**Albuterol is a synthetic adrenergic agonist that is selective for β<sub>2</sub>-receptors found on the surface of smooth muscle cells, skeletal muscle cells, and hepatocytes. Albuterol is available as a prescription medication for the treatment of bronchospasm and the prevention of exercise-induced bronchospasm in humans. It is available in tablet, extended-release tablet, aerosol, powder, and solution formulations. The aerosol formulations also contain fluorocarbon or chlorofluorocarbon propellants. Common trade names are Proventil® (Schering), Ventolin® (GlaxoSmithKline), Volmax® (Muro Pharmaceutical), and Airet® (Adams Laboratories).**

Pets are usually exposed to albuterol medications by gaining access to medication containers. Dogs in particular will chew or bite into albuterol aerosol canisters. In some cases, owners will inadvertently dose their pets with their own medication. In veterinary medicine, albuterol is used to treat bronchospasm and cough in dogs and cats and as a bronchodilator in horses.

As a selective β<sub>2</sub> agonist, albuterol has relatively few serious adverse effects at therapeutic doses. Albuterol loses selectivity when overdoses occur and β<sub>1</sub> effects can be seen. Albuterol overdoses are capable of causing severe hypokalemia and dysrhythmias. All cases of albuterol overdose warrant prompt decontamination when appropriate and close monitoring for a minimum of 12 hours postexposure.

**DIAGNOSTIC CRITERIA**

**Historical Information**

**Gender Predisposition:** No known gender predisposition.

**Age Predisposition:** Although there is no known age predisposition, younger animals may be at higher risk of exposure due to their innate curiosity.

**Breed Predisposition:** No known breed predisposition.

**Owner Observations:**
- Panting.
- Excessive thirst.
- Mild vomiting.
- Reddened or glazed eyes.
- Mild to moderate agitation.
- Shaking.
- Weakness (in dogs).

Owners frequently report suspicion of an elevated heart rate from visually observing the chest wall. Onset of action is usually rapid. Clinical signs may be observed within minutes of exposure. Occasionally, onset of action may be delayed (hours) following ingestion of extended-release tablets.

**Other Historical Considerations/Predispositions:** Animals with preexisting heart disease, geriatric animals, and debilitated animals may be at risk of developing more severe cardiovascular effects than those expected from healthy adult individuals. Concurrent administration of other sympathomimetic drugs may exacerbate the adrenergic effects of albuterol.

**Physical Examination Findings**

- Tachycardia is the most common finding and may be mild to severe. Heart rates of up to 300 bpm have been reported by veterinarians treating albuterol overdoses in dogs.
- Mild to moderate tachypnea is also common.
- Mild to moderate central nervous system (CNS) depression may be noted on physical examination.
- Hyperactivity or agitation is seen in some cases of albuterol overdose.
- Mild muscle tremors or fasciculations are possible.
- Weakness and evidence of hypotension, such as weak pulses and cerebral depression, may be seen.
- Premature ventricular contractions have been reported in some cases of albuterol overdose. The chlorofluorocarbon propellants in some albuterol inhalers have
been found to sensitize the heart to the arrhythmogenic effects of \( \beta \) agonists such as albuterol.

- Conjunctivitis and injected scleral vessels have been reported in some cases of albuterol inhaler exposure and may be secondary to peripheral vasodilation.
- Rarely, pulmonary edema, ruptured chordae tendineae, and death have been associated with albuterol exposure.

**Laboratory Findings**

- Mild to severe hypokalemia may be seen following albuterol overdose (normal range for dogs and cats is 3.6–5.6 mEq/l).
- Hypomagnesemia has been noted in human and dog studies (normal range in dogs, 1.0–1.4 mg/dl; in cats, 1.7–2.3 mg/dl).

**Other Diagnostic Findings**

- Electrocardiogram should be monitored for arrhythmias such as premature ventricular contractions and evidence of hypokalemia such as a prolonged QT interval.
- Arterial blood pressure should be monitored for hypotension. The average systemic arterial blood pressures for dogs and cats are:
  - Systolic 125 mm Hg.
  - Diastolic 80 mm Hg.
  - Mean 100 mm Hg.
- Systolic pressures <90 mm Hg or mean blood pressure <60 mm Hg generally require aggressive treatment.

**Summary of Diagnostic Criteria**

- Evidence of exposure to or administration of albuterol.
- Clinical signs and physical examination findings consistent with albuterol overdose, especially tachycardia and tachypnea.
- A majority of cases develop hypokalemia.

**Differential Diagnoses**

Most animals present with tachypnea, weakness, and profound tachycardia. Occasionally, mild transient tremors or agitation may be noted. The differential list for an acute onset of this combination of signs in a normally healthy animal is limited. Differentials that may result in one or more of these signs include:

- Other \( \beta \)-adrenergic agents such as isoproterenol, levalbuterol, terbutaline, salmeterol, metaproterenol, and bitolterol. Exposure history is needed to identify the agent involved.
- Cardiomyopathy may be ruled out by identifying cardiomegaly on radiographs or by echocardiography.
- Thyrotoxicosis following ingestion of thyroid hormone supplements may cause profound tachycardia and tachypnea. Hypokalemia is not expected in these cases.
- Tachycardia may develop from atropine overdose. Atropine will cross the blood–brain barrier, and animals exhibit excitability and dementia that is not expected with albuterol.

