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Inside This Issue

Brachycephalic (obstructive) Airway Syndrome, *Part 1 [OF 3 PART SERIES]*

Dr. Robert Waddell DACVS-SA

Definition

Brachycephalic (obstructive) airway syndrome is a general term that groups together a number of primary and secondary respiratory conditions that are commonly observed in the juvenile brachycephalic canine breeds. These are most often seen in conjunction, rather than individually, resulting in a congenital upper airway obstruction. Primary conditions include: elongated soft palate, hypoplastic trachea, nasopharyngeal stenosis (nasal turbinate abnormalities), and stenotic nares. Secondary conditions include everted laryngeal saccules, everted tonsils (amygdalitis), and laryngeal collapse. This part I of the article will discuss the incidence, signalment, etiology and pathophysiology. Part II will discuss clinical signs, diagnostics and

Signalment /Incidences

Affected canine breeds and their incidences include the English Bulldog (61% incidence), Pug (21%), Boston Terrier (9%), Boxer, French Bulldog, Pekingese, and Shih Tzu (less than 10%). Brachycephalic dog breeds have an odds ratio of 38 for the risk of developing this syndrome when compared to other canine dog breed types. Mesocephalic dog breeds that have been reported include Chow Chow, Pomeranian, and Rottweiler. Dogs can be affected as early as several months of age with a mean of 4 to 5 years of age. The mean weight of affected dogs is 21.5 kg. The canine male to female ratio has been reported to be 2:1 while the female to male ratio has been reported to be 1.6:1.

The incidences of the conditions involved with this syndrome are as follows: elongated soft palate 62 to 100%, hypoplastic trachea 11 to 46%, stenotic nares 17 to 94%, everted laryngeal saccules 39.4 to 87%, everted tonsils 5 to 56%, abnormal nasopharyngeal turbinates 20 to 100%, and laryngeal collapse 8 to 53%. The most common combination of these conditions, are those abnormalities present at birth, which are the elongated soft palate and stenotic nares. However, an elongated soft palate can occur independent of stenotic nares. The combination of elongated soft palate, stenotic nares,

This Part I of the article will discuss the incidence, signalment, etiology and pathophysiology.

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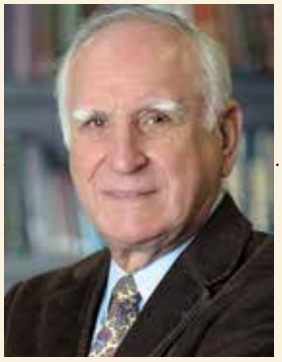
A Note from the Editor



This is our twelfth year publishing "LIVS in PlainView" and in 2020, LIVS has begun its 22nd year and has remained the pre-eminent veterinary referral center in our area.

Our island so far this winter, has hardly experienced more than an inch or so of snow and LIVS is well prepared to remain open, as before, in any eventuality. Of course we must be aware that February can be the worst month for snow, unless you're a skier.

The ill treatment of the bomb sniffing dogs the US sent to the Middle East has resulted in their deployment to be been halted for a time. These specially trained K-9s deserve to get the care they need to function properly. Not all recipients of these highly trained dogs treat dogs well.

In Norway, dozens of dogs have died after bouts of vomiting and diarrhea; the cause is not yet clear but two bacteria have been found in some dog's guts after necropsies, Providencia alcalifaciens and Clostridium perfringens. Hundreds of dogs have been stricken. The illness has affected many breeds of dogs of varying ages and it sets in quickly. Many dog owners are unable to get their affected dogs to a vet before they pass away. The dogs can seem fine in the morning and rapidly deteriorate in the afternoon. None of this has been reported in the US, so far.

We are exceptionally grateful to both Wendy and Gail Waller who have celebrated the holiday festivities at LIVS by providing an enormous buffet of delightfully tasty foods, salads, desserts and decadent NY cheesecake plus freshly filled, crispy cannoli. Their participation and assistance in the care of pets, some abandoned, all loved is boundless. We are proud to be in partnership with them in this endeavor.

At LIVS we are pleased to continue the extended hours for consultation in all our departments to serve our clients more efficiently. Appointments can be made through our telephone receptionists at 516 501-1700.

