

Injectable anesthesia in farm animals

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Introduction

Injectable anesthesia in farm animals been used on a routine basis in academia and in clinical practice in the United States of America. As an ambulatory clinician, the author has used various pharmaceuticals and combinations for sedation and short term generalized anesthesia, on farm animals in performing various techniques, clinical procedures, major and minor surgeries in the clinic and on the farm. There are many physical and mental challenges in dealing with farm animals when safely restraining or immobilizing them for any surgical or non-surgical procedures performed. The main goal is to effectively control the animal without injuring the /to subject/animal or the personnel involved. In most cases, for performing physical examination or minor surgery a chute, crush, ropes, or local anesthesia is sufficient to accomplish the task. However, on certain situations, sedatives, dissociative, and systemic analgesics can provide the mental distraction needed to reduce reflex reactions and override learned behaviors. This article will review some of the common uses of sedation and anesthesia in performing both minor and major surgeries using injectable anesthetic drugs in farm animals.

Pre-anesthetic Considerations

Important pre-anesthetic considerations involve thorough evaluation of patient health

status and demeanor. This examination helps determine if the patient is a suitable candidate for field anesthesia and may reduce liability should anesthetic complications occur. Major anesthetic challenges peculiar to ruminants include restriction of ventilation due to rumen size, continuous flow of saliva (volumes up to 16 and 200 litres/day in small ruminants and adult cattle respectively), regurgitation and aspiration of rumen content, if the animal is not properly fasted, and patient size. Functioning ruminants should be ideally fasted prior to general anesthesia according to the following guidelines: adult cattle (48-hrs. for hay, 36 hrs. for grain or concentrates and 12 hrs. for water), and small ruminants and camelids (24 to 48 hrs. for hay, 12 hrs. for water). Young livestock on a milk diet (<1.5 - 2 months of age) and swine should be fasted for ~ 12 hrs. (feed & water).

If a surgery or procedure necessitating a recumbent position performed out in the field, the ground surface should ideally be soft to help protect against injury during induction and recovery. Large ruminants are more difficult to physically control and require a somewhat larger “safety zone”. Except for a handful of cases, they typically do not attempt to stand up until they are well awake and functional. Good footing is the primary requirement for achieving a good recovery: an open grassy area is ideal. A stall or pen deeply bedded with shavings,

straw or sand provides a good surface, but a confined space increases risk for personnel involved and may interfere with the procedure. Proximity to a water source, lighting and easy access to emergency supplies is important.

It is imperative to position the patient properly when heavily sedated. Animals maintained in lateral recumbency should have their neck extended at all times to maintain upper airways patency. To allow flow of rumen fluid and saliva out from the oral cavity, pad or towels placed underneath the head and neck junction so that the opening of the mouth is below the level of the larynx. Down forelimb be pulled forward to prevent radial nerve paralysis. A thick pad or towels be placed underneath the down shoulder for further protection. Appropriate dorsal positioning especially in adult cattle can be difficult to obtain in a field setting. Head needs to be stabilized, rather than hanging to prevent excessive tension on neck structures. Short and thick neck and horn conformation of many cattle and goat breeds can make proper orientation difficult to achieve. Care be taken to protect the eyes in heavily sedated or anesthetized

animals especially when placed in lateral recumbency; the lids of the down eye should be closed and protected by a towel or pad.

Once an injectable sedation protocol is selected, the route of administration of these drugs (IV, IM, SC), and the demeanor must be decided by the clinician. Overall, the intravenous route is the most effective method of administration in terms of bioavailability and onset of action. However, the intravenous route may not always be practical under field conditions, especially when dealing with unruly large cattle and swine; in these animals, the intramuscular or subcutaneous route be used initially to achieve sedation. The limitations of intramuscular and subcutaneous injection include incomplete bioavailability, delayed onset of action, and the limited volume that be administered.

