PAPER

Use of silicone tracheal stoma stents for temporary tracheostomy in dogs with upper airway obstruction

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Objectives: To report the use of silicone tracheal stoma stents for temporary tracheostomy in dogs with upper airway obstruction.

Methods: Retrospective review of medical records for dogs in which silicone tracheal stoma stents were placed.

Results: Eighteen dogs had a silicone tracheal stoma stent placed for maintenance of a tracheostomy stoma for periods ranging from three hours to eight months. No intra-operative or immediate postoperative complications were recorded. In 11 dogs the stent was removed by simple traction after a period ranging from 36 hours to 6 weeks, and the tracheal stoma was left to heal by second intention. Five of the 18 dogs were determined as being tracheostomy dependent and underwent conversion to permanent tracheostomy after a period ranging from five days to eight months following stent placement. One dog was euthanased after three months, with the stent still in place, because of poor respiratory function, and one dog died of unrelated reasons. In 6 of 10 dogs (60%) where the stent was in place for five days or more, granulation tissue formation caused dislodgement of the stent.

Clinical Significance: Silicone tracheal stoma stents may be used as an alternative to conventional tracheostomy tubes in selected dogs with upper airway obstruction. Long-term use of the stent beyond five days is not recommended because of granulation tissue formation. The long-term consequences of partial tracheal ring resection are unknown.

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INTRODUCTION

Temporary airway diversion by means of tracheostomy is commonly employed as a means of alleviating severe episodes of upper airway obstruction (Sura & Durant 2012). A recent study reported a complication rate of 86% in dogs undergoing temporary tracheostomy and unsuccessful tracheostomy tube management resulted in death in 19% of the dogs included in that study (Nicholson & Baines 2012). The potential for displacement of the tube and obstruction with tracheal secretions means that successful outcome relies on intensive management to provide regular nebulisation, flushing, suctioning and cleaning (Nicholson & Baines 2010). It is therefore believed that there is justification for development of a novel technique that may improve the outcome of tracheostomy tube management in dogs, in accordance with recommendations set forth by the British Small Animal Veterinary Association Scientific Committee (Yeates *et al.* 2013).

The use of tracheal stoma stents as an alternative to tracheostomy tubes has been reported in human medicine (Hall & Watt 2008). Tracheal stoma stents assessed by human patients were found to be more comfortable than a tracheostomy tube and produce minimal tracheobronchial secretions (Hall & Watt 2008). According to the authors' knowledge, the use of a silicone tracheal stoma stent has not yet been reported in dogs.

Flesh tunnels are silicone stents used to maintain the patency of body piercings and have long been used as a form of jewellery in humans. Silicone flesh tunnels are manufactured according to the Food and Drug Administration (FDA) standards (Samco Silicone Products, Nuneaton, Warwickshire, UK) and are designed as hollow tubes with flanges at each end (see Fig 1).

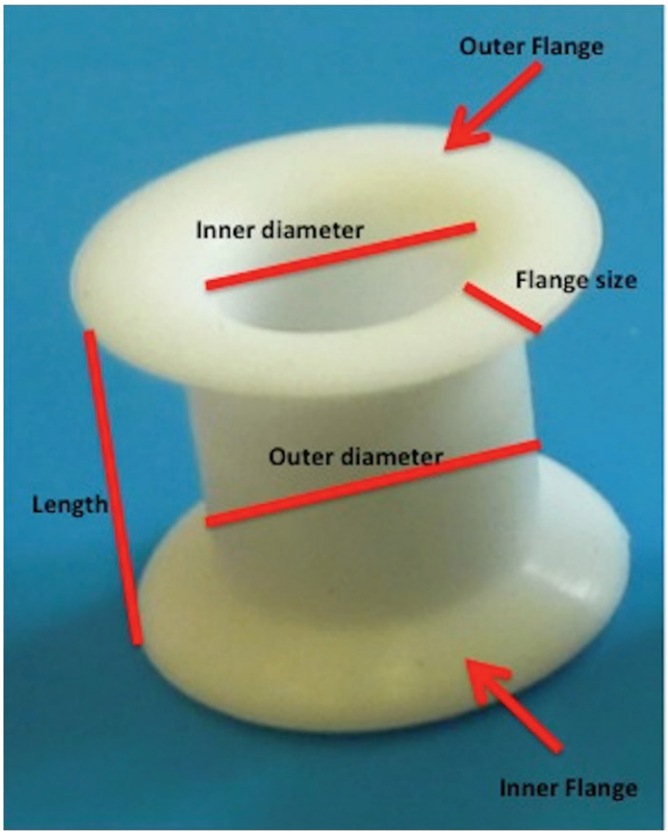

FIG 1. Silicone tracheal stoma stent (flesh tunnel). Annotated picture of 10-mm silicone tracheal stoma stent. Length, inner flange, outer flange, flange size, inner diameter and outer diameter are marked

Flesh tunnels are comparatively inexpensive (currently, £3 to 4) and readily available from body jewellery suppliers in sizes ranging from 4 to 50 mm in diameter.