We hope the New Year will bring to us, our loved ones, our families and pets the joys of life and a bright 2020.

Again, we welcome your comments e-mailed to lmarino@livs.org.

Leonard J. Marino, MD, FAAP, LVT

➤ *Continued from Page 1*

everted saccules, and everted tonsils is seen in 32% of cases. Of those with stenotic nares, 72% also have everted laryngeal saccules. Of those with everted laryngeal saccules, 66% have everted tonsils. Stenotic nares are considered congenital in the English Bulldog, French Bulldog, and Pug breeds. It is also seen commonly in the Boston Terrier, Boxer, Cavalier King Charles Spaniel, Lhasa Apso, Pekingese, and Shih Tzu breeds. Laryngeal collapse is seen in 28.3% of Pug dogs. Hypoplastic trachea is most commonly noted in the English Bulldog breed. The Chinese Shar Pei can be seen with stenotic nares, an elongated soft palate, and laryngeal paralysis. The incidence of canine stenotic nares exceeds that of feline (incidence of 2.6%). This condition is uncommonly found in feline breeds. Affected brachycephalic feline breeds include the Persian and Himalayan.

Etiology and Pathophysiology

According to Poiseuille's law, which mathematically relates air flow changes, pressure, and tube radius, a 50% decrease in the tube radius increases the resistance by a factor of 16 and increases negative pressure. Therefore, a slight decrease in tracheal cross-sectional area, results in a large increase in air flow resistance. This increases the work required for breathing. An increase in vagal tone may occur as well, further narrowing the airway and causing bradycardia. With obese patients, a decrease in tidal volume and functional residual pulmonary capacity complicates matters further.

Skull morphology

Brachycephalic dog breeds have a congenital skull malformation whereby the skull width is normal or wide, but its rostral length is shortened. These dogs have a soft tissue muscle mass due to acute and chronic muscle degeneration and necrosis is also seen. Histologic evidence of both muscle atrophy and hypertrophy along with fewer palatine peripheral nerve branches are found in dogs affected by elongated soft palates. These dogs also show positivity for dystrophin, suggesting a palatine myopathy. This may be caused, at least in part, by denervation of the palatine muscles. It is also suspected that the inspiratory depression during the inspiratory phase causes chronic vibration, airway turbulence, chronic barotrauma, and microtrauma, leading to alterations in the histopathology of the soft palate in adult brachycephalic dogs.

Brachycephalic dog breeds depict a more caudally located transition from hard to soft palate in relation to the last molar tooth. The soft palate is also longer than normal. The elongated soft palate extends beyond the epiglottic tip, causing vibration, inflammation, and soft tissue swelling. The soft tissue swelling obstructs the airway and inhibits the dorsal glottis during inspiration causing turbulence and increases in negative pressure. The soft palate stretches further. Based on computed tomography, the soft palate of Pugs appear significantly shorter and thinner than that of French Bulldogs. Macroglossia, seen commonly in brachycephalic breed dogs, also contributes to soft palate abnormalities by displacing the palate dorsally.

Skull morphology

There is also an association, based on computed tomography, between subclinical thickened bullae (the rostroventral aspect being thicker than the caudoventral aspect) that contain a smaller tympanic cavity luminal volume (mean volume of 0.41 mL, nonbrachycephalic dog breeds ranging from 0.85 mL to 2.5 mL) with middle ear material and thickened soft palates in 36% of brachycephalic dog breeds. Additionally, based on computed tomographic evaluation, the smallest nasopharyngeal cross-sectional areas were located dorsal to the caudal end of the soft palate in the Pug and French Bulldog breeds. Finally, the Pug breed has significantly smaller air-filled cavities at the location of the frontal sinus when compared to the French Bulldog, based on computed tomography. Brachycephalic dog breeds also commonly lack the normal three paranasal sinuses found in dogs.

The English Bulldog breed airway dilator muscles are hypotonic, resulting in airway obstruction. The muscle fibers in the breed also transitions from slow type I to fast type II myosin heavy-chain fibers, resulting in edema and inflammation. The resulting fibrosis further causes a constriction.

