Laparoscopic Anterior Versus Posterior Fundoplication for Gastroesophageal Reflux Disease

Systematic Review and Meta-Analysis of Randomized Clinical Trials

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Objective: To compare short- and long-term outcome after laparoscopic anterior fundoplication (LAF) versus posterior fundoplication (LPF) through a systematic review and meta-analysis of randomized clinical trials (RCTs).

Summary of Background Data: LPF is currently considered the surgical therapy of choice for gastroesophageal reflux disease (GERD). Alternatively, LAF has been alleged to reduce troublesome dysphagia and gas-related symptoms.

Methods: Four electronic databases (MEDLINE, EMBASE, Cochrane Library, and ISI web of Knowledge CPCI-S) were searched for RCTs comparing primary LAF versus LPF for GERD. The methodological quality was evaluated to assess bias risk. Primary outcomes were esophageal acid exposure time, heartburn, Dakkak dysphagia score (0–45) and reoperation rate. Short- and long-term results were pooled separately in meta-analyses as risk ratios (RRs) and weighted mean differences (WMDs).

Results: Eleven reports on 7 eligible RCTs (anterior vs. posterior total [n = 5]; anterior vs. posterior partial [n = 2]) comparing LAF (n = 345) versus LPF (n = 338) were identified. Short-term (6–12 months) esophageal acid exposure time (3.3% vs. 0.8%: WMD 2.04; 95% confidence interval [CI] [0.84–3.24]; $P < 0.001$), heartburn (21% vs. 8%; RR 2.71; 95%CI [1.72–4.26]; $P < 0.001$) and reoperation rate (8% vs. 4%; RR 1.94; 95%CI [0.97–3.87]; $P = 0.06$) were higher after LAF. In contrast, the Dakkak dysphagia score was lower after LAF (2.5 vs. 5.7; WMD –2.87; 95%CI [–3.88 to –1.87]; $P < 0.001$). There were no short-term differences in prevalence of esophagitis, regurgitation and perioperative outcomes. The higher rate of heartburn after LAF persisted during long-term (2–10 years) follow-up (31% vs. 14%; RR 2.15; 95% CI [1.49–3.09]; $P < 0.001$) with more PPI use (25% vs. 10%; RR 2.53; 95% CI [1.40–4.45]; $P = 0.002$). The long-term reoperation rate was twice as high after LAF (10% vs. 5%; RR 2.12; 95% CI [1.07–4.21]; $P = 0.03$). Long-term Dakkak dysphagia scores, inability to belch, gas bloating and satisfaction were not different.

Conclusions: Esophageal acid exposure time and the prevalence of heartburn are higher after LAF compared with LPF. In the short-term this is counterbalanced by less severe dysphagia. However, dysphagia scores become similar in the long-term, with a persistent substantial increase in prevalence of heartburn and PPI use after LAF. The reoperation rate is twice as high after LAF as well, mainly due to reinterventions for recurrent GERD. The prevalence of gas-related symptoms is similar. These results lend level 1a support for the use of LPF as the surgical treatment of choice for GERD.

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Laparoscopic fundoplication is the surgical approach of choice for gastroesophageal reflux disease (GERD). Three randomized clinical trials (RCTs) have recently demonstrated that the laparoscopic approach offers similar 5-year[1] and 10-year rates for disease control[2] compared with open fundoplication, with fewer incisional hernias.[2,3]

A fundoplication is created by wrapping the fundus of the stomach anteriorly or posteriorly around the esophagus. Currently, laparoscopic posterior fundoplication (LPF) is widely considered the surgical therapy of choice for GERD.[1–3] In North America total posterior fundoplication is considered the gold standard,[4–6] whereas partial posterior fundoplication is more common in Europe.[7] Generally, the aim of antireflux surgery is to control reflux symptoms with minimal postoperative dysphagia and gas-related symptoms. A recently published systematic review comparing posterior total to posterior partial fundoplication demonstrated that posterior fundoplication ensures excellent reflux control, although this is traded off against a high prevalence of postfundoplication symptoms.[7] Eleven percent of the patients develop dysphagia and 5% require dilation for dysphagia after LPF.[7] In addition, 12% of the patients suffer from the inability to belch and 29% report gas bloating after posterior fundoplication.[7] Therefore, the development of dysphagia and gas-related symptoms seem to be clinically important drawbacks associated with LPF.

Laparoscopic anterior fundoplication (LAF) has been proposed as an alternative operation aiming to reduce postfundoplication symptoms. Several RCTs have demonstrated that LAF reduces dysphagia[8–13] and gas-related symptoms,[10,11,13] when compared with LPF. Some RCTs suggest that this is offset by a higher reflux recurrence rate,[8,10–12,14–16] though other RCTs report similar reflux control.[9,13,17] As a result, these individual RTCs comparing LAF to LPF have not provided a definitive answer.

Up to date, no systematic review of literature exists to address this question. This study aims, therefore, to systematically review all RCTs comparing LAF to LPF for GERD. Short- and long-term outcomes are analyzed separately, to generate the highest level of evidence to determine which procedure should be regarded as the surgical therapy of choice.

METHODS

Study Selection

A systematic literature search with predefined search terms (Fig. 1) was carried out in MEDLINE (from 1960),[18] EMBASE (from 1980),[19] Cochrane Library (issue 1, 2010), and the ISI Web of Knowledge Conference Proceedings Citation Index – Science (CPCI-S; from 1990) databases for articles published to June 1, 2010 (Fig. 1).