The aim of this study was to report the successful use of a novel, silicone tracheal stoma stent (flesh tunnel) for temporary tracheostomy in 18 dogs with severe upper airway obstruction.

MATERIALS AND METHODS

The medical records for dogs presented between January 2011 and February 2014 undergoing tracheostomy with placement of a silicone tracheal stoma stent (flesh tunnel) for the management of acute upper airway obstruction were reviewed. Age, breed, sex, bodyweight, surgical procedure, immediate surgical outcome, duration of the tracheal stoma stent in situ, times replaced and reason for stent removal were recorded; intraoperative, postoperative and short-term complications were also recorded.

All dogs included in the study underwent routine haematological and biochemical investigations, thoracic and cervical radiographs and laryngoscopy; 20 mg/kg amoxicillin-clavulanate (Augmentin; GlaxoSmithKline UK) intravenously (iv) was administered peri-operatively. All animals were premedicated with a full opioid agonist, with or without an α-2 agonist. Anaesthesia was induced with 2 to 4 mg/kg propofol (PropoFlo™; Abbott Animal Health) iv to effect and maintained with sevoflurane (SevoFlo®; Abbott Animal Health) or isoflurane (IsoFlo®; Abbott Animal Health) in 100% oxygen. All dogs were intubated with a cuffed endotracheal tube. During placement of the tracheal stoma stent the isoflurane/sevoflurane was turned to 0%, and anaesthesia was maintained with intravenous propofol. The cuff on the endotracheal tube was deflated and the tube was pulled orally to facilitate insertion of the stent. Postoperative analgesia included full opioid agonists and non-steroidal anti-inflammatory drugs (NSAIDs), according to individual requirements, based on a modified Glasgow pain-scoring system (Holton *et al.* 2001). Dogs with severe pharyngeal inflammation were given steroids [0·5 mg/kg prednisolone (Prednicare; Dechra Veterinary Products) orally] instead of NSAIDs. Dogs with signs of regurgitation were medicated with 2 mg/kg ranitidine (Zantac; GlaxoSmithKline UK) orally and 500 mg/dog less than 20 kg sucralfate (Antepsin; Chugai Pharma UK Ltd). All dogs were fed their normal diet immediately after surgery and were discharged once they were stable for home care.

Airway assessment

Upper airway anatomy, presence of obstruction and laryngeal function were assessed in all dogs by direct laryngoscopy under a light plane of anaesthesia with 2 to 4 mg/kg propofol (PropoFlo™; Abbott Animal Health) iv and immediately postoperatively or during recovery from anaesthesia. Dogs with laryngeal collapse (LC) were assessed according to the grading developed by Leonard (1960). Dogs were determined to have secondary LC if the collapse was assessed to be secondary to brachycephalic obstructive airway syndrome (BOAS) (Monnet 2003), and primary LC if the dogs were non-brachycephalic breeds.

Groups

Dogs with tracheal stoma stent placement for the management of acute upper airway obstruction were divided into four main groups:

(1) *Dogs with BOAS and secondary LC needing tracheostomy while recovering from anaesthesia.*
The dogs underwent a combination of rhinoplasty, staphylectomy, sacculectomy and tonsillectomy as required. Dogs with poor anaesthetic recovery secondary to acute pharyngeal/larygeal swelling. The tracheal stoma stent was placed to maintain a patent airway while the swelling subsided.

(2) *Dogs with primary LC needing a tracheostomy while recovering from arytenoid lateralisation procedure (tieback surgery).*
The tracheal stoma stent was either placed intra-operatively after the lateralisation procedure (Nelissen & White 2012, White 2012) or postoperatively because of acute respiratory distress. The decision to place the stent at the same time as the lateralisation procedure was made because immediate postoperative assessment of the larynx revealed medial displacement of the contralateral arytenoid cartilage, which together with postsurgical inflammation was presumed to be a high risk for upper airway obstruction.