Nasopharynx abnormalities

An additional abnormality seen with the brachycephalic breed dogs is with turbinate formation. The normal process whereby the forming conchae stop developing before the mucosa of adjacent turbinate lamellae contact each other fails. These breeds also contain a limited ossified nasal capsule space. This results in aberrant turbinate formation whereby the rostral turbinates of the middle or ventral conchae (maxilloturbinates) extend rostrally beyond the point where the plica alaris branches into the ventral nasal conchae. Similarly, caudal aberrant turbinates (maxillo- and/or ethmoturbinates) extend caudally into the nasopharyngeal meatus. If the caudal turbinates extend into the nasopharynx, through the choanae, they are considered nasopharyngeal turbinates. Aberrant turbinates may be present unilaterally, bilaterally, symmetrically, asymmetrically, rostrally, caudally, or a combination thereof. Primary abnormalities associated with this alteration allow for secondary soft tissue changes that contribute to brachycephalic airway syndrome.

Computed tomographic evidence of increased nasal mucosal contact (at a mean of 7.8 contact points) and caudal aberrant nasal turbinates are significantly more prevalent in brachycephalic dogs when compared to normocephalic dogs. The incidence of caudal aberrant nasal turbinates that cause an upper airway obstruction in brachycephalic dog breeds is 66.7 to 77.8% based on computed tomography and anterior/posterior rhinoscopy. The incidence of caudal aberrant turbinates in the English Bulldog is up to 63%. Pug dogs show aberrant rostral turbinates in 90.9% of cases whereas the French Bulldog and English Bulldog breeds carry incidences of 56.4% and 26 to 36.4%, respectively. Interconchal (between With upper airway obstructions, the resistance to air flow causes an increase in pressure of the upper respiratory tract and it's accessory muscles during exhalation. The pleural pressure exceeds that of the atmospheric pressure, increasing the transmural pressure across the intrathoracic respiratory tract wall. The thoracic wall collapses and an increased air velocity results in decreased pressure in the collapsed airways, promoting narrowing. A positive cycle continues. With dynamic upper airway obstructions, inhalation occurs within the extrathoracic portion of the respiratory tract while forced exhalation occurs in the intrathoracic portion of the respiratory tract.

Continued on Page 6 ➤

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Brachycephalic (obstructive) Airway Syndrome, *Part 1*

➤ *Continued from Page 4*

With disease progression, open mouth breathing can occur. This results in decreased olfactory-mediated warming or humidification of air and decreased air filtration, predisposing to alveolar hypoventilation, decreased arterial oxygen concentrations, increased carbon dioxide concentrations, increased stress and strain on the distal lung, further changes to the intrapleural pressure, and a more negative intrapleural pressure. As disease progresses the laryngeal stages worsen, risking pulmonary edema due to a decreased intrathoracic pressure. Hypoxia and hypoventilation lead to vasoconstriction, a decrease in alveoli blood, and pulmonary hypertension, which can all result in cor pulmonale and right-sided congestive heart failure.

Habituation or desensitization occurs secondary to chronic hypoxemia from these airway changes. Peripheral chemoreceptor hyposensitization and a poor response to the low partial pressure of oxygen in arterial blood concentrations occurs in affected dogs.

Gastrointestinal alterations

These primary and secondary airway diseases may lead the way for secondary gastrointestinal conditions. However, because the brachycephalic breeds are also predisposed to primary gastrointestinal conditions, it may not be possible to discern all possible etiologies in a single affected patient.

Secondary diseases occur due to the changes in intrathoracic pressure differentials, and may include aerophagia, esophageal deviation, esophageal dilation, megaesophagus, gastric bloat, gastric dilatation and volvulus, pyloric stenosis, and sliding hiatal herniation. Megaesophagus is seen in 10% of cases afflicted with hypoplastic trachea. The combination of hypoplastic trachea and megaesophagus is found in 55% of affected Bulldogs. Based on brachycephalic dogs with stenotic nares, elongated soft palate, and laryngeal collapse evaluated by endoscopic and histologic evaluation, 97.3% of such patients showed esophageal, gastric, or duodenal abnormalities. These include distal esophagitis (37% incidence), diffuse gastritis (89%), and duodenitis (53%). These lesions may improve post-operatively in some patients.

