Anesthesia

Anesthesia is a state of controlled, temporary loss of sensation that is induced for medical or veterinary purposes. It may include some or all of **analgesia** (relief from or prevention of pain), **paralysis** (muscle relaxation), **amnesia** (loss of memory), and u**nconsciousness**. An individual under the effects of anesthetic drugs is referred to as being anesthetized.

Ther are three broad groups of anesthesia exist:

General anesthesia controllers central nervous system activity and results in unconsciousness and total lack of sensation, using either injected or inhaled drugs.

Sedation suppresses the central nervous system to a lesser degree, inhibiting both worry and creation of long-term memories without resulting in unconsciousness.

Regional and local anesthesia, which blocks transmission of nerve impulses from a specific part of the body. Depending on the situation, this may be used either on its own, or in combination with general anesthesia or sedation.

Local anesthesia is simple infiltration by the clinician directly onto the region of interest (e.g. numbing a tooth for dental work).

Peripheral nerve blocks use drugs targeted at peripheral nerves to anesthetize an isolated part of the body, such as an entire limb.

In preparing for a medical or veterinary procedure, the clinician chooses one or more drugs to achieve the types and degree of anesthesia characteristics appropriate for the type of procedure and the particular patient. The types of drugs used include general anesthetics, local anesthetics, hypnotics, dissociatives, sedatives, adjuncts, neuromuscular-blocking drugs, narcotics, and analgesics.

Pre-anesthesia is a drug that is given to a patient before anesthesia for surgery. Pre-anesthetic drugs are prescribed by doctors to patients for the following purposes: Sedation, calming and reducing anxiety of the patient. Reduce pain, reduce metabolism, reduce harmful reflexes. Limiting secretions in the respiratory tract, mouth, and throat, helping to reduce the risk of aspiration into the respiratory tract. Anti-nausea and vomiting, stabilize heart rate and blood pressure Increase effect of local anesthetics, anesthetics and allergy prevention

Stages of Anesthesia Based on Guedel's Classification

Stage 1 - Analgesia or Disorientation: This stage can be initiated in a preoperative anesthesiology holding area, where the patient is given medication and may begin to feel

its effects but has not yet become unconscious. This stage is usually described as the "induction stage." Patients are sedated but conversational. Breathing is slow and regular. At this stage, the patient progresses from analgesia free of amnesia to analgesia with concurrent amnesia. This stage comes to an end with the loss of consciousness.

Stage 2 - Excitement or Delirium: This stage is marked by features such as disinhibition, delirium, uncontrolled movements, loss of eyelash reflex, hypertension, and tachycardia. Airway reflexes remain intact during this phase and are often hypersensitive to stimulation. Airway manipulation during this stage of anesthesia should be avoided, including both the placement and removal of endotracheal tubes and deep suctioning maneuvers. There is a higher risk of laryngospasm (involuntary tonic closure of vocal cords) at this stage, which may be aggravated by any airway manipulation. Consequently, the combination of spastic movements, vomiting, and rapid, irregular respirations can compromise the patient's airway. Fast-acting agents help reduce the time spent in stage 2 as much as possible and facilitate entry to stage 3.

Stage 3 – Surgical Anesthesia: This is the targeted anesthetic level for procedures requiring general anesthesia. Ceased eye movements and respiratory depression are the hallmarks of this stage. Airway manipulation is safe at this level. There are four "planes" described for this stage. During plane 1, there is still regular spontaneous breathing, constricted pupils, and central gaze. However, eyelid, conjunctival, and swallow reflexes usually disappear in this plane. During plane 2, there are intermittent cessations of respiration along with the loss of corneal and laryngeal reflexes. Halted ocular movements and increased lacrimation may also occur. Plane 3 is marked by complete relaxation of the intercostal and abdominal muscles and loss of the pupillary light reflex. This plane is referred to as "true surgical anesthesia" because it is ideal for most surgeries. Finally, Plane 4 is marked by irregular respiration, paradoxical rib cage movement, and full diaphragm paralysis resulting in apnea.

