Postoperative regurgitation and respiratory complications in brachycephalic dogs undergoing airway surgery before and after implementation of a standardized perianesthetic protocol

Renata S. Costa DVM

Amanda L. Abelson DVM

Jane C. Lindsey ScD

Lois A. Wetmore DVM, ScD

From the Department of Clinical Sciences, Cummings School of Veterinary Medicine, Tufts University, North Grafton, MA 01536 (Costa, Abelson, Wetmore); and Center for Biostatistics and AIDS Research, Harvard T. H. Chan School of Public Health, Boston, MA 02115 (Lindsey). Dr. Costa's present address is the Department of Specialty Medicine, College of Veterinary Medicine, Midwestern University, Glendale AZ 85308.

Address correspondence to Dr. Costa (RCosta@midwestern.edu).

OBJECTIVE

To determine whether implementation of a standardized perianesthetic protocol was associated with reduced incidence of postoperative regurgitation, pneumonia, and respiratory distress in brachycephalic dogs undergoing general anesthesia for airway surgery.

ANIMALS

84 client-owned dogs.

PROCEDURES

A perianesthetic protocol that included preoperative administration of metoclopramide and famotidine, restrictive use of opioids, and recovery of patients in the intensive care unit was fully implemented for brachycephalic dogs in July 2014. Medical records of brachycephalic dogs (specifically Boston Terriers, French Bulldogs, English Bulldogs, and Pugs) undergoing anesthesia for airway surgery before (group A) and after (group B) protocol implementation were reviewed. Patient characteristics, administration of medications described in the protocol, surgical procedures performed, anesthesia duration, recovery location, and postoperative development of regurgitation, pneumonia, and respiratory distress were recorded. Data were compared between groups.

RESULTS

The proportion of dogs with postoperative regurgitation in group B (4/44 [9%]) was significantly lower than that in group A (14/40 [35%]). No intergroup differences in patient characteristics (including history of regurgitation), procedures performed, or anesthesia duration were found. Rates of development of postoperative pneumonia and respiratory distress did not differ between groups. A history of regurgitation was associated with development of postoperative regurgitation.

CONCLUSIONS AND CLINICAL RELEVANCE

Implementation of the described protocol was associated with decreased incidence of postoperative regurgitation in brachycephalic dogs undergoing anesthesia. Prospective studies are warranted to elucidate specific causes of this finding. (*J Am Vet Med Assoc* 2020;256:899–905)

Brachycephalic dogs are at high risk for development of perioperative complications such as regurgitation, aspiration pneumonia, and respiratory distress.[1–4] Dogs such as Pugs, English Bulldogs, French Bulldogs, and Boston Terriers have upper airway conformational abnormalities that include stenotic nares, an elongated soft palate, redundant pharyngeal folds, and a hypoplastic trachea. These abnormalities result in increased inspiratory effort and negative intrathoracic pressure contributing to an increased risk of vomiting and regurgitation.[1,5,6] In previous studies,[1,7] up to 97% of brachycephalic dogs were found to have esophageal, gastric, or duodenal abnormalities, which can predispose to an increased risk of aspiration pneumonia, concomitant with their respiratory signs.

General anesthesia, stress of hospitalization, and treatment with opioids are possible contributing factors to perioperative regurgitation.[8] Perianesthetic agents such as opioids and some sedatives decrease lower esophageal sphincter tone, and morphine and hydromorphone have been shown to increase the rates of vomiting and gastroesophageal reflux in dogs.[9–11] General anesthesia also increases the risk of subsequent aspiration pneumonia as a result of the patient's decreased awareness and ability to protect its airway.[11,12] Perioperative regurgitation may result in postoperative discomfort, continued regurgitation, esophageal stricture, and respiratory distress.[8,13,14]

Studies[2,7,8,11,12,15] have shown a higher incidence of postoperative regurgitation in brachycephalic

ABBREVIATIONS

CRI	Constant rate infusion
ICU	Intensive care unit

dogs than in other breeds. Although efforts have been made to reduce development of postoperative complications in these breeds with closer monitoring and better management of gastrointestinal disease, further improvements in anesthetic protocols are still required.[12]

