A Comprehensive Review of Brachycephalic Obstructive Airway Disease: Pathophysiology, Diagnosis, Management, and Future Perspectives

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Abstract

Popularity of brachycephalic breeds of dogs is ever-increasing, which is somewhat surprising given the fact that the awareness of Brachycephalic Obstructive Airway Syndrome (BOAS) and its many consequences is on the rise. The BOAS is a chronic, debilitating and progressive disease that starts early and shortens both the lifespan and health of these dogs. Although there is a strong genetic component to this condition, most brachycephalic dogs are not born having all these anatomical abnormalities. Rather, BOAS begins as stenotic nostril, continues with thickening of the nasal mucosa, followed by laryngeal softening and collapse, tracheal narrowing and bronchial collapse. Concurrently, other body systems also suffer, including the eyes, brain, skin, spine but most of all, the gastrointestinal system. The severity of BOAS can be greatly reduced through owner education, early detection of the condition and early treatment. This review article provides an overview of BOAS pathophysiology, clinical examination, grading scales, diagnosis and treatment of those patients. Dogs with BOAS share many common issues though this is still an individualised condition with many faces. Consequently, many different treatment options are described. Finally, prognostic factors and future trends are also discussed.

Key words: *brachycephaly; dogs; treatment; prevencija*

Introduction

Canine brachycephaly is a man-made condition resulting from years of highly selective breeding. There are several definitions of brachycephaly, so consequently the list of such breeds is incomplete (the American Kennel Club list 24 breeds). The most popular brachycephalic breeds are pug, French bulldog and English bulldog. Their popularity coincides with the severity of their clinical signs. The remaining 21 breeds, and several other breeds not traditionally considered brachycephalic breeds (such as Staffordshire terrier) may have some

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of the anatomical abnormalities typical for brachiocephalic breeds, though due to a lesser severity of their condition, most scientific research as focused on pugs, French bulldogs and English bulldogs (Ekenstedt et al., 2020).

Although public education regarding health problems of brachycephalic breeds is ever present, the popularity of these dogs is on the rise. It is highly unlikely that those drawn to this dog phenotype are completely unaware of all the possible health issues associated with them, though the motivating factors for deciding to acquire these breeds far outweighs the health concerns. Rounded skull, short muzzle, large forehead, large protruding eyes and bulging cheeks are infantile facial features, triggering the same positive emotions in adults as a human baby (Ekenstedt et al., 2020).

The defining characteristics of brachycephalic breeds are respiratory issues caused by several anatomical abnormalities. The umbrella term is brachycephalic syndrome, or more recently Brachycephalic Obstructive Airway Syndrome (BOAS). Unfortunately, respiratory issues are not isolated in these breeds, and nearly all face varying degrees of thermoregulatory, gastrointestinal, ophthalmological, dermatological, spinal, reproductive and dental problems. Most of those are related to conformational abnormalities. As respiratory problems are the most devastating consequence of their anatomical abnormalities, this review will focus on this aspect.

The impact of BOAS on the affected dog's quality of life, respiratory function, and overall well-being is best represented by the New Zealand Veterinary Association, in saying that pug, French and English bulldog health and welfare is too compromised to continue breeding (Packer et. al., 2019).

Scientific search applications such as Google Schoolar and Pubmed currently list well over 4500 brachycephalic syndrome related studies, indicating the strong progress in understanding this condition.

Pathophysiology of BOAS

BOAS is characterised by respiratory and thermoregulatory issues caused by several anatomical abnormalities.

Canine brachycephaly is usually defined by a high cephalic index, which is the ratio of skull length to skull width. The most prominent feature of such configuration is a shortening of the premaxillary and maxillary bones (muzzle) and latero-lateral widening of the skull. The nasal conchae are frequently aberrant and extending caudally into the nasopharynx. Frontal sinuses are reduced or absent (Krainer and Dupre, 2022).

Abnormality of respiratory tract

Liu et al. (2017) studied many conformational risk factors apart from cephalic index. They measured craniofacial ratio, eye width ratio, skull index, neck girth ratio and neck length ratio. It was found that stenotic nostrils, body condition score and neck girth ratio are applicable predictors for BOAS.