Stage 4 - Overdose: This stage occurs when too much anesthetic agent is given relative to the amount of surgical stimulation, which results in worsening of an already severe brain or medullary depression. This stage begins with respiratory cessation and ends with potential death. Skeletal muscles are flaccid, and pupils are fixed and dilated at this stage. Blood pressure is typically significantly lower than normal, with weak and thready pulses due to the suppression of the cardiac pump and vasodilation in the peripheral bloodstream. Without cardiovascular and respiratory support, this stage is lethal. Hence, the anesthetist's goal is to transition the patient as soon as possible to stage 3 of anesthesia and keep them there for the duration of the operation.

Drugs Used for Anesthetic Induction

The induction of anesthesia is the process of transitioning a patient from an awake to an anesthetized state. A rapid, smooth induction is desirable to avoid stress and sympathetic stimulation in the patient. Most drugs used to induce anesthesia provide anesthesia and muscle relaxation but have a relatively narrow therapeutic index, making anesthesia induction one of the most hazardous time periods of anesthesia.

Propofol

Propofol is unrelated to barbiturates, steroid anesthetics, or other drug classes. It increasing inhibition throughout the central nervous system. It is presently available as an emulsion containing propofol, soybean oil, glycerol, and egg lecithin. This emulsion is susceptible to contamination with bacteria and promotes bacterial growth.
Propofol administration results in a smooth transition to anesthesia, with time from injection to conditions suitable for endotracheal intubation in 30 to 60 seconds.

Etomidate

Etomidate is an imidazole derivative unrelated to barbiturates or other classes of induction agents.

Alphaxalone

Alphaxalone is a steroid anesthetic that causes anesthesia by enhancing GABA- and glycine-mediated central nervous system depression.

Inhalant Anesthesia

Inhalant anesthesia is the mainstay for provision of general anesthesia in small animals. Inhalants allow for rapid titration of anesthetic depth and a rapid recovery from anesthesia.
Inhalants cover all three aspects of the anesthetic triad, although analgesia is accomplished through the loss of conscious perception, not necessarily through modulation of the pain signal (although new evidence points to an effect of inhalant anesthetics on specific nociceptive receptors).

The inhalants in common use in clinical small animal practice are **isoflurane** and **sevoflurane**. Halothane has largely been replaced by isoflurane because halothane is more
soluble, causes a greater decrease in cardiac output, and predisposes the patient to cardiac arrhythmias. **Halothane** is also highly metabolized (20%), may induce liver toxicity, and is no longer less expensive than isoflurane.

PREMEDICATIONS

Benzodiazepines

Benzodiazepines have five main pharmacologic effects:
anxiolysis, sedation, anticonvulsant activity, spinal cord– mediated muscle relaxation, and amnesia.
Benzodiazepines have their mechanism of action at gamma-aminobutyric acid (GABA) receptors, the primary inhibitory neurotransmitters of the central nervous system (CNS).

Diazepam.
Diazepam is a highly lipid-soluble benzodiazepine with a prolonged duration of action. Because of its lipid solubility, it is rapidly taken up by the brain and redistributed to fatty tissues. It binds quickly to serum proteins, such as albumin, and is metabolized in the liver to active metabolites. These metabolites have prolonged half-lives and eventually are excreted by the kidneys. In dogs, the elimination half-lives of metabolites with high doses of diazepam can be as long as 6 hours. In cats, these half-lives are even longer—approximately 21 hours.

Midazolam.
Midazolam is a water-soluble benzodiazepine available for IM or IV injection; it does not cause pain with either route. Additionally, it has a rapid onset of action and rapid metabolism. These qualities make it a very good choice, especially when used as a premedication with an opioid in very young, elderly, or sick dogs and cats.

