

Anesthesia, Analgesia, and Miscellaneous Surgical Drug Recommendations for Agricultural Animals

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PURPOSE: This document provides recommendations for anesthetic, analgesic, and other surgical drugs for use with agricultural animals used in research, education, and testing at the University of Kentucky.

Inhalant Anesthesia in Pigs	Dose & Route	Withdrawal Period Prior to Marketing	Comments
Isoflurane Enflurane	To effect. In general, 3-4% induction, 1-2% maintenance; inhalation	Not Recommended for use in food animals	Precision vaporizer, adequate ventilation or scavenging essential to prevent personnel exposure
Injectable Anesthesia in Pigs	Dose & Route	Withdrawal Period Prior to Marketing	Comments
Ketamine	11-33 mg/kg IM, SC 10-33 mg/kg/hr IV infusion	2 day withdrawal for ≤ 10 mg/kg IM ¹	Restraint only. Provides little analgesia and minimal muscle relaxation
Ketamine & Xylazine	20 mg/kg (K) & 2 mg/kg (X) IM, SC	Not Recommended for use in food animals	Up to 20 minutes of anesthesia for minor surgical procedures. Should be used with atropine to prevent cardiac arrhythmia.
Ketamine & Medetomidine	1 mg/kg (K) & 0.1 mg/kg (M) IM, SC 5 mg/kg/hr (K) & 10 μ g/kg/hr (M) IV infusion	Not Recommended for use in food animals	Anesthesia for minor surgical procedures. Fewer complications than with Ketamine & Xylazine
Ketamine & Acepromazine	22-33 mg/kg (K) & 1.1 mg/kg (A) IM, SC	7 day withdrawal ¹	Excellent preanesthetic combination. Surgical procedures require additional general anesthetic.
Ketamine & Midazolam	33 mg/kg (K) & 500 μ g/kg (M) IM, SC	Not Recommended for use in food animals	
Ketamine & Diazepam	15 mg/kg (K) & 2 mg/kg (D) IM, SC	Not Recommended for use in food animals	
Tiletamine-Zolazepam (Telazol [®])	4-8.8 mg/kg IM, SC	Not Recommended for use in food animals	

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Telazol® & Xylazine	4-6 mg/kg (T) & 2.2 mg/kg (X) IM, SC	Not Recommended for use in food animals	Up to 20 minutes of anesthesia; may produce cardiovascular depression
Pentobarbital	20-40 mg/kg IV 5-40 mg/kg/hr IV infusion	Not Recommended for use in food animals	Very long recovery period postoperatively. Respiratory support should be available
Thiopental	6.6-30 mg/kg IV 3-30 mg/kg/hr IV infusion	Not Recommended for use in food animals	Respiratory support should be available
Thiamylal	15-20 mg/kg IV	Zero meat withdrawal at recommended dose	
NSAID Analgesia for Pigs	Dose & Route	Withdrawal Period Prior to Marketing	Comments
Aspirin	10-20 mg/kg PO q 4 h (Swindle and Adams 1988)	24 hour meat withdrawal ¹ Not Recommended for use in food animals	Veterinary justification as to why flunixin would not be an acceptable alternative is required under AMDUCA and must be documented in the animal's medical record. Use enteric coated tablets
Carprofen	2.0-3.0 mg/kg SC, PO bid	Not Recommended for use in food animals	Veterinary justification as to why flunixin would not be an acceptable alternative is required under AMDUCA and must be documented in the animal's medical record.
Flunixin	0.5 - 2.2 mg/kg SC, IM bid	12 day withdrawal following single 2.2 mg/kg dose, multiple doses increases withdrawal period	Not approved for use in breeding swine
Ketorolac	1.0 mg/kg IM, SC, PO bid	Not Recommended for use in food animals	Veterinary justification as to why flunixin would not be an acceptable alternative is required under AMDUCA and must be documented in the animal's medical record.
Ketoprofen	1.0-3.0 mg/kg IM, SC, PO bid (Fosse, Toutain et al. 2011, Calonge, Mayos et al. 2012, Schwab, Follich et al. 2012)	Not Recommended for use in food animals	Veterinary justification as to why flunixin would not be an acceptable alternative is required under AMDUCA and must be documented in the animal's medical record.
Meloxicam	0.4 mg/kg IM, SC sid	Not Recommended for use in food animals	Veterinary justification as to why flunixin would not be an acceptable alternative is required under AMDUCA and must be documented in the animal's medical record.