Pharyngeal collapse is defined as partial or complete collapse of the pharynx due to dorsal displacement of the soft palate, ventral deviation of the dorsal pharyngeal wall, or a combination thereof (Pollard et al., 2018). Pharyngeal collapse is sporadically mentioned and diagnosed in veterinary medicine, though Rubin et al. (2015) emphasise that the possibility is much higher in brachycephalic dogs, referring specifically to an English bulldog diagnosed with the condition and not having classical respiratory issues for that breed.

In their fluoroscopic study, Pollard et al. (2018) indicated that 72% of brachycephalic dogs had evidence of pharyngeal collapse, with pugs, French and English bulldogs as the breeds with the highest prevalence for this condition. The condition cannot be corrected surgically, but as with other BOAS related issues (hiatal hernia), surgical correction of nares and palate may alleviate some of the symptoms.

Hara et al. (2020) described a step further from pharyngeal collapse – pharyngeal contraction. They evaluated pharyngeal motion with dynamic 4D-CT imaging from free breathing in four dogs and observed that pharyngeal contraction worsened the respiratory states in those dogs. They stressed that if the laryngospasm continues without relief, it can lead to pulmonary oedema, cardiac dysrhythmias, cardiac arrest, and ultimately death.

Changes in skull conformation are mainly of bone origin and not soft tissue, meaning that soft tissues of the upper respiratory tract (nostrils, nasal mucosa, soft palate, tonsils and often tongue) do not scale proportionately with the bone reduction.

This leads to stenotic nares, soft palate displacement and hyperplasia, relative macroglossia, mucosal hypertrophy of turbinates, mucosal contact points, palatine tonsil overgrowth, everted laryngeal saccules, mucosal oedema, laryngeal collapse, hypoplastic trachea and bronchial collapse (Dupre and Heidenreich, 2016).

Stenotic nares are the most common anatomical change in dogs with BOAS. A grading system was described as follows: 0 = wide open, 1= mild, slightly narrowed, lateral nostril wall not in contact with the septum, 2 = moderate, lateral wall in contact with wall dorsally, but not ventrally, 3= nostrils almost closed (Liu et al., 2017).

The **nasal cavity** was somewhat ignored as part of brachycephalic syndrome until 2016, when Oechtering et al. (2016) used a combination of endoscopy and computer tomography to document intranasal obstruction in brachycephalic dogs. They described two additional structures not present in the non-brachycephalic nasal cavity: rostral and caudal aberrant turbinates. The most extreme reduction in airway space is caused by direct mucosal contact (Oechtering et al., 2016). It can be safely assumed that extreme intranasal obstruction greatly enhances heat intolerance in those dogs. In humans intranasal mucosal contact points can be linked to facial pain called rhinogenic contact point headache (Mantia et al., 2018), though it is not known whether there is a similar phenomenon in dogs.

Sharp et al. (2024) stated that nostrils are a dynamic structure, at least in non-brachycephalic dogs, meaning that they can increase their diameter in higher demand states, such as exercise or excitement. Their study included 974 brachycephalic dogs and concluded that brachycephalic dogs with moderate and severely stenotic nares have reduced nasal mobility compared to brachycephalic dogs with mildly stenotic or open nares. This suggests that there is an indication for stenotic nare resection, regardless of the intranasal anatomy.

Siedenburg and Dupre (2021) contributed to understanding upper airway dimension in pugs, French and English bulldogs by describing relative macroglossia in those breeds. Tongue volume normalised to bodyweight was significantly higher in English and French bulldogs than in pugs. Normalised to skull length, the cross-sectional area of the tongue was smaller in pugs than in French and English bulldogs. Although

surgical correction of increased tongue volume is still not described in dogs, this is still an important finding in understanding all factors contributing to difficulty in breathing and swallowing in pugs, French and English bulldogs.

Given the fact that all soft tissues of the head are redundant in comparison with bone, it is not surprising that this may present as a serious issue. Schabbing and Seaman (2017) described overgrown and oedematous glossoepiglottic mucosa causing a laryngeal obstruction in English bulldog.

Soft palate elongation and thickening is well documented and it is responsible for the majority of snorting, gagging, and retching, especially if it overlaps the epiglottis (Roedler et al., 2017). The soft palate does not have a fixed length and thickness in an adult dog, but can grow in both dimensions because of progressive increased airway resistance (Picheto et al., 2011). There is a positive correlation between soft palate thickness and the severity of clinical signs (Grand and Bureau, 2011). Elongated soft palate can even be seen in non-brachycephalic breeds and this requires treatment (Himel et al., 2023).

