Patients with hypertension (HT) are often subclinical or demonstrate clinical signs corresponding to another underlying disease process. However, chronically sustained HT can damage the eyes, kidneys, brain, and cardiovascular system; injuries referred to as target-organ damage (Table 1). The rationale for treating hypertension in dogs and cats is to minimize or prevent these injuries.

MEASUREMENT OF SYSTEMIC ARTERIAL BLOOD PRESSURE
Diagnosis and management of HT in dogs and cats should be based on the patient’s blood pressure (BP) measurement.

Selecting Patients
Routine screening of selected patients, rather than a general screening program, is recommended. While idiopathic HT occurs in dogs and cats, HT associated with concurrent clinical disease is the most common form in veterinary patients. The diseases most often associated with HT include:

- Chronic or acute kidney disease
- Hyperthyroidism
- Hyperadrenocorticism
- Diabetes mellitus
- Pheochromocytoma
- Hyperaldosteronism.
### Table 1. Target-Organ Damage Caused by Systemic Hypertension

<table>
<thead>
<tr>
<th>Target Organ</th>
<th>Target-Organ Damage</th>
<th>Appropriate Assessment Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brain</td>
<td>• Depression</td>
<td>Complete neurologic examination</td>
</tr>
<tr>
<td></td>
<td>• Seizures</td>
<td></td>
</tr>
<tr>
<td>Eyes</td>
<td>• Retinal detachment</td>
<td>Complete ocular examination (See Ten Tips to Improve Your Ophthalmology Skills, July/August 2011)</td>
</tr>
<tr>
<td></td>
<td>• Hemorrhage</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Vessel tortuosity</td>
<td></td>
</tr>
<tr>
<td>Heart &amp; blood vessels</td>
<td>• Left ventricular hypertrophy</td>
<td>Auscultation, ECG, thoracic radiographs, cardiac ultrasound</td>
</tr>
<tr>
<td></td>
<td>• Congestive heart failure</td>
<td></td>
</tr>
<tr>
<td>Kidney</td>
<td>• Renal azotemia</td>
<td>Blood creatinine, urine protein:creatinine ratio</td>
</tr>
<tr>
<td></td>
<td>• Proteinuria</td>
<td></td>
</tr>
</tbody>
</table>

ECG = electrocardiogram
Measurement of BP in patients with these conditions is recommended. As many diseases associated with HT occur in older animals, measurement of BP can be part of a geriatric screening profile, typically in dogs and cats over 8 years of age.

Medications may also cause secondary HT, with erythropoietin and corticosteroid administration being potential contributors.

Cuff Choice & Placement
Cuff choice and placement are important. The width of the chosen cuff should be 30% to 40% of the circumference of the measurement site (Figure 1). Most cuffs have an artery arrow imprinted on them, which does not need to be pointed in the direction of blood flow. However, the arrow should overlie the anatomic site of the vessel in the extremity.

Sites most commonly used in dogs and cats include:
- Tail (where the median caudal artery lies ventrally)
- Antebrachium (where the median artery and its branches are medial)
- Tarsus (where there are numerous ventral, dorsal, and arterial branches).

All of these sites provide comparable readings with choice dependent on animal comfort and operator preference. It is ideal for the cuff to be located at the level of the base of the heart because each 1 cm of distance the cuff lies below the heart base causes an artifactual increase of 0.7 mm Hg in the measurement result. In most patients and measurement positions, this artifact is not clinically important.

Measurement Devices
Most commonly, devices that indirectly measure blood pressure are utilized. These devices are usually based on Doppler (Figure 2) or oscillometric (Figure 3) principles. Doppler ultrasonic devices are most commonly used to screen for HT, but choice of measurement device depends on operator experience and preference.

Blood Pressure Results
It is important to recognize that screening for HT should be conducted in a calm, awake animal in a quiet environment by trained personnel. If the animal is distressed, anxious, or struggling during the measurement session, an artifactual increase in BP, referred to as “white-coat HT” can occur. Such measurements are considered unreliable.

