Using tracheal segments for replacement of cervical oesophagus: an experimental study†

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Abstract

OBJECTIVES: Segmental resection and anastomosis of oesophageal lesions are not performed as a routine clinical practice because of complications and associated problems, whereas tracheal resection and anastomosis are a routine clinical practice. In this experimental study, we resected a segment of cervical oesophagus and replaced it with a tracheal segment.

METHODS: In eight dogs (mixed races), weighing 20–30 kg, ageing 1–2 years, under general anaesthesia, through a cervical incision, 5 cm of cervical trachea was separated while preserving its attachments to surrounding fibroareolar tissues. Afterwards, 5 cm of the oesophagus was resected and replaced with a prepared segment of the trachea. Oral liquids were started at the first post-operative day; the animals were kept for 2 months and then euthanized. Quality of swallowing and voice were evaluated. After an autopsy, anastomoses were examined grossly and histopathologically.

RESULTS: No complications occurred during surgery. Swallowing function and voice were normal in all eight dogs after the operation. No sign of aspiration was seen in clinical and radiographic examinations after starting oral diet. In autopsy examination, anastomoses were patent without narrowing or abnormal mucosal changes. Remarkable histopathological findings in replaced tracheal segments were squamous metaplasia, atrophy and degeneration of mucosal glands and degeneration of cartilages.

CONCLUSIONS: Replacement of a segment of the oesophagus with an autogenous tracheal segment is a practical procedure with low complications and can probably be used for the treatment of cervical oesophageal lesions in human beings.

Keywords: Oesophagus · Reconstruction · Trachea

INTRODUCTION

In routine surgical practice, oesophageal lesions are usually resected and replaced with colon, small bowel, stomach or composite tissue flaps [1–7]. Very infrequently, it is possible to resect a short segment of the oesophagus and to anastomose the two remaining ends together [8–10]. It is feasible to resect short or long segments from other parts of the gastrointestinal tract and to anastomose the two intact ends together. A special anatomical structure of the oesophagus prohibits safe segmental resection and anastomosis of its lesions. Immediately after resection of the involved oesophageal segment, the two intact ends retract in a way that a considerable traction force is required to bring them together. Additionally, the presence of loose connective tissues instead of the serosal layer jeopardizes reliable repair of anastomotic sutures [11–13].

The situation is different for the trachea. Clinical studies have demonstrated that usually up to half of the tracheal length may be resected and the two remaining ends can be anastomosed together in a healthy individual [14, 15]. The reason is the presence of cartilaginous tissue in the trachea, which makes it possible to tolerate high anastomotic tension [16, 17]. Also, releasing manoeuvres performed easily on the trachea through a cervical incision have been described to considerably reduce anastomotic tension [18–20]. Replacement of a segment of the oesophagus with a segment of a normal and healthy trachea might be very useful in cases with strictures at oesophagogastric or oesophagocolic anastomoses. Resection of an oesophageal segment may also be required in patients suffering from small oesophageal tumours or oesophageal rupture due to trauma or caustic lesion. In some cases, primary oesophageal tumours in early stages can be treated by this method. Considering our experience in the treatment of post-intubation tracheal stenoses [21, 22], we decided to resect a segment of the cervical oesophagus and replace it with a segment of the trachea in an experimental
study. If this method shows promising results, it may be used for
patients suffering from cervical oesophageal lesions.

MATERIALS AND METHODS
In 20–30 kg mature adult dogs (mixed races), 5 cm of the cervi-
cal trachea was separated while preserving its attachments to
surrounding fibroareolar tissues. Afterwards, 5 cm of the oeso-
phagus was resected and replaced with the prepared segment of
the trachea. General anaesthesia was induced by administration
of intravenous ketamine 10 mg/kg and diazepam 0.2 mg/kg.
After endotracheal intubation, anaesthesia was maintained by
using halothane. Halothane was used with 4% concentration for
the first 3 min and with 1.5% concentration for the remaining
period of anaesthesia. Cephalosporin 0.05 mg/kg IM was used 5 min prior
to the induction of anaesthesia to relax the dogs and let us get
an IV line.