Tracheal hypoplasia is common in English bulldogs and while it does not necessarily produce clinical signs on its own, it is a negative prognostic factor for bronchopneumonia (Siedenburg and Dupre, 2021). A hypoplastic trachea will not improve in diameter after BOAS surgery (Regier et at., 2020). Tracheoscopy seem to be most precise diagnostic tool for tracheal size (Kaye et al., 2015).

Tamura et al. (2021) described difficult airway management during anaesthesia in two brachycephalic dogs because of an extremely narrow cricoid cartilage. Although hypoplastic trachea is commonly described in brachycephalic dogs, this was the first clinical case report describing a new addition in the whole array of abnormalities contributing to respiratory distress and its management in those breeds. A malformation of a hyoid was described in French bulldog (De Bruyn and Hosgood, 2022).

Palatine tonsil enlargement or protrusion is sometimes seen in brachycephalic breeds and while it is linked to decreased exercise tolerance, benefit of tonsillectomy is unclear (Turkki et al., 2022). Since low level inflammation of the tonsils is most likely mediated by gastroesophageal reflux, some surgeons advocate removal while others do not (Belch et al., 2017).

Laryngeal saccules eversion is also called stage 1 of laryngeal collapse. While some prefer to remove them, others claim they will reduce on their own if the airway issues cranial to them are properly addressed. Pugs have the smallest glottis opening relative to its body size and they are also significantly more affected by laryngeal collapse than other brachycephalic breeds (Haimel and Dupre, 2015).

Long term negative pressure gradient consequences do not stop at the laryngeal level but progress to bronchial collapse. Most commonly, collapsed bronchi are left main and left cranial dorsal (Reinnero and Masseau, 2021). Bronchial collapse is a relatively common incidental finding seen on lung CTs in non-brachycephalic dogs, but the pathophysiology of its occurrence in not the same, nor are the consequences (personal observation).

Middle ear effusions are often present as an incidental finding in brachycephalic breeds, most notably French bulldogs, in up to 41% of dogs. The cause is most likely found in dysfunc-

tion of the Eustachian tube (Milne et al., 2020).

Abnormalities of the gastrointestinal tract

Although this article mainly focuses on the respiratory system, overlapping physiological and anatomic mechanisms are required for breathing and swallowing, and thus one can affect the other (Grobman, 2021). The prevalence of gastrointestinal signs such as regurgitation, vomiting and dysphagia can be as high as 97% (Freishe and German, 2021). Hiatal hernia is also frequently described in brachycephalic dogs (Reeve at al., 2017), but seldom requires surgical treatment other than treating BOAS itself. In a recent study, 100% of dogs with hiatal hernia were brachycephalic (Eivers et al., 2019).

Oesophageal motility disorders are also common in brachycephalic breeds and predisposes them to gastroesophageal reflux disease (Kaye et al., 2018). One study links this disorder to idiopathic rhinitis (Gianella et al., 2020).

The most commonly described systemic consequences of BOAS are chronic hypoxemia, hypertension and hypercoagulability. Brachycephalic obstructive airway syndrome results from partial or complete multilevel airway obstruction. Anatomical abnormalities will work together to increase air flow and the pressure gradient during inspiration. This in turn causes secondary changes such as oedema of the upper airway mucosa, elongation and thickening of the soft palate and chronic inflammation. Oedema and inflammation will further contribute to narrowing of the airway lumen, increasing the inspiratory pressure further, and result in laryngeal saccules eversion, laryngeal softening, laryngeal collapse and bronchial collapse as a consequence. While the time frame for such events is not universal, laryngeal collapse has been described in dogs younger than 6 months (Ekenstedt et al., 2020).

Poor sleep quality as a result of sleep disorder breathing (SDB) is present in many brachycephalic dogs. Consequences of poor sleep quality as very well described in humans (Denison et al., 2021) and it can be assumed that at least some of them are present in dogs as well. SDB denotes any abnormal breathing during sleep. Niinikoski et al. (2023) described the use of the human Nukute neckband system in brachycephalic dogs and confirmed that SBD is common in brachycephalic dogs and found that the system was well tolerated by dogs.

