

Analgesia, Sedation and Anesthesia for Goats and Swine

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Introduction:

General anesthesia in goats and swine is often considered more difficult, has a higher complication rate, and has a higher morbidity and mortality rate than other large animal domestic species. General risk factors that increase anesthesia risks in all patients include:

- Poor health status of emergency patients
- Chronic illnesses
- Emergency procedures
- Prolonged anesthesia time

Additional risk factors in goats include:

- Lack of standardized or optimized anesthesia protocols
- Anatomical and physiological challenges with ruminants including.
 - Ruminal bloat or tympany
 - Regurgitation and aspiration
 - Rumens atony
- Hypothermia, particularly in smaller goats
- More difficult to intubate.

Additional risk factors in swine include:

- Lack of standardized or optimized anesthesia protocols
- More challenging to intubate.
- Laryngeal trauma with intubation
- Less available IV support
- Malignant hyperthermia
- Vomiting with aspiration
- Hypothermia in smaller pigs
- Obesity can obstruct the larynx.

A recent study in goats reported an overall perianesthetic mortality rate of 7.3% in 193 cases.¹ This was reduced to 3.4% in healthy goats undergoing elective procedures. This is higher than established perianesthetic mortality risk in horses (1.9%), dogs (0.17%), and cats (0.24%). A retrospective case series in swine (n=27) showed common complications for general anesthesia including hypoventilation (67%), hypotension (64%), hypothermia (48%), bradycardia (28%), and prolonged recovery time (22%).

Multimodal sedation and anesthesia protocols are commonly used in veterinary medicine. **Multimodal sedation and anesthesia provide safer and more consistent levels of anesthesia than the use of individual drugs by themselves.** Adding additional systemic or surgical site focused analgesia also helps lower the amount of systemic and inhaled anesthetic agents required for appropriate level of anesthesia. This can include systemic analgesia, local infiltration, regional nerve blocks or epidurals. Utilization of

these concepts can help decrease morbidity and mortality associated with analgesia, sedation, and anesthesia in goats and swine.

Multimodal Anesthesia Includes:

- Supplemental Analgesia
 - Local
 - Systemic
 - Regional
 - Constant Rate Infusion (CRI)
- Sedation
 - Alpha Agonists
 - Benzodiazepines
 - Opioids
- Anesthetic
 - Injectable
 - Inhalation
- Reversal Agents
 - Tolazoline
 - Atipamezole

Supplemental Oxygen, Airway, and Intubation

- Supplemental oxygen can always provide an additional level of safety.
 - Red Rubber Feeding Tube, various sizes.
 - Taped or sutured to nose or halter.
 - Recumbent sedation or anesthesia support.
 - Taped or sutured to nose or halter.
 - Use an oxygen bubbler to regulate flow and humidify the oxygen.
 - Oxygen Flow Rate
 - Listen to the tube and what sounds comfortable.
 - Single Tube @ 10 to 20 (ml/min)/kg
 - Estimated to increase the FiO₂ from 21% to 25-30%
 - Especially at higher altitudes above 5000 ft elevation.



Tracheal Intubation

- Equipment
 - Endotracheal Tubes of various sizes
 - ½ the external diameter of the trachea. Estimate by palpating neck.
 - OK to err a size smaller to make it easier to intubate.
 - 5-10 mm for piglets and kid goats
 - Up to 20 mm for adults



- Laryngoscope (Nasco, \$244)



- Flexible Stylet
 - Polypropylene urinary catheters sizes 4-8 French
 - JorVet Dog Urinary Catheter, 20-inch length
 - Used to direct the endotracheal tube between the arytenoids and into the trachea.



- Mouth Gag
 - Two pieces of cord or rope ~1/4 to 3/8 inch diameter tied separately in loops.
 - Hold one on lower jaw and one on upper jaw and pull them apart.
 - Other Options
 - Spring Type
 - Mouth Opener
 - Amazon, Large and Small sizes
 - DDP Schulze Mouth Gag



- Epiglottis
 - Must hook and displace the tip of the epiglottis ventrally to visualize the arytenoid opening.
 - Elongated Soft Palate with dorsal displacement of epiglottis.
 - Can entrap and obscure the tip of the epiglottis dorsally above the soft palate making it difficult to retract ventrally.
 - Try to correct by
 - Change the position of the head and neck.

- Increase or lessen tension on tongue.
- Use polypropylene catheter with laryngoscope to visualize entrapment and sweep the catheter between the soft palate and epiglottis so that you can catch the epiglottis with the laryngoscope and displace ventrally.

