Slide Esophagoplasty vs End-to-End Anastomosis for Recalcitrant Esophageal Stricture after Esophageal Atresia Repair

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BACKGROUND: Anastomotic stricture is a common complication after esophageal atresia (EA) repair. Patients with a recalcitrant stricture may require surgical intervention. The technique of reanastomosis after stricture resection can affect patient outcomes.

STUDY DESIGN: Patients with EA who underwent anastomotic stricture resection, from July 2010 to February 2017, were reviewed. After stricture resection, patients who had slide esophagoplasty performed were compared with those having conventional end-to-end anastomosis.

RESULTS: Fifty patients underwent stricture repair surgery by slide esophagoplasty (n = 12) or end-to-end (n = 38) anastomosis technique at a median age of 14 months (interquartile range [IQR] 6 to 23 months). Significantly fewer patients required dilation therapy after slide esophagoplasty: 6 of 12 (50%) compared with 32 of 38 (84%) in the end-to-end group (p = 0.02). The number of dilation sessions was significantly lower in the slide group vs the end-to-end (p = 0.004) group, with a risk ratio confirming the approximately half the number of dilations for the slide approach (risk ratio 0.57, 95% CI 0.38 to 0.86). Steroid injection was combined with dilation in 3 of 12 (25%) vs 22 of 38 (58%) in the slide and end-to-end groups, respectively (p = 0.10). Stent placement was used in none of slide cases vs 8 of 38 (21%) in the end-to-end group (p = 0.17). Stricture incision was performed in 1 of 12 (8%) in the slide group and 11 of 38 (29%) in the end-to-end group (p = 0.25). There were leak complications in fewer patients after slide esophagoplasty compared with end-to-end anastomosis: 1 of 12 (8%) vs 8 of 38 (21%) (p = 0.43).

CONCLUSIONS: Slide esophagoplasty may be a useful technique of anastomotic configuration for selected patients with recalcitrant esophageal stricture, offering more favorable outcomes compared with end-to-end anastomosis. (J Am Coll Surg 2018;226:1045−1050. © 2017 by the American College of Surgeons. Published by Elsevier Inc. All rights reserved.)

Anastomotic stricture is a common cause of morbidity after esophageal atresia (EA) repair, and it may be apparent at any time, from the early postoperative period to months or years later. This complication is defined as an intrinsic luminal narrowing at the level of the esophageal anastomosis that may lead to the patient becoming clinically symptomatic. In the majority of patients, anastomotic stricture can be effectively managed by endoscopic dilation therapy along with adjunctive treatments reserved for more refractory cases such as local steroid injection, electrocautery incision, or stent placement. Nonetheless, a surgical solution may be required for the stricture that is recalcitrant to all other nonsurgical managements.

Stricture resection and esophageal reanastomosis is the most common surgical intervention used for recalcitrant strictures. However, the risk of stricture formation remains after the second anastomosis, and

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Abbreviations and Acronyms

EA = esophageal atresia
EAT Center = Esophageal and Airway Treatment Center
IQR = interquartile range

patients may still need endoscopic treatments or even operative revision postoperatively. The technique of anastomosis configuration is one of the intraoperative factors that may affect the outcomes of esophageal reconstruction. The number of studies comparing different techniques is remarkably small, and there is a lack of consensus regarding the ideal anastomotic configuration. This study was performed to compare the patient outcomes of slide esophagoplasty and conventional end-to-end anastomosis after resection of a recalcitrant stricture.

METHODS

We retrospectively reviewed the medical records of all esophageal atresia patients who underwent anastomotic stricture resection at Boston Children's Hospital, from July 2010 to February 2017, under an approved institutional review board protocol (IRB-P00025957). The Esophageal and Airway (EAT) Center at Boston Children's Hospital is a multidisciplinary care team consisting of 3 pediatric surgeons, 1 pediatric cardiothoracic surgeon, 2 pediatric gastroenterologists, and 1 pediatric pulmonologist.

Data collection

The data collected included patient characteristics, age at resection surgery, interval between EA and stricture repairs, technique of anastomosis (slide esophagoplasty vs end-to-end), anastomotic complications, and postoperative endoscopic therapies including balloon dilation, steroid injection, electrocautery incision, and stent placement.