Clinical Presentation and Diagnosis

Clinical presentation may vary greatly depending on environmental factors, but generally includes stertor, stridor, inspiratory dyspnoea, and expiratory dyspnoea later in the course of disease, increase respiratory effort, shortness of breath, exercise intolerance and poor ability to thermoregulate (Ekenstedt et al., 2020).

Owner report and history

Owners of brachycephalic dogs are those who bring their pets to veterinarians because of breathing difficulties, but in most cases, they are oblivious to the objective severity of the condition. Packer states that ownership of brachycephalic dog breed is a complex phenomenon characterised by a strong dog-owner relationship and more importantly unrealistic perceptions of good health set against high levels of disease (Packer et al., 2019).

In an attempt to objectify owner reports, several questionnaires had been

proposed. Barker et al. (2021) described the breathing score in order to determine owner perceived and actual daily activity using an accelerometer. The owners had to grade the frequency and type of respiratory noise at rest, walking, during exercise, and sleeping. They were asked to note sleeping and activity patterns. The study had several limitations but the most important finding was the owners' misperceptions of normal breathing and activity patterns.

Owners can describe clinical signs in great detail but do not understand their clinical relevance. Pohl et al. (2013) prepared a 62-question owner survey about the influence of multilevel upper airway surgery on life quality, mainly concentrating on exercise and heat tolerance, sleeping and feeding habits. Kenny et al. (2022) noted that 75% of owners consider snoring, snorting and loud breathing normal.

There are several avenues to pursue to maximally objectify the severity of BOAS in a particular patient, but as much as this condition as similar it is also quite individualised, so there is no universally accepted gold standard in diagnostics. Decision on treatment modality is a combination of owner expectations, surgeon preference, and objective diagnostic tools. Using phenotypic evaluation only will almost always lead to underestimation of BOAS severity (Turkcu et al., 2023).

Fitness tests

Six minute walk test and 1000 m walk test were described to assess the severity of BOAS in English bulldogs (Lilja-Maula et al., 2017). Riggs and Liu (2017) described a 3-minute walk test and 5-minute walk test. Mach et al. (2022) described a treadmill based submaximal exercise test for pugs, and Turcku et al. (2022) used the same test for six different brachycephalic breeds. Dogs walked on a treadmill for 15 minutes, followed by a 2-minute break. After assessment, dogs were graded 0 to 3 (3 being the most severe). Noise intensity was also classified from 0 to 3. It was show that this type of test is relatively easy to perform and can be applied to most brachycephalic breeds, not just pugs. However, whether or not the test is universally applicable depends on equipment and the dog's willingness to participate.

Other grading systems include the Poncet-Dupre score which is a combination of respiratory and digestive clinical signs (Poncet et al., 2005). Symptoms score based on noisy breathing, exercise intolerance and anatomical abnormalities (Bernaerts et al., 2010).

Whole-body barometric plethysmography can be used for respiratory function testing. Whole-body barometric plethysmography flow traces are 93% specific and 90% sensitive to identify respiratory obstruction and has been validated to discriminate BOAS affected versus non-affected brachycephalic dogs (Liu et al., 2016). High specificity and sensitivity numbers of this test would make this modality the golden standard for BOAS functional diagnosis, though the availability of this test is still very low.

With whole-body barometric plethysmography, a BOAS index can be calculated, allowing for an objective evaluation of BOAS severity, risk for BOAS, and effectiveness of surgical treatment (Liu et al., 2016).

Brachy Sound

Using the technology in providing objective assessment of a patient is double-edged sword and probably should not be used as the only modality, regardless of the condition in question. However, as there is a huge discrepancy in own-

er perception and objective reality when it comes to brachycephalic breed health, every objective assessment modality can be useful. One such modality was explored in a study to objectify laryngotracheal auscultation by recording and analysing breathing sounds. Conclusion of the study group was that a combination of standardized fitness test and machine learning algorithm has immense potential in the diagnostics of BOAS (Oren et al., 2023).

Diagnostic imaging

Every diagnostic imaging technique will provide some additional information, but as BOAS has both static and dynamic components, not all are equally effective. Radiography should be a part of BOAS management as it can provide information about the following: soft palate length and thickness, tympanic bulla thickness, secondary heart and lung diseases and hiatal hernia.