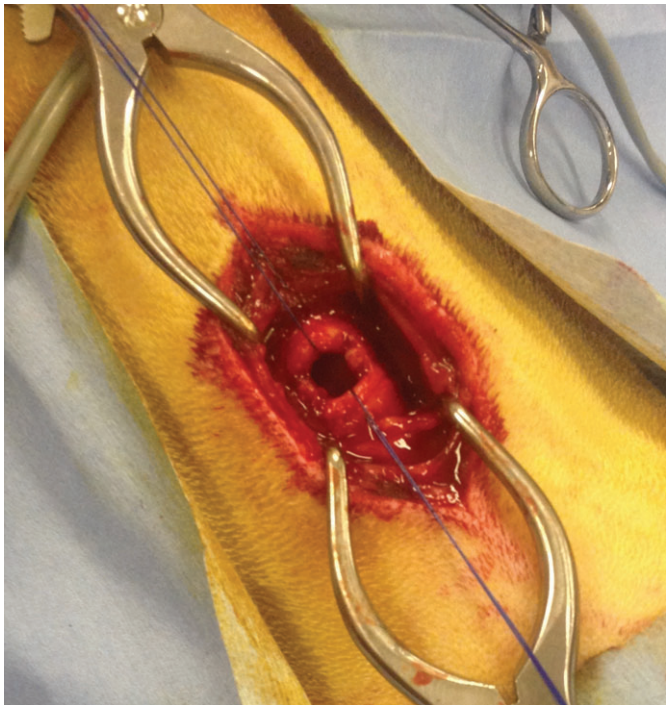

FIG 2. Ventral trachea prepared for stent placement; 40% of circumference of the tracheal ring is excised to facilitate placement of the silicone tracheal stoma stent (flesh tunnel). The adjacent tracheal rings are stabilised with 2 metric polypropylene stay sutures

(3) *Dogs with acute upper airway obstruction not undergoing additional airway surgeries.*
The tracheal stoma stent was placed to maintain a patent airway because of acute upper airway obstruction.

(4) *Dogs with a laryngeal mass.*
The tracheal stoma stent was used as an alternative to a permanent tracheostomy. The long-term use of the tracheal stoma stent in this case was selected by the owner after informed consent.

Surgical technique

All tracheostomies were performed by a board-certified surgeon or Resident. A ventral midline cervical approach was made through the skin and subcutaneous tissue and the sternohyoid muscles were separated to expose the ventral trachea. A transverse ventral tracheal incision of 50% of the tracheal circumference was created through the annular ligament between the third and fourth or the fourth and fifth tracheal rings. A section of approximately 40% of the circumference of the third or fourth tracheal ring was excised to create a "window" into the trachea and facilitate placement of the silicone tracheal stoma stent. Two-stay sutures using 2 metric polypropylene (Prolene; Ethicon) were placed around the cranial and caudal tracheal rings to facilitate stabilisation and widening of the tracheal stoma during insertion of the stent (see Fig 2). Partial excision of the tracheal ring was necessary to prevent the thin-walled silicone stent from being compressed by the entire tracheal rings. The size of the inserted tracheal stoma stent was assessed subjectively intra-operatively on a patient-by-patient basis by the surgeon; tracheal stoma stents with a diameter of

Table 1. Dimensions of the silicone tracheal stoma stents (flesh tunnels)

Inner diameter (mm)	Outer diameter (mm)	Flange size (mm)	Length (mm)
10	12	3	11
12	14	4	12
14	16	5	13

The thickness of the stent wall is 1 mm for all sizes.

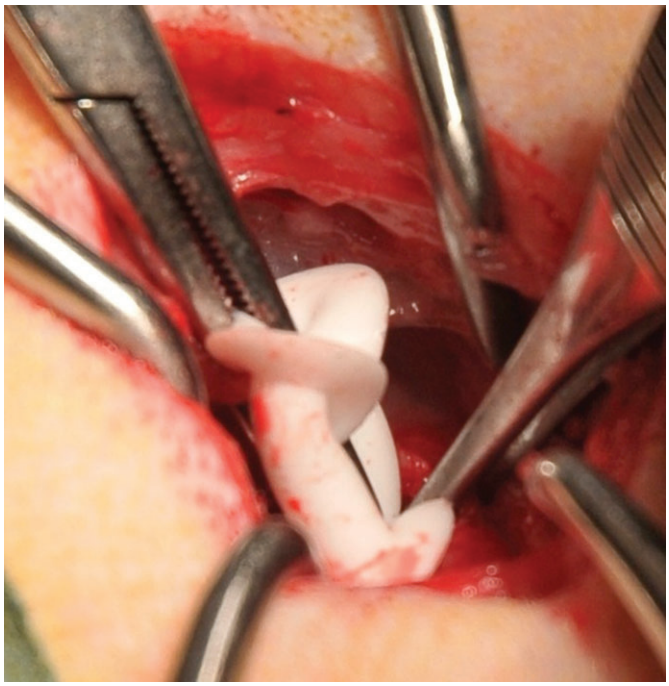

FIG 3. Tracheal stoma stent placement. The tracheal stoma stent (flesh tunnel) is compressed using mosquito forceps to facilitate insertion into the tracheal stoma