In 2013, a standardized perianesthetic protocol was created for brachycephalic dogs undergoing general anesthesia at the authors' facility. The implementation of this protocol aimed to decrease key perianesthetic complications observed in brachycephalic dogs, including development of postoperative regurgitation, aspiration pneumonia, and respiratory distress. The purpose of the study reported here was to determine whether implementation of the protocol was associated with reduced incidence of these 3 complications in brachycephalic dogs (specifically English Bulldogs, French Bulldogs, Boston Terriers, and Pugs) undergoing general anesthesia for airway surgery (with or without other procedures). We hypothesized that brachycephalic dogs that underwent general anesthesia after use of the protocol was implemented would have lower incidences of postoperative regurgitation, aspiration pneumonia, and respiratory distress than brachycephalic dogs that underwent such procedures prior to implementation of the protocol.

Materials and Methods

Protocol development

A perianesthetic protocol for brachycephalic dogs undergoing general anesthesia was developed by 3 board-certified clinicians, including diplomates from the American College of Veterinary Anesthesia and Analgesia, American College of Veterinary Surgeons, and American College of Veterinary Emergency and Critical Care. The aim of the protocol was to decrease the incidence of perioperative complications, including postoperative regurgitation, aspiration pneumonia, and respiratory distress, commonly observed in brachycephalic dogs undergoing general anesthesia. An additional goal of the protocol was to increase general institutional awareness of common perioperative complications seen in brachycephalic dogs. Dogs targeted by the protocol included English Bulldogs, French Bulldogs, Boston Terriers, and Pugs. The protocol described specific medication additions to the anesthetic protocol as well as changes in recovery guidelines (**Supplementary Appendix S1**, available at: avmajournals.avma.org/doi/suppl/10.2460/javma.256.8.899).

To address the potential complication of perioperative regurgitation, metoclopramide was included as part of the protocol for its prokinetic and antiemetic effects.[16,17] Famotidine was added as a gastrointestinal protectant to decrease gastric acid production and limit effects associated with regurgitation.[18,19] Primary clinicians were encouraged to obtain a thorough history from owners by asking specific questions regarding clinical signs such as difficulty eating, gagging, vomiting, and regurgitation. For patients with no history of regurgitation or vomiting, treatment with metoclopramide (0.5 mg/kg [0.23 mg/lb], SC) and famotidine (1.0 mg/kg [0.45 mg/lb], IV or SC) was to be initiated just prior to surgery, either shortly before premedication or as part of the premedication. For patients with a history of gastrointestinal signs undergoing a scheduled elective procedure, treatment with metoclopramide and a proton pump inhibitor was to be started 1 week prior to surgery. Continued administration of these medications in the postoperative period was performed when deemed necessary by the primary clinician.

In addition, the protocol stated that when possible, clinicians should select alternative analgesics such as lidocaine and ketamine and should avoid opioid administration if only surgery for treatment of brachycephalic obstructive airway syndrome was planned. This was included because certain opioids have been associated with increased occurrences of vomiting, gastroesophageal reflux, and regurgitation in dogs undergoing anesthesia.[1,20] Opioids were used if an additional nonairway surgery was being performed. In an attempt to ensure that patients did not experience discomfort from lack of adequate analgesia, patients were regularly assessed after surgery by use of pain scales, and appropriate analgesics were administered as needed, including opioids when indicated.

To address the concern of respiratory distress following airway surgery, dexamethasone sodium phosphate administration (0.15 mg/kg [0.07 mg/lb], IV) was recommended (if not contraindicated for the patient) immediately prior to surgical incision. However, the final decision to give dexamethasone or make other alterations to the protocol was left up to the surgeon responsible for the case and not a mandatory part of the protocol.

