

Surgical closure of the larynx for intractable aspiration pneumonia: cannula-free care and minimizing the risk of developing trachea–innominate artery fistula

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Abstract There is a risk of developing a fatal trachea–innominate artery fistula following laryngotracheal separation for the prevention of intractable aspiration pneumonia. We developed a novel technique of surgical closure of the larynx to avoid this complication and provide long-term cannula-free care.

Keywords Aspiration pneumonia · Laryngotracheal separation · Trachea–innominate artery fistula · Surgical closure of the larynx

Introduction

Surgical procedures for aspiration pneumonia due to dysphagia include laryngotracheal separation surgery, glottal closure surgery, and total laryngectomy. In the field of pediatric surgery, laryngotracheal separation is commonly performed at the same level of the trachea as a tracheotomy. However, this procedure has a potential risk of developing trachea–innominate artery fistula in long-term surveillance. It is an uncommon but fatal complication. There have been various treatment methods reported to prevent this lethal complication, such as brachiocephalic artery dissection, manubrium resection, and the tracheal valve method [1–3]. We have developed a promising new

surgical technique to prevent this complication that would be beneficial to most patients to have aspiration- and cannula-free care. Here, we introduce a glottis closure procedure in which the vocal cords are split after removal of the anterior parts of the thyroid and cricoid cartilages, which assures a wide tracheal hole without the shift of the trachea closer to the skin.

Operative procedure

The procedure is performed under general anesthesia in the supine position with the neck extended. In cases without previous tracheotomies, a longitudinal skin incision is made from the thyroid notch down to the lower edge of the cricoid cartilage. The cricoid cartilage is exposed to reveal the bilateral cricothyroid muscles, and the thyroid cartilage is prepared to expose the cartilage membrane on the anterior of both plates (Fig. 1a). The cricothyroid muscles are dissected at their cartilage attachments, and the anterior portions of the cricoid cartilages are removed with bone removal forceps. The anterior aspect of the thyroid cartilage is stripped from the laryngeal incisure to the median cricothyroid ligament, and the posterior aspects of the cartilage on both sides are stripped free from the cricothyroid membrane. Furthermore, the anterior free portion of the cartilage is removed (Fig. 1b, c). The tracheal intubation tube is extubated, and the mid-portion of the cricothyroid membrane is cut from the cricoid cartilage level to the subglottic area and a new flexible intubation tube is inserted from the operative field (Fig. 2a). Simultaneously, an anesthesiologist performs oral cavity suction to prevent salivary flow in the operative area. The glottic mucosa is horizontally and circularly incised at the level of the bilateral vocal cords and upper and lower mucosal flaps