Techniques of anastomosis

The technique of slide esophagoplasty was chosen when the surgeons believed that the anastomosis would be too narrow and subject to severe stricture formation if end-to-end anastomosis were performed, and they thought there was enough esophageal compliance to tolerate the slide anastomosis without excessive tension. Slide esophagoplasty was performed after stricture resection in which upper and lower esophageal segments were anastomosed after opposite side longitudinal incisions of about 1 to 1.5 cm in each segment (Fig. 1). However, in the conventional approach, the 2 esophageal segments were reconnected using an end-to-end anastomosis after excision of the stricture. Both techniques were performed using interrupted full-thickness sutures of 5-0 or 6-0 Prolene (Ethicon), placing an evenly distributed tension on the esophageal anastomosis.

Postoperative course

All patients underwent contrast esophagography within 2 weeks after the procedure to rule out the presence of an

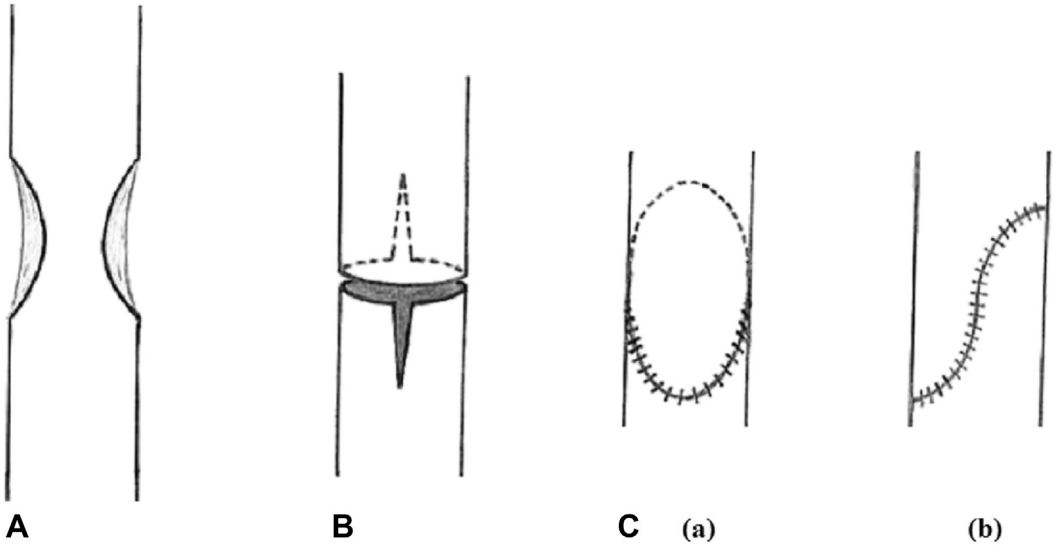

Figure 1. Esophageal stricture resection and slide esophagoplasty anastomosis technique. (A) Esophageal recalcitrant stricture. (B) Opposite side longitudinal incisions in upper and lower segments after stricture resection. (C[a]) Front and (C[b]) lateral views of slide anastomosis.

anastomotic leak, giving an early postoperative picture of the esophageal lumen. One week after an esophagram with no evidence of a leak, patients were scheduled for an esophagogastroduodenoscopy to assess for narrowing formed during healing and to proactively gently balloon dilate if needed.

Endoscopic therapies

The frequency and type of endoscopic procedures were decided with the EAT Center gastroenterologists based on the degree of narrowing and the usefulness of dilations in keeping the diameter of the esophagus consistent. The goal luminal diameter based on the age-related normal esophagus was 10 mm for infants 6 months of age or younger, 12 mm for infants older than 6 months and children to the age of 7 years, and 14 mm for children older than 7 years. Balloon dilation was implemented by using an incremental increase of 1 mm in the size of the dilator based on the "rule of 3" per single session after estimation of the narrowed luminal diameter. Adjunct therapy was considered in patients without any significant improvement in intraluminal diameter after 3 to 4 dilations. Intralesional steroid injections combined with dilation for at least 2 to 3 sessions were used before attempting another therapeutic approach. Triamcinolone acetate (10 mg/mL) at a dose of 1 to 2 mg/kg was injected in 4 quadrants directly into the scar tissue as well as submucosally above the stricture. Electrocautery incisional therapy with a needle knife was performed in selected patients to make radial incisions into the stricture with a shelf or dense ring of scar tissue in conjunction with dilation for preferential tearing along the incision site. Esophageal stents were temporarily placed as an alternative treatment for refractory stricture and post-anastomosis or post-dilation leak.