Recovery of all brachycephalic dogs was required to take place in the ICU to allow closer patient monitoring and earlier intervention if respiratory distress occurred. Extubation was to be delayed until the patient was fully alert, and patients were to be monitored for cough, nasal discharge, and fever (especially if stridor or stertor was present). Personnel were advised to consider sedation of the patient if necessary, as well as supplemental oxygen delivery via high-flow nasal cannula to facilitate recovery (intended for patients with signs of respiratory distress per other hospital protocols), and to be prepared for additional interventions (eg, reintubation, ventilator support, or temporary tracheostomy).

Protocol implementation

The protocol was created in December 2013 and fully implemented in July 2014. As part of protocol implementation, a specific informed consent form was given to owners of brachycephalic dogs being admitted to the hospital for any procedures that required sedation or general anesthesia, and a docu-

ment describing the protocol was distributed within the hospital. A meeting was held with anesthesia service staff to discuss the protocol, and all anesthetists were instructed to implement it. Finally, a copy of the protocol was posted in the anesthesia induction room for easy reference. The metoclopramide, famotidine, and dexamethasone sodium phosphate products used at the hospital during the study period were of various commercially available brands.

Case selection criteria

Electronic surgery logs from July 1, 2011, through December 31, 2016, were searched to identify brachycephalic dogs that underwent airway surgery (ie, staphylectomy) with or without other concurrent procedures. Keywords used in electronic records searches included airway, anesthesia, brachycephalic and dogs. Medical records of identified cases were then screened to include only Boston Terriers, French Bulldogs, English Bulldogs, and Pugs. Dogs were excluded if they had surgery between January 1, 2014, and June 30, 2014, to ensure that data were analyzed only for dogs undergoing procedures before and after the protocol had been fully implemented. Dogs were also excluded if they had been intubated because of a respiratory crisis and kept sedated with intubation until the time of surgery or if they had a temporary or permanent tracheostomy performed prior to surgery. The final data set was divided into dogs that underwent airway surgery from July 1, 2011, through December 31, 2013 (before protocol implementation; group A), and dogs that underwent airway surgery from July 1, 2014, through December 31, 2016 (after implementation of the protocol; group B). Each dog was included in the study only once.

Data collection

Data collected from the medical records included signalment (breed, age, sex and reproductive status, and body weight); American Society of Anesthesiologists physical status; anesthesia duration (from the start to the end of inhalation anesthesia delivery) rounded to the nearest half minute; procedures performed in addition to airway surgery; whether postoperative regurgitation, respiratory distress, or pneumonia developed; any history of vomiting and regurgitation (as reported by owners or noted in the hospital); and any prior history or preoperative finding of pneumonia as confirmed by radiography. For study purposes, regurgitation (defined in our hospital as passive discharge of liquids from the mouth or nose with no abdominal contractions noted) was identified if the word regurgitation was recorded in the medical record. When regurgitation occurred, this was noted, and the time between the end of anesthesia and the first regurgitation episode was calculated. Postoperative pneumonia was recorded when radiographic evidence was consistent with aspiration pneumonia as assessed by a board-certified veterinary radiologist (as indicated in the written record). Respiratory distress was considered present when the medical record indicated the need for supplementary oxygen administration, emergency intubation, or both.

Administration of famotidine, proton pump inhibitors, and metoclopramide by the owner or by hospital staff ≤ 24 hours before the start of anesthesia was recorded. Compliance with the requirements of the described protocol, including whether opioids were administered, preanesthetic administration of recommended drugs (metoclopramide, famotidine, and dexamethasone), and recovery of dogs in the ICU, were recorded.

Statistical analysis

Characteristics of dogs in groups A and B and proportions of dogs in each group that developed postoperative regurgitation, pneumonia, or respiratory distress were compared with a Fisher exact test (for categorical data) or Wilcoxon rank sum test (for continuous data). Associations between patient characteristics and the primary study outcome of postoperative regurgitation were also assessed with a Fisher exact test. Values of $P < 0.05$ were considered significant.

