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The Safety and efficacy of a new self-expandable intratracheal nitinol stent for the tracheal collapse in dogs

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To evaluate the potential utility of a self-expandable intratracheal nitinol stent with flared ends for the treatment of tracheal collapse in dogs, endotracheal stenting therapy was performed under fluoroscopic guidance in four dogs with severe tracheal collapse. During the 4 to 7 month follow-up, after stent implantation, clinical signs, including dyspnea and respiratory distress, dramatically improved in all dogs. The radiographs showed that the implanted stents improved the tracheal collapse, and there were no side effects such as collapse, shortening or migration of the stents. In conclusion, the self-expandable intratracheal nitinol stents provided adequate stability to the trachea and were effective for attenuating the clinical signs associated with severe tracheal collapse.

Keywords: dog, nitinol stent, tracheal collapse

Introduction

Tracheal collapse in dogs, due to dorsoventrally dynamic narrowing of the tracheal lumen during the respiratory cycle, mainly occurs in toy or miniature dog breeds. The clinical manifestations of this condition include a classic "goose honk" cough, dyspnea, cyanosis, and syncope. The etiology of this condition is not completely known. Response to treatment with antitussives, antibiotics, bronchodilators, corticosteroids, sedatives, and oxygen, as well as other forms of medical management, including weight reduction, exercise restriction, and a non-smoking environment, usually is limited [7]. Surgical methods used to manage tracheal collapse include the application of an extraluminal total ring or spiral prostheses [1,2,6,8]. Although the recovery rate following extraluminal stabilization is about 75% to 85%, this procedure is invasive. In addition, surgical reconstruction of thoracic tracheal segments is associated with a high mortality rate. Minimally invasive techniques used to treat tracheal collapse or tracheal stenosis in humans, dogs and cats include the implantation of intraluminal stainless-steel or nitinol stents [3-5,9-13]. Implantation of stainless-steel stents into dogs, however, has been associated with several complications, including stent migration and shortening, and granuloma formation [10,12]. Implantation of nitinol stents into 3 dogs with tracheal collapse resulted in the need for second operations to remove fractured stents, suggesting that these stents were short and weak [4,9,11]. The implantation of a self-expandable intratracheal nitinol stent with flared ends, to prevent stent migration, however, has not been assessed in dogs with tracheal collapse. We therefore evaluated the safety and efficacy of this new stent for clinical application in dogs with tracheal collapse.

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Materials and Methods

Animals

Four dogs were referred to the Veterinary Medical Teaching Hospital of the College of Veterinary Medicine at Konkuk University, for serious dyspnea of 4 weeks to over 12 months duration. They had received intermittent medical treatment at a local clinic, but their clinical signs had not improved. Fluoroscopy showed dorsoventral narrowing of the trachea in all 4 dogs, with grades II-IV tracheal collapse.

Implantation procedures

The selected stent diameters were 10~15% greater than the diameter of each trachea just caudal to the larynx, as measured on a lateral thoracic radiograph. The length of each stent was the distance from the mid-cervical to the mid-thoracic trachea in each dog. The diameter and length of each stent were measured on survey lateral radiographs, taken when the dogs were conscious. The dogs were placed under general anesthesia by intravenous administration of 6 mg/kg propofol (Hanapharm, Korea). Using a delivery

catheter (M.I.Tech., Korea), self expandable intratracheal nitinol stents (M.I.Tech., Korea), with flared shoulders at both ends to prevent migration, were inserted into the tracheas of the dogs under fluoroscopic control. Each dog was implanted with one stent, which was situated from the cervical to the thoracic trachea (Table 1). Medical management consisted of treatment with aminophylline (10 mg/kg BW; Hankukmypharm, Korea), carprofen (2.2 mg/kg BW; Pfizer, USA) and amoxicillin-clavulanic acid (12.5 mg/kg BW; Pfizer, USA) orally twice daily, body weight reduction, and occasional oxygen using a nebulizer, beginning 7 days before and continuing until 4 weeks after stent implantation. All dogs were examined by survey radiographs and fluoroscopy at 2 week or 1 month intervals following implantation, for between 4 and 7 months.

Results

Technical success was achieved in all 4 dogs. Radiographs taken after stent implantation showed widening of the previously narrowed tracheal lumen in all four dogs (Fig. 1). Soon after stent implantation, the respiratory dyspnea in all dogs improved dramatically, and the dogs resumed almost normal activity. Between 4 and 7 months after implantation, the dyspnea caused by tracheal collapse showed substantial recovery, and the radiographs showed no evidence of stent collapse, shortening or migration (Table 1).