Goat Analgesia, Sedation and Anesthesia Protocols

- **Goat Analgesia^{2,3}**
 - Local Infusion
 - Lidocaine up to 5 mg/kg total dose
 - Sheep and goats have a lower toxic dose than do cattle.
 - Systemic
 - Non-Steroidal Anti-Inflammatory Drugs
 - Flunixin Meglumine
 - 1-2 mg/kg IV, not to exceed 2 mg/kg in 24-hour period.
 - Meloxicam
 - Goats: 1-2 mg/kg PO q24h
 - Meloxicam has very different pharmacokinetics between the various livestock species. See chart at the end of the notes.
 - Gabapentin
 - 10-15 mg/kg PO total per day
 - Opioids
 - Morphine
 - Dose 0.05 to 0.1 mg/kg IV, IM, or SQ q6-8h
 - More consistent analgesia?
 - Less sedation than butorphanol
 - Butorphanol
 - Dose: 0.05 to 0.1 mg/kg IV, IM, or SQ q6-8h
 - Variable clinical analgesia
 - More sedation than morphine
 - Buprenorphine
 - Dose: 0.005 mg/kg IV q6-8h
 - Alpha-2 Adrenergic Agonists – all provide potent short-term analgesia (~ 1 hour) with sedation.⁴
 - Xylazine
 - Standing 0.01 to 0.05 mg/kg
 - Recumbency 0.05 to 0.1 mg/kg
 - Detomidine 0.05 mg/kg
 - Medetomidine 0.02 mg/kg
 - Dexmedetomidine 0.005 mg/kg
 - Constant Rate Infusion
 - Ketamine 0.1 – 0.4 mg/kg/h
 - Use during general anesthesia.
 - Tri-Fusion CRI

- Ketamine 5mg/l
- Morphine 5mg/l
- Xylazine 0.5mg/l
- CRI @ 3ml/kg/hr
- Delivers
 - Ketamine @ 0.015 mg/kg/hr
 - Morphine @ 0.015 mg/kg/hr
 - Xylazine @ 0.0015 mg/kg/hr
- Used to support very painful conditions in a hospital setting.
- Pentafusion CRI
 - Lidocaine 1000 mg/L
 - Ketamine 5 mg/l
 - Morphine 5 mg/l
 - Xylazine 0.5 mg/l
 - Acepromazine 0.5 mg/l
 - CRI @ 3 ml/kg/hr
 - Delivers
 - Lidocaine @ 3 mg/kg/hr
 - Ketamine @ 0.015 mg/kg/hr
 - Morphine @ 0.015 mg/kg/hr
 - Xylazine @ 0.0015 mg/kg/hr
 - Acepromazine @ 0.0015 mg/kg/hr
 - Provides slightly more sedation than Tri-Fusion protocol.
 - Can cause more hypotension due to acepromazine.
 - Spreadsheets make it easier to calculate correct concentrations and flow rates.

Livestock IV Analgesia CRI Calculator		
Date:		
Patient:		
Case Number		
	Goal Dosage Rate (mg/kg/hr)	Recommended Dosage Range (mg/kg/hr)
Lidocaine	3.0000	3
Ketamine	0.2000	0.015 - 0.6
Morphine	0.0200	0.015 - 0.025
Xylazine	0.0020	0.0015 - 0.0022
Acepromazine	0.0020	0.0015 - 0.0022
Goal Fluid Rate (ml/kg/hr)	2.0000	
Fluid Mix	Concentration (mg/L)	
Lidocaine	1500.00	
Ketamine	100.00	
Morphine	10.00	
Xylazine	1.00	
Acepromazine	1.00	
<small>Instructions: Fill in cells highlighted green with protocol parameters. Calculated fluid mix concentrations are determined in blue cells.</small>		

- Spinal and Epidural Anesthesia⁵
 - Select location based on area to provide regional analgesia.
 - Loss of motor function to area when using lidocaine, but not with morphine.
 - Can increase volume with sterile water or saline if you want to cover a wider area of the spinal cord.
 - For adult goats and swine, generally 0.1 ml/kg total volume will cover about 3-6 spinal segments.

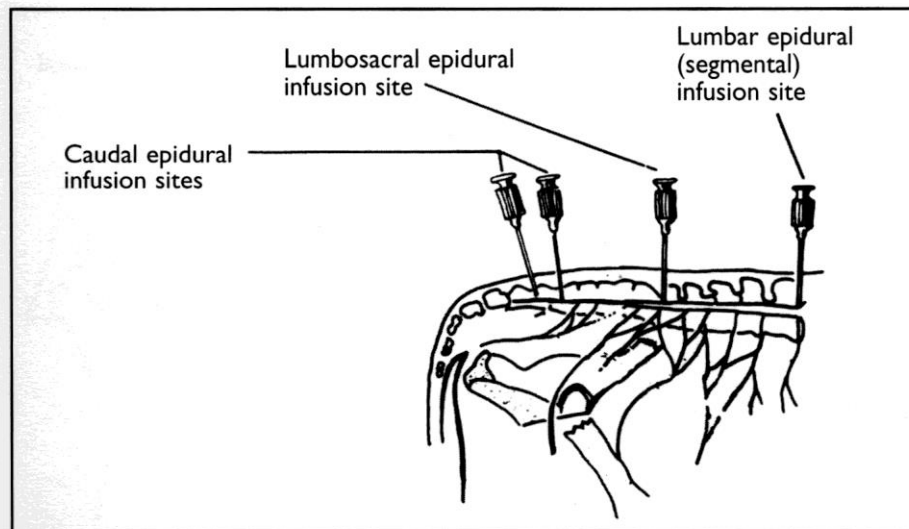


FIGURE 4-3. Epidural anesthesia infusion sites in cattle.

