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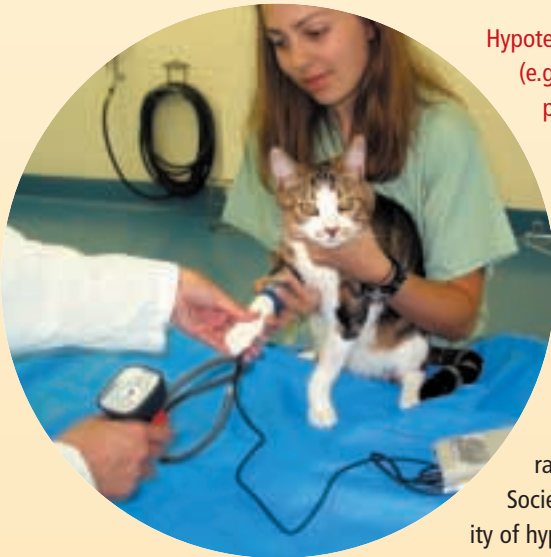
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# Measuring Blood Pressure

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## Overview

The principal function of the cardiovascular system is to generate the appropriate amount of intravascular pressure to ensure adequate tissue perfusion. In clinical practice, we can measure pressure within systemic arteries (commonly referred to as blood pressure, or BP) or within central systemic veins (central venous pressure). While central venous pressure has the strongest correlation with body fluid volume, arterial pressure is the driving force for tissue blood flow. As with most physiologic parameters, control systems normally regulate BP within an appropriate range, referred to as normal BP. If BP falls too low (i.e., systemic hypotension) organ perfusion may be inadequate; if it rises too high (i.e., systemic hypertension) organs may be overperfused or undergo barotrauma.



Hypotension is a frequent complication of anesthesia, some drugs or toxins, various forms of shock (e.g., hemorrhagic), and severe dehydration. On the other hand, systemic hypertension (i.e., high pressure within systemic arteries) is often observed in dogs or cats with kidney disease and hyperthyroidism as well as other metabolic conditions. To properly manage these conditions, it is becoming increasingly important for veterinarians to measure BP. Further, a diagnosis of systemic hypertension should always be based on determination of systemic arterial blood pressure. Antihypertensive agents should not be used unless reliable measurements of BP indicate the need.

## What Is Normal BP?

The definition of "normal" in the context of blood pressure is a difficult question. The Veterinary Blood Pressure Society has suggested interpretation of BP in light of clinical and laboratory findings. Species, gender, and age may also be considered in evaluating a patient's BP. The Society suggests that elevation (or depression) of BP causes a risk that is directly related to the severity of hypertension (or hypotension). Thus, BP that exceeds 150/95 mm Hg poses some risk for hypertensive end-organ injury, and intervention should be considered; values above 180/120 mm Hg pose a high risk and intervention (e.g., administration of a pharmacologic antihypertensive agent) is clearly indicated. Similarly, BP below 100/60 poses some risk for reduced organ perfusion; values below 70/40 pose a high risk that mandates intervention (e.g., intravenous fluid therapy and/or reduction of dosage of anesthetic agent).

## Patient Selection

There is no sufficient rationale for routinely measuring BP in all patients. Hypotension may be present in anesthetized animals as well as those with suspected or confirmed cardiovascular diseases, such as heart failure, arrhythmias, shock, or excessive hemorrhage. Hypertension is often suspected in dogs and cats that present with clinical diseases associated with hypertension or with clinical findings compatible with end-organ injury from high BP (Table). Because of the high prevalence of certain occult diseases in elderly patients, routine screening of geriatric dogs and cats is an appropriate consideration. We will focus on the measurement of BP in conscious animals as would be done in screening for systemic hypertension. The same general principles apply to the diagnosis of hypotension in anesthetized or critical care patients.

