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Veterinary Anesthetic and Analgesic Formulary

Edition 9.16

Adapted from the University of Colorado Denver IACUC Veterinary Anesthetic and Analgesic Formulary.

I. Introduction and Use of the CU Boulder Formulary

Basic Definitions:

- *Anesthesia*: central nervous system depression that provides amnesia, unconsciousness and immobility in response to a painful stimulation. Drugs that produce anesthesia may or may not provide analgesia (*1, 2*).
- *Analgesia*: The absence of pain in response to stimulation that would normally be painful. An analgesic drug can provide analgesia by acting at the level of the central nervous system or at the site of inflammation to diminish or block pain signals (*1, 2*).
- *Sedation*: A state of mental calmness, decreased response to environmental stimuli, and muscle relaxation. This state is characterized by suppression of spontaneous movement with maintenance of spinal reflexes (*1*).

Animal anesthesia and analgesia are crucial components of an animal use protocol. This document is provided to aid in the design of an anesthetic and analgesic plan to prevent animal pain whenever possible. However, this document should not be perceived to replace consultation with the university's veterinary staff. As required by law, the veterinary staff should be consulted to assist in the planning of procedures where anesthetics and analgesics will be used to avoid or minimize discomfort, distress and pain in animals (*3, 4*). Prior to administration, all use of anesthetics and analgesic are to be approved by the Institutional Animal Care and Use Committee (IACUC).

For each species listed in the formulary, the most commonly used anesthetic and analgesic drugs used on this campus are highlighted. These drugs can be considered the "front-line" of care. However, based on the research, procedure, and need, the most common drugs may not suffice and an individual drug

or a combination of drugs may be indicated to provide the safest and effective anesthetic and analgesic plan.

Dosages or dose-ranges are obtained from a variety of laboratory animal medicine and veterinary references which fail to precisely agree. Where dosage ranges are provided, the effective minimum and safely administered maximum are represented. Selection of dose can be based on veterinary recommendation, literature references, or procedural experience. Yet, when listing these drugs in an animal use protocol, drugs should be listed with approximate dose ranges. This provides flexibility for titration up or down for the individual animal or for the particular application.

For **anesthetic drugs**, the duration of action has not been provided. Duration of anesthesia is influenced by the drugs used, strain, age, sex, body weight, procedure performed and the amount of stimulus during the procedure. As a result, any published duration of action would be a generalization. For assistance in judging duration of action, consultation with a veterinarian is ideal when developing an anesthetic regimen. Due to all the factors that influence duration of anesthesia, anesthetic drugs should always be titrated to effect. If anesthesia is being maintained by a gas anesthetic (eg. Isoflurane) titration of anesthetic depth can be controlled almost immediately by adjusting the amount of anesthetic gas being administered to the animal. In addition, anesthetic duration can be extended for as long as the anesthetic gas is administered. In contrast, injectable anesthetics do not have this flexibility such that once a dose has been administered, it cannot be "removed" to end anesthesia to coincide with the end of the procedure. However, reversal drugs do exist for some of the drugs used in anesthetic combinations such as Medetomidine, which is efficiently reversed by Atipamezole (see α_2 antagonists below). In addition, injectable anesthetics may need to be re-administered so the anesthetic can initiate anesthesia if not achieved after the initial dose or accommodate the duration of the procedure. As a generalization, it is often recommended to re-administer 25-30% of the initial dose of the injectable anesthetic to lengthen the surgical anesthesia time. It is not acceptable to perform a surgical procedure unless the animal is fully anesthetized. Thus, if it is found that recommended dose ranges for injectable anesthetics are consistently too high (prolonged anesthesia or long recovery) or too low (return of reflex requiring repeated administration of drugs) for the procedure, the veterinary staff should be contacted. With veterinary consultation, further flexibility can be provided to more accurately titrate dosages prior to submitting a protocol modification to the Institutional Animal Care and Use Committee.

Independent of the method of anesthesia or duration of the procedure, animals should be monitored until awake, also referred to as "Recovered." Recovery from anesthesia is indicated by the ability to right themselves when laid on their side, maintain a sternal body position, and demonstrate spontaneous movement in response to environmental stimulation such as cage manipulation. Monitoring recovery allows for confirmation that animals will have negligible risk of harm from cage mates and be able/capable to reach water after-hours. In addition, without monitoring the duration of recovery, anesthetic dose cannot be titrated to effect which may result in prolonged anesthesia and recovery for a relatively brief procedure. As a result, plans for intra- and post-operative monitoring must be included in the IACUC protocol, and then practiced as written.

For **analgesic drugs**, doses and frequencies of administration are more difficult to gauge even with close clinical observation for discomfort. As a result, administration frequencies for analgesics are provided as strict guidelines supported by pain research in laboratory animal species or the standard of care in veterinary medicine. If an alternative regimen is desired, consultation with a veterinarian is required. A prime example of the importance of considering administration frequencies in analgesic use is the

consideration for overnight pain management. Most of the opioid analgesics (Buprenorphine, Fentanyl, Butorphenol, Oxymorphone, etc.) administered at 5:00 PM will not be effective at 8:00 AM the next morning. Thus, administration after typical business hours, use of extended release formulations, and/or trans-dermal patch can be considered depending on the species. Current longer-lasting non-steroidal anti-inflammatory analgesics (NSAIDs) [Meloxicam, Carprofen, Flunixin, Ketoprofen, etc.] analgesics have longer durations of action than opioids, and can be administered in conjunction with opioids to increase potency of effect and duration of action.

Independent of the analgesic drug(s) selected, the ideal administration regimen of analgesia includes pre-emptive (i.e. pre-surgical, pre-procedural) analgesic administration. This allows the analgesic to take effect prior to anesthesia so that the beneficial analgesic effects are experienced as the anesthesia is wearing off. This method of pre-emptive administration effectively prevents sensitization of pain sensory mechanisms which will prevent the "ramp-up" of pain sensation. Once ramp-up occurs, the threshold of pain stimulus is lowered thus requiring higher doses of analgesic for longer duration to control pain and discomfort as compared to an animal where analgesics were provided before the procedure. Prior administration can effectively be achieved by administering the analgesic regimen at least 30 min to 4 hrs prior to the potentially painful portion of the procedure.