CT provides more detail about the head, neck and thoracic anatomy (Grand and Bureau, 2011; Heidenreich et al., 2016). However, it requires general anaesthesia, which is not appealing to most owners of brachycephalic breeds and may not alter the course of treatment.

Endoscopy is the modality of choice for evaluation of nasal cavity (aberrant turbinates), larynx, trachea and bronchi (Schuenemann and Oechtering 2014). Surgical treatment and endoscopy can be performed during the same anaesthesia without increasing the odds of post-anaesthetic complications.

Infrared thermography

An impaired ability to thermoregulate is one of the main reasons brachycephalic dogs are mainly presented during summer. Guided by that by the fact that all other currently available modalities do not focus sufficiently on the physiological consequences of BOAS. Gallman et al. (2023) did a pilot study of using infrared thermography to assess impaired thermoregulation. The study demonstrated the potential utility of combining standard tests with infrared thermography to provide clinical recommendations to guide treatment.

Management Strategies for BOAS

As with many conditions in veterinary medicine management, the treatment of BOAS is multidisciplinary. The most important factor in successful management is likely the owner, above all by providing a favourable environment for the dog and by being adequately aware of the severity of clinical signs. Although BOAS can be managed conservatively, until breeding ethics sufficiently catch up, it can be considered a primarily surgical disease.

Conservative therapy includes weight management, keeping the excitement and stress level low, cooling when necessary, and giving drugs that reduce gastric acid secretion and provide gastrointestinal motility.

Surgical treatment should be individualised to each dog depending on the severity of the upper airway abnormalities. No optimal time to correct airway obstruction has been established. Still, most specialists would agree that proximal level obstructions should be corrected quite early in life in order to minimise the consequences on more distal levels. Currently, 6 months of age is considered a good starting point for most dogs, although some problems can be present even earlier. On the other hand, one should use good clinical judgement and not deny treatment for older dogs, because some studies show that some improvement

in clinical signs is possible, even in mature and middle-aged dogs (Haimel and Dupre, 2015).

Anaesthesia of brachycephalic dogs is complicated, with a nearly 1.6-fold higher risk for complications than normocephalic dogs. They are also more prone to post-anaesthetic complications (Grunheid et al., 2018). Some problems associated with brachycephalic breeds that may influence anaesthetic management are: the primary and secondary components of BOAS, gastrointestinal problems such as regurgitation, vomiting, gastroesophageal reflux, hiatal hernia, reduced corneal sensitivity and ulceration, hypercoagulable status, hypoxemia, hypercapnia, and relative hypertension (Downing and Gibson, 2018). On the other hand, Doyle et al. (2020) found that the chances of complications during subsequent anaesthetic events were decreased by 79% in dogs having previous surgical intervention to correct clinical signs of brachycephalic airway syndrome.

In most cases, surgical treatment addresses stenotic nares, soft palate and laryngeal saccules. The term multilevel surgery denotes these three issues, plus an additional procedure such as turbinectomy, tonsillectomy and partial laryngectomy.

