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Upper Airway Obstruction in Norwich Terriers: 16 Cases

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Background: Norwich Terriers have grown increasingly popular as show animals and pets, and awareness of respiratory problems within the breed is growing.

Objective: To describe components of obstructive upper airway syndrome in a nonbrachycephalic terrier breed.

Animals: Sixteen Norwich Terriers; 12 with and 4 without clinical signs of respiratory disease.

Methods: Prospective case series. Physical and laryngoscopic examinations were performed by 1 investigator in all dogs. Medical and surgical interventions were summarized and results of follow-up examination or owner reports were recorded.

Results: The study population was comprised of 9 females (6 intact) and 7 males (5 intact). Median age was 3.0 years (range, 0.5–11 years). Of 12 dogs presented for a respiratory complaint, physical examination was normal in 4 dogs. Laryngoscopic examination was abnormal in 11/12 dogs with redundant supra-arytenoid folds, laryngeal collapse, everted laryngeal saccules, and a narrowed laryngeal opening in most. Of 4 dogs lacking clinical signs, all had normal physical examination; however, 3/4 dogs had similar appearance of the larynx to dogs with clinical signs. Response to surgical intervention was minimal to moderate in all dogs.

Conclusions and Clinical Importance: Norwich Terriers suffer from an upper airway obstructive syndrome that differs from that encountered in brachycephalic breeds. Affected dogs are difficult to identify without laryngoscopic examination because of the lack of clinical signs and abnormalities in physical examination findings, despite severe airway obstruction. Care is warranted when anesthetizing Norwich Terriers because of the small size of the laryngeal opening.

Key words: Anesthesiology; Computed tomography; Genetics; Larynx; Pharynx; Respiratory tract endoscopy; Respiratory tract surgery.

Brachycephalic airway obstructive syndrome is characterized by any combination of stenotic nares, elongated soft palate, and everted laryngeal saccules.[1–6] Some authors consider laryngeal collapse as a component of brachycephalic syndrome,[1,7] and in the Bulldog, tracheal hypoplasia also can be found. Nasal narrowing and tracheal hypoplasia are considered as primary abnormalities, eversion of the saccules and laryngeal collapse are attributed to upper airway obstruction,[7] and elongated soft palate generally is a primary condition, but it could possibly become elongated or thickened because of negative inspiratory pressure within the airway, a process that occurs in other pharyngeal tissue.[7,8] Nasopharyngeal turbinates also can contribute to upper airway obstruction, are found most often in Pugs, and are likely a primary or congenital abnormality associated with shortening of the muzzle.[9]

The brachycephalic phenotype is defined by a severely shortened muzzle in a short and wide head; prognathism and wide-set prominent eyes are common. Quantification of brachycephaly is performed by calculating the skull index of the head. Subjects with a skull width-to-length ratio >0.8 are categorized as brachycephalic. In contrast, mesocephalic dogs have a smaller width-to-length ratio.[10,11] Typical breeds affected by bracycephalic syndrome include the English and French Bulldog, Pug, Boston Terrier, and Shi Tzu, and the chromosomal location for brachycephaly recently has been identified on Cfa 1 using genome-wide association.[12] The Norwich Terrier does not phenotypically resemble breeds with brachycephalic syndrome, but owners and breeders of Norwich Terriers have expressed concern regarding respiratory difficulty in the breed, and the Norwich and Norfolk Terrier Club (USA) has formed a "Health and Genetics Sub-Committee for Research on Upper Airway Syndrome in Norwich Terriers".[a] Genetic analysis of affected and unaffected dogs is ongoing as is investigation into the role of skull shape in brachycephaly.[12,13]

Specific examination findings and typical phenotypic appearance allow early recognition of brachycephalic syndrome, and surgical therapies such as stenotic nares resection, staphylectomy, and sacculectomy are associated with excellent outcome in most cases.[2,3,5,6] The purpose of this study was to describe signalment, historical data, clinical findings, laryngoscopic appearance, therapeutic interventions, and response to treatment in 16 Norwich Terriers examined by a single clinician (L.R.J.).