Results

Patient characteristics

The records search identified 234 dogs that underwent airway surgery during July 1, 2011, through December 31, 2016. Of these, 105 were of the 4 breeds of interest; 16 dogs that underwent surgery during the period when the protocol had been partially implemented and 5 that had been intubated owing to respiratory crisis and kept sedated until surgery or underwent tracheostomy prior to surgery were excluded. Of the remaining 84 dogs, 40 underwent surgery before (group A) and 44 underwent surgery after (group B) full implementation of the protocol. Ages and body weights of dogs in group A ranged from 0.5 to 14 years and from 6.1 to 30 kg (13.4 to 66 lb), respectively. The age and body weight of dogs in group B ranged from 0.6 to 13.4 years and from 5 to 33.1 kg (11 to 72.8 lb), respectively. Fifteen dogs in group A and 21 dogs in group B had preoperative radiographic results available. Patient characteristics were summarized **(Table 1)**. There were no significant intergroup differences for any of the assessed characteristics.

The duration of anesthesia was not significantly ($P = 0.20$) different between groups A (median, 107.5 minutes [interquartile range {25th to 75th percentile}, 60 to 157.5 minutes]) and B (median, 87.5 minutes [interquartile range, 52.5 to 132.5 minutes]). The proportion of dogs that underwent anesthesia for airway surgery alone (11/40 [28%] in group A and 21/44 [48%] in group B) versus airway surgery and other procedures did not differ significantly ($P = 0.07$) between groups. In group A, dogs underwent the following procedures in addition to the described airway surgery: castration (n = 9), ovariohysterectomy (3), ophthalmic procedures (7), superficial mass removal (4), transtracheal

Table 1—Comparison of characteristics for 84 Boston Terriers, English Bulldogs, French Bulldogs, and Pugs that underwent airway surgery (with or without other procedures) before (group A) and after (group B) implementation of a standardized perianesthetic protocol for brachycephalic dogs undergoing general anesthesia.

Characteristic	Group A (n = 40)	Group B (n = 44)	*P* value
ASA physical status			0.95
I	5 (13)	5 (12)	
II	24 (60)	28 (65)	
III	11 (28)	10 (23)	
Not recorded	0	1	
Breed			0.053
Boston Terrier	2 (5)	3 (7)	
English Bulldog	21 (53)	20 (45)	
French Bulldog	2 (5)	11 (25)	
Pug	15 (38)	10 (23)	
Age (y)	2.4 (0.8–5.4)	3.2 (1.0–7.5)	0.53
Sex and reproductive status			0.36
Sexually intact female	5 (13)	5 (11)	
Spayed female	15 (38)	11 (25)	
Sexually intact male	13 (33)	13 (30)	
Castrated male	7 (18)	15 (34)	
Weight (kg)	13.3 (10.9–24.6)	12.7 (10.6–22.3)	0.65
History of regurgitation	12 (30)	16 (36)	0.64
History of vomiting	6 (15)	11 (25)	0.29
History of pneumonia	10 (25)	5 (11)	0.15
Preoperative radiographic diagnosis of pneumonia*	4 (27)	4 (19)	0.69

Data are shown as number (%) or median (interquartile [25th to 75th percentile] range). Categorical and continuous data were compared between groups with Fisher exact and Wilcoxon rank sum tests, respectively. Values of $P < 0.05$ were considered significant.

*Preoperative radiography results were available for 15 and 21 dogs of groups A and B, respectively.

ASA = American Society of Anesthesiologists.

wash (1), cystotomy (2), tracheoscopy (2) and tibial plateau leveling osteotomy (1). In group B, additional procedures included castration (n = 11), ovariohysterectomy (5), ophthalmic procedures (4), superficial mass removal (2), and transtracheal wash (1).

Perianesthetic protocol

The proportion of dogs in group A that received metoclopramide as a preoperative treatment (5/40 [13%]) was significantly ($P < 0.001$) smaller than that in group B (39/44 [89%]). Similarly, a significantly ($P < 0.001$) smaller proportion of dogs in group A (6 [15%]) received famotidine immediately prior to surgery, compared with the proportion in group B (40 [91%]). Three dogs in group B (but none in group A) also received a proton pump inhibitor (omeprazole) immediately prior to surgery. Few dogs had received famotidine, a proton pump inhibitor, or both at home > 24 hours prior to airway surgery (2/40 [5%] in group A and 6/44 [14%] in group B; $P = 0.27$).

