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A Simple and Reliable Procedure Modification for Inverting Stripping Resection of the Esophagus

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Authors' contributions

This work was carried out in collaboration between all authors. Author MK designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors ST, YS, KM, NO, TN, SU, YE and HA managed the analyses of the study and managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Introduction: Inverting stripping resection is a well-described method of esophageal surgery. Although the indications for this procedure have decreased due to the widespread of endoscopic mucosal resection and the advancement of thoracoscopic surgery, familiarity with this procedure is important for the esophageal surgeon. We herein describe the inverting stripping procedure using simple and reliable methods.
Materials and Methods: Porcine esophagus was used. A model with a detached and non-detached site was made with a sponge, and stripping was performed. In our new technique, air was injected into the esophagus and stripping was performed. Clinically, the esophagus was examined from within the esophageal lumen using an endoscope.
Results: The porcine esophagus was stacked on itself without inverting. By pulling the stripper further, the esophagus was drawn into the sponge and appeared on the caudal side of the sponge

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inverted. With air supply, the esophagus did not stack up and the stripping was smooth. Endoscopically, esophageal stump is sequentially inverted.
Conclusion: During an inverting stripping resection, the esophagus is ultimately withdrawn into an invaginated state. However, this method can damage the esophagus. With our method, we can perform inverting stripping resection of the esophagus with minimal damage and resistance felt by the surgeon.

Keywords: Transhiatal esophagectomy; stripping; invagination, insufflation.

1. INTRODUCTION

Transhiatal blunt esophagectomy is indicated for patients who cannot tolerate a thoracotomy due to poor general condition, or for patients who are expected to have severe adhesions in the thoracic cavity due to tuberculosis or other infections [1,2]. On the other hand, thoracoscopic surgery has become more widespread, and minimally invasive esophageal resection has become more common. The pool of patients for whom a transhiatal esophagectomy is indicated is thus more and more limited. However, this method is one of the procedures that must be in the armamentarium of the esophageal surgeon. As a representative variation of this operation, invagination stripping of the esophagus is well described. In the stripping method, the more that the esophagus is dissected from the neck and the abdomen, the lower the risk of bleeding and nerve damage [3-6]. However, complete blunt finger dissection to the middle of the mediastinum is difficult. In such cases, the stripping method is useful. The esophagus can be removed both from the neck and the abdomen with this method. The esophagus can be extracted from either the neck or the abdomen with the mucosal surface everted by pulling down the stripper. Since the manoeuvre is performed blindly in the mediastinum, only the resistance transmitted to the stripper is reliant on visualisation. Moreover, it is not clear at what point the esophagus becomes invaginated.

In particular, if the esophagus is detached over a long distance, the esophagus can be handled easily like an accordion by towing the stripper. Also, even if esophagus becomes invaginated at the beginning of the stripping, there is the possibility that it will collapse without being inverted in the midpoint. It is difficult to distinguish between resistance in this folded state and resistance signifying detachment from surrounding mediastinal tissues. Even if the esophagus is piled up, invagination is started by forceful towing of the stripper, and the esophagus is sequentially dissected. While the sequence of events is not known as it is not visualised, it is desirable to initiate inversion from the beginning of the stripping. We sought to experimentally observe the results of stripping in the esophagus at the time of stripping and to confirm the technical success of our new technique for inverting stripping resection. We herein report our clinical experience with this novel technique.

2. MATERIALS AND METHODS

The fresh porcine esophagus was used for all experiments. The specimens were obtained from animals that had been sacrificed for use in approved non-gastrointestinal research studies. An esophagus was placed in the tube (Fig. 1a). In the vicinity of the center of the tube, the esophagus was passed through the sponge to a spot that was not detached from the surrounding tissue. Once the stripper was fixed to the distal esophageal stump, the stripper was pulled. In one technique, a model with a detached and non-detached site was made with a sponge, and stripping was performed. In the other technique, the air was injected into the esophagus and stripping was performed similarly. Further, we examined the method of closing the stump. Two type of stapler, linear and radial type, were used instead of purse string sutures for stump closure.

Based on these results, we carried out this method for stripping resection of the esophagus. Simultaneously, the esophagus was examined from within the esophageal lumen using an endoscope.