Stenotic nares

Stenotic nares resection (rhinoplasty) can be performed in brachycephalic pup-

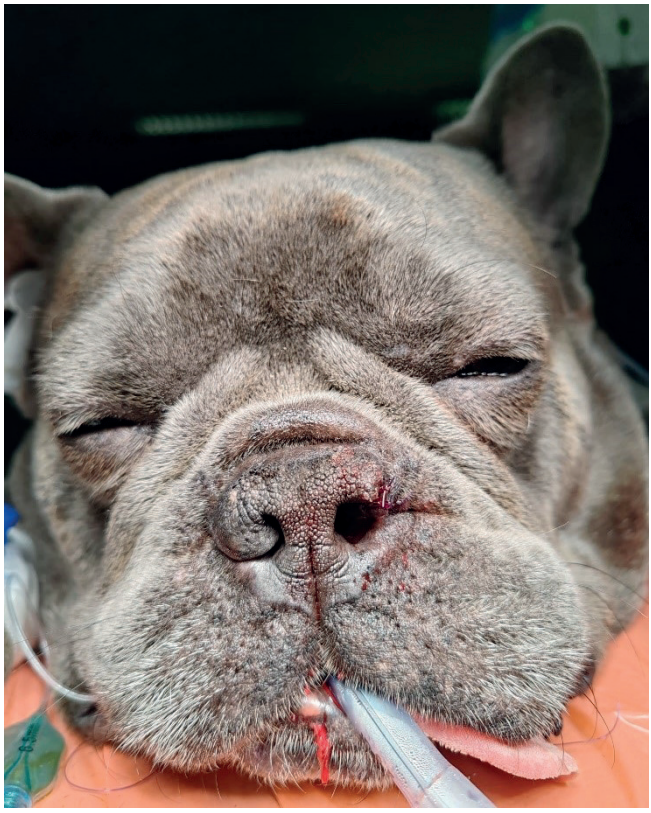

Figure 1. Comparison of opening of non-operated vs. operated nostril in French bulldog

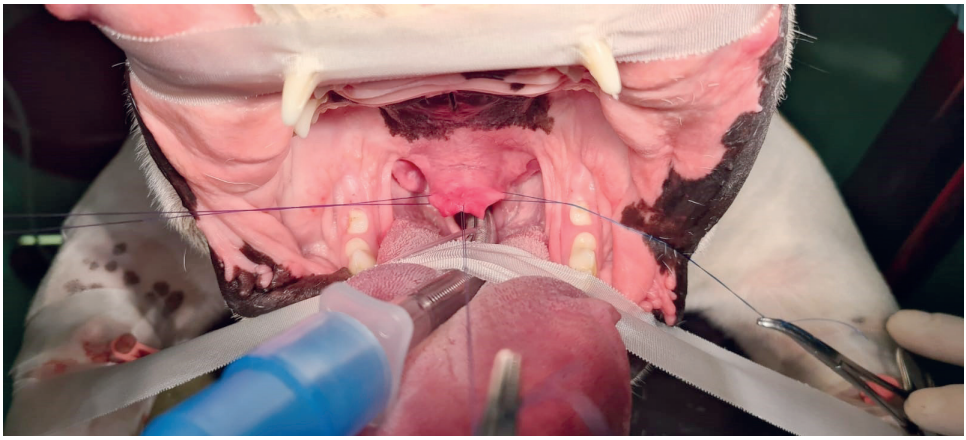

Figure 2. Overgrown soft palate in English bulldog

pies to reduce the likelihood of secondary upper airway obstruction (Krainer and Dupre, 2022) (Figure 1).

Alaplasty is by far the most commonly used technique in which wedge shaped pieces of ala nasi is removed and closed with resorbable sutures. Different versions of that technique have been described with similar results (Krainer and Dupre, 2022). Vestibuloplasty is poorly described in textbooks, although it is the technique of choice for some surgeons.

Trader's technique was originally described in 1949 and consists of removing part of the alar wing without suturing. It provides good cosmetic and functional results, but haemorrhaging can be substantial and prolonged (personal observation). This technique was used in study in 2008 with satisfactory results (Huck et al., 2008).

Trostel and Frankel (2010) used skin biopsy punch to perform nasal alloplasty in a study of 14 cases and report good to excellent results.

Turbinectomy

Turbinectomy and its laser-assisted variation (LATE) are aimed at removal of malformed obstructive parts of the ventral and medial nasal turbinates. LATE, combined with stenotic nares resection and palatectomy resulted in an excellent outcome (Krainer and Dupre, 2022). As some of the resected turbinates can grow back, albeit with fewer mucosal contact points, the long-term prognosis is still not completely known.

Soft palate

Surgery of the soft palate has two main desired goals: to reduced length and to reduce thickness, and for these goals two main surgical techniques are described with many variations in landmarks, surgical suture choice and cutting equipment. (Figure 2).

Cut and sew is originally described as a palate shortening technique in which the tip of the soft palate is grasped by forceps or stay suture and removed up to a desired landmark. The landmark can be the caudal, middle or rostral edge of the palatine tonsil. Regardless of the technique, the sewing part may not be necessary and instead, a variety of electrical cutting modality such as carbon dioxide laser, diode laser, bipolar sealing device and other can be used. Dunie-Merigot et al. (2010) found no differences in the final outcome comparing monopolar cautery, CO_2 laser and diode laser.