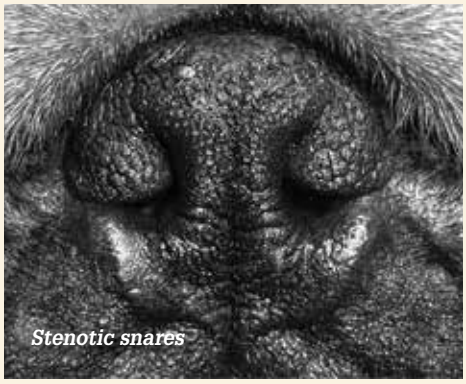
Clinical signs

Clinical signs can be divided into types (respiratory and gastrointestinal) and etiology (primary versus secondary). Most respiratory clinical signs are regarded as primary and most gastrointestinal clinical signs are regarded as secondary. As body weight increases, the clinical signs appear to worsen.

Respiratory clinical signs and their incidences include audible breathing (100% incidence), inspiratory stertor or stridor (69%), dyspnea (61%), respiratory distress (53%), difficulty sleeping, exercise intolerance, gagging, hyperthermia, increased respiratory noise, inspiratory dyspnea, open mouth breathing (most often seen in patients with stenotic nares), slow inspirations with a rapid expiratory phase, and syncope. In the brachycephalic dog breeds, less than 50% airway compromise can result in this altered breathing pattern. The clinical sign of slow inspirations associated with a rapid expiratory phase only develops in non-brachiocephalic breeds whose airway is compromised over 50%. The inspiratory dyspnea that occurs with expiration is especially exacerbated with increased activity levels, stressful situations, and with higher environmental temperatures. The combination of inspiratory and expiratory clinical signs may indicate concurrent soft palate elongation and everted laryngeal saccules, skull width to length ratio of 0.81 or greater, a craniofacial angle (between the skull base and the facial skull) of 9 to 14°, a craniofacial ratio of less than 0.1 to 0.49, a muzzle that comprises less than half of their cranial lengths, and an increased neck girth. The facial bone growth rate in these breeds is less than that of the head growth rate. When comparing glottis endoscopic and radiographic skull measurements in brachycephalic breeds clinical for brachycephalic airway syndrome with grade I laryngeal collapse, the glottic index in the Pug breed is smaller than that of the English Bulldog breed. Additionally, the larynx shape in the Pug and French Bulldog is more elliptical in shape when compared to the more rounded larynges seen in the English Bulldog breed. Based on computed tomography, Pugs also have a smaller cross-sectional area of the airway dorsal to the soft and hard palates than French bulldogs. Based on computed tomographic evaluation, 81% of affected Pugs showed no free airway space dorsal to the soft palate, compared to French Bulldogs.

Stenotic nares

Due to this skull malformation, the nares plates develop poorly. An increased airway resistance and a distention of the nasopharynx occurs. The stenotic nares are dorsolateral nasal cartilage malformations involving the epithelium externally and mucosa internally, resulting in short, thick, medial abnormalities that collapse inward with inspiration (axial deviation). A decrease in the transverse nares diameter is seen. Stenotic nares may be congenial or acquired. Acquired stenotic nares are due to the dorsal parietal cartilage obstructing the nares. The resulting air flow resistance causes an increase in upper airway negative pressure that attempts to overcome the resistance. Stridor, upper airway edema, inflammation and soft tissue stretching occur. Based on computed tomography and anterior/posterior rhinoscopy, nasal septum deviation is seen in 98.5% of Pugs, exceeding the incidence found in bulldogs (French Bulldogs 14.5% and English Bulldogs 0%).



