

Innovative prosthesis for tracheal collapse resolution

Canine tracheal collapse plays an important role in dogs because of its clinical signs that can lead to respiratory distress and death to those patients. Surgical management is in most cases very challenging because of its costs, difficulties on execution and limited techniques. In order to resolve this common disease we present a series of two cases that show a satisfactory surgical approach to resolve canine tracheal collapse with a new spiral prosthesis that was developed with a biocompatible device that has already been used to mold other prosthesis preconized for treatment and management of other problems such as cardiac valves.

Key-words: canine tracheal collapse, surgery, dogs.

Submitted in June 2016.

Accepted in November 2016.

Marcelo B Santos-Junior

PhD student in Animal Science at
Universidade Estadual do Norte Fluminense
– UENF, Campos dos Goytacazes, Brazil.

Saulo J Q Silva

Master science student in Animal Science at
UENF, Campos dos Goytacazes, Brazil.

Jussara P Scheffer

PhD student in Animal Science at UENF,
Campos dos Goytacazes, Brazil.

Silvia M R Cadena

Master science student in Animal Science at
UENF, Campos dos Goytacazes, Brazil.

Mariana S Ribeiro

Master science student in Animal Science at
UENF, Campos dos Goytacazes, Brazil.

Paula G A Cabral

Master science student in Animal Science at
UENF, Campos dos Goytacazes, Brazil.

Guilherme Monteiro

PhD student in Animal Science at UENF,
Campos dos Goytacazes, Brazil.

Fernanda Antunes

PhD in Farmacology - Universidade Federal
do Rio de Janeiro (UFRJ). Associated
professor / UENF, Campos dos Goytacazes,
Brazil. Laboratory of Animal Clinic and
Surgery (LCCA).

André L A Oliveira

PhD in Surgery - UFRJ. Associated
professor / UENF, Campos de Goytacazes,
Brazil. LCCA. E-mail:
lacerdvet@uol.com.br

Introduction

Tracheal collapse is a disease that's characterized by weakness and flattening of the tracheal rings normally associated with prolapse of the tracheal membrane into the lumen. There are several possibilities for these weaknesses such as congenital or inherited abnormalities. Mostly, those tracheal rings are formed by glycosaminoglycan's that bind water to the cartilage matrix ^{1,2}.

As dogs become older its normal to have an increase of the proteoglycan content combined with a decrease of the glycosaminoglycan's, chondroitin sulfate and cellularity of those rings, contributing for its flaccidity. Those changes can be focused or generalized with association of the main stem bronchi and lower bronchioles, characterizing a case of broncomalacia. Even though clinical signs depend on the severity of the tracheal collapse going from mild airway irritation signs to paroxysmal coughing and dyspnea as a result of dynamic airway collapse ^{1,3,4}.

Management of tracheal collapse is mostly done with medicine that reduces tracheal inflammation and diminish cough, which persistence worsens the tracheal inflammation. These medications could include: steroids, strategically used for short periods in order to diminish airway inflammation; antitussive agents; bronchodilators, such as theophylline that may improve mucociliary clearance and reduce diaphragm fatigue; antimicrobial administration only in cases that's a bacterial infection is proved to be present ^{2,3,5}.

About 71-93% of dogs respond well to treatment for a period over 12 months and some of those can even be gradually withdrawn from medicine management. However some patients,

even medicated, still present cough and may present airway distress secondary to pulmonary edema, which is a common complication seen in these patients ^{1,3}.

In cases which drug therapy were not succeeded and clinical signs are present, it is important to consider surgical procedures, specially because those patients have an considerable chance to develop airway distress or complications such as laryngeal paralysis. It is known that surgical management of tracheal collapse has been described, used and improved since the 70's ^{2,4-12}.

There are currently two types of surgical management that include placement of extraluminal stents or intraluminal stents. These last one is less invasive when compared to the extra-luminal technique however other complications have been reported such as fracture and migration of the intraluminal stent and both complications have a very important rule in patients survival ^{2,5,12-18}.

Surgical management is a great challenge in canine tracheal collapse, especially because there are few techniques described and most of them have some difficulties which can be infeasible its application. Therefore use of spiral prosthesis can represent an important alternative for this management.

