MUST HAVES:
Favorite Anesthesia And Analgesia Drugs, Gadgets And Techniques

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These are a few of my favorite things. Some you will have, some you won't, some might surprise you. The list encompasses equipment, drugs and techniques.

These are a few of my favorite things:

Esophageal stethoscopes to hear the heart beating
Lots of nice warm things for dog & cat heating
Analgesic infusions made of ketamine
These are a few of my favorite things

When the cat's cold
When a wound stings
When the heart is slow
I grab the most effective of favorite things
And then back to work I go

(apologies to Rodgers-Hammerstien and Julie Andrews)

Equipment and 'Stuff'

Esophageal stethoscope

One of the least expensive pieces of equipment you can buy. More accurate for counting heart rate than the ECG monitor (sometimes the monitor doesn't know which spikes to count on the ECG tracing) and more useful for indicating that the heart is actually beating (because sound = contraction/flow) than the ECG (electrical activity can occur without any cardiac function☹).
Advantages: EASY, cheap. Can hook up to a speaker so everyone in the room can help monitor the patient☺.
Disadvantages: MIGHT cause reflux esophagitis if inserted into the stomach; patient could bite it off if not removed before the patient wakes up.
TIP: To avoid inserting through the cardiac sphincter and into the stomach, measure the appropriate insertion distance by placing the esophageal stethoscope alongside the patient's head and neck with the tip of the stethoscope at the level of the olecranon. Place a piece of tape on the stethoscope that corresponds to the level of the canine teeth with the stethoscope in that position and then insert into the esophagus and stop when the tape reaches the canine teeth.
Source: Multiple companies

'Pop-Off' occlusion valve (or 'occlusion button')

Instead of completely closing the pop-off (or 'pressure relief') valve to give the patient a breath, just push this button for temporary closure of the valve. When you release the pressure on the button, the valve is automatically open. This prevents accidental prolonged closure of the valve – which can cause rapid pressurization of the breathing system and patient's the airway. Over-pressurization can cause cardiovascular collapse, pulmonary barotrauma, and death in a very short time (minutes).

Advantages: EASY, cheap. Can help to prevent a problem with dire consequences

Disadvantages: Takes two hands to give a patient a breath (small price to pay for safety); some models supposedly leak inhalant anesthetic (might be due to failure to close all the way).

Source: Multiple companies, eg, Surgivet and JD Medical.

ANYTHING to prevent hypothermia!!!

Hypothermia develops rapidly in patients under anesthesia and causes a variety of complications including clotting dysfunction, increased risk of infection, tissue hypoxia, acidosis, abnormal cardiac electrical conduction, myocardial ischemia, etc... (Noble 2006). Hypothermia also causes cerebral effects that decrease the patient's anesthetic needs. Unfortunately, the decreased anesthetic need is not always recognized and the delivery of anesthesia is not changed, resulting in an overdosage of anesthetic drugs. Although shivering in recovery may increase the body temperature, the intensive muscle movements associated with shivering causes discomfort and increases oxygen consumption by as much as 200% (Sessler 2002). In fact, in human medicine, an active area of research centers on prevention of shivering in the postoperative period. Finally - and importantly - hypothermia is the main cause of prolonged recoveries from anesthesia, and most anesthetic deaths occur in recovery.

Baja Silver Heat Products

These little 'blankets' are made from a 'special, aluminum-coated reflective nonwoven material that bounces up to 80% of your patient's radiant heat loss back towards the animal, providing what we like to call *"patient-powered" warming'* (quoted from Baja website).

Advantages: Easy to use; can use in places where you can't plug in a warming blanket; really help maintain body temperature!

Disadvantage: Also need active warming devices for most patients.

TIP: Start warming as soon as patient is induced. Body temperature starts dropping (quickly!) at induction since muscles relax (muscle activity helps produce body heat) and the thermoregulatory system is 'anesthetized' along with the patient.

Source: Animal Hospital Supply (animalhospitalsupply.com). Baja also makes a warm air blower especially for veterinary patients ☺. It is a lot cheaper than the Bair Hugger (which is not manufactured by a veterinary company☹).

Adapters for end-tidal carbon dioxide ($ETCO_2$) monitoring in small patients

The side-stream $ETCO_2$ monitor often underestimates the true end-tidal CO_2 value in small patients with high respiratory rates and low tidal volumes. By sampling lower in the airway, a more accurate value can be obtained.

Advantages: EASY, cheap. Improves accuracy of respiratory monitoring.
Disadvantages: You have to make the adapter so it is a little work;-). Occupies space in the ET tube so not recommended in REALLY small patients (anything that would need a size 3 or less ET tube).
Source: You☺.
TIP: Make this little tool by placing a urinary catheter down into the endotracheal tube (not beyond the tip of the endotracheal tube!) and sample gases from the catheter.
TIP: Another alternative is to use mainstream $ETCO_2$ monitors, which are more expensive and more likely to be damaged (because the sensor must be placed between the patient and the breathing system with each patient, rather than never handled because the sensor is in the machine [side stream monitors]) but will provide a more accurate $ETCO_2$ reading in most patients. Mainstream monitors also increase deadspace and cause some rebreathing of exhaled gases. But they are excellent $ETCO_2$ monitors!