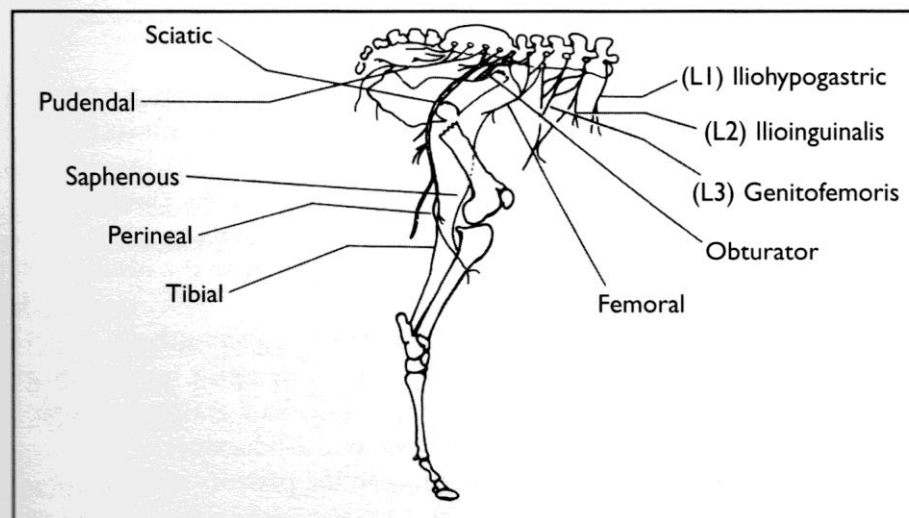


FIGURE 4-4. Nerves of the bovine pelvis.

From Noordsy, Food Animal Surgery, 4th Edition

- Sacral-Coccygeal
 - Lidocaine 2%, 1 ml/200 lb BW
 - Xylazine 0.02 to 0.05 mg/kg
 - Can combine lidocaine and xylazine together.
 - Blocks the tail, perineum, and caudal skin of the scrotum.
 - Does NOT block anterior scrotum, vaginal tunic, spermatic cord, or testicular nerve.
 - Potential for hind limb weakness and recumbency with xylazine

- Lumbosacral
 - Spinal (Intrathecal) or Epidural

- Lidocaine 1 mg/kg (spinal, intrathecal)
- Blocks caudal abdominal wall and peritoneum.
- Blocks motor innervation of hind limbs.
- Lowers levels of injectable or inhalation anesthesia required for procedure.
- Use as an adjunct for abdominal surgery.
 - Laparotomy
 - Umbilical resection
 - Cesarean Section
 - Tube Cystostomy
 - Mammectomy
 - Inguinal Hernia
- Epidural
 - Lidocaine 1-3 mg/kg (can use more than with intrathecal)
 - Morphine 0.05 to 0.1 mg/kg
- **Goat Combination Injectable Sedation Protocols**
 - Ketamine:Xylazine:Butorphanol (KXB) (Dr. Johnson's Cocktail)
 - Mix - Ketamine (100mg/ml), LA Xylazine (100mg/ml), and Butorphanol (10mg/ml) at a 10:1:1 ratio by volume.
 - Dose:
 - Sheep & Goats – 1ml/80-100lb IM
 - Alpaca - 1ml/40lb IM
 - Llama - 1 ml/50lb IM
 - If giving IV start with ¼ to ½ of the IM dose above.
 - Can partially reverse with tolazoline 100 mg/ml, 2 mg/kg IM
 - Sheep/Goat Ket-Stun STANDING
 - Dose
 - Butorphanol 0.025 mg/kg
 - Xylazine 0.025 mg/kg (goats may use more at 0.05 mg/kg)
 - Ketamine 0.1 mg/kg
 - Administer IV or IM. IV will give about 30-40 minutes of sedation. IM 45 to 60 minutes.
 - NOTE: This is slightly different from the cattle Ket-Stun protocol that has Butorphanol 0.025 mg/kg, Xylazine 0.050 mg/kg, and Ketamine 0.1 mg/kg
 - Some animals may lie down with this protocol.
 - This protocol provides conscious sedation while significantly limiting movement. Good for standing procedures including surgeries in combination with local, regional, or epidural analgesia.
 - Sheep/Goat Ket-Stun RECUMBENT
 - Dose
 - Butorphanol 0.025 mg/kg
 - Xylazine 0.025 mg/kg (goats may use more at 0.05 mg/kg)
 - Ketamine 1.0 mg/kg

- Administer IV or IM. IV will give about 30-40 minutes of sedation. IM 45 to 60 minutes.
 - This protocol provides conscious sedation while significantly limiting movement. Good for recumbent procedures including surgeries in combination with local or regional analgesia.
 - Medetomidine + Ketamine
 - Dose
 - Medetomidine 0.02 mg/kg
 - Could substitute dexmedetomidine at 0.005 mg/kg
 - Ketamine 2 mg/kg
 - Administer together IV or IM
 - Reversal: Atipamezole 100 mg/kg IV
 - Used for dehorning anesthesia along with lidocaine local blocks.
- **Goat General Anesthesia Induction**
 - General Anesthesia Ketamine or Propofol Induction
 - Sedate:
 - Midazolam 0.2-0.3 mg/kg IV
 - Butorphanol or Morphine 0.2-0.3 mg/kg IV
 - Induce:
 - Ketamine 3-5 mg/kg IV to effect
OR
 - Propofol 2-5 mg/kg IV to effect
 - Propofol may cause apnea and you should pre-oxygenate the patient before induction.
 - Additional increments of ketamine at 1 mg/kg can be given if necessary.
 - Intubate and maintain on isoflurane gas anesthesia.
 - Keep nose pointed downward in case of regurgitation.
 - Rolled up towel placed under neck.