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# How to Measure Blood Pressure

**B**lood pressure may be measured directly or indirectly. While direct measurement is the "gold standard," this technique has several drawbacks: It is technically difficult in unsedated dogs and cats; may be painful; and complications, such as hematoma formation, are more likely to occur. Indirect techniques are more easily applied to a clinical setting; such techniques require less restraint and are technically easier to do.

Indirect methods of blood pressure measurement include auscultatory, ultrasonic Doppler, oscillometric, and plethysmographic (See Aids & Resources, page 80). All of these indirect techniques use an inflatable cuff wrapped around an extremity. Pressure in the cuff is measured with manometer or pressure transducer. A squeeze bulb or automated device inflates the cuff to a pressure exceeding systolic blood pressure, thus occluding the underlying artery. Changes in arterial flow are

detected by one of several means as the cuff is gradually deflated; the value for cuff pressure at various levels of deflation is then correlated with systolic, diastolic, and/or mean blood pressure. This detection method varies among the different indirect devices.<sup>1</sup>



## Doppler

Doppler flowmeters detect blood flow as a change in the frequency of reflected sound (Doppler shift) due to the motion of red blood cells. Blood pressure is read by the operator from an aneroid manometer connected to the occluding cuff, which is placed proximal to the Doppler transducer. These devices use a detection unit, cuff, ultrasonic probe transducer, and aneroid manometer (Figure 1). The probe must be separately positioned distal to the cuff on the same limb (Figure 2). Doppler flowmeters are more reliable for measurement of systolic than diastolic BP.



## Oscillometric

Devices using the oscillometric technique (Figure 3) detect pressure fluctuations in the occluding cuff resulting from the pressure pulse. Machines using the oscillometric technique use a detection unit and cuff and generally determine systolic, diastolic, and sometimes mean BP as well as pulse rate.<sup>1</sup>

### Indications for Screening Dogs or Cats for Systemic Hypertension

- Acute or chronic kidney disease
- Hyperthyroidism (especially cats)
- Hyperadrenocorticism
- Diabetes mellitus (especially dogs)
- Hyperaldosteronism
- Pheochromocytoma
- Marked obesity
- Advanced age (dogs and cats > 10 years)
- Clinical findings compatible with hypertensive end-organ injury, such as
  - Blindness, retinal vascular tortuosity or hemorrhage, retinal detachment, hyphema
  - Seizures, ataxia, sudden collapse
  - Dyspnea, unexplained left ventricular hypertrophy or gallop rhythm
  - Proteinuria or low urine-specific gravity

The Doppler devices are generally easier to use and less expensive. However, they normally provide a reliable value for only systolic BP, often require two technicians to measure BP, and do not cycle automatically (Automatic cycling is useful in anesthetized or immobile critical care patients.). The choice of unit ultimately depends on the needs and preferences of the individual practice; a device should be evaluated on a trial basis for 4 to 6 weeks before a purchase is made.

### Site of Pressure Measurement

The cuff may be placed around the brachial, median, cranial tibial, or medial coccygeal arteries. For the Doppler technique, the cuff is usually placed over the median artery and the transducer is placed ventrally between the carpal and metacarpal pad<sup>1</sup> (Figure 4). Clipping hair and applying acoustic gel at the site of transducer placement may enhance the signal. It is often easier to hold the transducer in place, if the animal tolerates this. Alternatively, the transducer may be taped in place with 1 inch of white adhesive tape.

### Patient Positioning

The best position is the one in which the animal is most comfortable. Lying immobile in a relaxed position is preferred. However, some animals prefer to lie (Figure 8) or sit (Figure 9) on the examination table or in their owner's lap. The keys to patient positioning are that the patient should be in a sustainable, comfortable position; the extremity being cuffed must be readily accessible, relaxed in a natural position, and immobile; and stress should be minimized to the extent possible.



Since Doppler devices often make sounds that may alarm animals (especially cats), ear-phones should be used. For the oscillometric technique, the brachial (Figure 5) or coc-

cygeal (Figure 6) arteries in cats and the median (Figure 7) or coccygeal artery in dogs seem to provide the most reliable readings.