Masimo pulse oximeters

These pulse oximeters perform better than most other pulse oximeters in low flow situations (hypothermia, shock) and in small patients. Also useful is the pleth variability index (PVI), which can be used to guide fluid therapy in many hypovolemic patients (example of fluid therapy: http://www.masimo.com/pdf/clinical/pvi/Follin%20Assessment%20of%20the%20Pleth%20Variability%20Index%20ESA%202013.pdf)
Advantages: More likely to get a reading in low flow and small patients and can use to guide fluid therapy.
Disadvantage: Expensive when compared to other pulse oximeters (but not necessarily expensive when compared to other monitors)
TIP: Patients with high PVI variability are more likely to respond to fluid boluses than those with low variability (variability values are 1-100).
Source: Massimo manufactures them but multiple companies carry them.

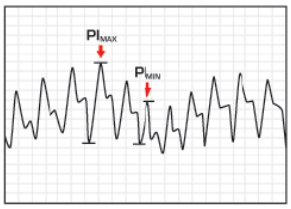


Diagram showing variability in pulse pressure during ventilation. From www.masimo.com

Other stuff I like

Foam hair curlers as cat mouth gags

We don't use mouth gags for anesthesia but, of course, mouth gags are commonly used in anesthetized patients. Unfortunately, opening the mouth of a cat too wide causes decreased blood flow in the maxillary arteries (Martin-Flores et al. Vet J. 2014 Apr;200(1):60-4), which are the main blood source for the retinae and brain in the cat. The decreased blood flow secondary to mouth gag use has been implicated in blindness and neurologic deficits. These deficits may resolve, but may be permanent and may result in euthanasia (Stiles et al. Vet J. 2012;193(2): 367-73).

Advantages: CHEAP! Doesn't force the mouth open excessively wide.

Disadvantages: May not open the mouth wide enough for some procedures in the caudal oral cavity. Can still open the mouth wider – but don't leave it that way too long!

TIP: Curlers can be rinsed off and re-used but just throw them away if the cat's mouth is particularly nasty or if the cat has any communicable disease. They are cheap!

Source: Any place that sells foam curlers!

IV fluid drip counters

If you don't have enough infusion pumps, get a drip counter! These are cheaper than pumps but still allow more accurate fluid dosing. Especially useful in anesthesia when a pump isn't really necessary (since the patient is unlikely to draw its leg back and stop the fluid flow into the vein) but fluid rate is critical to avoid over- or under-hydration.

Advantages: Cheap, increases accuracy of fluid dosing.

Disadvantages: Doesn't function as a pump (which it isn't supposed to do but if you need a pump, this isn't it).

Source: There are several types and several companies that sell these. My favorite is 'Drip Assist' at http://www.hallowell.com/index.php?pr=z000A2773

Syringe pumps or other volume-limiting devices

I use these for administration of drugs (analgesic CRIs, dopamine, etc…) but just as often use them for delivery of IV fluids to cats and really small dogs. A great way to avoid under- or over-hydration (the latter is a fairly common problem in really small patients). Over-hydration can lead to edema in a variety of tissues, most notably pulmonary edema.

Advantages: EASY to titrate drugs and fluids at an accurate dose.

Disadvanges: Some pumps are expensive; you have to learn to program them – which isn't all that hard but is something else to learn.

TIP: Have the technicians learn to program the pump and pretend you don't know how so that you don't have to do it;-). The technicians will be the ones using it most often anyway☺.

TIP: If you don't want syringe pumps, use buretrols (or any other fluid limiting device) when administering fluids to really small patients. OR, my favorite, just pull up the amount of fluid that the patient needs over the expected surgery duration into a syringe and have the anesthetist titrate it in a couple of mls at a time while they are monitoring the patient. Not a continuous method of delivery but close enough to continuous, and avoids overhydration. So for example, a 3 kg cat that needs 5 ml/kg/hour IV fluids that will be anesthetized for 2 hours, we draw up 3 kg x 5 ml/kg/hr x 2 hours = 30 mls of fluid into a syringe.

Source: Multiple companies

Hallowell ventilators

Not all practices need ventilators but if you have a high surgical caseload, especially if the caseload includes geriatric or sick/compromised patients that might not breathe normally during anesthesia (or if you just like ventilators!), your practice might benefit from a ventilator. Ventilators take the place of a person breathing for the animal (assuming that the patient isn't breathing well on its own), allowing the person more time to monitor and support (eg, changing fluid rates, providing analgesia, etc…) the patient. My favorite ventilator company is Hallowell, who makes ventilators especially for veterinary patients☺. The ventilators come with interchangeable bellows so that you can ventilate patients of a wide variety of body sizes with one unit. And the customer service is excellent!

