REVIEW ARTICLE

Partial Anterior vs Partial Posterior Fundoplication Following Transabdominal Esophagocardiomyotomy for Achalasia of the Esophagus

Meta-regression of Objective Postoperative Gastroesophageal Reflux and Dysphagia

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Objectives: To review transabdominal esophagocardiomyotomy (surgical treatment of achalasia) of the esophagus and to compare outcomes of partial anterior vs partial posterior fundoplication.

Data Sources: An electronic search was conducted among studies published between January 1976 and September 2011 using the keywords *achalasia*, *myotomy*, *antireflux surgery*, and *fundoplication*.

Study Selection: Prospective studies of transabdominal esophagocardiomyotomy were selected.

Data Extraction: Outcomes selected were recurrent or persistent postoperative dysphagia and an abnormal 24-hour pH test result. Studies were divided into the following 3 groups: myotomy only, myotomy with anterior fundoplication, and myotomy with posterior fundoplication. Studies were weighted by the number of patients and by the follow-up duration. Event rates were calculated using meta-regression of the log-odds with the inverse variance method.

Data Synthesis: Thirty-nine studies with a total of 2998 patients were identified. The odds of postoperative dysphagia were 0.06 (95% CI, 0.03-0.12) for myotomy only, 0.11 (95% CI, 0.09-0.14) for myotomy with anterior fundoplication, and 0.06 (95% CI, 0.04-0.08) for myotomy with posterior fundoplication. The odds of a postoperative abnormal 24-hour pH test result were 0.37 (95% CI, 0.12-1.08) for myotomy only, 0.16 (95% CI, 0.11-0.24) for myotomy with anterior fundoplication, and 0.18 (95% CI, 0.13-0.25) for myotomy with posterior fundoplication. The increased odds of postoperative dysphagia in the group undergoing myotomy with anterior fundoplication compared with the group undergoing myotomy with posterior fundoplication were statistically significant ($P < .001$). However, the incidence of a postoperative abnormal 24-hour pH test result was statistically similar.

Conclusion: Partial posterior fundoplication when combined with an esophagocardiomyotomy may be associated with significantly lower reintervention rates for postoperative dysphagia, while providing similar reflux control compared with partial anterior fundoplication.

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ACHALASIA OF THE ESOPHAGUS is a rare primary motility disorder characterized by aperistalsis of the esophageal body and failure of appropriate lower esophageal sphincter relaxation in response to a swallow.[1,2] Since Willis[3] first described this disorder in 1674 and used a whale sponge attached to a whale bone to dilate the lower esophageal sphincter, various techniques, both endoscopic and surgical, have been described to palliate the resulting dysphagia. All techniques are focused toward the forced disruption of the lower esophageal sphincter.[4,5] In 1914, Ernest Heller described a surgical myotomy of the lower esophagus and proximal stomach.[6] Today, laparoscopic esophagocardiomyotomy has become the therapeutic modality of choice, providing consistent and long-lasting palliation of dysphagia.[7,8]

However, myotomy can potentiate in the reflux of gastric contents into the esophagus. This, combined with the lack of peristalsis and clearance of the refluxate, can lead to prolonged periods of acid exposure to the distal esophagus.[9,10] It is clear that an esophagocardiomyotomy should be combined with an antireflux procedure to limit the gastroesophageal reflux disease (GERD) that is seen in the postoperative period.[11] A complete 360° fundoplication (Nissen) can result in a

high incidence of treatment failure from the standpoint of dysphagia.[12,13] Hence, partial fundoplication is commonly combined with an esophagocardiomyotomy.

