Scientific contribution/Original research/Invited lecture

Anaesthetic Management for Dogs Treated Surgically for Brachycephalic Syndrome: A Preliminary Study

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Abstract:
Brachycephalic breeds have various health problems due to anatomic abnormalities that represented brachycephalic obstructive airway syndrome (BOAS). BOAS is characterized by stenotic nostriles, an elongated soft palate, aberrant nasal conche, everted laryngeal saccules, laryngeal collapse and hypoplastic trachea and is clinically observed by dyspnea, stridor, exercise intolerance and vomiting. Staphylectomy and resection of the ala nasi for surgical treatment of BOAS was performed in 30 brachycephalic dogs (BOAS group) (14 French bulldogs, 9 Boston terriers, and 7 pugs). There were two control groups, a group of 15 non-brachycephalic dogs and a group of 11 brachycephalic dogs that did not have surgery associated with BOAS. The dogs in the BOAS group had significantly higher body temperature compared to the control group of brachycephalic dogs, but not compared to the group of non-brachycephalic dogs. Internal diameter of the endotracheal tube was significantly smaller in the BOAS group and in the control group of brachycephalic dogs compared with the group of non-brachycephalic dogs. The time of extubation after general anaesthesia was significantly longer in the BOAS group compared to both control groups. The brachycephalic dogs for surgical correction of BOAS should be provided with gastroprotectives, antiemetics, dexamethasone and analgesics before surgery, sedation should be minimal to achieve earlier recovery from anaesthesia and spontaneous breathing without support. After surgery of the BOAS, dogs should be provided with non-steroidal analgesics, gastroprotectives and metoclopramide, they should be restrained from vigorous playing and exercise for at least 10 days.

Keywords: Brachycephalic dog; Anaesthesia; Brachycephalic obstructive syndrome

Citation: Lukanc B, Nemec Svete A, Erjavec V. Anaesthetic management for dogs treated surgically for brachycephalic syndrome: a preliminary study. Proceedings of Socratic Lectures. 2021; 6:15-21. https://doi.org/10.55295/PSL.2021.D.003

1. Introduction

Brachycephalic dogs are characterised by severe shortening of the facial and nasal bones, resulting in upper airway deformity (Downing and Gibson, 2018). These include narrowed nostrils, elongated soft palate, hypoplastic trachea, laryngeal collapse, and eversion of the laryngeal saccules (O'Dwyer, 2017). These anatomic features result in upper airway obstruction (Doxey and Boswood, 2004) and brachycephalic obstructive airway syndrome (BOAS) (O'Dwyer, 2017). BOAS is clinically manifested by dyspnea, stridor, snoring, disturbed sleep patterns, exercise intolerance, and syncope. Two-thirds of brachycephalic dogs also have stridor at rest and 90% snore during sleep (Roedler et al., 2013). In severe cases, BOAS can lead to acute pulmonary oedema (Downing and Gibson, 2018). Forceful inspiration against an obstruction can increase negative intrapleural pressure, the pressure is transmitted to the interstitium and alveoli causing an increase in the hydrostatic gradient. Fluid transudate from the pulmonary capillaries to the pulmonary interstitium occurs, resulting in pulmonary oedema. Elevated negative pressures result in an increase in venous return to the right side of the heart, increasing pulmonary artery pressure while decreasing left ventricular function and increasing afterload. Pulmonary blood volume and pulmonary venous pressure increase, leading to an increase in hydrostatic pressure and oedema formation (Lang et al., 1990). To alleviate these respiratory signs in brachycephalic breeds, surgical treatment such as resection of the ala nasi and resection of the soft palate (staphylectomy) is often required (Aron and Crowe, 1985). This procedure is performed under general anaesthesia.

Due to upper airway problems and difficult breathing, many brachycephalic dogs often have gastrointestinal abnormalities such as regurgitation, vomiting, gastroesophageal reflux, cardial atony, gastritis, gastric retention, distal oesophagitis and pyloric hyperplasia, stenosis and atony, and duodenal inflammation (Poncet et al., 2006; Gruenheid et al., 2018). Clinical signs of gastroesophageal reflux include ptyalism, regurgitation, and vomiting (Poncet et al., 2006).

