Monitoring Blood Pressure

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Measurement of blood pressure (BP) is the most commonly applied objective indicator of tissue and organ perfusion. Arterial blood pressure is determined by cardiac output and systemic vascular resistance (SVR). Cardiac output (CO) is dependent on heart rate (HR) and stroke volume (SV), which, in turn, is determined by cardiac contractility, preload and afterload. Mean arterial pressure represents the driving force for organ perfusion.

> **Doppler systems** rely on the detection of a shift in frequency of ultrasound waves by reflection off red blood cells. The transducer is placed over a peripheral artery distal to an occlusive cuff. The cuff is inflated until blood flow is occluded; the cuff is then slowly deflated. The pressure on the sphygmomanometer when audible blood flow is first detected is an estimate of the systolic BP. Diastolic BP cannot be reliably measured with this technique. Although these systems are robust, inexpensive, and can be used in a wide variety of species, there is a learning curve with their use and they are non-automated.
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> **Oscillometric devices** operate by measuring the fluctuations (oscillations) in pressure caused by movement of the arterial walls. Typically, mean arterial pressure is detected and systolic and diastolic are calculated based on proprietary algorithms, although systolic pressure is also sometimes measured. Recent improvements in algorithms for veterinary patients have made these devices more clinically useful.

In general, indirect monitors tend to underestimate gold-standard direct arterial measurements and may be particularly inaccurate during periods of hypotension. These devices are best for monitoring trends. Inappropriate cuff sizes will give falsely elevated (small) or depressed (large) readings and blood pressure values may not be obtained by oscillometric devices during periods or tachycardia or other arrhythmias.

In order to ensure adequate perfusion of the brain and kidneys, mean arterial BP should be maintained above 60 mmHg and systolic BP above 80 mmHg.

Hypotension during anesthesia should be addressed as follows:

1. **Decrease delivery of inhalational anesthetic.**
   Is the patient too deep? Can partial injectable techniques be used? Would additional analgesics allow a reduction of inhalant? Reassess depth frequently.

2. **Ascertain that heart rate is appropriate.**
   Because blood pressure is dependent on cardiac output (BP=CO x SVR) and cardiac output is dependent on heart rate (CO=HR x SV), increasing HR, **if** the patient is bradycardic, may increase BP. An anticholinergic (atropine or glycopyrrolate) may therefore be indicated; however, if the animal has received an alpha-2 agonist such as dexmedetomidine (Dexdomitor) in the past hour or so, reversal with atipamezole (Antisedan) should be considered before the use of an anticholinergic (atropine or glycopyrrolate).

3. Provide intravascular volume

Optimize preload with crystalloid fluid boluses. Many healthy anesthetic patients may be volume-depleted due to deprivation of water. In addition, inhaled anesthetic agents can cause profound peripheral vasodilation and a relative volume-depletion.

Assuming normal cardiac status, boluses of 5 to 20 mL/kg of crystalloids may be attempted. Though controversial, artificial colloids (Hetastarch or Vetstarch) can be considered if crystalloid boluses are ineffective or if hypoalbuminemia exists.

These first 3 steps should control blood pressure in most healthy animals undergoing procedures of short length. If they are unsuccessful, before moving onto the next step in a healthy patient, stop and reassess the situation. Check the depth of the patient again; is the BP reading to be trusted – double check with another monitor or on another limb; is the patient severely hypothermic and vasoconstricted or is there an arrhythmia or movement that will affect the BP reading?

4. **Employ inotropes +/- vasopressors**

Choice of drug depends greatly on the overall status of the patient.

For example, dopamine is often quite effective in increasing BP in healthy, volume-replete patients. However, septic patients may need a combination of pressors and inotropes to improve blood pressure.

Dopamine 2-20 mcg/kg/min

Dobutamine 2-20 mcg/kg/min

Ephedrine 0.03 -0.1 mg/kg (dilute & give in small boluses to effect)

Vasopressin 0.5 – 5 mU/kg/hr

Norepinephrine 0.05 – 2 mcg/kg/min

Epinephrine 0.005 – 0.05 mcg/kg/min