All patients sedated or anesthetized with injectable drugs be monitored closely. Heart rate, respiratory rate, mucous membranes colour and capillary refill time checked at regular intervals during and following the anesthetic episode. Also, anesthetic depth should be assessed throughout as described in Table 1.

Table 1. Clinical signs used to monitor anesthetic depth in food animals

Anesthetic depth	Eye position	Palpebral reflex
Light	Central	Present
Adequate	Rolled down (toward nose)	Absent
Deep	Central	Absent

Chemical Restraint Techniques

Xylazine - α_2 -Adrenergic agonist

Xylazine sedation is useful for facilitating short diagnostic or therapeutic procedures on less cooperative patients.

Although patients generally tolerate mildly uncomfortable stimuli, not very reliable for, standing sedation to provide significant analgesia. Duration of xylazine sedation and analgesia is dose dependent, generally lasting about 30 to 40 minutes following intravenous administration in

standing or laterally recumbent patients. In dorsally recumbent patients, the duration of enhanced cooperation provided by intravenous xylazine may be as short as 20 minutes. Duration typically doubled with intramuscular administration, although intensity is commensurately reduced. Clinicians who have tried the “ketamine stun” technique tend to prefer it to pure xylazine chemical restraint (Table 2).

Xylazine (0.05 mg/kg IV or 0.1 mg/kg IM) results in recumbency in 50% of

tractable cattle. Xylazine (0.1 mg/kg IV or 0.2 mg/kg IM) results in recumbency in most tractable cattle. Anxious or unruly patients are more resistant and somewhat higher doses of xylazine may be required to produce recumbency. Titrated administration (e.g., initial conservative dose that supplemented if necessary) minimizes the amount of xylazine administered and the degree of adverse side effects produced. Physical methods can also be used to produce recumbency once the patient is sufficiently sedated.

Table 2. Dose range of xylazine expected to produce standing sedation with a low incidence of recumbency

Patient type	IV ^a	IM
Dairy breeds	0.0075-0.01 mg/kg	0.015-0.02 mg/kg
Tractable cattle	0.01-0.02 mg/kg	0.02-0.04 mg/kg
Anxious cattle	0.02-0.03 mg/kg	0.04-0.06 mg/kg
Extremely anxious or unruly cattle	0.025-0.05 mg/kg	0.05-0.1 mg/kg

Abbreviations: IM, intramuscularly; IV, intravenously.

^aAdministering the IV dose IM further reduces the possibility of recumbency.

Detomidine

Detomidine is a more potent α_2 -adrenergic agonist. Because ruminants have increased sensitivity to xylazine, the dose relationship between xylazine and detomidine in ruminants does not reflect

these differences (Table 3). Detomidine doses used in ruminants are similar to those used in equine patients. Detomidine produces greater cardiorespiratory depression than xylazine and not be used in animals to produce recumbent sedation.

Table 3. Dose range of detomidine expected to produce standing sedation with a low incidence of recumbency

Patient type	IV ^a	IM
Tractable cattle	0.002-0.005 mg/kg	0.006-0.01 mg/kg
Anxious cattle	0.005-0.0075 mg/kg	0.01-0.015 mg/kg
Extremely anxious or unruly cattle	0.01-0.015 mg/kg	0.015-0.02 mg/kg

Information regarding the use of detomidine in ruminants is limited. The dose ranges provided are estimates and should be adjusted based on experience.

Abbreviations: IM, intramuscularly; IV, intravenously.

^aAdministering the IV dose IM further reduces the possibility of recumbency.

α_2 -Adrenergic agonist and opioids

An opioid is preferred (butorphanol or morphine) be administered to augment the level of systemic analgesia in ruminants when sedated with α_2 -adrenergic agonists like xylazine or detomidine. Butorphanol (0.05-0.1 mg/kg IV or IM) in smaller ruminants, 0.02-0.05 mg/kg IV or IM in larger ruminants) or morphine (0.05-0.1 mg/kg IV or IM) can be administered with the initial dose of α_2 , or added in situations when patient's cooperation needs improvement. The α_2 dose can typically be reduced somewhat when used in conjunction with an opioid.

