

Nursing on the Front Line: Recognizing Hemodynamic Changes

Stephen Cital RVT, SRA, RLAT, VTS-LAM (Res. Anesthesia)
<http://www.stephencital.com>

A holistic approach to the patient and watching trends rather than focusing on specific numbers is still standard. Goal directed monitoring also has its place in intensive care settings, but can lead to missed clinical signs or features. It is crucial to have trained staff monitor critical patients. It may even be necessary to have one dedicated technician for a particular animal in the ICU setting with little distraction, especially if the patient was a ASA IV or above. Advanced techniques to monitor hemodynamic parameters can involve placing a central line for central venous pressure measurement or even placing and maintaining an arterial catheter. This sort of monitoring is still a gold standard. As we all know this may be difficult and not practical for the duration of a case or feasible in a certain species. Not to mention financially burdensome to the client or out of the scope of your practice's needs and abilities. This, in turn, can lead to less effective treatment and response in our patients. There is now non-invasive technology which includes Perfusion Index (PI) and Pleth-Variability Index (PVI). These are two newer monitoring parameters that can be very telling when obtained correctly. The perfusion index is the ratio of the pulsatile blood flow to the non-pulsatile or static blood in peripheral tissues. What this means is now we can monitor peripheral tissue perfusion in our patients non-invasively giving better insight into our fluid therapy management, cardiac/renal output, and efficacy of medications. A defined reference variable is not yet established in the canine or feline patient or any other species for that matter, other than humans, which tends to be quite broad. However, the PI parameter, as well as all of the other non-conventional parameters, is great for trending and monitoring. The PI is also a great tool for assessing the efficacy of opioids and epidurals. When full onset of the opioid or epidural occurs, we see a spike in the PI showing via vasodilation.

The Pleth Variability Index (PVI) is a new technology even in human medicine. It is a measurement of the change of perfusion index with a complete respiratory cycle. With this in mind, PVI is most reliable with patients undergoing mechanical ventilation. In a scientific abstract presented at the American College of Veterinary Anesthesiologists conference, one research group found that the PVI had a good correlation in detecting hypovolemia and return to normovolemia in dogs, but could not be used in definitively stating hypervolemia. Several more recent veterinary papers on PVI have come out with positive conclusions as to the reliability of predicting fluid responsiveness using this non-invasive tool.

History- A clear history should be gathered about the patient, from its primary veterinarian, surgeon, anesthetist and any other sources.

- Patient background (age, sex, code status)
- Type of operation and outcome if applicable
- Indications for operation and pre-operative diagnosis
- Current inotropes, vasopressors, or anti-hypertensives (if any)
- Need for cardiac pacing when applicable
- Bleeding risks and clotting times
- Other significant co morbidity, with emphasis on those conditions that may alter the post-operative management or course (asthma, diabetes, renal failure, hepatic failure, etc.)
- Medications
- Allergies

Physical exam and assessment

- Verify that the patient's oxygen saturation is adequate. Check the ABG results as soon as they are available. If this is not available an SpO2 and monitoring of the pH, bicarbonate and electrolytes must be evaluated.
- Verify correct ventilator settings if applicable.

- Check the initial hemodynamic readings (HR, BP, cardiac output and index, CVP) and determine what vasoactive infusions the patient is on and at what rates.
- Check the patient's heart rhythm. Verify pacemaker settings if the patient is connected to one.
- Examine heart sounds. Listen for murmurs.
- Check all peripheral pulses. Do repeated assessments if there is concern for acute limb ischemia. A Doppler can be placed for on a peripheral limb for continuous evaluation.
- Do a more complete neurologic exam

Labs and tests Electrocardiogram

- Note any changes of ECG
- Rhythm - post-operative bradycardias, blocks, or atrial fibrillation
- ST-T changes - diffuse non-specific changes are not uncommon and may reflect pericardial inflammation or ischemic events
- Chest X-Ray
- Rarely used in the non-research sector, verify correct position of the Swan-Ganz catheter.
- FAST scan U/S

Laboratory Results

- Hemoglobin
- Coagulation parameters (PLT, PT, PTT, ACT)
- Renal and liver chemistry
- Potassium, magnesium, calcium - a vigorous diuresis is common in the first few hours after the OR. This can lead to significant hypokalemia and hypomagnesaemia which increases the likelihood of post-operative dysrhythmias. Standing orders are in place to replace these electrolytes.
- Glucose - tight glycemic control post-operatively reduces morbidity in humans.
- Cardiac markers - elevations of CPK, CPK-MB, and troponins are non-specific. They should be assessed as part of the overall clinical picture including the hemodynamic status of the patient and the EKG.