In rodent species, historically, the use of analgesics such as Acetaminophen (Children's Tylenol® Elixir) and Ibuprofen (Children's Advil® Elixir) have been administered in the drinking water for post-surgical procedures. This was performed based on the assumption that continuous administration of drug by consumption in the water would provide a hands-off, stress-free, continuously-administered level of analgesic therapy. With continued investigation, it has been demonstrated that water and food consumption post-surgically and/or post-anesthesia are neither constant nor consistent (*5-9*). As a result, analgesics may not be consumed by the patient. "Confirmed administration" is encouraged by routes such as injection or oral/gastric gavage to insure that the patient receives the appropriate dose of medication to better manage discomfort.

Independent of the quality of design and integration of an anesthetic and analgesic plan into a research protocol, that plan is only as good as the skill and care with which it is applied. Training is available from the veterinary staff of the Office of Animal Resources through routinely scheduled classes or by request for all personnel that work with laboratory animals.

II. Drug Considerations

Inhalant agents: Isoflurane (Forane®, Iso, IsoFlo®)
Isoflurane is the first choice of anesthetic used for animal restraint or surgical procedures in laboratory animal species. Isoflurane is delivered via a nose-cone and inhaled in rodents or provided through an intratracheal tube in larger species. The concentration of drug can be administered to effect by adjusting the percent of displacement of O_2 with a precision vaporizer and compressed O_2. Maintenance anesthesia is typically between 1.5-3% Isoflurane. Induction of anesthesia with gas is typically achieved with < 2 min exposure to 3-5% Isoflurane.

Advantages: Rapid induction and recovery. A precision vaporizer provides the ability to precisely titrate the level of anesthesia during a procedure. Liquid Isoflurane is not a DEA controlled drug.

Disadvantages: Upfront cost associated with a precision vaporizer; requires either passive or active scavenging of waste and exhaled anesthetic gas; occupational health exposure to anesthetic gas should

be limited; prolonged analgesic effect is not achieved after the animal is awake; depressed respiratory rate and decreased blood pressure.

Additional Notes: Advantages typically outweigh disadvantages as gas anesthesia is the first recommendation for anesthetic administration due to rapid induction, recovery, and precise dose titration during the procedure. In addition, the duration of anesthesia can be easily adjusted for a variety of procedures ranging from 30 seconds up to many hours. To overcome cost and logistics, the OAR provides and maintains precision vaporizers with accompanying compressed O_2 for use while within the animal facilities. Concurrent use of analgesics such as opioids or NSAIDs is encouraged as Isoflurane has no analgesic properties once the animal is awake from the procedure. Occupational exposure is always a concern. Gas anesthesia must be vented from the room (table-top back-draft vents, biosafety cabinet [BSC] with 100% exhaust outside the building) or filtered through passive scavenging using activated charcoal canisters. Charcoal canisters must be weighed on a very regular basis and replaced before the canister gains the maximum allowed weight during use, which is listed on the canister.

Cyclohexamines: Ketamine (Ketoset®), Tiletamine

Ketamine is the most commonly used injectable anesthetic used in a variety of species. However, Ketamine used as the sole anesthetic is not recommended. In most cases, Ketamine is used in combination with other injectable agents such as α_2 agonists or benzodiazepines to reduce or eliminate many of the less desirable side effects if used alone. In rodents, Ketamine combined with Xylazine or Ketamine + Xylazine + Acepromazine are the preferred anesthetics when gas anesthesia cannot be used.

Advantages: Ketamine has a wide margin of safety in most species; residual analgesic effect following anesthetic recovery, most commonly used drug (in combination) for injectable anesthesia in rodents.

Disadvantages: Ketamine alone does not provide muscle relaxation and muscle spasms may be observed; DEA license required for use as Ketamine is a Class III controlled substance; surgical anesthesia may be limited depending on the species; prolonged recovery as compared to gas anesthetics (true for any injectable anesthesia)

Additional details about Ketamine combinations:

A) Ketamine + Xylazine or **Ketamine + Xylazine + Acepromazine**. Both or all 3 drugs can be mixed in a single syringe prior to administration. Ketamine + xylazine (with or without acepromazine) is the most common injectable anesthetic cocktail used in rodent species. In rodents, the addition of acepromazine to the ketamine/xylazine cocktail increases the depth of anesthesia and substantially prolongs the duration of anesthesia as well as recovery time (*10*). The benefit of adding acepromazine to the combination will be dependent on the duration of anesthesia needed for the procedure. If following the first injection of anesthetic the animal does not achieve the desired level of anesthesia, it is generally recommended to re-dose with 25% of the initial dose of the cocktail used. If after re-dosing, the animal still has a withdraw reflex (i.e. toe pinch present), re-dosing as second time increases the potential for surgical complications and death. It is recommended to consult with a veterinarian. If after an adequate surgical plain is achieved and withdraw response returns yet additional surgical time is needed, it is recommended to re-dosing with either 50% of the initial dose of ketamine only, or 25% of the initial ketamine + xylazine dose (*11*). It has been demonstrated that the anesthetist should wait for the return of a toe pinch reflex before administering additional anesthetics to avoid unacceptable mortality. It should be known that the duration of action of the α_2 agonist

(xylazine, Dexmedetomidine, etc.) is much longer than the duration of effect of ketamine. Acepromazine should never be re-dosed in rodents due to the long duration of effect.
B) Ketamine + Diazepam: Both drugs can be mixed in a single syringe prior to administration. Advantages include limited cardiovascular effects including minimal hypotension as compared to Ketamine/Xylazine combinations. However, in rodents, Ketamine/Diazepam only provides light anesthesia so it may only be appropriate for chemical restraint. As a result, this is a relatively infrequently used anesthetic option in rodents. However, this combination provides rapid induction of anesthesia in cats with favorable duration.
C) Tiletamine + Zolazepam (Telazol®): Tiletamine is a similar drug as Ketamine and is available already formulated with Zolazepam under the trade name Telazol®. In combination, Telazol® is very similar to the anesthetic combination of Ketamine and Diazepam. Primarily used in larger species such as cats and pigs. The primary advantage is that a smaller injection volume is needed to induce sedation/anesthesia. However, this drug combination is not considered safe for use in rabbits. Once Telazol® has been reconstituted, discard after 4 days if stored at room temperature or after 14 days if stored refrigerated.

Alpha-2 Agonists: Dexmedetomidine (Dexdomitor®), Xylazine (Rompun®)
Alpha-2 agonists are used for their sedative and analgesic properties in a variety of species. Used as the sole agent, they do not produce an adequate level of anesthesia for even minor surgical procedures. However, in combination with Ketamine, α_2-agonists become much more useful and effective as anesthetics for surgical procedures.