Swine Sedation and Anesthesia Protocols

Swine present a unique challenge for sedation and anesthesia due to a wide variability in response to injectable anesthetics. They have a high tolerance to xylazine and ketamine, and often require quite high doses for sedation. Swine are also more challenging to intubate.

- Elongated soft palate can hide the epiglottis.
- Use of a flexible stylet (polypropylene catheter) rather than a rigid metal stylet.
- Dorsal pharyngeal diverticulum
- Lateral ventricles
- Right cranial bronchus before the tracheal bifurcation
- Laryngospasm
- Use a laryngoscope.

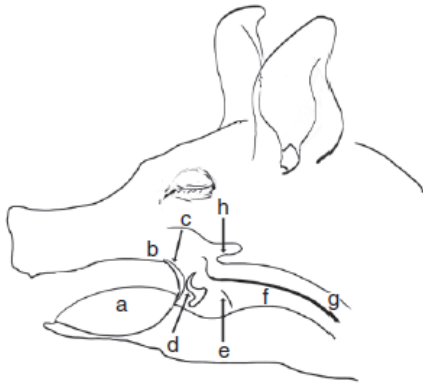


FIGURE 1 | Swine oropharyngeal anatomy. a, tongue; b, soft palate; c, epiglottis; d, vocal cord; e, lateral ventricle; f, trachea; g, esophagus; h, pharyngeal diverticulum.

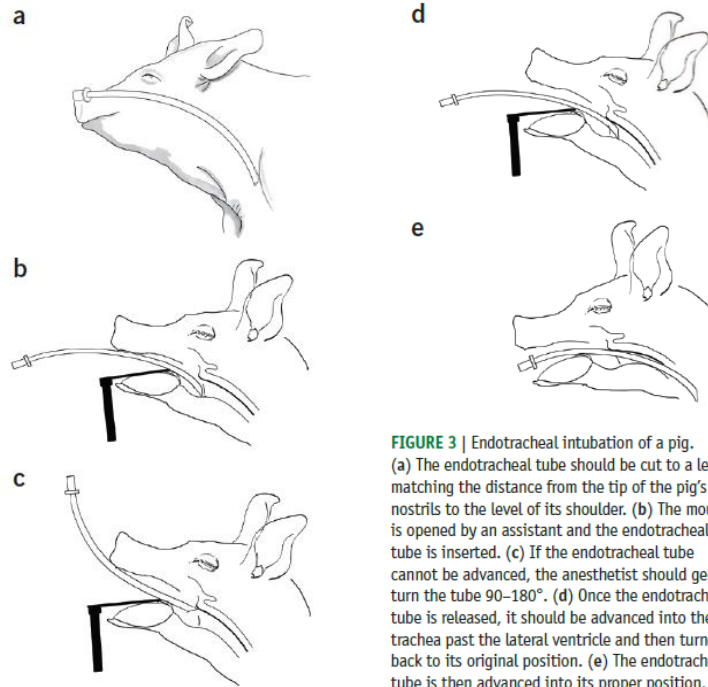


FIGURE 3 | Endotracheal intubation of a pig. (a) The endotracheal tube should be cut to a length matching the distance from the tip of the pig's nostrils to the level of its shoulder. (b) The mouth is opened by an assistant and the endotracheal tube is inserted. (c) If the endotracheal tube cannot be advanced, the anesthetist should gently turn the tube 90–180°. (d) Once the endotracheal tube is released, it should be advanced into the trachea past the lateral ventricle and then turned back to its original position. (e) The endotracheal tube is then advanced into its proper position.

Chum H, Pacharinsak C. Endotracheal intubation in swine. *Lab Anim (NY)* 2012;41:309-311.⁶

- Swine Analgesia – Utilize similar approaches and dosages compared to goats.
 - Local Infusion
 - Lidocaine 1 to 4 mg/kg total dose
 - Similar toxicity threshold compared to goats.
 - Systemic
 - Non-Steroidal Anti-Inflammatory Drugs
 - Flunixin Meglumine
 - 2.2 mg/kg IM
 - Meloxicam
 - Swine: 0.5 mg/kg PO q24h
 - Meloxicam has different pharmacokinetics between the various livestock species. See chart at the end of the notes.
 - Gabapentin
 - 10-15 mg/kg PO total per day
 - Opioids
 - Morphine
 - Dose 0.05 to 0.1 mg/kg IV, IM, or SQ q6-8h
 - More consistent analgesia?
 - Less sedation than butorphanol
 - Butorphanol
 - Dose: 0.05 to 0.1 mg/kg IV, IM, or SQ q6-8h
 - Variable clinical analgesia
 - More sedation than morphine
 - Buprenorphine
 - Dose: 0.005 mg/kg IV q6-8h