10, 12 or 14 mm were used. The dimensions of the flange and length of the stent varied marginally with the diameter of the tracheal stoma stent used (see Table 1). The tracheal stoma stent was compressed using mosquito forceps (see Fig 3) and inserted into the tracheal stoma in such a way that the inner flange of the stent was contained within the tracheal lumen and the external flange was anchored to the skin (see Fig 4). The inner flange thereby prevented inadvert ejection from the trachea. The outer flange of the stent was sutured to the skin with 1·5 or 2 metric polypropylene (Prolene; Ethicon), using either single interrupted or horizontal mattress sutures (see Fig 5).

Management of tracheal stoma stent

The dogs were closely monitored during the first 24 hours postoperatively in a surgical ward, which was staffed at all times by an intern and three registered veterinary nurses.

The tracheal stoma stents were cleaned immediately postoperatively with a cotton bud moistened with saline (see Fig 6). The lumen of the stent was shallowly suctioned and nebulised using aseptic techniques every 2 to 4 hours for 24 hours following which care was reduced to 8-hour intervals, in accordance

FIG 4. Tracheal stoma stent (flesh tunnel) fully inserted in the tracheal stoma

FIG 5. Tracheal stoma stent sutured in place. The tracheal stoma stent has been sutured to the skin with horizontal mattress sutures

FIG 6. Cleaning of tracheal stoma stent in situ. Dog 14 with the tracheal stoma stent in situ. The stent is cleaned with a moist cotton bud

with individual requirements. No deep suctioning of the trachea was performed. The skin surrounding the tracheostomy site was cleaned with sterile saline and barrier cream (Sudocream®, Forest Tosara Ltd) was applied as necessary. For dogs that were discharged with the tracheal stoma stent in situ, owners were instructed in cleaning the stent with a moist cotton bud as required.

Long-term tracheostomy management

Before removal of the tracheal stoma stent, the lumen of the stent was temporarily covered with a soft dressing to assess if the dog was able to be non-tracheostomy-dependent. If occlusion of the stent resulted in severe upper respiratory stridor, reassessment of the upper airways was performed. The dog was determined to be tracheostomy dependent if the examination revealed persistent LC or obstruction. In these dogs the temporary tracheostomy was converted to a permanent tracheostomy.

Conversion to a permanent tracheostomy stoma was defined as removal of the tracheal stoma stent with concurrent revision and enlargement of the tracheostomy site. Briefly, the stoma was enlarged by resection of additional tracheal rings and the trachea was elevated by apposing the sternohyoid muscles dorsal to the trachea and the tracheal mucosa was sutured to the skin (Sura & Durant 2012). The conversion was not complicated by the previous surgery performed for tracheal stoma stent placement.

Replacement of the tracheal stoma stent was defined as removal of the current stent with resection of the granulation tissue at the tracheostomy site and re-insertion of a new unused tracheal stoma stent.

Table 2. Characteristics, indications, complications and outcome of dogs treated with a tracheal stoma stent