3. RESULTS

3.1 Experimental Model

The esophagus was stacked without inverting (Fig. 1b). By pulling the stripper further, the head of the stripper advanced, albeit with resistance (Fig. 1c,d). The esophagus on the left side of the sponge was drawn into the sponge, and appeared on the right side of the sponge after

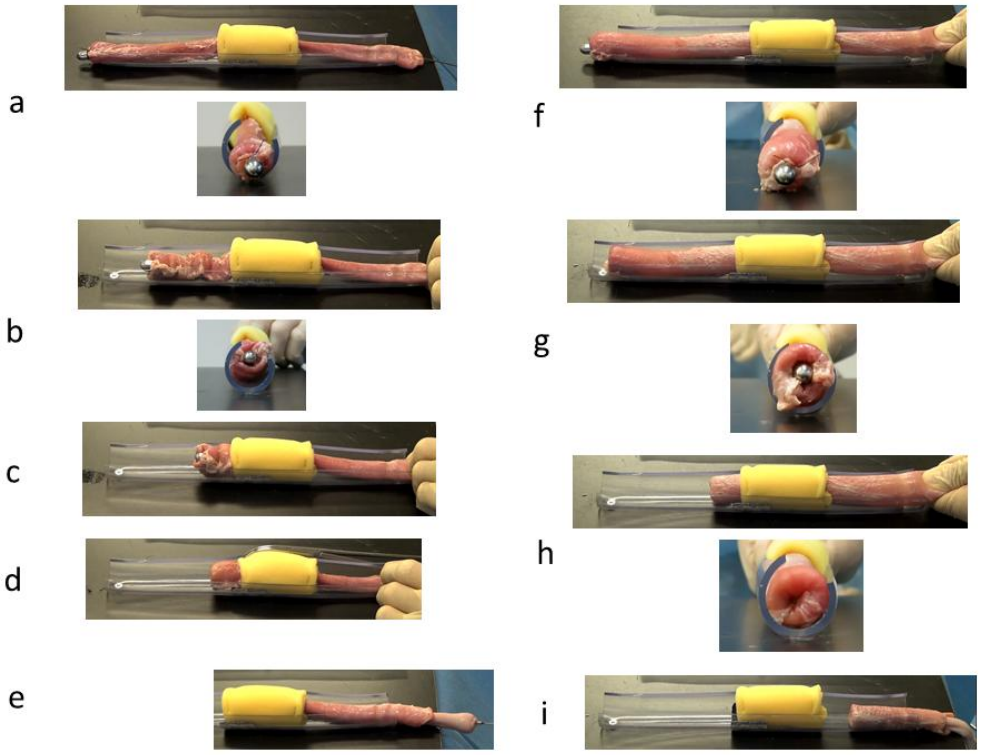

Fig. 1. Experimental model
a: Esophagus was placed in the tube and stripper was fixed with esophagus
b: Esophagus was stacked without inverting
c: Head of the stripper advanced with great resistance
d: Esophagus has started to invert
e: Esophagus was drawn out from the sponge
f: Air was injected from the anal side of the esophagus
g: Stump of the esophagus began to invert
h : Esophagus was inverted sequentially
i: Esophagus was drawn out from the sponge

inversion (Fig. 1e). With further pulling, the esophagus was drawn out from the sponge.

In a different group, stripping was performed as the air was injected from the left side of the esophagus (Fig. 1f). With simultaneous pulling of the stripper, the stump of the esophagus began to invert (Fig. 1g). During the stripping, the esophagus did not bunch up and stripping was smooth and with little resistance (Fig. 1h,i).

In comparing the two different types of staplers, only the radial type was inverted easily (Fig. 2).

3.2 Surgical Technique

3.2.1 Procedures in the neck

The neck manipulation is performed with a collar incision along the skin crease. The left sternothyroid and sternohyoid muscles are transected. After identification of the esophagus behind the common carotid artery, the dorsal side of the esophagus is dissected from the surrounding tissues. While protecting the left recurrent nerve, the esophagus is dissected circumferentially and encircled with a Penrose Drain. The cervical and upper thoracic esophagus is detached with neck manipulation.