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Phenylbutazone	4-20 mg/kg PO bid	Not Recommended for use in food animals	Veterinary justification as to why flunixin would not be an acceptable alternative is required under AMDUCA and must be documented in the animal's medical record. Use enteric coated tablets
Opiate Analgesia for Pigs	Dose & Route	Withdrawal Period Prior to Marketing	Comments
Butorphanol	0.1-0.3 mg/kg IM qid(Swindle and Adams 1988)	Not Recommended for use in food animals	
Buprenorphine	0.01-0.05 mg/kg IM, IV q 8-12 h(Hermansen, Olesen et al. 1986, Rodriguez, Cooper et al. 2001)	Not Recommended for use in food animals	
Burpenorphine SR	0.12-0.27 mg/kg SC q 72 h	Not Recommended for use in food animals	
Fentanyl	0.02-0.05 mg/kg IM, IV q 2 h(Swindle and Adams 1988); 30-100 µg/kg/hour IV infusion	Not Recommended for use in food animals	
Fentanyl transdermal patch	5 µg/kg/h transdermal(Harvey-Clark, Gillespie et al. 2000, Wilkinson, Thomas et al. 2001)	Not Recommended for use in food animals	Highly variable efficacy between different strains and various animals. May require significantly higher doses in specific individuals
Meperidine	2-10 mg/kg IM, qid	Not Recommended for use in food animals	
Oxymorphone	0.15 mg/kg IM qid	Not Recommended for use in food animals	
Pentazocine	1.5-3.0 mg/kg IM qid	Not Recommended for use in food animals	
Sufentanil	5-10 µg/kg IM q 2 h; 10-30 µg/kg/hour IV infusion	Not Recommended for use in food animals	
Tramadol	1-4 mg/kg PO tid	Not Recommended for use in food animals	

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Misc. Surgery Drugs for Pigs	Dose & Route	Withdrawal Period Prior to Marketing	Comments
Atropine	0.05 mg/kg IM; 0.02 mg/kg IV	28 day ¹	Anticholinergic
Glycopyrrolate	0.004-0.01 mg/kg IM, SC, IV	Not Recommended for use in food animals	Anticholinergic
Dantrolene	5 mg/kg IV	Not Recommended for use in food animals	Treatment for Malignant Hyperthermia
Bretylium tosylate	3.0-5.0 mg/kg IV q 30 min.	Not Recommended for use in food animals	Antiarrhythmic

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Inhalant Anesthesia in Sheep	Dose & Route	Withdrawal Period Prior to Marketing	Comments
Isoflurane Enflurane	To effect. In general, 3-4% induction, 1-2% maintenance; inhalation	Not Recommended for use in food animals	Precision vaporizer, adequate ventilation or scavenging essential to prevent personnel exposure
Injectable Anesthesia in Sheep	Dose & Route	Withdrawal Period Prior to Marketing	Comments
Ketamine	22-44 mg/kg IM; 10 mg/kg/hr IV infusion	48 hr milk withdrawal/ 3 day meat withdrawal at ≤ 10 mg/kg ¹	Restraint only. Provides little analgesia and minimal muscle relaxation
Ketamine & Xylazine	5-10 mg/kg (K) & 0.2 mg/kg (X) IM; 2.2-7.5 mg/kg (K) & 0.1 mg/kg (X) IV	48 hr milk withdrawal/ 4 day meat withdrawal at ≤ 0.3 mg/kg xylazine ¹	Up to 20 minutes of anesthesia for minor surgical procedures.
Ketamine & Medetomidine	1-1.5 mg/kg (K) & 25-50 μ g/kg (M) IM 0.5 mg/kg (K) & 20 μ g/kg (M) IV	72 hr milk withdrawal/ 3 day meat withdrawal ¹	
Ketamine & Acepromazine*	22-33 mg/kg (K) & 1.1 mg/kg (A) IM, SC	48 hr milk withdrawal/ 7 day meat withdrawal ¹	
Ketamine & Midazolam*	33 mg/kg (K) & 500 μ g/kg (M) IM, SC	Not Recommended for use in food animals	
Ketamine & Diazepam	2.2-7.5 mg/kg (K) & 0.1-0.375 mg/kg (D) IV	Not Recommended for use in food animals	
Guaifenesin	100 mg/kg IV	48 hr milk withdrawal/ 3 day meat withdrawal ¹	Muscle relaxation only. No analgesia or unconsciousness. Must be used with other agents.
Propofol	2-8 mg/kg IV	Not Recommended for use in food animals	Administer to effect for short procedures or anesthetic induction
Tiletamine-Zolazepam (Telazol®)	2.2 mg/kg IM	Not Recommended for use in food animals	
Telazol® & Xylazine	4 mg/kg (T) & 0.1 mg/kg (X) IM	Not Recommended for use in food animals	