Warming

Effects of hypothermia

- Predisposes to ventricular dysrhythmias and lowers VF threshold
- Increases SVR; increases afterload and myocardial workload
- Patient shivering causes increased peripheral O₂ consumption
- Decreases CO₂ production; a patient who has a respiratory alkalosis (low PCO₂) on initial ABG usually will increase their PCO₂ with rewarming
- Coagulopathy; impairs platelet function and the coagulation cascade. Rewarming is an important part of the treatment of a bleeding patient.

Hemodynamic management

Hypotension and low cardiac output

1. $BP = CO \times SVR$
2. $CO = HR \times SV$ (stroke volume)
3. Stroke volume is determined by preload, contractility, and afterload
4. Bradycardias or tachydysrhythmias that decrease ventricular filling can decrease CO.

There are numerous causes for hypotension post-operatively. Proper management of the hypotensive patient in the ICU requires that the precise etiology for the hypotension is determined and therapy is directed towards reversal of this specific problem. Equation 1 demonstrates that hypotension can be caused by a "pump problem" (low cardiac output) or a low SVR (arterial "circuit" problem). The following is an approach to managing the hypotensive patient:

1. Look at the recent hemodynamic parameters.
 2. Assess the cardiac output/index. Is this a "pump" problem? Or is it due to low SVR?
 3. Look at the cardiac rhythm.
 4. Look at the CVP to assess preload.
 5. Is the afterload high?
 6. Is contractility decreased?
- Is this tamponade? Look at the recent hemodynamic parameters obtained from the Swan-Ganz catheter or evaluate via echo.
 - Assess the cardiac output/index.
 - If the cardiac index is in the normal range or high, then the patient does not have a significant "pump" problem and the cause of the hypotension is secondary to diminished peripheral arterial tone (low SVR). A vasopressor agent should be considered. The differential diagnosis of low SVR includes;
 - SIRS - a proportion of patients post CPB will have significant cytokine increases
 - Sepsis
 - Anaphylactic or anaphylactoid reactions
 - Drug-induced, toxicological - nitrates, antihypertensives, narcotics and sedatives, etc
 - Adrenal insufficiency (Was the patient steroid dependent pre-operatively?)
 - Hyperthyroidism, hypothyroidism
 - Neurogenic (spinal) shock
 - If the cardiac index (CI) is low then the cause of the hypotension is inadequate flow or a "pump" problem.
 - Look at the cardiac rhythm. Absolute or relative bradycardias or tachycardias can lead to decreased CO and should be corrected.
 - Look at the CVP to assess preload. A patient with a low CI and a CVP that is "relatively" low should be given a fluid challenge. Remember, what you really are interested in is a volume measurement (preload= right or left end-diastolic volume), but what you are measuring are pressures (CVP = Right or left ventricular end-diastolic pressures).
 - High afterload. Secondary to vasoconstriction and hypertension.
 - Decreased contractility. This should be managed with inotropic agents while simultaneously looking for the cause.
 - Tamponade
 - Acute valvular regurgitation. Check for a new regurgitant murmur.

Appropriate systemic arterial blood pressure is vital for survival in any species. In practice, we are faced with many reasons and conditions to obtain and interpret a patient's blood pressure, such as anesthesia, cardiovascular disease and kidney disease. Both high and low blood pressure can be detrimental to our patients, so careful and accurate monitoring techniques are necessary. The two most common methods of non-invasive blood pressure (NIBP) measurement are Doppler ultrasound with a sphygmomanometer and oscillometry (Cardell or other machine). High definition (HD) oscillometry is a newer indirect technique and is becoming more common. Whenever taking a NIBP, it is important to note the trends of the data collected. NIBP is not an exact reflection of the patient's true blood pressure, as there are many variables that can affect the results.