Based on those information's the aim of the present work is to report a new device, developed with the support of our research group, used to treat tracheal collapses in dogs with an extraluminal surgical approach. This device is made of a nickel and titanium alloy, also known as nitinol alloy, with a spiral form.⁹

Case description

Two client-owned dogs were referred to our service with a previous diagnostic of tracheal collapse in order to have surgical management. Both patients presented with intermittent cough and cyanosis.

The first patient was a male pug not sterilized and had 8 months by the time of the procedure. Although it was brachycephalic, the patient did not have any other respiratory anomalies besides tracheal collapse. According to owners patient presented a

cough with a 9 score in a range from 0 to 10, presented breath difficult and cyanosis.

The second patient was thirteen years old sterilized female pinscher with a heart murmur. The

patient presented a cough graded as 10 and was already treated for cardiac disease. Even though there was no improvement in clinical signs after cardiac treatment. Evaluating its pre-operative radiography its possible to observe a left atrial enlargement besides tracheal collapse, better seen through inspiration and across the thoracic inlet, as shown in **Figure 1**.

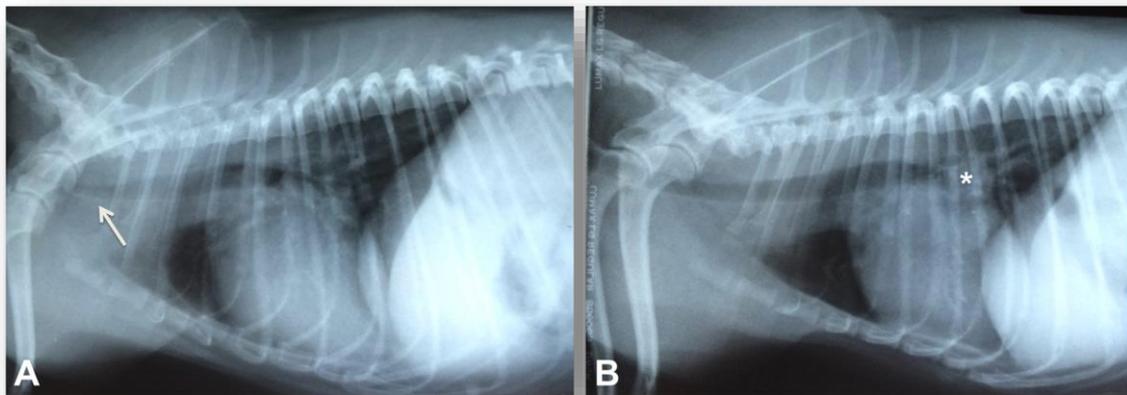


Figure 1 Lateral radiography views of one patient showing important tracheal collapse across the thoracic inlet during inspiration (A) and a discreet tracheal collapse at the same location during expiration (B). Also note a left atrium enlargement, asterisk, mostly seen during expiration (B).

Both surgeries were performed in dorsal recumbency and the patient was maintained with a stretched neck supported by a pillow. An incision was made through ventral cervical midline from larynx to manubrium, preceded with division of the sternocephalic and sternothyroid muscles through midline, always attempting to

laryngeal recurrent nerves in order to avoid any damage.

After tracheal identification, two stay sutures were placed around a cranial tracheal ring in order to cranially tract the trachea, surgeon carried on with dissection of the peritracheal tissue in order

to make a tunnel around trachea so the prosthesis could be implanted.

Nitinol spiral prosthesis was inserted exactly around the collapsed trachea, visualization of the prosthesis, after implantation, can be appreciated in **Figure 2**. Than sternohyoideus muscle,

sternocephalicus muscle and skin were routinely closed

Post-operative radiography's were taken and prosthesis was seen as a radiopaque image around trachea. Post-operative radiography can be seen in **Figure 3**.