Zolazepam.
Zolazepam is combined with tiletamine, a NMDA receptor antagonist, and is sold under the name of **Telazol**. It probably is most useful when used for restraint or for very short procedures. Telazol can be given IM, IV, or transmucosally. Because onset of action is variable, the patient should be carefully observed once Telazol has been given. Duration of action is dose dependent and somewhat variable.

Acepromazine
Acepromazine has been the most commonly used tranquilizer in veterinary medicine for many years. It can provide profound sedation at small doses, but side effects limit its usefulness in elderly(old), sick, or trauma patients. The widespread practice of administering acepromazine as a premedication and then maintaining anesthesia with an inhalant anesthetic (e.g., isoflurane, sevoflurane) with inadequate monitoring contributes to the high incidence of hypotension in small animal surgical patients.

Alpha-2 Agonists
In small animal veterinary medicine, the alpha-2 agonists most commonly used are medetomidine and dexmedetomidine.
Historically,

xylazine

was used for many years, but it does not have selectivity for alpha-2 versus alpha-1 receptors, as do medetomidine and dexmedetomidine. Medetomidine is a racemic mixture, with dexmedetomidine being the active isomer. Therefore dexmedetomidine is twice as potent as medetomidine. Selective alpha-2 agonists may be used as premedication in healthy small animals for their sedative, analgesic, and muscle relaxant properties.

Anticholinergics

Atropine and glycopyrrolate are anticholinergic medications often added to the premedication arsenal. With an increase in monitoring abilities, the routine addition of this class of drug to the premedication regimen is often unnecessary.

Both atropine and glycopyrrolate act at parasympathetic cholinergic sites to increase heart rate and decrease salivation.
Atropine has a greater effect on heart rate as compared with glycopyrrolate. However, glycopyrrolate has a slightly greater effect on decreasing oral secretions compared with atropine. Atropine and/or glycopyrrolate should be easily available for intravenous treatment of bradycardia in the anesthetized patient.

INDUCTION MEDICATIONS

Propofol
Propofol is an insoluble drug that requires a lipid emulsification. Soybean oil is used for the oil phase, and egg lecithin as the emulsifying agent.
Because this solution can support bacterial growth, it is recommended to discard unused portions after 6 hours.
Propofol quickly crosses the blood-brain barrier and exerts its action centrally on GABA receptors. Propofol causes rapid hypnosis, but no analgesia, when given as an intravenous bolus. It is metabolized in part by the liver and is excreted in the urine. However, propofol clearance exceeds hepatic blood flow, emphasizing redistribution of propofol into other tissues, including the lungs.

Ketamine
Ketamine is a dissociative anesthetic that has been used for several years in veterinary medicine. It is a central nervous system depressant that produces its dissociative properties. It has an onset of approximately 1 minute with rapid crossing of the blood-brain barrier when given as an intravenous bolus. It is metabolized by the liver into a less potent but active metabolite.
The use of ketamine, not as an induction agent but as part of a multimodal approach, has increased in both veterinary and human medicine.
Ketamine produces cardiovascular effects that resemble sympathetic nervous system stimulation with increased heart rate and blood pressure, cardiac output, and cardiac oxygen demand. Ketamine should be avoided in tachycardic, hypertensive, subaortic stenosis, hypertrophic cardiomyopathy, or sympathetically depleted patients. Because ketamine directly stimulates the sympathetic nervous system, chronically ill patients may experience a decrease in cardiac output and blood pressure, reflecting depleted catecholamine stores.

OPIOIDS
Opioids have been the workhorse for pain relief in both human medicine and veterinary medicin. When used alone, they have a long list of potential side effects. Of most notable concern is respiratory depression, which fortunately is much less likely in dogs and cats than in some species. Other side effects include nausea and vomiting, decreased appetite, decreased gastrointestinal peristalsis, constipation, hallucinations, and excitement.
When an opioid is used, it is best given as part of the premedication regimen, especially in healthy animals. Oftentimes a single opioid analgesic is used throughout the perioperative period.