Advantages: Produces analgesia of short duration; can be combined with Ketamine to produce adequate surgical anesthesia in many species; effects can be reversed with a subcutaneous α_2 antagonists injection such as Atipamezole; not a DEA controlled drug; not irritating when administered IM or IP.

Disadvantages: Cardiovascular depression (decreased heart rate, cardiac output, and hypotension); transient hyperglycemia following administration which may have research significance; causes vomiting in cats.

Additional Notes: Dexmedetomidine vs. Medetomidine. The first generation medetomidine (Domitor®) contained two isomers of the compound, one active and one inactive. Through drug refinement, the company created the second generation formulation called Dexmedetomidine (Dexdomitor®) which contains only the active isomer of the drug. Because only the active form is present, it is considered twice as potent. Medetomidine (Domitor®) should no longer be available commercially. It has been suggested to re-calculate drug dose combinations that used medetomidine by dividing the medetomidine dose in half to provide the dose of dexmedetomidine, as it is twice as potent. However, published formulations of drug combinations have either not taken this advice or have reduced other drug dosages in these combinations to compensate for the increased potency of dexmedetomidine. We suggest using caution when re-tooling drug combinations with dexmedetomidine, starting with half the medetomidine dose when using dexmedetomidine, then working up if either anesthesia depth or duration are not adequate.

Alpha-2 Antagonists: Atipamezole (Antisedan®), Yohimbine
Alpha-2 antagonists are used as reversal agents for α_2 agonists. Administration at the end of a procedure where the anesthetic combination included Xylazine or Medetomidine, an α_2 antagonist will aid in reducing anesthesia time and prompting anesthetic recovery. Atipamezole is 200 - 300x more selective

for the α_2 receptor than Yohimbine. Thus, as a reversal agent, Atipamezole will provide a more rapid displacement of the α_2 agonist, providing a more rapid reversal than Yohimbine.

Advantages: Can reduce duration of sedation and anesthesia caused by α_2 agonist.

Disadvantage: Reverses any analgesic benefit of α_2 agonist; can cause muscle tremors, increased respiratory rate, and hyperemic mucous membranes; has no use as a stand-alone drug.

Additional Notes: Reversal is not required when using an α_2-agonist in an anesthetic combination but can be utilized in situations to reduce prolonged recovery times. Atipamezole (α_2 antagonist), was developed in conjunction with Medetomidine (α_2 agonist) so that 5 mg of Atipamezole is used to reverse 1 mg of Medetomidine (*12*). Due to the high specificity of Atipamezole for the α_2 receptor as compared to Xylazine, only 1 mg of Atipamezole is administered to reverse every 10 mg of Xylazine administered (*13*). Yohimbine is also an α_2 antagonist and can be used to reverse Xylazine at a standard dose of 0.2 mg/kg, independent of the Xylazine dose administered. While both are reversal agents for α2 agonists, the onset of reversal of Yohimbine is much longer than that of Atipamezole due to differences in selectivity of the α_2 receptor between the two drugs.

Table of alpha-2 antagonist reversal agents as referenced on previous page.

Alpha 2 Agonist Reversal (Xylazine and Dexmedetomidine)		
Atipamezole (Medetomidine Reversal)	5 mg for every 1 mg of Medetomidine, IM, SC	Reversal
Atipamezole (Xylazine Reversal)	1 mg for every 10 mg of Xylazine, IM, SC	Reversal
Yohimbine (Xylazine Reversal)	0.2 mg/kg, IM SC	Reversal

Benzodiazepines: Diazepam (Valium®), Midazolam, Zolazepam
This class of drug can provide marked sedation in a variety of species; however, there is no analgesic effect. Used alone, these drugs will not provide a true anesthetic state as awareness persists with relaxation even at high dosages. As a result, these drugs are primarily used as sedative, pre-anesthetics and the induction of anesthesia but are never used alone to provide or maintain anesthesia.

Additional Notes: Benzodiazepines are DEA Class IV controlled substances. Midazolam is favored over Diazepam because pharmaceutical grade preparations of Diazepam are formulated in a non-water soluble compounds that should only be administered intravenously. Midazolam is water-soluble and is provided in preparations where intramuscular injections are acceptable.

Barbiturates: Sodium Pentobarbital (Nembutal®), Methohexital, Thiopental
Barbiturates function as $GABA_A$ agonists and are considered to be good anesthetic agents but provide unreliable sedation at low dosages and inadequate analgesic effect at any dose. Pentobarbital, the most commonly used drug of this class, is considered a long acting anesthetic. Methohexital and Thiopental are considered short and ultra-short acting anesthetics and were more commonly used as induction agents in large animal species.

Advantages: Rapid anesthetic onset; provides a prolonged duration of surgical anesthesia; decades of use has characterized many research side effects; Pentobarbital is the active drug in manufactured euthanasia solutions (Euthasol®, Fatal-Plus®).

Disadvantages: Prolonged recovery time; inadequate analgesic properties; extremely expensive; narrow margin of safety; produces respiratory depression at higher dosages; non-rodent species may

experience a distressful anesthetic recovery; DEA License required for use as a Class II controlled substance.

Additional Notes: Sodium pentobarbital is the primary active ingredient in Fatal Plus®, Sleepaway®, Euthasol®, and VetOne Euthanasia Solution which are manufactured euthanasia solutions. In addition to pentobarbital, Euthasol® and VetOne Euthanasia Solution also contains the active ingredient phenytoin sodium, which is an antiepileptic drug which suppresses brain activity. All three products contain non-active ingredients include preservatives and coloring. The preservatives (benzyl alcohol, isopropyl or ethyl alcohol) are bacterial static, preventing bacterial growth. The added coloring (blue or pink [Rhodamine B]) aid in identifying the solution while in the syringe, preventing confusion and inadvertent euthanasia of animals. Pentobarbital administration at euthanasia dosages (2-3x anesthetic dose) initiates a rapid and deep anesthesia causing a dramatic decrease in blood pressure and blocking the respiratory centers in the brain stopping respiration, followed by halting of cardiac function. While pentobarbital sodium is the active ingredient in these solutions, the intent of these solutions is euthanasia only. These solutions are not to be diluted to provide deep anesthesia for recovery procedures or prolonged anesthesia for terminal procedures. They can be used at lower dosages if the procedure that is being performed is "seamlessly" leading to death such as in transcardial perfusion with fixation solution or tissue harvest (*14*). No unintended consequences have been reported on research results with the use of euthanasia solutions for euthanasia of research rodents or larger species. Due to the combination of drugs within euthanasia solutions they are considered DEA Class III controlled substance where sodium pentobarbital alone is a DEA Class II controlled drug.

