Gastric Tube Elongation as a Salvage Option for High Gastroesophageal Anastomosis after Esophagectomy for Esophageal Cancer Postprint

Authors: Zhong Hai, Li Xiang, Liang Hongsen, Liu Nanbo, Liu Yufan, Zhang Junhua, Wu Xu

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Abstract

Objective: To introduce the innovative surgical technique of tubular stomach elongation and report successful cases of esophageal cancer resection and esophageal-tubular gastric cervical anastomosis performed using this method.

Methods: We report five patients with esophageal cancer admitted to our department from September 2015 to October 2016, including two cases diagnosed with cervical esophageal cancer and three with middle thoracic esophageal cancer. Patients with cervical esophageal cancer underwent hypopharyngectomy, total laryngectomy, esophageal inversion stripping, and gastric-pharyngeal anastomosis. Patients with middle thoracic esophageal cancer underwent esophageal cancer resection via a left cervical, right thoracic, and midline abdominal triple-incision approach with esophageal-gastric cervical anastomosis. Intraoperatively, insufficient gastric length was encountered, making anastomosis to the pharynx difficult, thus necessitating tubular stomach elongation surgery to maximize tubular gastric length.

Results: All patients achieved successful surgical outcomes with favorable postoperative recovery. Upper gastrointestinal contrast studies performed 7-12 days postoperatively revealed no significant abnormalities, and patients were discharged in stable condition 2-3 weeks postoperatively.

Conclusion: During esophageal cancer resection with high esophageal-gastric anastomosis, if insufficient tubular gastric length or high anastomotic tension is encountered, tubular stomach elongation surgery may represent a viable emergency option.

Full Text

Tubular Gastric Elongation Surgery for High Esophageal-Gastric Anastomosis After Esophageal Cancer Resection: Analysis of 5 Cases

Zhong Hai, Li Xiang, Liang Hongsen, Liu Nanbo, Liu Yufan, Zhang Junhua, Wu Xu
Department of Thoracic Surgery, Huiqiao Medical Center, Southern Hospital, Southern Medical University, Guangzhou 510515, China

Abstract

Objective To introduce tubular gastric elongation surgery as an innovative surgical technique and report successful cases of esophageal cancer resection with esophageal-gastric tube cervical anastomosis using this method.

Methods We report five patients with esophageal cancer treated in our department from September 2015 to October 2016, including two with cervical esophageal cancer and three with mid-thoracic esophageal cancer. Patients with cervical esophageal cancer underwent pharyngectomy, total laryngectomy, esophageal inversion and stripping, and gastric oropharyngeal anastomosis, while those with mid-thoracic esophageal cancer underwent esophagectomy via left neck, right chest, and midline abdominal incisions with cervical esophageal-gastric anastomosis. In all cases, the gastric length was found to be insufficient for oropharyngeal anastomosis, necessitating tubular gastric elongation surgery to maximize gastric tube length.

Results All patients underwent successful surgery with good postoperative recovery. Upper gastrointestinal contrast studies performed 7–12 days postoperatively showed no significant abnormalities, and patients were discharged in stable condition 2–3 weeks after surgery.

Conclusion Tubular gastric elongation surgery may serve as an excellent contingency option when the gastric tube is too short or anastomotic tension is excessive during high esophageal-gastric anastomosis following esophageal cancer resection.

Keywords: tubular gastric elongation surgery; esophageal cancer; gastric tube; high esophageal-gastric anastomosis

Introduction

The incidence of esophageal cancer has been increasing annually in China, with surgical resection becoming a crucial curative treatment modality. Traditional esophageal substitutes include the stomach, jejunum, and colon. Due to its rich blood supply and convenient accessibility, the stomach has long been the preferred organ for esophageal replacement [1]. Creating a gastric tube (tubular

stomach) conforms well to anatomical principles and yields fewer postoperative complications, making it the most commonly used technique in clinical practice. However, occasionally due to a small stomach or other factors, the gastric tube may be too short after construction, or the length may be barely adequate but result in excessive anastomotic tension, creating significant surgical challenges. From September 2015 to October 2016, five esophageal cancer patients in our department experienced insufficient gastric tube length. Professor Wu Xu of the Thoracic Surgery Department employed an innovative technique—tubular gastric elongation surgery—to appropriately increase gastric tube length, successfully applying it in these patients. This article explores the clinical feasibility and safety of this novel surgical method.

