Abstract: Brachycephalic airway syndrome (BAS) is a group of primary and secondary abnormalities that result in upper airway obstruction. Several of these abnormalities can be addressed medically and/or surgically to improve quality of life. This article reviews potential complications, anesthetic considerations, recovery strategies, and outcomes associated with medical and surgical management of BAS.

Medical Management
Medical management of airway obstruction associated with BAS is aimed at decreasing airway turbulence and the resulting inflammation and edema.1 For patients with BAS, stress should be minimized, a cool environment supplied, exercise restricted, and an ideal weight maintained.2-5 Supplemental oxygen is administered immediately if an animal exhibits signs of severe respiratory distress.6 If medical management is inadequate to relieve severe dyspnea, emergency tracheostomy is sometimes indicated.3,6 Treatment of hyperthermia includes active cooling with room-temperature, isotonic IV fluids and placing the animal in a cool area.6,7 A single dose of a short-acting antiinflammatory glucocorticoid (e.g., dexamethasone, 0.5 to 2 mg/kg IV, IM, or SC) can be beneficial to reduce acute airway swelling and edema.3,6 It is extremely important to minimize stress in patients with respiratory distress, as stress can exacerbate clinical signs and, in worst-case scenarios, cause death.6 These patients may benefit from sedation (e.g., butorphanol, 0.2 to 0.4 mg/kg IV, IM, or SC; acepromazine, 0.02 mg/kg with a maximum dose of 1 mg IV, IM, or SC; diazepam 0.2 mg/kg IV) to reduce anxiety associated with respiratory distress.3,6 Potentially stressful examination techniques and diagnostics, such as radiography and blood work, should be postponed until the patient is stabilized.6

For certain components of BAS, such as hypoplastic trachea, surgical treatment is not an option. In dogs with hypoplastic trachea, the tracheal cartilages overlap, preventing the trachealis muscle, which spans the dorsal aspect of the cartilages, from functioning properly.8 In a normal trachea, the tracheal lumen narrows when the trachealis muscle constricts and dilates when it relaxes.8 In a hypoplastic trachea, the impaired function of the trachealis muscle results in a persistently narrowed tracheal lumen and, therefore, greater turbulence as a result of increased airflow velocity.8 This is a congenital condition, and English bulldogs have been found to be more frequently affected, with an average ratio between the tracheal diameter and the thoracic inlet distance (TD:TI ratio) of 0.13.3,5,7-10 A TD:TI ratio <0.16 is diagnostic for hypoplastic trachea.6,8,9,11 (For more information on the TD:TI ratio, see the July 2012 companion article.) Brachycephalic breeds in general have a narrower trachea compared with nonbrachycephalic breeds.7,9,10 A hypoplastic trachea is not necessarily a negative prognostic indicator as long as other secondary changes, such as laryngeal collapse, have not occurred.10,12 Because there is no surgical treatment for this condition, weight reduction and lifestyle modification are keys to management.13,14

Many dogs with BAS have concurrent GI disorders. Treatment can include H2 blockers, proton pump inhibitors, prokinetics, antibiotics, antacids, and steroids.15-17 With treatment, clinical and endoscopic improvement of GI disorders in dogs with BAS has been documented.15-17

Surgical Treatment
The goal of surgery is to provide adequate airflow by reducing airway obstructions.1

Stenotic Nares
Stenotic nares are nostrils with abnormally narrow openings.3 The malformed dorsolateral nasal cartilages

Key Facts
- Brachycephalic airway syndrome (BAS) can lead to life-threatening airway obstruction.
- Surgical techniques have been described to reduce upper airway obstruction associated with BAS.
- Early treatment of abnormalities associated with BAS can lead to an overall better long-term prognosis.
collapse inward on inspiration, resulting in difficulty breathing through the nose.\textsuperscript{3,11,18} This condition is found in 50\% to 85\% of dogs with BAS.\textsuperscript{7,11,19,20} The goal of surgery is to increase the diameter of the nares to allow adequate airflow past the dorsolateral cartilage folds.\textsuperscript{8} It is recommended to perform rhinoplasty in puppies with this abnormality at 3 to 4 months of age to avoid progression to secondary changes, such as laryngeal collapse or pharyngeal edema.\textsuperscript{6,8,9}