Opioids: Buprenorphine (Buprenex®), Oxymorphone, Fentanyl, Morphine, Butorphanol
Opioid drugs produce their effect by binding three different receptors [mu (μ), kappa (κ), and delta (δ)] as either agonists, partial agonists or antagonists. The location of these receptors vary, but in general, reside within the brain and spinal cord.

Advantages: Provide potent analgesia; concurrent administration can lower the dose of inhalant or barbiturate general anesthetic for surgery; mechanism mediated by receptor binding in the brain and spinal cord; long history of use in research; reversible with Naloxone.

Disadvantages: DEA Controlled Class II-IV drugs; high potential for human abuse and addiction; relatively short duration of action; repeated use may result in tolerance development.

Additional Notes: Duration of effect has continuously hampered the use of opioids in research animals. In general, opioids are short acting drugs. The longest duration of effect by an injectable administration route is Buprenorphine which can provide analgesia for up to 12 hrs in some species. Transdermal patches have also been developed to provide longer duration of action up to approximately 3 days. However, these patches are physically limited to use in species larger than rabbits due to the size of the patches. Most recently, liposomal encapsulated opioids have been developed which are showing promise in providing 48-72 hrs duration of analgesia with one injection (Buprenorphine SR™) (*15, 16*).

Non-steroidal Anti-Inflammatory Drugs (NSAIDs): Carprofen (Rimadyl®), Meloxicam (Metacam®), Flunixin meglumine (Banamine®), Ketoprofen (Ketofen®), Ibuprofen (Advil®), Acetaminophen (Tylenol®)*

Members of this group represent 13 different classes of drugs which share inhibitory activity of the cyclooxygenase (COX) enzyme. The COX enzyme facilitates the production of Prostoglandin G_2 (PGG_2) which then follows a variety of enzymatic processes in the production of several compounds that are involved in normal physiological processes and production of Prostoglandin E_2 (PGE_2). PGE_2 specifically plays a role in the perception of pain in the periphery and within the central nervous system. Thus, blockade of PGE_2 by COX inhibition is effective in control of discomfort at the site of insult and within the central nervous system. Two forms of the COX enzyme have been well characterized (COX-1 and COX-2). As a result, COX inhibitors are often referenced as non-selective COX inhibitors or selective COX-2 inhibitors. This distinction has been made because inhibition of COX-2 is believed to be the predominant method of NSAID function to provide analgesia and anti-inflammatory action even though this "consensus" is still under debate. Over the past 10 years, several NSAIDs have emerged for veterinary use that are COX-2 selective, such as Carprofen and Meloxicam which can be administered once every 12-24 hours in most species.

Advantages: Newer drugs (Carprofen, Meloxicam) include a long duration of analgesic activity; newer drugs demonstrate analgesic quality that rivals some opioids; not a DEA controlled substance; there are multi-route administration methods for several NSAIDs; relative safety when administered at prescribed dosages.

Disadvantages: Contraindicated for inflammation models, infectious disease, or coagulation research due to anti-inflammatory properties; COX-1 side effects such as: gastrointestinal complications, prolonged coagulation times, and changes in kidney function with non-COX-2 selective forms.

Additional Notes: Analgesic combinations that include NSAIDs *plus* opioids would be considered an ideal combination for the control and prevention of discomfort due to the demonstrated harmony and difference in mechanism of action. In contrast, it is discouraged to combine multiple NSAIDs in combination or use NSAIDs in combination with steroids (Prednisone, Prednisolone, and Dexamethasone) as the incidence of complications increase. Oral dosing of analgesics following anesthesia results in questionable consumption of the drug due to decreased water consumption following anesthesia, as demonstrated in rodents. *For simplicity, acetaminophen is included here in the NSAID class, but is not technically an NSAID and works independently of COX-1 and COX-2.

NSAID Dilution for Small Mammals: Personal communication with Pfizer Animal Health indicates that dilution of Carprofen (Rimadyl®) with sterile saline has been reported in veterinary medicine for product dilution. However, the company cannot provide stability or other product details once diluted from the original concentration. It is the position of the CU Boulder Veterinary Staff that sterile saline diluted Carprofen is appropriate and once diluted should be stored refrigerated and disposed of after 30 days.

Example of Carprofen Dilution: Dilutions of Carprofen can be made in a 3-5 mL sterile Red-Top Vacutainer blood sample tube. Manufacturer stock concentration of small animal Carprofen is 50 mg/mL. The dose for rodents is typically 5 mg/kg. For mice, it is assumed that most will weigh approximately 25-30 grams. This can vary significantly between strains and with age. Dilute 0.1 mL of the manufacturer stock Carprofen (50 mg/mL) into 3.9 mL of sterile saline (0.9% NaCl). This will give you a diluted stock concentration of 1.25 mg/mL so that you would give approximately 0.1 mL per 25 g of body weight of each mouse.

Local Anesthetics: Lidocaine, Bupivacaine (Marcaine®), Ropivacaine (Naropin®), Proparacaine (Alcaine® Ophthalmic)

Local anesthetics block nerve impulses by specifically binding the voltage-gated Na^+ channel in the nerve cell membrane at the site of insult. Reversible drug binding stabilizes the ion channel preventing the transmission of action potentials, thus preventing nerve information transmission to the spine and brain. Local anesthetic routes of administration include topical to mucus membranes (nose, eye, etc.) or injected directly into the tissue that will be incised/cut and around nerve bundles that provide sensation to the surgical site. Administration of local anesthetics prior to the painful stimulus (eg. incision) would be considered an adjunct analgesic to opioid and NSAID analgesics. Use as the primary analgesic is discouraged due to the short duration of effect (hours).

Advantages: Pre-operative and intra-operative administration directly on or at the incision site can provide a good adjunct in pain relief to general anesthesia and systemic analgesics administered after a procedure. Drugs of this class are not controlled substances.

Disadvantages: Avoid administering by intramuscular and intravenous injections as both routes reach systemic circulation very rapidly. Signs of overdose or systemic toxicity include seizures and death. Dilution of stock concentration is encouraged to provide more accurate dose administration.