No difference in the proportions of dogs that had preoperative opioid administration was found between groups A (38/40 [95%]) and B (36/44 [82%]; $P = 0.09$). However, intraoperative (22 [55%] vs 12 [27%], respectively; $P = 0.014$) and postoperative (35 [88%] vs 20 [45%], respectively; $P < 0.001$) opioid administration was significantly less common for group B than for group A. Among dogs that received opioids after surgery, the types of opioids administered were significantly ($P = 0.044$) different between groups; 25 of 35 (71%) patients in group A received buprenorphine hydrochloride, compared with 8 of 20 (40%) in group B. No significant ($P = 1.0$) difference in the perioperative administration of dexamethasone was found between groups A (30/40 [75%]) and B (32/44 [73%]). A significant ($P < 0.001$) difference was noted between groups in terms of location of recovery, with 44 of 44 (100%) dogs in group B undergoing recovery in the ICU, compared with 31 of 40 (78%) dogs in group A.

Postoperative regurgitation, pneumonia, and respiratory distress

The incidence of postoperative regurgitation was significantly ($P = 0.007$) lower in group B (4/44 [9%]) than in group A (14/40 [35%]). Eighteen of 84 (21%) dogs had postoperative regurgitation; 10 of these 18 had a history of regurgitation, and 2 of these 10 also had intraoperative regurgitation. History of regurgitation (found in 28/84 [36%] dogs) was the only investigated patient characteristic significantly ($P = 0.046$) associated with development of postoperative regurgitation. Thirteen of 18 dogs regurgitated > 6 hours after extubation. No differences in the incidence of postoperative pneumonia (2/40 [5%] in group A and 1/44 [2%] in group B; $P = 0.60$) or respiratory distress (11 [28%] in group A and 8 [18%] in group B; $P = 0.43$) were found.

Discussion

Results of the present study supported that the described perianesthetic protocol for brachycephalic dogs was beneficial for patients undergoing general anesthesia for airway surgery, with a significantly lower incidence of postoperative regurgitation for dogs that underwent surgery after the protocol was implemented (group B) than for dogs that had surgery before this time (group A). Brachycephalic dogs may benefit from treatment with gastrointestinal medications such as metoclopramide and famotidine prior to anesthesia even if they have no apparent clinical signs (ie, vomiting or regurgitation), as 71 of 73 (97%) brachycephalic dogs in 1 study[1] had gastrointestinal lesions identified by endoscopy. In the present study, 39 of 44 (89%) dogs in group B received metoclopramide and 40 (91%) received famotidine, compared with 5 of 40 (13%) and 6 (15%), respectively, in group A. Metoclopramide may decrease development of postoperative regurgitation and reflux by increasing lower esophageal sphincter tone,[17] and it improves acid clearance from the esophagus by increasing amplitude of esophageal peristaltic contractions in dogs.[4,17] For dogs in the present study without a history of regurgitation, metoclopramide was administered as a single preoperative dose of 0.5 mg/kg, SC, and this dose was within the published range of 0.2 to 0.5 mg/kg (0.09 to 0.23 mg/lb).[21] There is little information in the literature on the effects of specific doses of metoclopramide on regurgitation in brachycephalic dogs. However, in 1 study[16] of healthy anesthetized dogs (breeds not specified), lower dosages of metoclopramide (0.4 mg/kg [0.18 mg/lb], IV, as a bolus followed by a CRI of 0.3 mg/kg/h [0.14 mg/lb/h]) did not decrease the risk of gastroesophageal reflux during general anesthesia, whereas higher dosages (1 mg/kg, IV, as a bolus followed by a CRI of 1 mg/kg/h) did. It is possible that higher doses of metoclopramide, its administration by CRI, or both could help to further decrease the incidence of postoperative regurgitation in brachycephalic dogs.

