TITLE: Relationship between brachycephalic airway syndrome and gastrointestinal signs in three breeds of dog

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Relationship between brachycephalic airway syndrome and gastrointestinal signs in three breeds of dog

Abstract:

Objectives: To assess the breed-specific prevalence of, and effects of corrective airway surgery on, gastrointestinal signs in French bulldogs, English bulldogs and pugs presenting with brachycephalic airway syndrome to a referral teaching hospital.

Materials and Methods: In this retrospective study, ptyalism, regurgitation and vomiting were graded at presentation using a previously established scoring system. Staphylectomy and nares resection were performed on all dogs. Gastrointestinal signs were re-assessed via telephone follow-up at least 6 weeks after surgery.

Results: Ninety-eight dogs were included: French bulldogs (n=43), English bulldogs (n=12) and pugs (n=43). Overall population prevalence of all gastrointestinal signs was 56%. Breed-specific prevalence for French bulldogs was 93%, English bulldogs 58% and pugs 16%. There was post-surgical clinical improvement in gastrointestinal signs for the whole study population, especially in French bulldogs.

Clinical Significance: The prevalence of gastrointestinal signs in dogs presenting with brachycephalic airway syndrome and improvement in these clinical signs following corrective surgery may vary between breeds.

Introduction

Brachycephalic airway syndrome (BAS) is a broad term describing obstructive airway disease in brachycephalic dogs. Gastrointestinal (GI) disease in brachycephalic dogs is likely related to the upper airway anatomical abnormalities (Poncet et al. 2005, Dupré & Heidenreich 2016) but a definitive aetiopathogenesis or correlation between brachycephalic GI and respiratory disease has not been established. Nevertheless, the negative intra-thoracic pressure generated on inspiration is believed to contribute to gastro-oesophageal reflux (Hardie et al. 1998, Hunt et al. 2002). Prevalence of GI disease in brachycephalic dog populations, especially in the French bulldog, has been reported to be as high as 97% (Poncet et al. 2005, Fasanella et al. 2010, Meola 2013, Dupré & Heidenreich 2016). Clinical GI signs include dysphagia, regurgitation, vomiting and ptyalism and may be related to hiatal hernia, pyloric stenosis and oesophageal deviation or diverticulum (Poncet et al. 2005).

BAS scoring systems provide graded assessment of respiratory and GI signs (Poncet et al. 2005). Traditionally, ptyalism, regurgitation and vomiting have been assessed together, with the highest grade determining the overall classification. Assigning an overall grade for each dog is clinically useful, but subsequently determining whether therapies have an effect on a specific GI sign is problematic. The aetiopathogenesis of individual GI signs (ptyalism, regurgitation or vomiting) in brachycephalic dogs is not understood.

Significant improvement of GI and respiratory signs following surgical management of airway obstruction has previously been reported (Haimel & Dupré 2015). Stenotic nares (prevalence 43% to 85%) and an elongated soft palate (86% to 96%) are the anatomic anomalies that are commonly addressed surgically (Poncet et al. 2005, 2006, Torrez & Hunt 2006, Riecks et al. 2007, Fasanella et al. 2010) and there are several surgical techniques reported for rhinoplasty and staphylectomy that aim to decrease airway resistance. However, BAS encompasses additional anatomical airway abnormalities not corrected by rhinoplasty and staphylectomy, such as narrow (naso-)pharyngeal and laryngeal dimensions, tracheal hypoplasia, abnormal conchal growth or turbinate protrusion (Vilaplana Grosso et al. 2015, Oechtering et al. 2016a, 2016b). In addition, there are breed-specific anatomical airway differences between English and French bulldogs, and pugs (Caccamo et al. 2014) making response to surgery, with respect to respiratory and GI signs, unpredictable. The purpose of this study was to evaluate three common brachycephalic dog breeds, their respective prevalence of GI signs, and response to a standardised surgical airway treatment.