Additional Notes: For rodent use, dilute 1-2% Lidocaine to 0.5%, and 0.5% Bupivacaine to 0.25%, to allow for more accurate dosing and realistic volume to infuse at the incision site. [Note: 1% solution is equal to 10 mg/mL]. Ropivacaine requires no dilution prior to use. Lidocaine is a fast acting, short duration local anesthetics. Bupivacaine is a slow onset, long acting local anesthetic. When used in combination (Lidocaine plus Bupivacaine in the same syringe) the benefits of both drugs can be achieved, namely rapid onset with long duration of local anesthesia. In addition, the duration of efficacy of local anesthetics can be extended by the addition of epinephrine to the injected solution. Epinephrine causes local vasoconstriction of blood vessels in the area of the injection resulting in decreased systemic absorption leading to prolonged duration of action. Preparations of Lidocaine and Bupivacaine can be purchased pre-combined with epinephrine (1:200,000).

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Mouse Anesthetics and Analgesics

Modified 9/2016

Inhaled Anesthetic Drugs			
Agent	**Dosage**	**Route**	**Comments (*Ref.*)**
Isoflurane	Induction: 3-5% Maintenance: 1.5-3%	Inhaled Nose Cone	Administer via precision vaporizer & compressed O_2. Open-drop method with IACUC approval (*17, 18*).

Injectable Sedation Drugs/Combinations			
Agent(s)	**Dosage**	**Use**	**Comments (*Ref.*)**
Fentanyl	0.8 mg/kg, IP	Sedation	(*19*)
Ketamine | Medetomidine	50 | 0.5 mg/kg, IP	Sedation	(*20*)
Ketamine | Xylazine	50 | 10 mg/kg, IP	Sedation	(*21*)

Injectable Anesthetic Drugs/Combinations			
Agent(s)	**Dosage**	**Use**	**Comments (*Ref.*)**
Ketamine | Xylazine	80-100 | 7.5-16 mg/kg, IP IM	Anesthesia	(*1*)
Ketamine | Xylazine |Acepromazine	100 | 2.5 | 2.5 mg/kg, IP IM	Anesthesia	(*1, 10*)
Ketamine | Xylazine |Acepromazine	80 | 8 | 1 mg/kg, IP IM	Anesthesia	(*11*)
Ketamine | Medetomidine	75 | 1.0 mg/kg, SQ IP	Anesthesia	(*22*)
Pentobarbital (Nembutal)	50-90 mg/kg, IP	Anesthesia	(*1, 23*)
Propofol	12-26 mg/kg, IV	Anesthesia	(*1*)
Telazol®	7.5-45 mg/kg, IP IM	Anesthesia	(*23*)

Local Anesthetics			
Agent	**Dosage**	**Use**	**Comments (*Ref.*)**
Lidocaine (1-2%)	2-4 mg/kg (max 7 mg/kg), SQ	Local Block	Onset 5-10 min, Duration 0.5-1 hr (*24*)
Bupivacaine (0.5% Marcaine®)	1-2 mg/kg (max 8 mg/kg), SQ	Local Block	Onset 15-30 min, Duration 4-8 hrs (*24, 25*)
Ropivacaine (0.2% Naropin®)	1-2 mg/kg (max 8 mg/kg), SQ	Local Block	Onset 15-30 min, Duration 4-8 hrs (*24*)
Alpha 2 Agonist Reversal (Xylazine and Medetomidine)			
Agent	**Dosage**	**Use**	**Comments (*Ref.*)**
Yohimbine (Xylazine Reversal)	0.2 mg/kg, IM SC	Reversal	(*26*)
Atipamezole (Medetomidine Reversal)	5 mg for every 1 mg of Medetomidine, IM, SC	Reversal	(*22, 26*)
Atipamezole (Xylazine Reversal)	1 mg for every 10 mg of Xylazine IM, SC	Reversal	(*13, 26*)

Analgesics (Pain Relief)			
Opioid	**Dosage**	**DEA**	**Dosing Frequency (*Ref.*)**
Buprenorphine (Buprenex®)	0.05-0.2 mg/kg, SC IP	Yes	6-12 hrs (*1, 26-29*)
Buprenorphine SR™	0.5-1.0 mg/kg, SC	Yes	72 hrs (*15*)
Buprenorphine ER (Animalgesics®)	3.25 mg/kg, SC	Yes	48-72 hrs (*16*)
Oxymorphone	0.2-0.5 mg/kg, SC IP	Yes	4-6 hrs (*26*)
Fentanyl	0.05 mg/kg, IP	Yes	4-6 hrs (*1*)
NSAID Anti-Inflammatory Drug			
Carprofen (Rimadyl®)	5 mg/kg, SC IP	No	24 hrs (*1, 27*)
Meloxicam (Metacam®)	2 mg/kg, SC IP	No	24 hrs (*27, 30*)
Meloxicam SR™	4.0 mg/kg, SC	No	72 hrs
Ketoprofen (Ketofen®)	5 mg/kg, SC	No	12-24 hrs (*1, 27*)
NSAID (Water Dosing)			
Ibuprofen (Children's Advil® Elixir)*	40 mg/kg or 0.2 mg/mL, PO	No	Continuously (*5, 27*)
*** Initiate 24-48hrs before surgery to allow for acclimation** (*5-8*).			

Rat Anesthetics and Analgesics

Modified 9/2016

Inhaled Anesthetic Drugs			
Agent	**Dosage**	**Route**	**Comments (*Ref.*)**
Isoflurane	Induction: 3-5% Maintenance: 1.5-3%	Inhaled Nose Cone	Administer via precision vaporizer & compressed O_2. Open-drop method with IACUC approval (*17, 18*).

Injectable Anesthetic Drugs/Combinations			
Agent(s)	**Dosage**	**Use**	**Comments (*Ref.*)**
Ketamine | Xylazine	40-80 | 5-10 mg/kg, IP IM	Anesthesia	(*1, 27*)
Ketamine | Medetomidine	60-90 | 0.5 mg/kg, IP	Anesthesia	(*1, 27, 31*)
Pentobarbital (Nembutal)	30-60 mg/kg, IP	Anesthesia	(*1, 27*)
Propofol	10 mg/kg, IV	Anesthesia	(*1, 26*)
Telazol®	50-80 mg/kg, IP	Anesthesia	(*26*)

Local Anesthetics			
Agent	**Dosage**	**Use**	**Comments (*Ref.*)**
Lidocaine (1-2%)	2-4 mg/kg (max 7mg/kg), SQ	Local Block	Onset 5-10 min, Duration 0.5-1 hr (*24*)
Bupivacaine (0.5% Marcaine®)	1-2 mg/kg (max 8 mg/kg), SQ	Local Block	Onset 15-30 min, Duration 4-8 hrs (*24, 25*)
Ropivacaine (0.2% Naropin®)	1-2 mg/kg (max 8 mg/kg), SQ	Local Block	Onset 15-30 min, Duration 4-8 hrs (*24*)