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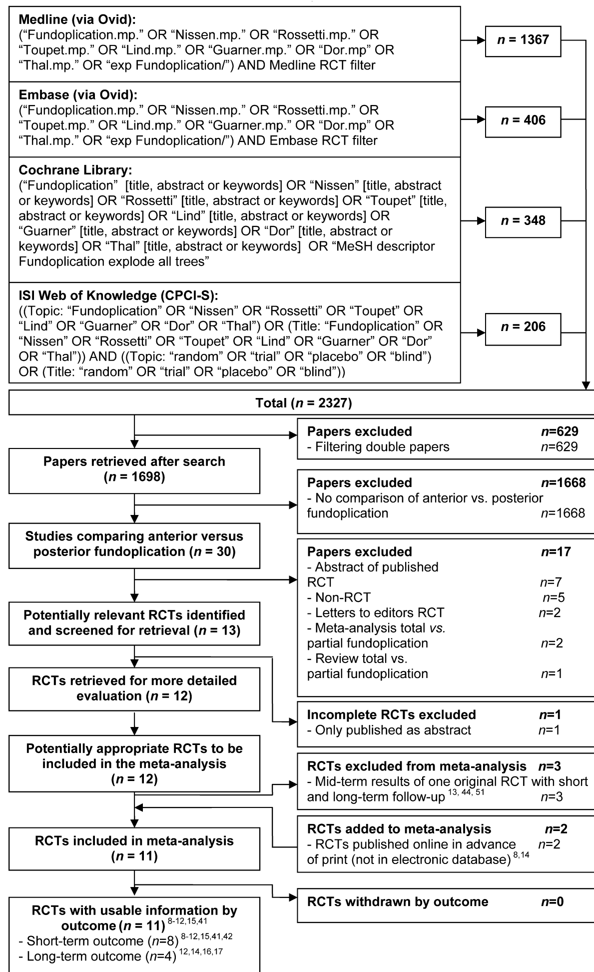

FIGURE 1. Flow-chart illustrating the details of the search strategy and study selection process according to the QUOROM-statement.[22–24] RTC indicates randomized clinical trial; MesH, medical subject heading; CPCI-S, conference proceedings citation index—science.

All identified articles were screened for cross-references. Language restrictions were not applied.

Inclusion Criteria

Title and abstract of all identified articles were screened and selected according to the following inclusion criteria: study population—adult patients with established GERD undergoing primary antireflux surgery; intervention—clearly documented surgical technique of LAF and LPF, irrespective of division of the short gastric vessels;[20] study outcomes—at least one of the outcome measures reported below; study design—patients assigned to either LAF or LPF by random allocation; publication—published as a full article in a peer-reviewed journal.

Exclusion Criteria

Studies were excluded from analysis if they did not meet the inclusion criteria, or if the corresponding author was not able to provide data requested and it was impossible to extract or calculate appropriate data from the published results. Abstracts of RCTs were excluded as the methodological quality and the risk of bias of these studies could not be assessed.

Outcomes of Interest and Definitions

Primary outcomes were: esophageal acid exposure time on pH monitoring, heartburn, the validated Dakkak dysphagia score (0, no dysphagia; 45, severe dysphagia)[21] and reoperation rate. Secondary outcomes included endoscopic esophagitis, regurgitation, PPI use, inability to belch, gas bloating, ability to relieve bloating, satisfaction with intervention, willingness to undergo surgery again, lower esophageal sphincter (LES) pressure and LES relaxation nadir pressure on manometry, operating time, conversion rate, in-hospital complications and length of hospital stay. Short- (6–12 months) and long-term (2–10 years) results were pooled separately in meta-analysis. Subgroup analysis was performed after exclusion of RCTs with 90-degree anterior fundoplication, because short-term[10,11] and long-term[14] reflux control after this procedure is poor compared with short-term[9] and long-term[17] effectiveness of 180-degree fundoplication.

Data Extraction

Titles and abstracts of all retrieved records, and subsequently full-text articles, were examined independently by 2 authors (J.A.B., D.J.R.) according to the Quality of Reporting of Meta-analyses (QUOROM) guidelines.[22–24] The following data were extracted separately by the same 2 authors (J.A.B., D.J.R.) for all studies meeting the inclusion criteria: reference of study, study population characteristics, study design, inclusion and exclusion criteria and number of participating subjects for each endpoint. For dichotomous outcomes, the number of events was recorded and for continuous outcomes means and standard deviations (SDs) were registered. In case of discrepancies, a third author (UAA) was consulted and agreement was reached by consensus.

Authors of all the original RCTs were contacted to provide missing data. When authors could not provide missing data, the following methods of handling missing data were applied. If the number of patients per arm was missing for an outcome, an equal distribution between both arms was assumed. Missing SDs were either imputed based on ranges when available[25] or based on the average SDs reported by other RCTs for the same outcome.[18] If both means and SDs were missing, they were imputed based on the medians and ranges[25] or based on medians and interquartile ranges,[18] according to availability.