3.2.2 Abdominal procedure

Abdominal manipulation is performed using either an upper midline incision or a laparoscope. The abdominal and lower thoracic esophagus is detached to the extent possible via the esophageal hiatus with abdominal manipulation. Blood vessels such as the proper esophageal artery are cauterized with energy devices.

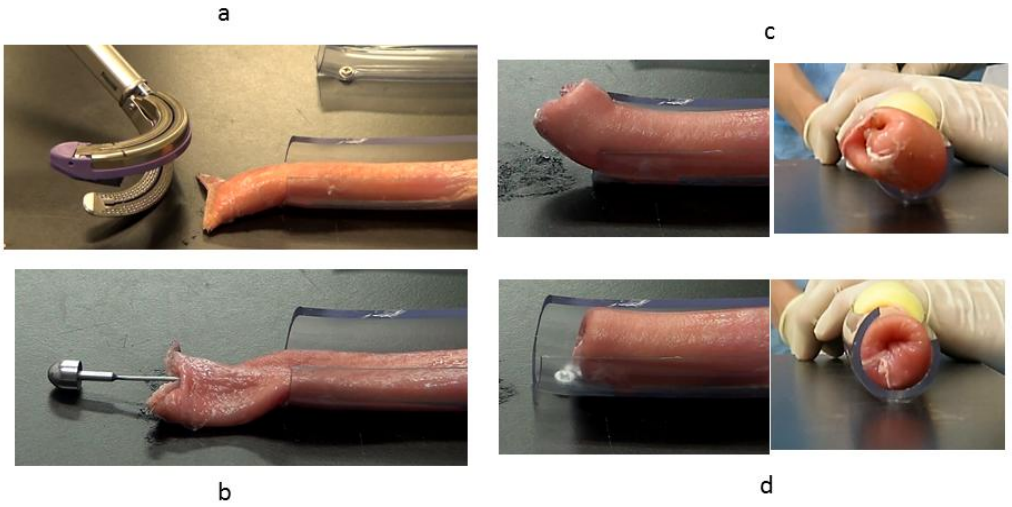

Fig. 2. Experimental model: Closing methods of the esophageal stump

a: Stump of esophagus closed with a radial-type stapler
b: Stripper was inserted from the stomach
c Air was injected from the caudal side of the esophagus
d: Stump of the esophagus is easily inverted

3.3 Stripping

After manipulation from the neck and abdomen, it is possible to measure the distance required for stripping by measuring the distance between the peeled edges and the nose with the nasogastric tube. The stomach is separated proximally art using an automatic stapler. The cervical esophagus is detached after pursestring sutures application. The esophageal stump is grasped with intestinal forceps so as to not to fall into the mediastinum. A vein stripper is inserted toward the abdomen form the caudal-side of the esophagus. The stripper is left out of the stomach wall (Fig. 3c). The vein stripper and the distal stump of the esophagus are affixed firmly with suture (Fig. 3a). After opening a small hole in the anterior wall of the stomach, a gastroscope is inserted into the esophagus (Fig. 3b). The esophagus distends via insulfflation (Fig. 4a). After confirming that the esophagus has expanded, the stripper is pulled downwards (Fig. 4b). It can be observed that the esophageal stump is sequentially inverted (Fig. 3d). The resistance of the stripper can be felt at the non-detached part (Fig. 4c). When this resistance disappears, stripping is complete (Fig. 4d). It is important to confirm hemostasis from the neck and abdomen. Finally, reconstruction of digestive system is performed and surgery is completed.

4. DISCUSSION

A well-described method for esophageal resection is transhiatal blunt esophagectomy. In recent years, endoscopic mucosal resection and endoscopic submucosal dissection have become more widespread, and indications for blunt esophagectomy have been reduced. In addition, thoracoscopic surgery has been a factor in reducing indications for a transhiatal approach. Our method is indicated as a radical surgery option for patients with superficial but circumferential, mucosal cancer, or multiple early cancers of the esophagus that are difficult endoscopic or thoracoscopic resection cases. As a palliative operation, this method is indicated for patients for whom differential lung ventilation is unfeasible due to poor pulmonary function and either open-chest or thoracoscopic surgery is difficult due to such reasons as severe pleurodesis and poor general condition. On the other hand, chemoradiation is an available option if surgery is to be avoided. However, pneumonitis after radiation therapy can cause pulmonary compromise. We believe that blunt esophagectomy with invagination stripping is a good alternative in such cases.