Alpha 2 Agonist Reversal (Xylazine and Medetomidine)			
Agent	**Dosage**	**Use**	**Comments (*Ref.*)**
Yohimbine (Xylazine Reversal)	0.2 mg/kg, IM SC	Reversal	(*26*)
Atipamezole (Medetomidine Reversal)	5 mg for every 1 mg of Medetomidine, IM, SC	Reversal	(*26*)
Atipamezole (Xylazine Reversal)	1 mg for every 10 mg of Xylazine IM, SC	Reversal	(*13, 26*)

Analgesics (Pain Relief)			
Opioid	**Dosage**	**DEA**	**Dosing Frequency (*Ref.*)**
Buprenorphine (Buprenex®)	0.05-0.2 mg/kg, SC IP IV	Yes	6-12 hrs (*1, 26-28, 32*)
Buprenorphine SR	1.2 mg/kg, SC	Yes	72 hrs (*15*)
Buprenorphine ER (Animalgesics®)	0.65 mg/kg, SC	Yes	48-72 hrs
Oxymorphone	0.2-0.5 mg/kg, SC IM	Yes	4-6 hrs (*26*)
Fentanyl	0.05 mg/kg, IP IM	Yes	4-6 hrs (*1*)
NSAID Anti-Inflammatory Agent			
Carprofen (Rimadyl®)	5 mg/kg, SC IP	No	24 hrs (*1, 27*)
Meloxicam (Metacam®)	1-2 mg/kg, PO SC	No	24 hrs (*27*)
Meloxicam SR™	4.0 mg/kg, SC	No	72 hrs
Ketoprofen (Ketofen®)	5 mg/kg, SC	No	12-24 hrs (*27*)
NSAID (Water Dosing)			
Ibuprofen (Children's Advil® Elixir)*	40 mg/kg or 0.4 mg/mL, PO	No	Continuously (*27*)
Acetaminophen (Tylenol® Elixir)*	300 mg/kg or 2-4.5 mg/mL, PO	No	Continuously (*1, 23, 27*)
* Initiate 24-48hrs before surgery to allow for acclimation (5-8).			

Neonatal Rodent Anesthetics and Analgesics

Modified 9/2016

Inhaled Anesthetic Drugs			
Agent	**Dosage**	**Route**	**Comments (*Ref.*)**
Isoflurane	Induction: 3-5% Maintenance: 1.5-3%	Inhaled Nose Cone	Administer via precision vaporizer and compressed O_2. (*1*) Open-drop method with IACUC approval (*17, 18*).

Hypothermia

Hypothermia Method: Mouse and rats pups up to 6 days of age may be anesthetized by hypothermia when inhalant anesthetic is not feasible.

- Hypothermia induction: Place the pup in a latex/nitrile glove finger and immerse the glove finger in crushed ice and water (2-3°C or 35-37°F) up to the level of the head so that the head of the pup is visible. Anesthesia induction takes 5-8 minutes.
- Procedure: Remove the pup from the ice bath and place on a re-freezable ice pack. A piece of gauze or cloth should prevent direct contact of the pup's skin with the freezable ice pack. Duration of anesthesia on an ice pack is 15 minutes maximum.
- Hypothermia Recovery: Rapid warming should be avoided. Pups can be placed in a small incubator (32-35 °C or 90-95°F) for gradual warming over 20-30 minutes. Once warmed for this time, circulating warm water blankets can be used until mobile where complete recovery takes 30-60 minutes. Once mobile, pups may be mingled with the litter to aid in covering the procedure smells on the pup then the litter returned to the dam.

Comments (*Ref.*): (*1, 33-38*)

Injectable Anesthetic Drugs/Combinations			
Agent(s)	**Dosage**	**Use**	**Comments (*Ref.*)**
Ketamine | Xylazine	40-80 | 5-10 mg/kg, IP	Anesthesia	(*37*)
Pentobarbital	30-40 mg/kg, IP	Anesthesia	(*34*)
Comments: Injectable anesthetics in neonatal rodents is unpredictable and has a >50% rate of mortality (*34*). Use of injectable anesthetics should only be considered in neonates >6 days of age and where gas anesthesia is not feasible.			

Analgesics (Pain Relief)			
Opioid	**Dosage**	**DEA**	**Dosing Frequency (*Ref.*)**
Morphine	5-10 mg/kg, SC	Yes	6 hrs (*37*)
Buprenorphine (Buprenex®)	0.05-0.2 mg/kg, SC IP	Yes	6-8 hrs (*37*)
Fentanyl	0.05 mg/kg, IP	Yes	4 hrs (*39*)

Guinea Pigs Anesthetics and Analgesics

Modified 2-6-2012

Inhaled Anesthetic Drugs			
Agent	**Dosage**	**Route**	**Comments (*Ref.*)**
Isoflurane	Induction: 3-5% Maintenance: 1.5-3%	Inhaled Nose Cone	Administer via precision vaporizer & compressed O_2.

Injectable Sedation for Induction Drugs/Combinations			
Agent	**Dosage**	**Use**	**Comments (*Ref.*)**
Acepromazine	0.5-1.5 mg/kg IM 2.5-5 mg/kg IP	Sedation	(*26, 27*) (*1*)
Ketamine	20-120 mg/kg IM	Sedation	Wide safety margin (*1, 27*)

Injectable Anesthetics Combinations			
Agent(s)	**Dosage**	**Use**	**Comments (*Ref.*)**
Ketamine | Acepromazine	20-40 | 0.5 mg/kg, IM IP	Anesthesia	(*26, 27*)
Ketamine | Xylazine	20-40 | 2 mg/kg, IM IP 87 | 13 mg/kg, IM IP	Anesthesia	Non-surgical (*1, 27*) Surgical (*1*)
Ketamine | Medetomidine	40 | 0.25-0.5 mg/kg, IM	Anesthesia	20-30 min duration (*27*)
Ketamine | Diazepam	20-40 | 2-3 mg/kg, IM IP	Anesthesia	(*26, 27*)
Fentanyl | Diazepam	1.0 mg/kg, IM | 5 mg/kg, IP	Anesthesia	Minor surgical event (*1*)
Telazol®	20-40 mg/kg, IM IP	Anesthesia	(*26*)
Pentobarbital	15-40 mg/kg, IP	Anesthesia	(*23, 26, 27*)