Discussion

In this study, intratracheal placement of the nitinol self-expandable stents was simple and without complications. In contrast to self-expanding stainless steel biliary wall stents and other nitinol stents [4,9-11], none of the nitinol expandable stents were broken, shortened or migrated. The flared ends of the stent likely prevented stent migration and increased stent stability. Dorsoventral radiographs comparing the length and location of each stent with the number of cervical and thoracic vertebrae showed no stent migration. The nitinol stents closely mimicked the physiological conditions of the airways. In addition, inflammatory reactions to the nitinol stents have been found to be minimal, without excessive accumulation of secretions

Table 1. Effect of self expandable intratracheal nitinol stent on clinical signs in dogs with tracheal collapse

Case No.	Breed	Age (years)	Sex	Weight (kg)	Grade of tracheal collapse*	Stent size (diameter-length)	Site of stent	Results (clinical signs)
1	Pug	8	FS	8.5	III	10-60 mm	CT-TT	No coughing and dyspnea
2	Pomeranian	9	M	6.7	IV	10-80 mm	CT-TT	No coughing and dyspnea
3	Shih-tzu	6	FS	5.0	II	10-100 mm	CT-TT	No coughing and dyspnea
4	Poodle	5	M	1.6	III	8-60 mm	CT-TT	No coughing and dyspnea

*Grade I tracheal collapse is a 25% reduction in lumen diameter. Grade II collapse is a 50% reduction in lumen diameter. Grade III collapse is a 75% reduction in lumen diameter. Grade IV collapse the lumen is obliterated on lateral thoracic radiograph. M: male, F: female, FS: neutered female, CT-TT: cervical trachea to thoracic trachea.

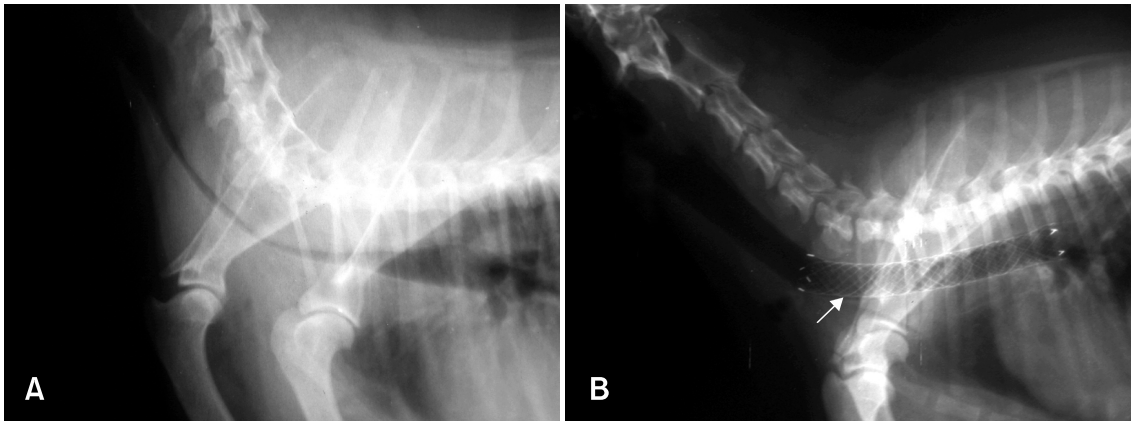

Fig. 1. Lateral radiographs before (a) and after (b) intratracheal placement of self expandable nitinol stent with flare ends in a dog with tracheal collapse. Collapsed trachea is extended and sustained (white arrow).

and without erosion through the airway walls [14]. We had previously implanted the same stents with flared ends into the trachea of normal dogs; after 2 years, necropsy examination showed no granulation tissue in the trachea.

Nitinol stents show maximum expansion at body temperature, with the dorsoventral forces of the collapsed trachea distributed equally on the surface of the stent, thus preventing stent collapse and migration. Our results demonstrated that stents located from the mid-cervical to the thoracic trachea increased the diameter of the entire cervical to thoracic tracheal area. Coughing and dyspnea disappeared and the dogs resumed normal activity.

Stent implantation is a minimally invasive, effective, easy and brief procedure that can be used to treat tracheal collapse. Nitinol stents can easily be produced with external dimensions tailored to fit an individual trachea or bronchus. Once implanted into the trachea or bronchus, the stent retains the same external diameter and increases the rigidity of the tracheobronchial wall. The nitinol stent is mounted, in a compressed form, over an introducing catheter, onto which it is fixed by a sheath. Once released from the introducing catheter by removal of the cover and exposes to body temperature, the stent expands to a preset diameter due to a "shape memory effect", which prevents stent collapse [14]. In this study, both ends of the nitinol stent gradually spread outward with no stent migration. In addition, each dog required implantation of only one stent for treatment of tracheal collapse, whereas dogs required multiple implantations of other nitinol stents [4,9,11].

In conclusion, we found that implantation of self- expandable intra-tracheal nitinol stents into dogs provided adequate stability to the trachea with intraluminal placement. These results suggest that the new nitinol stent is safe and effective for the treatment of dogs with tracheal collapse.

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