

## Compendium

# Canine Brachycephalic Airway Syndrome: Pathophysiology, Diagnosis, and Nonsurgical Management

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**Abstract:** Canine brachycephalic airway syndrome is a progressive disease that affects many brachycephalic dogs. This article describes the components of this syndrome and focuses on acute emergency management and long-term conservative management of these patients. Surgical management is described in a companion article.

For more information, please see the companion article, "Canine Brachycephalic Airway Syndrome: Surgical Management"

Canine brachycephalic airway syndrome (BAS), also known as *brachycephalic syndrome* and *brachycephalic airway obstructive syndrome*, has been reported in many brachycephalic breeds, including the shih tzu, boxer, English and French bulldogs, Lhasa apso, Pekingese, pug, shar-pei, and Boston terrier.<sup>1-4</sup> In these breeds, a congenital malformation results in skull bones of normal width but shortened length.<sup>3-5</sup> These inherited bony changes lead to the secondary soft tissue abnormalities that characterize BAS. Stenotic nares and elongation of the soft palate are the primary anatomic features of BAS. Secondary changes include eversion of the laryngeal saccules (stage I laryngeal collapse), laryngeal collapse (stages II and III), and enlargement of the tonsils.<sup>3,5-8</sup> Hypoplastic trachea is seen concurrently in some brachycephalic breeds (particularly English bulldogs) but is considered independent of BAS.<sup>6,9</sup> **TABLE 1** lists the frequency of each BAS component identified in four studies. Differences in incidence may be explained by the variation in canine populations in different countries. An Australian study<sup>10</sup> noted a high incidence of elongated soft palate alone in Cavalier King Charles spaniels (6 of 15 dogs), a breed not commonly associated with BAS in the United States.

### Pathophysiology

Pathology in BAS results from the changes in air pressure and flow in the upper airway.<sup>3,4,11</sup> The relationship between the radius of a tube, pressure, and flow can be modeled using Poiseuille's law,<sup>12</sup> which shows that a 50% reduction in tube

radius leads to a 16-fold increase in resistance to flow. To maintain airflow as the radius decreases, pressures in the airway must become more negative. In dogs with BAS, stenosis of the nares and distortion of the pharyngeal region lead to an increase in negative pressure during inspiration.<sup>5,11</sup> This results in stretching of the soft palate, which may already be elongated; swelling of the airway; eversion of the laryngeal saccules; edema and inflammation of tonsillar tissue; and, ultimately, inward collapse of the weakened laryngeal cartilages. A vicious cycle develops: collapse of the laryngeal cartilage further decreases the radius of the airway, which increases the velocity of airflow and the negative pressure in the airway, leading to further collapse. This cyclic pathology is why severe cases of BAS can demonstrate advanced laryngeal collapse and why early surgical intervention is recommended to correct identified BAS components in affected dogs.

### Clinical Presentation

Stenotic nares and elongated soft palate are often present at birth, with clinical signs being progressive from young adulthood.

**Table 1. Incidence of Brachycephalic Airway Syndrome Components**

Study	Stenotic Nares	Elongated Soft Palate	Everted Saccules <sup>a</sup>	Laryngeal Collapse <sup>b</sup>
Poncet et al <sup>18</sup>	84.9% (62/73)	95.9% (70/73)	54.8% (40/73)	69.9% (51/73)
Poncet et al <sup>9</sup>	85.2% (52/61)	100% (61/61)	54.1% (33/61)	63.9% (39/61)
Torrez and Hunt <sup>10</sup>	42.5% (31/73)	86.3% (63/73)	58.9% (43/73)	53.1% (34/64)
Riecks et al <sup>17</sup>	58.1% (36/62)	87.1% (54/62)	58.1% (36/62)	8.1% (5/62)

<sup>a</sup>Stage I laryngeal collapse

<sup>b</sup>Stages II and III laryngeal collapse



**Figure 1.** Evaluation of the soft palate. This palate extends beyond the tip of the epiglottis and the tonsillar crypts.