Statistical analysis

Univariable analysis was performed to determine significant differences between the 2 techniques of esophageal anastomosis using Fisher's exact test for categorical variables and the Mann-Whitney U-test for continuous variables, described by the median and interquartile range (IQR). Poisson regression is a convenient approach for estimating the relative risk ratio using count data.[1] Poisson regression was applied to compare the outcomes of anastomosis techniques according to the number of dilation sessions required afterward. Adequacy of the fitted model for comparing dilations between the 2 groups was evaluated by the deviation statistic.[2] Statistical analysis was conducted using IBM SPSS Statistics version 23.0 (IBM Corp). A 2-tailed p value < 0.05 was considered statistically significant.

RESULTS

From July 2010 to February 2017, a total of 50 patients (27 female, 23 male) underwent stricture repair surgery by slide (n = 12) or end-to-end (n = 38) technique at a median age of 14 months (IQR 6 to 23 months). Resection of recalcitrant stricture was performed at a median interval of 9 months (IQR 5 to 18 months) from EA repair. Patient characteristics are summarized in Table 1. Three cases of slide esophagoplasty were in patients who had undergone previous attempts at stricture resection with end-to-end anastomosis.

Median follow-up was 15 months (IQR 12 to 18 months) in the slide esophagoplasty group and 41 months (IQR 26 to 64 months) in the end-to-end anastomosis group. Details of endoscopic therapies implemented after esophageal anastomosis are listed in Table 2. Significantly fewer patients required dilation therapy after slide esophagoplasty: 6 of 12 patients (50%) compared with 32 of 38 (84%) after end-to-end anastomosis (p = 0.02). Poisson regression analysis indicated a significantly lower number of dilation sessions in the slide vs end-to-end group (likelihood ratio test = 8.17, p = 0.004), with a risk ratio confirming that the number of dilations is approximately half for the slide approach (risk ratio 0.57, 95% CI 0.38 to 0.86) (Fig. 2). The deviation goodness of fit test was used to assess how closely the Poisson model's predictions were to the observed number of dilations and indicated a good fit of the model, with no evidence of overdispersion.

Steroid injections were used as adjunctive therapy to balloon dilations in 3 of 12 (25%) vs 22 of 38 (58%) patients in the slide esophagoplasty and end-to-end

Table 1. Patient Characteristics

Characteristic	Slide esophagoplasty (n = 12)	End-to-end (n = 38)	p Value
Male, n (%)	5 (42)	18 (47)	0.99
EA with TEF, n (%)	10 (83)	27 (71)	0.48
EA with long gap (>4 cm), n (%)	3 (25)	16 (42)	0.33
EA and stricture repairs interval, mo, median (IQR)	8 (5−10)	11 (5−18)	0.35
Age at stricture resection, mo, median (IQR)	11 (5−21)	15 (7−24)	0.43

EA, esophageal atresia; IQR, interquartile range; TEF, tracheoesophageal fistula.

Table 2. Endoscopic Therapies

Therapy	Slide esophagoplasty (n = 12)	End-to-end (n = 38)	p Value
Balloon dilation, n (%)	6 (50)	32 (84)	0.02*
No. of dilation sessions, median (IQR)	3 (2–5)	5 (3–10)	0.004*
Intralesional steroid injection, n (%)	3 (25)	22 (58)	0.10
Electrocautery incisional therapy, n (%)	1 (8)	11 (29)	0.25
Stent placement, n (%)	0	8 (21)	0.17

*Statistically significant.

anastomosis groups, respectively (p = 0.10). Stricture incisional therapy using needle knife electrocautery was performed in 1 of 12 (8%) patients in the slide esophagoplasty group and 11 of 38 (29%) in the end-to-end anastomosis group (p = 0.25). Stents were temporarily placed in none of the slide esophagoplasty patients vs 8 of 38 (21%) patients with end-to-end anastomosis for a refractory stricture or an esophageal leak (p = 0.17).

Postoperative leak at the anastomosis occurred in 1 of 12 (8%) patients after slide esophagoplasty, and there was no leak after endoscopic dilation of the stricture. However, esophageal leak was found in 8 of 38 (21%) of the end-to-end anastomosis patients, 4 of whom were post-anastomosis, and the remaining 4 were post-dilation (8% vs 21%, p = 0.43). Six patients with an end-to-end anastomosis eventually required esophageal replacement with jejunal interposition after failure to achieve sustained luminal patency caused by complicated anastomotic stricture (n = 4) or leak (n = 2). Complications after each anastomotic technique are listed in Table 3.