Bleeding from the mediastinum after blunt esophagectomy is one of the most frequent complications [4]. In order to minimize this risk, it is important to dissect the esophagus as far as

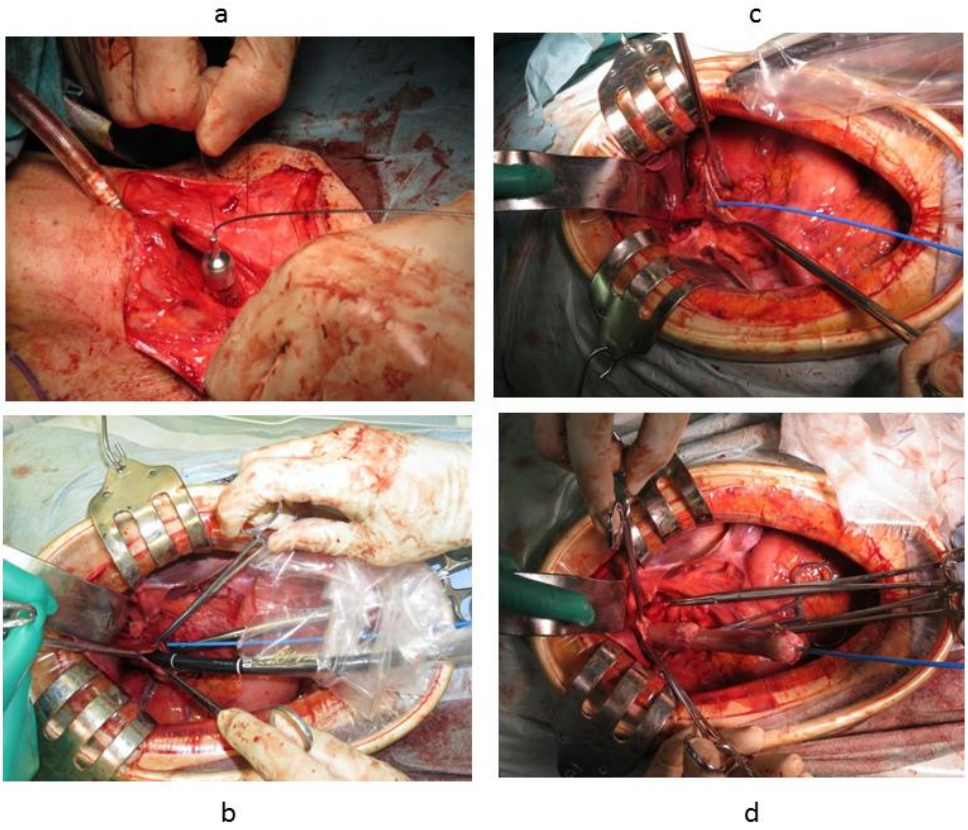

Fig. 3. Operative findings

a: Vein stripper and the cephalad end of the esophagus are affixed
b: Gastroscope is inserted into the esophagus
c: Stripper is left out of the stomach wall
d: Esophageal end is sequentially inverted

possible from the neck and abdomen while ensuring hemostasis [7]. This reduction of the distance that must be bluntly stripped reduces the risk of bleeding. On the other hand, if the dissected distance becomes longer, it is difficult to invaginate the esophagus.

Depending on the magnitude of the frictional force generated in “α” and “β” as shown in Fig. 5a, the surgeon can decide whether or not to invaginate. Invagination will occur if “α” is larger (Fig. 5b). If “β” is larger, the esophagus will be held like an accordion (Fig. 5c). However, since this phenomenon occurs within the mediastinum, visual confirmation is not possible. As can be inferred from the results of our experiments, the esophagus will be visualized only to the point where the dissection has been completed. At this point, a large amount of resistance will be felt, and invagination will begin. This resistance arises as the esophageal stump and the head of the stripper pass through the un-dissected esophagus. In some cases, the head of the stripper fixed to the esophageal stump can damage the esophagus. Our new method is a simple and reliable to confirm esophageal invagination from the lumen of the esophagus via insufflation through gastroscopy. That being the case, gastroscopy is not necessary at all. If the esophagus is expanded by insufflation, invagination will be performed reliably without the need for visualization. Insufflation via gastroscopy is possible for up to approximately 20 cm^3/sec. However, it is sufficient if the esophagus lumen expands only slightly; there is no need to generate a lot of pressure.

