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Esophageal reconstruction in very long atresias by elongation of the lesser curvature

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Abstract. The treatment of long esophageal atresias is associated with numerous risks and complications. Bouginage and circular (Livaditis) or spiral myotomy permits the proximal blind pouch to be lengthened by a maximum of 2–3 cm. For longer atresias interposition of a loop of colon or stomach or intrathoracic displacement of the stomach becomes necessary. These measures make actual reconstruction of the esophagus impossible; new means for total preservation of the available esophagus and cardia must be sought. Experimental studies on cadavers have shown that mobilization of the distal esophagus is possible only to a limited extent due to the fixation of the lesser curvature and left gastric artery and that tension on the esophagus affects primarily this curvature. Ligation of the left gastric artery and transverse/diagonal division of the lesser curvature permits mobilization of 6–8 cm of distal esophagus with preservation of the cardia, ensuring that primary anastomosis of the esophageal ends is always possible. We have performed mobilization and transverse division of the lesser curvature using a stapler in five children with an esophageal gap of 4–8 cm. The esophageal anastomoses were tension-free and either intrathoracic or cervical. In one case of atresia without a tracheoesophageal fistula the esophagus was drawn retrosternally to the neck, making a thoracotomy unnecessary. In all patients a semifundoplication was performed as an anti-reflux measure and a pyloroplasty was done to improve gastric emptying. Complications were few after these procedures: one leaking anastomosis in the neck closed spontaneously, two stenoses required bouginage of the anastomosis. In most cases of esophageal atresia, even those with very long gaps, primary anastomosis of the esophagus is possible by elongating the lesser curvature. Substitution plasty can always be avoided. Our results in five children with this procedure have been encouraging.

Key words: Esophageal atresia – Surgical Technique – Replacement of esophagus – Esophageal elongation

Introduction

The treatment of long-gap esophageal atresia continues to be a difficult task for the pediatric surgeon. Livaditis [2] and similar myotomies permit a gain of 1 to maximally 3 cm in length to be obtained. Similar results are achieved by long-term bouginage or Rehbein's "olive" method [7]; complications are common, however, and failures usually require subsequent replacement procedures using stomach, colon, or jejunum. For distances of over 5 cm, esophageal replacement is almost always necessary. The child becomes viable, but no genuine peristaltic swallowing function ever develops. Complications due to reflux and the risk of later malignant degeneration are important additional disadvantages, as is the fact that all replacement procedures require sacrifice of the distal esophagus and cardia. We have therefore sought options that enable the entire proximal and distal portions of esophagus as well as the cardia to be preserved while still permitting a low-risk anastomosis to be carried out.

Materials and methods

To reach an alternative solution, four questions must be considered:
1. Why can the distal esophagus not be mobilized?
2. Where are the impeding points of tension?
3. Can these be eliminated surgically?
4. If mobilization is possible, can the amount of length necessary be calculated?

The following answers have been found:
1. The distal esophagus and cardia are held in place by numerous ligamentous structures as well as arteries and veins from the lesser curvature.
2. It has been clearly seen in many autopsy specimens from children and adults that the ability of the distal esophagus to be mobilized is limited chiefly by the muscular tension of the lesser curvature and the left gastric artery. Angioradiologic studies and injected specimens have shown that the main blood supply to the cardia and distal esophagus is provided by branches of the left gastric artery; collaterals arise from the posterior and short gastric arteries, branches of the splenic artery (Fig. 1 a–e).
3. After ligation and division of the main trunk of the left gastric artery and its second gastric branch, adequate circulation to the cardia and esophagus is still provided by the collateral vessels. This step alone permits a gain of 2–3 cm in length, and after a diagonal incision in the lesser curvature the cardia and esophagus can be mobilized by an additional 4–6 cm.