Advantages: Ventilators can normalize respiratory function in anesthetized patients and decrease the workload of the anesthetist.

Disadvantages: Moderately expensive, need to learn how to use them (which isn't very hard).

Source: Hallowell at www.hallowell.com

Drugs and Techniques

Dopamine

Our patient population has changed over the last several decades from predominately young and healthy to more and more often aged or sick. These patients are more likely to experience adverse effects during anesthesia and one of the most common of those effects is hypotension. Of all of the drugs we use, the inhalants are one of the biggest contributors to hypotension. Fortunately, the effects are often dose-dependent so decreasing the anesthetic concentration generally improves blood pressure – at least in young, healthy patients. Older patients or patients with some concurrent diseases may be more susceptible to the inhalant-induced decrease in myocardial contractility, or may have disease that decreases contractility. In these patients, a positive inotropic drug like dopamine (or dobutamine) is the most effective and rapid way to improve blood pressure.

Advantages: CHEAP, effective, easy to administer as an infusion.

Disadvantages: You have to make an infusion.

Source: Most pharmacies and distributors.

TIP: See infusion guidelines at the end of this document.

Ketamine

Of course ketamine is an old drug (over 50 years old!) and you probably already have it, but are you using it as a constant rate infusion (CRI)?

Painful impulses cause N-methyl-D-aspartate (NMDA) receptors (among others) in the dorsal horn of the spinal cord to depolarize and prolonged depolarization of these receptors can lead to an amplification of the pain stimulus, resulting in what we commonly refer to as central

sensitization, 'wind-up' or 'hypersenstization'. When this occurs, the patient may feel more pain than expected (hyperalgesia) or even feel pain in response to a non-painful stimulus (allodynia). By administering drugs that antagonize these receptors (like ketamine), we are able to alleviate this exaggerated response and make the pain easier to control. Ketamine is the NMDA-receptor antagonist most commonly used in veterinary medicine and NMDA receptor antagonist effects are achieved when ketamine is used as a low-dose CRI. A single high-dose bolus of ketamine (eg, like the anesthetic induction dose) can serve as a loading dose for a CRI but is unlikely to provide analgesia when used alone. Furthermore, the NMDA receptor antagonists strictly mediate hypersensitivity and do not provide true analgesia, thus, these drugs must be administered in conjunction with true analgesic drugs (eg, opioids or NSAIDs).

Advantages: CHEAP! Easy to use as an infusion, treats pain in a very unique way so great part of multimodal analgesia.
Disadvantages: Can cause dysphoria if the dose is too high; controlled drug – which is really just something to remember, not a disadvantage.
Source: Multiple companies
TIP: See dosing charts at the end of this document.

Lidocaine
Another oldie but goodie that you already have! But, again, are you using it as a constant rate infusion?

Lidocaine can be administered systemically to provide analgesia. In addition to pain relief, lidocaine CRIs are anti-inflammatory, antiarrhythmic and improve postoperative GI function (proven in humans and horses – work still to be done in dogs and cats). The mechanism of action of systemic lidocaine is not entirely clear. Proposed mechanisms include blockade of sodium channels or potassium currents in the dorsal horn of the spinal cord and direct inhibition of abnormal electrical charges from injured or inflamed peripheral nerves.

Lidocaine CRIs are extremely useful in dogs but are somewhat controversial in cats because: 1) cats appear to be more sensitive to the lidocaine-induced side effects than other species are, and 2) there is evidence that lidocaine may cause excessive cardiovascular depression in cats. Point 1 is potentially (although not unequivocally) true and a lower dosage of lidocaine is recommended for cats than is recommended for dogs. Point 2 is most commonly reported in anesthetized cats and the cardiovascular depression could result from a physiologic interaction between lidocaine and anesthetic agents. Also, some argue that lidocaine CRI has been used successfully for anti-arrhythmic therapy in cats without undue cardiovascular depression and should be appropriate for analgesia, especially since the dose for analgesic therapy is actually on the low end of the dose used for anti-arrhythmic therapy. Because of the uncertainty of lidocaine effects in cats, some veterinarians feel that lidocaine CRI is not warranted in the cat at all while others feel that it is an appropriate means to treat pain, especially in patients where other options may be limited. If lidocaine CRI is chosen, using low dosages in conscious cats (ie, not under anesthesia) is recommended. Lidocaine CRIs are commonly used in dogs, especially in

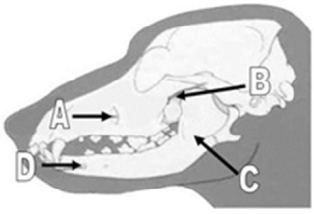
dogs with gastro-intestinal pain (eg, pain from exploratory laparotomy, gastric dilatation-volvulus [GDV], pancreatitis, parvovirus, etc…).