The cuff should be placed at, or close to, the level of the aortic valve. If this cannot be done, an adjustment should be made for gravitational effect, with a 1.0-mm Hg change in blood pressure expected for each 1.3 cm of vertical distance between the level of the cuff and the level of the aortic valve (placing a cuff below heart level artificially raises the measurement). However, this adjustment is generally necessary for only large-breed dogs.

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#### PROCEDURE PEARL

BPs above 180/120 mm Hg or below 70/40 pose a high risk, and intervention is clearly indicated.

**PROCEDURE PEARL**

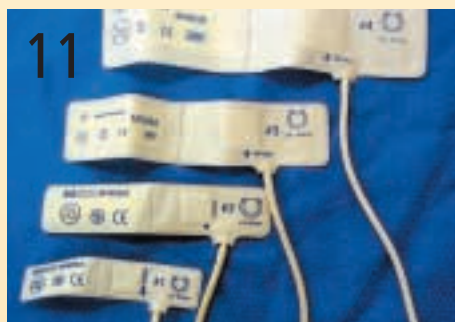
Important considerations for patient positioning include making sure the animal is in a sustainable, comfortable position, with the extremity being cuffed readily accessible, relaxed in a natural position, and immobile. Stress should be reduced to the extent possible.



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**Cuff Choice**

There are many cuff choices (Figure 10), with cuff width being the most important characteristic. The site of cuff placement should be carefully measured, and cuff width should be 30% to 40% of limb circumference. An oversized cuff may give erroneously low recordings; an undersized cuff yields falsely high readings. Many cuffs indicate which side should face the patient, cuff size (a number), cuff width (in mm), portion of the cuff to place over the artery, and/or the range of limb circumferences for which the cuff should be used (Figure 11).



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**Anxiety-Induced Artifact**

The visit to the veterinary clinic, restraint, noises, odors, and other unusual stimuli may induce anxiety and falsely elevate the BP measurement. Anxiety may be minimized by obtaining BP measurements before a physical examination or other manipulations to which the animal may object; taking all measurements in a quiet room in a calm, reassuring manner; and allowing the animal to acclimate to its surroundings for at least 5 (and preferably 15) minutes before obtaining measurements. If possible, the owner should be present.

**PROCEDURE PEARL**

Width is the most important consideration in choosing a cuff.

**Blood Pressure Measurement Technique**

The same individual (preferably a technician with a calm demeanor) should perform all BP measurements following a standard, written protocol. Measurements should be obtained only in a calm, minimally restrained, and motionless patient. Regarding choice of equipment, it is perhaps most important to use an indirect device with which the operator has

experience and confidence (often developed by practice on healthy animals presented for vaccination).

Use a cuff of appropriate width; choice of site depends on operator preference and patient comfort. The operator should obtain at least 5 to 7 consistent measurements (< 20% variation in systolic readings) from the first cuff placement. The cuff should be removed and replaced. An additional five to seven consistent measurements should be taken from the second placement. Repositioning should be repeated as often as necessary until results agree.

The first value from each cuff position is discarded; then an average of all other values is calculated. Alternatively, all values can be averaged after the first, highest, and lowest readings are discarded. The overall average is considered the final value. If in doubt, the entire process should be repeated on another day or later the same day. A diagnosis of systemic hypertension should never be based solely on a single BP measurement session. Measuring BP is a complex process and requires at least 15 minutes under ideal circumstances and perhaps 45 minutes or more in difficult cases.

**Records**

All pertinent data—measurements, the method of determining averages, cuff size and site, position of animal, device used, name of individual taking the measurements, and attitude of patient during measurement—should be recorded for future reference. It is generally best to create a special form to assure completeness of records. For comparative purposes, the same device and site for cuff placement should be used each time the patient is evaluated. ■

See Aids & Resources, back page, for references, contacts, and appendices.