Several techniques have been described for rhinoplasty to widen stenotic nares, including horizontal and vertical wedge resections. For both resection procedures, the animal is positioned in sternal recumbency with the chin on a pad and the head secured to the surgical table to avoid malpositioning.\textsuperscript{7} The nares margin is held with Brown-Adson forceps while a V-shaped incision is made with a \#11 blade.\textsuperscript{7} In the case of a vertical wedge resection, the first incision is made medially and the second is made laterally.\textsuperscript{3} Hemorrhage is controlled by pressure and reapposition of the edges with three or four simple interrupted ligatures of 3-0 or 4-0 monofilament absorbable suture such as polydioxanone (FIGURE 1). Alternatively, an electrosurgical device or CO\textsubscript{2} laser can be used for tissue resection.

Another rhinoplasty technique, originally described in 1949 (the Trader technique), has recently been reintroduced.\textsuperscript{18} In this procedure, a portion of the dorsolateral nasal cartilage is excised, beginning at the dorsal-most opening of the external nares and angling ventrolaterally to the 3:30 or 8:30 o’clock position for the left and right nostril, respectively (FIGURE 2). The site is not sutured but is allowed to heal by second intention.\textsuperscript{18} Direct pressure and topical phenylephrine (1\% solution diluted 10 ×) are used at the surgeon’s discretion to control hemorrhage.\textsuperscript{18} Because the Trader technique does not employ suture, the technical difficulty as well as surgical time is decreased compared with other wedge techniques.\textsuperscript{18} It is advantageous in animals with very small noses.\textsuperscript{18} In addition, a greater amount of tissue can be resected compared with other wedge resection techniques.\textsuperscript{18} No scarring or nasal depigmentation were observed in one study of this technique in puppies.\textsuperscript{18}

Ellison\textsuperscript{21} evaluated use of alapexy as an alternative technique for correction of stenotic nares. This technique works by holding the nostril in a laterally fixed position rather than removing alar wedges. In this study, an elliptical incision measuring 0.5 to 1 cm long by 3 mm wide was created on the ventrolateral aspect of the alar skin.\textsuperscript{21} A second incision was created 3 to 5 mm lateral to the alar incision on the muzzle.\textsuperscript{21} These incisions were then apposed by placing three or four interrupted sutures or a simple continuous
pattern of 4-0 polydioxanone along the adjacent edges. The outer edges were apposed by placing three or four interrupted sutures of polypropylene suture. Postoperatively, the nostril was significantly wider and permanently held in an abducted position (FIGURE 3). Alapexy was found to be more time consuming than conventional techniques.

**Elongated Soft Palate**

Elongated soft palate is diagnosed when the soft palate extends more than 1 to 3 mm past the tip of the epiglottis. This redundant palate obstructs the dorsal glottis during inspiration, resulting in increased airway turbulence. Elongation of the soft palate is diagnosed in 80% to 100% of patients with BAS. Palatoplasty, or soft palate resection, is performed to remove a sufficient amount of tissue to allow adequate airflow through the upper respiratory tract. During soft palate resection, the tongue is retracted rostrally and ventrally to allow visualization of the soft palate and laryngeal tissues. A Babcock or an Allis forceps is used to advance the caudal margin of the soft palate rostrally, and two stay sutures are placed at the edges of the soft palate to be used for manipulation and to mark the desired resection site. Careful measurement is required; insufficient removal of tissue will result in continued airway obstruction, whereas overzealous resection can result in nasopharyngeal reflux. The tip of the epiglottis and middle to caudal third of the tonsillar crypt are used as the landmarks for incision placement. Use caution when using the epiglottis to determine length, as the epiglottis can be influenced by the position of the head and neck, endotracheal tube placement, and traction on the tongue and jaw. The palate is transected and sutured in increments using a simple continuous pattern, apposing the nasal and oral mucosal edges (FIGURE 5). Traditionally, scissors or a scalpel is used for transection; however, an electroscalpel, a bipolar sealing device (BSD), or a CO2 laser can be used, which can reduce surgery time and improve hemostasis. Suturing is not always necessary when the BSD or laser are used. Postoperatively, 85% to 90% of dogs exhibit improvement, but some still have intermittent stridor.