Local Anesthetics			
Agent	**Dosage**	**Use**	**Comments (*Ref.*)**
Lidocaine (1-2%)	2-4 mg/kg, SQ	Local Block	Onset 5-10 min, Duration 0.5-1 hr (*24*)
Bupivacaine (0.5% Marcaine®)	1-2 mg/kg, SQ	Local Block	Onset 15-30 min, Duration 4-8 hrs (*24, 25*)
Ropivacaine (0.2% Naropin®)	1-2 mg/kg, SQ	Local Block	Onset 15-30 min, Duration 4-8 hrs (*24*)

Alpha 2 Agonist Reversal (Xylazine and Medetomidine)			
Agent	**Dosage**	**Use**	**Comments (*Ref.*)**
Yohimbine (Xylazine Reversal)	0.2 mg/kg, IM SC	Reversal	(*27*)
Atipamezole (Medetomidine Reversal)	5 mg for every 1 mg of Medetomidine, IM, SC	Reversal	(*12*)
Atipamezole (Xylazine Reversal)	1 mg for every 10 mg of Xylazine IM, SC	Reversal	(*13*)

Analgesics (Pain Relief)			
Opioid	**Dosage**	**DEA**	**Dosing Frequency (*Ref.*)**
Oxymorphone	0.2-0.5 mg/kg, SC IM IP	Yes	6-12 hrs (*26, 27*)
Buprenorphine (Buprenex®)	0.05 mg/kg, SC IM IP	Yes	8-12 hrs (*26, 27*)
Butorphanol	0.4-2 mg/kg, SC IM IP	Yes	4-12 hrs (*26, 27*)
NSAID Anti-Inflammatory Drug			
Meloxicam (Metacam®)	0.5 mg/kg, PO, SC	No	24 hrs (*1*)
Carprofen (Rimadyl®)	1-4 mg/kg, PO, SC	No	24 hrs (*27*)
Flunixin (Banamine®)	2.5 mg/kg, IM	No	12-24 hrs (*26*)
Ketoprofen (Ketofen®)	1 mg/kg, SC IM	No	12-24 hrs (*27*)
NSAID Agent (Water Dosing)			
Ibuprofen (Children's Advil® Elixir)	10 mg/kg, PO in water	No	4 hrs (*27*)

Gerbil Anesthetics and Analgesics

Modified 6-12-2012

Inhaled Anesthetic Drugs			
Agent	**Dosage**	**Route**	**Comments (*Ref.*)**
Isoflurane	Induction: 3-5% Maintenance: 1.5-3%	Inhaled Nose Cone	Administer via precision vaporizer & compressed O_2.

Injectable Sedation for Induction Drugs/Combinations			
Agent	**Dosage**	**Use**	**Comments (*Ref.*)**
Xylazine	5-10 mg/kg, SC IM	Sedation	(*26*)
Medetomidine	0.05-0.2 mg/kg, SC	Sedation	(*27*)
Diazepam	3-5 mg/kg, SC IM	Sedation	(*26*)
Midazolam	1-3 mg/kg, SC IM	Sedation	(*26, 27*)

Injectable Anesthetics Combinations			
Agent(s)	**Dosage**	**Use**	**Comments (*Ref.*)**
Ketamine | Xylazine	50-70 | 2-5 mg/kg, SC IM IP	Anesthesia	(*26, 27*)
Ketamine | Medetomidine	75 | 0.25-0.5, SC IM IP	Anesthesia	(*1*)
Telazol®	50-80 mg/kg, IM IP	Anesthesia	(*1, 26*)
Pentobarbital	60 mg/kg, IP	Anesthesia	(*26*)

Local Anesthetics			
Agent	**Dosage**	**Use**	**Comments (*Ref.*)**
Lidocaine (1-2%)	2-4 mg/kg, SQ	Local Block	Onset 5-10 min, Duration 0.5-1 hr (*24*)
Bupivacaine (0.5% Marcaine®)	1-2 mg/kg, SQ	Local Block	Onset 15-30 min, Duration 4-8 hrs (*24, 25*)
Ropivacaine (0.2% Naropin®)	1-2 mg/kg, SQ	Local Block	Onset 15-30 min, Duration 4-8 hrs (*24*)

Alpha 2 Agonist Reversal (Xylazine and Medetomidine)			
Agent	**Dosage**	**Use**	**Comments (*Ref.*)**
Yohimbine (Xylazine Reversal)	0.2 mg/kg, IM SC	Reversal	(*26*)
Atipamezole (Medetomidine Reversal)	5 mg for every 1 mg of Medetomidine, IM, SC	Reversal	(*26*)
Atipamezole (Xylazine Reversal)	1 mg for every 10 mg of Xylazine IM, SC	Reversal	(*13, 26*)

Analgesics (Pain Relief)			
Opioid	**Dosage**	**DEA**	**Dosing Frequency (*Ref.*)**
Buprenorphine (Buprenex®)	0.05-0.2 mg/kg, SC IM IP	Yes	8-12 hrs (*26, 27*)
Oxymorphone	0.2-0.5 mg/kg, SC IM IP	Yes	6-12 hrs (*26, 27*)
Butorphanol	1-5 mg/kg, SC IM IP	Yes	2-4 hrs (*26, 27*)
NSAID Anti-Inflammatory Drug			
Meloxicam (Metacam®)	1-2 mg/kg, SC	No	24 hrs (*27*)
Carprofen (Rimadyl®)	5 mg/kg, SC	No	24 hrs (*27*)
Flunixin (Banamine®)	2.5 mg/kg, SC	No	12-24 hrs (*26, 27*)
Ketoprofen (Ketofen®)	5 mg/kg, SC	No	12-24 hrs (*27*)
NSAID (Water Dosing)			
Ibuprofen (Children's Advil Elixir)**	2-4.5 mg/mL drinking water, PO	No	Given in water bottle (*27*)
Acetaminophen (Children's Tylenol Elixir)**	7.5 mg/kg PO	No	Given in water bottle (*26*)
** Due to limited water consumption by this species, please seek veterinary consultation of administration of analgesics in the water to gerbils.			

Rabbit Anesthetics and Analgesics

Modified 6-2-2016

Inhaled Anesthetic Drugs			
Agent	**Dosage**	**Route**	**Comments (*Ref.*)**
Isoflurane	Induction: 3-5% Maintenance: 1.5-3%	Inhaled ±Nose Cone ±Intubation	Administer via precision vaporizer & compressed O_2.

