

Colon Interposition for Corrosive Esophageal Stricture: Single Institution Experience with 119 Cases

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Summary: The colon is an alternative graft organ for esophageal reconstruction. The present study reviewed our experience with the colon interposition for esophageal replacement following corrosive ingestion, to evaluate the outcomes of colon interposition based on our surgical experience. The clinical data of 119 patients who underwent colon interposition for esophageal replacement from January 2005 to March 2017 were retrospectively analyzed. The routes of the colon interposition were retrosternal in 119 (100%). The median operative time was 390 min (range: 290–610 min) and the median blood loss was 615 mL (range: 270–2500 mL). Of these 119 patients, the cervical anastomosis was performed at the hypopharynx ($n=20$, 16.8%), the larynx ($n=3$, 2.5%), and the cervical esophagus ($n=96$, 80.7%). Five patients experienced cervical anastomotic leakage (4 cases for esophagus-colon, and one for hypopharynx-colon). One patient experienced wound infection of the abdominal wall. Three patients had injury of recurrent laryngeal nerve and hoarseness. Three patients had stress ulcer with bleeding and treated with octreotide. Two patients suffered from incomplete intestinal obstruction. The postoperative follow-up was made for 12 months in all patients and all of them were alive. In conclusion, The colon is well-suited for esophageal reconstruction. The selection of the colon graft should be flexible and be based on the inspection of blood supply and the length needed. We must therefore make every effort to reduce the number of postoperative complications, and improve the quality of life for patients.

Key words: corrosive esophageal stricture; colon interposition; outcomes

Esophageal reconstruction for patients with multiple or diffuse caustic strictures, intolerable to liquid diet, should be performed with the anticipation of satisfactory function for a full lifetime. In most cases, the stomach usually severely injured is not a suitable candidate for esophageal substitution. After the first case of esophageal reconstruction employing a subcutaneously tunneled transverse colon conduit, the colonic conduit has become a safer and preferred graft for reconstruction of the esophagus for its advantages including long length, acid resistance and excellent vessels^[1-4]. But multiple procedures and longer hospital time were required. With the refinement of surgical techniques, colon interposition for these cases of caustic esophageal strictures can now be done with minimal complications in our department.

1 MATERIALS AND METHODS

1.1 Clinical Data

In the period from January 2005 to March 2017, 119 patients with esophageal caustic cicatricial strictures after ingestion of chemicals underwent esophageal replacement with colon interposition at the Department of Thoracic Surgery, Renmin Hospital of Wuhan University, China. There were 68 men and 51 women with age ranging from 2 to 65 years (mean 33 years). The interval between caustic cicatricial stricture and esophageal reconstruction ranged from 6 months to 45 years (mean: 3.7 years). Ninety-two patients were operated on after 6 months to 1 year; 18 patients after 1 year to 3 years; and 9 patients after 3 to 45 years. The patients were classified according to the uppermost level of stricture, including hypopharynx and esophageal ostium. Hypopharyngeal strictures were confirmed in 3 patients (2.6%), oesophageal ostium strictures in 20 patients (16.8%), and cervical and thoracic esophageal strictures in 96 patients (80.7%). Six patients had the history of gastric perforation, and 2 had gastric outlet obstruction from stricture.

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Preoperatively, all patients underwent a preoperative esophagogastroscope to identify the level and severity of the stricture. Severe stricture of larynx and pharynx always presented with obliteration of the piriform sinus and adhesion of the epiglottis, so an additional fibrolaryngoscopy was performed. Colonoscopy was also performed to rule out inflammatory bowel disease, colon cancer, and other diseases. Selective angiography of the lower mesenteric artery ($n=2$, 1.7%) was not performed routinely. Bowel preparation and parenteral nutritional support were carried out for 3 days in accordance with the routine practices in our department. Poor nutritional status may require preoperative supplementation such as gastrostomy tube feeding or total peripheral nutrition, to improve the nutritional status of patients.

1.2 Surgical Procedures

The patient was placed in a supine position with the head rotated to the right. The neck, chest, and abdomen were prepared. Colon was exposed through a laparotomy via a midline approach, and dissected from the sigmoid to the ileocecum, sometimes to the jejunum. A left cervicotomy was chosen according to the site of the strictures (the cervical collar curved incision chosen sometimes).

1.3 Selection of Esophageal Substitute

The choice of the colonic portion used for oesophageal reconstruction depended on the required length of the graft, and the encountered colonic vascular anatomy. The left colic artery, middle colic artery, and right colic artery were identified, sometimes the ileal branch of ileo-colic artery and appendicular artery were included. The colonic arteries were identified in the mesentery by transillumination and palpation. Favorable blood flow in the marginal artery of the selected intestinal canal was also verified by palpation. The dissection of the mesenteric vein should be performed with great caution since these vessels were extremely fragile and even minor injury would result in a mesenteric hematoma. Atraumatic vascular clamps were used to temporarily occlude the vessels and to identify any ischemic change of the transverse and ascending colon before ligation. Before resecting the colic vessels, the length of the colonic segment was measured using a string; the length of the corresponding vascular arcades was also measured beginning from the origin of the ascending branch of the left colic artery or middle colic artery. We feel this offers a more accurate measure of the length of the colonic conduit required to reach the neck, reducing the incidence of redundancy in the colonic graft.