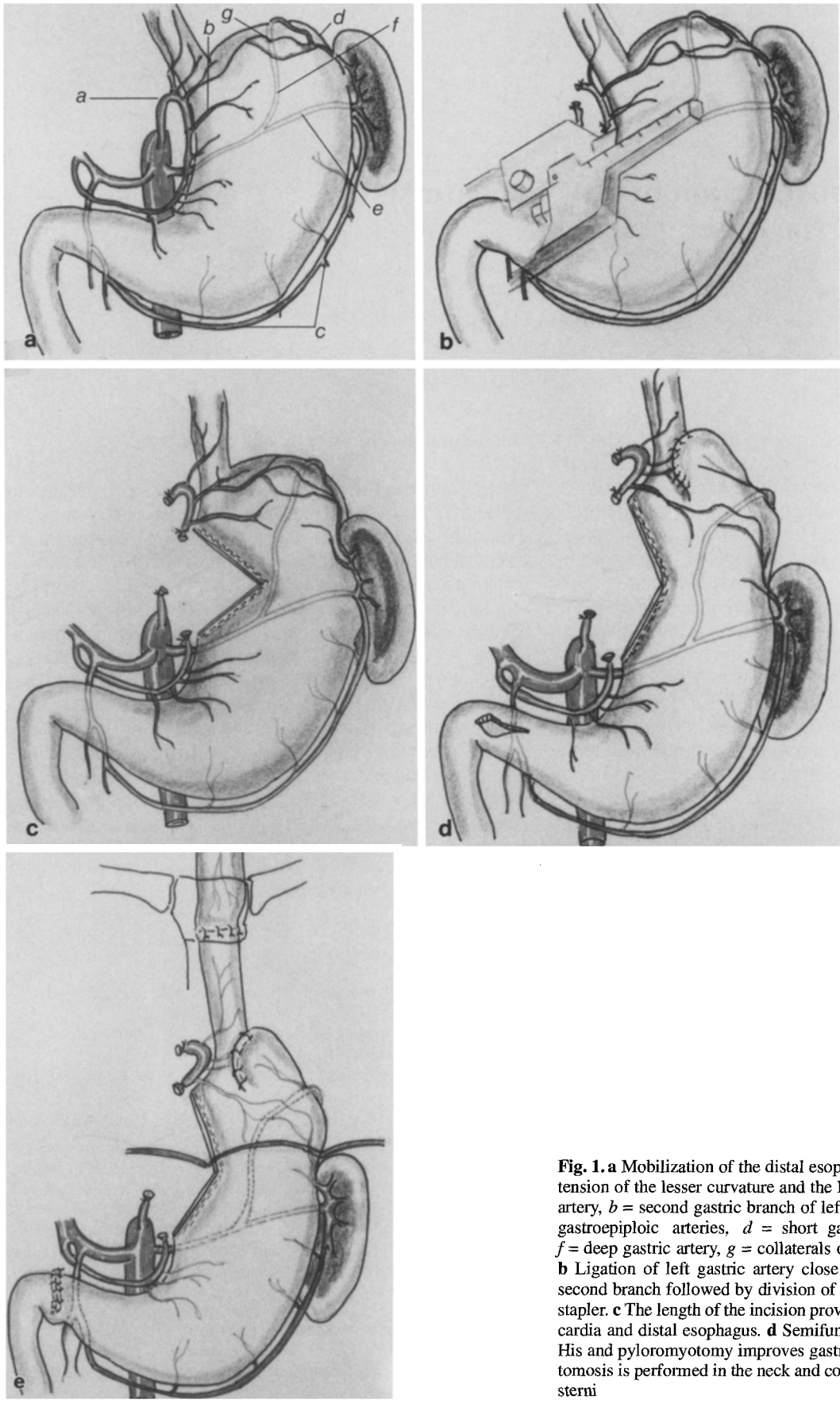


Fig. 1. a Mobilization of the distal esophagus is limited by the muscular tension of the lesser curvature and the left gastric artery (*a* = left gastric artery, *b* = second gastric branch of left gastric artery, *c* = right and left gastroepiploic arteries, *d* = short gastric artery, *e* = splenic artery, *f* = deep gastric artery, *g* = collaterals of deep and short gastric artery). **b** Ligation of left gastric artery close to the main trunk and after its second branch followed by division of the lesser curvature using a GIA stapler. **c** The length of the incision provides a twofold lengthening of the cardia and distal esophagus. **d** Semifundoplication restores the angle of His and pyloromyotomy improves gastric emptying. **e** Esophageal anastomosis is performed in the neck and comes to lie behind the manubrium sterni