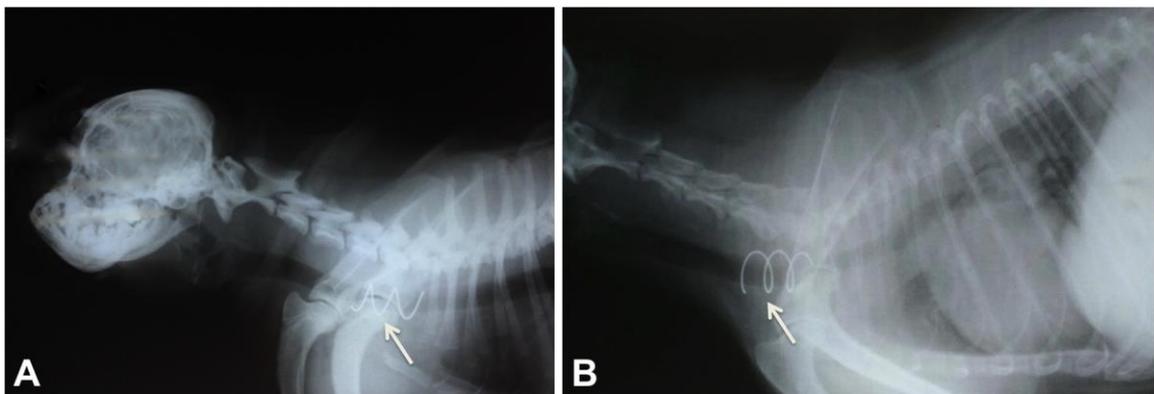
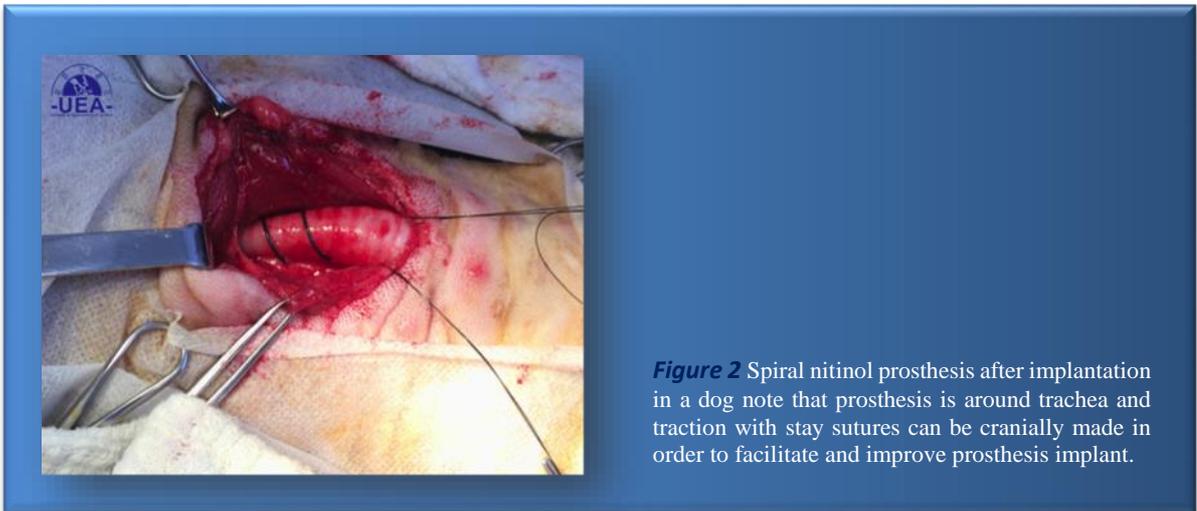


Figure 3 Post-operative lateral radiography views of the first patient described (A) and second patient described (B) showing nitinol spiral prosthesis as a radiopaque image (arrows).

Patients were followed up by the veterinarians that referred them to our service and owners were phoned interviewed in order to establish patient's conditions. Questions such as: improvement of cough; respiratory condition; need

of medicine to control cough after surgery, other surgical procedures for respiratory signs, diagnose of cardiac problem and grade for the cough before and after surgical procedure. Data related to those answers can be seen in **Table 1**.

Table 1 Questions asked to pet owners for follow up information after implant of nitinol prosthesis.

	Patient 1	Patient 2
Does patient still alive?	Yes	Yes
Had the cough improved?	Yes	Yes
Respiratory condition.	Better	Better
Was it necessary any medicine to treat cough	No	No
Has the patient been diagnosed with cardiac disease?	No	Yes
Was any other surgical procedure necessary to treat respiratory problems?	No	No
Grade of cough before surgery.	9,0	10,0
Grade of cough after surgery.	4,0	3,0

Discussion

Post-operative radiography's shown prosthesis location as a radiopaque spiral image, evaluating those images and comparing than with pre-operative exams was possible to note a considerably improvement of the tracheal collapse. From December 2015 to September 2016 no complications after surgery

procedures happened in any of the patients. Contrary to what was observed by some authors we do not have any complications to report yet. However this is limited number of reported cases so studies with more cases are needed ^{2, 3, 5, 8, 11, 18}.