Abbreviation:

UCD VMTH University of California Veterinary Medical Teaching Hospital

Materials and Methods

Norwich Terriers presented to the University of California, Davis William R. Pritchard Veterinary Medical Teaching

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Hospital (UCD VMTH) for examination of the upper respiratory tract between February 2010 and March 2013 were prospectively evaluated. The electronic medical record system also was searched for all additional Norwich Terriers presented during this time frame. Specific data collected for study dogs included age, sex, body weight, and body condition score at the time of initial examination. A complete respiratory history including any previous airway examinations or surgeries was recorded. All dogs included in this study received standard physical and laryngoscopic examinations performed by one of the authors (L.R.J.). Physical examination included subjective assessment of size of the external nares, evaluation of nasal airflow, soft palate palpation, and auscultation of the larynx, trachea, and lungs as well as a general physical examination.

Anesthetic protocols were individualized for each dog as determined by members of the UCD VMTH Anesthesia Service. Laryngoscopy was performed in all dogs using a rigid or flexible endoscope,[b,c] and was digitally recorded for future review. Oropharyngeal features assessed during laryngoscopy included tonsils, soft palate length, laryngeal saccules, laryngeal structure, and laryngeal function. Specifically, tonsils were examined for enlargement, hyperemia, and position (in or out of crypts). Soft palate length was assessed in relation to the caudal tonsillar crypts and the degree of overlap of the epiglottis (in mm) was estimated. The larynx was assessed for edema or hyperemia, and the size and position of the arytenoids was noted. The internal opening of the larynx was subjectively assessed for size and conformation. Degree of laryngeal collapse was graded using the classification scheme described by Leonard, with saccular eversion classified as Grade 1 and collapse involving the cuneiform or corniculate processes of the arytenoids as Grade 2 or 3, respectively.[7] Laryngeal function was considered appropriate if abduction was noted on inspiration under a light plane of anesthesia with or without stimulation of respiration with doxapram hydrochloride. Results of endoscopy were summarized and digital files were reviewed for consistency in reporting.

When clinically indicated, endoscopic examination of the choanae, trachea, and bronchi was performed after laryngoscopic examination. The choanae were evaluated for symmetry and size by use of a flexible endoscope[c] in a retroflexed position above the soft palate. The trachea was examined using a rigid[b] or flexible[c] endoscope. Tracheal collapse was identified and characterized based on the grading scheme of Tangner and Hobson.[14]

Depending on presenting complaints and clinical findings, cervical and thoracic radiography or computed tomography of the skull sometimes were performed. Radiographs were performed in awake animals and images were reviewed by a board-certified radiologist (A.H.C.) who was blinded to the clinical presentation of the dogs. Computed tomographic[d] studies were performed with the dogs in sternal recumbency and under general anesthesia. Images were obtained using bone and soft tissue algorithms with reformatted 0.6 mm images of the area of interest. A single observer (A.H.C.) retrieved DICOM CT images for each dog and reviewed them on a dedicated image viewing station using commercially available viewing and analysis software.[e] Transverse images were used primarily for evaluation, but sagittal and dorsal multiplanar reformatting images also were used at the viewer's discretion. In dogs that had skull CT performed, skull index was calculated as the width-to-length ratio of the skull as described.[11]

Medical and surgical interventions were retrieved from the medical record. Response to the treatment was determined by follow-up examination or telephone conversations with owners. Owners provided a subjective assessment of overall health, activity level, breathing pattern (normal or labored), respiratory sounds (quiet or noisy/loud), and indicated current medications being used. All physical examinations and telephone interviews were conducted by the same author (L.R.J.).

Age, weight, and body condition score were assessed for normality using D'Agostino & Pearson omnibus normality test.[f] Normally distributed data are presented as mean ± standard deviation; non-normally distributed are presented as median with range.

