Stressors, Pressers and Heartache Disasters

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Appropriate blood pressure is vital for sustaining a healthy cardiovascular, cerebral and internal organ system. Without healthy blood pressure these systems can suffer, leading to chronic disease processes and death. In veterinary medicine monitoring blood pressure is still relatively new when compared to the human medical field and refining the best techniques in accurate measurement and treatment is under constant research. Nearly every species we deal with has physiologic differences and tolerances when it comes to their blood pressure and how effective various modalities work in each species. The following is a very broad overview of common medications used to treat abnormal blood pressure under anesthesia, with a focus on hypotensive correction.

Treating hypertension or hypotension (MAP <60mmHg for many species) while under anesthesia should never first start with pharmacological agents unless the patient has a pre-diagnosed cardiovascular condition. Treatment for either hyper or hypotension should first start with a carful patient assessment. These are some questions that should run through your head before moving to pharmaceutical intervention. Is the patient too light or painful? Is the gas inhalant or total IV anesthesia rate too high? Is the fluid therapy adequate? Are my monitoring devices (i.e. Doppler or mechanical blood pressure monitors) appropriately placed and do the numbers appear to match with how the animal looks clinically? Does my patient have an underlying cardiac issue? Does my patient have an arrhythmia?

Atropine- Although not typically considered a blood pressure medication, atropine plays an important role in treating certain arrhythmias under anesthesia. Neonates and immature animals are more reliant on heart rate for appropriate cardiac output and thus blood pressure. While atropine has fallen out of favor in the pre-medication plan it is a drug that warrants shelf space in all operating rooms.

Ephedrine- Ephedrine is a safe, yet somewhat expensive option in the first line of pharmaceutical intervention of hypotension. Ephedrine increases cardiac output, heart rate, blood pressure, coronary blood flow, and myocardial oxygen consumption. It reduces the need and time for CRI's of other vasopressors and inotropes with its longer duration of action. Ephedrine is used in human medicine second to phenylephrine for hypotension during pregnancy and fetal surgery. One study found in dogs a bolus only lasted 5 minutes and the increases of cardiac output and increased BP were merely transient. Ephedrine also causes stimulation of the respiratory centers and bronchodilation.

Dopamine- This is a highly dose dependent drug. For effective increases in MAP in dogs and cats research suggests rates starting at 7μg/kg/min to increase the A1-adrenergic agonist effects take the lead. The effect will increase systemic and pulmonary vascular resistance, venous return, and possibly PVC's due to splenic contraction. Tachycardia can occur at higher dose rates. When using dopamine it is recommended to decrease the CRI in a stepwise manner. The receptor effects of dopamine are dose dependent. Dopamine stimulates the release of endogenous norepinephrine from presynaptic storage sites at adrenergic receptors causing an endogenous sympathomimetic effect. There is some debate on the use of dopamine in felines as they lack the typical distribution of dopamine receptors found in canines.

Dobutamine- Dobutamine is another commonplace inotrope used to treat hypotension related to poor cardiac output. Current thought regarding the medication for treatment of hypotension during inhalation anesthesia is that it lacks good predictable effects, especially in cats. Higher doses ~10mcg/kg/min were needed to produce vascular resistance in dogs and an increase in cardiac output, but caused vasodilation in cats. In both studies minimal to no increase in blood pressure was noted.

Phenylephrine- Phenylephrine is a direct-acting sympathomimetic amine with strong Alpha1-adrenergic receptor

agonist effects. It is used intravenously during anesthesia to increase systemic vascular resistance therefore increasing blood pressure. Phenylephrine is the first line medication for hypotension during fetal surgery.

Norepinephrine- This medication has largely B-adrenergic receptor mediated effects. At sufficient doses we see an increase in cardiac output, increased SYS, DIA and MAP, along with systemic and pulmonary vascular resistance. Coronary arterial flow is also increased via vasodilation. Tachycardia is less pronounced compared to epinephrine.

Epinephrine 0.01–1 μg/kg/min
Norepinephrine 0.01–0.2 μg/kg/min
Dobutamine 1–20 μg/kg/min
Phenylephrine 0.2–2 μg/kg/min
Dopamine 1–10 μg/kg/min, >10 μg/kg/min Primarily α effects
Ephedrine 0.05–0.5 mg/kg

Airway management:

Traditional endotracheal intubation uses a sterile or thoroughly disinfected endotracheal tube for each patient to prevent the spread of infectious disease. The endotracheal tube should be lubricated with a very this layer of sterile xylocaine or K-Y jelly. The author also uses an extremely thin layer of sterile non-water based eye lubricant to avoid the drying out of the lubricant and subsequent traumatizing removal of soft tissue during longer procedures. The is also a commercially available spray for ETT's called SILKOSPRAY by Rusch. Operators should avoid using a lubricant containing benzocaine, as this can lead to a dose-dependent methemoglobinemia (MetHb), which does not bind oxygen and most hospitals are unable to test for MetHb in clinic.
Intubation may stimulate the vagus nerve, increasing parasympathetic tone especially in dogs. This may result in bradycardia, hypotension and cardiac dysrhythmias. If the animal has an underlying cardiovascular disease, cardiac arrest may occur. Atropine or glycopyrrolate can be given as part of the premedication. This is also a consideration when eye surgery is going to be performed or repeated movement of the head/throat region in preventing the parasympathetic stimulation.