Materials and Methods

Patient and Clinical Data:

Medical records of client-owned English bulldogs, French bulldogs and pugs that presented to a veterinary teaching hospital for further investigation of BAS (January 2014 to December 2015) were retrospectively reviewed. Dogs were eligible for inclusion of pure breed, with complete records of GI and respiratory signs, as described by Poncet et al. (2005), and had undergone staphylectomy and nares resection for surgical management of BAS. Exclusion criteria included additional airway surgical techniques (e.g. tonsillectomy or sacculectomy), incomplete medical records, and respiratory or GI disease suspected of being unrelated to BAS. All dogs were graded and examined under the supervision of a Board-certified surgeon (GtH). Baseline clinical data obtained from medical records included signalment (breed, age, sex and body weight) and frequency of ptyalism, regurgitation and vomiting (Poncet et al. 2005).

Pharyngolaryngoscopy and head, neck and thoracic CT were performed in all patients under general anaesthesia. Ethical approval for this study was granted by the Ethics and Welfare Committee of the Royal Veterinary College (URN 2015 1363).

Surgical procedure:

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Owner assessment and follow-up:

On initial presentation, owners were asked to fill out a "brachycephaly" questionnaire (Table S1, Supporting Information). The GI grades and definitions were those used by Poncet et al. (2005); other questions pertaining to aural and neurological abnormalities were also added but not used in this study. Dogs were grouped according to frequency and nature of individual GI signs. Grade 1 included dogs that never vomited and only had occasional regurgitation or ptyalism. Grade 2 included dogs that had occasional to regular vomiting, regular regurgitation or regular to daily ptyalism. Grade 3 included dogs that had daily to constant regurgitation and vomiting, or frequent-to-constant ptyalism (Poncet et al. 2005). In addition, a specific score for each individual sign (regurgitation, vomiting, ptyalism) was assigned for each dog. The respiratory grades and definitions were the same as previously reported (Poncet et al. 2005). Grade 1 included dogs that neither had exercise intolerance nor syncope, had occasional inspiratory efforts, and up to daily snoring. Grade 2 included dogs that had occasional or regular exercise intolerance, regular-to-frequent inspiratory efforts and often snored. Grade 3 dogs had syncope, daily-to-constant exercise intolerance, constant inspiratory effort and snoring. The highest grade was recorded as the individual grade for each patient. Although reported previously, this grading scheme has not been validated.

Follow-up communication was made by telephone at least 6 weeks after surgery, and within 6 months of patient discharge. Owners were asked to verbally complete the same questionnaire. Clinical signs were assessed at 6 weeks postoperatively (T>6 weeks). This time point was selected as a medium-term outcome.

Statistical analysis:

Statistical analyses were performed using commercially available software (SPSS). Normality was determined graphically and using the Shapiro-Wilk test. Normally distributed data were presented as mean (±sd). Non-normally distributed data were presented as median (inter-quartile range, range). A Mann-Whitney U test was used to assess gender differences in age and weight. Continuous variables were assessed for linear association using Spearman's rho (ρ) correlation test. Paired comparisons between pre- and postsurgical grades were not performed due to insufficient patients within each category.

Results

Population:

One hundred and seven dogs were reviewed with nine excluded (incomplete records n=7, only staphylectomy performed n=1, crossbreed n=1). Thus, 98 brachycephalic dogs were included in this study: pug (n=43), French bulldog (n=43) and English bulldog (n=12). Sixty-four dogs were male (43 male neutered) and 38 were female (eight female neutered). The population age was 24·5 months (IQR 26·5, Range 4 to 109), and weight was 10·5 kg (IQR 4·4, Range 4·5 to 28·3). Follow-up was achieved in all cases (n=98).

GI scores:

Of the 98 brachycephalic dogs analysed, 43% were grade 1 (n=43), 26% were grade 2 (n=25), and 31% were grade 3 (n=30). The overall prevalence of significant GI signs, defined as grade 2 or higher, was 56% (n=54/98). The breed-specific prevalence of grade 2 or 3 GI signs for French bulldogs was 40/43 (93%), English bulldogs 7/12 (58%) and pugs 7/43 (16%) (Table 1).