Two types of partial fundoplication are used with an esophagocardiomyotomy, namely, posterior fundoplication or anterior fundoplication. Each approach has its proponents. Posterior fundoplication is thought to keep the edges of the myotomy open, resulting in improved palliation of dysphagia. It may be a better antireflux operation compared with anterior fundoplication in the nonachalasia setting.[14-16] On the other hand, supporters of anterior fundoplication believe that it provides superior reflux control because the phrenoesophageal ligaments are preserved, it covers potential mucosal injuries, and it is easier to perform.[17-20] Hence, a lack of consensus exists as to the best choice of partial fundoplication to be combined with the myotomy. The scarcity of randomized controlled trials addressing this question reflects the fact that achalasia is a rare disease. The only multi-institutional randomized controlled study[21] to date comparing the 2 partial fundoplications showed no statistical differences in outcomes; however, the study was underpowered, and the authors noted that the follow-up data among patients in the study were suboptimal. Hence, a meta-analysis may be a practical solution to answer this important question. We present a meta-regression of studies describing outcomes of transabdominal esophagocardiomyotomy, with the objective to identify the type of partial fundoplication that provides effective control of GERD without impairing the palliation afforded by the myotomy.

METHODS

STUDY DESIGN

An electronic search (MEDLINE, EMBASE, Google Scholar, and Cochrane Central Register of Controlled Trials) was conducted among articles published between January 1976 and September 2011 using the keywords *achalasia*, *myotomy*, *antireflux surgery*, and *fundoplication*. The following exclusion criteria were applied: non–English-language publications, abstracts only, case reports, and retrospective studies. Articles were also excluded if they reported outcomes on transthoracic esophagocardiomyotomy (because a difference in the lower extent of the myotomy on the gastric cardia is achieved via transthoracic myotomy compared with transabdominal myotomy). If overlapping study populations were identified, then the latest article with the largest population was selected. Full-text copies of each article were checked manually to supplement the electronic search. Patients who underwent a complete fundoplication in combination with esophagocardiomyotomy were also excluded because of a high heterogeneity in study design and results.

Articles meeting the inclusion criteria were then reviewed, and the following data were extracted: number of patients, follow-up duration, type of surgical approach (open vs laparoscopic transabdominal esophagocardiomyotomy), incidence of objective postoperative GERD (abnormal 24-hour pH test result), treatment failure (persistent or recurrent dysphagia needing reintervention or endoscopic reoperation), and type of fundoplication used in conjunction with the myotomy (myotomy only, myotomy with anterior fundoplication, or myotomy with posterior fundoplication). Event rates (treatment failure and abnormal 24-hour pH test result) were calculated in patient-months. We used the total number of patients in the study and the follow-up duration to calculate dysphagia rates. To calculate GERD rates, we used the number of patients in the study who underwent objective 24-hour pH testing and the time elapsed until testing as the follow-up duration.

STATISTICAL ANALYSIS

The odds of postoperative treatment failure and objective GERD were calculated using weighted means, determined by the number of patients and the follow-up duration as already described. We used a random-effects meta-regression (to correct for the heterogeneity in operative technique among the 3 groups) of the log-odds with the inverse variance method to calculate the estimated event rates.[22-24]

RESULTS

Thirty-nine studies with a total of 2998 patients were identified using the study inclusion criteria. Twenty-eight of these studies reported objective postoperative GERD rates (in 1686 patients). Eleven were randomized controlled studies; the remaining 28 were prospective studies. **Table 1** lists the randomized controlled studies,[11,20,21,25-32] and **Table 2** lists the prospective studies[15,19,33-58] identified. Thirty-one studies reported on the laparoscopic approach, and 8 studies reported on the open transabdominal approach. The distributions of the studies reporting the 3 approaches (myotomy only, myotomy with anterior fundoplication, and myotomy with posterior fundoplication) are given in **Table 3**. A preponderance of the studies reported myotomy with anterior fundoplication (30 studies with 1165 patients undergoing a postoperative 24-hour pH test). The myotomy-only group comprised 7 studies with 178 patients undergoing a postoperative 24-hour pH test, and the myotomy with posterior fundoplication group comprised 9 studies with 343 patients undergoing a postoperative 24-hour pH test.

The odds of postoperative treatment failure from recurrent or persistent dysphagia were higher in the myotomy with anterior fundoplication group compared with the myotomy-only group or the myotomy with posterior fundoplication group (**Table 4**). However, the odds of an abnormal 24-hour pH test result were significantly higher in the myotomy-only group compared with both fundoplication groups. The odds of an abnormal 24-hour pH test result were nonsignificantly higher in the myotomy with posterior fundoplication group compared with the myotomy with anterior fundoplication group.