Stenotic snares

Normal snares

Elongated soft palate

There is an absence of histologic caudal soft palate changes in neonatal brachycephalic dogs that are found in adult brachycephalic dog breeds (thickened superficial epithelium, broad edema of the lamina propria, mucous gland hyperplasia and diverse muscular modifications). The actual cause of soft palate thickening in severely affected brachycephalic dogs is an increase in stroma within the lamina propria and increased proportions of salivary tissue within the rostral portion of the soft palate. A reduction in lamellae of different conchae) and intraconchal (between lamellae of the same concha) mucosal contacts are evident in 91.7 to 94% of brachycephalic dogs with 100% being affected bilaterally based on computed tomography. An intranasal stenosis

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Brachycephalic (obstructive) Airway Syndrome, *Part 1*

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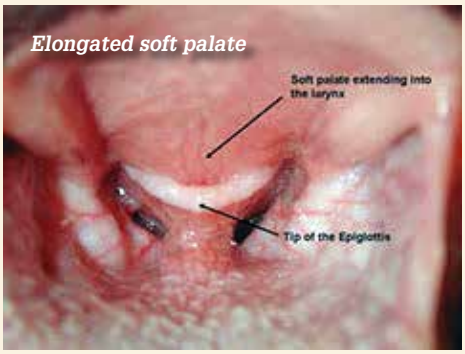

develops, which may occur in conjunction with choanal abnormalities. The Pekingese breed may also be affected by aberrant turbinates. Of nonclinical brachycephalic breeds, 100% are affected with abnormal turbinates based on computed tomography. These changes are seen in 20% of cats.

A grading system for caudal aberrant turbinates has been described. Grade 0 disease describes those dogs without turbinates being visible in the ventral nasal meatus. Grade 1 disease describes those dogs with turbinates visible in the ventral meatus. Grade 2 disease describes those turbinates that are visible within the nasopharyngeal meatus, but do not extend through the choanae. Grade 3 disease describes those turbinates that extend through the choanae. Grade 4 disease describes those turbinates that are visible in the nasopharynx. Those with minimal aberrations (grade 1 disease) make up 17.5 to 36% of cases, those with mild aberrations (grade 2) make up 57 to 70%, and those with moderate aberrations (grade 3) make up 7 to 12.5% of such cases. Bilateral disease is seen in all English Bulldogs with 77.5% having the same grade on both sides.

Secondary changes

The secondary diseases that comprise brachycephalic airway syndrome (everted laryngeal saccules, everted tonsils, and laryngeal collapse) are thought to be due to increases in negative pressure created during inspiration that result in stretching, eversion, and inflammation of the structures involved.

Due to an increase in negative pressure and inflammation, the laryngeal saccules become everted and the tonsils emerge from their crypts. The everted laryngeal saccules, in conjunction with the elongated soft palate, cause a dynamic obstruction of the ventral rima glottidis and luminal narrowing. Over time, the cuneiform and corniculate laryngeal cartilages weaken, and the larynx collapses inward. As the medial laryngeal cartilages collapse medially, vocal folds become obstructed. These changes decrease the airway radius further, increasing the air flow velocity, increasing negative pressure, and promoting irritation (pharyngeal and laryngeal edema), protrusion, and obstruction. These changes continue to worsen with inward collapse of the larynx.

Hypoplastic trachea

Hypoplastic trachea is characterized by congenitally small, rigid tracheal cartilage rings with apposed or overlapping ends that inhibit the trachealis muscle and cause shortening of this muscle and the dorsal elastic membrane. The affected trachea has a narrow, shortened, or absent dorsal tracheal membrane. These abnormalities result in a consistently narrowed lumen and turbulent airflow. The English Bulldog breed has the highest incidence of tracheal hypoplasia, with a predisposition towards male dogs.

Lower airway alterations

The percent change in respiratory parameters in dogs four months after nasal obstruction have been quantified. The alterations seen with unilateral obstruction include a compliance change of -3.8, a lower airway resistance change of -7.3, a functional residual capacity change of +5.9, an intrapleural pressure change of-4.6, and a body weight change of +5. The alterations seen with partial bilateral obstruction include a compliance change of -4.3, a lower airway resistance change of +154, a functional residual capacity change of +24, an intrapleural pressure change of-30, and a body weight change of -9.4. The alterations seen with bilateral obstruction include a compliance change of +27, a lower airway resistance change of -50, a functional residual capacity change of +12, an intrapleural pressure change of -75, and a body weight change of +73. These changes cause an increase in airway resistance and a decrease in pulmonary compliance. Rhinomanometric studies show that intranasal resistance is significantly higher in brachycephalic dogs when compared to normal dogs.