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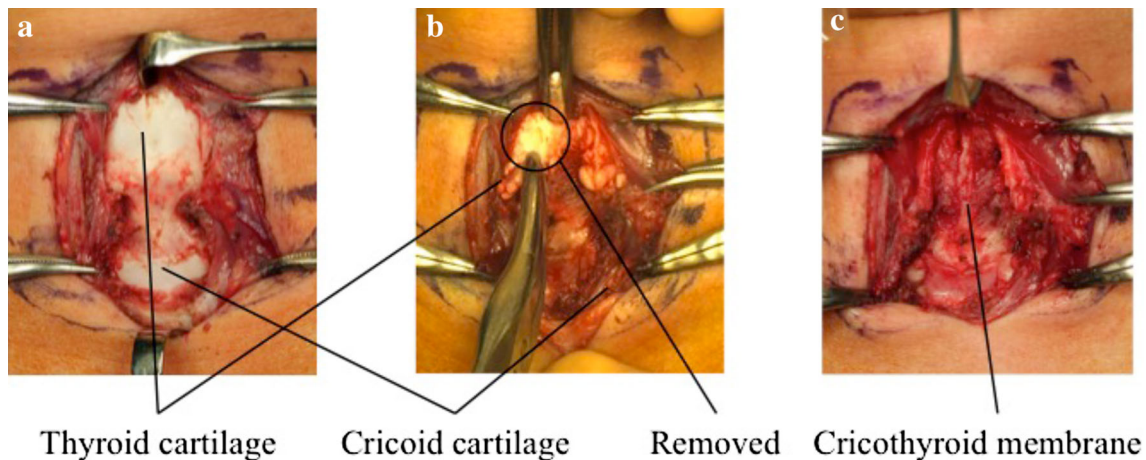
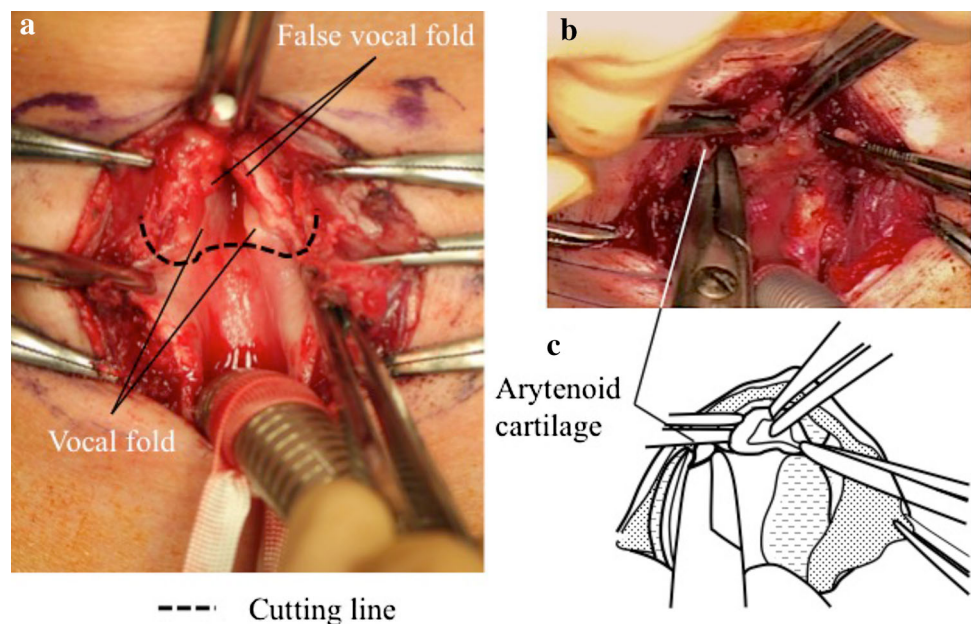


Fig. 1 **a** Anterior portions of the cricoid and thyroid cartilages are exposed. **b** The cricoid and thyroid cartilages are removed with bone removal forceps leaving the posterior cricothyroid membrane intact. **c** Ensure the large field of intact cricothyroid membrane

Fig. 2 **a** The mid-portion of the cricothyroid membrane is cut from the cricoid cartilage level to the subglottic area, and a horizontal cut is made at the bilateral vocal cords. **b, c** Both sides of the arytenoid cartilages exposed on the cricoid cartilage are transected (another patient's photo)



are prepared (Fig. 2a). The lateral cricoarytenoid muscles are also prepared to be freed from the thyroid cartilage to secure safe suture margins. Both sides of the arytenoid cartilages exposed on the cricoid cartilage are transected (Fig. 2b, c). Upper and lower mucosal flaps are sutured from the back to front, respectively, at the midline to create a two-layer suture bed (Fig. 3a, b). On one side, a sternohyoid muscle flap is made to fill the space between the two beds (Fig. 3c). The lower suture bed becomes the upper edge of the trachea, and the first tracheal cartilage becomes the lower edge, thus allowing a wider tracheal hole (Fig. 4). In cases with previous tracheostomies aiming to be cannula-free, the skin incision can be extended to create a long, wide trachea. The original tracheostomy hole

is undisturbed in cases in which the tracheostomy requires to be preserved.

Case report

A 9-year-old boy with cerebral palsy had a history of repeated aspiration pneumonia due to a swallowing disorder. Previously, the patient was orally taking in meals; however, aspiration symptoms gradually progressed to occur with any type of food injected through the stomach fistula. Under general anesthesia, surgical closure of the larynx with removal of the cricoid and thyroid cartilages was performed. A wide tracheal hole was created (Fig. 4),

Fig. 3 **a, b** Upper and lower beds are created leaving dead space between the two layers. **c** Sternohyoid muscle pedicle is freed and placed between the two beds leading to a rigid three-layer closure