**TREATMENT RECOMMENDATIONS**

**Initial Treatment**

**Decontamination**

- In cases of tablet ingestion in the asymptomatic patient, emesis may be induced in the first 10–15 minutes of exposure if pet owners have access to 3% hydrogen peroxide at home (owners can administer 1–2 ml/kg PO at home after a small meal).
- Emesis should not be induced if the exposure involved liquid, powder, or aerosol formulations due to their quick absorption and subsequent rapid onset of CNS depression.
- Gastric lavage may be helpful if performed within approximately 2 hours of ingestion if large numbers of tablets (which may clump in the stomach slowing absorption) are ingested.
- Activated charcoal (1–2 g/kg powder formulation mixed in a slurry, PO) should be administered if large numbers of tablets or any number of extended-release tablets are ingested. A cathartic should be administered with the activated charcoal. Sorbitol (3 ml/kg of a 70% solution) and magnesium sulfate (Epsom salts; \( \frac{1}{4} \) tsp/10 lb body weight) are examples of cathartics that may be administered with the activated charcoal or given shortly afterward.

**Treatment of Symptomatic Animals**

- Hypokalemia is the most common electrolyte abnormality detected following albuterol overdose. Potassium should be supplemented only after hypokalemia has been confirmed by checking serum potassium levels.
- Potassium levels can vary substantially over the course of the toxicosis, and there is a risk of developing hyperkalemia if supplementation is overly aggressive. The rate of potassium supplementation should not exceed 0.5 mEq/kg/hr.

**TABLE 1**

<table>
<thead>
<tr>
<th>Serum K (mEq/l)</th>
<th>KCl/L of Fluids (mEq/l)</th>
<th>Max Rate (ml/kg/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1–3.5</td>
<td>30</td>
<td>16</td>
</tr>
<tr>
<td>2.6–3.0</td>
<td>40</td>
<td>11</td>
</tr>
<tr>
<td>2.1–2.5</td>
<td>60</td>
<td>8</td>
</tr>
<tr>
<td>&lt;2.0</td>
<td>80</td>
<td>6</td>
</tr>
</tbody>
</table>

- Tachycardia (heart rates in excess of 160 bpm in large-breed dogs or 180 bpm in small-breed dogs) may be caused by the direct action of albuterol on β-receptors as a reflex action secondary to peripheral vasodilation and subsequent hypotension or as a combination of both factors. Propranolol (0.02–0.06 mg/kg IV slowly, start with lower dose and give over 2–3 minutes) should be administered to control tachycardia.

- Propranolol has also been found to reverse hypokalemia in cases of albuterol overdose and may be effective in treating premature ventricular contractions.

- Propranolol should not be used exclusively to treat moderate to severe hypokalemia. Potassium should be supplemented in these cases.

- Fluid supplementation may be helpful in alleviating hypotension and reflex tachycardia. Care should be taken to avoid lowering the serum potassium further with aggressive fluid administration.

- Animals presenting with agitation or mild tremors may require sedation. Diazepam (0.5–2 mg/kg IV) is usually effective in controlling any CNS excitation that propranolol administration does not reverse. Rarely, paradoxical excitement occurs after diazepam use.

**Supportive Treatment**
- Administer IV fluids.
- Restrict activity until asymptomatic.

**Home Management**
Patients should be monitored for weakness for the first 12 hours after being sent home. If weakness is observed, the animal should have electrolytes and cardiovascular status reevaluated. Once the animal has fully recovered, no additional treatment is usually necessary.

**Milestones/Recovery Timeframes**
- Most animals recover completely within 12 hours of exposure if treated appropriately; however, some require 24–48 hours for full recovery.
- Patients with premature ventricular contractions and/or weakness despite appropriate treatment may not fully recover for up to 48 hours postexposure.
- The plasma half-life of immediate-release albuterol tablets in dogs is estimated to be 3 hours. The half-life in cats has not been established.

**Treatment Contraindications**
- Propranolol should be used with great caution in asthmatic cats because it may cause bronchoconstriction.
- Fluids containing dextrose may stimulate insulin release, which could further decrease serum potassium levels.
- Metoprolol and other selective β1 antagonists are not generally effective in controlling clinical signs following albuterol toxicity.

**PROGNOSIS**

**Favorable Criteria**
- Rapid response to treatment generally indicates a good prognosis.
- Animals with persistent weakness and/or premature ventricular contractions that are otherwise in stable condition generally have a favorable prognosis.
- Healthy, adult animals with no serious, underlying health conditions generally have a favorable prognosis.

**Unfavorable Criteria**
- Animals that develop pulmonary edema following albuterol exposure may have a poor prognosis.
- Geriatric animals and those individuals with cardiac disease may be more likely to have a poor response to treatment.

**RECOMMENDED READING**