Figure 3. Post-operative condition (after folded-flap palatoplasty)

Folded flap palatoplasty

This is an excellent technique that addresses both length and thickness of the soft palate, thus providing an obstruction relief on two levels (Krainer and Dupre, 2022). Although the learning curve for this technique is a bit steeper than for the previously described one, it is the author's technique of choice for most patinets (Figure 3).

H-pharyngoplasty

Carabolona et al. (2021) described an interesting technique which is a variation of a similar treatment used in human medicine. It uses laser to excise both the palatine tonsils and soft palate with a resulting wound resembling the letter H. The study was done on 432 patients and appears promising but more similar studies are needed before final verdict.

Split staphilectomy

Holloway et al. (2022) described this technique in a study of 75 cases. It addresses both the length and thickness of the soft palate. While it seems straightforward and has very low morbidity rates, its novelty does not allow adequate comparison with regular techniques.

Temporary palatopexy

Temporary palatopexy is a simple procedure that may be a useful method for managing brachycephalic dogs in an upper airway crisis. It can be most useful in clinics without an intensive care unit needed for tracheostomy management (Sun et al., 2022).

Laryngeal sacules

Resection of laryngeal saccules can be done using electrocautery, scissors, biopsy cut forceps or tonsil snares, but the question remains whether it is needed at all. Given that the surgical outcome is similar whether or not saccules are removed and the fact that there is the possible of complication such a laryngeal webbing, removal was recommended only when its contribution to obstruction is significant (Krainer and Dupre, 2022).

Partial laryngectomy is no longer recommended as it has over a 50% mortality rate (Krainer and Dupre, 2022).

If everything else fails, a salvage procedure in the form of permanent tracheostomy could be performed, although a 50-80% rate of major complications is reported, such as aspiration pneumonia, stoma stenosis and skinfold occlusion. Age was found to be positively associated with need for temporary tracheostomy (Krainer and Dupre, 2022).

Surgical and post-operative complications

BOAS surgery is not as technically demanding as its complete management. Postoperative complications are not common but when they occur, they can be devastating. Dyspnea secondary to soft palate bleeding and swelling as well as pharyngeal swelling occurs in up to 23.4% of patients (Krainer and Dupre, 2022).

Treatment of the most serious complications that occur in the acute post-operative period include oxygen supplementation, corticosteroid administration, nebulization with epinnephrine-adrenaline (Krainer and Dupre, 2022) and reintubation to check for bleeding and to provide adequate ventilation and oxygenation.

Although quite common i.e., 4.7 to 34.5%. Krainer and Dupre (2022), postoperative regurgitation is usually self-limiting and may even not require special treatment. Still, perioperative use of metoclopramide and proton pump inhibitors seems to decrease its risk (Costa et al., 2020).

A regurgitation study was done by Appegrain et al. (2022) on 51 hospitalised brachycephalic dogs and concluded that 84% of dogs displayed abnormal reflux and that the occurrence of reflux was not associated with owner-assessed preoperative respiratory and gastrointestinal grade, laryngeal collapse grade, and previous airway surgery.

In the author's experience, post-operative aspiration pneumonia is very rare. Nevertheless, brachycephalic dogs have a 3.77 fold higher risk than other breeds, especially those with both respiratory and gastrointestinal clinical signs (Krainer and Dupre, 2022).

The brachycephalic risk score (BRisk) was developed to predict the risks of post-operative complications in dogs presented for BOAS treatment. Categories included the type of brachycephalic breed, surgical history, planned procedure, body condition score, level of compromise at admission, and rectal temperature at admission. The study concluded that the score developed from admission data in this study accurately rated the risk of negative outcome of dogs undergoing corrective surgery for BOAS (Tarricone et al., 2019).

Prognosis, Quality of Life, and Long-Term Monitoring

Prognosis

Prognosis in BOAS surgery has to be observed both from an objective and owner's point of view and needs to be thoroughly discussed with the owner prior to surgery. This may seem self-evident but in comparison to most other areas of surgery, prognosis is not as easily explained. There is a general agreement between specialists and probably owners that surgical treatment of BOAS will provide certain benefit. However, what many owners fail to grasp is that BOAS surgery is palliative and not curative.

