

New Insights into the Brachycephalic Predicament

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Brachycephalicism

Breeds such as Bulldogs (English and French), Boston Terriers, Pugs, Pekinese, Shi Tzus, Lhasa Apsos, have been selectively bred for short muzzles. This desire for a flat face and foreshortened skull has resulted in the brachycephalic breeds having a plethora of primary anatomical abnormalities that compromise their ability to breathe. Veterinarians are faced with the challenge of ameliorating the quality of living for these compromised little dogs.

Primary anatomic abnormalities:

- Thickened and poorly developed nasal planum and cartilages, leading to stenotic nares,
- Excessive amounts of nasal and nasopharyngeal mucosae
- Abnormal conchae, compressed into a limited bony nasal cavity,
- An overlong soft palate that extends too far into the laryngopharynx, and is often thickened,
- Macroglossia.

Secondary changes:

These primary anatomical changes cause upper airway resistance, increased inspiratory effort and marked negative nasopharyngeal and laryngeal pressures on inspiration. The combination of high negative pressures and turbulent airflow cause secondary changes:

- Edema, inflammation and stretching of the pharyngeal and laryngeal tissues
- Eversion and edema of the laryngeal ventricles (first stage of laryngeal collapse)
- Dynamic pharyngeal wall dynamic collapse
- Advanced laryngeal collapse (second and third stage)

These secondary changes generate further obstruction, thus exacerbating the negative pressures, and a vicious downward spiral occurs. There is also strain on lung mechanics from greater changes in intrapleural pressure due to the greater negative inspiratory pressures. The resultant increase in pulmonary resistance has been attributed to increased tone in respiratory muscles and bronchial smooth muscles. This can lead to right side cardiac hypertrophy, termed 'cor pulmonale'.

In some breeds, especially the bulldog, this syndrome can be somewhat exacerbated by tracheal hypoplasia. Hypoplastic tracheas without concurrent upper respiratory or cardiovascular compromise are tolerated quite well. (Enlarged tonsils are also thought by some to increase turbulence and play a role in obstruction).

Affected breeds will tolerate an amazing amount of chronic respiratory obstruction by increasing the workload on their respiratory muscles, and chronically increasing the tone of their pharyngeal muscles.

The normal brachycephalic:

The "normal" brachycephalic dog typically has some degree of inspiratory dyspnea, and gurgly, stertorous breathing with gagging. Tidal breathing flow-volume loop (TBFVL) analyses in brachycephalics are consistent with upper airway obstruction – and they show the same abnormal TBFVL shape whether they are clinical or considered normal. Brachycephalics have a tendency to open mouth breathe to obtain better airflow by avoiding the chronically obstructed nasal passages. They are prone to hyperthermia because they lack the air circulation through the nasal passages, which is so important for heat regulation in the dog (via the lateral nasal glands). Air movement can be severely impeded by stenotic nares and the increased nasal mucosal contact points within the nasal cavity. Thus brachycephalics generally have poor exercise tolerance, and may gag and cough when eating and drinking (due to the thickened and elongated soft palate compromising deglutition). They often show signs of sleep disordered breathing and may have chronically low O₂ saturation levels, and be polycythemic.

Chronic GI disease has also been reported in brachycephalic dogs (gastroesophageal reflux, gastric retention, pyloric hyperplasia and stenosis), and in one study, the severity of digestive signs correlated with respiratory signs. More recently, primary bronchial abnormalities have also been reported – they have thickened submucosal layer to their respiratory tract lining, and an increased number of mucus producing goblet cells, compared to their mesaticephalic counterparts.

Brachycephalic Airway Syndrome

Affected brachycephalics can present to the veterinarian with a range of clinical signs, from mild to severe respiratory distress. The history is usually chronic, with variable signs of mouth breathing, stertor, exercise intolerance, gagging and dysphagia. Occasionally the history will report an acute-on-chronic course. Affected animals are prone to abrupt and sometimes serious decompensation from various precipitating factors: stress, over excitement, exercise, high ambient temperatures, sedation (including premedications and recovery from anesthesia and surgery). Acutely decompensated cases show severe stertor, frothing at the mouth and nares, hyperthermia, tachypnea, tachycardia, cyanosis, and collapse.

Emergency treatment of the decompensated brachycephalic

Emergency treatment is indicated for animals in moderate to severe respiratory distress. This should be done before full clinical evaluation of the case is performed, and with minimal restraint and stress:

- Allow the patient to assume a comfortable position (often sternal)
- Oxygenate (via mask, oxygen cage, nasal insufflation)
- Start intravenous fluids
- Administer corticosteroids (dexamethasone 1mg/kg IV)
- Sedation (combinations of agents : acepromazine/butorphanol; diazepam (*beware of relaxing pharyngeal muscles- monitor closely*).
- Cool (fan over ice water, icepacks in axilla/groin, alcohol rub)

Occasionally induction of anesthesia and endotracheal intubation will be only way to maintain an airway. Temporary tracheostomy can also be performed. Remember to use a smaller endotracheal tube than you would for a mesaticephalic or dolichocephalic dog of similar size.