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Pentobarbital	20-30 mg/kg IV	Not Recommended for use in food animals	Very long recovery period postoperatively. Lower dosage reported for castrated animals
Thiopental	4-20 mg/kg IV	24 hr milk and meat withdrawal at ≤ 5 mg/kg ¹	
Thiamylal	8-15 mg/kg IV	Zero meat withdrawal at recommended dose	
NSAID Analgesia for Sheep	Dose & Route	Withdrawal Period Prior to Marketing	Comments
Aspirin	50-100 mg/kg PO bid	Not Recommended for use in food animals	
Carprofen	2.0-4.0 mg/kg SC, IV sid	Not Recommended for use in food animals	
Flunixin	1 mg/kg SC, IM, IV sid	Not Recommended for use in food animals	Limit to 3 days duration
Ketoprofen	1.0 mg/kg IM, SC, IV sid	Not Recommended for use in food animals	Limit to 3 days duration
Meloxicam	0.5 mg/kg IM, SC q 12 h	Not Recommended for use in food animals	Use q 8 h in goats
Phenylbutazone	20 mg/kg IV bid	Not Recommended for use in food animals	
Opiate Analgesia for Sheep	Dose & Route	Withdrawal Period Prior to Marketing	Comments
Butorphanol	0.5 mg/kg IM q 2-3 h	Not Recommended for use in food animals	
Buprenorphine	0.005-0.01 mg/kg IM q 4-6 h	Not Recommended for use in food animals	
Fentanyl	2.5 μ g/kg IM q 2-4 h	Not Recommended for use in food animals	
Fentanyl transdermal patch	2-3 μ g/kg/hr	Not Recommended for use in food animals	Place on shaved area at least 4 hours prior anticipated need

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Meperidine	2-10 mg/kg SC, IM, q 6 h 2 mg/kg IM, IV q 2-4 h	Not Recommended for use in food animals	
Oxymorphone*	0.15 mg/kg IM qid	Not Recommended for use in food animals	
Pentazocine*	1.5-3.0 mg/kg IM qid	Not Recommended for use in food animals	
Sufentanil*	5-10 µg/kg IM q 2 h; 10-30 µg/kg/hour IV infusion	Not Recommended for use in food animals	
Tramadol*	1-4 mg/kg PO tid	Not Recommended for use in food animals	
Misc. Surgery Drugs for Sheep	Dose & Route	Withdrawal Period Prior to Marketing	Comments
Atropine	0.05 – 0.2 mg/kg IM, IV	Not Recommended for use in food animals	Anticholinergic – Not recommended as routine premedication due to potential adverse effects on GI physiology
Glycopyrrolate	0.01 mg/kg IM, IV	Not Recommended for use in food animals	Anticholinergic – Not recommended as routine premedication due to potential adverse effects on GI physiology

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Inhalant Anesthesia in Cattle	Dose & Route	Withdrawal Period Prior to Marketing	Comments
Isoflurane Enflurane	To effect. In general, 3-4% induction, 1-2% maintenance; inhalation	Not Recommended for use in food animals	Precision vaporizer, adequate ventilation or scavenging essential to prevent personnel exposure
Injectable Anesthesia in Cattle	Dose & Route	Withdrawal Period Prior to Marketing	Comments
Ketamine	10 mg/kg IM; 2 mg/kg IV	48 hr milk withdrawal/ 3 day meat withdrawal	Restraint only. Provides little analgesia and minimal muscle relaxation
Ketamine & Xylazine	2 mg/kg (K) & 0.1 mg/kg (X) IV	72 hr milk withdrawal/ 5 day meat withdrawal	Up to 20 minutes of anesthesia for minor surgical procedures.
Ketamine & Medetomidine	0.5 mg/kg (K) & 20 µg/kg (M) IV	72 hr milk withdrawal/ 3 day meat withdrawal	
Chloral hydrate, Pentobarbital, & Magnesium Sulfate (Chloropent®)	20-50 mg/100 lbs body weight	No withdrawal period required	
Guaifenesin	100 mg/kg IV	48 hr milk withdrawal/ 3 day meat withdrawal	Muscle relaxation only. No analgesia or unconsciousness. Must be used with other agents.
Ketamine & Midazolam*	33 mg/kg (K) & 500 µg/kg (M) IM, SC		
Ketamine & Diazepam	2.2-10 mg/kg (K) & 0.1-0.5 mg/kg (D) IV		
Propofol	4-6 mg/kg IV		Administer to effect for short procedures or anesthetic induction
Tiletamine-Zolazepam (Telazol®)	1-4 mg/kg IV		
Telazol® & Xylazine	1 mg/kg (T) & 0.05 mg/kg (X) IM		
Pentobarbital	20-30 mg/kg IV	Not Recommended for use in food animals	Very long recovery period postoperatively. Lower dosage reported for castrated animals
Thiopental	20-25 mg/kg IV		
Thiamylal	8-15 mg/kg IV	Zero meat withdrawal at recommended dose	