Risk of Bias Assessment

Risk of bias was assessed of all articles using both the Cochrane Collaboration's tool for assessing risk of bias[18] and the Jadad scoring system.[26]

Statistical Analysis

Statistical analyses were performed following the recommendations of the Cochrane Collaboration and QUOROM guidelines.[22–24] Outcomes reported by 3 or more studies were pooled in meta-analyses. Short- and long-term results were analyzed separately. Dichotomous and continuous outcomes were presented as risk ratios (RRs) and weighted mean differences (WMDs), respectively. Data were pooled using the Mantel–Haenszel and the inverse-variance method for dichotomous outcomes and for continuous outcomes, respectively. Trials with zero events in both arms were excluded from meta-analysis. Trials with zero events in one arm were included in the analysis by adding a continuity correction of 0.5 to all cells in the 2×2 table of that study. As a robustness assessment, meta-analyses with RCTs with zero events in one arm were also performed using risk differences in a sensitivity analysis. For all analyses the 95% confidence interval (CI) was calculated.

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TABLE 1. Details of Included RCTs Comparing LAF Versus LPF

Author	Year	Period	Method	n	Degrees	Crural repair	DSGV	Bougie	Fixation to Esophagus†	Short-Term FU	Long-Term FU
Baigrie[12]	2005	1999–2001	Anterior	79	180	Yes	No	NR	No	12 (ref. 12)	24 (ref. 12)
			Posterior	84	360	Yes	No	56 Fr	No		
Chrysos[41]	2004	NR	Anterior	12	180	Yes	No	None	Yes	6 (ref. 41)	
		NR	Posterior	12	360	Yes	No	None	No		
Khan[8]	2010	NR	Anterior	53	180	Yes	No	None	Yes	12 (ref. 8)	
		NR	Posterior	50	180	Yes	No	None	Yes		
Lundell[15,16,42]	2003/2007	NR	Anterior	47	120	Yes	No	None	Yes	12 (refs. 15, 42)	65 (ref. 16)
			Posterior	48	180–200	Yes	Yes	None	Yes		
Spence[11]	2006	1999–2003	Anterior	40	90	Yes	No	None	Yes	12 (ref. 11)	
			Posterior	39	360	Yes	No	52 Fr	No		
Watson 1999[9,17]	1999/2004/2008	1995–1997	Anterior	54	180	Yes	No	None	Yes	6 (ref. 9)	120 (ref. 17)
			Posterior	53	360	Yes	No	52 Fr	No		
Watson 2004[10,14]	2004/2010	2000–2003	Anterior	60	90	Yes	No	None	Yes	6 (ref. 10)	60 (ref. 14)
			Posterior	52	360	Yes	Yes	52–60 Fr	No		

Degrees indicates circumference of the wrap; DSGV, division of the short gastric vessels; FU, follow-up (months); NR, not reported; Fr, French.
†Fixation of the fundoplication to the esophagus.

Heterogeneity was calculated using Higgins χ^2 test,[27] and inconsistency in study effects was quantified by I^2 values.[18,28] The fixed-effects model was used if no heterogeneity was present (χ^2 $P > 0.100$ and $I^2 < 50\%$). If excessive heterogeneity was present, data were first rechecked and the DerSimonian random-effects model was used when heterogeneity persisted.[29] Funnel plots were used to help identify the presence of publication or other types of bias.[30–32] Review Manager software (RevMan© v. 5.0.16) provided by The Cochrane Collaboration was used for data management and statistical analyses.

RESULTS

Description of Studies

A total of 2327 potential relevant publications were identified (Fig. 1). Thirty papers comparing anterior versus posterior fundoplication were identified. Five studies did not randomly allocate patients.[33–37] Two meta-analyses,[20,38] 1 review,[39] and 1 German publication that was published as an abstract only without a peer-reviewed publication[40] were excluded. Two RCTs were added that had been published online in advance of print and were not listed in the electronic database.[8,14] Finally, 11 publications on 7 original RCTs[8–12,15,41] comparing laparoscopic anterior versus posterior fundoplication were identified. Eight publications[8–12,15,41,42] reported short-term results and 4 publications evaluated long-term outcome[12,14,16,17] (Fig. 1).

The 7 included trials were published between 1999 and 2010, all with at least 6 months of follow-up. A total of 683 fundoplications (345 LAF; 338 LPF) were performed. In all patients, a standardized LAF with a circumferential range of 90 to 180 degrees or a standardized LPF with a circumference of 180 to 360 degrees was created after crural repair. Two trials divided the short gastric vessels in the LPF group.[10,14–16,42] One trial enrolled patients with esophageal dysmotility and included 11 patients of this subgroup in both arms (Table 1).[9,17] Patient characteristics and indications for surgical treatment are listed in Table 2.