Diagnosis and Evaluation

Diagnosis should take into account the signalment, history, clinical signs and physical examination. Routine haematology, serum biochemistries, endoscopy and blood gases may be indicated in older or more acutely compromised patients. Always investigate carefully an older animal with an acute on chronic presentation. Nasal tumors, epidermal nasal inclusion cysts, polyps, granulomas, envenomizations and pharyngeal or nasal foreign bodies can occur in these dogs.

The young brachycephalic will usually have normal parameters, although polycythemia can be seen with chronic hypoxia. Cardiac and respiratory evaluations should be performed (starting with auscultation and thoracic radiography), especially if there is a history of collapse (possible syncope). You don't want to miss a pulmonic stenosis! Endoscopic evaluation of the esophagus, stomach, and duodenum with biopsies may be indicated in dogs showing severe gastrointestinal signs.

Try to avoid repeated sedations or anesthetic episodes for these patients. The owner must be aware that you need to anesthetise the dog so that you can accurately evaluate it, and thus give a more realistic prognosis. Discussion with the owner should take place and the decision made to proceed with surgery under the diagnostic anesthesia. Discussions should also include the expected outcome and degree of improvement (see later).

Radiography is useful to assess the soft palate and larynx, and also to check out the trachea and cardiopulmonary status. HOWEVER, take care not to aggravate any respiratory distress – sedation is recommended, and sometimes waiting until general anesthesia is induced is prudent. Lateral cervical, DV and lateral thoracic views should be taken. The tracheal diameter in brachycephalic breeds is usually smaller than other breeds, and the English Bulldog has an even smaller trachea than other brachycephalic breeds. A hypoplastic trachea will have a tracheal diameter to thoracic inlet (TD/TI) ratio less than 0.20, and English Bulldog less than 0.16. Animals in respiratory distress will

often swallow air - do not misinterpret air in the oesophagus or stomach as megaesophagus or GDV. Hypoxic animals may be in a state of acidosis, often with nausea/vomiting. Look out for aspiration pneumonia.

Examination of the nares can be performed at the time of general physical examination. In brachycephalic breeds the cartilaginous plates forming the nares are shortened, thickened, and medially displaced, so that when covered by the thickened, keratinized epithelium they effectively obliterate the nostrils. The dorsal parietal cartilages, occupying the lateral aspects of the nostrils cause most of the obstruction. Although most people do not perform **rhinoscopy**, recent studies by Oechtering (Vet Surg 2016) have established that there is a large component of abnormally developed conchae that contribute to intranasal obstruction in brachycephalic dogs. Head **CT imaging** is also useful to observe the conchae, as well as pick up other issues such as intranasal epidermoid cysts (Murgia et al, JSAP 2014). At MSU, we routinely CT older brachycephalics.

Oropharyngeal examination is typically performed at induction of anaesthesia immediately prior to surgical intervention. Trying to examine the larynx and pharynx of the *conscious* animal is unrewarding. Following induction, hold the jaws wide open, lips retracted and the tongue pulled a little rostrally. Draw up extra injectable agent, take your time, and have an endotracheal tube close by. It is of paramount importance to accurately assess the degree of primary and secondary changes, as this will affect prognosis:

- In brachycephalic dogs, the soft palate overlies most of the epiglottis (in normal dogs, it should be just at the tip). It can actually be sucked into the rima glottidis, blocking normal passage of air through the larynx, and causing marked upper respiratory noise as it jiggles around in the airway. It often is thickened and edematous from the constant trauma from movement, and this exacerbates the condition. With time, the soft palate will elongate even further as it is repeatedly stretched into the larynx. Bulldogs (in particular) will have a thickened caudal edge of their soft palate.
- To obtain an adequate view of the larynx, a tongue depressor or other flat instrument should be used to elevate the soft palate dorsally. The laryngeal ventricles will often be everted into the rima glottidis in animals with any prolonged history, due to the excessive negative pressures created by increased inspiratory effort. This is regarded as the first stage of laryngeal collapse, and is present in over half cases presented. As the ventricles prolapse, they become edematous and inflamed and will further compromise airflow through the rima glottidis. These everted ventricles can be observed at the base of the glottis, immediately rostral to the vocal folds, and caudal to the vestibular folds.
- Three stages of **laryngeal collapse** have been proposed:
 1. Laryngeal ventricles eversion and edema
 2. Aryepiglottic collapse (cuneiform process and aryepiglottic fold deviate toward the midline)
 3. Corniculate collapse (the corniculate processes rotate and collapse ventro-medially, touching each other, and the cuneiform processes tend to overlap).