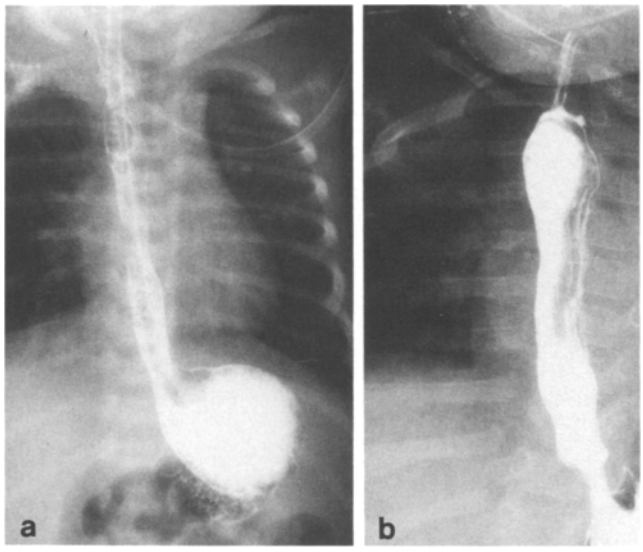


Fig. 2. Premature baby with tracheoesophageal fistula. A gap of 2.5 cm made primary anastomosis impossible. **a** Anastomosis was achieved in the neck after transdiaphragmatic ligation of the left gastric artery; **b** barium swallow 2 weeks postoperatively. Abdominal semifundoplication for gastroesophageal reflux was done at the age of 6 weeks

4. The length of esophagus required corresponds exactly to one-half the length of the incision in the lesser curvature; conversely, an incision of 3 cm in the lesser curvature provides a gain of 6 cm in length.

Can this experimental model be realized in practice? Two ways are possible. For distances of up to 3 cm, ligation of the left gastric artery alone is sufficient. This can be accomplished transthoracically, after a small diaphragmatic incision, or abdominally (Fig. 2 a and b). For longer distances, when no tracheoesophageal fistula is present the procedure is performed abdominally.

After mobilizing the left lobe of the liver, the cardia is exposed and the distal esophagus is dissected free in the hiatus and mediastinum. The left gastric artery is ligated close to the main trunk, followed by its second gastric branch. The fundus and posterior gastric wall are then mobilized, with careful preservation of the posterior and short gastric arteries. Traction on the esophagus will now reveal the main site of tension on the lesser curvature. A gastric incision of the calculated length is made using a GIA stapler. After a semifundoplication to restore the angle of His and a pyloroplasty, a retrosternal tunnel is fashioned into which the distal esophagus, cardia, and a portion of the fundus are placed. The intra-abdominal portion of the stomach comes to lie prehepatically. The esophageal anastomosis can be made without difficulty at the neck, so that no thoracotomy is necessary (Fig. 3).

Results

We have performed partial gastric transfer with preservation of the cardia and distal esophagus in five children with long gaps. In two cases ligation of the left gastric artery as described was sufficient, and in three an additional incision of the lesser curvature was necessary. All the children have had excellent development and are able to eat and drink normally.

Two children developed fistulas in the neck; both closed spontaneously. In four cases the anastomosis required 1 to 8 bouginages. Gastric emptying occurred promptly due to the pyloroplasties. Two children still have mild gastroesophageal reflux. The gastrostomies could be closed permanently 14 days postoperatively. In all cases functional follow-up examinations 1–7 years postoperatively showed normal peristalsis of the proximal and distal esophagus but not in the anastomotic area.