Comparing studies to gain a more objective perspective of the prognosis is not rewarding, as those studies are

mostly retrospective with too many different variables that can all contribute to the outcome (Krainer and Dupre, 2022).

Prognosis is also complicated by some studies indicating recurrence of clinical signs in almost 100% of cases (Krainer and Dupre, 2022).

Thermoregulation issue is the most treatment resistant feature of BOAS. However, Zgank et al. (2023) in a pilot study observed improved postoperative thermoregulation in French Bulldogs.

Owners have to be aware that brachycephalic dogs will never have the health span of normo-cephalic dogs and that they have to prepared for long-term management based mostly on strict weight control, and avoidance of strenuous exercise and temperature extremes.

Emerging Trends and Future Directions

The future for brachycephalic dogs could bring some improvements, but whether or not that improvement will be substantial enough is questionable. First, it is very difficult to change human nature, which is the primary component behind the popularity of brachycephalic breeds. Second, though not a completely separate reason, and also part of a human nature, is the financial component. Breeders of brachycephalic dogs, knowing exactly why their breeds are popular, will not hurry to improve breeding practices and genetic testing. All this was mirrored in a study by Asbjer et al. (2024). The study was in the form of a questionnaire with 1602 owners, 1551 breeders, 118 show judges and 557 show participants. While all sides agreed on the fact that health issues related to conformity threaten the health of brachycephalic breeds, disagreement was noted the further measures to be taken.

Marchant et al. (2019) found a genetic base for upper airway syndrome in the Norwich terrier, whose symptoms greatly resemble BOAS in brachycephalic breeds. Although air resistance caused by upper airway abnormalities is believed to be a major causative factor of BOAS, similar symptoms in non-brachycephalic dog with known genetic mutation provide some hope that a similar genetic makeup could also be found in brachycephalics.

Throughout this review, early intervention and early treatment is accentuated as the best chance for brachycephalic breeds to lead an easier, if not completely normal life. In the light of the disagreement between vets, owners and show judges, early treatment can only be provided through improved public education, and earlier and more objective detection methods of those patients than would have the most benefit from surgery. New surgical techniques and improvement of old ones will definitely become available, though their benefit will only be seen if applied early enough.

Conclusion

Brachycephalic obstructive airway syndrome is an extremely complex chronic condition that causes progressive health deterioration in brachycephalic breeds. Although there are over 20 brachycephalic breeds, pugs, French bulldogs and English bulldogs represent the extreme side of the spectrum. Respiratory difficulties are the cornerstone of their clinical presentation and almost all other body system suffer the consequences. Owner education and early detection of BOAS is of critical importance to maximally enhance treatment success and the well-being of brachycephalic dogs.

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Pregled brahicefalne opstruktivne bolesti dišnih putova: patofiziologija, dijagnoza, liječenje i perspektive

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Popularnost brahicefaličnih pasmina pasa je u stalnom porastu, a i svijesti ljudi o njihovim zdravstvenim problemima je isto tako u porastu. Brahicefalični sindrom je kronična, iscrpljujuća progresivna bolest koja skraćuje životni vijek pasa tih pasmina. Iako postoji genetska komponenta ovog stanja većina brahicefaličnih pasa se ne rađa sa svim anatomskim promjenama koje su dio ovog sindroma. Sindrom počinje sa suženim nosnicama, a nastavlja se zadebljanjem nosne sluznice, produljenjem i zadebljanjem mekog nepce, opuštanjem i kolapsom grkljana. Ove pasmine pate i od problema s drugim organskim sustavima: „očiju, mozga, kože, kralježnice, ali ponajviše probavnog sustava". Stupanj ozbiljnosti ovog stanja može se smanjiti edukacijom vlasnika, ranim otkrivanjem te ranim liječenjem. Ovaj pregledni članak obuhvaća patofiziologiju brahicefaličnog sindroma, klinički pregled, stupnjevanje, dijagnozu i liječenje. Psi s brahicefaličnim sindromom dijele mnoge zajedničke karakteristike. Ovo je stanje s različitim simptomima stoga su posljedično opisane i različite tehnike liječenja. U ovom preglednom članku dani su i neki prognostički faktori i trendovi.

Ključne riječi: *brahicefalični sindrom, pas, liječenje, prevencija*