- Alpha-2 Adrenergic Agonists – all provide potent short-term analgesia (~ 1 hour) with sedation.
 - Xylazine 0.1 – 0.5 mg/kg
 - Detomidine 0.05 – 0.1 mg/kg
 - Medetomidine 0.03-0.08 mg/kg
 - More specific alpha-2 agonist than detomidine.
 - Fewest cardiovascular effects of this class of agents in swine.
 - Racemic mixture (dexmedetomidine + Levomedetomidine) where only dexmedetomidine portion is active.
 - Dexmedetomidine 0.005 – 0.010 mg/kg
 - Most expensive as it is the purified dextrorotary isomer of the racemic mixture medetomidine.
- Spinal and Epidural Anesthesia
 - Sacral-Coccygeal Epidural
 - More difficult in swine than ruminants. Space is smaller.
 - Lidocaine 2%, 0.1 mg/kg (1 ml/200 lb BW)
 - Xylazine 0.02 to 0.05 mg/kg
 - Can combine lidocaine and xylazine together.
 - Blocks the tail, perineum, and caudal skin of the scrotum.
 - Does NOT block anterior scrotum, vaginal tunic, spermatic cord, or testicular nerve.
 - Potential for hind limb weakness and recumbency with xylazine

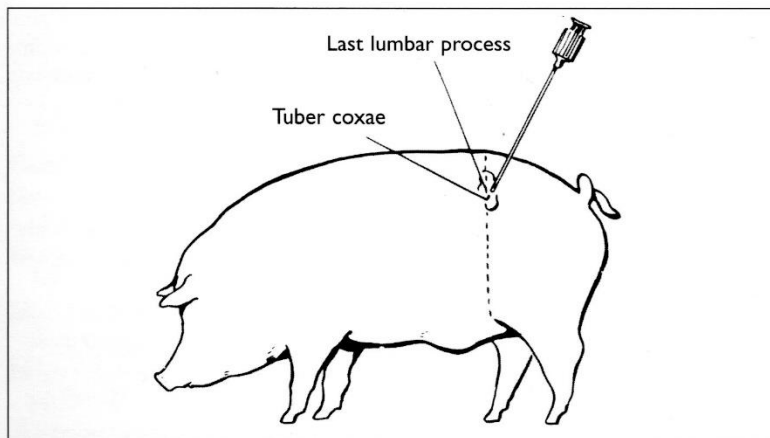


FIGURE 4-13. Lumbosacral epidural in the pig. The juncture of an imaginary transverse line connecting the crests of the ilia and an imaginary vertical line running from the fold of the flank to the tuber coxae is the site of injection.

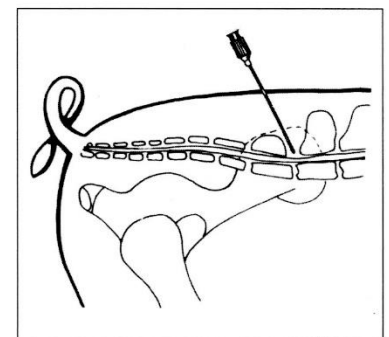


FIGURE 4-14. Lumbosacral epidural in the pig. In the adult animal, the needle is inserted in the midline, 2 to 5 cm (1 to 2 inches) caudal to the imaginary transverse line.

From Noordsy, Food Animal Surgery, 4th Edition

- Lumbosacral
 - Spinal (Intrathecal) or Epidural
 - Lidocaine 1 mg/kg (spinal, intrathecal)
 - Blocks caudal abdominal wall and peritoneum.
 - Blocks motor innervation of hind limbs.

- Lowers levels of injectable or inhalation anesthesia required for procedure.
- Use as an adjunct for abdominal surgery.
 - Laparotomy
 - Umbilical resection
 - Cesarean Section
 - Inguinal Hernia
- Epidural
 - Lidocaine 1-3 mg/kg (can use more than with intrathecal)
 - Morphine 0.1 mg/kg
 - Can dilute in saline to increase coverage along spinal column.
- **Swine Sedation Protocols**
 - Intranasal Midazolam⁷:
 - 0.2 - 0.3 mg/kg
 - Best for pigs <30 lb BW
 - Instill slowly into nasal passages using syringe with flexible teat canula
 - Xylazine/Ketamine
 - Sedation
 - Xylazine 0.5-1 mg/kg
 - Ketamine 1-2 mg/kg
 - Recumbency
 - Xylazine 2 mg/kg
 - Ketamine 11-30 mg/kg
 - Combine and give IM.
 - Xylazine/Butorphanol/Ketamine
 - Xylazine 2 mg/kg
 - Butorphanol 0.2-0.3 mg/kg
 - Ketamine 10 mg/kg
 - Combine and give IM.
 - Midazolam/Ketamine
 - Midazolam 0.1-0.5 mg/kg
 - Ketamine 10-15 mg/kg
 - Combine and give IM.
 - Midazolam/Telazol
 - Midazolam 5mg/kg IM
 - Telazol 4mg/kg IM
 - Intubate and maintain with isoflurane.
 - Xylazine/Midazolam/Ketamine
 - Xylazine 2 mg/kg
 - Midazolam 0.25 mg/kg
 - Ketamine 20 mg/kg