Once again, air turbulence and vibrations irritate the laryngeal mucosa causing it to become inflamed and edematous. Advanced laryngeal collapse will be discussed in more detail below.

- Always check for **epiglottic retroversion** (Flanders et al, JAVMA 2009) as another possible cause for dyspnea. The signs are not quite the same, but can be confusing. The tongue should be not retracted, and the epiglottis pushed caudally to see if the hyoepiglotticus muscle is lax and allows the epiglottis to go through the rima glottidis.

Surgical Intervention in Brachycephalic Airway Syndrome

Treatment is aimed at eliminating exacerbating conditions and surgically relieving upper airway obstruction following accurate assessment of the condition. It is preferable to operate at a young age when secondary changes are minimal, as these animals will have a better prognosis, and will also have less concurrent issues. Importantly, early surgery will prevent (or minimise) progression of the disease. Operating early will also (hopefully) avoid an acute episode of decompensation in a situation where immediate emergency veterinary attention may not be available. Intervention after the main growth spurt, but within the first year of life is preferred (6 – 12 months of age).

Atraumatic surgical technique should be practised to minimise post-operative edema, which can be quite dramatic following pharyngeal and laryngeal surgery. This involves the use of:

sharp incisions (with scalpel or sharp scissors);

- gentle tissue handling (using stay sutures or atraumatic forceps for retraction);
- fine suture material with a swaged, cutting needle;
- CO₂ laser

Short-acting corticosteroids can be administered pre-operatively to minimise edema and inflammation (0.5 mg/kg dexamethasone). Just one dose. Do not use with NSAIDs.

Care must be taken with anaesthetising these animals and they should always be regarded as high anesthetic risks, especially during induction and recovery. Cases should be listed early in the day so recovery can be closely monitored. Pre-oxygenation is indicated following premedication. A prokinetic agent such as metoclopramide or cisapride is generally administered this time. Some surgeons use glycopyrrolate to reduce salivary secretions. Propofol or alfaxalone is often used as an induction agent followed by isoflurane. Intravenous injection can then be used to maintain anaesthesia if the animal is extubated for the intraglottic procedures (i.e., resection of ventricles).

The animal must be precisely positioned to facilitate surgery. The animal is placed in sternal recumbency with the maxilla hung in a sling of tape, and the mandible pulled downwards. There must be nothing touching the ventral neck area as this can distort the larynx when viewed per os. The lips should be retracted and out of the way and the tongue pulled rostrad.

Widening of the nares (rhinoplasty)

A cuneiform wedge resection of the rostral aspects of the dorsal parietal cartilages can be performed with a no.11 scalpel blade. Hemorrhage is best controlled by pressure, and will stop when sutures are placed. The cut edges are apposed with fine (4-0 or 5-0), simple interrupted sutures of synthetic absorbable material. There are several modifications of the wedge resection (ventral, lateral). Another technique that has recently been revived is the straight amputation of the dorsal parietal cartilage, an excellent technique with laser. When this is performed, the surgeon can extend the cut into the ala fold and further open the airway. An alapexy technique has also been described.

Laser-assisted Turbinectomy

More recently, laser-assisted turbinate excision (LATE) has been proposed for improving the intranasal component of the obstructive syndrome. Rostral aberrant turbinates, caudal aberrant turbinates and mucosal contact points are obliterated using a diode laser. Once validated, this technique may provide significant improvement to dogs that have significant remaining airflow impediment following the current standard-of-care procedures.

Partial resection of the soft palate (staphylectomy, palatoplasty)

The soft palate is ideally resected to be level with the caudal pole of the tonsils, or so that it lies just on the tip of the epiglottis with the tongue in normal position. Rostral tongue traction is relaxed temporarily and the appropriate point on the midline soft palate marked with a scalpel blade. There are several techniques described for resecting the overlong soft palate in brachycephalic dogs:

- **Progressive resection & suturing:** The tip of the soft palate is grasped with Allis tissue forceps or stay suture and it is retracted rostrally. Stay sutures are placed at the most lateral aspects of each free edge and also pulled rostrally. The palate is incised from a lateral traction suture to the reference mark at its midline. The incised edge is then sutured in a continuous pattern (4-0 or 5-0 synthetic absorbable), ensuring that both nasal and oral mucosa of the soft palate are included in the bites. It is important that these mucosal surfaces are apposed as this provides haemostasis and subsequent healing without granulation tissue formation. The cut and sew technique is repeated for the second half of the soft palate.
- **Satinski:** An alternative method for soft palate resection involves the use of an atraumatic vascular forceps (eg, Satinskys) to grasp the soft palate and rostral traction through the jaws of the forceps until the reference mark is reached. The forceps are then closed to the first lock and the excess soft palate resected. The soft palate and forceps are oversewn with a simple continuous suture, left free at both ends. As the forceps are gently withdrawn, the sutures are snugged down and secured at each end. This technique also ensures the inclusion of nasal mucosa in the suture line. Fine (4-0 or 5-0) synthetic absorbable suture material is recommended.