Famotidine reduces acid production and is used for empirical treatment of vomiting, regurgitation, and esophagitis in dogs.[18,19] In awake children with gastroesophageal reflux disease, administration of famotidine for 2 weeks decreased the frequency of regurgitation.[22] Extrapolating from previous studies[18,19,22] of dogs and people, administration of famotidine prior to surgery may decrease the risk of regurgitation in brachycephalic dogs; however, further studies are required to investigate the effects of this drug in such patients.

Decreased administration of opioids was another possible contributing factor to the lower incidence of postoperative regurgitation after the described protocol was implemented. Although no difference was found in the proportion of dogs that received opioids prior to surgery in group B, compared with group A (likely because many dogs underwent procedures in addition to airway surgery that necessitated this treatment for adequate analgesia), the proportion of dogs in group B that received opioids during or after surgery was significantly lower. Opioids, especially full μ-opioid receptor agonists, are known to delay gastric emptying and increase the occurrence of regurgitation, vomiting, and gastroesophageal reflux in dogs.[11,20] Avoidance of postoperative opioid administration when possible was recommended by the anesthesia department for dogs undergoing airway surgery alone, but this did not pertain to patients having other surgical procedures. The decision to decrease postoperative opioid administration was independent from the perianesthetic protocol for brachycephalic dogs and may have reflected a change in attitude toward opioids and an increase in perceived effectiveness of nonopioid analgesic protocols. The awareness raised by the protocol about postoperative complications in brachycephalic dogs redirected clinicians to prescribe opioids to dogs that had signs of pain after surgery, instead of providing opioids as a default treatment for all patients having surgery. The reduction in opioid administration in the present study appeared to result from a decrease in buprenorphine administration. To our knowledge, no studies have evaluated the effects of buprenorphine on regurgitation and gastroesophageal reflux in dogs.

All brachycephalic dogs undergoing general anesthesia at our facility after the protocol was implemented were required to be placed in the ICU for recovery. Closer monitoring during the recovery period may have resulted in early identification of signs of nausea and regurgitation or respiratory distress, allowing for immediate intervention.

In our study, the incidence of postoperative regurgitation was higher for dogs that had a history of regurgitation than for dogs that did not, and this finding was in agreement with those in previous studies.[1–3] All dogs that had intraoperative regurgitation in the present study had a history of regurgitation and also developed postoperative regurgitation. Although the number of dogs with such signs in the study was small, when taken together with the previously discussed results of other investigations, the findings suggested treatment with gastrointestinal protectants prior to anesthesia should be considered for all brachycephalic dogs, especially those with a history of regurgitation or vomiting, and brachycephalic dogs that regurgitate intraoperatively may benefit from administration of gastrointestinal protectants as part of their postoperative care.

Thirteen of 18 dogs that developed postoperative regurgitation in the present study had their first recorded episode > 6 hours after extubation. To our knowledge, the timing of postoperative regurgitation has not been reported in dogs. This delay in start of regurgitation could have been attributable to sedative effects, with the combination of the loss of sedative effects from anesthesia drugs and stress of hospitalization resulting in increased respiratory effort and rate and regurgitation. Stress of hospitalization is a possible contributing factor to the development of regurgita-

tion.[8] Strategies to decrease hospitalization time and reduce stress and anxiety in hospitalized patients could further decrease the incidence of postoperative regurgitation. Postoperative regurgitation in dogs of the study reported here could also have been caused by intraoperative gastroesophageal reflux. Investigators of 1 study[11] found gastroesophageal reflux in 8 of 30 (27%) dogs that underwent anesthesia without an opioid, with incidences ≥ 15 of 30 (50%) in dogs that received morphine.[11] Gastroesophageal reflux can cause esophageal irritation, which may predispose a patient to regurgitation.[23,24] Because dogs of the present study were not monitored for gastroesophageal reflux, it was unknown whether this contributed to the incidence of postoperative regurgitation.

Despite the lower incidence of postoperative regurgitation in group B, compared with group A, no intergroup differences were found in the development of respiratory distress and postoperative pneumonia, although the number of dogs that developed pneumonia (3 of 88 [3%] for both groups combined) was very small. The low rate of postoperative pneumonia was consistent with rates of 0% to 5% reported for brachycephalic dogs in the past 13 years.[2,7,12] To evaluate potential effects of the brachycephalic protocol on development of these complications, a much larger study would be required.