With regard to the method of closing the stump of the esophagus, the purse string suture is classically described. This is why closing the stump centered on the head of the stripper is advantageous for invagination. Using our method, the esophagus was easily inverted even if the stump was closed with a radial-type stapler.

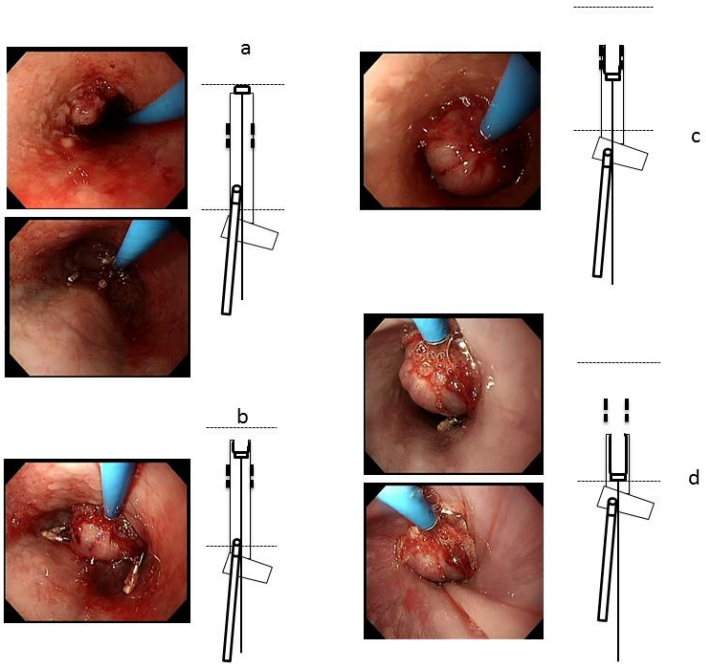

Fig. 4. View from the esophageal lumen
a: Esophagus expands after insufflation with a scope
b: Stripper is pulled downwards
c: Resistance of the stripper can be felt at the non-detached part
d: Stripping is completed

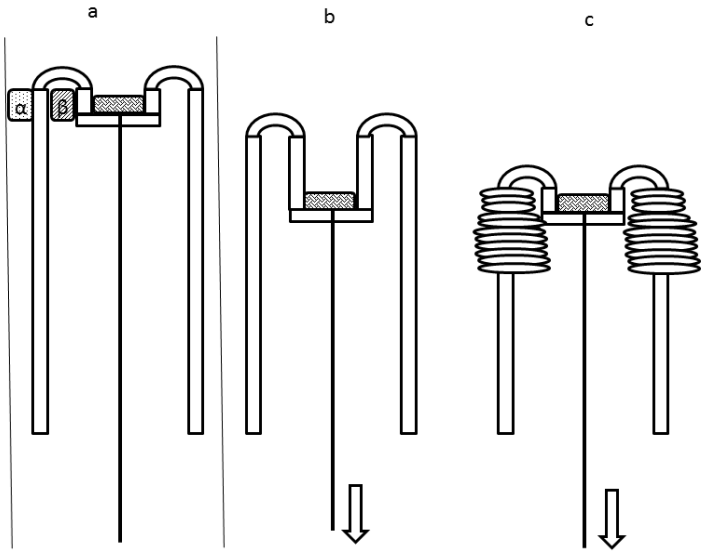

Fig. 5. Schema of stripping
a: Magnitude of the frictional forces outside and inside of the esophageal lumen
b: Invaginated esophagus
c: Remaining esophagus

5. CONCLUSION

While indications for inverting stripping resection of the esophagus are less frequent, it is undoubtedly an important procedure for esophageal surgeons. This method, which can be carried out conveniently with only an air supply devices that can be used in the operating

room, seems to be very meaningful as a method that enables simple and reliable procedure for inverting stripping resection of the esophagus.

CONSENT

It is not applicable.

ETHICAL APPROVAL

Authors confirmed that all necessary ethical approval from institutions was obtained.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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