Ketamine

Ketamine is by far the most common injectable anesthetic agent used in large animal or farm animal practice. Ketamine is an N-methyl-D-aspartate receptor antagonist, possesses potent analgesic effects at sub anesthetic doses. Sub anesthetic doses of ketamine used in chemical restraint in "Ketamine Stun".

Telazol

Telazol is a combination of equal parts by weight of tiletamine hydrochloride a dissociative anesthetic similar to ketamine, a N-methyl-D-aspartate receptor antagonist, and Zolazepam hydrochloride a benzodiazepine with minor tranquilizing properties. Due to high cost of this product, primarily used in large animal practice for capturing intractable patients.

Ketamine Stun

The author prefers ketamine stun in cattle in performing caesarian sections,

vasectomy, caudal epididymectomy etc. Ketamine is a dissociative anesthetic commonly used in veterinary medicine. Ketamine possesses potent analgesic effects when administered at subanesthetic doses. Adding a small dose of ketamine to more traditional chemical restraint combinations greatly enhances the level of patient cooperation. This technique is called the "**ketamine stun**" (or stun) because of the stunned effect it produces in patients when administered IV at doses that produce recumbency. These patients appeared to be awake, but seem oblivious to surroundings and procedure performed. The intravenous effect is quite brief (approximately 15 minutes) and patients typically stand and appear fairly normal at that time, this state can be referred to as semi-anesthetized, but perhaps chemical hypnosis is more appropriate. Dosing must be more conservative when using the ketamine stun technique in standing patients. This limits the degree of systemic analgesia relative to what can be achieved in recumbent patients, but still provides improved patient cooperation when compared with more traditional methods of standing chemical restraint in both ruminants and horses.

The α_2 adrenergic agonist (xylazine) possess potent sedative and analgesic effects. Opioids (butorphanol) are analgesic, but they possess central nervous system effects that when combined with a tranquilizer or sedative produces a greater level of mental depression. Ketamine is an N-methyl-D-aspartate receptor antagonist that possesses potent analgesic effects at subanesthetic doses. Ketamine was included in the stun technique for its analgesic properties, likely contributes to the mental aspect of

the enhanced cooperation exhibited by patients under the influence of the ketamine stun technique. By combining drugs, one is able to use smaller doses of the individual components while still achieving the desired level of effect.

Ketamine stun techniques divided into two broad categories: standing and recumbent. The standing ketamine stun

used primarily in large ruminants and horses. The recumbent ketamine stun, used primarily in the small ruminants, camelids, and foals. The level of effect achieved is determined by three variables (Dose, Route of administration, Initial demeanor of the patient). The stun cocktail can be administered IV, IM or SQ depending on the systemic analgesia, patient cooperation, and duration desired (Table 4).

Table 4. Route of administration determines the relative impact of the ketamine stun technique

Parameter	Relative Ranking
Intensity (analgesia/cooperation)	IV >> IM > SQ
Onset	IV >> IM > SQ
Duration of effect	SQ > IM >> IV

Clinical application of the ketamine stun in food animal patients can be divided into four basic categories.

Intravenous recumbent stun

The intravenous recumbent stun used for short procedures or procedures requiring high level of systemic analgesia and patient cooperation.

A combination of xylazine (0.025-0.5 mg/kg), butorphanol (0.05-0.1 mg/kg), and ketamine (0.3-0.5 mg/kg) is administered IV. Onset is approximately 1 minute. Patients gracefully become recumbent. Patients seem to be awake, but seem oblivious to surroundings and procedures being performed. Mild random head or limb motion is not unusual, but purposeful movement or vocalization are signs of an inadequate stun level and additional drug should be administered. One half of the initial ketamine dose should be administered IV and is often effective. If, after allowing 60 to 90 seconds for onset, this additional half dose of ketamine fails

to produce the desired level of analgesia, a second half dose of ketamine along with one half of the initial dose of xylazine should be administered IV.