Number	Signalment	Airway pathology/grade LC* (and primary treatment)	Reason for tracheal stoma stent placement	Duration of stent placement	Complications related to stent	Tracheostomy dependent	Further procedure	Still alive/euthanased
1	French bulldog, eight years, FN, 8 kg	BOAS/LC III (Folded palatoplasty Rhinoplasty)	Poor recovery from airway surgery	8 months	Granulation tissue formation causing dislodgement	Yes	Revision of tracheal stoma stent Conversion to permanent tracheostomy	Euthanased two months after permanent tracheostomy because of severe bronchopneumonia
2	Bulldog, four years, ME, 30 kg	BOAS/LC II (Resection of everted laryngeal saccules Folded palatoplasty Rhinoplasty Tonsillectomy)	Poor recovery from airway surgery	10 days	Granulation tissue formation causing dislodgement	No	Stent removed at postoperative re-examination	Still alive
3	Pug, four years, FN, 7 kg	BOAS/LC III (Resection of everted laryngeal saccules Folded palatoplasty Rhinoplasty)	Poor recovery from airway surgery	7·5 months	Granulation tissue formation causing dislodgement	Yes	Revision of tracheal stoma stent Conversion to permanent tracheostom	Still alive
4	French bulldog, three years, ME, 9 kg	BOAS/LC III Rhinoplasty (Arytenoid lateralisation attempted)	Poor recovery from airway surgery	5 days	Granulation tissue formation causing dislodgement	Yes	Conversion to permanent tracheostomy	Still alive
5	Pug, four years, FE, 7 kg	BOAS/LC III (Folded palatoplasty Rhinoplasty Tonsillectomy Resection of everted laryngeal saccules)	Poor recovery from airway surgery	6 weeks	N/A	No	Stent removed after six weeks	Still alive
6	WHWT, 12 years, ME, 12 kg	Laryngeal mass (biopsy)	Elective placement during primary procedure (poor recovery anticipated)	10 weeks	Granulation tissue formation causing dislodgement	Yes	Revision of tracheal stoma stent Conversion to permanent tracheostomy	Still alive
7	Norwich terrier, seven years, MN, 6 kg	Primary LC III (Arytenoid lateralisation Resection of everted laryngeal saccules)	Elective placement during primary procedure (poor recovery anticipated)	3 months	N/A	Yes	N/A	Euthanased after three months because of deterioration of airway function.
8	CKCS, nine years, FN, 8 kg	BOAS /LC III	Elective placement (poor recovery anticipated)	3 hours	N/A	N/A	N/A	Euthanased in hospital because of progression of thrombcytopaenia
9	CKCS, seven years, FN, 8 kg	BOAS/LC II (Folded palatoplasty Tonsillectomy Resection of everted laryngeal saccules)	Poor recovery from airway surgery	2 days	N/A	No	Stent removed before discharge from hospital	Still alive
10	Yorkshire terrier, nine years, FN, 4 kg	Primary LC III (Bilateral arytenoid lateralisation)	Poor recovery from airway surgery	10 days	N/A	No	Stent removed at postoperative re-examination	Still alive
11	Cocker spaniel, eight years, ME, 20 kg	Primary LC III (Staphylectomy Arytenoid lateralisation)	Elective placement during primary procedure (poor recovery anticipated)	11 days	Granulation tissue formation causing dislodgement	Yes	Conversion to permanent tracheostomy	Still alive
12	Cross breed, 12 years, FN, 14 kg	Primary LC III (Bilateral arytenoid lateralisation)	Poor recovery from airway surgery	3 days	N/A	No	Stent removed before discharge from hospital	Still alive
13	CKCS, six years, FN, 10 kg	BOAS/LC I (Folded palatoplasty Tonsillectomy)	Poor recovery from airway surgery	36 hours	N/A	No	Stent removed before discharge from hospital	Still alive

Table 2. (Continued)

Number	Signalment	Airway pathology/grade LC* (and primary treatment)	Reason for tracheal stoma stent placement	Duration of stent placement	Complications related to stent	Tracheostomy dependent	Further procedure	Still alive/euthanased
14	Miniature poodle, four years, FN, 3·5 kg	Primary LC III (Arytenoid lateralisation Resection of everted laryngeal saccules)	Elective placement during primary procedure (poor recovery anticipated)	3 days	N/A	No	Stent removed before discharge from hospital	Still alive
15	Pug, two years, FE, 6 kg	BOAS/LC III (Folded palatoplasty Rhinoplasty Tonsillectomy Resection of everted laryngeal saccules)	Poor recovery from airway surgery	4 days	N/A	No	Stent removed before discharge from hospital	Still alive
16	Bichon frise, 10 years, FN, 10 kg	Primary LC III (Arytenoid lateralisation Folded palatoplasty Resection of everted laryngeal saccules)	Elective placement during primary procedure (poor recovery anticipated)	2 days	N/A	No	Stent removed before discharge from hospital	Still alive
17	French bulldog, two years, MN, 9 kg	BOAS/LC II (Staphylectomy Rhinoplasty Tonsillectomy Resection of everted laryngeal saccules)	Poor recovery from airway surgery	6 days	N/A	No	Stent removed before discharge from hospital	Still alive
18	Pug, one year, M, 7 kg	BOAS/LC II/MMM	Elective placement (poor recovery anticipated)	2 days	N/A	No	Stent removed before discharge from hospital	Still alive

BOAS Brachycephalic obstructive airway syndrome, LC Laryngeal collapse, MMM Masticatory muscle myositis, FN Female neutered, FE Female entire, MN Male neutered, ME Male entire, WHWT West Highland White terrier, CKCS Cavalier King Charles spaniel, N/A Not applicable
*Leonard 1960

Removal of the tracheal stoma stent was performed after cutting the skin sutures by simple traction without sedation or further intervention.