Operators should not be forceful in the intubation technique as this can damage the larynx, pharynx, or soft palate and lead to tissue edema. Ideally, the tip of the endotracheal tube should be past the larynx and not beyond the thoracic inlet. If the tube is advanced too far, it may enter one bronchus, resulting in ventilation to only one lung. Premeasure the length of the endotracheal tube and the distance between the nose and the thoracic inlet prior to anesthesia. A general rule of thumb is once the cuff of the ETT has pas the arytenoids advance about a centimeter more, then stop. The end of the tube should be at the level of the animal's incisors to eliminate dead space and respiratory resistance.

Laryngeal Mask Airways (LMA's) for the veterinary patient were introduced by Docsinnovent with the v-gel™ for rabbits and felines (soon to have a canine and equine model), which is a modified tube that only covers the supraglottic region. Although ET intubation is the author's preferred method, v-gel™ offers a quick and easy approach when ET intubation proves too difficult. They are not ideal for animals requiring oral surgery as they take up a decent amount of space in the mouth and the potential for fluid leakage around the tube if undergoing a dental procedure. The other limiting factor is they require capnography to ensure proper placement. The tubes themselves have a build in port for sidestream capnography, but also support mainstream capnography with an adaptor that will add to the total deadspace. Older sidestream machines may not be ideal for small patients as some machines require taking 50-200 ml/min of the ventilated gasses for sampling.

In the event an animal cannot be intubated, the **forced mask ventilation technique** may need to be utilized. This technique consists of fitting a patient with a mask that covers the nose and mouth with as few leaks as possible. The head should be placed so that the trachea is fully extended and as straight as possible to allow easier

movement of air. There are various pre-manufactured masks, but at times it is necessary to create a homemade mask out of syringe cases, small bottles or tubing. Taking advantage of the patient's bottom incisors case be useful for masks made form syringe cases. The technique involves using a larger suture or small sized string tied/looped around the top incisors or canines and pulled through the mask. Letting the string hang out the end and pulling taught as the non-rebreathing circuit is connected will ensure a sealed mask. Careful attention should be paid to not create ocular trauma with careful positioning and plenty of eye lubricant. If the forced mask ventilation technique is used, it is important to remember to protect the animal's eyes. It is too often a mask is left putting pressure or digging into the inferior eye socket. This technique can also lead to gas in the stomach that may need to be treated postoperatively by tubing or carefully expressing the air out.

If direct visualizationof the glottis or a portion of it is not possible, *Jane* E. *Ouandt,* DVM., M.S., DACVA descrives the following techniques; in the case of a pharyngeal or an oral mass, one method to use is **retrograde intubation**. A hypodermic needle is passed through the ventral aspect into the skin of the neck and into the trachea at the junction of the second and third tracheal rings. A guide wire, or canine urinary catheter that will pass easily through the needle, is maneuvered through the needle cranially into the larynx, pharynx and oral cavity. It is then used as a guide for the passage of the endotracheal tube. After the tip of the tube is within the larynx, the needle and guide wire can be removed. The endotracheal tube is then advanced into the final position. Subcutaneous emphysema and pneumothorax are possible complications with this technique.
In an emergency situation a **tracheostomy** can be performed. Indications for a tracheostomy include relieving an upper respiratory tract obstruction, facilitate removal of respiratory secretions, decrease dead space, provide a route for inhalant anesthesia when oral or facial surgery is complex, reduce resistance to respiration, when you are unable to orally intubate, reduce the risk of closed glottis pressure, or cough, following pulmonary or cranial surgery.

To perform a tracheostomy make a midline skin incision on the ventral neck equidistant from the larynx and the manubrium. Part the two sternohyoid muscles on the midline and continue blunt dissection down to the tracheal rings. Make an incision transverse between the rings; keep the incision small, only big enough for the tracheostomy tube. Alternatively, make a longitudinal incision to include two or three tracheal rings. Don't place the incision too close to the first tracheal ring, or it could potentially damage the cricoid cartilage and lead to subglottic laryngeal stenosis. Place stay sutures around the tracheal ring adjacent to the incision on either side of the surgical opening. The sutures will aid in placement of the tube and are left in, labeled cranial and caudal, to help when the tube is routinely replaced or cleaned, or if it gets dislodged.
The tube ideally is two-thirds to three-fourths of the tracheal diameter. If a specifically designed tracheostomy tube is not available, an endotracheal tube can be used but may need to be cut so it is short enough that it does not go into one bronchus. Fasten the tube in place by tying it around the neck with umbilical tape or gauze. The soft tissue is loosely closed with sutures and the skin is closed with non-absorbable sutures. It is important to allow any air escaping around the tube to vent to the outside and not accumulate under the skin.