Methodological Quality of Included Studies

The trials had good methodological quality, with a mean Jadad score of 4 (range 1–5; Table 3). Three trials lacked double blinding[8,15,16,41,42] and 2 trials did not conceal allocation.[15,16,41,42] One trial did not report the method of sequence generation[15,16,42] and another study did not report loss to follow-up.[41] Four trials reported a sample size calculation.[8–11,14,17]

Short-Term Outcomes

PPI use was the only short-term outcome that was not reported by 3 or more studies. Mean esophageal acid exposure time on 24-hour pH monitoring was higher after LAF (3.3% vs. 0.8%; WMD 2.04%; 95% CI [0.84–3.24]; $P < 0.001$; Fig. 2). The percentage of patients with heartburn was higher after LAF as well (21% vs. 8%; RR 2.71; 95% CI [1.72–4.26]; $P < 0.001$; Fig. 3). In contrast, the mean Dakkak dysphagia score was lower after LAF (2.5 vs. 5.7; WMD –2.87; 95% CI [–3.88 to –1.87]; $P < 0.001$; Fig. 4) and this was accompanied by a lower LES relaxation nadir pressure (4.3 mm Hg vs. 8.0 mm Hg; WMD –3.12 mm Hg; 95% CI [–6.04 to –0.21]; $P = 0.04$; Fig. 5). The number of surgical reinterventions was twice as high after LAF compared with LPF, although this difference did not reach statistical significance (8% vs. 4%; RR 1.94; 95% CI [0.97–3.87]; $P = 0.06$; Fig. 6). In the LAF group, 18 of 22 reoperations were performed for recurrent GERD and 1 for dysphagia. In contrast, 2 of 11 surgical reinterventions after LPF were for recurrent GERD and 8 for dypshagia.

There were no differences in the prevalence of esophagitis and regurgitation (Table 4). The prevalence of inability to belch and gas bloating were similar as well (Table 4). The ability to relieve bloating was higher after LAF (77% vs. 60%; RR 1.30; 95% CI [1.12–1.50]; $P < 0.001$; Fig. 7). Satisfaction with intervention, willingness to undergo surgery again and LES pressure were not different (Table 4).

Operating time, conversion rate, in-hospital complications and length of hospital stay were similar for both groups (Table 4). The included trials reported no mortality. Sensitivity analysis of outcomes with zero events in one arm (heartburn, gas bloating, and conversion) yielded similar results. Funnel plots did not demonstrate evidence of publication bias (Fig. 8).

Subgroup analysis after exclusion of 2 RCTs[10,11] that performed 90 degree LAF yielded similar results: mean esophageal acid exposure time (4.0% vs. 1.1%; WMD 3.36%; 95% CI [0.61–6.10]; $P = 0.02$), heartburn (21% vs. 7%; RR 2.93; 95% CI [1.72–5.02]; $P < 0.001$), Dakkak dysphagia score (2.0 vs. 4.1; WMD –2.03; 95% CI [–2.68 to –1.39]; $P < 0.001$) and ability to relieve bloating (85% vs. 71%; RR 1.21; 95% CI [1.01–1.45]; $P = 0.04$). The only discrepancies compared with the main analysis were that the difference in

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TABLE 2. Patient Characteristics

Author	Method	Age (years)	Male/Female Sex	Esophageal Dysmotility/Total	Indication for Surgical Treatment
Baigrie[12]	Anterior	NR	45/34	NR	pH or endoscopically proven GERD
	Posterior	NR	49/34	NR	
Chrysos[41]	Anterior	58	4/8	0/12	pH or endoscopically proven GERD
	Posterior	52	9/3	0/12	
Khan[8]	Anterior	43	36/17	0/53	pH or endoscopically proven GERD
	Posterior	43	38/12	0/50	
Lundell[5,16,42]	Anterior	47	34/13	NR	Chronic GERD
	Posterior	46	38/18	NR	
Spence[11]	Anterior	46	24/16	0/40	pH or endoscopically proven GERD
	Posterior	47	19/20	0/39	
Watson 1999[9,17]	Anterior	NR	NR	11/54	pH or endoscopically proven GERD
	Posterior	NR	NR	11/53	
Watson 2004[10,14]	Anterior	47	35/25	0/60	pH or endoscopically proven GERD
	Posterior	49	33/19	0/52	

GERD indicates gastroesophageal reflux disease; NR, not reported; pH or endoscopically proven GERD, GERD proven on upper endoscopy or 24-hour pH-monitoring.

TABLE 3. Risk of Bias Summary

	Baigrie[12]	Chrysos[41]	Khan[8]	Lundell[15,16,42]	Spence[11]	Watson 1999[9,17]	Watson 2004[10,14]
Adequate sequence generation	Yes	Yes	Yes	No	Yes	Yes	Yes
Allocation concealment	Yes	No	Yes	No	Yes	Yes	Yes
Blinding (observer)	Yes	No	No	No	Yes	Yes	Yes
Blinding (patient)	Yes	No	NR	No	Yes	Yes	Yes
Adequate report on loss to follow-up	Yes	No	Yes	Yes	Yes	Yes	Yes
Free of other sources of bias	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Jadad score	5	2	3	1	5	5	5

NR indicates not reported.

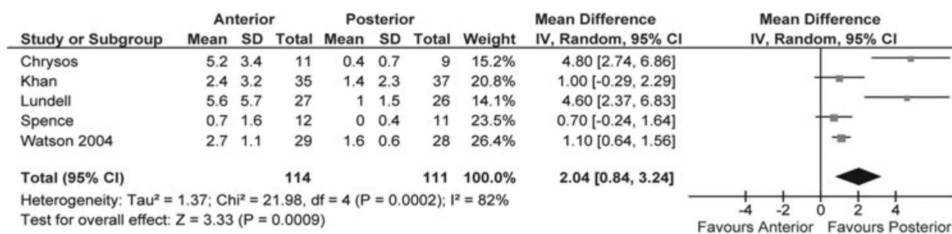

FIGURE 2. Short-term acid exposure.

surgical reintervention (9.8% vs. 3.8%; RR 2.60; 95%CI [1.11, 6.08]; $P = 0.03$), regurgitation (13% vs. 7%; RR 3.61; 95% CI [1.79–7.25]; $P < 0.001$) and LES pressure (18.7 mm Hg vs. 25.5 mm Hg; WMD –5.65 mm Hg; 95% CI [–10.74 to –0.56]; $P = 0.03$) were significant and the difference in LES relaxation nadir pressure was not significant in the subgroup (5.7 mm Hg vs. 10 mm Hg; WMD –2.99 mm Hg; 95% CI [–8.05 to 2.08]; $P = 0.25$).