Proclaimed advantages of using a CO2 laser include minimal hemorrhage, swelling, and postoperative pain; potential bactericidal properties; and reduction of surgery time by half. The laser acts by coagulating small vessels and sealing lymphatic vessels and nerve endings. As a direct result of reduced hemorrhage, visualization of the surgical field is improved compared with traditional sharp resection. Postoperative swelling may be reduced if tissue handling is minimized, and signs of pain are decreased due to sealing nerve endings. Disadvantages of using this modality for soft palate resection are equipment cost and potential safety hazards to personnel. Laser use requires a laser-safe room with posted signs, closed windows and doors, minimal personnel traffic, and use of laser-safe goggles. The endotracheal tube must also be protected because oxygen can accelerate the burning of flammable materials. Studies have shown that long-term outcome did not differ among breeds, and there was no significant difference in outcome regardless of whether the traditional sharp resection method or CO2 laser were used.

Researchers at the University of Georgia compared the histopathologic findings after soft palate resection using a BSD or CO2 laser. The BSD provides tissue compression and adjusts the bipolar current depending on the impedance to current flow.
A recently described folded flap palatoplasty technique results in a thinner soft palate that is folded on itself, relieving obstruction of both the nasopharynx and oropharynx (FIGURE 6).

**Everted Laryngeal Saccules**

Everted laryngeal saccules occur as a result of prolonged upper airway obstruction. The tissue just rostral to the vocal cords is pulled into the ventral glottis, further obstructing the already narrowed airway lumen (FIGURE 4). Saccule eversion is the first stage of laryngeal collapse. Everted laryngeal saccules are encountered in 40% to 60% of patients with BAS.

Removal of everted saccules involves grasping them with forceps, applying gentle retraction to further evert the tissue, and transecting them with Metzenbaum scissors, a #15 blade, an electroscalpel, a tonsil snare, or a laryngeal cup forceps (FIGURE 7). Saccules can also be twisted before transection to reduce hemorrhage. Sutures are not indicated because hemorrhage is usually minimal.

**Laryngeal Collapse**

Laryngeal collapse can be classified as stage I, II, or III. Stage I refers to eversion of the laryngeal saccules. In advanced stages of BAS, laryngeal cartilage loses its integrity and collapses inward. Stage II collapse indicates that the cuneiform processes have come into apposition. Stage III is diagnosed when the corniculate processes are apposed in addition to the changes seen in stages I and II. Moderate to severe laryngeal collapse (stages II and III) is seen in 50% to 64% of dogs with BAS.

Treatment recommendations for laryngeal collapse vary depending on the stage of collapse at the time of diagnosis. Stage I can be managed by correction of the underlying cause (e.g., stenotic nares or elongated soft palate). Stage II may require treatment, such as a partial arytenoidectomy, to open the rima glottis. Stage III is treated with a permanent tracheostomy.

A retrospective study in 2006 evaluated the histories, clinical findings, and management of seven brachycephalic puppies (ranging in age from 4 to 6 months) with stage I, II, or III laryngeal collapse secondary to BAS. These puppies underwent resection of the nares, palate, and saccules after presenting for exercise intolerance and increased respiratory noise and effort. The authors concluded that laryngeal collapse secondary to BAS is seen in puppies younger than 6 months and advocated assessment and surgical correction of BAS in brachycephalic puppies as soon as clinical signs are evident to avoid progression of laryngeal changes.
An Australian study examined the incidence of laryngeal collapse and postoperative outcome in 73 dogs with BAS. These dogs had surgery to correct stenotic nares, an elongated soft palate, and/or everted laryngeal saccules. Short-term results were available for 64 dogs, and long-term results were available for 46 dogs. Laryngeal collapse, described as mild (medial deviation of the cuneiform cartilages), moderate (cuneiform cartilages touching each other), or severe (cuneiform cartilages collapsed medially and ventral glottis completely obstructed) was observed in 34 of 64 dogs at the beginning of the study. Telephone interviews conducted between 19 and 77 months postoperatively documented that 26 of 46 dogs were much improved after surgery, 15 of 46 had some improvement, and 5 of 46 did not have any signs of improvement. Long-term outcome was favorable for BAS corrective surgery, even if laryngeal collapse was present.