Gastrointestinal clinical signs include ptyalism, regurgitation, and vomiting. Vomiting occurs when eating and is especially seen with the Bulldog breeds who are afflicted with sliding hiatal herniations. This occurs due to difficulty swallowing, duodenitis, duodenogastric reflux, and esophageal deviation. Gastrointestinal clinical signs are present in 74% of dogs with brachycephalic airway syndrome. It appears that the presence of gastrointestinal clinical signs is proportional to the level of respiratory disease present. This is especially so in those dogs of large body weights, male dogs, and in the French Bulldog breed. French bulldog breeds may present with lower activity levels and more severe digestive signs than Pugs pre-operatively. ❑

More to come...

Please look forward to Part 2 and Part 3 of this series which will discuss diagnostics and treatment options.

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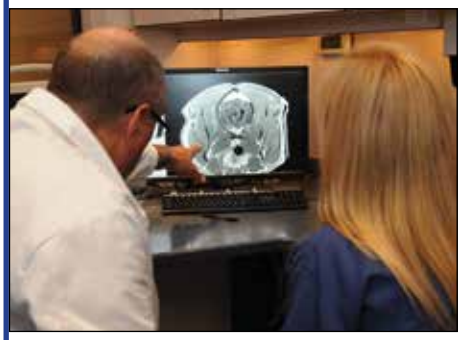

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John S. Sapienza, DVM, Diplomate, ACVO

Ciliary body ablation using Ciliary body ablation using either injectable gentamicin or cidofovir is an option to control glaucoma in select patients where vision has been lost and medical control is not attained. Enucleation, evisceration with an intraocular prosthesis or chemical ciliary ablation exist as end stage salvage procedures to eliminate the need for additional medications and to control the ocular pain associated with glaucoma. If the patient is not a suitable candidate for a general anesthesia procedure, then chemical ablation of the ciliary body is an appropriate consideration for that patient with uncontrolled glaucoma.

With the intravitreal chemical ablation technique, the patient is briefly sedated (no general anesthesia is necessary), and a subconjunctival injection of lidocaine is administered. The antibiotic gentamicin or the anti-viral drug cidofovir have both been documented to cause non-selective destruction of the ciliary body when injected into the vitreous cavity. A vitreocentesis or an anterior chamber paracentesis (aqueocenetesis) is performed to remove some intraocular fluid, and then the chosen drug is injected into the vitreous. Postoperatively, the eye is treated with topical anti-inflammatory medications, oral antibiotics as well as oral pain relief.

The overall success rate of a chemical ciliary ablation is greater than 95% in our experience. In theory, the injection can be repeated if the initial injection is not successful to control in controlling the intraocular pressure (IOP). Complications associated with this procedure include poor IOP control, corneal ulcer formation (associated with exposure keratopathy), and resultant too low IOP causing phthisis bulbi. Although phthisis bulbi may be noted as a result of any chemical ablation, we feel that a small non-painful eye is much comfortable than a buphthalmic eye with uncontrolled glaucoma. Chemical ablation is a routine non-surgical option to control chronic glaucomatous eyes in a patient that is incapable of undergoing a general anesthesia procedure, and is a lower cost alternative to a more invasive surgical procedure. Ciliary ablation is only advised in eyes that are blind by the glaucoma, as the ciliary injection will surely result in blindness. Furthermore, ciliary ablation is contraindicated in cases of eyes with known or even unknown intraocular neoplasia. There is discussion that intraocular injections may predispose some cats to the development of an intraocular sarcoma in the future, therefore, ciliary ablations are never recommended as therapy for cats with chronic glaucoma.

Although not our first choice for glaucoma therapy in most instances, ciliary body ablation with an intravitreal chemical injection can be considered in cases of dogs that are already blind with chronic glaucoma which who are poor anesthesia candidates or if the clients have financial constraints. If you have any questions or comments, please do not hesitate to contact us. ❑

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