Respiratory scores:

Analysing all 98 brachycephalic dogs, 20/98 (20%) were grade 1, 40/98 (41%) were grade 2 and 38/98 (39%) were grade 3. Sub-division of breeds showed that 15/43 (35%) French bulldogs were grade 1, 11/43 (25%) were grade 2 and 17/43 (40%) were grade 3; for pugs the figures were: 4/43 (9%) grade 1, 26/98 (61%) grade 2 and 13/98 (30%) grade 3; and for English bulldogs: 1/12 (8%) grade 1 (n=1/12), 4/12 (33%) grade 2, and 7/12 (58%) grade 3.

Pre- versus post-surgical analysis of GI signs:

Patient follow-up was achieved in all brachycephalic patients. There were notable trends in GI scores pre- and postsurgery; statistical analyses were not performed due to insufficient numbers (Table 1). Following dichotomisation of dogs into grade 1 and grades ≥2, the number of regurgitation grades ≥2 decreased postoperatively from 50 to 13 (74% reduction). There was a similar postoperative decrease in dogs with vomiting grades ≥2 from 23 to 12 (48% reduction).

When assessing French bulldogs only, the number of dogs with a regurgitation grade ≥ 2 decreased postoperatively from 37 to seven (81% reduction). There was a similar postoperative decrease in vomiting grade ≥ 2 from 16 to eight (50% reduction). There were insufficient postoperative scores in other breeds and categories for comparison (Table 2).

Discussion

Our results suggest that French bulldogs affected with BAS have a higher prevalence of presurgical regurgitation and vomiting (98%) compared to English bulldogs (58%) and pugs (16%), consistent with previous reports (Roedler et al. 2013, Haimel & Dupré 2015). There was an overall postoperative reduction in the number of dogs with grade ≥2 regurgitation and vomiting, of 74% and 48%, respectively. This appeared to be most notable in the French bulldog. Therefore, staphylectomy and nares resection should be considered an essential part of the treatment for French bulldogs presenting with grade 2 or 3 vomiting or regurgitation, in addition to respiratory signs consistent with airway obstruction. As neither pugs nor English bulldogs appeared to improve after airway surgery with respect to GI signs, specific investigation to identify underlying aetiology may be indicated in these breeds. This corroborates with other studies that showed that pugs and English bulldogs did not show significant owner-perceived improvement for GI grading scores following airway surgery (Poncet et al. 2005).

Our population had greater variation of respiratory scores than was reported by Poncet et al. (2005). Breed analysis in our study showed the majority of dogs were at least grade 2 (i.e. grade 2 or 3); with 65% of French bulldogs, 91% of pugs and 92% of English bulldogs scored at grade 2 or higher respiratory category.

Our results show a reduction in GI signs after airway surgery in all brachycephalic dogs, but particularly French bulldogs. It has previously been concluded that the staphylectomy and nares resection improved the degree of intra-thoracic airway pressure during inspiration (Dupré & Heidenreich 2016). Decreased pressures are thought to reduce gastro-oesophageal reflux and this could be the reason for reduction in GI grade after airway surgery (Hardie et al. 1998, Hunt et al. 2002). Further investigations are also required to determine if the GI signs in different brachycephalic breeds have different aetiology (e.g. are hiatal hernias more prevalent in some brachycephalic breeds?). Interestingly, a previous study demonstrated improvement of GI signs in pugs following folded flap palatoplasty and wedge rhinoplasty, but whether this was due to selective or combined improvement in ptyalism, regurgitation and/or vomiting is not clear (Haimel & Dupré 2015).

We suggest three possible explanations leading to the improvement in GI signs, in French bulldogs, compared to other breeds. Firstly, French bulldogs may have a higher prevalence of hiatal hernias, compared to pugs and English bulldogs. Thus, performing airway surgery that reduces intra-thoracic airway pressures may reduce the degree of herniation. Whether there is a difference in hiatal hernia prevalence between French bulldogs and other breeds is unknown, although type 1 hiatal hernias are most commonly reported in young Chinese shar-peis and English bulldogs (Callan et al. 1993, Hunt et al. 2002).