Long-Term Outcomes

In the long-term, 3 of 4 primary outcomes and 6 of 10 secondary outcomes were reported by 3 or more studies. LAF resulted in a persistent 2-fold higher rate of heartburn compared with LPF at long-term follow-up (31% vs. 14%; RR 2.15; 95% CI [1.49–3.09]; $P < 0.001$; Fig. 9). This was associated with more PPI use in the LAF group (25% vs. 10%; RR 2.53; 95% CI [1.40, 4.45]; $P = 0.002$; Fig. 10). Dakkak dysphagia scores (4.6 vs. 5.6; WMD –1.46; 95% CI [–3.16 to 0.24]; $P = 0.09$; Fig. 11) and the ability to relieve bloating (56% vs. 50%; RR 1.07; 95% CI [0.84–1.35]; $P = 0.59$; Fig. 12) became similar in the LAF and LPF group with extension of follow-up. The reoperation rate remained twice as high after LAF in the long-term (10% vs. 5%; RR 2.12; 95% CI [1.07–4.21]; $P = 0.03$; (Fig. 13). In the LAF group, 18 of 22 reoperations were performed for recurrent GERD and 1 for dysphagia. In contrast, 2 of 11 surgical reinterventions after LPF were for recurrent GERD and 8 for dysphagia.

In line with the short-term outcome, there were no differences in inability to belch, gas bloating, satisfaction with intervention and willingness to undergo surgery again (Table 5). Sensitivity analysis of outcomes with zero events in one arm (heartburn and reoperation rate) yielded similar results. Funnel plots did not demonstrate evidence of publication bias.

Subgroup analysis after exclusion of an RCT that performed 90 degree LAF[14] yielded similar results: PPI use (25% vs. 13%; RR 1.97; 95% CI [1.03–3.76]; $P = 0.04$), Dakkak dysphagia score (4.2 vs. 5.3; WMD –1.46; 95% CI [–4.10 to 1.17]; $P = 0.28$) and ability to relieve bloating (44% vs. 46%; RR 0.93; 95% CI [0.65–1.34];

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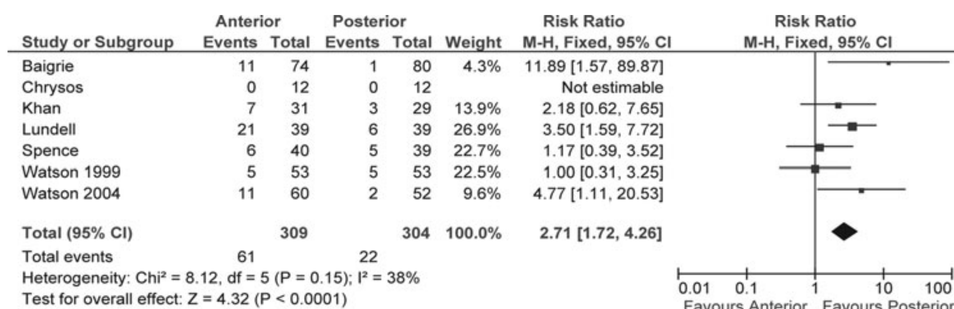

FIGURE 3. Short-term heartburn.

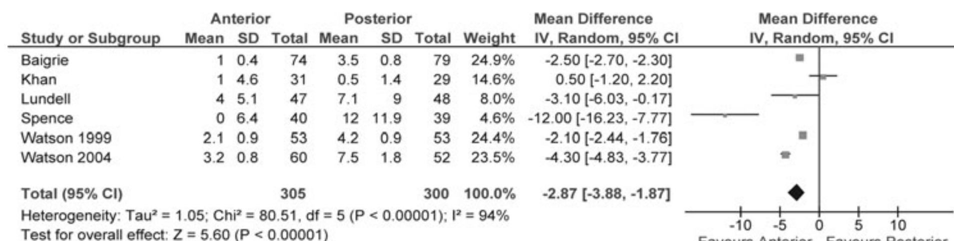

FIGURE 4. Short-term Dakkak dysphagia score.

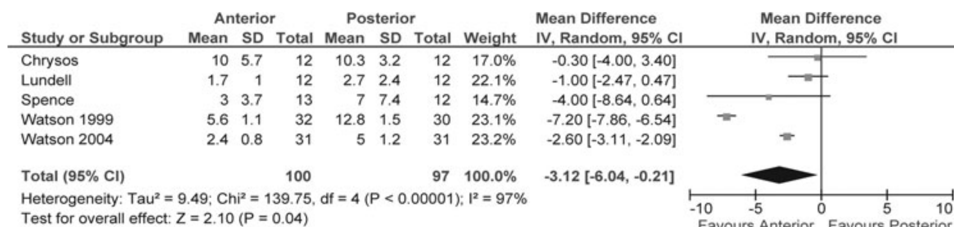

FIGURE 5. Short-term LES relaxation nadir pressure (mm Hg).