Injectable Sedation for Induction Drugs/Combinations			
Agent(s)	**Dosage**	**Use**	**Comments (*Ref.*)**
Acepromazine	0.25-1.0 mg/kg, IM	Pre-med	(*1, 26, 27*)
Xylazine	1-5 mg/kg, IM, SC	Pre-med	(*26*)
Medetomidine	0.25 mg/kg, IM	Pre-med	(*27*)
Diazepam	1-5 mg/kg, IM	Pre-med	(*26*)
Midazolam	1-2 mg/kg, IM	Pre-med	(*26*)
Propofol	5-8 mg/kg, IV	Induction	(*26*)

Injectable Anesthetics Combinations			
Agent(s)	**Dosage**	**Use**	**Comments (*Ref.*)**
Ketamine | Xylazine	25-35 | 5 mg/kg, IM SC	Anesthesia	(*1, 26, 27*)
Ketamine | Medetomidine	15-35 | 0.25-0.5 mg/kg, IM SC	Anesthesia	(*1, 26, 41, 42*)
Ketamine | Diazepam	20-40 | 1-5 mg/kg, IM SC	Anesthesia	(*26*)
Pentobarbital	20-40 mg/kg IV	Anesthesia	(*1, 26*)

Local Anesthetics			
Agent	**Dosage**	**Use**	**Comments (*Ref.*)**
Lidocaine (1-2%)	2-4 mg/kg, SQ	Local Block	Onset 5-10 min, Duration 0.5-1 hr (*24*)
Bupivacaine (0.5% Marcaine)	1-2 mg/kg, SQ	Local Block	Onset 15-30 min, Duration 4-8 hrs (*24, 25, 43*)
Ropivacaine (0.2% Naropin)	1-2 mg/kg, SQ	Local Block	Onset 15-30 min, Duration 4-8 hrs (*24*)

Alpha 2 Agonist Reversal (Xylazine and Medetomidine)			
Yohimbine (Xylazine Reversal)	0.2 mg/kg, IM SC	Reversal	(*26*)
Atipamezole (Medetomidine Reversal)	5 mg for every 1 mg of Medetomidine, IM, SC	Reversal	(*26, 41*)
Atipamezole (Xylazine Reversal)	1 mg for every 10 mg of Xylazine IM, SC	Reversal	(*13, 26*)

Analgesics (Pain Relief)			
Opioid	**Dosage**	**DEA**	**Dosing Frequency (*Ref.*)**
Fentanyl Trans-Dermal Patch	½ of 25 mcg/hr per 3 kg body wt.	Yes	72 hrs. Apply patch 24 hrs prior to surgery. (*12, 27, 44*)
Oxymorphone	0.05-0.2 mg/kg IM SC	Yes	8-12 hrs (*26*)
Fentanyl	0.005-0.02 mg/kg IV	Yes	0.5-1 hrs (*12, 27*)
Buprenorphine (Buprenex®)	0.01-0.05 mg/kg IM SC IV	Yes	8-12 hrs (*1, 26, 27*)
Buprenorphine SR Lab	0.15 mg/kg SC	Yes	72 hrs
Butorphanol	0.1-0.5 mg/kg IM SC IV	Yes	4-6 hrs (*1, 27*)
NSAID Anti-Inflammatory Drug			
Meloxicam (Metacam®)	0.3 mg/kg PO SC	No	24 hrs (*1, 45*)
Carprofen (Rimadyl®)	4 mg/kg SC 1-2.2 mg/kg PO	No	24 hrs (*27*) 12 hrs (*27*)
Flunixin (Banamine®)	1.0 mg/kg IM SC	No	12-24 hrs. Do not administer for longer than 3 days (*1, 26*)
NSAID Agent (Water Dosing)			
Ibuprofen (Children's Advil® Elixir)	7.5 mg/kg PO	No	Given in water bottle (*26*)

Non-Pharmaceutical Grade Anesthetics

[Use Requires Scientific Justification and IACUC Approval]

Modified 5-7-2014

Mice

Non-Pharmaceutical Grade Injectable Anesthetics			
Agent	**Dosage**	**Use**	**Comments (*Ref.*)**
Tribromoethanol (TBE) †	300 mg/kg, IP	Anesthesia	(*1, 23*)
Pentobarbital ††	50-90 mg/kg, IP	Anesthesia	(*14*)
Choral Hydrate	370-400 mg/kg, IP	Anesthesia	(*1, 23*)
Alpha Chloralose	114 mg/kg, IP	Anesthesia	5% solution (*1, 23*)
EMTU (Inactin)	80 mg/kg, IP	Anesthesia	(*23*)
Ethyl Carbamate (Urethane)	1.25-2.5 g/kg, IP	Anesthesia	Carcinogen. Not to be used for survival surgical procedures (*21*)

Rats

Agent	**Dosage**	**Use**	**Comments (*Ref.*)**
Tribromoethanol (TBE) †	300 mg/kg, IP	Anesthesia	(*23*)
Pentobarbital ††	30-60 mg/kg, IP	Anesthesia	(*14*)
Choral Hydrate	300-450 mg/kg, IP	Anesthesia	4-5% solution (*1, 23, 69*)
Alpha Chloralose	55-65 mg/kg, IP	Anesthesia	(*1, 23, 69*)
EMTU (Inactin)	80-100 mg/kg, IP	Anesthesia	(*23, 69*)
Ethyl Carbamate (Urethane)	1-1.5 g/kg, IP	Anesthesia	Carcinogen. Not to be used for survival surgical procedures (*1, 23*)

Prior to the selection of a non-pharmaceutical grade anesthetic to be used as the primary anesthetic for an experimental procedure, please review the CU Boulder IACUC Policy Use for Non-Pharmaceutical Grade Chemicals/Compounds. The document will provide guidance in establishing scientific justification for the use of a non-pharmaceutical grade drug where other pharmaceutical grade drugs exist for the same or similar purpose.

† The use of Tribromoethanol (TBE) is restricted by the CU Boulder IACUC because a pharmaceutical grade preparation of the drug is no longer available where other pharmaceutical anesthetics do exist that can fulfill the same purpose. Please refer to the IACUC approved procedure for the preparation, storage, use and disposal of TBE in the CU Boulder IACUC Policies.

†† Recent exorbitant cost increases of pharmaceutical grade pentobarbital have placed it logistically into the unavailable category. However, pharmaceutical grade Nembutal® may still be found and purchased at times. This section refers to the purchase of reagent grade power for the production of stock solution.

The internet link for CU Boulder IACUC page is: http://www.colorado.edu/vcr/iacuc

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