Discussion

The first successful operation of an esophageal atresia some 50 years ago signified hope for survival that presently can be fulfilled in 80% of all cases. A smooth postoperative course is not always the rule, but most complications can be treated conservatively. In 5% of cases an operation is not feasible due to extreme prematurity or severe chromosomal and organ malformations; 15% do not survive an initial operation because of cardiac or pulmonary anomalies, septicemia, or cerebral hemorrhage.

Of special interest are those cases where primary anastomosis is not achievable (long gap, prematurity, staging) or if severe complications (leak, disruption) following the first operation necessitate a cervical esophagostomy

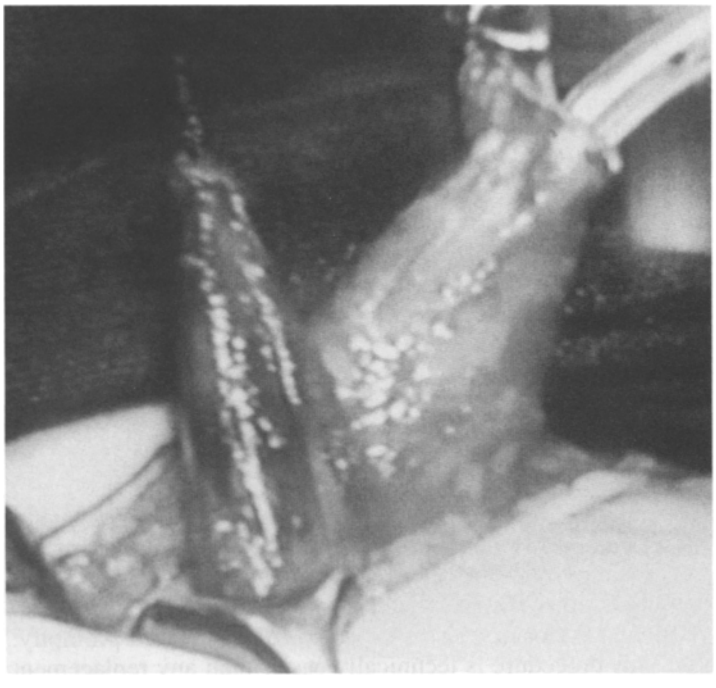
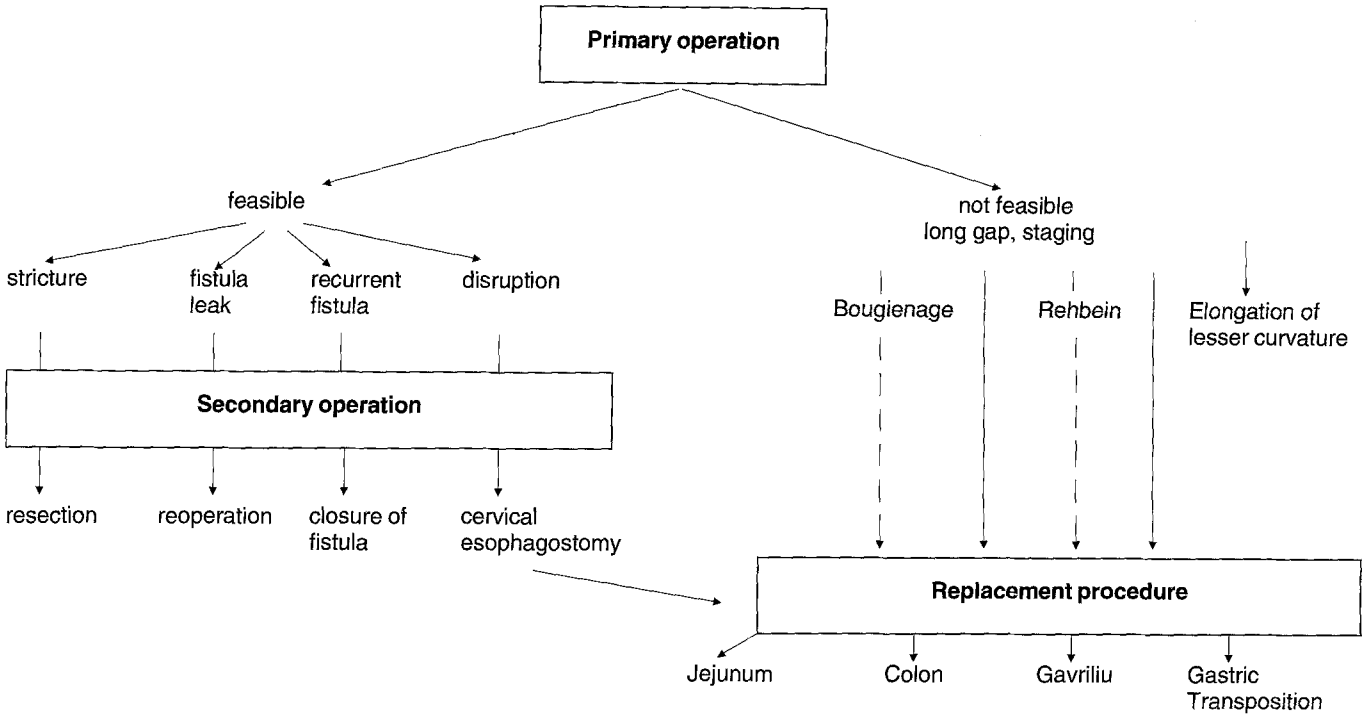