DISCUSSION

Anastomotic stricture remains one of the main complications occurring after EA repair, with a variable incidence of 23% to 70% reported in the literature based

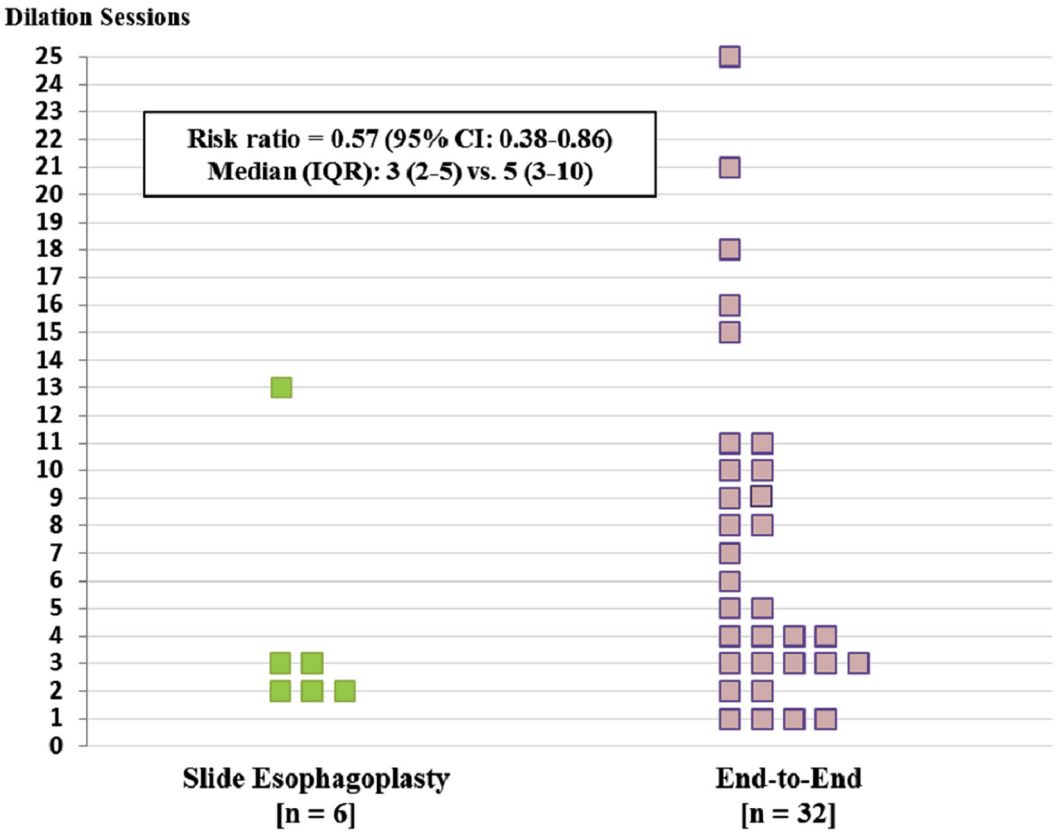

Figure 2. Distribution of the number of esophageal dilation sessions for each anastomosis techniques. Poisson regression modeling indicates that the number of dilation sessions with slide anastomosis is approximately half that of end-to-end anastomosis (p = 0.004). IQR, interquartile range.

Table 3. Complications

Complication	Slide esophagoplasty (n = 12)	End-to-end (n = 38)	p Value
Leak, n (%)	1 (8)	8 (21)	0.43
Post-anastomosis, n	1	4	
Post-dilation, n	0	4	
Esophageal replacement, n (%)	0	6 (16)	0.31
Stricture, n	0	4	
Leak, n	0	2	

on the criteria used to describe a stricture and its response to treatments.[3-12] Endoscopic dilation is the mainstay of esophageal stricture treatment. However, there is no consensus on the frequency and interval between dilation sessions, and this is often individualized based on the severity of the stricture and the patient's response to treatments. Finally, the persistence of a clinically relevant stricture despite all nonsurgical treatments leads to consideration of surgical intervention. Patients undergoing stricture resection and esophageal reconstruction may postoperatively encounter anastomotic complications including leak and stricture formation, requiring endoscopic interventions or even operative revision. The studies reporting surgical repair of anastomotic strictures are limited and without conclusive recommendations.[6,13,14]

After creation of an esophageal anastomosis, the wound-healing process can result in varying degrees of intrinsic luminal narrowing at the anastomotic region, which may progress to a clinically relevant stricture. The timing of the first screening or assessment of suspected anastomotic stricture is not universally agreed upon. Our preferred strategy is an early proactive endoscopic evaluation 3 weeks after anastomosis and routine dilations if indicated, even in the absence of symptoms. Patients with a reduced luminal diameter compared with a normal age-related esophagus are scheduled for balloon dilation every 1 or 2 weeks until the lumen maintains its patency. Once the diameter of the esophagus remains consistent, dilations can then be spaced further out or stopped. All patients are followed at least every 1 to 2 years.