At least 5 measurements should be taken. The readings giving the highest and lowest value for systolic BP should be discarded with the final result determined as the average of the remaining 3 or more values, as long as these remaining systolic BP results are within 20 mm Hg. If the remaining systolic BPs differ by more than 20 mm Hg, the measurement session should be repeated.
The following should all be recorded:
• Animal’s position and attitude
• Cuff size and measurement site
• Cuff site circumference (cm)
• Results of all BP measurements
• Rationale for excluding values
• Final (mean) result
• Interpretation of the result by the veterinarian

It is customary to conduct at least 2 measurement sessions, separated by 30 minutes or more, before concluding that an animal is in need of antihypertensive therapy.

TREATMENT OF HYPERTENSION
The initial assessment of an animal suspected to have HT should include:
• Recognizing conditions that may be contributing to an increase in BP
• Identifying and characterizing target-organ damage
• Determining if there are any concurrent conditions that may complicate antihypertensive therapy (eg, heart or kidney disease).

Because HT is often a silent, slowly progressive condition requiring vigilance and life-long therapy, it is important to be absolutely certain about the diagnosis. A decision to use antihypertensive drugs should be based on the BP stage (Table 2) and integration of all clinically available information. The ultimate goal of therapy is to minimize target-organ damage while providing a good quality of life.

Which Patients to Treat
In people, any reduction of BP that does not produce overt hypotension lowers the risk of target-organ damage. This finding remains to be confirmed in dogs and cats but both the American College of Veterinary Internal Medicine (ACVIM) Hypertension Consensus Panel3 and the International Renal Interest Society (IRIS)4 recommend that BP be categorized on the basis of risk of future target-organ damage (Table 2).

Although interbreed differences in BP exist in dogs, only the difference for sighthounds (20 mm Hg higher values for each category) mandates separate categorization at present.

The general consensus is to institute therapy in a patient with evidence of target-organ damage (Table 1) if reliable measurements of BP indicate that systolic BP (SBP) exceeds 160 and/or diastolic BP (DBP) exceeds 100 mm Hg (AP2 or AP3).

Antihypertensives
Antihypertensive therapy must be individualized to the patient and concurrent conditions. Regardless of the initial BP, the ideal goal of therapy would be to reduce the risk of future target-organ damage to substage AP0 (SBP < 150 and/or DBP < 95 mm Hg).3,4 The response to effective antihypertensive therapy is typically a 25 to 50 mm Hg decline in BP. The minimal goal is to reduce the risk for target-organ damage by lowering the patient to a new stage.

In a hypertensive crisis, where severe ocular or central nervous system target-organ damage is present, emergency treatment requires immediate reduction in BP. However, in other circumstances, BP reduction should be achieved with gradual, persistent lowering of BP over several weeks.

Table 2. International Renal Interest Society Staging: Risk for Future Target-Organ Damage*

<table>
<thead>
<tr>
<th>Blood Pressure Substage</th>
<th>Systolic Blood Pressure</th>
<th>Diastolic Blood Pressure</th>
<th>Risk for Target-Organ Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>AP0</td>
<td>&lt; 150</td>
<td>&lt; 95</td>
<td>None or minimal</td>
</tr>
<tr>
<td>AP1</td>
<td>150 – 159</td>
<td>95 – 99</td>
<td>Low</td>
</tr>
<tr>
<td>AP2</td>
<td>160 – 179</td>
<td>100 – 119</td>
<td>Moderate</td>
</tr>
<tr>
<td>AP3</td>
<td>≥ 180</td>
<td>≥ 120</td>
<td>High</td>
</tr>
</tbody>
</table>

*The patient’s BP stage should be selected as the higher of the 2 assessments if reliable measurements provide different risk assessments based on the patient’s systolic and diastolic BPs.
Dogs with Hypertension