$P = 0.71$). The differences in heartburn (28% vs. 10%; RR 2.41; 95% CI [0.95–6.11]; $P = 0.06$) and reoperation rate (12% vs. 6%; RR 2.01; 95% CI [1.00–4.07]; $P = 0.05$) were similar as well and the only discrepancy compared with the main analysis was that the differences of the subgroup were at the limit of statistical significance.

DISCUSSION

Between 2004 and 2010, 7 RCTs were published comparing LAF and LPF for GERD.[8,11,12,14,16,17,41] These individual trials are inconclusive and are too small to identify significant differences regarding the most important determinants of successful antireflux surgery: objective reflux control and the need for surgical reintervention. Previous meta-analysis on antireflux surgery[7,20,38,43] have not reviewed 9 recent publications on 6 of 7 original RCTs comparing LAF to LPF.[8,13–17,41,42,44] More importantly, 4 recent papers[13,14,16,17] on 5- and 10-year outcome have not yet been pooled in meta-analysis. Long-term follow-up is critical to evaluate differences in reflux control and reoperation rate. Previous systematic reviews on antireflux surgery lack meta-analysis of long-term outcome and definite conclusions regarding the surgical procedure of choice.[7,20,38,43] This meta-analysis aims to provide this evidence by pooling short and long-term outcomes separately.

The methodological quality of the 7 RCTs included in this meta-analysis was good, with a mean Jadad score of 4. Surgical techniques of the included trials were standardized and similar: in all patients a 90 to 180 degrees anterior or 180 to 360 degrees posterior fundoplication was created after crural repair. Two trials divided the short gastric vessels in the LPF group.[10,14–16,42] This is not likely to introduce any bias because it has previously been demonstrated that division of the short gastric vessels does not influence outcome.[20] One trial enrolled a small number of patients with esophageal dysmotility.[9] This study analyzed patients with and without esophageal dysmotility together as 4 RCTs have shown that outcome of fundoplication is similar in patients with normal and abnormal esophageal motility.[45–48] There were no other potential sources of bias.

The current short-term results demonstrate that esophageal acid exposure time, as measured with 24-hour pH monitoring, is higher after LAF. The clinical impact of this higher acid exposure is illustrated by a 2-fold higher rate of recurrent heartburn compared with LPF. The short-term reoperation rate is twice as high after LAF with the notable fact that 80% of these reinterventions are performed for recurrent GERD. In the short-term this is counterbalanced by a lower LES relaxation nadir pressure, resulting in a lower Dakkak dysphagia score and less difficulty to relieve bloating in the LAF group. Physiological studies have previously demonstrated that LES relaxation nadir pressure is the only standard manometry parameter correlated with postfundoplication dysphagia.[49,50]

The present long-term results demonstrate that Dakkak dysphagia scores and ability to relieve bloating become similar with extension of follow-up. The individual results of the 4 RCTs underline that dysphagia decreases during long-term follow-up.[12,14,16,17]

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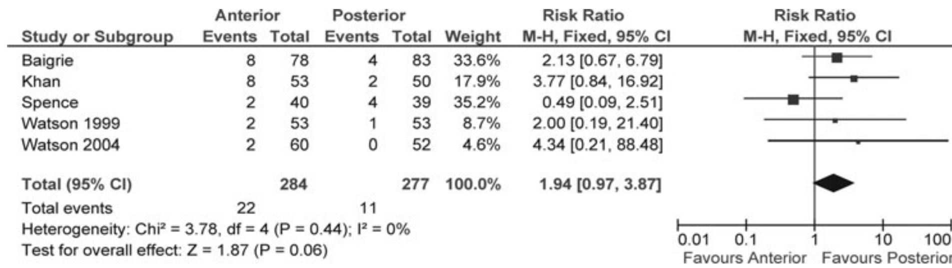

FIGURE 6. Short-term reoperation rate.

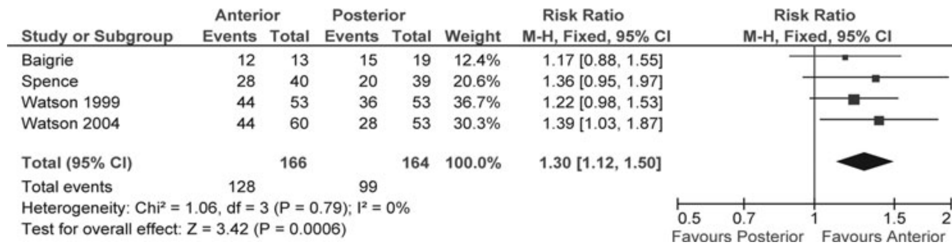

FIGURE 7. Short-term ability to relieve bloating.