Morphine
Morphine is the prototypical opioid, and references are frequently made to it when one opioid is compared with another. Onset of action of morphine is approximately 15 to 30 minutes, and duration of action is 3 to 4 hours. It is the lower lipid solubility of morphine that slows its onset of action when given intravenously. But this lower lipid solubility means that it may last in the epidural space for 12 to 24 hours, providing prolonged analgesia postoperatively for abdominal and even thoracic surgeries. Morphine undergoes hepatic and renal conjugation into two metabolites, one active and the other inactive.

Hydromorphone
Hydromorphone is a derivative of morphine that has become a popular alternative to morphine and oxymorphone. Its action lasts 2 to 6 hours, and it is approximately five to ten times more potent than morphine. It also has a relatively slow onset of action of approximately 15 to 20 minutes when given IV. It may be given IM and subcutaneously (SC),

Oxymorphone
Oxymorphone is similar to morphine but does not cause histamine release. It is appropriate for moderate to severe pain. Although oxymorphone causes sedation, panting, and sometimes hypothermia, it seems to cause less vomiting than morphine or hydromorphone in dogs and cats. It can be administered IM, IV, SC, or as an epidural injection.

Opioid Antagonists

Respiratory depression and sedation caused by opioids may be reversed with several different opioid antagonists. Opioids should be antagonized carefully in patients because the antagonist may also reverse analgesia. Rapidly reversing the analgesia may produce tachycardia, hypertension, dysrhythmias, hypoventilation, and even aggressive behavior. Antagonists such as naloxone may be used to reverse opioid side effects such as excessive mental or respiratory depression. To make naloxone easier to titrate, dilute to a 1 : 10 solution with saline. Naloxone currently comes in a 0.4-mg/ml vial. Diluting 1 : 10 makes the concentration a and seizures may be present with worsening levels of toxicity.
Local anesthetics depress myocardial automaticity with resulting bradycardia and heart block. Additionally, they cause vasodilation. The combination of bradycardia, heart block, and hypotension may end in cardiac arrest.

Lidocaine
is widely used in veterinary medicine. Its rapid onset of action and short duration of 1 to 2 hours make it a versatile drug with many clinical applications. For nerve blocks, it is recommended to use lidocaine at 2 to 4 mg/kg in cats; in dogs, a dose of 5 mg/kg may be used. Because epinephrine prolongs systemic uptake of local anesthetics, lidocaine may be used at 7 mg/kg when combined with epinephrine for regional anesthesia.
Epinephrine probably should not be used with local anesthetic when halothane is

used as the inhalational agent because of myocardial sensitization to catecholamines caused by halothane.

Bupivacaine

has a slower onset of action and may take 15 to 20 minutes to take effect. Its duration of action is usually 4 to 6 hours. In dogs and cats, the total dose of bupivacaine should not exceed 2 mg/kg for regional anesthesia.

Last, local anesthetics do not work in environments where infection or fluid accumulation is present.

Topical Anesthetic

Several topical anesthetics deserve mention. The first is LMX4 (Ferndale Healthcare, Ferndale, Mich.). LMX4 is a 4% lidocaine cream that takes approximately 20 to 30 minutes to take effect. This topical anesthetic may be applied to assist in closure of small wounds, IV catheter placement, or spinal/ epidural placement in awake patients. Hair removal is necessary for direct placement of LMX4 onto the skin. However, no occlusive dressing is required, as was needed with older products.

REGIONAL ANESTHESIA

Generally, local anesthetics are used in regional techniques and are most effective when given before surgical stimulation.

Several regional anesthetic techniques, including

1- Topicalanesthesia,
2- local infiltration,
3- peripheral nerve block,
4- intraarticular injection,
5- spinal block,
6- epidural block,

The two most commonly used local anesthetics in animal practice are lidocaine and bupivacaine, this discussion of local anesthetics is limited to these drugs.