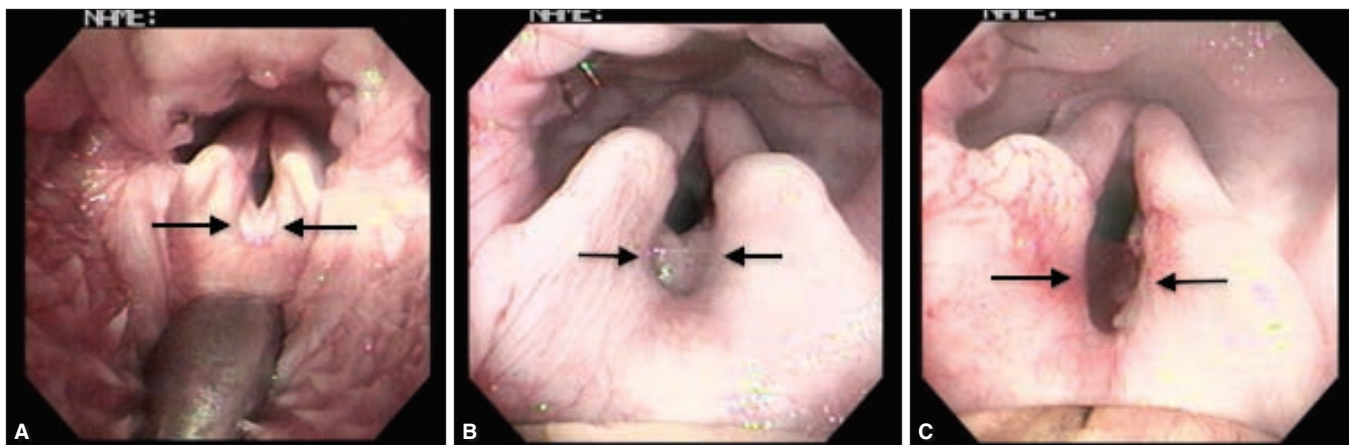
Most brachycephalic dogs are evaluated between 2 and 4 years of age due to worsening clinical signs,<sup>2,6,13-15</sup> although bulldogs tend to present between 1 and 2 years of age.<sup>16,17</sup> The literature shows a higher prevalence of BAS (2:1) in male dogs,<sup>6,8,18</sup> although one study<sup>10</sup> showed a higher prevalence in females (1.6:1). Clinically affected dogs present for inspiratory stertor/stridor, gagging, productive coughing, difficulty swallowing or sleeping, dyspnea, cyanosis, and hyperthermia.<sup>1,3,6,7,12,17</sup> These dogs are often worse after exercise, excitement, or stress or with increased environmental temperature or humidity.<sup>2,12</sup> No difference was seen when comparing body weights of dogs presenting for BAS and similar populations presenting for nonrespiratory issues,<sup>17</sup> although an association between increased body weight and the severity of respiratory issues is a clinically recognized phenomenon.

### Diagnosis

The physical examination should include an evaluation of the respiratory pattern. An inspiratory dyspnea that corrects with open-mouth breathing has been reported when only the nares are involved.<sup>3,5,14</sup> Involvement of the soft palate and laryngeal saccules often leads to inspiratory and expiratory dyspnea, the severity of which depends on the degree of additional upper airway pathology.<sup>14</sup> Brachycephalic dogs with <50% reduction in airway diameter show an obstructive breathing pattern with a slow inspiratory phase and rapid expiratory phase.<sup>4,5</sup> In non-brachycephalic dogs, this pattern is often seen only with >50% reduction in airway diameter. This demonstrates the confounding role that stenotic nares and other BAS components have on respiratory function in affected dogs. Regardless of the respiratory patterns observed, definitive diagnosis can be established only with an upper airway examination.

The upper airway examination should evaluate the soft palate, tonsils, laryngeal saccules, and laryngeal function. It is best performed under a light plane of IV anesthesia using thiopental (4.5 mg/kg to effect<sup>4</sup>) or propofol (3 to 6 mg/kg).<sup>2</sup> The examination should be planned so that surgical correction, if warranted, may be performed within the same anesthetic episode. Both the owner and veterinarian should be aware that sedation or anesthesia without correction of airway pathology has the potential to precipitate an episode of acute respiratory distress.<sup>3,4,12,16,18</sup> Indications for immediate surgical correction versus tracheostomy are discussed in the Emergency Management section.