- The initial therapeutic choice is often an angiotensin-converting enzyme inhibitor (ACEI). The starting dosage should be at or above the lower end of the recommended range (Table 3).
- The upper limit of the recommended dosage for ACEIs is controversial as some experts will stop at this dosage and consider adding a different agent, typically a calcium channel blocker (CCB), while others will increase the ACEI dosage further.
- If an antihypertensive agent of choice is only partially effective, the usual approach is to increase the dosage and, if still ineffective, then add another drug. While not ideal, many dogs with significant hypertension will require more than 2 agents.
- Certain disease conditions may be best addressed by adding specific classes of agents to the ACEI/CCB combination, such as:
  - Alpha- (e.g., phenoxybenzamine) and beta-blockers (e.g., atenolol) or surgical excision for pheochromocytoma
  - Aldosterone-receptor blocker (e.g., spironolactone) or surgical excision for primary hyperaldosteronism.
- Diuretics (e.g., hydrochlorothiazides) are not commonly used, but may be useful, especially in patients with concurrent hypertension and nephrotic syndrome.
- Angiotensin-receptor blockers represent a newer class of agents that block the binding of angiotensin II to its receptors, having similar overall effects to ACEIs. At this time, the effects and safety profiles of these drugs in dogs and cats are not well known. However, dosage recommendations are available for dogs (Table 3).

Cats with Hypertension

- In cats with HT, the principles are as for dogs, though the initial therapeutic choice should be a CCB, typically amlodipine.
- Second choice agents, particularly in proteinuric cats, would be an ACEI.
- Beta-blockers (e.g., atenolol) have fallen out of favor for initial treatment of HT in people due to poor outcomes in several clinical trials. Their use in veterinary patients has most often been for hyperthyroid cats because they antagonize the effects of elevated heart rate and cardiac output. One study found that atenolol decreased systolic blood pressure in 70% of hyperthyroid cats but did not reliably decrease pressure into the minimal or moderate target organ damage risk category.
- Many experts recommend a CCB as initial therapy in hyperthyroid cats with HT, adding a beta-blocker if additional antihypertensive efficacy is needed.
- It is important to remember that hyperthyroid cats are more likely to have HT after therapeutic intervention to lower their thyroid hormone levels, perhaps due to an associated worsening of renal function.

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**Table 3. Oral Agents for Antihypertensive Therapy for Dogs and Cats**

<table>
<thead>
<tr>
<th>Class</th>
<th>Drug</th>
<th>Usual Oral Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Dogs</td>
</tr>
<tr>
<td>Aldosterone antagonist</td>
<td>Spironolactone</td>
<td>1–2 mg/kg Q 12–24 H</td>
</tr>
<tr>
<td>Alpha-1 blocker</td>
<td>Prazosin</td>
<td>0.5–2 mg/kg Q 8–12 H</td>
</tr>
<tr>
<td></td>
<td>Phenoxybenzamine</td>
<td>0.25 mg/kg Q 8–12 H or 0.5 mg/kg Q 24 H</td>
</tr>
<tr>
<td>Angiotensin-converting enzyme inhibitor (ACEI)</td>
<td>Benazepril, enalapril</td>
<td>0.5–2 mg/kg Q 12 H</td>
</tr>
<tr>
<td>Angiotensin-receptor blocker</td>
<td>Losartan, irbesartan</td>
<td>0.5–1 mg/kg/D or 1–5 mg/kg Q 12–24 H</td>
</tr>
<tr>
<td>Beta-blocker</td>
<td>Atenolol</td>
<td>0.25–1 mg/kg Q 12 H</td>
</tr>
<tr>
<td>Calcium channel blocker (CCB)</td>
<td>Amlodipine</td>
<td>0.1–0.75 mg/kg Q 24 H</td>
</tr>
<tr>
<td>Direct vasodilator</td>
<td>Hydralazine</td>
<td>0.5–2 mg/kg Q 12 H (start at 0.5 mg/kg)</td>
</tr>
<tr>
<td></td>
<td>Acepromazine</td>
<td>0.5–2 mg/kg Q 8 H</td>
</tr>
<tr>
<td>Thiazide diuretic</td>
<td>Hydrochlorothiazide</td>
<td>2–4 mg/kg Q 12–24 H</td>
</tr>
</tbody>
</table>
Emergency Treatment for Hypertension

• An exception to the above gradual approach, where substantial time (weeks) is allowed between dosage adjustment, is animals with AP3 and evidence of severe or progressing neural or ocular target-organ damage.