TABLE 4. Short-Term Outcome

Short-Term Outcome	RCTs (*n*)	LAF	LPF	RR	WMD	CI	*P*
Esophagitis	3	8/67 [12%]	4/72 [6%]	2.17		0.67, 7.02	0.19
Regurgitation	5	36/225 [16%]	25/214 [12%]	1.09		0.28, 4.24	0.90
Inability to belch	5	21/201 [10%]	44/188 [23%]	0.52		0.21, 1.25	0.14
Gas bloating	6	50/245 [20%]	63/245 [26%]	0.76		0.56, 1.03	0.07
Satisfaction with intervention	5	213/258 [83%]	214/253 [85%]	0.98		0.91, 1.05	0.55
Willing to undergo surgery again	5	257/276 [93%]	241/270 [89%]	1.04		0.96, 1.14	0.35
LES pressure (mm Hg)	6	17.7 (*n* = 135)	16.6 (n = 133)		-3.87	-10.56, 2.82	0.26
Conversion rate	6	7/298 [2%]	4/290 [1%]	1.57		0.50, 4.91	0.44
Operating time (min)	5	67 (*n* = 280)	68 (n = 272)		-1.60	-8.79, 5.58	0.66
In-hospital complications	5	17/286 [6%]	15/278 [5%]	1.06		0.54, 2.08	0.86
Length of hospital stay (days)	4	2.5 (*n* = 208)	2.4 (n = 199)		0.09	-0.05, 0.24	0.21

RCT indicates randomized clinical trial; LAF, laparoscopic anterior fundoplication; LPF, laparoscopic posterior fundoplication; RR, risk ratio; WMD, weighted mean difference; CI, confidence interval.

The current results demonstrate that differences in these postfundoplication symptoms between LAF and LPF are most prominent in the early postoperative period and gradually fade with time. In contrast, the higher rate of heartburn after LAF persists during long-term follow-up. Twice as many patients have recurrent GERD after LAF, with more PPI use compared with LPF. The long-term reoperation rate is twice as high after LAF as well and recurrent GERD is the indication for surgical reintervention in more than 80% of the patients. There are no differences in the ability to belch and gas bloating in both the short and the long-term. The high PPI use after LAF probably explains why patient satisfaction was similar in both groups, despite the higher rate of recurrent GERD compared with LPF. The short and long-term results of subgroup analysis after exclusion of 2 RCTs[10,11] that performed 90 degree LAF were similar.

On the basis of the current results LPF should be regarded as the fundoplication of choice for GERD. LPF comprises both posterior total (Nissen) and posterior partial fundoplication. A modified Toupet fundoplication, including crural repair and division of the short gastric vessels, is by far the most commonly performed posterior partial fundoplication.[7] This study does not include separate analysis of posterior total and posterior partial fundoplication, because the individual results of 10 RCTs and 2 meta-analyses of these studies have demonstrated that reflux control is similar.[7,20] A subgroup analysis of the first meta-analysis demonstrated no differences in reflux recurrence detected by either endoscopy and/or pH-metry or symptoms between posterior partial (Toupet) fundoplication and posterior total fundoplication (Nissen) at 30 [6–60] months.[20] The second meta-analysis showed that Toupet fundoplication has a similar rate of recurrent pathological acid exposure, esophagitis and reflux symptoms compared with Nissen fundoplication at 23 months [12–60], with homogeneity of 1-, 2-, and 5-year outcome.[7] A recent systematic review that included 10-year follow-up studies confirmed that there are no differences in esophagitis, heartburn, and reflux recurrence.[43] The second meta-analysis also found that posterior partial fundoplication reduces dysphagia, gas-related symptoms and reoperation rate compared with posterior total fundoplication.[7] On the basis of the level 1a evidence provided by our previous meta-analysis[7] and this study, it could be argued that laparoscopic posterior partial fundoplication offers effective reflux control with minimal postfundoplication symptoms, and can be considered the surgical procedure of choice for GERD.

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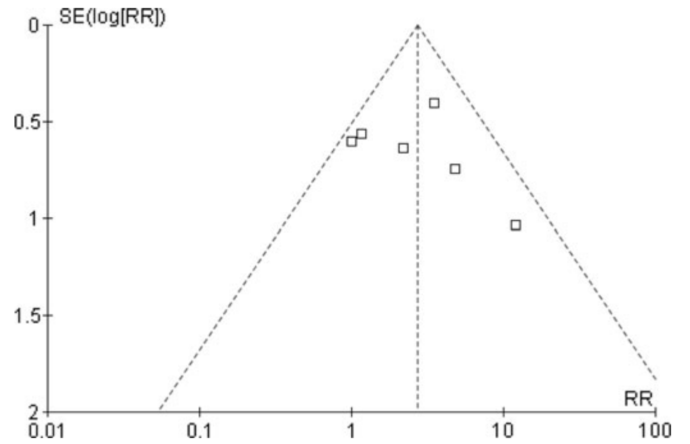


FIGURE 8. Funnel plot short-term heartburn.

Study or Subgroup	Anterior Events	Anterior Total	Posterior Events	Posterior Total	Weight	Risk Ratio M-H, Fixed, 95% CI
Baigrie	11	79	0	84	1.6%	24.44 [1.46, 407.90]
Lundell	26	43	11	45	34.9%	2.47 [1.40, 4.36]
Watson 1999	8	41	7	48	20.9%	1.34 [0.53, 3.37]
Watson 2004	21	53	12	44	42.6%	1.45 [0.81, 2.61]
Total (95% CI)		**216**		**221**	**100.0%**	**2.15 [1.49, 3.09]**
Total events	66		30			

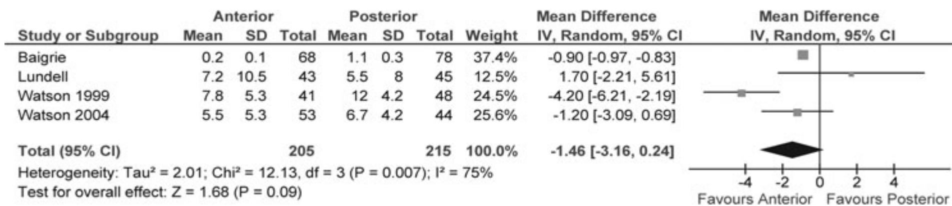
Heterogeneity: Chi² = 5.82, df = 3 (P = 0.12); I² = 48%
Test for overall effect: Z = 4.10 (P < 0.0001)

FIGURE 9. Long-term heartburn.