Local anesthetics block sodium channels from inside the nerve cell, thus preventing sodium channel activation and membrane depolarization.

Local Infiltration

Local infiltration may be done before incision or just after closure of an incisional wound. It may be performed before surgical incision by injecting local anesthetic subcutaneously at the surgical site. If injected after closure, local anesthetic needs to be injected subcutaneously on both sides of the incision line, starting just above the incision and finishing just below. After inserting a needle, always aspirate to make sure the needle is SC and not IV.

Nerve Blocks

The key to success for any nerve block is correct placement of the needle tip near the target nerve before injection of local anesthetic. This can be variably successful with blind techniques. A peripheral nerve stimulator (PNS) is a valuable adjunct for needle placement and localization of the nerve(s).

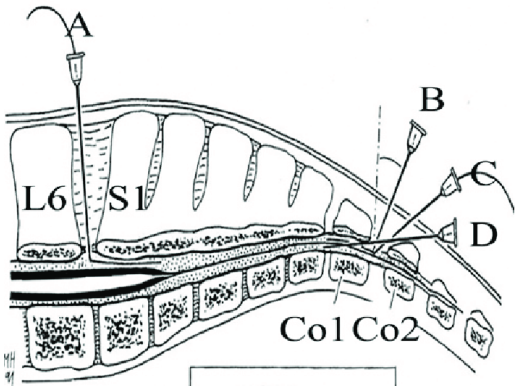
This usually occurs after 1 to 2 ml is injected. Injecting in 3 to 5 ml fractions and aspirating before each fraction minimizes the risk of intravascular injection.
The goal of using the nerve stimulator is to place the needle as close to the nerve as possible without penetrating the nerve.

Intraarticular Block

Intraarticular bupivacaine block may provide analgesia after stifle, hip, shoulder, and elbow surgeries. Overdistention of the joint is painful and may result in increased respiratory and heart rates. Lidocaine and bupivacaine at a dose of 1 to caudal aspect of the hard palate.

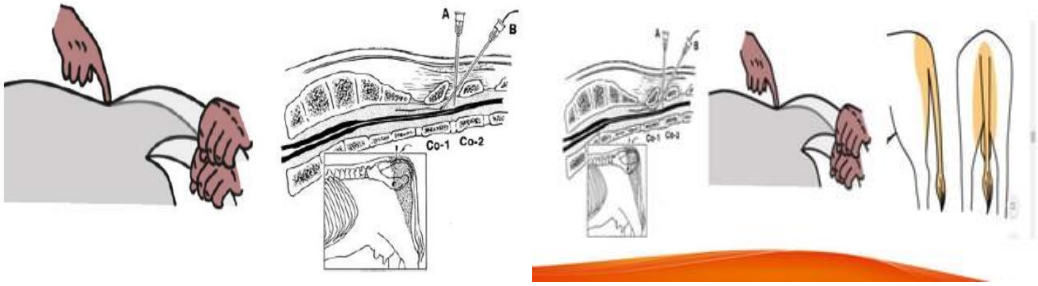
Epidural

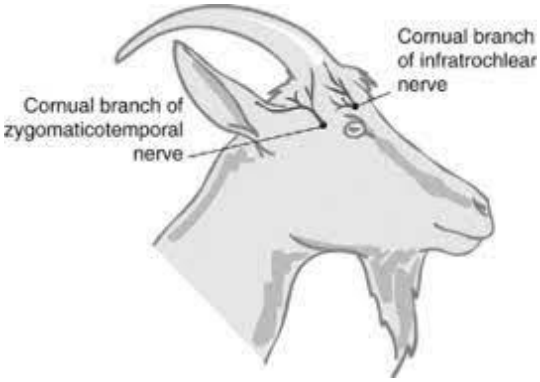
Epidurals may be safely administered to dogs after local desensitization of the skin with subcutaneous injection of lidocaine or LMX4 cream. Sedation with an opioid and use of a benzodiazepine often provide sufficient compliance for safe epidural injection in a dog. However, general anesthesia usually is required for safe epidural administration in cats and occasionally in some dogs.
Supplies needed include a spinal needle (20 gauge or 22 gauge), sterile gloves, an appropriate dose and volume of the selected drug, a syringe to administer the drug, a glass test syringe, and a fenestrated drape. In conscious patients, a syringe and needle with lidocaine are necessary to desensitize the skin if LMX4 cream has not been used.
When an epidural is performed in dogs, the spinal cord variably ends at L6-L7; the dural sac ends at L7-S1. In cats, the cord and dural sac usually extend one vertebra more caudal, and cord termination may be as caudal as S3. Therefore, dural punctures are more likely in cats than in dogs.