Doppler ultrasound measurement

Doppler ultrasound measurement is the most common blood pressure measurement technique used in small animal practice. In dogs, the reading attained most closely correlates to the systolic blood pressure, whereas in felines recent research is showing that it is more closely correlated to the mean arterial pressure (MAP). Some specialists will add 15 points to a Doppler derived pressure to better estimate the systolic pressure. Limitations when using the Doppler method include the user's acute hearing, patient movement and cuff placement. A minimum of four readings should be taken to show a trend with the readings, discarding the first reading.

Supplies

Sphygmomanometer, blood pressure cuffs, ultrasound transmission gel, tape, clippers OR a NIBP machine

General tips

Blood pressure readings should be measured in a quiet, comfortable environment after the patient has become acclimated (i.e., without disturbance) for at least a few minutes, but acclimation is rarely possible for acutely or critically ill patients. Cats have good control of peripheral vasoconstriction and can become peripherally constricted under stress.

The patient should remain still in lateral recumbency during measurements to optimize accuracy. If necessary the patient can be restrained gently or have a towel placed over the head as a relaxation method. If the patient cannot be restrained in lateral recumbency because of agitation, respiratory distress, or other reasons, a standing BP can be obtained and a corrective equation used. Chemical restraint should be avoided.

The size of the cuff is important and should measure 40% of the appendage circumference in dogs and 30% in cats. Using a cuff that is too large will typically give falsely low blood pressure readings, while the opposite is true for a cuff that is too small.

Placement of the cuff is important. The most important thing is that the limb you use is at heart level whenever possible. Options for cuff placement when using the Doppler technique include mid-radius on the forelimb and proximal to the hock on the hindlimb. The base of the tail is also an effective site in small dogs and cats. For oscillometric techniques, place the cuff mid-radius on the forelimb, the mid-tarsus on the hindlimb, or the base of the tail. The cuff tubing is placed over the artery on all locations and methods. The transducer tubing will ideally be directed away from the patient and towards the monitoring device. The cuff should be placed at the most even and cylindrical portion of the appendages.

To acquire the most accurate blood pressure values, cuff height off the floor or table should be as close to the level of the right atrium as possible.

Do not secure the cuff with tape tightly, as this will restrict airflow to the cuff's bladder and cause inaccurate readings. A very loose piece can be used if absolutely necessary.

Do not place the cuff on a compromised limb or a limb with an arterial catheter, an IV catheter or a pulse Ox probe.

Technique

1. When using the Doppler unit, shave a small area on the posterior aspect of the paw, just above the largest pad on the front or hindlimb. If using the tail, shave a small area on the ventral aspect of the tail below where the cuff will be. When using the hindlimb, you can also shave and place the crystal over the more medial dorsal pedal artery. Apply a small amount of ultrasound conduction gel and use the Doppler crystal to find the clearest audible pulse. Secure the crystal head lightly with tape or hold still in place.
2. Using the sphygmomanometer, inflate the cuff until the pulse is no longer audible. Slowly release the pressure while listening for the first audible trace of the pulse to return and record this number. The first blood pressure measurement should be discarded.
3. Additional blood pressure measurements should be obtained for a minimum of 3 to 7 consecutive measurements. Consistent recordings with less than 20% variability are acceptable. Once these values have been obtained, they should be averaged to yield the blood pressure measurement.

If the patient is sitting or standing and the height difference between the cuff and the right atrium exceeds 10cm, subtract 0.8mmHg for every 1cm the cuff sits below the right atrium.

Example:

Initial systolic reading via Doppler or oscillometric reading was 160mmHg.

The top of the cuff is 23cm below the right atrium.

$$23\text{cm} \times 0.8\text{mmHg} = 18.4\text{mmHg}$$

Corrected value:

$$160\text{mmHg} - 18.4\text{mmHg} = 141.6\text{mmHg}$$

If oscillometric machines are used repeat steps 1-3 and record readings. Use corrected value equation if patient is standing or sitting.

4. Once a pressure is taken, record the cuff size, patient positioning, appendage used and placement of crystal in the medical record for future readings. Keeping the method consistent is key.