- Combine and give IM.
 - Detomidine/Midazolam/Butorphanol
 - Detomidine 20-60 ug/kg IM (may be omitted in quiet pigs)
 - Midazolam 0.3mg/kg IM
 - Butorphanol 0.3mg/kg IM
 - May need to top off with 0.5-2.0mg/kg Ketamine IV for intubation or mask with isoflurane.
 - Detomidine/Midazolam/Ketamine
 - Detomidine 0.1 mg/kg IM
 - Midazolam 0.2 mg/kg IM
 - Ketamine 5 mg/kg IM
 - Provides good injectable anesthesia for short procedures. Extended time to wake up fully.
 - Medetomidine/Midazolam/Butorphanol
 - Medetomidine 10-20 ug/kg IM
 - Midazolam 0.1-0.5 mg/kg IM
 - Butorphanol 0.1-0.2 mg/kg IM
 - Reversal: You can reverse the medetomidine with atipamezole at 2-4 times the medetomidine dose (0.02-0.08 mg/kg IM).
 - Dexmedetomidine/Butorphanol/Ketamine
 - Dexmedetomidine, 0.04 mg/kg
 - Butorphanol, 0.2 mg/kg
 - Ketamine, 4 mg/kg
 - Combine and give IM.
- **Swine General Anesthesia Protocols**
 - **Pot Bellied Pig Induction**
 - Sedation
 - Midazolam 0.2 – 0.3 mg/kg IM
 - Butorphanol or Morphine 0.2 – 0.3 mg/kg IM
 - More sedation with Butorphanol?
 - Inhalation Induction:
 - Isoflurane 5% to effect
 - IV Induction:
 - Propofol 3-5mg/kg
 - Note that Propofol may cause apnea and could be a complication if the animal is difficult to intubate.
 - Intubate and maintain on isoflurane 2-3%.
 - **Domestic Swine Telazol/Ketamine/Xylazine (TKX)**

<u>Mix:</u>	<u>Final Concentration:</u>
○ Telazol 500 mg vial	Tiletamine 50mg/ml and Zolazepam 50mg/ml
○ 2.5ml Ketamine 100mg/ml	50mg/ml

- 2.5ml Xylazine 100mg/ml 50mg/ml

Dose at 1ml/50-70lb BW IM. Smooth but prolonged recovery. Can intubate. Apnea is common. Duration 45-60 min.

Reversal: Tolazoline 100 mg/ml, 2.0 mg/kg IM

Be cautious in Pot Bellied Pigs as they can have prolonged recovery times. Recommend reversal with tolazoline.

- **Antiemetic Drugs for Swine**
 - **Maropitant 10mg/ml, dose at 1 mg/kg SQ or IM**

Reversal Drugs for Goats and Swine

- Atipamezole: 0.05 mg/kg, give ½ IV and ½ IM. ⁸
- Tolazoline: 2 mg/kg IM
 - Only available as compounded drug
 - Consider AMDUCA
- Yohimbine: 0.125 mg/kg IM (no longer available)

Withdrawal Times

- Many of the drugs and dosages that we use for livestock analgesia are extra label uses. It is important to be conservative in establishing your withdrawal times.
- Food Animal Residue Avoidance Databank
 - www.FARAD.org

Table • 5-6

Meat and Milk Withdrawal Intervals (WDI) for Some Analgesic Drugs in Farm Animals

DRUG	SPECIES	DOSE AND ROUTE	MEAT WDI	MILK WDI
Flunixin	Cattle	1.1-2.2 mg/kg IV once	4 days	36 hours
Flunixin (Banamine-S)	Swine	2.2 mg/kg IM	14 days	N/A
Xylazine	Cattle, sheep, goats	0.05-0.3 mg/kg IM	4 days	24 hours
		0.3-2 mg/kg IM	10 days	120 hours
		0.016-0.1 mg/kg IV	5 days	72 hours
Detomidine	Cattle, sheep, goats	Up to 0.08 mg/kg* IV/IM	3 days	72 hours
Ketamine	Cattle, sheep, goats	Up to 2 mg/kg IV*	3 days	48 hours
		Up to 10 mg/kg IM*		
Lidocaine	Cattle	Up to 10 mg/kg* IV/IM	2 days	
		Up to 15 mL of 2% solution (epidural)		
		Up to 2 g in 100 mL SQ (infiltration)		
Lidocaine with epinephrine	Cattle, sheep, goats	SQ (epidural/infiltration)*	1 day	24 hours

*Single and multiple doses.

From: Fubini, Farm Animal Surgery, 2nd Edition.

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Suggested Meloxicam Dosages for Livestock

	Cattle	Sheep	Goats	Llama	Swine
Oral Bioavailability	100%	75%	79 ± 19%	76% (range 48-92%)	75-100%
C max	3.10 ug/ml		0.736 ± 0.184 ug/ml	1.314 ug/ml	1.07 ug/ml
T max	11.64 h	12 h	15 ± 5 h	21.4 h	2.4 h
T ½	27.54 h	14-16 h	11.8 ± 1.7 h	22.7 h (range 18-20.8 h)	6.83 h
Recommended Dosing	Load at 1mg/kg PO followed by 0.5 mg/kg q24h for 5 days. Then can move to 0.5mg/kg PO q48 h for longer term.	1 mg/kg PO q24h for 2-3 day to reach steady state, then q48h	1-2 mg/kg PO q24h	1 mg/kg PO q48-72 h	0.5 mg/kg PO q24 h
Reference	Veterinary Therapeutics 2009, 10:E1–E8 and AABP Proceedings vol 43.	Not yet published	J Vet Pharmacol Therap 2010, 34:64-69	BMC Veterinary Research 2012, 8:85	J Vet Pharmacol Therap 2015, 38(3):265-270

The plasma therapeutic level in horses is 0.2 ug/ml (200 ng/ml).

Meat Withdrawal: Suggested minimum 21 days

Milk Withdrawal: Suggested minimum 5 days, FARAD most recently suggests 14 days as precautionary.