The aim of our study was to investigate the anaesthetic management of brachycephalic dogs, focusing on specific anaesthetic procedures to avoid potential complications before, during, and after anaesthesia.

2. Materials and Methods

In our preliminary study, 30 brachycephalic dogs (BOAS group), 21 males (M), 9 females (F), including 14 French bulldogs (FB), 9 Boston terriers (BST), and 7 pugs were included for surgical treatment of BOAS. Staphylectomy was performed by folded flap palatoplasty (FFP) and resection of ala nasi was performed by vertical edge alaplasty. There were two control groups, a group of 15 (7M, 8F) non-brachycephalic dogs and a control group of 11 (6M, 5F) brachycephalic dogs (FB, BST and pugs) that underwent surgery unrelated to BOAS.

Clinical examinations of the dogs were performed on the day of surgery without sedation. Dogs were presented with respiratory and gastrointestinal signs but were otherwise healthy.

Food was withheld for 14 hours and water for two hours before anaesthesia. Before premedication, the dogs were given maropitant (Prevomax 10 mg/ml, Eurovet Animal Health B.V., AE Bladel, The Netherlands) 1 mg/kg intravenously, pantoprazole (Nolpaza 40 mg, Krka, Nova mesto, Slovenia) (0.78 - 1.18) mg/kg intravenously, metoclopramide (Vomend 5 mg/ml, Eurovet Animal Health BV, AE Bladel, The Netherlands) 0.17 - 0.26 mg/kg subcutaneously, dexamethasone (Dexamethason Krka 4 mg/ml, Krka, Novo mesto, Slovenia) (0.09 - 0.16) mg/kg intramuscularly.

Before premedication and induction, dogs were preoxygenated with 100% oxygen (2 – 3) l/min using the flow-by technique. Premedication included butorphanol (Butomidor 10 mg/ml, Richter Pharma, Wels, Austria) (0.12 - 0.33) mg/kg and midazolam (Midazolam Accord 1mg/ml, Accord Healthcare, Poland Sp.z.o.o., Pabianice, Poland) (0.045 -

0.14) mg/kg intravenously (3 – 55) minutes before intravenous induction with propofol (Propomitor 10 mg/ml, Orion Corporation Orion Pharma, Espoo, Finland). Propofol was titrated (2.1 - 13.1 mg/kg) for (5 – 20) minutes during endoscopic examination of the larynx and trachea, in the meantime oxygen was administered by flow-by (2 – 3) l/min as close as possible to the dog's mouth. The dogs were intubated with a cuffed endotracheal tube and endoscopic examination of the nasopharynx was performed. Anaesthesia was maintained with isoflourane (Isoflurine 1000 mg/g, Chemical Iberica PV, Espana) in 100% oxygen. Before surgical incision, the dogs were administered carprofen (Rycarfa 50 mg/ml, Krka, Novo mesto, Slovenia) (3.2 - 4.1) mg/kg intravenously. The eyes were lubricated to prevent drying and corneal damage. Surgery of ale nasi and soft palate was performed.

When the dogs were awake after surgical correction of the upper airway, the BOAS group of dogs were given buprenorphine (Bupredine Multidose 0.3 mg/ml, La Vet Beheer BV, TV Oudewater, The Netherlands) (0.01-0.02) mg/kg was administered intravenously to the group BOAS. Six hours after the first dose of dexamethasone, the same dose of dexamethasone was repeated intramuscularly

For home care, dogs received carprofen (Rycarfa, Krka, Novo mesto, Slovenia) 2 mg/kg orally for 5 to 7 days, metoclopramide (Reglan 10 mg, Alkaloid, Skopje, Macedonia) 0.2 mg/kg twice daily, 14 days, esomeprazole (Nexium 20 mg, AstraZeneca UK Limited, Cheshire, Great Britain) 1 mg/kg, twice daily, 14 days.