Follow-up

All dogs were re-examined between 10 and 14 days postoperatively. Dogs in which the tracheal stoma stent was used long term were examined at intervals beyond 14 days based on individual requirements of the dog. In addition, telephone updates were given by the owners in the interim period; however, this also varied among dogs.

RESULTS

Complete data sets were available for 18 dogs. The dogs were predominantly small breeds (see Table 2), median age was six years (range 1 to 12 years) and median weight was 8 kg (range 3·5 to 30 kg). Apart from one dog with severe immune-mediated thrombocytopenia (ITP), no major abnormalites were identified on the complete blood count and serum biochemistry studies. Thoracic radiographs revealed mild bronchointerstitial pattern in two dogs. Cervical radiographs revealed a thickened and elongated soft palate in eight dogs, and a mineralised soft tissue mass in the larynx of one dog. No abnormalities were seen on the radiographs of the other dogs. One dog underwent magnetic resonance imaging (MRI) for investigation of masticatory muscle myositis (MMM).

The median duration of tracheal stoma stent in situ was five days (range three hours to eight months). Eleven of the eighteen dogs (61%) proved to be non-tracheostomy-dependent and had the tracheal stoma stent removed by simple traction and the stoma left to heal by second intention, while five of the eighteen dogs (28%) needed conversion to permanent tracheostomy. Two of the eighteen dogs (11%) were euthanased with the tracheal stoma stent still in situ. None of the eleven non-tracheostomy-dependent dogs needed further intervention with the tracheostomy following removal of the tracheal stoma stent, and none exhibited respiratory difficulty without the tracheostomy.

Group 1: 9 of 18 (50%) cases

Six of these nine dogs (66%) were determined to be non-tracheostomy-dependent once the swelling subsided, and removal of the tracheal stoma stent occurred after a median of five days (range 36 hours to 6 weeks), wheras three of the nine dogs (33%) were assessed to be tracheostomy dependent and underwent conversion to a permanent tracheostomy after a median of 7·5 months (range five days to eight months) (see Table 2).

Group 2: 6 of 18 (33%) cases

In four of these six dogs a tracheal stoma stent was placed at the same time as the arytenoid lateralisation procedure, while in two of the six dogs the stent was placed in the postoperative period because of acute respiratory distress. Four of the six dogs (66%) were determined to be non-tracheostomy-dependent once the surgical swelling subsided and underwent removal of the tracheal stoma stent after a period of median three days (range 3 days to 10 days) (see Table 2). Two of the six dogs (33%) were assessed to be tracheostomy dependent, one of them underwent conversion to permanent tracheostomy after 11 days, while the other used the tracheal stoma stent long term (three months) as an alternative to conversion to a permanent tracheostomy. This dog was euthanased by the referring veterinary surgeon after three months because of deterioration of airway function despite insertion of the tracheal stoma stent. No postmortem examination of the dog was performed.

Group 3: 2 of 18 (11%) cases

One of these two dogs were under investigation for ITP, but needed a tracheostomy because of acute airway obstruction secondary to LC (see Table 2). This dog was euthanased within three hours of tracheal stoma stent placement as the owners declined further treatment for progression of the underlying ITP. The second dog suffered acute pharyngeal/laryngeal inflammation secondary to severe regurgitation while under general anaesthesia for MRI. A tracheal stoma stent was placed before recovery from the general anaesthesia to prevent upper airway obstruction in the peri-operative period. This dog was assessed to be non-tracheostomy-dependent once the airway swelling subsided, and underwent removal of the tracheal stoma stent after two days.

Group 4: 1 of 18 (6%) cases

One dog with an unresectable laryngeal chondroma had a tracheal stoma stent placed as a short term palliative solution while awaiting biopsy results of the mass (see Table 2). However according to the owner's wishes, following informed consent, the tracheal stoma stent was maintained long term. This dog was tracheostomy dependent and underwent conversion to a permanent tracheostomy after 10 weeks.

Seven of the eighteen dogs (39%) were discharged to home care with the tracheal stoma stent in situ within four days of stent placement (see Table 2); management at home consisted of cleaning with a moist cotton bud varying from 4 to 8 times daily.

Ten dogs had the tracheal stoma stent in place for five days or more. In six of these dogs (60%), granulation tissue resulted in dislodgement of the stent from the lumen of the trachea. Granulation tissue formed circumferentially around the skin stoma, and the dermal thickening consequently resulted in a "pull-out" of the inner flange of the stent from the the tracheal stoma. Replacement of the tracheal stoma stent following excision of the granulation tissue was performed in three dogs (see Table 2). Granulation tissue was not recorded in any of the eight dogs that had the tracheal stoma stent in situ for four days or less.