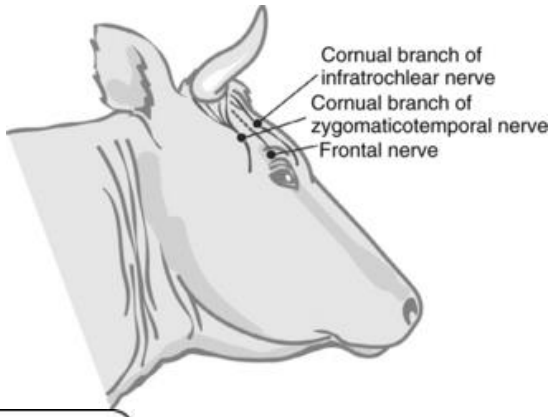


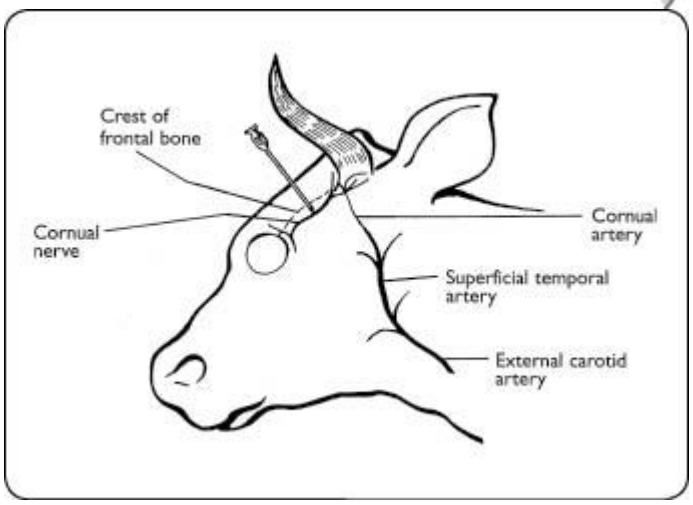
L6: sixth lumbar vertebrae, S1: first sacral dorsal spinous process, Co1 and Co2: first and second coccygeal vertebrae. A: cranial epidural anesthesia between L6 and S1: catheter placement for continuous caudal epidural anesthesia (technically demanding, infrequently performed). B: needle placement for caudal anesthesia perpendicular direction. C: needle introduction under 45° approximately. Once the needle is inserted, the catheter can be introduced over a distance of 10 to 30 cm into the epidural space. After placement of the catheter, the needle can be removed and the catheter can be secured to the skin. D: needle placement in the caudal part of the Co1-2 interspace under an angle of approximately 30° for caudal anesthesia

Caudal epidural









Local anesthesia

We use local blocks very commonly in large animal species. Often bovine standing surgery can be performed without sedation and just with local anesthesia and added analgesics. Epidurals are also relatively easy in dairy cattle and can help with many perineal procedures. More and more horse surgery is being done standing with sedation and local blocks.

