Blood Pressure Monitoring from a Nursing Perspective

PART 2: BLOOD PRESSURE MONITORING TECHNIQUES

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Systemic arterial blood pressure is created by the pumping action of the heart, circulating arterial blood volume, and the smooth muscle tone of blood vessel walls.

Arterial blood pressure is essential for adequate perfusion of tissues, delivering oxygen for energy demands. The ability to measure and monitor blood pressure trends provides important data about patient cardiovascular status and may help define approach to treatment.

Part 1 of this article series—Overview of Blood Pressure Monitoring (January/February 2015 issue)—discussed terms associated with blood pressure measurement, indications for measurement, and normal and abnormal blood pressure values. This second article describes types of blood pressure monitors and provides step-by-step instructions on performing blood pressure measurement.

MONITORING TECHNIQUES

Arterial blood pressure can be measured in 2 ways:

1. **Direct arterial blood pressure** (DABP) monitoring—considered the gold standard—uses an arterial catheter connected to a pressure transducer. This system allows continuous monitoring of patient systolic, diastolic, and mean arterial pressure (SAP, DAP, and MAP, respectively) and also simplifies collection of samples for arterial blood gas analysis. However, DABP monitoring is not used as frequently as other methods because an arterial catheter must be placed.

2. **Indirect arterial blood pressure** (IABP) monitoring relies on noninvasive detection of arterial blood flow or vessel wall movement in a peripheral artery and provides intermittent measurements of arterial blood pressure.

   IABP monitoring is the most frequently used technique in clinical practice; the most commonly used indirect methods are Doppler ultrasonography and oscillometric blood pressure monitoring. To obtain an IABP reading, a cuff is inflated over an artery until arterial blood flow is occluded. Normal arterial blood pressure values for adult dogs and cats are listed in Table 1.

INDIRECT BLOOD PRESSURE MONITORING: Doppler Ultrasonography

Doppler technology uses 10 MHz ultrasound waves to detect blood flow in a peripheral artery (Figure 1), which is then made audible via the probe/crystal and a speaker. The Doppler technique does not provide a measurement of MAP or DAP in small animals. While some studies have reported that Doppler readings may more closely reflect MAP than SAP in cats, the most recent study

<table>
<thead>
<tr>
<th>BLOOD PRESSURE VALUES</th>
<th>DOGS</th>
<th>CATS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic arterial pressure</td>
<td>90 to 140 mm Hg</td>
<td>80 to 140 mm Hg</td>
</tr>
<tr>
<td>Diastolic arterial pressure</td>
<td>50 to 80 mm Hg</td>
<td>55 to 75 mm Hg</td>
</tr>
<tr>
<td>Mean arterial pressure</td>
<td>60 to 100 mm Hg</td>
<td>60 to 100 mm Hg</td>
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</table>
was performed on healthy anesthetized cats. Therefore, most clinicians consider that Doppler readings in awake animals estimate SAP.

**Advantages**

Doppler ultrasonography has several advantages when compared with other blood pressure monitoring techniques; the technology is:

- Relatively easy to use, not requiring a great deal of expertise
- Affordable and readily available in most clinical settings
- Appropriate to use in patients with significant hypotension and cardiac arrhythmias
- Commonly used in small animals (cats, small dogs, rabbits, ferrets, other exotic species).

**Blood Pressure Measurement: Step by Step**

Table 2 lists the supplies needed for Doppler ultrasonographic blood pressure measurement.

1. Select a peripheral artery for Doppler probe placement; common locations include the dorsal pedal artery, digital artery, and coccygeal artery.
2. Clip the hair coat over the chosen artery, or wet it with alcohol, and apply ultrasound coupling gel to the Doppler probe.
3. Place the Doppler probe over the artery, oriented parallel to blood flow (Figure 2); the probe is considered correctly placed when pulsatile blood flow is audible.
4. Connect a pressure cuff to a sphygmomanometer and place the cuff proximal to the Doppler probe.
5. Inflate the cuff until the artery is occluded and Doppler sounds are no longer audible; then slowly deflate the cuff, while observing the sphygmomanometer.
6. Record the pressure at which the first audible arterial pulse is heard as the SAP.
7. Obtain several consecutive measurements; average the middle 3 readings, and record the average as the SAP. Make sure to use the same limb and same size cuff for serial blood pressure measurements.

**Preventing Inaccurate Results**

Several factors can result in erroneous readings:

- Cuff size is critically important to obtain accurate Doppler readings.
- A cuff that is too large falsely decreases the reading.