**Everted Tonsils**

Tonsils evert from their crypts secondary to increased negative pressure and may contribute to upper airway obstruction. Everted tonsils can be treated by tonsillectomy; however, if the primary factors of BAS can be addressed and corrected and the tonsils return to their correct position, a tonsillectomy may not be required. If the tonsils protrude into the oropharynx, creating irritation or obstructing air passage, removal has been suggested.

**Nasopharyngeal Turbinates**

Nasopharyngeal turbinates (nasal turbinates in the nasopharynx) have been thought to contribute to upper airway obstruction by obstructing intranasal airways through compression and aberrant growth. Obstruction by hyperplastic turbinates can be alleviated by laser-assisted turbinectomy, which can be performed using an endoscopic laser. The goal of this procedure is to excise aberrant tissue, thereby reducing resistance to airflow. Unfortunately, turbinectomy is tedious and long, and there is potential for regrowth.

**Anesthetic Considerations and Recovery**

Adequate presurgical medication and oxygenation are important for brachycephalic breeds. Induction and intubation should be as rapid as possible. Perioperative corticosteroids are recommended to reduce inflammation. Administration of an anticholinergic, such as atropine or glycopyrrrolate, is suggested to combat the bradycardic effects of neuroleptanalgesics as well as the effects of vagal stimulation resulting from glottic handling. Extubation should be delayed as long as possible to ensure that the patient is able to breathe adequately. Supplemental oxygen should be available as needed. Administration of nasal oxygen for a few hours may facilitate a smoother recovery. Temporary tracheostomy may be indicated if inflammation is severe and the animal experiences respiratory distress that cannot be controlled with sedation and supplemental nasal oxygen. The patient’s respiratory rate and effort should be monitored for at least 12 to 24 hours after surgery, and analgesics should be administered to control pain. Food should be withheld for 18 to 24 hours postoperatively because eating may traumatize swollen tissues and cause additional swelling, obstruction, or aspiration. Gastroprotectant drugs are administered postoperatively and include a proton pump inhibitor (omeprazole, 1 mg/kg/d q24h) and a prokinetic (cisapride, 1 to 2 mg/kg/d q8h).

**Complications**

Postoperatively, close monitoring is important because inflammation or bleeding can obstruct the larynx and trachea, impairing respiration and leading to respiratory distress. Other potential postoperative complications include coughing, nasal discharge, gagging, voice change, regurgitation, vomiting, noncardiogenic pulmonary edema, and aspiration pneumonia. As with any surgical procedure, infection or dehiscence can occur.

**Postoperative Outcomes**

Most dogs with BAS show improvement in both respiratory and gastrointestinal clinical signs postoperatively. In one study, 1-year follow-up information on 34 dogs that had undergone surgery to correct BAS abnormalities (stenotic nares, elongated soft palate, and everted laryngeal saccules) was obtained. Of these dogs, 16 had an excellent outcome (marked improvement in clinical signs without exercise restriction), 16 had a good outcome (improvement in clinical signs with some exercise limitations), and one had a fair outcome (no improvement in clinical signs), and one had a poor outcome (severity of clinical signs increased postoperatively). The authors of the study concluded that surgical treatment of BAS was associated with an overall favorable outcome, regardless of age, breed, specific diagnoses, or number and combinations of diagnoses. It has also been found that animals with laryngeal collapse showed clinical improvement after only resection of the nares, palate, and saccules, although complete resolution of signs was rare. In dogs that underwent upper airway corrective surgery, digestive clinical signs lessened and did not recur, whereas patients that did not receive upper airway corrective surgery continued to have recurrent GI signs. One study conducted a 6-month follow-up of patients that underwent upper respiratory tract surgery along with GI medical treatment. Statistical analysis of the results showed a significant improvement of the respiratory and GI tract signs postoperatively. The authors found that GI treatment in...
conjunction with BAS surgery decreased the complication rate and improved overall prognosis in patients that presented for BAS.17