The soft palate should be evaluated with the head and tongue in a neutral position and without an endotracheal tube present, as these factors influence the location of the soft palate (**FIGURE 1**).<sup>19</sup> In dogs with a normal airway, the soft palate should not extend past the tip of the epiglottis or the mid to caudal aspect of the tonsillar crypt.<sup>2,18,20</sup> If the laryngeal saccules are everted, they will appear as shiny, white, convex structures cranial to the vocal cords along the ventrolateral surface of the laryngeal lumen (**FIGURE 2**).<sup>3,19</sup>



**Figure 2.** Everted laryngeal saccules in two dogs. (A) Everted laryngeal saccules (arrows). No edema is seen, and these saccules were left in place. The dog had a significant improvement in respiratory signs with staphylectomy alone. This dog's nares were not stenotic. (B) Everted, edematous laryngeal saccules are seen between the vocal cords as shiny, white, convex structures (arrows). These have been effectively described to one author of this article (M.T.) as resembling "inside-out pants pockets." (C) The same dog as in Figure 2B after resection of the saccules.

Medial flattening and tipping of the laryngeal cartilage, curling or flattening of the epiglottis, and inability to visualize the vocal cords indicate laryngeal collapse.<sup>15,21</sup> This can be difficult to differentiate from laryngeal paralysis. In simple cases of laryngeal paralysis, the laryngeal cartilage is well formed and shows no abduction during inspiration, but paradoxical inward deviation of the laryngeal cartilage and laryngeal collapse can be seen in more complicated cases.<sup>21</sup> The degree of swelling of the airway should also be noted during the examination.

Thoracic radiography should be performed to rule out concurrent cardiac and pulmonary pathology that may influence the anesthetic and surgical protocol and prognosis. Dogs that have experienced an acute respiratory crisis should be specifically evaluated for evidence of aspiration pneumonia and noncardiogenic pulmonary edema. Studies<sup>9,22</sup> have shown an association between brachycephalic conformation and the presence of congenital cardiac defects, so a complete cardiac examination (electrocardiography, echocardiography) may be indicated in patients with physical or radiographic findings attributable to the cardiovascular system.

Although tracheal hypoplasia is considered independent of BAS, the trachea should be evaluated. Historically, a diagnosis of concurrent tracheal hypoplasia was associated with a worse prognosis after surgery for BAS.<sup>15,16</sup> However, more recent studies have found no correlation between degree of tracheal hypoplasia and severity of respiratory signs in preoperative patients<sup>8,9</sup> and no significant differences in outcome between dogs surgically treated for BAS with and without tracheal hypoplasia.<sup>6,8</sup> To determine the tracheal lumen diameter-to-thoracic inlet (TD/TI) ratio, the diameter of the thoracic inlet (the ventral border of T1 to the inner surface of the manubrium) is compared with the diameter of the tracheal lumen where it crosses the thoracic inlet on a lateral thoracic projection.<sup>9,12,23</sup> Median ratios are 0.116 for bulldogs, 0.157 for non-bulldog brachycephalic breeds, and 0.208 for non-brachycephalic breeds.<sup>12,23</sup> A TD/TI ratio below the relevant number establishes the diagnosis of tracheal hypoplasia.

Results of blood tests (complete blood cell count, serum chemistry panel) and urinalysis are usually normal in dogs with BAS without any concurrent medical conditions. If respiratory signs are severe, acid-base and blood gas abnormalities may be observed.<sup>4,15</sup>