DISCUSSION

Upper airway obstruction in dogs may be a challenging condition to treat and temporary airway diversion in the form of a tracheostomy is often needed. Placement of a silicone tracheal stoma stent may provide a novel and alternative form of temporary tracheostomy management in dogs with acute upper airway obstruction.

Tracheal stomas may be created by transverse incision of the annular ligament or by excision of sections of adjacent tracheal rings (Sura & Durant 2012). Excision of approximately 40% of the circumference of the tracheal ring was necessary to permit the insertion of the compressed tracheal stoma stent into the tracheal stoma. Placing of the tracheal stent without excising a part of the tracheal ring may lead to compression of the thin walled silicone by the adjacent tracheal rings resulting in a less secure fit of the internal flanges inside the tracheal lumen. Additionally, compression of the silicone walls may compromise the stent lumen and lead to recurrent signs of upper airway obstruction. It could be argued that using a stiffer implant would obviate the need for a partial tracheal ring resection however this hypothesis was not tested. Excising 40% of the circumference of a tracheal ring makes the tracheal stoma stent placement more invasive than a temporary tracheostomy tube placement. Although insertion of the tracheal stoma stent is more invasive than tracheostomy tube insertion, removal of the stent is as simple as temporary tracheostomy tube removal, and can be performed without sedation. Despite the additional cartilage resection, healing of the tracheostomy site appears to be similar to conventional tracheostomy tube removal. Following removal of the tracheal stoma stent, the stoma site was allowed to heal by second intention without closure of the tracheostomy site as this may lead to subcutaneous and mediastinal emphysema and even pneumothorax (Hackett 2003). The long-term consequences of the partial tracheal ring resection are unknown, and long-term follow-up with tracheoscopy or three-dimensional (3D) imaging would be required to understand this better.

Tracheostomy tube placement in the dog is associated with a high prevalence of complications, with reported rates of 43 to 86% (Harvey & O'Brien 1982, Hedlund *et al*. 1988, Guenther-Yenke & Rozanski 2007, Stepnik *et al*. 2009, Nicholson & Baines 2012), and a recent study reported unsuccessful tracheostomy tube management to result in a 19% mortality rate (Nicholson & Baines 2012). A direct comparison between the study by Nicholson & Baines (2012) and the current study however cannot be made because of the differences in study population and inclusion criteria. Postoperative complications reported to occur with conventional tracheostomy tubes include obstruction, dislodgement, swelling of the stoma site, gagging, coughing, vomiting, subcutaneous emphysema, pneumomediastinum, respiratory distress, aspiration pneumonia, pneumothorax, haemorrhage and sinus bradycardia (Harvey & O'Brien 1982, Hedlund *et al.* 1988, Guenther-Yenke & Rozanski 2007, Stepnik *et al.* 2009, Nicholson & Baines 2012). None of these potentially life threatening complications were noticed in the immediate postoperative period for the dogs managed with the tracheal stoma stents. Owing to the retrospective nature of this study, it is possible that some of these complications occurred, but were inadequately recorded. Dislodgement of the inner flange from the tracheal stoma could have gone unnoticed, as the stomal airflow or airflow bypassing the stent via the upper airway may still have been sufficient enough to prevent upper airway obstruction. Additionally, the cartilage resection of the tracheal ring may reduce the generation of negative airway pressure during inspiration and reduce dynamic airway collapse even if the tracheal stoma stent is dislodged.

Although there were no episodes of airway compromise, the development of excessive granulation tissue at the stoma site causing stent instability was encountered in six of ten dogs (60%), where the tracheal stoma stent was used for five days or longer. Long-term use of the tracheal stoma stent beyond five days can therefore not be recommended. Granulation tissue formation was not reported as a complication by Nicholson & Baines (2012); however the tracheostomy technique (no cartilage resection), tube material (polyvinyl chloride) and duration of tracheostomy tube management (mean 2·95 days) were different. Granulation tissue formation can be seen as a predicted sequel to placement of tracheal stoma stent as tracheal mucosa to skin closure is not performed and healing of the incision is prevented by the stent. Three dogs underwent surgical revision of the stoma with re-insertion of a new tracheal stoma stent; however, it should be emphasised that revision surgery is not ideal and that conversion to a permanent tracheostomy should be performed as soon as the dog is determined to be tracheostomy dependent. No complications with the tracheal stoma stent or granulation tissue formation were recorded in any of the eight dogs that had the stent in situ for four days or less, which suggests that the tracheal stoma stent is suitable for short-term use as an alternative to conventional tracheostomy tubes.