Fig. 3. After elongation of the lesser curvature and retrosternal pull-through, esophageal end-to-end anastomosis can be performed without tension in the neck



Scheme 1. Contraindications and complications of primary anastomosis

Table 1. Frequency of postoperative disruption of a primary anastomosis

	Cases	Disruption
Campbell et al. (1982)	70	6 = 8.5%
Louhimo and Lindahl (1983)	500	11 = 2.2%
Sigge and Franz (1984)	132	11 = 8.3%
Spitz et al. (1987)	148	4 = 2.7%
Schärli (1991)	47	3 = 6.4%
Total	897	35 = 3.9%

(Scheme 1). A major leak or a disruption may be corrected with a new anastomosis. In most cases it is advisable to perform a cutaneous esophagostomy rather than to attempt a risky reanastomosis [1, 3, 10, 12] (Table 1). Various procedures have been recommended to correct these cases.

1. Procedures preserving the esophagus

Rehbein's olive technique [7] has given favorable results in the author's hands in 18 of 22 patients. This procedure has not found wide acceptance. Severe strictures, mediastinitis, and recurrent fistulae are common complications.

Bouginage of the proximal and distal segments has been used frequently since the first publication of Howard and Myers [4]. However, longitudinal growth of the esophageal segments without bouginage occurs within 6–10 weeks [6]. Complications include repeated aspirations and strictures of the final anastomosis.

Proximal myotomies offer limited lengthening of the esophagus. Diverticulum formation and peristaltic disturbances may necessitate reanastomosis [5].

2. Replacement procedures

Colon interposition. Intrathoracic positioning is more frequently followed by dilatation, angulation, and kinking than if the retrosternal route is used. Complications include cervical leakage (31%), stricture formation (16%), and ileus (6%). The mortality among 233 cases collected in the literature [9] was 5%, and 3.5% of the colons became gangrenous. It is advisable to resect the distal esophagus since esophagitis and ulcerations are common complications [8]. Secondary procedures are necessary due to obstructive ileus, elongation of the colon, and hemorrhage from peptic ulcerations.

Gavriliu technique. Complications following this procedure are even more frequent, as can be calculated from a collective review of 88 cases [9]. Mortality is 7% and cervical leaks occur more frequently (50%). Strictures are seen in one-third of the patients, necrosis and perforations in 8%.

Total gastric transposition. In a large series of 34 cases, Spitz [11] has reported a mortality of 8.8% and complications in 20 patients.