1.4 Selection of Routes for Reconstruction

Originally, we preferred colon interposition via the retrosternal route because of good cosmesis with relatively low risk, taking good care of releasing the compression of the graft and tension of the anastomosis

site. The colon was guided by a string into the neck through the retrosternal route.

1.5 Proximal Cervical Anastomosis

After careful evaluation of the level of the caustic stricture, the anastomosis was performed above the level of the abnormal mucosa. An end-to-end manner with a single-layer and broad-border hand-sewn with delayed absorbable sutures was used for esophago-colo, pharyngo-colo, larynx-colo or esophago-ileum anastomoses. The distal end of esophagus in the neck was closed with continuous suture.

During larynx-colo anastomoses, the larynx and upper end of the trachea were dissected, the tracheotomy was done and the intubation was changed to make for anaesthesia. Thyroid cartilage, annularity cartilage and trachea cartilage were eliminated and corresponding mucosa was preserved, with superior laryngeal artery protected. The upper end of the colon was anastomosed to the larynx using an end-to-end pattern with a single-layer anastomosis. The upper side (the supraglottic area) was opened to the oropharynx. A nasogastric tube was inserted via a nostril to pass the esophageal substitute before the completion of cervical anastomosis.

1.6 Abdomen Anastomosis

The colonic grafts with supplying arteries were lifted through the retrogastric space. An end-to-side cologastric anastomosis was carried out technically on the anterior surface of the stomach near the greater curve, or to the jejunum when the stomach suffered from a gastric perforation or gastric outlet obstruction. Finally, the residual of the descending colon and the anal end of the ascending colon or ileum were anastomosed manually by sewing or autosuture device. Special attention should be paid to the closure of the mesocolic defect to avoid a further internal hernia. A feeding jejunostomy was constructed for early postoperative nutritional management.

2 RESULTS

All colon was positioned in the isoperistaltic direction through the retrosternal route, supplied from the ascending branch of the left colic artery (105 cases) through marginal vessels, and the rest 14 cases from middle colic artery. Seventy-nine patients were given esophageal reconstructions with the whole transverse colon plus part of the ascending and ascending colon, 36 cases with the whole ascending and transverse colon, and 4 cases with part of transverse colon, the whole ascending transverse colon and terminal ileum (fig. 1). Of these 119 patients, the cervical anastomosis was performed at the hypopharynx (20, 16.8%), the larynx (3, 2.5%), and the cervical esophagus (96, 80.7%).

There were no operative or in-hospital mortalities, and 95.7% ($n=114$) of patients were discharged



Fig. 1 A long segment of the colon with terminal ileum

directly to home with a normal oral diet. The integrity of the anastomosis of the colon-gastrostomy was confirmed by water soluble contrast radiography on postoperative day 7–10. Then the nasogastric tube was removed and the patients started a liquid diet on the next day without leakage occurring. The patients were often accompanied with deglutition disorders for they didn't have food for quite a while. Physical exercise therapy for deglutition disorders was performed before a normal diet.

Five patients experienced cervical anastomotic leakage (4 for esophagus-colon, and 1 for hypopharynx-colon). Four cases completely recovered after dressing changes and nutritional support, and one case took more than 180 days to heal before oral food intake could be started. One patient experienced wound infection of the abdominal wall, which was improved after dressing changes. Three patients had injury of unilateral recurrent laryngeal nerve and hoarseness because of scar adhesions; three patients with stress ulcer with bleeding were cured by administration of proton-pump inhibitors and octreotide; and 2 patients suffered from incomplete intestinal obstruction. The postoperative follow-up was made for 12 months in the whole patients and all of them were alive.

The physical condition of the patient after surgery was checked every month for the first six months, and every two months until one year. The patients' body weight data before and after surgery were retrospectively obtained from their charts. The peri-operative data for colon interposition ($n=119$) were shown in table 1.