We used a random-effects meta-regression model using the inverse variance of the log-odds to calculate the estimated event rates (Table 4). Again, the addition of fundoplication reduced the estimated postoperative GERD rates from 27.0% to 14.3% for the myotomy with anterior fundoplication group and 15.8% for the myotomy with posterior fundoplication group. The estimated postoperative dysphagia rates requiring reintervention were significantly higher in the myotomy with anterior fundoplication group compared with the myotomy with posterior fundoplication group (10.1% vs 5.9%, $P < .001$). These estimated event rates are shown in **Figure 1** and

Table 1. Randomized Controlled Studies

Source	Open vs Laparoscopic	Follow-up Duration, mo	No. of Patients		
			Total	With Dysphagia	With GERD
Myotomy Only					
Csendes et al,[25] 1989	**Open**	62	41	1	12
Falkenback et al,[26] 2003	Open	40	10	0	9
Richards et al,[11] 2004	Laparoscopic	6	21	0	10
Simić et al,[20] 2010	Laparoscopic	36	22	0	2
Myotomy With Posterior Fundoplication					
Kostic et al,[27] 2007	Laparoscopic	15	25	1	NA
Rawlings et al,[21] 2012	Laparoscopic	6	24	1	4
Myotomy With Anterior Fundoplication					
Suárez et al,[28] 2002	Laparoscopic	17.5	14	1	NA
Zaninotto et al,[29] 2004	Laparoscopic	12	20	2	1
Richards et al,[11] 2004	Laparoscopic	6	22	1	2
Rebecchi et al,[30] 2008	Laparoscopic	125	71	4	4
Novais and Lemme,[31] 2010	Laparoscopic	3	43	NA	2
Simić et al[20] 2010	Laparoscopic	36	62	3	6
Rawlings et al,[21] 2012	Laparoscopic	6	36	3	10
Boeckxstaens et al,[32] 2011	Laparoscopic	12	106	7	23

Abbreviations: GERD, gastroesophageal reflux disease; NA, not available.

Table 2. Prospective Studies

Source	Open vs Laparoscopic	Follow-up Duration, mo	No. of Patients		
			Total	With Dysphagia	With GERD
Myotomy Only					
Kumar et al,[33] 1998	Laparoscopic	27	19	2	NA
Richards et al,[34] 1999	Laparoscopic	8.3	16	2	2
Finley et al,[35] 2007	Laparoscopic	12	24	0	NA
Robert et al,[36] 2008	Laparoscopic	2	106	0	7
Myotomy With Posterior Fundoplication					
Swanström and Pennings,[37] 1995	Laparoscopic	16	9	0	0
Vogt et al,[15] 1997	Laparoscopic	12	18	2	0
Perrone et al,[38] 2004	Laparoscopic	26	94	4	NA
Khajanchee et al,[39] 2005	Laparoscopic	9	121	11	16
Wright et al,[40] 2007	Laparoscopic	45	63	3	NA
Ortiz et al,[41] 2008	Laparoscopic	72	149	3	19
Myotomy With Anterior Fundoplication					
Mitchell et al,[42] 1995	Laparoscopic	12	14	2	1
Morino et al,[43] 1997	Laparoscopic	NA	21	0	1
Anselmino et al,[44] 1997	Laparoscopic	12	43	2	2
Ackroyd et al,[19] 2001	Laparoscopic	24	82	1	NA
Pechlivanides et al,[45] 2001	Laparoscopic	12	29	3	3
Mineo and Ambrogi,[46] 2004	Open	107	39	4	3
Douard et al,[47] 2004	Laparoscopic	50	52	4	6
Douard et al,[47] 2004	Open	51	30	2	3
Ramacciato et al,[48] 2003	Laparoscopic	12	12	1	NA
Csendes et al,[49] 2006	Open	190	64	6	60
Ruffato et al,[50] 2006	Open	109	174	15	NA
Gockel et al,[51] 2006	Open	55	108	7	NA
Bessell et al,[52] 2006	Laparoscopic	12	95	21	NA
Finley et al,[35] 2007	Laparoscopic	12	71	4	NA
Wright et al,[40] 2007	Laparoscopic	46	52	9	NA
Ferulano et al,[53] 2007	Laparoscopic	60	35	3	4
Zaninotto et al,[54] 2008	Laparoscopic	6	407	39	17
Tsiaoussis et al,[55] 2008	Laparoscopic	12	76	7	20
Yu et al,[56] 2010	Laparoscopic, open	60	216	21	24
Chen et al,[57] 2010	Laparoscopic	60	125	20	NA
Di Martino et al,[58] 2011	Laparoscopic	24	30	2	4