The level of systemic analgesia produced varies depending on the doses administered, but tends to be intense. Surgical levels of analgesia is achieved with this technique, but the use of local anesthetic blockade should be used whenever feasible to reduce the risk of patient awareness and stress. Duration of the stun effect is approximately 15 minutes and patients typically are able to stand and walk immediately or shortly after this point. The intravenous recumbent stun is designed for short procedures. One should plan ahead and work fast. Supplemental doses of ketamine or xylazine can be administered to extend duration, but this technique is not intended for procedures that are expected to last significantly beyond the 15-25

minute range. The degree of extension is relative to the amount of supplemental drug administered.

The recumbent intravenous stun has proved very useful for facilitating a wide variety of short procedures in camelids and small ruminants.

Intramuscular or subcutaneous recumbent stun

The intramuscular or subcutaneous recumbent stun used for procedures requiring a longer duration of chemical restraint. The level of systemic analgesia is not as intense, and local anesthetic blockade should be used to reduce the risk of patient awareness and stress. Umbilical hernia repair is an example of the procedures performed using this technique. This approach is also useful for improving cooperation in patients that have gone down before or during a surgical procedure.

A combination of butorphanol (0.025 mg/kg), xylazine (0.05 mg/kg), and ketamine (0.1 mg/kg) is administered IM or SQ. Subcutaneous administration is preferred because it provides a slightly longer duration of effect. Onset time is approximately 3 to 10 minutes. Patients are obtunded enough to require (and tolerate) intubation when placed in dorsal recumbency. The duration of effect with subcutaneous administration is approximately 45 minutes. Patients should be ambulatory within 30 minutes following this point.

The level of systemic analgesia produced by the intramuscular or subcutaneous recumbent stun is not as intense, but this approach does provide an

enhanced level of patient cooperation that can make procedures much more pleasant for both patient and clinician.

Intravenous standing stun

The intravenous standing stun typically used to provide a transient improvement in patient cooperation. Small doses of intravenous ketamine can markedly improve the degree of patient cooperation in standing chemical restraint. Butorphanol (0.05-0.1 mg/kg IV or IM in smaller ruminants, 0.02-0.05 mg/kg IV or IM in larger ruminants) or morphine (0.05-0.1 mg/kg IM or IM) be added to augment the level of analgesia and patient control.

Intramuscular or subcutaneous standing stun

5-10-20 technique

The intramuscular or subcutaneous standing stun used for most standing procedures in ruminant patients. The level of systemic analgesia is limited and local anesthetic blockade be used to reduce the risk of patient awareness and stress. Standing flank laparotomy is an example of the procedure performed using this technique.

A combination of butorphanol (0.01 mg/kg), xylazine (0.02 mg/kg), and ketamine (0.04 mg/kg) is administered IM or SQ. In a 500 kg cow this equates to butorphanol (5 mg), xylazine (10 mg), and ketamine (20 mg). For a 680 kg patient the doses are 7 mg butorphanol, 15 mg xylazine, and 25 mg ketamine. Morphine (25 mg for 500 kg cow, 30 mg for 680 kg cow) can be substituted for butorphanol.

Subcutaneous administration is preferred to minimize the risk of recumbency. In very unruly cows, intramuscular administration provides better patient control. Onset is 5 to 10 minutes with subcutaneous administration. Cows stood quietly during the caesarean sections (many were ill mannered before the ketamine stun). The duration of effect is approximately 60-90 minutes. Additional xylazine and ketamine can be administered SQ to extend the duration of chemical restraint. Recumbency has occasionally

occurred with re-administration of 50 of all three components. Current recommendation for supplemental drug administration is 25%-50% of the initial xylazine and ketamine doses (0-2.5-5) and (0-5-10), respectively, depending on the degree of cooperation and time required to complete the procedure. A similar approach (10-20-40 technique) has been used successfully in adult bulls. Preputial surgery (with local anesthetic block) is an example of the procedures performed using this technique.