Drugs

Lidocaine – Lidocaine is the predominant local anesthetic agent used. Species sensitivity varies with small ruminants and camelids much more sensitive than cattle. Horses are relatively insensitive. The following guidelines are useful to consider as high end doses. Calculate how much you can give and then decide if you need to dilute the drug. Diluted drug still works but has a shorter duration. Hint: 2% lidocaine is 20mg/ml.

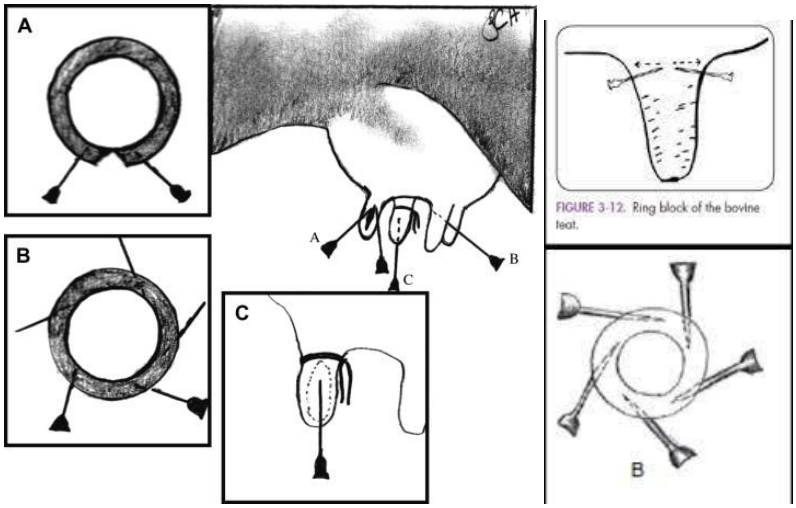
Mepivicaine lasts longer than lidocaine and can be used for longer procedures if needed. Mepivicaine is commonly used in equine procedures. Bupivicaine can be more tissue toxic and is typically isn't used except for therapeutic long term blocks (laminitis treatment).

Types of blocks

Nerve blocks: If we know where the nerve is, we can just put local anesthetic near the nerve. Eg dehorning blocks, paravertebral blocks, lameness blocks

Line blocks: Local anesthetic is injected in the line of the planned incision. This does deform the tissue planes but is the easiest to perform; no guessing required.

Field blocks: The nerves to a region are blocked using specific types of line blocks. An L block is used in the flank to block the regional paravertebral nerves.



Ring blocks: A specific type of field block. The entire limb is encircled with subcutaneous local anesthetic to reach any and all nerves

Regional iv blocks: A tourniquet is placed on the limb and local anesthetic injected into a vessel below the tourniquet. The local anesthetic is diluted to the level that it pushes out of the vasculature and into the tissues (typically 20 cc +). This is mock up in a calf using a butterfly catheter (you are supposed to hold the wings up to help direct it).

Epidural

The most common epidural agent in food animals is again lidocaine. We typically use 2-8 mg/kg BW, or 5 cc as starting amount in a standard size dairy cow. Lidocaine epidurals can cause ataxia and even recumbency. Lidocaine can be combined with xylazine for longer duration effects with less risk of recumbency; the combination is more common in horses than in cattle. Detomidine can be mixed with lidocaine in horses, as well. In cattle, detomidine leaves the epidural space quickly so more resembles intramuscular detomidine than epidural detomidine. Ketamine and morphine are other options for epidurals.

Lidocaine/xylazine combo – lidocaine 0.22mg/kg + xylazine 0.05 mg/kg, saline added to total volume of 5.7ml

Combination lasts about 300 minutes vs 80 minutes for lidocaine alone

Epidurals are typically performed in the sacrococcygeal space (the most movable space when the tail is pumped up and down). In dairy cattle, a 1.5″ 18 ga needle is inserted in that space at a 45° angle so that the hub is angled toward the tail. A drop of lidocaine is put in the needle hub and should be sucked down into the needle when the epidural space

is reached. This is known as the hanging drop technique. It works well in most dairy cattle but isn't as useful in obese animals. If the needle is positioned so the bevel is up, the drug will diffuse further forward. If the bevel is pointed down, this will tend to keep the drug in the caudal region.