Surgical approach was through an 8–10 cm midline cervical
longitudinal incision beginning over the cricoid cartilage, extend-
ing downwards. After incising the skin, deep cervical fascia was
cut in the midline, strap muscles were retracted laterally and the
anterior surface of the trachea was released downwardly from
cricoid to the level of the lower trachea. The trachea was tran-
sected in two places: below the third ring and 5 cm below the
first transection. During separation of this 5 cm tracheal
segment, we tried our best to preserve the soft tissue attach-
ments and small vessels that were attached to it laterally and
posteriorly (Fig. 1). A 5 cm oesophageal segment was resected
afterwards. During resection of the oesophagus, we tried to
avoid damaging the fibroareolar tissues around the separated
tracheal segment. The two tracheal ends were anastomosed
together by using interrupted Vicryl sutures. Two supportive
sutures were placed in the lateral sides of the tracheal ends to
pull them closer for easier tying of anastomotic sutures. After
anastomosing the tracheal ends and re-establishing the airway,
the separated tracheal segment was placed and anastomosed
between the two free oesophageal ends (Fig. 2). Running 2-0
polysuture were used for anastomosing the two oesophage-
geal ends to the tracheal segment. The incision was closed after-
wards. Neither drain nor nasogastric tube was used
post-operatively. Prophylactic antibiotic therapy (cephalosporin 22
mg/kg) was administered during the operation and continued
for 48 h. Soft diet was started the day after the operation and
replaced with normal diet after 7 days.

The dogs were kept for 2 months. During this period, they
were examined repeatedly, their eating and other voice (barking)
were closely evaluated and we looked for any sign or symptom
of aspiration or pulmonary infection. Also, bronchoscopic evalu-
aton of the anastomoses and larynx was done for all animals.
After 2 months, the dogs were euthanized and underwent
autopsy. Anastomotic sites were evaluated precisely, and the
anastomosed segments were removed and assessed
histopathologically.

This study was approved by the Research Council of University
and School of Veterinary Medicine in 2008 to be performed on
eight dogs.

RESULTS
Eight dogs aged 1–2 years (seven males and one female) under-
went surgery. The mean weight was 24.25 kg (20–30 kg).The
mean period of surgery was 82 min (range 70–120). Bleeding
was insignificant in all cases (<15 ml). Surgical incision,
exposure of the trachea and oesophagus and resection of seg-
ments of them took about 25% of the total duration of operation,
whereas anastomosing the two ends of trachea and
placing and anastomosing the separated tracheal segment to the
free oesophageal ends took about 75% of the total duration of operation. Performing the anastomosis was easy, and the surgery
was carried out by one surgeon and one assistant. In comparison
with humans, it seemed that the length and mobility of the
trachea and oesophagus were more in dogs. Therefore, less traction
force was required to reach the two tracheal ends together,
and the bleeding was less as well. All eight dogs regained con-
sciousness after the operation and were transferred to the care
unit. On the first post-operative day, oral fluids were started. On
clinical examination and observations, swallowing function was
normal with no signs of aspiration (i.e. cough or regurgitation
during swallowing). Their voice was normal as well. One of the
dogs developed malaise and anorexia 1 week after the oper-
ation, which continued for a few days. Swallowing and voice
looked normal in this dog, but after the emergence of these
symptoms, she developed recurrent cough and the diagnosis of
pneumonia was suggested for her. Antibiotic therapy and

Figure 1: Tracheal segment (arrow) is separated while preserving its surround-
ing fibroareolar tissues and vessels.