Results

All Dogs (n = 16)

Between February 2010 and March 2013, 16 Norwich Terriers at the UCD VMTH underwent thorough evaluation of the respiratory system performed by one of the authors (L.R.J.) and form the study population. These dogs represented 43% of all Norwich Terriers seen at the UCD VMTH during this period. The study population consisted of 9 females (6 intact) and 7 males (5 intact). Median age was 3.0 years (range, 10.5–11 years). Median body weight was 6.1 kg (range, 4.6–9.5 kg). Body condition score was 4/9 in 2 dogs, 5/9 in 6 dogs, 6/9 in 4 dogs, and 7/9 in 4 dogs (median of 5). External nares, nasal airflow, and soft palate palpation were normal in all dogs.

Dogs with Respiratory Signs (n = 12)

Twelve of the 16 dogs were presented specifically for the evaluation of respiratory noise or apparent respiratory difficulty that was described as chronic or lifelong in 10 dogs, acute in 1 dog, and acute-on-chronic in 1 dog. Before initial examination at the UCD VMTH, 3 of 12 dogs had undergone upper airway surgery including staphylectomy (1), staphylectomy and tonsillectomy (1), and bilateral sacculectomy (1). On presentation to the UCD VMTH, 1 of these 3 dogs with previous upper airway surgery had a normal respiratory examination. The remaining 2 of 3 dogs had stridor and stertor auscultated over the larynx. Six Norwich Terriers that had not undergone prior surgery also had stridor and stertor auscultated whereas the remaining 3 dogs had normal physical examination findings.

Laryngoscopic examination was abnormal in 11 of 12 dogs presented for assessment of respiratory disease (Table 1). In one of these dogs, soft palate elongation of 5–8 mm was noted. Tonsils were large and outside of the crypts in 9/10 dogs examined. Tonsils had been surgically excised in one of the remaining dogs and findings were not recorded for the other dog in this group. Bilateral, severe grade 1 laryngeal collapse (saccular eversion) was present in 9/12 dogs. Severe redundancy of supra-arytenoid tissue, which appeared to originate from the piriform recess, was noted in 9/12 dogs (Fig 1), and in 6 dogs, the tissue appeared cystic (Fig 2), but no fluid could be aspirated. Laryngeal collapse was recognized in 8 of 9 dogs with redundant supra-arytenoid tissue, but collapse could not be differentiated as grade 2 or grade 3 because redundant tissue obscured the corniculate processes. These 8 dogs with laryngeal collapse and 1 additional dog also had

Table 1. Physical examination and laryngoscopic findings in Norwich Terriers with and without owner-reported clinical signs of respiratory disease. Entries within the table represent the number of dogs that displayed abnormal physical examination findings in conjunction with various combinations of laryngoscopic abnormalities.

	Stertor or Stridor on Physical Exam	Everted Saccules	Redundant Supra-Arytenoid Tissue	Laryngeal Collapse	Narrowed Larynx
Dogs with respiratory signs (n = 12)					
6	5	6	6	6	6
1	1	0	1	1	1
1	1	0	1	0	0
1	1	0	0	0	0
1	0	1	1	1	1
1	0	1	0	0	1
1	0	1	0	0	0
Dogs without respiratory signs (n = 4)					
3	0	3	3	3	3
1	0	0	0	0	0

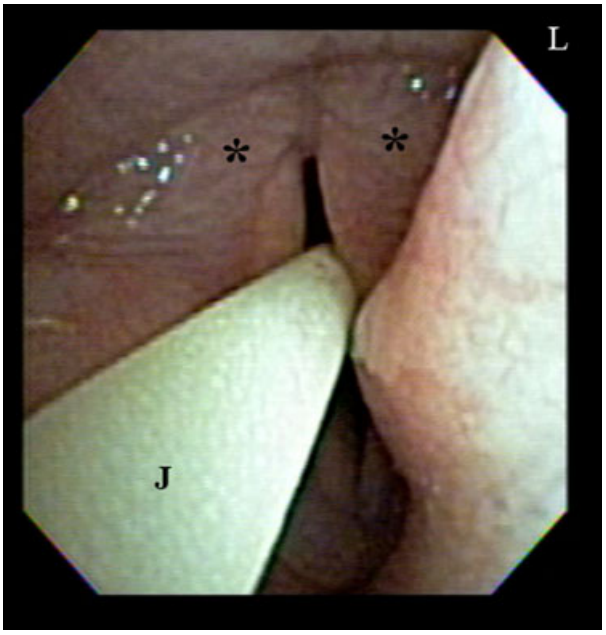

Fig 1. Laryngoscopic image from a Norwich Terrier with bilateral diffuse swelling above the arytenoids indicative of redundant supra-arytenoid folds (*). A polypropylene jet ventilator catheter (J) is inserted through the laryngeal aditus.