## Emergency Management

Emergency medical therapy of dogs in crisis focuses on relief of dyspnea or cyanosis and reduction of stress and hyperthermia.<sup>3</sup> Establishment of IV access is recommended as soon as possible without causing additional stress. A rectal temperature should be taken at presentation, and active cooling should be instituted in dogs with temperatures above 103°F (39.44°C). Animals in acute distress should be placed in a cool, dry environment with supplemental oxygen. To prevent overheating, a cool environment is indicated even if the patient is normothermic. Oxygen supplementation should be provided with minimal stress; options include the use of flow-by oxygen, an intranasal catheter, an oxygen cage, or endotracheal intubation. Sedation with acepromazine can be

beneficial; we recommend an initial dose of 0.005 mg/kg IV (or SC)<sup>3</sup> to decrease the risk of acepromazine-induced vasodilatory hypotension, with incremental increases in dose up to 0.02 mg/kg IV or SC<sup>3</sup> as needed. The onset of effect should be approximately 15 minutes, and doses should not be repeated in the acute crisis more often than every 15 minutes, up to a total dose of 0.02 mg/kg. Anti-inflammatory doses of short-acting corticosteroids (e.g., dexamethasone: 0.05 to 0.1 mg/kg IV)<sup>3</sup> can be used; higher doses and repeat doses of dexamethasone should be avoided due to the high risk of gastrointestinal (GI) ulceration.<sup>2</sup> Aerophagia, esophageal dilation, sliding hiatal hernia, or gastric dilatation with or without volvulus may also occur in patients during acute crisis.<sup>4,18</sup>

Placement of a tracheostomy tube may be necessary to bypass upper airway swelling in severe cases.<sup>3,12</sup> Patients that are in severe distress, are unable to be intubated, have severe laryngeal or airway swelling, or are in distress with suspected pulmonary pathology as a result of their disease (aspiration pneumonia, pulmonary edema) would likely benefit from temporary tracheostomy and a short period (1 to 3 days) of conservative management before surgical correction. Surgical correction of the identified BAS components can be pursued once the acute crisis has resolved.

## Medical Management

Long-term conservative medical therapy comprises a weight management program and management of the dog's lifestyle.<sup>18</sup> Although one study was not able to correlate increased body weight and the severity of respiratory signs,<sup>17</sup> this is a clinically recognized problem, and weight loss should be recommended in BAS patients that are overweight or obese. Dogs with BAS should avoid activity in warm or humid weather. Walks should be kept short and taken at a cool time of day, and dogs should be walked on a harness to take pressure off the upper respiratory system. In the hospital setting, patients should be handled in a manner that minimizes stress and keeps them cool and calm.<sup>18</sup>

Brachycephalic dogs have been identified as having a high incidence of GI issues, including hiatal hernias, pyloric stenosis, and esophageal deviation.<sup>18</sup> A 2005 study showed that 74% of

### Key Points

- Primary components of BAS include stenotic nares and elongated soft palate. Secondary components include everted laryngeal sacculles, laryngeal collapse, and enlarged tonsils.
- BAS is a progressive disease and should be treated early.
- Animals with BAS often present in respiratory distress and should be treated supportively to decrease dyspnea, cyanosis, and hyperthermia and to minimize stress.
- Diagnosis of BAS requires an upper airway examination. This examination should be performed during the same anesthetic event as surgical correction, if correction is indicated.
- Treatment of concurrent GI disease may improve outcomes following BAS surgery.



dogs presenting with respiratory signs had moderate to severe GI signs (ptyalism, regurgitation, vomiting).<sup>18</sup> There was a strong correlation between the severity of respiratory signs and the severity of GI signs that was statistically significant in overweight brachycephalic dogs, males, and French bulldogs.<sup>18</sup>

In 2006, the same researchers found that dogs with upper respiratory and GI disorders had improved clinical outcomes when treatment was instituted for both conditions concurrently compared with correction of airway pathology alone.<sup>8</sup> Corrective surgery was performed on the identified components of BAS, and dogs were treated with various GI medications based on histopathologic findings for 2 to 3 months. The researchers found that in more than 80% of cases, digestive tract signs resolved on a short- and long-term basis, even when medical therapy was discontinued. It should be noted that many BAS patients demonstrate an improvement in GI signs after surgery for BAS alone.<sup>8</sup> This is most likely attributable to the improvement in airway pressures following surgery and the indirect effects on the GI tract (decreased aerophagia, decrease or resolution of sliding hiatal hernias). However, the above studies found that 89% of owners of dogs treated concurrently for GI signs reported good or excellent resolution of BAS signs compared with 68% of owners of dogs that received surgical treatment of BAS alone.<sup>8,18</sup> This suggests that concurrent treatment of primary GI tract disease further improves the outcomes in patients with BAS and GI disease. This significant improvement in positive outcomes after surgery supports the notion that all surgical BAS candidates should be evaluated and treated for concurrent primary GI disease.<sup>18</sup>

