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.
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 cervical trachea was separated while preserving its attachments to surrounding fibroareolar tissues. Afterwards, 5 cm of the oesophagus 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 time period. Acepromazine 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, extending 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 transected 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 attachments 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 prolene sutures were used for anastomosing the two oesophageal ends to the tracheal segment. The incision was closed afterwards. Neither drain nor nasogastric tube was used post-operatively. Prophylactic antibiotic therapy (cephazolin 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 their voice (barking) were carefully evaluated and we looked for any sign or symptom of aspiration or pulmonary infection. Also, bronchoscopic evaluation 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) underwent 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 eight cases (<15 ml). Surgical incision, exposure of the trachea and oesophagus and resection of segments 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 consciousness 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 operation, 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 surrounding 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.
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 reflex 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

**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

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**Figure 3:** Tracheo-oesophageal anastomotic site (arrow). Tracheal mucosa shows squamous metaplasia, oesophageal muscles have atrophied at the anastomotic site and chondrolysis of the tracheal cartilage has started.

**Figure 4:** Chondrolysis (thin arrow) and inflammation of the submucosal glands (thick arrow) are seen in the tracheal segment anastomosed to the oesophagus.
more interesting results could be obtained. We hope to do so in the future.

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REFERENCES