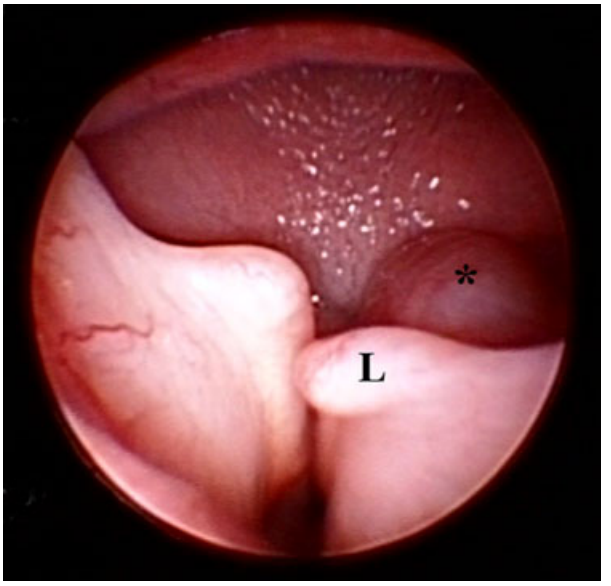

Fig 2. Laryngoscopic image from a Norwich Terrier showing grade 2 laryngeal collapse with the left cuneiform process (L) folded inward toward the right and a cystic appearance to redundant supra-arytenoid tissue (*) over the left arytenoid.

narrowing of the larynx caudal to the vocal fold, primarily ventrally, resulting in a V-shape appearance to the internal surface of the thyroid cartilage (Fig 3).

In 1 of 12 dogs, staphylectomy had been performed before referral and the larynx was normal on examination, although tonsillar eversion out of the crypts was noted. In this dog, an inflammatory choanal mass was identified and removed endoscopically using flexible biopsy forceps and 3-prong grabbers. A second dog had malformation of the nasopharynx with bands of tissue causing nasopharyngeal stenosis of the right choana. Endoscopic examination of the choanae was normal in the remaining 10 dogs examined. Grade I/IV tracheal collapse (<25% collapse) was found in 4 dogs, the trachea was normal in 4 dogs, and the remaining 4 dogs did not have a tracheal examination performed.

Dogs without Respiratory Signs (n = 4)

In 4 of 16 dogs, airway screening was performed at the owners' request despite lack of a history of respiratory noise or difficulty. One dog previously had undergone laser resection of laryngeal saccules when it was examined for acute respiratory difficulty after a bee

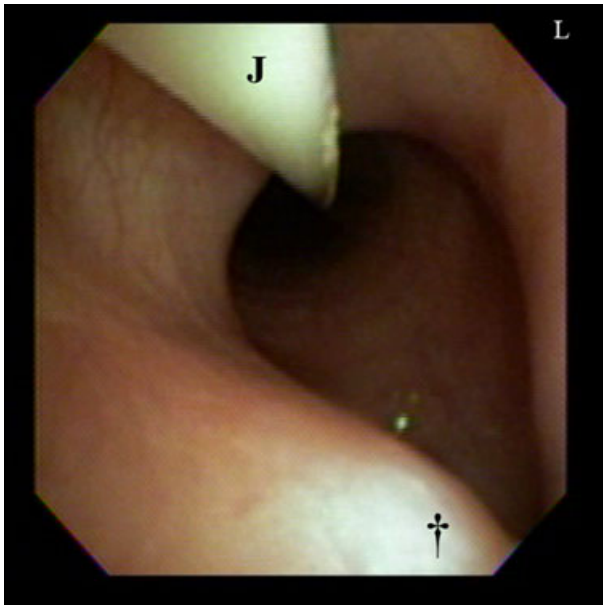

Fig 3. Laryngoscopic image from a Norwich Terrier with ventral narrowing of the larynx in the region of the thyroid cartilages (†). A polypropylene jet ventilator catheter (J) at the top of the image has been passed down the trachea.