## Conclusion

Dogs with BAS often present at a young age with typical clinical signs associated with the upper respiratory tract. Emergency treatment is aimed at alleviation of dyspnea or cyanosis and reduction of stress and hyperthermia. Long-term conservative therapy for BAS consists mainly of weight management and environmental modifications. Because of the progressive nature of the disease, early surgical intervention is recommended to halt or delay secondary changes. Treatment of concurrent GI disease may improve outcomes following corrective BAS surgery. Surgical treatment options are discussed in a companion article.

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**1. Which list correctly identifies the primary and secondary anatomic features of BAS?**

- a. primary: everted laryngeal sacculles, stenotic nares; secondary: elongated soft palate, enlarged tonsils, laryngeal collapse
- b. primary: elongated soft palate, everted laryngeal sacculles; secondary: stenotic nares, enlarged tonsils, laryngeal collapse
- c. primary: stenotic nares, elongated soft palate; secondary: everted laryngeal sacculles, enlarged tonsils, hypoplastic trachea
- d. primary: stenotic nares, elongated soft palate; secondary: everted laryngeal sacculles, enlarged tonsils, laryngeal collapse

**2. What congenital malformation leads to the soft tissue changes that characterize BAS?**

- a. cleft palate
- b. skull bones of shortened length and normal width
- c. persistent right aortic arch
- d. underdevelopment of the frontal lobe of the brain

**3. Which of the following statements regarding everted laryngeal sacculles is true?**

- a. They are also considered stage I laryngeal collapse.
- b. They have a red, swollen appearance.
- c. Laryngeal collapse can occur without eversion of the sacculles.
- d. Eversion of the sacculles is congenital in dogs with BAS.

**4. According to Poiseuille's law, a 50% reduction in airway diameter leads to a \_\_\_\_\_ increase in resistance to airflow.**

- a. twofold
- b. sixfold
- c. 16-fold
- d. 25-fold

**5. Most dogs with BAS present for evaluation due to worsening clinical signs**

- a. at birth.
- b. between 2 and 4 years of age.
- c. between 6 and 7 years of age.
- d. after 10 years of age.

**6. Which statement regarding management of BAS patients is true?**

- a. Sedation is contraindicated in dogs that present in acute crisis.
- b. Acute medical therapy focuses on relief of dyspnea or cyanosis and reduction of stress and hyperthermia.
- c. Weight loss in obese dogs does nothing to relieve clinical signs of BAS.
- d. Dogs with BAS are prone to hypothermia and should be kept in a warm environment.

**7. Tracheal hypoplasia is diagnosed when**

- a. the TD/TI ratio is below 0.116 in bulldogs or below 0.157 in non-bulldog brachycephalic patients.
- b. the trachea appears small on lateral radiography.
- c. tracheal palpation elicits a cough.
- d. all of the above

**8. The soft palate should be evaluated**

- a. with the head and tongue in a neutral position.
- b. with the tongue pulled as rostral as possible.
- c. without regard to head position.
- d. with the tongue substantially depressed.

**9. Which of the following statements is true regarding patients with BAS?**

- a. A high percentage of dogs with BAS also have concurrent GI disorders.
- b. All candidates for BAS surgery should be evaluated for concurrent GI disorders.
- c. In one study, treatment of concurrent GI disorders improved outcome following BAS surgery.
- d. all of the above

**10. Surgical intervention to correct BAS abnormalities**

- a. should be undertaken only if medical therapy is ineffective.
- b. should be considered only in cases of advanced laryngeal collapse.
- c. is best performed early to halt or delay secondary changes.
- d. is not necessary for most affected dogs.