Anesthetic Drugs (Table 5) & Anesthetic Protocols (Table 7 & 8)

Table 5. Indications, dosage and side effects of common anesthetic drugs used in food animals

Anesthetic drug	Drug class	Indications	Side effects to consider	Dosage (mg/kg)	Route	Duration (min)
Xylazine	α -2 Agonist	Short-term sedation Muscle relaxant Mild analgesia	Cardiorespiratory depression Bloat, recumbency Hyperglycemia Abortion (3rd trimester)	0.05 0.1-0.2	IV IM	20-30 30-40
Detomidine	α -2 Agonist	Longer sedation 20x analgesic/sedative than xylazine	Similar to Xylazine except: Safe to use in pregnant cows ↓ Likelihood of recumbency	0.005-0.02 0.02-0.04	IV IM	Dose dependent
Ketamine	Dissociative	In association for general anesthesia	Respiratory depression No muscle relaxation	2-3 3-4	IV IM	15-20 20-30
Diazepam	Benzo diazepine	Anticonvulsant Sedation	Cardiorespiratory depression	0.5-1: seizure 0.05-0.2: sedation	IV slow IV slow	30-45
Butorphanol	Opioid agonist/ antagonist	Analgesia Sedation	May induce excitation if given by itself	0.05-0.2 0.2-0.5	IV IM	45-60
Morphine	Pure opioid agonist	Analgesia	Respiratory depression ↓ GI motility	0.05-0.2 0.05-0.5	IV, IM IM, SC	240-360 (4-6 hrs.)
Guafenesin	Central Skeletal Muscle Relaxant	Muscle relaxation	No analgesia	100	IV drip	Drip rate dependent
Tiletamine/ Zolazepam	Dissociative /Benzodiazepine	General anesthesia Analgesia Muscle relaxation	Respiratory depression Long but smooth recovery	5	IM	60-90
Acepromazine	Dopamine & α -1 antagonist	Mild sedation Calming effect	No analgesia, hypotension Penile prolapse → trauma	0.01-0.02 0.03-0.1	IV IM	120-240 (2-4 hrs.)

Table 6. Dosage of common reversal anesthetic drugs used in food animals

Anesthetic drug	Drug class	Indications	Side effects to consider	Bo/OV/Cap/Camelids Dosage (mg/kg)	Swine Dosage (mg/kg)	Route
Tolazoline	α -2 Antagonist	Reversal α -2 agonist	Adverse reaction possible when given IV fast	1-2	1-2	IV slow IM, SC
Yohimbine	α -2 Antagonist	Reversal α -2 agonist		0.125-0.2	0.1-0.2	IV slow, IM
Atipamazole	α -2 Antagonist	Reversal α -2 agonist	Most appropriate α -2 reversal in camelids	0.125-0.2	0.2	IM, SC
Flumazenil	Benzodiazepine antagonist	Reversal for benzodiazepines		0.1	0.01	IV
Naloxone	Opioid antagonist	Reversal for opioids		0.03	0.5-2	IV, IM