Figure 2: Tracheal segment is placed and sutured to the two free ends of the
oesophagus (thin arrow). Anastomosis of the two tracheal ends has also been
performed (thick arrow). The separated tracheal segment repositioned to the
left and behind trachea.
general care were started and resulted in complete recovery after 2 weeks. The assigned veterinarian believed that suspected pneumonia in this dog was not due to aspiration. All dogs were euthanized and inspected grossly and histopathologically after 2 months. Autopsy examinations in all dogs revealed no stenosis at tracheo-tracheal or tracheo-oesophageal anastomoses. The main histopathological findings were transformation of the columnar epithelium of the replaced trachea to squamous epithelium, degeneration of cartilage in some areas, atrophy of oesophageal muscles at the tracheo-oesophageal anastomotic site and inflammation of the tracheal submucosal glands (Figs 3 and 4).

**DISCUSSION**

In this experimental study on dogs, we resected a segment of cervical oesophagus and replaced it with a segment of trachea. The surgical procedure was relatively simple, fast and accompanied by minimal surgical trauma. No significant complication was seen. A mild pneumonia that occurred in one of the dogs was probably not directly related to the method of surgery and was treated with oral antibiotic therapy. In this study, we noticed that the cervical trachea in dogs was longer than that in humans, which made this surgery easier in dogs. So, it was possible to be performed in dogs. Although no such experience has been reported in humans [9], based on our experience in relation to lots of resection and anastomoses of the trachea [21], it might be performed in human beings, too. The need for such techniques in clinical practice is not rare, for instance, oesophageal stenosis at the anastomotic site to colon or stomach in the neck, cervical oesophageal strictures due to caustic agents and cervical oesophageal perforations. Even a segment of the trachea might be interplaced between cervical oesophagus and colon or stomach when colon or stomach does not reach the neck during oesophagectomy. Also this operation can be potentially performed inside thorax. For example, in infants with atresia of oesophagus, it might be possible to resolve the defect by replacing a segment of the trachea.

Two technical points should be mentioned here: first, although trachea has no obvious vascular pedicle, preserving the posterior and lateral fibroareolar attachments could maintain the tracheal blood supply. It was feasible to preserve these attachments since the separated tracheal segment had to be moved posterolaterally only for a few centimetres. Secondly, by anastomosing the tracheal segment to the oesophagus, this segment was placed parallel to the trachea itself, and we were concerned that the reciprocating pressure between the replaced segment and the trachea itself may prevent normal swallowing or breathing function. However, it was not an issue in real practice, and the separated tracheal segment spontaneously repositioned to the left and behind the trachea and therefore there was no pressure between them (Fig. 2). In several studies, it has been understood that resecting a segment of cervical trachea and anastomosing the two free tracheal ends are relatively simple procedures with minimal complications in humans [10]. Tracheal surgeries in humans mostly aim to remove strictures or tumoural lesions. The presence of these situations usually makes the surgical approach more complicated, while obtaining similar results in human beings might be possible if an intact segment of the trachea is resected and anastomosed to the oesophagus. In fact, treatment of patients with cervical oesophageal strictures at the site of oesophagogastric or oesophagocolic anastomoses is complicated and sometimes impossible [4, 5]. Based on this study, these conditions may be treatable by replacing the involved area with 2–3 cm of the trachea. Gastrooesophageal reflux is probable and could be prohibitive when a segment of trachea is placed between oesophagus and stomach, but if the tracheal segment is placed between esophagus and colon, there would probably be no problem. We did not see any reflux signs or symptoms in operated dogs. It may be possible to use this method for cases with cervical oesophageal tumours.

In a study by Gaujoux et al. [23], they used fresh allografts from aorta to replace the oesophagus, but the results were not satisfactory due to prolonged need for stents and frequent changes.

In the other study conducted by Juhasz et al. [24], a cryopreserved tracheal allograft was used. Although the results regarding swallowing were satisfactory, the length and diameter of the graft decreased in this study. In our study, no change was observed in the diameter and length of the transposed tracheal segment. Also, a tracheal segment, which has its own blood supply, we expect to replace a longer segment of the oesophagus with a shorter segment of trachea without any decrease in the length or lumen of the replaced trachea. If this assumption proves to be true, many cases of cervical oesophageal cancer may be treated by this method. In this study, follow-up time was 2 months, and if we followed up more than 2 months, certainly
more interesting results could be obtained. We hope to do so in the future.

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