Among the intraoperative factors implicated in the pathogenesis of stricture formation, the technique of anastomosis plays an important role. End-to-end anastomosis is the conventional method of connection between the 2 esophageal ends. However, this type of anastomosis may be associated with a relatively high probability of stricture formation during the healing process. Contraction promoted during the remodeling phase of wound healing causes a varying degree of luminal narrowing in the setting of a circular end-to-end anastomosis,[15] and subsequent fibrotic change can result in stricture formation at the level of the esophageal anastomosis. A few studies in human and animal models have described modifications for oblique anastomosis to obtain a better outcome than with transverse end-to-end anastomosis.[16-18] Nonetheless, the choice of anastomotic method remains a matter of debate concerning success rate, postoperative complications, and quality of life.

In this study, we introduced slide esophagoplasty as a new technique of esophageal anastomosis with the aim of establishing a wide anastomosis with an elongated configuration of the suture line. The anastomosis of 2 esophageal ends after opposite side longitudinal incision in each segment provides a circumferentially distributed suture line. Dispersion of anastomotic tension to more than 1 plane can be effective in decreasing the severity of possible narrowing formed as a consequence of the normal healing process. Moreover, the anastomotic cross-sectional area fashioned from sliding 2 esophageal ends together is wide enough to remain open without significant stricture formation, despite wound contraction. Slide esophagoplasty demonstrates a functional technique to exchange length for width at the anastomosis, which is best used in cases in which an additional 1 cm or more length of overlap can easily be obtained. A significant decrease in the number of patients requiring endoscopic interventions, along with fewer dilation sessions, demonstrates the feasibility of slide esophagoplasty compared with end-to-end anastomosis.

This study was limited by its retrospective nature and relatively small cohort size, which included a heterogeneous group of complex patients requiring adjunct therapies. Extending the number of patients undergoing slide esophagoplasty with longer follow-up would be valuable for providing stronger and more generalized evidence. Future studies can include long-term outcomes concerning upper segment motility in slide esophagoplasty patients with a dilated proximal esophagus.

CONCLUSIONS

Because of the diversity and complexity of the EA population, an effective treatment of anastomotic stricture is often challenging. Slide esophagoplasty may be a useful

technique of anastomotic configuration in selected patients with recalcitrant esophageal stricture, offering more favorable outcomes compared with those after end-to-end anastomosis.

Author Contributions

Study conception and design: Kamran, Smithers, Manfredi, Hamilton, Jennings
Acquisition of data: Kamran
Analysis and interpretation of data: Kamran, Smithers, Manfredi, Hamilton, Ngo, Zurakowski, Jennings
Drafting of manuscript: Kamran
Critical revision: Kamran, Smithers, Manfredi, Hamilton, Ngo, Zurakowski, Jennings

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Invited Commentary

Richard G Weiss, MD
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Dr Jennings and colleagues describe a new technique for repair of stricture that has failed nonoperative management after esophageal atresia repair. Their report is important both because it is one of the largest series of patients in the literature that addresses this specific complication (n = 50), and it comes from a multidisciplinary group that has developed strong interest and expertise in pediatric esophageal problems. The results are preliminary and deserving of more study. The new technique of slide esophagoplasty, perhaps somewhat analogous to slide tracheoplasty, is retrospectively compared with end-to-end anastomosis after resection of recalcitrant esophageal strictures. Two statistically significant results are reported: patients undergoing slide esophagoplasty are less likely to need any postoperative dilatations for recurrent stricture, and those who do need fewer dilatations.

The precise technical details of surgical anastomoses have always been (and likely will continue to be) as much the art of surgery as the science of surgery. There are likely almost as many opinions on how to do an anastomosis as there are surgeons. It is something passed down from one generation to the next, occasionally with some evidence to support one opinion or another. This article adds to the evidence, but as the authors state, more study is needed.

There are multiple limitations to this study, some of which are discussed by the authors.