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**TABLE 2. Required Supplies for Doppler Measurement**

- Clippers or alcohol for either clipping or wetting hair
- Doppler unit and sphygmomanometer
- Ultrasound coupling gel
- Inflatable cuff, the width of which should be:
  - In dogs, 40% of the limb circumference
  - In cats, 30% of the limb circumference
- Rubber tubing, which connects inflatable cuff and sphygmomanometer
- Earphones, if it is difficult to hear the Doppler signal
A cuff that is too small falsely elevates the reading.

- Patients must be held/restrained during Doppler measurements; however, this handling may increase the animal’s blood pressure.
- Patient position during Doppler measurement can contribute to inaccurate readings; ideally, patients should lie in lateral recumbency, with the cuff positioned on the limb at the level of the right atrium.1,4
- Obtaining Doppler measurements in patients with severe peripheral vasoconstriction (hypovolemia, shock, significant hypothermia) can be difficult; therefore, accuracy of readings in these patients can be affected by degree of vasoconstriction.3,4

**INDIRECT BLOOD PRESSURE MONITORING:** Oscillometric Measurement

Oscillometric measurement (Figure 3) provides values for SAP, MAP, DAP, and pulse rate; therefore, this type of blood pressure monitoring provides more information than Doppler measurement.1,3,4 Most oscillometric devices measure the MAP; then calculate the SAP and DAP via programmed algorithms; therefore, the MAP is the most reliable reading.4

Advantages
Oscillometric blood pressure measurement has several advantages over Doppler methodology; the:

- Process is more automated, requiring less technical skill; the operator simply chooses the appropriate cuff size, places it on the patient, and hits the start button
- Monitors can be programmed to measure blood pressure at timed intervals (e.g., Q 15 min)
- Automated nature of measurement helps ensure that elevated values are less likely a result of stressful patient handling.1,4

Disadvantages
However, oscillometric techniques tend to be less accurate in patients;3,4
- Under 5 kg
- With cardiac arrhythmias, significant tachycardia or bradycardia, vasoconstriction, or hypothermia
- That are moving or shivering.

Blood Pressure Measurement: Step by Step

1. Place the cuff—attached to an oscillometric monitor—on a distal artery; common locations for oscillometric cuff placement are similar to those used for Doppler blood pressure measurement.
2. Once the device is started, the cuff automatically inflates to a pressure that occludes arterial blood flow.
3. As the cuff is deflated, the arterial wall oscillations increase at SAP, maximize at MAP, and decrease at DAP.4
4. The oscillometric monitor display will show numeric values for SAP, MAP, and DAP as well as pulse rate.
5. Compare the oscillometric pulse rate with a manually obtained pulse rate to determine accuracy: if the rates do NOT match, it is likely that the blood pressure readings on the monitor are inaccurate.

**DIRECT BLOOD PRESSURE MONITORING**

In general, DABP monitoring (Figure 4 and Figure 5, page 96) is indicated for any critical patient, but specific indications in the clinical setting include patients:

**Preventing Inaccurate Results**

As discussed in the **Indirect Blood Pressure Monitoring:** Doppler Ultrasonography section:

- Selection of an appropriately sized cuff is crucial to obtaining accurate values; cuff selection is outlined in Table 2.
- To ensure accuracy, it is important to take several consecutive readings; then compare the readings to ensure that the values are reproducible.
- Ideally, the same size cuff and same limb should be used for all consecutive blood pressure measurements.
• Presenting in hypovolemic or septic shock
• In congestive heart failure, especially when receiving powerful vasodilator medication for purpose of afterload reduction
• Requiring vasopressors or mechanical ventilation
• Receiving medication for severe hypertension
• Demonstrating a high anesthetic risk.

DABP monitoring is NOT indicated in healthy, ambulatory patients because these patients are more likely to disconnect an arterial line, or remove the arterial catheter, increasing the risk for arterial hemorrhage.

**Advantages**

DABP has many advantages over other methods of blood pressure monitoring. Two of the most important advantages include:

• “Real-time” monitoring of blood pressure and blood pressure trends, even in extremely hypotensive patients; this up-to-the-minute information about a patient’s hemodynamic status enables clinicians to gauge whether a specific therapy is working or if additional, immediate intervention is necessary.
• Handling and restraint of the patient is usually limited to the initial arterial catheter placement; therefore, DABP values are less prone to falsely elevated readings related to stress of restraint and handling.