Nicholson & Baines (2012) reported that bulldogs had a higher prevalence of failed tracheostomy tube management [5 of 11 (45%)] than non-bulldogs [3 of 31 (10%)]. Although only one bulldog was included in this study, 11 of 18 (61%) dogs had BOAS; none of these dogs died or were euthanased as consequence of failed tracheal stoma stent management; however, one dog was euthanased for unrelated disease (see Table 2). Seven of the eleven dogs (64%) with BOAS proved to be non-tracheostomy-dependent following removal of the tracheal stoma stent, which may indicate that the stent may be successfully used as an alternative to conventional tracheostomy tubes in selected cases of dogs with BOAS.

It is possible that the tracheal stoma stent with its deep flange creates a more secure communication between the tracheal lumen and skin surface than the longer, more rigid and unsecured cylinders of conventional tracheostomy tubes. Additionally, the short, straight lumen of the stent may reduce the potential for mucus plugging, and facilitate cleaning and the removal of mucoid plugs, without removing the stent from the trachea, because of enhanced visualisation of the lumen. Unlike the conventional tracheostomy tube, the stent does not extend deep into the tracheal lumen, which may result in less production of tracheobronchial secretions. Even if not directly comparable to the present study group, a human case report (Hall & Watt 2008) demonstrated less tracheobronchial secretions and increased comfort levels with a similar tracheal stent when compared with tracheostomy tubes. Further investigations are needed to observe if this is applicable to dogs. Obstruction of a tracheostomy tube within the tracheal lumen may result in complete obstruction of the upper airways, resulting in negative pressure and dynamic airway collapse. A recent study (Wignall & Baines 2014) found

that cuffed tracheostomy tubes resulted in significantly increased airway pressures when compared with uncuffed tracheostomy tubes. It is believed that this is less likely to happen with the tracheal stoma stent, as obstruction of the stent would only compromise the airflow through the stoma and not through the upper airways as there is minimal intraluminal component.

A disadvantage with the tracheal stoma stent is that it cannot easily be connected to an anaesthetic circuit. The stent can therefore not be used for dogs needing continuous postoperative ventilation or for dogs needing a tracheostomy during anaesthesia to improve surgical access to the mouth and pharynx. The tracheal stoma stent is therefore only indicated for temporary bypass of the upper airway in dogs not requiring continuous ventilation.

None of the dogs in the current study died during the initial hospitalisation period as a consequence of complications associated with the tracheal stoma stent placement although one dog was euthanased whilst still hospitalised because of progression of underlying ITP. In hindsight, immediate euthanasia instead of tracheal stoma stent placement would have been a better option for this dog. One dog was euthanased by the referring veterinary surgeon three months following tracheal stoma stent placement because of further deterioration of its airway function, however no postmortem examination was performed. Deterioration of airway function because of dislodgement of the inner flange of the stent from the tracheal lumen or other possible complications such as airway obstruction by excessive granulation tissue or stricture, pneumonia, or lower airway obstruction from mucus plugging, could therefore not be excluded.

Seven of eight dogs that needed the tracheal stoma stent for 10 days or more were discharged with the stent in situ within four days of placement and managed at home for periods ranging from 10 days to 8 months (median of 10 weeks). All these dogs had the tracheal stoma stent placed in the initial study period, which reflects the limitation of a retrospective study. Follow-up was difficult once the dogs were discharged for home care, and such an approach is not recommended for futures cases. A dog is considered tracheostomy dependent if it is unable to breathe without a tracheostomy within a time frame of five days post surgery, and a permanent tracheostomy should be considered if airway bypass is needed beyond that time.

Limitations of this study include small numbers of dogs and the retrospective nature. Despite these limitations the aim was to document the novel use of silicone tracheal stoma stents (flesh tunnels) in temporary tracheostomies as an alternative to conventional tracheostomy tubes in dogs with upper airway obstruction.

Conclusions

Silicone tracheal stoma stents (flesh tunnels) provide a novel approach to the management of temporary tracheostomy in dogs with upper airway obstruction, and may in selected cases provide a suitable alternative to conventional tracheostomy tubes. The tracheal stoma stent appears to be relatively easy to insert and may result in a more stable fit within the trachea than conventional tracheostomy tubes. The stents do not occupy the tracheal lumen, and the improved visualisation of the short, straight lumen of the stent may facilitate easy cleaning and removal of mucoid plugs. Longer-term use (>5 days) cannot be recommended because of granulation tissue formation, and conversion to a permanent tracheostomy is advised if a dog is tracheostomy dependent beyond this time. The long-term consequences of partial tracheal ring resection are unknown.

Conflict of interest

None of the authors of this article has a financial or personal relationship with other people or organisations that could inappropriately influence or bias the content of the paper.

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