3 DISCUSSION

Colon replacement for alimentary tract reconstruction may be the best option to ensure oral feeding and a good quality life, for the following advantages:

Table 1 Peri-operative data for colon interposition ($n=119$)

Parameters	Outcome
Operation time (min; range)	390 (290–610)
Intra-operative blood loss (mL; range)	615 (270–2500)
Median duration until oral intake (days; range)	15 (9–21)
Intensive-care-unit stay (days; range)	2.3 (1–3)
Median postoperative stay (days; range)	17.9 (14–34)

the colon has stable vascular structures, and the colon interposition graft is long enough to be pulled up to the lower pharynx or even higher locations, ensuring the cervical anastomosis without tension by using a graft with sufficient length and blood supply. The normal location and functions of the stomach can be maintained; and the infants and young children can achieve good long-term quality of life after the surgery^[5–8]. However, esophageal replacement procedures are often associated with significant morbidity and death, because of poor body nutrition, complicated operative procedures and contamination of three or four anastomotic sites. From our experience in esophageal reconstruction, we believe that the colon with adequate vascular supply and sufficient length for cervical anastomosis without tension should be ensured; great attention should be given to the peri-operative management, including the control of pulmonary infection and systemic nutrition support via feeding tube to build up their general condition before surgical intervention^[9–11].

3.1 Blood-Supplying Vessel for the Colon Interposition Graft

In our study we reported an in-hospital mortality of 0% (0/119), a graft necrosis rate of 0%, an anastomotic leakage rate of 4.2% (5/119), and an anastomotic stricture rate of 0% (0/119). The preparation of a long segment of the colon with a good blood supply is a guarantee of success in colon interposition for esophageal replacement^[11, 12]. We favor using a left colon graft fed by the left colic artery, even though the right colon is favored by many surgeons. The left colic artery is a branch of the inferior mesenteric artery. With constant distribution, this artery travels to the left side of the abdomen for about 4–8 cm and divides into an ascending and a descending branch. The ascending branch is thick and large, similar in diameter to the middle colic artery. Maguire *et al*^[13] used the inferior mesenteric artery as a blood-supplying vessel for intestines, indicating that the inferior mesenteric artery or left colic artery is superior to other vessels in blood supply.

Special attention should also be paid to the thickness and pathways of the veins parallel with the arteries of the same names. Obstruction of venous reflux will ultimately cause the edema, stasis, and necrosis of the colon interposition graft. Knezević *et al*^[14] found that the majority of colon interposition graft necrosis was caused by the obstruction of venous reflux, which was difficult to be found during the

surgery. Any compression or distortion of a vascular pedicle in bowel should be avoided; particularly, when one trunk vein was thin and the other trunk vein was dilated, an abnormal pathway of venous reflux may exist^[8]. Once the colon interposition graft becomes deep dark or edematous, it must be removed in a timely manner, with permanent cervical esophagostomy.

3.2 Location and Method of Colonic Anastomosis

The cervical esophagus must be carefully anatomized, along with preoperative endoscopy and laryngoscopy. If there is no obvious stricture at the beginning of the esophagus, the cervical esophagus-colon anastomosis can be performed. If the scar involves the pharyngoesophagus, a total esophagectomy from the beginning of the esophagus must be conducted. Piriform recess-colon anastomosis is then performed, during which the cricoid periosteum should be preserved and the recurrent laryngeal nerve be properly protected^[9]. If the scar stenosis of cervical esophagus is cord-like, or accompanied with larynx/epiglottis injury, pharyngeal stenosis/atresia, larynx-colon anastomosis should be performed. During the surgery, the thyroid cartilage, cricoid cartilage, and tracheal cartilage are removed while the larynx, trachea mucosa, and perichondrium are preserved. Bilateral superior laryngeal artery as well as the superior laryngeal nerve and recurrent laryngeal nerve should be carefully protected. Colon-tracheobronchial remnant anastomosis is performed, and permanent tracheostomy is performed at the lower end of the trachea. For abdominal lesions, mechanical anastomosis between the anterior wall of stomach and the colon is usually required. However, in patients with gastric post-burn scar contracture or in patients whose stomach has been removed, colon-jejunum mechanical anastomosis is performed.

The method and skills of anastomosis must be carefully selected. Esophagus-colon anastomosis is routinely performed using a single-layer and broad-border suture, with a good blood supply and without twisted esophageal muscle fibers or contaminated spaces. Around the suture, the inflammatory cell infiltration is low. The anastomosis is soft and highly dilative, causing no ischemia and necrosis of the colon interposition graft. Generally, the caliber of the colon interposition graft is larger than that of esophagus; therefore, during the end-to-end anastomosis, the stitches must be well matched and the mucosa tightly aligned without tension. Suturing should not be performed in a dense and deep manner, and poorly aligned mucosa should also be avoided. During the hypopharynx-colon anastomosis, the cricoid periosteum must not be injured when dividing the beginning of the esophagus; in addition, a single layer suturing is used between the anterior colonic wall and cricoid periosteum, between collaterals and piriform recess, and between the posterior colonic wall and posterior pharyngeal wall.

In conclusion, the colon is well-suited for esophageal reconstruction. The colon graft should be flexibly selected and has good blood supply and appropriate length. The left colon is preferably used.

Conflict of Interest Statement

The authors declared that we have no conflicts of interest to this work. We declare that we do not have any commercial or associative interest that represents a conflict of interest in connection with the work submitted.

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