Conclusion
BAS can be diagnosed and successfully managed with knowledge of the abnormalities and treatment options. Dogs that have BAS can lead a more normal life with medical and surgical management.

References
### Brachycephalic Airway Syndrome: Management

1. **Medical management of BAS includes**
   a. weight management, minimal stress, and a humid environment.
   b. nasal oxygen, weight management, and moderate exercise.
   c. exercise restriction, a cool environment, and weight management.
   d. strict cage rest, a cool environment, and minimal stress.

2. **_________ is/are the most common abnormality in animals with BAS.**
   a. Stenotic nares
   b. Everted laryngeal saccules
   c. Elongated soft palate
   d. Moderate to severe laryngeal collapse

3. **The landmarks for incision placement when performing a palatoplasty are**
   a. tip of the epiglottis and the middle to caudal third of the tonsillar crypt.
   b. tip of the epiglottis and the most rostral aspect of the tonsillar crypt.
   c. just caudal to the epiglottis and the middle to caudal third of the tonsillar crypt.
   d. just caudal to the epiglottis and the most rostral aspect of the tonsillar crypt.

4. **Dogs with stenotic nares should undergo rhinoplasty when they are**
   a. first diagnosed with stenotic nares.
   b. 2 to 3 years of age.
   c. full grown.
   d. 3 to 4 months of age.

5. **Which is a disadvantage of using a CO₂ laser compared with traditional sharp techniques for soft palate resection?**
   a. increased hemorrhage
   b. special safety precautions
   c. increased postoperative pain
   d. increased postoperative swelling

6. **Which statement is false regarding laryngeal collapse?**
   a. Stage I refers to the eversion of the laryngeal saccules.
   b. Stage II refers to the apposition of the corniculate processes.
   c. Stage III is treated with a permanent tracheostomy.
   d. Laryngeal collapse is caused when the laryngeal cartilages lose their integrity and collapse inward.

7. **Which statement regarding hypoplastic trachea is correct?**
   a. Brachycephalic breeds generally have a narrower trachea than nonbrachycephalic breeds.
   b. There are several surgical options for treatment of a hypoplastic trachea.
   c. The tracheal rings are fused along their dorsal edge.
   d. Presence of a hypoplastic trachea is always a negative prognostic indicator.

8. **Which of the following statements is false?**
   a. An elongated soft palate is diagnosed in 80% to 100% of dogs with BAS and can be corrected by palatoplasty.
   b. Everted laryngeal saccules are seen in 40% to 60% of dogs with BAS and are treated by removal.
   c. Stenotic nares are diagnosed in 50% to 85% of dogs with BAS and can be corrected by rhinoplasty.
   d. Everted tonsils should always be treated by tonsillectomy.

9. **Overall prognosis after surgical correction of BAS components depends on**
   a. breed.
   b. age.
   c. presence of a hypoplastic trachea.
   d. none of the above

10. **Recovery from anesthesia for patients that have undergone surgery to correct BAS abnormalities should include which steps?**
    a. delay extubation, feed as soon as animal has completely recovered from anesthesia, monitor respiratory effort
    b. monitor respiratory effort for 12 to 24 hours, withhold food for 18 to 24 hours, provide pain control as needed
    c. extubate as soon as possible, withhold food for 18 to 24 hours, provide pain control as needed
    d. sedate the animal, delay extubation, feed as soon as animal has completely recovered from anesthesia