Abbreviations: GERD, gastroesophageal reflux disease; NA, not available.

Table 3. Distribution of Studies and Patients

Group	Total No. of Studies	Total No. of Patients	No. of Studies With Postoperative 24-Hour pH Test Results	No. Patients With Postoperative 24-Hour pH Test Results
Myotomy only	7	240	6	178
Myotomy with anterior fundoplication	30	2197	21	1165
Myotomy with posterior fundoplication	9	561	6	343

Table 4. Estimated Postoperative Event Rates

	Dysphagia		GERD	
Group	Odds (95% CI)	Rate (95% CI), %	Odds (95% CI)	Rate (95% CI), %
Myotomy only	0.06 (0.03-0.12)	6.38 (3.69-10.81)	0.37 (0.12-1.08)	27.12 (11.39-51.87)
Myotomy with anterior fundoplication	0.11 (0.09-0.14)	10.12 (8.27-12.33)	0.16 (0.11-0.24)	14.3 (10.43-19.37)
Myotomy with posterior fundoplication	0.06 (0.04-0.08)	5.85 (4.12-8.22)	0.18 (0.13-0.25)	15.82 (12.27-20.15)

Abbreviation: GERD, gastroesophageal reflux disease.

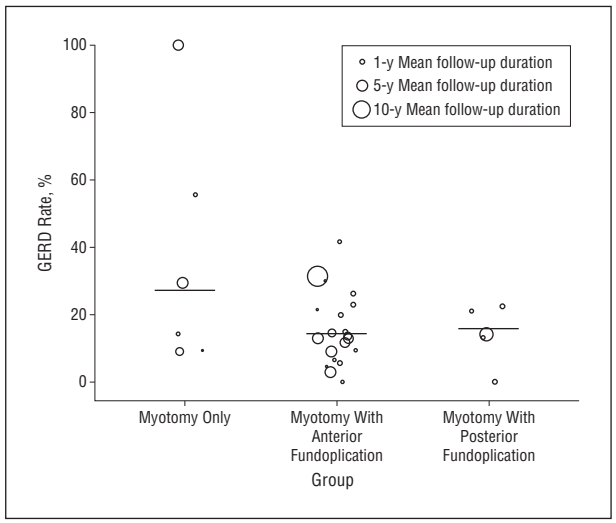

Figure 1. Estimated postoperative gastroesophageal reflux disease (GERD) rates (postoperative 24-hour pH test results). The horizontal lines represent the mean estimated rates.

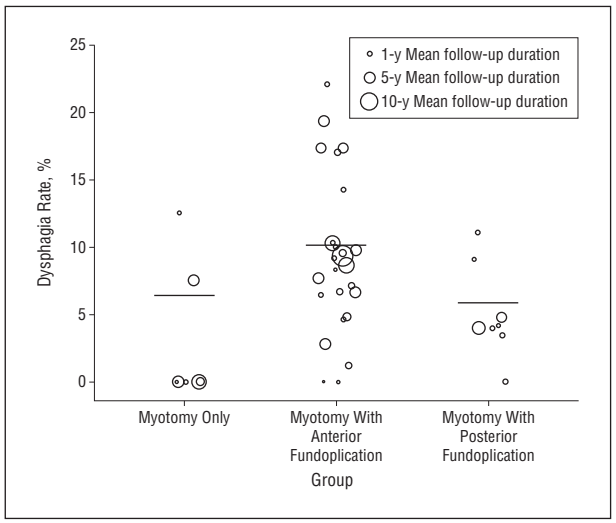

Figure 2. Estimated postoperative dysphagia rates. The horizontal lines represent the mean estimated rates.