Advantages: CHEAP! Easy to use as an infusion; treats pain, improves GI motility, etc…
Disadvantages: None – unless you overdose it (which is true of every drug!)
Source: Multiple companies
TIP: See dosing charts at the end of this document.

Local/regional blocks
If you aren't doing local/regional analgesia, you are missing out on one of the best (but cheap!) analgesic modalities.
Advantages: GREAT analgesia, easy, cheap, decreases chance of central sensitization
Disadvantages: Few adverse effects
Some of my favorites: Testicular block, caudal maxillary block, epidurals (lumbosacral and sacro-coccygeal)

- Testicular block
  - Isolate the body of the testicles
  - Inject lidocaine or bupivacaine into the body of the testicle until you feel 'pressure'.
    - The drug will migrate up spermatic cord.
  - The dose will be volume limited due to the size of the testicular tissue
    - Calculate 1 mg/kg bupivacaine or 4 mg/kg lidocaine and the volume that will 'fit' is about ½ of the calculated volume
    - This will generally be 1/4 - 2 ml per testicle in dogs and cats
  - For incision directly over testicle (cats), continue infiltrating as the needle exits the testicular body to block the skin and subcutaneous tissue.
  - For incision in other location (dogs), inject local anesthetic in skin and subcutaneous tissue at site of incision.

- Caudal Maxillary Block



  - Insert the needle percutaneously along the ventral border of the zygomatic process approximately 0.5 cm caudal to the lateral canthus of the eye (needle B in diagram; used with permission from Pfizer Animal Health). The needle is directed medially and slightly cranially (in an angle that would draw an imaginary line with the premolars on the opposite side of the head) until it hits bone. At this site, the maxillary nerve enters the pterygopalatine fossa. Aspirate and slowly inject 0.1-1.0 mls local anesthetic.
  - An alternate technique is to approach the pterygopalatine fossa from the ventral margin of the orbit or from inside the mouth just caudal and medial to the last molar.
  - A second alternate technique is to approach the pterygopalatine fossa from the bony orbit. The needle would be placed at the midpoint of the ventral rim of the bony orbit and inserted straight down between the globe and the bone.

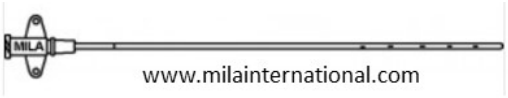
- *Lumbosacral epidural analgesia*
  - **Opioids** are most commonly used but local anesthetic drugs can be used in conjunction with opioids.

        - 0.1 mg/kg morphine (preservative-free is gold standard but morphine with preservative is commonly used in veterinary medicine)
        - Dilute to 1 ml/4.5 kg with bupivacaine, sterile saline or sterile water
    - Provides up to 24 hours of analgesia with little to no systemic effects. The opioids will cause sensory blockade but will not cause motor blockade. The local anesthetics can cause motor blockade, however, the motor effects are generally minimal or absent by the time the patient recovers from anesthesia to the point that it is ambulatory.
    - Consider for any pain in caudal half of patient. Examples include, rear limb soft tissue or orthopedic surgery, abdominal exploratory and bladder surgeries, surgeries on the tail or perineal region, etc…
    - Technique:
        - Place the anesthetized patient in sternal or lateral recumbency
            - Legs can be placed forward or to the back. I prefer forward in cats and small dogs.
        - Locate the wings of the ilium and palpate the lumbo-sacral (LS) space (almost directly in line with the wings of the ilium on the mid-line).
        - Clip and scrub this region. Wear gloves and use a small drape or glove wrapper.
        - Insert an epidural needle into the caudal portion of the LS site with the needle angled at approximately 45^{o} from vertical.
        - Slowly advance the needle until the epidural space is entered.
            - 'Hanging' drop often works (aspiration of fluid in the hub of the needle as the epidural space is entered).
            - Several 'pops' will be felt.
            - 'Walking off' the bone is the most definitive determination of proper placement of the needle.
        - STOP as soon as the space is entered and slowly inject the drug.
            - The drug should inject easily if the needle is in a space.
            - If the drug does not inject easily, back up a VERY tiny amount and try again.
        - Once drug has been injected, remove needle and proceed with surgery.
            - If local anesthetic drugs have been used, may want to lay patient with surgical side down for about 5 minutes.
        - Opioid epidurals do NOT affect motor function of the rear limb or diaphragm. Local anesthetic drugs can affect motor function but rarely do (volumes that are described here do not migrate far enough cranially to affect the diaphragm so ventilation is not impaired).
    - Complications include ineffective block (by far most common complication), epidural hematoma or abscess, hyperalgesia (VERY rare). Contraindications include bleeding disorders (to prevent hematomas) and skin disease over the LS space (to prevent abscesses). Abnormal pelvic anatomy (either from congenital lesions or trauma) may make epidurals difficult.