Clinical signs such as cough and cyanosis can happen when dogs have respiratory diseases or

cardiac diseases^{1-3, 19-26}. The first patient, presented at this case report, was brachiocephalic and its clinical signs could be associated to brachycephalic syndrome however other problems such as elongated soft palate or stenotic nares weren't present. The second patient had a heart murmur and was already treated for cardiac disease. As seen in pre-operative radiography this patient presented with left atrium enlargement and this could justify clinical signs. However even treated for cardiac disease, cough stood very frequent and we believed that presence of tracheal collapse could be the cause.

Both patients have diminished considerably its clinical signs such as cough, from 50% to 70% improvement, and did not present any more cyanosis or respiratory discomfort. Based on clinical improvement and complementary exams findings we concluded that clinical signs associated with tracheal collapse have been solved.

Those findings can be prove that the prosthesis attempt to correct this disease and is a very promising structure to be surgically used, specially because its made by a material that is preconized as good biocompatible product and has been used in a lot of other devices, such as cardiac valves, vena cava filters and orthopedic materials^{12, 14, 27, 28}.

Besides this its form facilitate the implant and the is no need of sutures for fixation contributing to a less inflammation response which avoid other complications such as described for extraluminal polypropylene prosthetic tracheal rings²⁹.

Conclusions

After evaluation of those two cases we concluded that nitinol spiral prosthesis shown to be a satisfactory strategy for surgical management of canine tracheal collapse.

Funding

InPulse Animal Health supported the prosthesis developed to those patients.

Conflict of Interest Statements

The authors declare that there is no conflict of interest.

References

- 1 Maggiore AD. **Tracheal and Airway Collapse in Dogs.** *Veterinary Clinics of North America: Small Animal Practice.* 2014; 44: 117-27.
- 2 Johnson L. **Tracheal Collapse: Diagnosis and Medical and Surgical Treatment.** *Veterinary Clinics of North America: Small Animal Practice.* 2000; 30: 1253-66.
- 3 Tappin SW. **Canine tracheal collapse.** *Journal of Small Animal Practice.* 2016; 57: 9-17.
- 4 Beal MW. **Tracheal Stent Placement for the Emergency Management of Tracheal Collapse in Dogs.** *Topics in Companion Animal Medicine.* 2013; 28: 106-11.
- 5 Becker WM, Beal M, Stanley BJ and Hauptman JG. **Survival after Surgery for Tracheal Collapse and the Effect of Intrathoracic Collapse on Survival.** *Veterinary Surgery.* 2012; 41: 501-6.
- 6 Tangner CH and Hobson HP. **A Retrospective Study of 20 Surgically Managed Cases of Collapsed Trachea.** *Veterinary Surgery.* 1982; 11: 146-9.
- 7 Hobson H. **Total ring prosthesis for the surgical correction of collapsed trachea.** *Journal of the American Animal Hospital Association.* 1976.