Case Series

We treated five male patients with esophageal cancer between September 2015 and October 2016, including two with cervical esophageal cancer and three with mid-thoracic esophageal cancer. All cases were confirmed as esophageal squamous cell carcinoma by PET-CT and endoscopic biopsy preoperatively. Among the two cervical esophageal cancer patients, one had recurrent disease after radiotherapy and the other was a primary case; both underwent pharyngectomy, total laryngectomy, esophageal inversion and stripping, permanent tracheostomy, gastric tube pharyngeal anastomosis, and jejunostomy. The three mid-thoracic esophageal cancer patients all had super-long esophageal lesions (>8 cm [3]), with one patient demonstrating a lesion length of 22.5 cm on upper gastrointestinal series (confirmed by the Ministry of Education' s Novelty Search Center as the world' s longest esophageal cancer [4]). All three underwent esophagectomy via left neck, right chest, and midline abdominal incisions with cervical gastric tube anastomosis, with tubular gastric elongation surgery performed in each case.

In the two cervical esophageal cancer patients, excessive resection of the hypopharynx and larynx by the otolaryngology team resulted in an excessively high resection plane, making the gastric tube too short. Tubular gastric elongation surgery was performed on the already-constructed gastric tubes, achieving approximately 3 cm of additional length. In the three mid-thoracic esophageal cancer patients, preoperative assessment indicated small stomachs, suggesting that conventional gastric tube construction might not permit cervical anastomosis. Therefore, we directly applied the tubular gastric elongation technique during initial gastric tube creation.

Surgical Technique

Conventional Gastric Tube Construction

Through a midline abdominal incision, the stomach is mobilized while preserving the right gastroepiploic vascular arcade along the greater curvature. The pylorus and duodenal bulb are released. The entire stomach is stretched flat

and straight with appropriate tension. Starting from an appropriate location at the gastric fundus along the lesser curvature, a linear cutting stapler is used to resect gastric tissue, preserving only the greater curvature to create a tubular stomach. During resection, the cutting line should remain parallel to the stretched greater curvature to produce a vertical tubular shape with a diameter generally >3 cm. This conventional method represents the first elongation of the gastric tube, yielding a length significantly greater than the lesser curvature but slightly less than the greater curvature, which is usually sufficient for high anastomosis.

Elongation Technique for Already-Constructed Gastric Tubes

This method primarily addresses situations where the gastric tube is found to be too short after initial construction. The constructed gastric tube is stretched flat and straight with appropriate tension. Along the lesser curvature cutting line (the site of the initial linear stapler cut), the linear cutter stapler is used to create multiple triangles at specific angles and intervals [the base length of the triangles (A in [Figure 1: see original paper]) and the base angles (angle D in [Figure 1: see original paper]) are determined based on the gastric tube diameter and required elongation]. These triangles are then straightened (sides B and C in [Figure 1: see original paper] are unfolded into a straight line). According to the geometric principle that the sum of two sides of a triangle is greater than the third side, the gastric tube is clearly lengthened, resolving the problem of insufficient length.

Direct Construction of an Elongated Gastric Tube

Similar to conventional gastric tube construction, the stomach is routinely mobilized. However, when creating the gastric tube along the lesser curvature, instead of cutting parallel to the greater curvature with the linear stapler as in traditional methods, the tubular gastric elongation technique is applied directly. Triangles with connected bases are created along the lesser curvature using the linear cutter stapler. After unfolding the stomach, based on the principle that the sum of two sides exceeds the base, the gastric tube is obviously longer than a conventional one. Schematic diagrams and theoretical illustrations of these gastric tube construction methods are shown in [Figure 2: see original paper].