- *Sacrococcygeal or intercoccygeal epidural*
    - This block is often used to provide analgesia for tail amputations, perineal urethrostomies, and placement of urinary bladder catheters for urethral obstructions.
    - Move the tail up and down in a 'pumping' motion while palpating the sacrococcygeal region of the patient. The first movable space at the caudal end of the sacrum is either the sacrococcygeal or intercoccygeal space. Either site is appropriate for injection.

- Insert a 22-G needle through the skin ON MIDLINE at a 45-degree angle to the skin surface.
- Proceed slowly until needle enters the space (generally hit bone and 'walk off' the bone).
- Hanging drop technique often works. Should have no resistance on injection.
- Use lidocaine for rapid onset (0.1-0.2 ml/kg 2% lidocaine), can add an opioid (same as for lumbosacral epidural) for long-term analgesia. Don't inject air, air bubble may cause incomplete block since this is a very small space.

Wound diffusion catheters



Wound diffusion catheters (or 'soaker' catheters) allow us to provide long-duration analgesia to incisions or wounds. Since the skin is highly innervated, incision/wound pain is usually a major component of the overall pain experienced by a patient. The catheter is buried in the incision, either in the muscle or under the skin, and bupivacaine or lidocaine is infused through the catheter either via a continuous pump or by intermittent injection (bupivacaine q4-8 hours; lidocaine q2-4 hours – usually shortest time interval for the first dose after the dose delivered at catheter placement and extended time as the patient becomes more comfortable).
Advantages: Great analgesia, easy to use. Moderately expensive (about $20) but very cost effective when the duration of analgesia is considered.
Disadvantages: Really none. No increase in wound infection, no negative impact on healing (analgesia has a positive impact on healing), rare seroma formation
Source: MILA International (www.milainternational.com) makes catheters for veterinarians. Buy MILA!

Gabapentin

Excellent drug for many patients with chronic pain. Gabapentin is commonly used to control seizures in both human and veterinary patients. In addition to the antiseizure activity, gabapentin has been shown to be effective in treating a variety of chronic pain conditions (including post-herpetic neuralgia, diabetic neuropathy, complex regional pain syndrome, inflammatory pain, central pain, malignant pain, trigeminal neuralgia, HIV-related neuropathy, and headaches) in humans. Gabapentin has a variety of uses in chronic pain in veterinary medicine too and scenarios for addition of gabapentin include:

- Anytime pain may be 'neuropathic'
- All patients with painful backs/necks that have present in moderate to severe pain
- All patients with painful backs/necks that have not resolved with NSAIDs or steroids
- All patients post back/neck surgery
- Any patient with difficult to diagnose, difficult to characterize pain
- Any patient with known nerve damage

Advantages: Cheap; easy to administer; safe and main adverse effect is sedation so easy to monitor effects/adverse effects; when the patient has neuropathic pain the drug provides moderate to profound analgesia.
Disadvantage: Have to work to find the right dose for each patient (not really a disadvantage, just something to know ahead of time – and to tell the owner ahead of time).

TIP: See dosing information at the end of this document.
Source: Any pharmacy, most distributors

Other drugs that I like

Propoflo28®

Regular propofol but with a preservative so that the bottle does not have to be discarded 6 hours after opening.
Advantages: Can keep using the vial for 28 days after the bottle is open! Has the advantages of regular propofol (easy to titrate to effect, cleared from the body by multiple routes). No need to carry both forms of propofol – just Propoflo28!
Disadvantage: None other than the regular effects of propofol (causes dose-dependent respiratory and cardiovascular depression).
TIP: Use preoperative sedatives so that the patient only needs a low dose of propofol for induction
NOTE: The preservative in Propoflo28 (benzyl alcohol) is NOT toxic to cats (Taylor et al 2012).
Source: Any distributor that carries Abbott Animal Health drugs

Recuvyra®

Transdermal fentanyl. The product is applied directly to the skin and rapidly absorbed so that there is minimal chance of human fentanyl exposure from the patient. Analgesia is moderate to profound in 2-4 hours and lasts 4+days.
Advantages: Profound analgesia (fentanyl!) for at least 4 days! Can send controlled drugs home in the dog not with the owner, so no chance for owner abuse of the drug.
Disadvantages: POTENT fentanyl product (50 **mg**/ml) so must be handled very carefully in the clinic.
TIP: Because the FDA requires that drugs be tested alone, the label dose of many drugs (including Recuvyra) is often higher than necessary for most clinical patients that are commonly receiving multiple drugs. Try 75% of the label dose.
TIP: Occasionally a dog will be a little more sedate postoperatively than you are comfortable with. Administer a dose of butorphanol (0.2 mg/kg IV) to partially reverse the Recuvyra. Often one dose is all you need to get the dog to a point that you are comfortable with. If the dog gets sedate again (usually doesn't happen), administer another dose of butorphanol. Repeat as needed. Naloxone can also be used but it totally reverses the Recuvyra.
Source: Any distributor that carries Elanco Animal Health drugs