Fig 4. Transverse CT image through the larynx showing medial to lateral narrowing of the ventral portion of the luminal diameter of the larynx at the level of the thyroid cartilages (†). The image was obtained from a standard soft tissue setting at a window of 350 and level of 50.

sting 2 years previously, but no other dogs had been evaluated previously for respiratory complaints. Physical examination findings were normal in all 4 dogs. On laryngoscopic examination (Table 1), 1 dog had malformation of the soft palate, with minor elongation on the right and translucency of the palate on the left. Tonsils were large and outside of the crypts in all 4 dogs. Moderate to severe saccular swelling and eversion was noted in 3 of 4 dogs, including the dog with previous saccular resection. Redundant supra-arytenoid folds were noted in 3 of 4 dogs similar to that described for dogs with clinical signs of respiratory disease, with a cystic appearance in 2 dogs. Cuneiform cartilages were in medial apposition in these 3 dogs, and ventral narrowing of the thyroid cartilage was evident, as described for dogs with clinical signs of respiratory disease. Grade I/IV tracheal collapse (<25% collapse) also was present in these 3 dogs. The choanae were normal in 3 of 3 dogs examined; a flexible endoscope was not available to examine the final dog in this group.

Additional Imaging

Cervical and thoracic radiographs were performed in 10/12 dogs with respiratory complaints. Laryngeal structures were assessed as ill-defined in 9/10 dogs, with diminished visualization of the margins of the arytenoid and cricoid cartilages, generalized increased soft tissue opacity of the larynx, and loss of visualization of the gas column through the laryngeal region. One dog had radiographic evidence of upper airway obstruction, seen as caudal retraction of the larynx and straightening of the hyoid apparatus. Five of the 10 dogs had a linear soft tissue opacity superimposed over the dorsal tracheal lumen in the region of the neck or thoracic inlet, representing a redundant dorsal tracheal membrane or superimposition of the ventral margin of the esophagus. Four of the 10 dogs had thickening of the tympanic bullae. In all dogs, the intrathoracic structures were considered normal.

Computed tomography of the skull and neck was performed in 2 dogs. In both dogs, the laryngeal lumen caudal to the vocal fold appeared laterally compressed (Fig 4), which correlated with laryngoscopic assessment of a narrowing in the lumen at this level. This was a subjective assessment as (to the authors' knowledge) there are no published measurements to objectively quantify the severity of laryngeal collapse in dogs using computed tomography. A choanal mass was identified in 1 dog. CT findings of normal (n = 1) and thickened osseous bulla (n = 1) agreed with radiographic findings in dogs that had both imaging modalities performed. Skull index in 2 dogs that had CT performed was calculated as 0.59 and 0.64.

Treatment

No treatment was employed in any of the 4 dogs presented only for airway screening. Surgical or medical therapy was employed in all 12 dogs presented for respiratory complaints. Staphylectomy using a Ligasure™ device[g] was performed in the dog with an elongated soft palate, and a choanal granuloma characterized by fibrous and inflammatory tissue (neutrophilic, lymphoplasmacytic, and histiocytic with intralesional foreign material) was removed endoscopically in 1 dog. Both dogs also received a tapering dose of glucocorticoids over 7–10 days post-

operatively. In 7/12 dogs with everted saccules, bilateral sacculectomy was performed using Allis forceps for retraction and Metzenbaum or laparoscopic scissors for resection. One dog had unilateral sacculectomy performed. Five of these 8 dogs and 2 additional dogs that did not have surgical intervention were treated with inhaled steroids or administered PO prednisone.