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NSAID Analgesia for Cattle	Dose & Route	Withdrawal Period Prior to Marketing	Comments
Aspirin	100 mg/kg PO, q 12 h	24 hours milk and meat withdrawal Not Recommended for use in food animals	Veterinary justification as to why flunixin would not be an acceptable alternative is required under AMDUCA and must be documented in the animal's medical record.
Flunixin	2.2 mg/kg SC, IM, IV sid	IV: 36 hr milk withdrawal/4 day meat withdrawal IM: 72 hr milk withdrawal/>30 days meat withdrawal	Limit to 3 days duration Extralabel use (IM route of administration is extralabel use) for ease of drug administration is not permitted under AMDUCA
Meloxicam	0.5 mg/kg IV, SC q 12 h	Not Recommended for use in food animals	Veterinary justification as to why flunixin would not be an acceptable alternative is required under AMDUCA and must be documented in the animal's medical record.
Ketoprofen	3.3 mg/kg IV, IM q 24 hrs	7 day meat withdrawal and 24 hour milk withdrawal Not Recommended for use in food animals	Veterinary justification as to why flunixin would not be an acceptable alternative is required under AMDUCA and must be documented in the animal's medical record.
Phenylbutazone	5 mg/kg PO q 48 hrs	Illegal in Dairy Cattle 20 months of age or older: FDA-CVM 40-50 day meat withdrawal following oral or IV administration, >55 day meat withdrawal following IM administration in Beef Cattle Not Recommended for use in food animals	Veterinary justification as to why flunixin would not be an acceptable alternative is required under AMDUCA and must be documented in the animal's medical record.
Opiate Analgesia for Cattle	Dose & Route	Withdrawal Period Prior to Marketing	Comments
Butorphanol	0.5 mg/kg IM q 2-3 h	Not Recommended for use in food animals	
Buprenorphine	0.005-0.01 mg/kg IM q 4-6 h	Not Recommended for use in food animals	

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Fentanyl	2.5 µg/kg IM q 2-4 h	Not Recommended for use in food animals	
Fentanyl transdermal patch	2-3 µg/kg/hr	Not Recommended for use in food animals	Place on shaved area at least 4 hours prior anticipated need
Meperidine	2-10 mg/kg SC, IM, q 6 h 2 mg/kg IM, IV q 2-4 h	Not Recommended for use in food animals	
Oxymorphone*	0.15 mg/kg IM qid	Not Recommended for use in food animals	
Pentazocine*	1.5-3.0 mg/kg IM qid	Not Recommended for use in food animals	
Sufentanil*	5-10 µg/kg IM q 2 h; 10-30 µg/kg/hour IV infusion	Not Recommended for use in food animals	
Tramadol*	1-4 mg/kg PO tid	Not Recommended for use in food animals	
Misc. Surgery Drugs for Cattle	Dose & Route	Withdrawal Period Prior to Marketing	Comments
Atropine	0.05 – 0.2 mg/kg IM, IV	6 day milk withholding, 28 day meat withdrawal	Anticholinergic – Not recommended as routine premedication due to potential adverse effects on GI physiology
Glycopyrrolate	0.01 mg/kg IM, IV	Not Recommended for use in food animals	Anticholinergic – Not recommended as routine premedication due to potential adverse effects on GI physiology

