachnoid space). Intrathecal xylazine has a fast onset of action (\pm 20 min), longer duration of analgesia (\pm 100 min) and produced higher nociceptive threshold compared to detomidine (onset \pm 50 min, duration \pm 60 min). Sedation and recumbency can occur with spinally administered α_2 - adrenergic agonists. The local anaesthetics **lignocaine** (2%) and **bupivacaine** (0.5%) can be injected into the for subarachnoid lumbosacral anaesthesia is 0.1-0.15 ml/kg.

Effective analgesic therapy in sheep is difficult due to:

- Opioid drugs have limited effectiveness whilst in other species are most effective and suitable for treatment of severe pain
- are the most effective analgesic drug group for analgesia in sheep however they are associated with sedation and cardiopulmonary depression
- NSAIDs are effective for musculoskeletal pain and abdominal pain but have the potential side effect of gastrointestinal ulcerations. If used alone they may however not be sufficient for severe postoperative pain.

Analgesia techniques and drugs should be combined in order to maximise efficacy. If possible a NSAID should be administered preoperatively and continued postoperatively. Opioids can be administered as part of anaesthetic premedication and continued postoperatively. Local and regional anaesthesia techniques should be used when ever possible. Low doses of α_2 - adrenergic agonists can be given if systemically if other protocols are insufficient.

8. Drug Doses for Sheep

The drugs and doses listed below have been used in sheep but are to be used with some care in this species. Careful assessment of the patient should be done before drug administration. **Whilst efforts have been made to ensure that the information below is correct any responsibility of error is declined by the author.**

	IV mg/kg	IM/SC mg/kg	Comments
<u>Sedatives</u>			
Acepromazine	0.02-0.05	0.05-0.2	
Xylazine	0.02-0.15	0.05-0.3	
Detomidine	0.03	0.5	Not suitable for IM injection
Diazepam	0.2-0.5	1.0-1.5	
Midazolam	0.4-0.8	0.5-1.0	
<u>Anaesthetics</u>			
Thiopental	25		
Propofol	4-6		
Alfaxolone	1-3		
Zoletil	4	4	
Ketamine	5-10	20-30	
Ketamine + Diazepam	0.2		
MAC Halothane	0.7-0.9		
MAC isoflurane	1.0-1.5		
MAC Sevoflurane	3.3		
<u>Analgesics</u>			
Fentanyl	0.01		Short duration (up to 1 hr)
Fentanyl transdermal	100 µg/60 kg		Duration?
Butorphanol	0.2		Duration up to 2 hrs
Buprenorphine	0.006-0.01		Slow onset, duration up to 3 hrs
Xylazine	0.05		Short duration (<1 hr)
Flunixin	2.2		Duration up to 2 hrs
Meloxicam	0.2		Not much data available
Phenylbutasone	2.2		

9. Cardiopulmonary parameters in awake and anaesthetised sheep

	awake	anaesthetised
HR (beats/min)	100-120	80-150
RR (breaths/min)	20-40	20-40
Mean arterial pressure (mmHg)	92-100	75-100
Systolic/diastolic arterial pressure	100-140/70-90	80-120/60-80
Tidal Volume (ml)	7-8	7-8

This document was written by:

Christina Dart DrVetMED DVSc MVSc MACVSc Diplomate ACVA
Senior Registrar
Registered Specialist in Veterinary Anaesthesia
University of Sydney, Camden

31/05/2005