Outcome

Repeat laryngeal examination was performed in 4 dogs 4.5–10 months after initial examination. Two dogs that had bilateral sacculectomy and postoperative inhaled fluticasone were examined at the time of surgery for neutering. One of these dogs that had a cystic mass and redundant supra-arytenoid tissue lateral to the right arytenoid noted originally displayed regression of both on follow-up examination 4.5 months later and was free of clinical signs 25 months later. In the second dog, clinical signs had resolved, but re-examination 10 months later was identical to the initial examination, with enlarged hyperemic tonsils bilaterally, recurrent bilateral saccular eversion, laryngeal collapse, and a cystic structure dorsal to the left corniculate process as seen previously. Two dogs in which enlarged tonsils, saccular eversion, severe cystic swelling lateral to the arytenoids, and a narrowed larynx were found developed respiratory distress 5–7 months after the initial examination. The first dog had displayed no clinical signs at initial examination and had therefore received no treatment, but at reassessment 7 months later, unilateral sacculectomy was performed. In the second dog, bilateral sacculectomy and inhaled steroids had controlled clinical signs for 5 months at which point acute respiratory distress developed. Laryngeal examination at this time disclosed enlargement of previously documented redundant supra-arytenoid tissue causing worsened airway obstruction (Fig 5). An imbrication procedure was performed to resect the redundant, cystic tissue above 1 arytenoid.[h] The patient was placed in sternal recumbency, with the head elevated and extended. The jaw was opened and the mouth rinsed with chlorhexidine. The redundant left-sided mucosa was grasped with laparoscopic babcock forceps and excised with laparoscopic scissors. The excision extended from the aryepiglottic fold to the interarytenoid grove. The transected edges were sutured with 5-0 Vicryl in a simple continuous and cruciate pattern. Hemorrhage was controlled by gentle compression. Remnants of everted laryngeal saccules were removed with laparoscopic metzenbaum scissors, and inhaled steroids were continued postoperatively. Histopathology of the periarytenoid tissue was characterized by severe regionally extensive edema and predominantly plasmacytic inflammation.

Follow-up information was obtained by telephone in 9 dogs ranging from 9 to 36 months after initial examination and in 3 dogs 1–3 months after evaluation. Seven of 12 dogs that had originally presented with respiratory complaints had persistent clinical signs. Four of these 7 were on no medication and the remaining 3 received inhaled steroids intermittently. One dog that was treated with bilateral sacculectomy was no longer demonstrating clinical evidence of respiratory disease. The 3 most recently managed cases were free of clinical signs. Three of the 4 dogs that lacked clinical signs initially remained free of respiratory complaints despite substantial evidence of obstructive airway disease on initial examination in 2 of these 3 dogs.

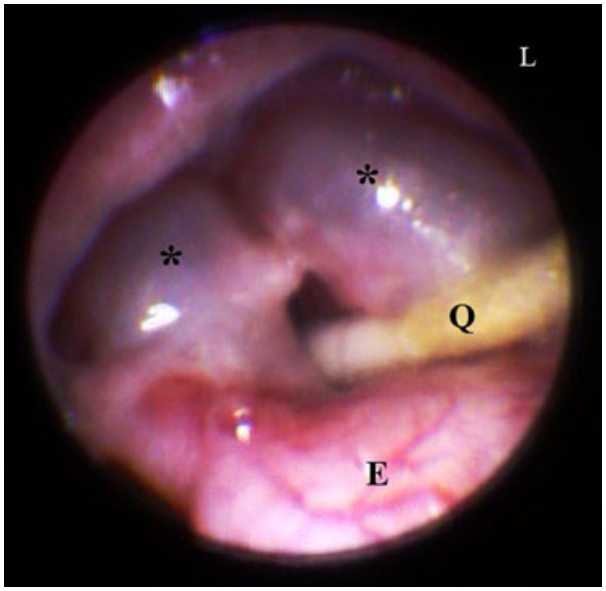

Fig 5. Laryngoscopic image from a Norwich Terrier with a Q-tip (Q) inserted through the laryngeal aditus. Redundant supra-arytenoid folds (*) have a cystic appearance that obscures the arytenoids. The epiglottis (E) is ventral in the image.