Simbadol®

FDA-approved buprenorphine for CATS! The drug can be administered subcutaneously (SQ) and analgesia lasts 24 hours. Regular buprenorphine has really poor absorption when administered SQ and the compounded 'extended release' buprenorphine that supposedly lasts 72 hours has NO PHARMACOKINETIC DATA to support this claim. The duration of Simbadol is supported by FDA-approved data.
Advantages: It's buprenorphine – which we know and love in cats! PROVEN 24 hour duration. FDA approval.
Disadvantages: Not commercially available yet – but will be soon!!!
Source: Any distributor that carries Abbott Animal Health drugs.

Alpha-2 agonists (medetomidine, dexmedetomidine)

If you aren't using these sedative-analgesic, reversible drugs, you are missing out on an excellent drug class! Especially in cats☺. The alpha-2 induced drop in heart rate is actually a good thing because it is a normal physiologic response to increased blood pressure – and maintenance of adequate blood pressure is extremely important. The pale mucous membranes are annoying but not indicative of trouble, it just so happens that the greatest concentration of alpha-2 receptors on vessels is in the periphery (including the mucous membranes) so the greatest vasoconstriction (and subsequent pale mucous membranes) are right where we want to assess patient color☹.

Table 1: Dobutamine / Dopamine Infusion

Add 4.0 mls (50.0 mg) of dobutamine (12.5 mg/ml) or 1.25 mls (50.0 mg) of dopamine (40 mg/ml) to 250 mls saline. The concentration of either CRI will 200 microg/ml (3.3 microg/drop with 60 drop/ml set). The standard dobutamine dose is 1-5 microg/kg/min (up to 10 microg/kg/min can be used if necessary) and the standard dopamine dose is 1-10 microg/kg/min. For mild to moderate hypotension start at 2 microg/kg/min and for profound hypotension start at 5 microg/kg/min. If no response in 3-5 minutes, increase the rate by 1-2 microg/kg/min every 3-5 minutes until the blood pressure starts to improve or the maximum dose is reached. If the maximum dose is reached and there is no response either the drug is not effective (expired?) or the problem is not cardiac contractility. In this case, check for other causes of hypotension (eg, bradycardia, inadequate fluid volume, vasodilation, etc…).

The following chart works for a 60 drop/ml set and the number in the column is equal to the drops/min (which also works out to be the mls/hr with a 60 drop/ml set). Appropriate dosing in patients over 40 kg needing high dosages of dopamine or dobutamine will require a 10 or 15 drop/ml set. For really small patients, the infusion can be made more dilute so that you can administer more drops/min.

Weight/kg	**1**	**2.5**	**5**	**7.5**	**10**	**12.5**	**15**	**20**	**25**	**30**	**35**	**40**
Dose in microg/kg/min	**Drops/min using a 60 drop/ml set.** Number of drops/min have been rounded up or down, as appropriate. Because the dose is a range and not an absolute value, rounding does not jeopardize safety. The actual drops the patient gets per minute will also have to be rounded – for example 61 drops/min is hard to count but 60 drops/min=1 drop/sec is quite easy.											
2	1	1	3	5	6	8	9	12	15	18	21	24
4	1	3	6	9	12	15	18	24	30	36	42	48
5	2	4	8	11	15	19	23	30	38	45	53	61
6	2	5	9	14	18	23	27	36	45	54	63	73
8	3	6	12	18	24	30	36	48	61	72	85	97
10	3	8	15	23	30	38	45	61	76	91	106	121