**Disadvantages**

However, DABP monitoring is not used extensively because it has several drawbacks:

• The equipment necessary to monitor DABP (e.g., pressure transducers, hemodynamic monitors) can be cost prohibitive, especially when not used frequently.
• Arterial catheters are invasive, and arterial access can be technically difficult to obtain and maintain.
• Complications that can result from arterial catheterization include bleeding from the catheter insertion site, hematoma formation, significant hemorrhage if the system becomes disconnected, infection, and arterial thrombosis with possibility of necrosis of the tissues distal to the catheter.

**Blood Pressure Measurement: Step by Step**

Table 3 lists the supplies needed for DABP measurement (Figure 6).

1. Place and secure an arterial catheter; common sites for arterial catheterization include the dorsal pedal artery, coccygeal artery (Figures 7 and 8), and medial auricular artery.1,2
2. Once the arterial catheter is placed and secured, connect it to the DABP monitoring system.
3. At one end of the system—the end farthest away from the patient—a fluid administration set is connected to a heparinized bag of 0.9% sodium chloride (Table 3).
4. Pressurize the fluid bag to a range between 250 and 300 mm Hg: the goal is to achieve a pressure
in the fluid bag greater than the patient’s systolic pressure, which prevents back flow of arterial blood into the monitoring system.1,2
5. The fluid bag tubing connects to a pressure transducer, which is connected by a cable to the physiologic monitor, mounted on a board placed at the level of the patient’s heart. At the other end of the transducer, semi-rigid tubing connects to the arterial catheter’s T-set.
6. Once the pressure transducer is connected to the monitor, zero it at the level of the patient’s right atrium. Once zeroed, the pressure transducer converts the pressure changes in the artery to an electrical signal that is displayed on the monitor as a pressure wave form; numeric values for SAP, MAP, and DAP are also displayed.1
7. Flush the DABP monitoring system with heparinized saline before connecting it to the patient.
8. Supervise patients with arterial catheters at all times and carefully care for the catheter:
   • Clearly label the catheter, allowing easy identification as arterial rather than venous and, thereby, alerting personnel NOT to administer medications through the catheter.
   • Rewrap the catheter, at a minimum, once daily; rewrap soiled catheters promptly.
   • While the catheter is unwrapped, evaluate the insertion site for redness, warmth, swelling, pain, or discharge; remove catheters that are painful or oozing from the insertion site.
   • Document when the catheter is rewrapped and note the appearance of the insertion site in the medical record.
   • Consider putting an E-collar on patients to prevent access to arterial catheters.
   • Do NOT maintain arterial catheters in cats for longer than 6 to 12 hours owing to increased risk for arterial thrombosis.

Preventing Inaccurate Results
Although DABP is considered the gold standard in blood pressure monitoring, a number of situations can cause erroneous readings, which can be prevented by:
• Using only semi-rigid tubing to connect the pressure transducer to the patient—the use of compliant tubing results in excessive damping of the pressure wave, causing inaccurate readings
• Ensuring air bubbles are not present in the system
• Checking the semi-rigid tubing for kinks
• Making sure the pressure bag is inflated to at least 250 mm Hg
• Reassessing the transducer level; if the transducer is displaced, replace it to approximately the level of the right atrium and zero to the patient
• Ensuring that the arterial catheter is patent; flush the arterial catheter if needed.

### TABLE 3.
Required Supplies for DABP Measurement

- Arterial catheter
- T-set primed with heparinized saline
- DABP transducer system primed with heparinized saline
- Transducer cable
- Physiologic monitor that displays DABP wave form and numeric values for SAP, DAP, and MAP
- 250-mL bag of heparinized saline (1 U heparin/1 mL 0.9% sodium chloride)
- Pressure bag
- Board for stabilization of the transducer

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FIGURE 7. Patient with coccygeal arterial catheter; note that arterial catheters should not be maintained in cats for longer than 6 to 12 hours owing to risk for arterial thrombosis.

FIGURE 8. Close-up image of coccygeal arterial catheter in a cat.

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IN SUMMARY

Veterinary nurses play a fundamental role in patient care. Appropriately monitoring patient blood pressure, documenting results, interpreting them, and communicating changes and concerns to the clinician provides all members of the veterinary team with an opportunity to proactively manage potential problems.

DABP = direct arterial blood pressure; DAP = diastolic arterial pressure; IABP = indirect arterial blood pressure; MAP = mean arterial pressure; SAP = systolic arterial pressure

References

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