Discussion

Brachycephalic obstructive airway syndrome is a serious and life-threatening condition that requires identification and intervention to avoid asphyxiation, particularly during anesthetic induction or recovery. This study identified several features in Norwich Terriers similar to brachycephalic airway disease and reports new findings in obstructive upper airway disease. Firstly and most importantly, approximately 1/4 of Norwich Terriers in this study were presented for airway screening in the absence of clinical complaints of respiratory disease. Without owner or breeder awareness of the type of abnormalities found in this breed, the condition would have gone undiagnosed. In the dogs examined here, supra-arytenoid swelling and laryngeal narrowing necessitated use of an endotracheal tube smaller than would be used in a dog of comparable weight. This highlights the fact that Norwich Terriers should be considered challenging anesthetic candidates similar to classic brachycephalic breed dogs and should be watched carefully in postanesthetic recovery because of the potential for airway obstruction.

Secondly, half of the Norwich Terriers examined here had normal physical examination findings, despite subsequent identification of severe airway obstruction. This finding may have been impacted by clinical bias because the examiner was not masked to the presence or absence of clinical signs. However, knowledge of the clinical presentation should have led to increased awareness of abnormal respiratory noise and overinterpretation of respiratory sounds, rather than normal physical examination findings. Typical findings in classic brachycephalic dogs include a combination of elongated soft palate, stenotic nares, and everted laryngeal saccules,[3,5] although some dogs have only 1 or 2 components of the syndrome. Given the lack of clinical signs, lack of external evidence of brachycephalic syndrome, and a normal physical examination, laryngoscopic examination is essential to determine the presence or absence of obstructive laryngeal disease in Norwich Terriers. Appropriate screening of breeding animals by an experienced observer will be essential to decrease the occurrence of this syndrome in the breed.

In typical brachycephalic breeds, an association between stenotic nares, everted laryngeal saccules, and everted tonsils is reported,[5] suggesting that nasal obstruction with associated alterations in air flow causes microtrauma and secondary changes to soft tissue structures. However, in the Cavalier King Charles Spaniel, external nasal structures typically are normal, with elongated soft palate and laryngeal collapse found most commonly,[2] suggesting an alternate site of airflow obstruction in this breed. In the group of Norwich Terriers examined here, no nasal obstruction was noted and the palate was normal in most dogs. The site of obstruction appeared to be at or within the larynx, with narrowing caudal to the vocal fold that decreased luminal diameter, presumably leading to airflow obstruction, trauma to upstream tissues, and severe redundancy of supra-arytenoid tissue that further obstructed air flow.

Redundant supra-arytenoid tissue has been reported with congenital laryngomalacia, a disorder of uncertain etiology in humans.[15–17] Laryngeal collapse is recognized as a component of brachycephalic syndrome and also has been reported in very young (<6 months old) brachycephalic dogs.[1] Additional investigations are needed to determine if congenital laryngomalacia affects dogs and whether the condition described in Norwich Terriers examined represents a variant of this syndrome. Most dogs in this study were young when clinical signs prompted veterinary care, but some dogs appear to have compensated well for the syndrome, presenting for evaluation as late as 6 and 11 years. Redundant supraglottic tissue also has been reported in a human patient with acquired laryngeal dysfunction associated with previous trauma,[8] and it is plausible that supra-arytenoid swelling in the Norwich Terriers examined here developed secondary to airflow obstruction at the level of the larynx. Subsequent laryngeal collapse may have resulted from mechanical compression of cartilage by swollen supra-arytenoid tissue or by interference with muscular abduction of the cartilage. Interestingly, this tissue swelling has not been reported previously in dogs with laryngeal collapse or laryngeal paralysis, suggesting something distinct about the Norwich Terrier breed. Also, the swelling and laryngeal collapse resolved in 1 dog that had bilateral sacculectomy performed here, suggesting that partial alleviation of airway obstruction was sufficient to decrease trauma to tissue and swelling of tissue folds, although persistent or recurrent clinical signs in the remaining dogs treated in similar fashion suggests that such resolution is uncommon.