External pharyngotomy is a type of intubation that can be performed for oropharyngeal surgery or orthopedic procedures of the mandible or maxilla. This type of intubation aids in the visualization of the area and allows for normal dental occlusion so that proper reduction of jaw fractures can be achieved. Initially place the endotracheal tube orally. Make a skin incision near the angle of the mandible. Pass hemostats bluntly through the incision into the caudal part of the pharynx. Remove the endotracheal tube adapter. grasp the tube. and pull it through from the pharynx through the subcutaneous tissue and skin incision. Replace the adapter and connect the tube to the breathing circuit. Secure with tape and suture. Extubation is done with the cuff deflated and the tube pulled through the skin incision.

Jet insufflation is a technique similar to the retrograde intubation except a small oxygen tube is connected to the need or catheter tip and the air is forcefully pushed into the lungs. It is imperative that the air can escape, otherwise causing lung injury.

Drug	Drug Class	Dose	Time to Effects	Effects on BP	Effects on HR	Efficacy in Species	Fetal Safety	Mechanism of action	Notes
Dopamine ($0.70 per ml)	Adrenergic /Dopaminergic inotrope	10-12 mcg/kg/min (Alpha effects)	2-5 minutes, last 5-10 minutes post cessation	++	+++	C, F, NHP, O, S, B	Most likely safe, but use with caution	Precursor to norepi and indirectly releases norepi causing vasoconstriction	2-10 mcg/kg/min, organ and GFR are increase sans vascular resistance
Dobutamine ($0.40 per ml)	Beta adrenergic inotrope	1-20 mcg/kg/min	2-5 minutes, Peaks at 10 minutes lasts 5-10 minutes post cessation	++ Dose dependent	++ Dose dependent	C, F, NHP, O, S, B, R(High dose)	Most likely safe	Increase myocardial contractility (can increase cardiac O2 demands)	Good for alveolar fluid buildup, patient must be hydrated, Liver is primary metabolizer. Can produce ectopic HB's, chest pain, palpitations, nausea and headaches.
Phenylephrine ($7.72 per ml)	Alpha adrenergic agonist Vasopressor	0.5-3 mcg/kg/min in NaCl or D5W	Immediate, lasts 5-10 minutes post cessation	+++	0-+ (report of reflex bradycardia, correct with atropine)	C, F, NHP, O, S, B, R, L	Safe and preferred in humans. Can cause uterine contraction.	Vasoconstriction, slight decrease in cardiac output with increase in coronary flow.	Use in hydrated patients
Ephedrine ($26.50 per ml)	Sym. Bronchodilator/ Vasopressor	0.03-0.25 mg/kg bolus, q 5 min	immediate	+++	+++	C, F, NHP, O, S, B, R, L	Safe for healthy fetus (excreted in milk)	releases norepi causing vasoconstriction (Can deplete norepi)	Do not use in cardiac patients
Norepinephrine ($39.00 per ml)	Alpha & Beta Adrenergic Vasopressor Cardiac inotrope	0.01-0.2 mcg/kg/min, max dose of 2 mcg/kg/ min. Add 4mg to 1L 5% Dextrose sol. run at 0.75-1.5 **mls**/kg/hr	immediate	+++	0-+ (report of reflex bradycardia, correct with atropine)	C, F, NHP, O, S, B, R, L	Do no use for viable pregnancy	Vasoconstriction, coronary artery dilator, slight increase in cardiac contractility	Use in hydrated patients. Good for Septic patients, high doses can lead to poor perfusion
Epinephrine ($6.00 per ml)	Alpha & Beta Adrenergic agonist	0.01-1 mcg/kg/min, START LOW	immediate, lasts 5-10 minutes post cessation	+++	+++	C, F, NHP, O, S, B, R, L	Do no use for viable pregnancy	Vasoconstriction, Increased cardiac contractility, increase in coronary and pulmonary flow	Better for increasing systolic BP, can Decrease Diastolic. Use in hydrated patients only. Can cause poor tissue perfusion at high doses.
Vasopressin ($69.50 per ml)	Hormone	20 pressor U/ml, 1-4mU/kg/min	Immediate	+++	0-+	C, F, NHP, O, S, B, R, L	Do no use for viable pregnancy	vasoconstriction	Hepatic flow increase