• This generally constitutes an emergency, where combination therapy with an ACEI plus a CCB is an appropriate first step in dogs, and a CCB will often be used alone in cats.

• A direct vasodilator, such as nitroprusside or hydralazine, is an alternative treatment choice in hypertensive emergencies.

• The goal of emergency treatment in either species is to reduce BP within hours to slow rapidly progressing ocular or neural target-organ damage, adjusting dosages within that time frame as necessary.

Dietary Considerations

While available evidence suggests sodium restriction alone generally does not reduce BP, high salt intake may produce adverse consequences in some settings. Therefore, low-salt diets are recommended for hypertensive patients.

MONITORING ANTIHYPERTENSIVE THERAPY

In most situations, HT is not an emergency and 3 to 4 weeks should be allowed between dosage adjustments.

Initial Recheck

• A dog in IRIS Stage 1 or 2 chronic kidney disease (CKD) should be evaluated 3 to 14 days after any change in antihypertensive therapy.

• In unstable patients and those with IRIS Stage 3 or 4 CKD, this recheck should be conducted earlier, perhaps within 3 to 5 days.

• Patients deemed to be hypertensive emergencies and hospitalized patients, particularly those receiving fluid therapy or pharmacological agents with cardiovascular effects, should be assessed daily or several times daily depending on severity of crisis. The purpose of these short-term assessments is to identify findings that are unexpected (eg, new or worsening target-organ damage) or adverse effects (eg, marked worsening of azotemia or systemic hypotension).

Clinical findings of weakness or syncope coupled with a BP < 110/60 mm Hg indicates systemic hypotension and therapy should be adjusted accordingly. Hypotension is uncommon if the initial diagnosis of HT was correct.

There has been some concern about acute exacerbation of azotemia with ACEI therapy, but this is unusual and modest increases in blood creatinine concentration (< 30%) are generally tolerable.

Further Evaluation

Re-evaluation is appropriate at 1 to 4 month intervals, depending on stability (more frequent if BP or other conditions are unstable) and degree of hypertension (more frequent if BP remains > 180 mm Hg).

Follow-up evaluations to assess efficacy and adjust therapy should include:

• Assessment of BP

• Blood creatinine concentration

• Urinalysis with quantitative assessment of proteinuria

• Funduscopic examination

• Any other specific evaluations depending on circumstances (eg, target-organ damage, causes of secondary hypertension, concurrent conditions).

A key predictive indicator of antihypertensive efficacy is its effect on proteinuria: a benefit is predicted if the antihypertensive regimen is antiproteinuric (eg, normalizes the urine protein:creatinine ratio to < 0.2 or reduces the ratio by at least 50%).

The frequency and nature of re-evaluations will vary depending on:

• BP stage

• Stability of BP

• Other aspects of the health of the patient

• Frequency of dosage adjustment to antihypertensive therapy.

Since signs of progression of target-organ damage can be subtle, BP should be closely monitored over time in patients receiving antihypertensive therapy, even when HT is seemingly well-controlled.

For further information on staging chronic kidney disease, visit iris-kidney.com/pdf/IRIS2009_Staging_CKD.pdf

ACEI = angiotensin-converting enzyme inhibitor;
BP = blood pressure; CCB = calcium channel blocker;
CKD = chronic kidney disease;
DBP = diastolic blood pressure; HT = hypertension;
IRIS = International Renal Interest Society;
SBP = systolic blood pressure

References


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