Development of standardized protocols or standard operating procedures facilitates implementation of new therapeutic strategies, increases awareness of the need to manage specific patients differently, and may improve patient care.[25] Adherence is required for standardized protocols to be effective, but ensuring compliance may be difficult. To improve compliance with the perianesthetic protocol for brachycephalic dogs, several steps were taken, including distribution of the protocol around the hospital, meeting with the anesthesia service staff, providing thorough instructions on how to implement the protocol, and displaying the protocol in the anesthesia induction room. We found 100% compliance in regard to recovery location during the relevant part of the study period, but some lack of compliance with other aspects of the protocol. The part of the protocol that was the least often followed was administration of dexamethasone before airway surgery. Perioperative corticosteroid administration (at an antiinflammatory dose) is commonly recommended to reduce postoperative swelling and edema, but its efficacy in brachycephalic dogs following airway surgery has not been evaluated systematically.[26] Although not analyzed in our study, our review of the records indicated some clinicians prefer to administer NSAIDs instead of steroids as an antiinflammatory agent, likely because of this factor. Additionally, some brachycephalic dogs were receiving NSAIDs prior to surgery, and therefore, dexamethasone was not given. Another part of the protocol that was not strictly adhered to was the recommended gastroprotectant treatment; of the 44 dogs in group B, 4 (9%) did not receive famotidine (or a proton pump inhibitor) and 5 (11%) did not receive metoclopramide prior to surgery. It is unclear why these medications were not given, but the finding highlighted the challenges in implementing and enforcing a standardized medical protocol.

The present study had limitations that should be considered when interpreting the results, including its retrospective design, which relied on accurate documentation in the medical records. Some records may have been incomplete, and some complications may have been underreported. However, we considered it more likely that regurgitation episodes were underreported in group A than in group B, as implementation of the brachycephalic protocol was expected to raise awareness and improve documentation of signs of nausea, retching, and regurgitation in dogs, which all recovered in the ICU. There may have been differences between groups that were not accounted for in the analysis, potentially confounding the results. Owing to the small study sample, results should be viewed as exploratory and hypothesis generating. The aim of this study was to evaluate the overall effects of implementing the described perianesthetic protocol for brachycephalic dogs undergoing airway surgery, and investigation of the contributions that each specific factor or combination of factors made to the reduced incidence of postoperative regurgitation in these patients was beyond its scope. Prospective studies that include larger numbers of dogs are needed to further elucidate the benefits of specific components of the protocol.

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From this month's *AJVR*

Novel use of an activity monitor to model jumping behaviors in cats

Kate P. Sharon et al

OBJECTIVE
To develop methods to identify and characterize activity monitor (AM) data signatures for jumps performed by cats.

ANIMALS
13 healthy client-owned cats without evidence of osteoarthritis or degenerative joint disease.

PROCEDURES
Each cat was fitted with the same AM, individually placed in an observation room, then simultaneously recorded by 3 video cameras during the observation period (5 to 8 hours). Each cat was encouraged to jump up (JU), jump down (JD), and jump across (JA) during the observation period. Output from the AM was manually annotated for jumping events, each of which was characterized by functional data analysis yielding relevant coefficients. The coefficients were then used in linear discriminant analysis to differentiate recorded jumps as JUs, JDs, or JAs. To assess the model's ability to distinguish among the 3 jump types, a leave-one-out cross-validation method was used, and the misclassification error rate of the overall categorization of the model was calculated.

RESULTS
Of 731 jumping events, 29 were misclassified. Overall, the mean misclassification error rate per cat was 5.4% (range, 0% to 12.5%), conversely indicating a correct classification rate per cat of 94.6%.

CONCLUSIONS AND CLINICAL RELEVANCE
Results indicated that the model was successful in correctly identifying JUs, JDs, and JAs in healthy cats. With advancements in AM technology and data processing, there is potential for the model to be applied in clinical settings as a means to obtain objective outcome measures. (*Am J Vet Res* 2020;81:334–343)

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