TABLE : Dosages for constant rate infusions (CRIs) used in CATS.				
Drug	Loading Dose	CRI dose	Quick Calculation	Comments
Morphine (M)*	0.10 mg/kg IM	0.03 mg/kg/hr (0.5 mic/kg/min)	Add 15 mg to 500 ml fluid & run at 1 ml/kg/hr	Cat may need light sedation; can be combined with K &/or L
Hydromorphone (H)	0.025 mg/kg IV	0.01 mg/kg/hr	Add 5 mg to 500 ml fluid & run at 1 ml/kg/hr	May cause hyperthermia; can be combined with K &/or L
Fentanyl (F)	0.001-0.003 mg/kg IM or IV (1-5 mic/kg IV)	2-5 mic/kg/h (0.03-0.08 mic/ kg/m)post-op 5-20 mic/kg/h (0.08-0.3 mic/ kg/m intra-op	For 5 mic/kg/h, add 2.5 mg to 500 ml fluid & run at 1 ml/kg/hr	2.5 mg=50 ml F, remove 50 ml LRS before adding F; can be combined with K &/or L.
Methadone	0.1-0.2 mg/kg IV	0.12 mg/kg/hr	Add 60 mg to 500 ml fluid & run at 1 ml/kg/hr	MAY cause sedation; can be combined with K &/or L.
Butorphanol	0.1 mg/kg IV	0.1-0.2 mg/kg/hr	Add 50 mg to 500 ml fluid & run at 1 ml/kg/hr for 0.1 mg/kg/hr	Only moderately potent & has ceiling effect - use as part of multimodal protocol
Ketamine (K)*	0.25-0.5 mg/kg IV	0.12-0.6 mg/kg/hr (2 -10 mic/kg/ min)	Add 60 mg to 500 ml fluid & run at 1 ml/kg/hr for 0.12 mg/kg/hr	Generally combined with opioids; may cause dysphoria
Lidocaine (L)	0.25 mg/kg IV	1.5 mg/kg/hr (25 mic/kg/min) Some sources recommend no more than 10 mic/kg/min in cats	Add 750 mg to 500 ml fluid & run at 1 ml/kg/hr 10 mic/kg/min would be 300 mg lidocaine in 500 ml fluid with a rate of 1 ml/kg/hr	750 mg=37.5 ml, remove 37.5 ml LRS before adding L; can be combined with opioid &/or K; **Lidocaine MAY be contraindicated in the cat due to cardiovascular effects.**
Medetomidine (Med) or Dexmedetomidine (D)	1-5 mic/kg Med 1-2 mic/kg D Can be IV or IM May not be necessary	0.001-0.004 mg/kg/hr Med (1-4 mic/kg/hr) 0.0005-0.002 mg/kg/hr D	Add 500 mic Med or 250 mic D (0.5 ml of either) to 500 ml fluid and run 1-4 ml/kg/ hr	Provides analgesia and light sedation. Excellent addition to opioid CRI, or can be administered as solo drug CRI.
Morphine* / Ketamine*	M: 0.10 mg/kg IM K: 0.25-0.5 mg/kg IV	0.03 mg/kg/hr M & 0.12 mg/kg/hr K	Add 15 mg M & 60mg K to 500 ml fluid & run at 1 ml/kg/hr	Can be administered up to 3 ml/kg/hr but dysphoria MAY occur. Can substitute, F, or methadone for M.
Morphine / Ketamine / Lidocaine (MLK)	M: 0.10 mg/kg IM K: 0.25-0.5 mg/kg IV L: 0.25 mg/kg IV	0.03 mg/kg/hr M, 0.12 mg/kg/hr K; 1.5 mg/kg/hr L	Add 15 mg of M, 60 mg K and 750 mg (or 300 mg) L to 500 ml fluid & run at 1 ml/kg/hr	Can substitute H, F or methadone for M.

* Any of the drug amounts in the bag of fluids can be decreased and the fluids administered at a higher rate if necessary. For example, for morphine, ketamine and morphine/ketamine infusions, 7.5 mg of morphine & 30 mg of ketamine can be used and the CRI administered at 2 ml/kg/hr if more fluids are needed.

TABLE 3: Dosages for constant rate infusions (CRIs) used in DOGS.				
Drug	Loading Dose	CRI dose	Quick Calculation	Comments
Morphine (M)*	0.5 mg/kg IM (or 0.25 mg/kg SLOWLY IV)	0.12-0.3 mg/kg/hr (2.0mic/kg/min-3.3mic/kg/min	Add 60 mg to 500 ml fluid & run at 1 ml/kg/hr for 0.12 mg/kg/hr	MAY cause sedation; can be combined with K &/or L.
Hydromorphone (H)	0.05-0.1 mg/kg IV	0.01-0.05 mg/kg/hr	Add 5-24 mg to 500 ml fluid & run at 1 ml/kg/hr	MAY cause sedation; can be combined with K &/or L.
Fentanyl (F)	0.001-0.003 mg/kg IM or IV (1-5 mic/kg IV)	2-10 mic/kg/h (0.03-0.2 mic/ kg/m)post-op 3-40 mic/kg/h (0.05-0.7 mic/ kg/m intra-op	For 5 mic/kg/h, add 2.5 mg to 500 ml fluid & run at 1 ml/kg/hr	2.5 mg=50 ml F, remove 50 ml LRS before adding F; can be combined with K &/or L; Intra-op dose can be up to 20-40 mic/kg/h
Methadone	0.1-0.2 mg/kg IV	0.12 mg/kg/hr	Add 60 mg to 500 ml fluid & run at 1 ml/kg/hr	MAY cause sedation; can be combined with K &/or L.
Butorphanol	0.1 mg/kg IV	0.1-0.2 mg/kg/hr	Add 50 mg to 500 ml fluid & run at 1 ml/kg/hr for 0.1 mg/kg/hr	Only moderately potent & has ceiling effect - use as part of multimodal protocol
Ketamine (K)*	0.25-0.5 mg/kg IV	0.12-0.6 mg/kg/hr (2 -10 mic/kg/ min)	Add 60 mg to 500 ml fluid & run at 1 ml/kg/hr for 0.12 mg/kg/hr	Generally combined with opioids; may cause dysphoria; post-op dose may be higher
Lidocaine (L)	0.5 – 1.0 mg/kg IV	1.5-3.0 mg/kg/hr (25-50 mic/kg/min)	Add 750 mg to 500 ml fluid & run at 1 ml/kg/hr for 25 mic/ kg/min	750 mg=37.5 ml, remove 37.5 ml LRS before adding L; can be combined with opioid &/or K.
Medetomidine (Med) or Dexmedetomidine(D)	1-5 mic/kg Med 1-2 mic/kg D Can be IV or IM May not be necessary	0.001-0.004 mg/kg/hr Med (1-4 mic/kg/hr) 0.0005-0.002 mg/kg/hr D	Add 500 mic Med or 250 mic D (0.5 ml of either) to 500 ml fluid and run 1-4 mls/kg/hr	Provides analgesia and light sedation. Excellent addition to opioid CRI, or can be administered as solo drug CRI.
Morphine* / Ketamine*	M: 0.5 mg/kg IM K: 0.25-0.5 mg/kg IV	0.12 mg/kg/hr M & 0.12 mg/kg/hr K	Add 60mg M & 60mg K to 500 ml fluid & run at 1 ml/kg/hr	Can be administered up to 3 ml/kg/hr but sedation or dysphoria MAY occur. Can substitute H, F or methadone for M
Morphine / Ketamine / Lidocaine (MLK)	M: 0.5 mg/kg IM K: 0.25-0.5 mg/kg IV L: 0.5 mg/kg IV	0.12 mg/kg/hr M, 0.12 mg/kg/hr K; 1.5 mg/kg/hr L	Add 60 mg of M, 60 mg K and 750 mg L to 500 ml fluid & run at 1 ml/kg/hr	Can substitute H, F or methadone for M. Dr. Muir's dose is 3.3 mic/kg/min M, 50 mic/kg/min L; 10 mic/kg/min K.