3. Transposition of the cardia

Transposition of the cardia by elongation of the lesser curvature has hitherto been followed by only minor complications. Stenoses of the anastomotic area are amenable to bouginage. The occurrence of fistulae is of minor importance, since the anastomosis is made in the neck and spontaneous closure can be expected if it is drained promptly. This procedure is technically easier than any replacement

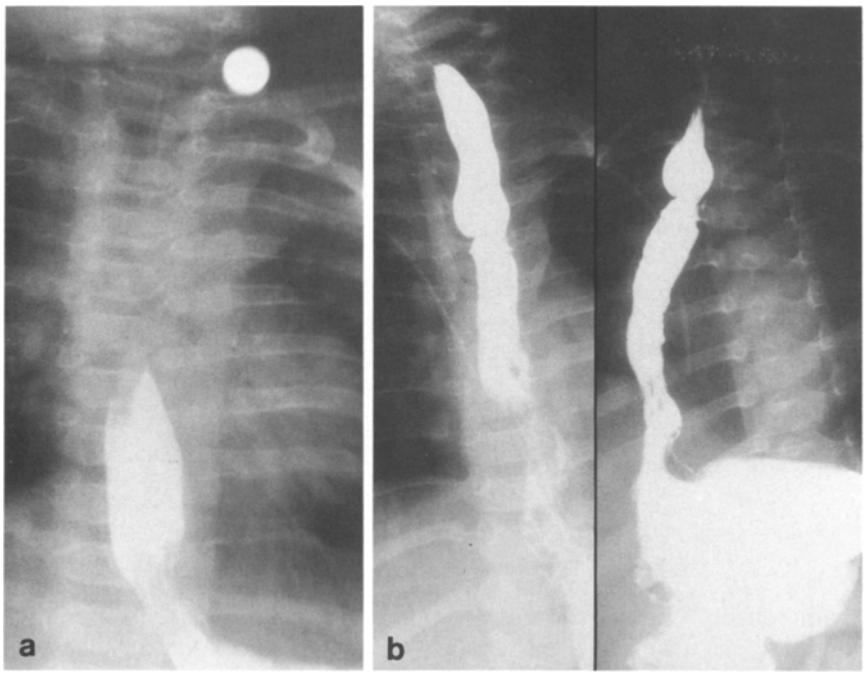


Fig. 4. a Esophageal atresia without fistula. The gap was 6 cm. **b** Barium swallow 2 months after elongation of the distal esophagus by diagonal incision of the lesser curvature and retrosternal pull-through

operation. Observation of a sufficient blood supply to the lower esophagus and cardia is essential for successful elongation of the esophagus. Ligation of the left gastric artery close to the main trunk and after its gastric branch have preserved sufficient circulation. Care is taken that the deep and short gastric and splenic vessels remain intact.

Pulmonary and infectious complications are rare, since thoracotomy is avoidable in cases of esophageal atresia without fistula. Left or right cervical esophagostomy has not been of any disadvantage. In three patients spontaneous elongation of the upper pouch has occurred, which facilitated end-to-end anastomosis in the neck. The ability to swallow and esophageal peristalsis have been normal except in the anastomotic area. Gastroesophageal reflux would occur in all patients despite preservation of the cardia, and we therefore recommend performing a short semifundoplication to restore the angle of His. Interruption of at least one vagus nerve could cause delayed gastric emptying. For this reason, it seemed advisable to perform a pyloromyotomy or pyloroplasty.

Experience with this new technique is limited. We do, however, feel encouraged to assume that most replacement procedures using colon, stomach, or jejunum will be avoidable in the future. The favorable postoperative course of our patients justifies this presumption (Fig. 4a and b).

The following conclusions can be drawn from our experience with this technique:

1. Lengthening of the lesser curvature and ligation of the left gastric artery permit mobilization of the lower esophagus and cardia by 6–8 cm.
2. This procedure has the advantages that all portions of the esophagus and the cardia remain intact and direct anastomosis is possible.
3. The retrosternal pull-through makes a thoracotomy unnecessary, since the anastomosis can easily be made in the neck.
4. Pyloroplasty and reconstruction of the angle of His are necessary supplementary procedures to prevent reflux.
5. The results to date in five patients have been altogether favorable.
6. This technique is functionally superior to all replacement procedures using stomach, colon, or jejunum. It is to be expected that most replacement operations will be avoidable in the future.

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