LIVESTOCK SERVICE ANESTHESIA PROTOCOLS

Calf Protocols:

1) Calf General Anesthesia Induction

Sedate:

- Diazepam or Midazolam 0.1 – 0.2 mg/kg IV
- Morphine or Butorphanol 0.1 mg/kg IV

Induce:

- Ketamine or Propofol 3-5 mg/kg IV

Propofol may cause apnea and you should pre-oxygenate the patient before induction.

Intubate and maintain on isoflurane.

Cost for a 50kg calf using ketamine is <\$10.00. Using propofol is about \$20.

Adult Cattle

1) Bovine Induction for Gas Anesthesia:

- Guaifenesin 50 to 100 mg/kg
- Ketamine 2 mg/kg

Administered to effect followed by intubation and maintenance on either halothane or isoflurane gas anesthesia.

2) Bovine Induction with “Triple Drip”:

- Guaifenesin 1 L (5% or 50 mg/ml)
- Ketamine 1000mg (10ml 100mg/ml)
- Xylazine 100 mg (1ml 100mg/ml)

Add ketamine and xylazine to a liter bottle of 5% guaifenesin.

Induce anesthesia with a dose of 0.5-1 ml/kg.

Maintain with approximately 2.2 ml/kg/hr.

3) Cattle Ket-Stun **STANDING**

- Butorphanol 0.01 – 0.025mg/kg (double the amount if using morphine)
- Xylazine 0.02 – 0.05mg/kg
- Ketamine 0.04 – 0.1mg/kg

Typical starting dose for an adult bovine is 5 mg Butorphanol, 10 mg Xylazine, and 20 mg Ketamine. Mix and administer IV, IM or SQ. Provides good sedation and analgesia for standing procedures in cattle. Higher xylazine doses are more likely to cause the animal to lie down.

Stock Bovine Ket-Stun Solution for standing procedures

Drug	Concentration	Total ml	Total mg	Final Concentration
Butorphanol	10 mg/ml	5 ml	50 mg	6.25 mg/ml
Xylazine	100 mg/ml	1 ml	100 mg	12.5 mg/ml
Ketamine	100 mg/ml	2 ml	200 mg	25 mg/ml

Dose at 0.1ml per 50kg BW to give final dose of 0.05 mg/kg Ketamine, 0.025 mg/kg Xylazine, and 0.0125 mg/kg Butorphanol.

4) Bovine Ket-Stun **RECUMBENT**

- Butorphanol 0.025 mg/kg (double the amount if using morphine)
- Xylazine 0.05 mg/kg
- Ketamine 1.0 mg/kg

Mix and administer IV, IM or SQ. IV administration is more rapid and more likely to cause recumbency. Provides good sedation and mild analgesia for recumbent procedures in cattle. Surgical procedures will require additional local or regional anesthesia.

5) Systemic “Tri-Fusion” Analgesia CRI

- Morphine 100mg
- Xylazine 10mg
- Ketamine 100mg
- In 20 L Electrolytes
- Administer at 3ml/kg/hr

Small Ruminant & Camelid:

1) Ketamine:Xylazine:Butorphanol (Dr. Johnson’s Cocktail)

Mix

- Ketamine (100mg/ml), LA Xylazine (100mg/ml), and Butorphanol (10mg/ml) at a 10:1:1 ratio.

Dose:

- Alpaca - 1ml/40lb IM
- Llama - 1 ml/50lb IM
- Sheep & Goats – 1ml/80-100lb IM

If giving IV start with ½ to 1/3 IM dose.

Can partially reverse with tolazoline 100 mg/ml, 2 mg/kg IM

2) Sheep/Goat Ket-Stun **STANDING**

- Butorphanol 0.025 mg/kg
- Xylazine 0.025 mg/kg (goats may use more at 0.05 mg/kg)
- Ketamine 0.1 mg/kg

Administer IV or IM. IV will give about 30-40 minutes of sedation. IM 45 to 60 minutes.

Sheep and goats are more likely to lie down than cattle with this protocol.

This protocol provides conscious sedation while significantly limiting movement. Good for standing procedures including surgeries in combination with local or regional analgesia.

3) Sheep/Goat Ket-Stun **RECUMBANT**

- Butorphanol 0.025 mg/kg
- Xylazine 0.025 mg/kg (goats may use more at 0.05 mg/kg)
- Ketamine 1.0 mg/kg

Administer IV or IM. IV will give about 30-40 minutes of sedation. IM 45 to 60 minutes.

This protocol provides conscious sedation while significantly limiting movement. Good for recumbent procedures including surgeries in combination with local or regional analgesia.

4) General Anesthesia Ketamine or Propofol Induction

Sedate:

- Midazolam 0.2-0.3 mg/kg IV
- Butorphanol or Morphine 0.2-0.3 mg/kg IV

Induce:

- Ketamine 3-5 mg/kg IV to effect

OR

- Propofol up to 2-5 mg/kg IV to effect

Propofol may cause apnea and you should pre-oxygenate the patient before induction.

Additional increments of ketamine at 1 mg/kg can be given if necessary.
Intubate and maintain on isoflurane gas anesthesia.