Data were analyzed with commercial software (IBM SPSS 25.0, Chicago, Illinois, USA). Descriptive statistics were used to describe the basic features of the data. The Shapiro-Wilk test was performed to test whether the data were normally distributed. A one-way ANOVA with Tukey HSD post hoc test in the case of a normal distribution of the data or a Kruskal-Wallis test followed by multiple comparison and Bonferroni correction in the case of non-normal distribution of the data were used to test for statistically significant differences in the measured parameters (age, weight, pulse, body temperature, internal diameter of endotracheal tube, time of extubation after general anaesthesia) between the groups of BOAS patients (FB, BST, pugs), as well as between the group of all BOAS patients (all BOAS breeds combined), the group of non-brachycephalic dogs, and a control group of brachycephalic dogs. The data that were normally distributed are reported as means ± SDs; the data that were not normally distributed are reported as medians and IQR (IQR - 25th to 75th percentile). A value of $p < 0.05$ was considered significant.

3. Results

Baseline characteristics of groups of patients and control dogs, and measured parameters are summarized in **Table 1**.

Groups of BOAS patients (FB, BST, and pugs) did not differ in pulse, internal diameter of endotracheal tube, the time of extubation after general anaesthesia and body temperature; FB had significantly higher weight than BST ($P = 0.013$) and pugs ($P = 0.010$). Furthermore, FB were significantly younger than BST ($P = 0.043$) and pugs ($P = 0.026$). All dogs in BOAS group had significantly higher body temperature in comparison to control group of brachycephalic dogs ($P = 0.024$), but not in comparison to group of non-brachycephalic dogs (**Table 1**).

Internal diameter of endotracheal tube was significantly smaller in BOAS group ($P < 0.001$) and control group of brachycephalic dogs ($P = 0.002$) in comparison to group of non-brachycephalic dogs. But there was no significant difference in ID of endotracheal tube between BOAS group and control group of brachycephalic dogs (**Table 1**).

The time of extubation after general anaesthesia was significantly longer in BOAS group compared to group of non-brachycephalic dogs ($P < 0.001$) and control group of brachycephalic dogs ($P = 0.029$) (**Table 1**).

Heart rate (HR) in FB ranged from 100 bpm to 140 bpm (median 126 bpm), in BST ranged from 88 bpm to 160 bpm (median 120 bpm) and in pugs from 96 bpm to 190 bpm (median 120 bpm) (**Table 1**).

The time of extubation after general anaesthesia was significantly longer in BOAS group compared to the group of non-brachycephalic dogs ($P < 0.001$) and control group of brachycephalic dogs ($P = 0.029$) (**Table 1**).

The dogs in BOAS group were significantly younger compared to the group of non-brachycephalic dogs ($P = 0.020$) (**Table 1**).

Table 1: Selected parameters in different breeds of brachycephalic dogs and in different groups of dogs.

		Age (months)	Weight (kg)	Number of dogs n (F/M)	Tempera-ture (° C)	HR (bpm)	ID endotra-cheal tube (mm)	Extubation time after the end of surgery (min)	Duration time of anaesthe-sia (min)
		Median (IQR)	Mean ± SD		Mean ± SD	Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)
FB		16.0(11.0 – 35.5)	11.7± 2.2	14 (11/3)	38.8 ± 0.5	126(100–131)	6.0 (5.5 – 6.0)	23 (19 – 31)	65 (54 – 80)
BST		55.0(36.5 – 86.0)	9.2 ± 1.6	9 (7/2)	38.5 ± 0.5	120(100–139)	5.5 (5.0 – 5.8)	20 (15 – 30)	85 (60 – 98)
Pug		73-0(33.0 – 93.0)	8.9 ± 1.4	7 (3/4)	38.5 ± 0.6	120(110–172)	6.0 (5.5 – 6.0)	20 (15 – 20)	60 (50 – 65)
BOAS group (14 FB + 9 BST + 7 pugs)		38.0(15.0 – 73.8)	10.3± 2.2	30 (21/9)	38.7 ± 0.5	120(100–136)	5.8 (5.5 – 6.0)	10 (16 – 30)	65 (55 – 80)
Group of nonbrachi-cephalic dogs		117.0(14.0 –148.0)	8.9 ± 1.9	15 (7/8)	38.6 ± 0.4	110(88 – 122)	7.5 (7.0 – 8.0)	7 (5 – 13)	55 (40 – 90)
Control group of brachicephalic dogs		86.0 (42.0 – 118.0)	10.5± 2.0	11 (6/5)	38.2 ± 0.6	120(92 – 120)	6.0 (5.4 – 6.6)	12 (10 – 17)	90 (60 – 100)