Figure 2. The GERD control rates are equivalent between the 2 groups; however, the dysphagia rates were higher in the myotomy with anterior fundoplication group compared with the myotomy with posterior fundoplication group.

COMMENT

Laparoscopic esophagocardiomyotomy combined with partial fundoplication has become the preferred modality for the treatment of achalasia because of its consistent and durable palliation of dysphagia.[7,8,59] The only randomized controlled trial[21] comparing anterior vs posterior partial fundoplication showed a trend toward a higher reintervention rate for dysphagia in the anterior fundoplication group (8% vs 4%); however, the study was underpowered to reach statistical significance. The results of our meta-regression analysis demonstrate that both partial fundoplications are associated with equivalent control of GERD; however, anterior fundoplication is associated with higher reintervention rates for postoperative dysphagia compared with posterior fundoplication. One can only speculate as to the reason for this difference, including that posterior fundoplication keeps the edges of the myotomy open and avoids the potential adhesions that may develop between the myotomy and anterior fundoplication, resulting in fewer reinterventions for postoperative dysphagia.[14-16]

Although a 360° posterior fundoplication has been shown to be an effective antireflux procedure in the setting of aperistalsis of the esophageal body, it is associ-

ated with an unacceptably high rate of recurrent or persistent postoperative dysphagia requiring reintervention.[12,13] A recent multi-institutional European randomized controlled trial[32] showed equivalence between pneumatic dilation and laparoscopic esophagocardiomyotomy with anterior fundoplication. The study design, results, and applicability to the United States have been questioned. The experience of the surgeons in the study's surgical arm and the change in the pneumatic dilation protocol during the trial because of a high perforation rate are some of the shortcomings of the study that have been called into question. Laparoscopic esophagocardiomyotomy with partial fundoplication has replaced other modalities, including endoscopic and transthoracic approaches to the management of this disease in North America.[8]

Typical GERD symptoms of heartburn and regurgitation in patients with achalasia are an unreliable indicator of true GERD as measured by objective 24-hour pH test results. Preoperative heartburn is seen in up to 40% of patients with achalasia and can be due to stasis, fermentation, and esophageal dilation, in addition to true GERD. Postoperative GERD symptoms also correlate poorly with true GERD.[60-62] Hence, we used the incidence of an abnormal postoperative 24-hour pH test result to denote the true incidence of GERD.

Our study has limitations. Achalasia is a rare disease, accounting for the scarcity of randomized controlled trials with long-term follow-up data. Heterogeneity also exists among the studies in the baseline patient demographics, the severity of disease, the technical details of the surgical procedure, and the reporting of outcomes. We tried to correct for this using well-defined inclusion and exclusion study criteria and using a random-effects model. However, our inclusion and exclusion criteria may have affected the study results. Publication bias and other unknown confounding factors may also have influenced our findings.

Our study results indicated that the addition of fundoplication limits the reflux that is seen after obliteration of the lower esophageal sphincter. The addition of posterior fundoplication does not increase the postoperative failure rates from the standpoint of dysphagia compared with myotomy only, while significantly reducing the postoperative GERD rates. Anterior fundoplication when combined with an esophagocardiomyotomy is associated with equal control of GERD compared with posterior fundoplication, but at the price of almost double the reintervention and failure rate for dysphagia. Hence, laparoscopic partial posterior fundoplication combined with an esophagocardiomyotomy may be the procedure of choice for achalasia of the esophagus.

In conclusion, achalasia of the esophagus is commonly treated with a laparoscopic esophagocardiomyotomy. Partial posterior fundoplication in combination with an esophagocardiomyotomy may be associated with significantly lower reintervention rates for dysphagia, while providing similar reflux control compared with partial anterior fundoplication.

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