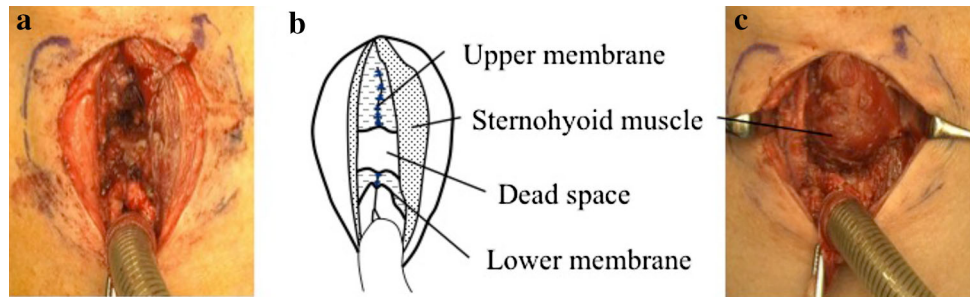


Fig. 4 A photo of a permanent tracheostoma taken 60 days postoperatively

and the tracheal cannula was extubated on the seventh postoperative day after careful observation. The patient has been cannula-free for more than 2 years and 4 months without any complications.

Ethics

This study was approved by the Ethics Committee of Fukushima Medical University and complies with the Helsinki Declaration.

Discussion

The laryngotracheal separation procedure was the first reported by Lindeman et al., and it has become one of the general procedures for surgical treatment of dysphagia [4, 5]. This type of surgery can significantly improve the patient’s quality of life by preventing aspiration [6, 7]. Conversely, granuloma formation, tracheal hole stenosis, suture failure, and trachea–innominate artery fistula have been reported as lethal complications following laryngotracheal separation [1, 8–12]. Reported prophylactic surgeries for trachea–innominate artery fistula include

innominate artery dissection, manubrium resection, and the tracheal valve method. Prophylactic surgery itself imposes another invasive procedure on patients [1–3]. To avoid trachea–innominate artery fistulas, we have introduced three important surgical concepts: (1) removal of the anterior portions of the thyroid and cricoid cartilages provides secure suture of two-layer closure of vocal mucosal flaps and insertion of a protective sternohyoid muscle flap, (2) creating the trachea incision at a position higher than the first ring of the trachea produces a wide tracheal hole leading to a cannula-free state, and (3) the entire circumference of the trachea can be preserved intact without pulling the trachea forward, producing permanent patency of the tracheal hole without stenosis. There are previous papers concerning the same issues [13–16]. The difference between these papers and our procedure includes the two points of our new technique. First, it is the difference in the extent of resection of the thyroid cartilage and the entire circumference of cricoid cartilage. They remove the anterosuperior portion of the thyroid cartilage into a U-shaped, or form a laryngofissure by cutting the thyroid cartilage in the midline, or remove the cricoid cartilage [13–16]. In our new technique to remove the anterior of the thyroid cartilage and the cricoid cartilage, the wide operative field is obtained and a wide tracheal hole is created. Therefore, the safe suture and the cannula-free can be expected. In the second, it is the difference of the glottis mucosa incision line. They make an incision between the false vocal cord and the vocal cord (supraglottic closure), or under the vocal cord (subglottic closure) [13–16]. On the other hand, in our new technique to incision in the vocal cord on 2/3, the upper valve is thick and the tracheostomy position is away from the innominate artery.

We have performed this procedure in six cases that ranged in age from 9 to 28 years (Table 1). The mean operative time was 2 h 7 min, the mean blood loss was 9 g. The observation periods ranged from 14 to 28 months, and trachea cannula-free states were obtained in five of six patients. One patient had tracheal stenosis caused by severe scoliosis of the cervical spine.

Table 1 Patient data

No.	Age (years)	Sex	Primary disease	Preexisting tracheostomy	Operation time (min)	Blood loss (ml)	Observation periods (months)
1	9	M	Cerebral palsy	–	129	15	28
2	20	M	Encephalopathy	–	176	1	26
3	28	M	Cerebral palsy	–	153	1	23
4	21	M	Cerebral palsy	+	113	20	23
5	23	M	Microcephaly	+	120	15	17
6	15	M	Cerebral palsy	–	76	1	14

Conclusions

We have introduced a new closure surgery in which we remove the thyroid and cricoid cartilages and use a three-layer closure method. We hope this procedure leads to the prevention of pneumonia, reduces the risk of trachea-innominate artery fistula, ensures trachea cannula-free conditions, and improves the quality of life for patients and caregivers.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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