- **Laser:** Following appropriate protection from the ET tube, laser amputation of the caudal soft palate is quick and atraumatic, and is our most favored technique. The soft palate is mobilised with stay sutures as previously described and the laser cut angled to provide a tapering finish to the caudal soft palate. It is important to remove residual char following the laser cut. Oversuturing is optional, but is typically performed at our institution.
- **Palatoplasty:** a technique of folding over the caudal palate was recently described, where a tapering of the caudal soft palate is obtained. This is recommended for thick soft palates.

Excision of everted laryngeal ventricles

Surgical resection of everted laryngeal ventricles is achieved either with the ET tube pushed dorsally, or with temporary extubation and intravenous anaesthetic support as needed. The tongue is pulled rostrad and the ventricle is grasped with a long handled, fine-tipped instrument (Gerald forceps). The ventricle is then gently teased into full eversion and amputated at its base with long handled scissors (Reynolds or Sweet scissors). Be careful not to cut or traumatize the vocal folds at this time. Any haemorrhage (there should not be much) can be controlled with pressure. An alternative technique is to use a diode laser and endoscope.

Post-operative care

Attentive post-operative monitoring is extremely important with brachycephalic patients regardless of the surgical intervention performed. Physical maintenance of an airway should extend well into the recovery period, and observation continued until the animal is ambulatory. If allowed to recover in a cool, quiet environment without stimulation, the animal will generally tolerate the endotracheal tube until fairly conscious. Oxygen can then be provided in the form of nasal or nasotracheal catheter, mask, or oxygen cage, until it has been determined that the patient can manage on room air without developing respiratory distress.

Once a patient has been extubated, one should be prepared to re-intubate, with intravenous anaesthetic agents drawn up and the i/v catheter still in place. If marked post-operative edema is causing respiratory embarrassment, racemic epinephrine can be nebulized. If still no improvement, a temporary tracheostomy tube can be placed (a rare requirement). With short-acting steroids, the swelling usually resolves within 24 - 48 hours. Antibiotics are not usually indicated for these surgeries.

Animals that have a history of regurgitation will benefit from a prokinetic agent such as metoclopramide, for a week or two post-operatively.

Prognosis

The final outcome depends on the degree of primary changes and the severity of secondary changes at the time of surgery. In patients without advanced laryngeal collapse, widening the nares, shortening the soft palate and excising the everted laryngeal sacculles should relieve moderate to severe signs of respiratory distress. These patients will breathe with less effort, will be more tolerant of exercise and excitement, and will maybe make less noise. Much will depend on the amount of intranasal obstruction – good indication for head and neck CT. As long as the owner is informed as to what to expect, client satisfaction is high.

The young patient that is only mildly affected, with no secondary changes, may not show marked improvement post-operatively. It should be pointed out to the owner, however, that the condition would now not progress at the rate that it would have done without surgery. Even the 'normal' brachycephalic should have its upper airway evaluated.

Complications

Recovery is typically uncomplicated following surgery. Watch carefully for post-operative regurgitation as this can lead to aspiration. Occasionally, some gagging and coughing can be seen early in the recovery period, usually associated with eating or drinking. Rarely, inflammation and edema can cause obstruction and if animals are not monitored closely, death can result. Voice changes have been reported with laryngeal surgery– this generally indicates that the vocal cords have been damaged during saccullectomy.

Overshortened soft palate:

Nasal regurgitation and rhinitis/sinusitis is seen following a too radical resection. Correction should be performed as soon as possible, to prevent a chronic rhinitis and permanent changes to the nasal conchae. Buccal mucosal flaps can be developed, or a mucoperiosteal flap from the hard palate has also been described. Correction of an overshortened soft palate is usually a specialist procedure.

Collapsed larynx:

Animals with more advanced laryngeal collapse will still have some of their respiratory distress alleviated with surgical resection of the above redundant tissues. In these cases, it is still worth performing the above procedures initially, along with owner counselling. If signs are not adequately improved following nares, soft palate and laryngeal ventriculectomy, a few specialists will perform a castellated laryngofissure (or ventral laryngotomy), vocal fold resection & suture, and bilateral lateralization of the vocal processes of the arytenoid cartilages. Other recommendations are to perform a permanent tracheostomy. Permanent tracheostomy is a salvage procedure, and requires moderate maintenance, but can dramatically improve quality of life.