The role of surgery in the airway syndrome of Norwich Terriers is unclear. Resection of stenotic nares and staphylectomy are well-established techniques for brachycephalic breeds with excellent outcome reported when the procedures are performed by experienced surgeons.[2,5,18] Sacculectomy remains a controversial surgical technique in brachycephalic syndrome because eversion is a secondary process, and it has been suggested that eversion will resolve when obstruction to airflow is alleviated by other surgical procedures. However, this theory was refuted by a previous study in which staphylectomy, nares resection, and unilateral saccular resection failed to result in regression of contralateral saccular swelling.[6] Interestingly, our study documented return of mucosal eversion post-resection of the saccules, which could result in recurrence of obstruction to airflow. Surgeons should take care to remove as much everted saccular tissue as feasible and relieve the upper airway obstruction as effectively as possible to avoid this late sequela. Clients also should be warned that if the primary anatomical abnormalities cannot be completely resolved, saccule eversion can recur. Repeat airway examination should be performed if respiratory obstruction recurs.

Computed tomography in 2 dogs examined here suggested narrowing in the ventral region of the thyroid cartilage in the position that also appeared narrowed during laryngoscopy, although CT was performed under anesthesia with endotracheal intubation. Three dimensional reconstruction of CT images has proved valuable in identifying specific causes of laryngeal and tracheal obstruction in dogs,[19] but to the authors' knowledge, no information is available on laryngeal dimensions in small breed dogs or in brachycephalic dogs that could be compared to findings in the Norwich Terriers of this study. Further investigation is required, along with physiologic and anatomic assessment.

Airway obstructive disorders can be life threatening and in the absence of obvious physical examination features of brachycephalic syndrome, additional means are needed to identify affected dogs. Barometric whole body plethysmography has been used to identify functional parameters that distinguish between normal and brachycephalic breeds.[4] Expiratory-to-inspiratory time ratio is close to 2.0 in normal dogs and is decreased in brachycephalic dogs consistent with obstruction to inspiratory flow. Peak expiratory-to-inspiratory flow ratio is higher in brachycephalic dogs than in normal dogs as a reflection of extrathoracic obstruction to inspiratory airflow. Unfortunately, pulmonary function

testing is not readily available in veterinary medicine, but this would be a useful noninvasive screening tool. Recently, biomarkers have been assessed in dogs with brachyphalic syndrome, and approximately half of affected dogs showed increased cardiac troponin concentrations.[20] However, this may be more important as a marker of cardiac strain in brachycephalic dogs than as a marker of respiratory disease. Evidence of systemic inflammation also has been discovered in brachycephalic dogs, with significantly higher plasma concentrations of inflammatory cytokines TNF-α, IL-10, IL-13, and IL-17A as well as increased nitrated proteins compared to control dogs.[21] It is unclear whether any of these markers could be used within a breed to distinguish normal from affected dogs.

Specific genetic analysis has not been performed in breeds such as the Norwich Terrier and Cavalier King Charles Spaniel that display only selected features of brachycephalic syndrome, but findings of breed distinctions in the manifestation of brachycephalic syndrome suggest that variable genes or differential expression of genes involved in brachycephaly could be involved in various dog breeds. Increased awareness of brachycephalic features in atypical breeds is important for providing a safe anesthetic episode. Further investigation and selective breeding away from affected individuals will be important for the survival and success of the Norwich Terrier breed.

Footnotes

[a] The Norwich and Norfolk News, No. 93, Fall 2006
[b] Endoscopy Support Services, Brewster, NY
[c] Olympus Corporation, Melville, NY
[d] General Electric Medical Instruments, Lightspeed 16, Milwaukee, WI
[e] eFilm 2.0, Milwaukee, WI
[f] Graph Pad Prism Version 5, San Diego, CA
[g] Covidien, Boulder, CO
[h] Personal communication, Professor Gerhard Oechtering, University of Leipzig

Acknowledgment

Conflict of Interest: Authors disclose no conflict of interest.

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