*Any of the drug amounts in the bag of fluids can be decreased and the fluids administered at a higher rate if necessary. For example, for morphine, ketamine and morphine/ketamine infusions, 30 mg of morphine & 30 mg of ketamine can be used and the CRI administered at 2 ml/kg/hr if more fluids are needed.

Table 4: Gabapentin for pain relief in dogs and cats

Gabapentin is commonly used to control seizures in both human and veterinary patients. In addition to the antiseizure activity, gabapentin has been shown to be effective in treating a variety of chronic neuropathic pain conditions (including post-herpetic neuralgia, diabetic neuropathy, complex regional pain syndrome, inflammatory pain, central pain, malignant pain, trigeminal neuralgia, HIV-related neuropathy, and headaches) in humans.

Multiple mechanisms have been proposed for the action of gabapentin and pregabalin but the current leading theory is that the drugs cause inhibition of pre-synaptic calcium currents via high-voltage-activated calcium channels containing the alpha-2-delta-1 subunit. This inhibition leads to reduced presynaptic neurotransmitter release and attenuation of postsynaptic excitability.

- Main adverse effect is sedation, although diarrhea and/or ataxia can occur (not common)
- Partially metabolized by liver, partially excreted unchanged by kidney so hepatic or renal disease can slow elimination of gabapentin (might need to decrease the dose to account for accumulation due to decreased clearance) but the drug does not cause hepatic or renal damage.
- Although no research manuscripts are available regarding the use of gabapentin in dogs and cats for the treatment of chronic pain, this is a common recommendation:
    - The dosage generally ranges from 1-10 mg/kg PO BID to QID but dosages as high as 50 mg/kg have been anecdotally reported.
    - Generally, gabapentin therapy is initiated at 3-5 mg/kg PO BID and dosages increased as necessary.
    - Increase by about 25% every 3 days until the patient gets relief or gets sedate. IF THE PATIENT DOESN'T GET RELIEF OR SEDATION, YOU HAVEN'T REALLY TRIED GABAPENTIN!
    - If the patient becomes sedate with the first 1-3 doses, decrease the dose and start again. Gradually increasing the dose over time often decreases the incidence of sedation.
    - If the patient is to be removed from gabapentin therapy (eg, the patient is 'cured' or the gabapentin is not working), the drug should be gradually withdrawn over a period of one to three weeks (depending on the duration of therapy) to prevent rebound hyperalgesia.
    - Gabapentin has a variety of uses in chronic pain and scenarios for addition of gabapentin should include:
        - Anytime pain may be 'neuropathic'
        - All patients with painful backs/necks that have present in moderate to severe pain
        - All patients with painful backs/necks that have not resolved with NSAIDs or steroids
        - All patients post back/neck surgery
        - Any patient with difficult to diagnose, difficult to characterize pain
        - Any patient with known nerve damage
        - Patients with long-standing chronic pain that is not controlled by NSAIDs (or NSAIDs are not an option for treatment)