Secondly, as there is anatomical variation of the upper airways between brachycephalic breeds, our surgical procedures may not have *effectively* altered airway pressures to the same degree in each breed. Heidenreich et al. (2016) found pugs had significantly smaller nasopharyngeal cross-sectional areas despite smaller soft palate dimensions, than French bulldogs. Similarly, Ginn et al. (2008) reported that 82% of canine cases with nasopharyngeal turbinates were pugs. This result could support our findings, suggesting that pugs may not benefit as much as French bulldogs from staphylectomy because significant residual upper airway resistance may persist. Furthermore, Caccamo et al. (2014) described varying glottic indices and different laryngeal shapes between brachycephalic breeds. The exact contribution to airway pressures, particularly intra-thoracic, of all anatomical airway anomalies is unknown in brachycephalic breeds. Pharyngeal narrowing or collapse has been documented although their prevalence in specific breeds is not known (Rubin et al. 2015). Pugs have been reported to demonstrate a higher prevalence of laryngeal collapse (96%) than French bulldogs (77%) and tracheal hypoplasia has the highest prevalence in English bulldogs (Coyne & Fingland 1992, Riecks et al. 2007, Clarke et al. 2011, Haimel & Dupré 2015). Laryngeal narrowing and collapse and tracheal hypoplasia could potentially negate surgical benefits and explain our inability to find significant improvement in GI signs in the pugs and English bulldogs.

Finally, pugs and English bulldogs may have an entirely different mechanism of regurgitation and vomiting that may not be influenced by intra-thoracic pressures. Studies on the breed-specific contributions of different forms of GI disease in brachycephalic dogs are lacking. Our results suggest that pugs and English bulldogs (compared to French bulldogs) may require additional GI diagnostic tests for full evaluation of regurgitation and vomiting. Prospective studies evaluating the exact aetiopathogensis of GI signs in the different brachycephalic breeds and effect of airway surgery on these signs are needed.

There are several limitations beyond those inherent to the retrospective nature of our study. Poncet et al. (2005) classification scheme relies heavily on owner ability to witness, recognise and distinguish between signs of vomiting or regurgitation, and then accurately report these to the attending veterinary surgeon. Despite explanation, owner interpretation of events is subjective and/or varied. In addition, unwitnessed clinical signs may have underestimated frequency and thus grade severity.

In conclusion, clinicians should be aware of a moderate to high prevalence of GI signs in French bulldogs, English bulldogs and pugs presenting with concurrent respiratory disease. There is likely to be specific breed variation in severity and aetiopathogenesis of these signs. Our results indicate that improvement in GI signs following corrective surgery for BAS may vary between breeds, with the French bulldog demonstrating the greatest reduction in GI signs after airway surgery.

Conflicts of interest

The authors declare no conflict of interests related to this article

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Table 1. Gastrointestinal scores at "pre" and "6-weeks post" surgery, for all dogs

Grade		Presurgery (T=0)			Postsurgery (T≥6 weeks)		
		1	2	3	1	2	3
All dogs(n=98)	Pty. (n=)	92	5	1	91	6	1
	Reg. (n=)	48	25	25	85	6	7
	Vom. (n=)	75	13	10	86	10	2

Table 2. Breed-specific gastrointestinal scores at "pre" and "6-weeks post" surgery

Grade		Presurgery (T=0)			Postsurgery (T≥6 weeks)		
		1	2	3	1	2	3
Pug (n=43)	Pty. (n=)	43	0	0	43	0	0
	Reg. (n=)	38	4	1	41	2	0
	Vom. (n=)	40	2	1	41	1	1
French bulldog (n=43)	Pty. (n=)	38	5	0	39	4	0
	Reg. (n=)	6	19	18	36	2	5
	Vom. (n=)	27	9	7	35	7	1
English bulldog (n=12)	Pty. (n=)	11	0	1	10	1	1
	Reg. (n=)	7	1	4	10	1	1
	Vom. (n=)	10	2	0	11	1	0