ID – internal diameter in mm; IQR interquartile range - 25th-75th percentile, F-female, M-male, FB-French bulldog, BST-Boston terrier, n-number of dogs, HR-heart rate, bpm-beats per minute, a - significantly ($P = 0.0024$) higher compared to control group of brachycephalic dogs; b - significant difference compared to BOAS group ($P < 0.001$) and compared to control group of brachycephalic dogs ($P = 0.002$); c – significant difference compared to group of non-brachycephalic dogs ($P< 0.001$) and compared to control group of brachycephalic dogs ($P = 0.029$).

4. Discussion

Anaesthesia of brachycephalic dogs is thought to pose a greater risk compared to other dog breeds because the airway is abnormal in brachycephalic dogs (Gruenheid M, et al., 2018). During the preanesthetic evaluation, it is important to obtain a thorough history and perform a detailed clinical examination to identify possible preexisting comorbidities and risk factors for the individual patient (Downing and Gibson, 2018). This is beneficial in assessing the risk of anaesthesia. In some patients, anaesthesia can be delayed if the problems can be resolved prior to anaesthesia. Brachycephalic dogs with BOAS have a reduced capacity for heat dissipation by painting because of their anatomic abnormalities. Therefore, maintaining normothermia during the perioperative period and postoperatively is critical to avoid respiratory distress (Downing and Gibson, 2018). It is important to reduce stress and consecutive hyperthermia in dogs before and after anaesthesia. At the Veterinary Faculty we leave nervous and agitated dogs under the supervision of their owners until premedication. When accompanied by their owners, they remain calm.

Due to high negative intrathoracic pressure, these dogs have a high prevalence of gastroesophageal reflux, which is associated with an increased risk of oesophagitis and aspiration pneumonia (Shaver et al., 2017). Poncet et al. (2006) recommended that dogs undergoing upper airway surgery receive concomitant gastroprotectives and prokinetics postoperatively to prevent vomiting and aspiration pneumonia and improve prognosis.

The severity of respiratory and gastrointestinal signs was positively correlated in French bulldogs, males, and heavy brachycephalic dogs (Poncet et al., 2006).