Theoretical Model

To facilitate calculation and demonstration, we established a right triangle model for theoretical proof. Clinically, the maximum effective length of commonly used linear cutter staplers is 60 mm. In [Figure 2: see original paper], which illustrates the theoretical model of tubular gastric elongation using a right triangle, sides A, B, and C and angle D correspond to those in [Figure 1: see original paper]. Assuming side C represents the maximum stapler cut length (C = 60 mm), the lengths of all sides and the degree of elongation can be calculated

based on different base angles D using the formulas sinD = B/A and cosD = C/A.

Clinical Results and Theoretical Basis

Clinically, [Figure 3: see original paper] and [Figure 4: see original paper] show intraoperative photographs. All five patients who underwent tubular gastric elongation surgery recovered well postoperatively. Upper gastrointestinal contrast studies performed 7–12 days after surgery revealed no significant abnormalities, and patients were discharged in stable condition 2–3 weeks postoperatively. Theoretically, as clearly shown in the schematic diagram in [Figure 2: see original paper], because B + C > A, tubular gastric elongation surgery can significantly lengthen the gastric tube. Moreover, the cutting length and angle can be adjusted according to intraoperative conditions, allowing flexible clinical application. This represents an innovative and feasible new surgical method.

Discussion

Most surgeons consider the stomach an ideal esophageal substitute [5] due to its rich blood supply, limited operative field to the upper digestive tract, and anatomical continuity with the esophagus, which conforms to physiological digestive characteristics. A gastric tube is created by mobilizing and releasing vessels, fascia, and fat around the lesser curvature, then reshaping the stomach into a tubular form by resecting the lesser curvature side while preserving the greater curvature for anastomosis with the esophageal stump. Literature shows that compared with whole stomach replacement, gastric tube construction increases gastric length, with tubular stomachs reaching 28–42 cm (mean 39 cm), generally sufficient for thoracic or cervical anastomosis [6]. Buunen [7] constructed 20 gastric tubes preserving a 4 cm greater curvature width, ligating the left gastroepiploic vessels at the splenic hilum, and found that gastric tube length could be extended by at least 5 cm compared with whole stomach replacement. This demonstrates that gastric tubes provide greater flexibility for anastomosis, making gastric tube esophageal replacement the preferred technique for thoracic surgeons in esophageal cancer surgery.

However, clinicians occasionally encounter absolute or relative gastric tube length insufficiency: (1) in cervical esophageal cancer requiring radical resection with high resection planes, necessitating gastric tube elevation to the hypopharynx or oropharynx for anastomosis; (2) patients with prolonged inability to eat or minimal intake causing gastric degeneration; (3) esophageal disease combined with gastric disease requiring partial gastrectomy and resulting in insufficient gastric tissue; and (4) congenital small stomach or "small stomach" status after previous gastric resection. These scenarios create significant challenges and may prevent surgical treatment in special patients (such as those with congenital small stomach or previous partial gastrectomy) or require more invasive alternatives like jejunal or colon interposition [8–10]. Tubular

gastric elongation surgery addresses these issues, offering hope for previously inoperable patients and serving as an emergency solution for insufficient gastric tube length during high esophageal-gastric anastomosis after esophagectomy.

Although tubular gastric elongation surgery can increase gastric tube length, it inevitably sacrifices some tube width. Therefore, its application has certain prerequisites. Current research has not definitively established optimal gastric tube width, though 3–5 cm is generally considered appropriate [11–13]. While some studies suggest advantages for gastric tubes <3 cm width [14,15], no consensus exists on the minimum appropriate width. We therefore recommend that tubular gastric elongation surgery only be used when the final tube width exceeds 3 cm; if width is already <3 cm, we do not recommend this technique.

Despite advantages over other esophageal reconstruction methods, gastric tube esophageal replacement still has complications and shortcomings that require clinical solutions. The pursuit of an "artificial esophagus" remains the dream and goal of esophageal surgeons. With advances in biomaterials and 3D printing technology [16,17], gastric tube esophageal replacement may eventually be superseded by artificial esophageal substitutes [18].

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Note: Figure translations are in progress. See original paper for figures.