Study or Subgroup	Anterior Events	Anterior Total	Posterior Events	Posterior Total	Weight	Risk Ratio M-H, Fixed, 95% CI
Lundell	10	43	3	45	21.9%	3.49 [1.03, 11.82]
Watson 1999	11	41	9	48	61.8%	1.43 [0.66, 3.11]
Watson 2004	13	53	2	44	16.3%	5.40 [1.29, 22.64]
Total (95% CI)		**137**		**137**	**100.0%**	**2.53 [1.40, 4.55]**
Total events	34		14			

Heterogeneity: Chi² = 3.41, df = 2 (P = 0.18); I² = 41%
Test for overall effect: Z = 3.09 (P = 0.002)

FIGURE 10. Long-term PPI use.



Study or Subgroup	Anterior Mean	Anterior SD	Anterior Total	Posterior Mean	Posterior SD	Posterior Total	Weight	Mean Difference IV, Random, 95% CI
Baigrie	0.2	0.1	68	1.1	0.3	78	37.4%	-0.90 [-0.97, -0.83]
Lundell	7.2	10.5	43	5.5	8	45	12.5%	1.70 [-2.21, 5.61]
Watson 1999	7.8	5.3	41	12	4.2	48	24.5%	-4.20 [-6.21, -2.19]
Watson 2004	5.5	5.3	53	6.7	4.2	44	25.6%	-1.20 [-3.09, 0.69]
Total (95% CI)			**205**			**215**	**100.0%**	**-1.46 [-3.16, 0.24]**

Heterogeneity: Tau² = 2.01; Chi² = 12.13, df = 3 (P = 0.007); I² = 75%
Test for overall effect: Z = 1.68 (P = 0.09)

FIGURE 11. Long-term Dakkak dysphagia score.

Study or Subgroup	Anterior Events	Anterior Total	Posterior Events	Posterior Total	Weight	Risk Ratio M-H, Fixed, 95% CI
Baigrie	11	11	10	11	19.6%	1.10 [0.86, 1.40]
Watson 1999	12	41	17	48	29.3%	0.83 [0.45, 1.52]
Watson 2004	36	53	25	44	51.1%	1.20 [0.87, 1.64]
Total (95% CI)		**105**		**103**	**100.0%**	**1.07 [0.84, 1.35]**
Total events	59		52			

Heterogeneity: Chi² = 1.21, df = 2 (P = 0.55); I² = 0%
Test for overall effect: Z = 0.54 (P = 0.59)

FIGURE 12. Long-term ability to relieve bloating.

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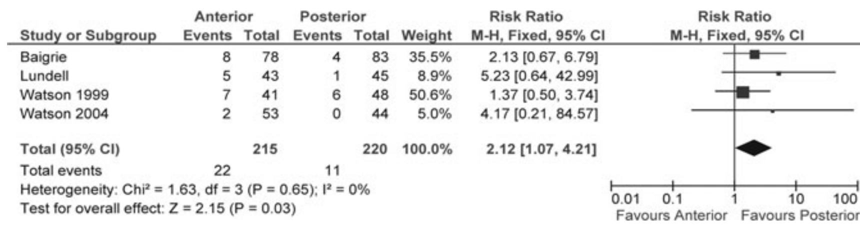

FIGURE 13. Long-term reoperation rate.

TABLE 5. Long-Term Outcome

Long-Term Outcome	RCTs (n)	LAF	LPF	RR	CI	*P*
Inability to belch	4	24/155 [15%]	49/158 [31%]	0.53	0.25, 1.11	0.09
Gas bloating	3	53/131 [40%]	46/140 [33%]	1.12	0.84, 1.49	0.45
Satisfaction with intervention	4	167/204 [82%]	195/214 [91%]	0.89	0.74, 1.08	0.23
Willing to undergo surgery again	3	121/132 [92%]	126/135 [93%]	0.99	0.90, 1.09	0.84

RCT indicates randomized clinical trial; LAF, laparoscopic anterior fundoplication; LPF, laparoscopic posterior fundoplication; RR, risk ratio; CI, confidence interval.

In conclusion, LAF is associated with higher esophageal acid exposure time and prevalence of heartburn compared with LPF. In the short-term this is counterbalanced by less severe dysphagia compared with LPF. However, dysphagia scores become similar in the long-term, with a persistent higher rate of recurrent heartburn and PPI use after LAF. The reoperation rate is twice as high after LAF as well, mainly due to reinterventions for recurrent GERD. Perioperative outcomes, patient satisfaction and the prevalence of gas-related symptoms are similar. These results lend level 1a support for the use of LPF as the surgical treatment of choice for GERD.

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