- 8 Chisnell HK and Pardo AD. **Long-Term Outcome, Complications and Disease Progression in 23 Dogs After Placement of Tracheal Ring Prostheses for Treatment of Extrathoracic Tracheal Collapse.** *Veterinary Surgery.* 2015; 44: 103-13.
- 9 Ayres SA and Holmberg DL. **Surgical treatment of tracheal collapse using pliable total ring prostheses: results in one experimental and 4 clinical cases.** *The Canadian Veterinary Journal.* 1999; 40: 787-91.
- 10 Trinterud T, Nelissen P and White RAS. **Use of silicone tracheal stoma stents for temporary tracheostomy in dogs with upper airway obstruction.** *Journal of Small Animal Practice.* 2014; 55: 551-9.
- 11 Tinga S, Thieman Mankin KM, Peycke LE and Cohen ND. **Comparison of Outcome After Use of Extra-Luminal Rings and Intra-Luminal Stents for Treatment of Tracheal Collapse in Dogs.** *Veterinary Surgery.* 2015; 44: 858-65.
- 12 Durant AM, Sura P, Rohrbach B and Bohling MW. **Use of Nitinol Stents for End-Stage Tracheal Collapse in Dogs.** *Veterinary Surgery.* 2012; 41: 807-17.
- 13 Dengate A, Culvenor JA, Graham K, Braddock JA and Churcher RK. **Bronchial stent placement in a dog with bronchomalacia and left atrial enlargement.** *Journal of Small Animal Practice.* 2014; 55: 225-8.
- 14 Sura PA and Krahwinkel DJ. **Self-expanding nitinol stents for the treatment of tracheal collapse in dogs: 12 cases (2001–2004).** *Journal of the American Veterinary Medical Association.* 2008; 232: 228-36.
- 15 Mittleman E, Weisse C, Mehler SJ and Lee JA. **Fracture of an endoluminal nitinol stent used in the treatment of tracheal collapse in a dog.** *Journal of the American Veterinary Medical Association.* 2004; 225: 1217-21.
- 16 Mroz R, Kordecki K, Kozłowski M, et al. **Severe respiratory distress caused by central airway obstruction treated with self-expandable metallic stents.** *J Physiol Pharmacol.* 2008; 59: 491-7.
- 17 Sun F, Usón J, Ezquerro J, Crisóstomo V, Luis L and Maynar M. **Endotracheal stenting therapy in dogs with tracheal collapse.** *The Veterinary Journal.* 2008; 175: 186-93.
- 18 Woo H-M, Kim M-J, Lee S-G, et al. **Intraluminal tracheal stent fracture in a Yorkshire terrier.** *The Canadian Veterinary Journal.* 2007; 48: 1063-6.
- 19 Johnson LR and Pollard RE. **Tracheal Collapse and Bronchomalacia in Dogs: 58 Cases (7/2001–1/2008).** *Journal of Veterinary Internal Medicine.* 2010; 24: 298-305.
- 20 Schober KE, Hart TM, Stern JA, et al. **Effects of treatment on respiratory rate, serum natriuretic peptide concentration, and Doppler echocardiographic indices of left ventricular filling pressure in dogs with congestive heart failure secondary to degenerative mitral valve disease and dilated cardiomyopathy.** *Journal of the American Veterinary Medical Association.* 2011; 239: 468-79.
- 21 Ohad DG, Rishniw M, Ljungvall I, Porciello F and Häggström J. **Sleeping and resting respiratory rates in dogs with subclinical heart disease.** *Journal of the American Veterinary Medical Association.* 2013; 243: 839-43.
- 22 Poncet CM, Dupre GP, Freiche VG and Bouvy BM. **Long-term results of upper respiratory syndrome surgery and gastrointestinal tract medical treatment in 51 brachycephalic dogs.** *Journal of Small Animal Practice.* 2006; 47: 137-42.
- 23 Reynolds CA, Brown DC, Rush JE, et al. **Prediction of first onset of congestive heart failure in dogs with degenerative mitral valve disease: The PREDICT cohort study.** *Journal of Veterinary Cardiology.* 2012; 14: 193-202.
- 24 Chetboul V, Lefebvre HP, Sampedrano CC, et al. **Comparative Adverse Cardiac Effects of Pimobendan and Benazepril Monotherapy in Dogs with Mild Degenerative Mitral Valve Disease: A Prospective, Controlled, Blinded, and Randomized Study.** *Journal of Veterinary Internal Medicine.* 2007; 21: 742-53.

- 25 Kwart C, Häggström J, Pedersen HD, et al. **Efficacy of Enalapril for Prevention of Congestive Heart Failure in Dogs with Myxomatous Valve Disease and Asymptomatic Mitral Regurgitation.** *Journal of Veterinary Internal Medicine.* 2002; 16: 80-8.
- 26 Boswood A and Murphy A. **The effect of heart disease, heart failure and diuresis on selected laboratory and electrocardiographic parameters in dogs.** *Journal of Veterinary Cardiology.* 2006; 8: 1-9.
- 27 Kim J-y, Han H-j, Yun H-y, et al. **The Safety and efficacy of a new self-expandable intratracheal nitinol stent for the tracheal collapse in dogs.** *Journal of Veterinary Science.* 2008; 9: 91-3.
- 28 Gillespie MJ, Minakawa M, Morita M, et al. **Sutureless Mitral Valve Replacement: Initial Steps Toward a Percutaneous Procedure.** *The Annals of Thoracic Surgery.* 2013; 96: 670-4.
- 29 Moser JE and Geels JJ. **Migration of extraluminal tracheal ring prostheses after tracheoplasty for treatment of tracheal collapse in a dog.** *Journal of the American Veterinary Medical Association.* 2013; 243: 102-4.