Inhalant Anesthesia in Horses	Dose & Route	Comments
Isoflurane Sevoflurane	Horses must be induced using injectable anesthesia. Immediately after, 3-4% for induction, 1-2% (2-3% Sevo) maintenance	Precision vaporizer, adequate ventilation or scavenging essential to prevent personnel exposure It is highly recommended that a veterinarian or veterinary technician with experience in large animal anesthesia assist with any inhalation anesthesia involving horses.
Injectable Anesthesia & Sedation in Horses	Dose & Route	Comments
Ketamine & Xylazine	2.2 mg/kg (K) & 1.1 mg/kg (X) IV	Can be readministered to prolong anesthesia at ½ the induction dose of both drugs.
Tiletamine-Zolazepam (Telazol®)	1.1-1.65 mg/kg IV	Should be used in conjunction with detomidine (0.02mg/kg IV) May provide longer anesthesia time than ketamine.
Guaifenesin (10%) Ketamine (0.2%) Xylazine (0.1%)	100 mg/ml 2 mg/ml 1 mg/ml	Mixed together, typically in pre-made guaifenesin. Rate 1-2ml/kg/hr after induction bolus. Minimize anesthesia time to minimize prolonged recovery.
Xylazine	0.3-1.1 mg/kg IV	Lasts ~15min- There is considerable variability in the sensitivity to this drug. Always start with the lowest possible dose. For best sedative effect, combine with butorphanol.
Romifidine	0.05-0.1 mg/kg IV	Lasts ~30min- There is considerable variability in the sensitivity to this drug. Always start with the lowest possible dose. For best sedative effect, combine with butorphanol.
Detomidine	0.01-0.02 mg/kg IV 0.015-0.02 mg/kg IM (allow 20min to take effect)	Lasts ~45min- There is considerable variability in the sensitivity to this drug. Always start with the lowest possible dose. For best sedative effect, combine with butorphanol.
Butorphanol	0.01-0.02 mg/kg IV	Minimal sedative effect and may cause excitation when given alone. Must be combined with xylazine, romifidine, or detomidine for best effect.
NSAID Analgesia for Horses	Dose & Route	Comments
Flunixin meglumine	1.1 mg/kg IV or PO q 12hrs	DO NOT administer IM in horses due to regular occurrence of clostridial myositis
Ketoprofen	2.2 mg/kg IV q 24hrs	Limit use to 5 days or less.
Phenylbutazone	2.2-4.4 mg/kg PO or IV q 12-24hrs	Extreme care must be taken if administering IV due to tissue damage secondary to extravasation Dose should be minimized whenever possible, especially if administering q 12 hrs

REFERENCES:

Calonge, R., et al. (2012). "Local tolerance assessment of different NSAIDs administered by intramuscular route in swine." Journal of Veterinary Pharmacology and Therapeutics **35**: 154-155.

Fosse, T. K., et al. (2011). "Ketoprofen in piglets: enantioselective pharmacokinetics, pharmacodynamics and PK/PD modelling." Journal of Veterinary Pharmacology and Therapeutics **34**(4): 338-349.

Harvey-Clark, C. J., et al. (2000). "Transdermal fentanyl compared with parenteral buprenorphine in post-surgical pain in swine: a case study." Laboratory Animals **34**(4): 386-398.

Hermansen, K., et al. (1986). "The Analgesic Effect Of Buprenorphine Etorphine And Pethidine In The Pig A Randomized Double Blind Cross-Over Study." British Journal of Pharmacology **89**(PROC. SUPPL): 673P-673P.

Rodriguez, N. A., et al. (2001). "Antinociceptive activity of and clinical experience with buprenorphine in swine." Contemporary Topics in Laboratory Animal Science **40**(3): 17-20.

Plumb, Donald C.(2015). Plumb's Veterinary Drug Handbook, 8th ed., Wiley, Blackwell.

Robinson, N.E. and K. Sprayberry (2009). Current Therapy in Equine Medicine, 6th ed., Saunders Elsevier.

Schwab, S., et al. (2012). "Ketoprofen - practical use and efficacy for post-surgical analgesia in piglet castration." Tierärztliche Umschau **67**(6): 207...213-207...213.

Swindle, M. M. and R. J. Adams (1988). Experimental surgery and physiology : induced animal models of human disease. Baltimore, Williams & Wilkins.

Wilkinson, A. C., et al. (2001). "Evaluation of a transdermal fentanyl system in yucatan miniature pigs." Contemporary Topics in Laboratory Animal Science **40**(3): 12-16.

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