Table 7. Injectable anesthetic protocols for bovine, ovine and caprine species

Protocol	Dosage	Route	Species	Indications	Duration (min)
Telazol 500 mg Ketamine 250-400mg Xylazine 100 mg	1.25-1.5 mL/100 Lbs. (Ov, Cap) 1 mL/100 lb (Bov)	Pole syringe or dart gun → IM	Bov Ov Cap	Capture & immobilization	~40-60
*Butorphanol *Xylazine *Ketamine	0.025 mg/kg 0.05 mg/kg 0.1 mg/kg	IV IM or SC	Bov	Standing sedations (bucking stock) Recumbent sedation (Routine surgery)	~15-20 ~30-40
*Butorphanol *Xylazine *Ketamine	0.05-0.1 mg/kg 0.025-0.05 mg/kg 0.3-0.5 mg/kg	IV	Bov	Short procedure requiring lateral or sternal recumbency, analgesia, and patient cooperation	
*Butorphanol *Xylazine *Ketamine	5 mg or 10 mg 10 mg or 20 mg 20 mg or 40 mg	IM or SC	Bov	Chemical restraint for standing C-section in beef cows (340 - 660 Kg Body weight)	~60-90
5%Guaifenesin 1L Ketamine 1000mg Xylazine 50-100mg "IV triple drip"	Induction: 1mL/kg Maintenance: 2 mL/kg/hr.	IV → catheter (drip set)	Bov	Procedure requiring good muscle relaxation (ex: <i>cast application</i>)	~60-90
Xylazine (X) Ketamine (K)	(X): 0.05 mg/kg (K): 2 mg/kg (X): 0.1 mg/kg (K): 4mg/kg	IV IM	Bov Ov Cap	General anesthesia – routine surgery Prolongation: administer ½ of initial ketamine dose	~30-40 ~40-60

*Ketamine stun

Table 8. Injectable anesthetic protocols for swine

Protocol	Dosage	Route	Indications	Duration (min)
Acepromazine	0.2-0.5 mg/kg	IM	Sedation	~ 30
Xylazine	0.5-3 mg/kg	IM	Sedation	~ 30
Medetomidine	10-20 mg/kg	IM	Sedation	~ 60
Butorphanol	0.1-0.2 mg/kg			
Midazolam	0.1-0.5 mg/kg			
Xylazine	1 mg/kg	IM	Sedation in pot belly pigs (especially geriatric patients)	~ 60
Glycopyrrolate	0.01 mg/kg			
Butorphanol	0.05 mg/kg			
Xylazine	1 mg/kg	IM	Sedation for caesarian section (use higher ketamine dosage for heavier sedation)	~ 60
Midazolam	0.2 mg/kg			
Ketamine	2-10 mg/kg			
Midazolam	0.5 mg/kg	IM	Sedation for geriatric pot belly pigs.	~ 30-40
Ketamine	5-10 mg/kg			
Pig cocktail #1: 5 ml Telazol 500 mg - powder Ketamine 250 mg Xylazine 250 mg	1 mL/50kg	IM	General anesthesia (prolonged recovery)	~ 60-90
Pig cocktail #2: 5 ml Telazol 500 mg - powder Xylazine 300 mg Sterile water 2 mL	1 mL/25kg	IM	General anesthesia (less chance of apnea compared to pig cocktail #1) Inguinal hernia Castration	~ 60
Pig cocktail #3: 5 ml Telazol 500 mg - powder Xylazine 150 mg Sterile water 3.5mL	4 mL/200 kg	IM	General anesthesia Cesarean section Hernia repair	~60

*Xylazine 1 mL = 100 mg

Withdrawal Times Suggested

Since most anesthetic drugs have a short half-life and are typically administered once at a low dose on an mg/kg basis, the incidence of volatile residues in meat or milk is fairly rare. In addition, anesthetized food animals going through a surgery are unlikely to be slaughtered shortly after the procedure. The time necessary for recovery

and healing of the surgical wound is usually long enough for most anesthetic drugs to clear before slaughter. It is recognized that tests for anesthetic residue are not performed routinely, in contrast to tests for antibiotic residues. Reaction in people caused by consumption of milk or meat contaminated with anesthetic drugs residues has not been documented.

Table 9. Recommended withdrawal times associated with injectable anesthetic drugs (*Bovine*)

Anesthetic drug	Meat withdrawal (days)	Milk withdrawal (hours)
Xylazine	4	24
Detomidine	3	72
Acepromazine	7	48
Ketamine	3	72
Thiopental	4	Not determined (ND)
Tiletamine/Zolazepam	30	ND
Diazepam	30	ND
Midazolam	14	ND
Butorphanol	19	72
Guaifenesin	3	48
Atropine	14	72
Tolazoline	8	48
Yohimbine	7	72

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