Flank anesthesia

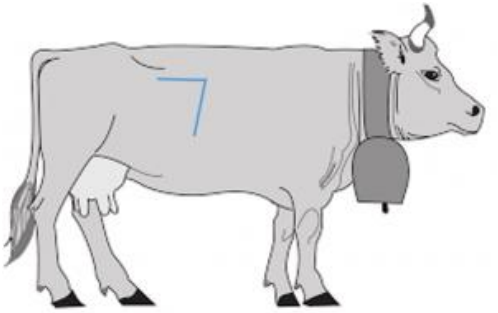
Flank surgery is common in cattle and requires a good local block. Options include a line block (at the incision site), an inverted L and paravertebral blocks.

Line block

A line block is an injection of subcutaneous lidocaine along the site of the incision. Relatively straightforward, it is often used when nothing else is working. The block can be easier on the animal if a longer needle is used and is inserted through the site of the last injection. This minimizes the number of pokes in unblocked skin. For flank incisions, it is important to also place lidocaine deeper in the muscle layers.

The main disadvantage of a line block is distortion of the surgery field.

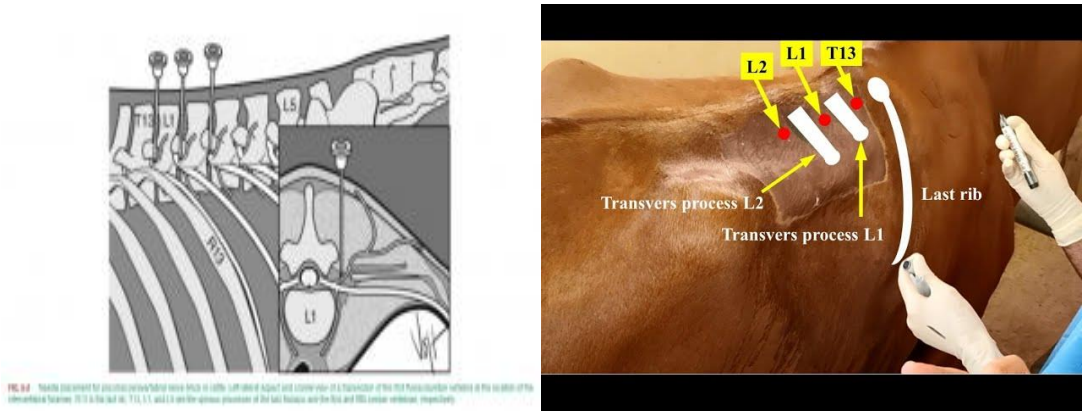
Inverted L block



This block is similar to the line block but is used to block the nerves as they come down the flank and avoids lidocaine directly in the surgery field. The lidocaine is injected in two long lines – one just behind the last rib and one below the transverse processes of the vertebrae. The injection must be deep enough to get the deeper nerves and typically does not block the peritoneum.

Proximal paravertebral block

For this block, the spinal nerves T13, L1 and L2 are blocked as directly as possible as they exit the spinal cord. This creates a more



effective block. When the block is working, the cow will bend toward the opposite side as muscles are relaxed. The flank will also be warmer due to related vasodilation.

At each site, ~20 ml of lidocaine is injected. Needles are inserted above the transverse processes T13, L1 and L2 and walked off the dorsal margin of each bone. A long needle is used to block the nerve branches both above and below the fascia.

This block can be challenging in very large beef breeds due to difficulty palpating landmarks.

Distal paravertebral block

This block is also aimed at spinal nerves T13, L1 and L2 but is coming at them from a more distal position. As the nerves traverse caudally, the injection sites are at the tips of L1, L2 and L4. At each site, 10-20 ml of lidocaine is injected.