Brachycephalic dogs have increased vagal tone compared with non-brachycephalic dogs, which could contribute to the development of bradycardia during general anaesthesia (Doxey and Boswood, 2004). No dog in our study required treatment for bradycardia.Brachycephalic breeds have learned to compensate for their breathing insufficiencies, but sedated and anaesthetized animals cannot compensate for laboured breathing, so the anesthetist should pay attention to their breathing (O'Dwyer, 2017). It is important to administer only as much sedation as necessary and to avoid excessive sedation and relaxation of pharyngeal muscle tone, which leads to relaxation with consequent worsening airway obstruction and hypoventilation. If acute and complete respiratory obstruction occurs, it is necessary to proceed directly with general anaesthesia (Murrel, 2016). For sedation, we used butorphanol and midazolam mixed together and administered slowly intravenously for up to 5 minutes to control the effect of sedation. When the dogs lay down and fell asleep, we stopped titrating the drugs. Preoxygenation should be used before induction to prolong the time of desaturation after apnoea which is desirable in dogs with respiratory disorders and when endotracheal intubation may be difficult and delayed (McNally et al., 2009). If the preoxygenation represent a stress and may exacerbate respiratory difficulties than preoxygenation poses a greater risk than benefit. Five minutes before and during intravenous sedation, dogs were preoxygenated with 100% oxygen to fill the alveoli with a higher than normal oxygen concentration. Guidelines for selection of endotracheal tube size in dogs are based on normal body weight. However, these guidelines cannot be used for brachycephalic dogs (Reminga and King, 2017), which is consistent with our findings that the ID of the endotracheal tube was significantly smaller in all dogs of brachycephalic breeds. However, in the BOAS group, pugs had the lowest body weight, but BST had the smallest endotracheal tube. Therefore, endotracheal tubes with different internal diameters should be prepared before sedation and induction of general anaesthesia. In brachycephalic dogs, endotracheal tubes should be shorter than in non-brachycephalic dogs. In addition, equipment for aspiration of saliva, mucous or regurgitated content should be prepared before premedication of brachycephalic dogs. There was no significant difference in the size of the endotracheal tube between the BOAS group and the control group of brachycephalic dogs, which may indicate that difficult breathing in brachycephalic breeds is mainly caused by airway obstruction by soft tissue rather than by the diameter of the trachea. This was also confirmed by the markedly improved breathing of brachycephalic dogs after nose and soft palate surgery. During recovery, brachycephalic dogs should be positioned in sternal recumbency with the head elevated, neck extended, and tongue pulled rostrally from the mouth to keep the airway open (Downing and Gibson, 2018). Extubation of the endotracheal tube should be delayed as long as possible and should not be done while dogs are still sedated (Adshead, 2014). Dogs should not be extubated until muscle tone returns and they are able to hold their head up independently. The time to extubation after general anaesthesia was significantly longer in the BOAS group than in the two control groups. Therefore, it is important for the anesthetist to have sufficient time for brachycephalic dogs to recover, especially when the dogs are anaesthetized for surgical correction of BOAS. The anesthetist also needs more time before the start of anaesthesia to prepare all medications and equipment needed for general anaesthesia of brachycephalic dogs.

When dogs are fully awake and breathing well for several hours without needing supplemental oxygen, they are stable enough to be discharged to home care.

When brachycephalic dogs are sedated for various reasons, they must be monitored closely for upper airway obstruction. The postoperative period is the most common time for a dog to die. Most dogs die within 3 hours of the end of the procedure (Brodbelt et al., 2008).

However, some dogs become very agitated, stressed, and even hyperthermic when left in the cage during the postoperative period. Therefore, we advise leaving them in the hospital unit under the supervision of their owner until they are stable enough to go

home. In very rare cases, when dogs are extremely agitated, even when accompanied by their owner, they need to be sedated to calm them down. Before discharge, dogs are given analgesics and cortisone, but not sedation.

Corrective surgery of the upper airway in brachycephalic dogs is beneficial to reduce postanaesthetic complications when subsequent surgical and diagnostic procedures are anticipated (Doyle et al., 2020). Despite all the anaesthetics risks and potential complications during and after the surgical procedure, we strongly encourage owners to have their dog with BOAS undergo upper airway surgery early in life, as it will greatly improve the dog's breathing and well-being.

5. Conclusions

When anaesthetizing brachycephalic dogs, we use minimal sedation to achieve earlier recovery from anaesthesia. It has been our experience that the dogs are much calmer when they are with their owner. When we keep them separated from their owner in the clinic, they are so agitated that most of them require sedation.

Brachycephalic dogs for surgical correction of BOAS should be given gastroprotectives, antiemetics, dexamethasone, and analgesics. They should be fasted at least 12 hours before anaesthesia to prevent vomiting.

For anaesthesia, we should prepare a narrower and shorter endotracheal tube than in non-brachycephalic dogs of the same weight, as well as an aspirator for possible aspiration of saliva, mucus, and blood from the mouth and trachea.

Extubation time for brachycephalic dogs is much longer in brachycephalic dogs than in non-brachycephalic dogs.

After BOAS surgery dogs should be discharged home with nonsteroidal antiinflammatory drugs, gastroprotectives, and metoclopramide. They should be restrained from vigorous playing and exercise for at least 10 days.

Funding: This research was supported by Slovenian Research Agency (research program No. P4-0053).

Institutional Review Board Statement: All procedures complied with the relevant Slovenian governmental regulations (Animal Protection Act UL RS, 43/2007).

Conflicts of Interest: The authors declare no conflict of interest.

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