5) Camelid Ket-Stun **STANDING**

- Butorphanol 0.05 mg/kg (double the amount if using morphine)
- Xylazine 0.25 mg/kg
- Ketamine 0.5mg/kg

Administer together IV or IM

6) Camelid Ket-Stun **RECUMBENT**

- Butorphanol 0.05 mg/kg (double the amount if using morphine)
- Xylazine 0.25 mg/kg
- Ketamine 1.0 mg/kg

Administer together IV or IM

Swine:

1) Pot Bellied Pig Induction

Sedate:

- Midazolam 0.2 – 0.3 mg/kg IV
- Butorphanol 0.2 – 0.3 mg/kg IV or Morphine 0.2-0.3 mg/kg

Inhalation Induction:

- Isoflurane 5% to effect

IV Induction:

- Propofol 3-5mg/kg

Note that Propofol may cause apnea and could be a complication if the animal is difficult to intubate.

Intubate and maintain on isoflurane. Note that potbellied pigs are difficult to intubate, and you should use a flexible stylet rather than a rigid metal stylet.

2) Domestic Swine Telazol

Mix:

Final Concentration:

- Telazol 500 mg vial Tiletamine 50mg/ml and Zolazepam 50mg/ml
- 2.5ml Ketamine 100mg/ml 50mg/ml
- 2.5ml Xylazine 100mg/ml 50mg/ml

Dose at 1ml/50-70lb BW IM. Smooth but prolonged recovery. Can intubate. Apnea is common. Duration 45-60 min.

Reversal: Tolazoline 100 mg/ml, 2.0 mg/kg IM

Be cautious in Pot Bellied Pigs as they can have prolonged recovery times. Recommend reversal with tolazoline.

3) Midazolam/Telazol

Midazolam 5mg/kg IM

Telazol 4mg/kg IM

Intubate and maintain with isoflurane.

4) Xylazine/Ketamine

Xylazine 2 mg/kg

Ketamine 20 mg/kg

Combine and give IM.

5) Xylazine/Butorphanol/Ketamine

Xylazine 2 mg/kg

Butorphanol 0.2 mg/kg

Ketamine 10 mg/kg

Combine and give IM.

- 6) Xylazine/Midazolam/Ketamine
Xylazine 2 mg/kg
Midazolam 0.25 mg/kg
Ketamine 20 mg/kg

Combine and give IM.

- 7) Midazolam/Ketamine
Midazolam 0.1-0.5 mg/kg
Ketamine 10-15 mg/kg

Combine and give IM.

- 8) Dexmedetomidine/Butorphanol/Ketamine
Dexmedetomidine, 0.04 mg/kg
Butorphanol, 0.2 mg/kg
Ketamine, 4 mg/kg

Combine and give IM. Note, the cost is about \$1.20/kg, mostly due to Dexmedetomidine.

- 9) Detomidine/Midazolam/Butorphanol
Detomidine 20-60 **ug/kg** IM (may be omitted in quiet pigs)
Midazolam 0.3mg/kg IM
Butorphanol 0.3mg/kg IM

May need to top off with 0.5-2.0mg/kg Ketamine IV for intubation or mask with isoflurane.

- 10) Detomidine/Midazolam/Ketamine
Detomidine 0.1 mg/kg IM
Midazolam 0.2 mg/kg IM
Ketamine 5 mg/kg IM

Provides good injectable anesthesia for short procedures. Extended time to wake up fully.

- 11) Medetomidine/Midazolam/Butorphanol
Medetomidine 10-20 ug/kg IM
Midazolam 0.1-0.5 mg/kg IM
Butorphanol 0.1-0.2 mg/kg IM

Reversal: You can reverse the medetomidine with atipamezole at 5 mg of atipamezole for each mg medetomidine. This is administered IM.

Ket-Stun Protocols

Ket-Stun protocols are used to provide light (standing) to heavy (recumbent) multi-modal sedation. These protocols are NOT intended for anesthesia. When performing surgical procedures, adjunct local or

regional anesthesia is required. They can be given IV, IM, or SQ depending on the effect that you would like. IV administration works better for inducing recumbency.

Species	Standing	Recumbent
Bovine	Butorphanol: 0.025 mg/kg Xylazine: 0.05 mg/kg Ketamine: 0.1 mg/kg	Butorphanol: 0.025 mg/kg Xylazine: 0.05 mg/kg Ketamine: 1.0 mg/kg
Sheep & Goats	Butorphanol: 0.025 mg/kg Xylazine: 0.025 mg/kg Ketamine: 0.1 mg/kg	Butorphanol: 0.025 mg/kg Xylazine: 0.025 mg/kg Ketamine: 1.0 mg/kg
Camelids	Butorphanol: 0.05 mg/kg Xylazine: 0.25 mg/kg Ketamine: 0.5 mg/kg	Butorphanol: 0.05 mg/kg Xylazine: 0.25 mg/kg Ketamine: 1.0 mg/kg

Analgesics

- Buprenorphine: 0.005 mg/kg IV q6-8h
- Butorphanol: 0.05-0.1 mg/kg IV, SQ or IM q6-8h
- Morphine: 0.05-0.1 mg/kg IV, SQ or IM q6h
- Flunixin Meglumine: 1 mg/kg IV q12-24h

Reversal Drugs

- Atipamezole: 0.05 mg/kg, give ½ IV and ½ of dose IM.
- Tolazoline: 2 mg/kg IM
- Yohimbine: 0.125 mg/kg IM (no longer available)