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Laparoscopic repair of hiatus hernia: Does mesh type influence outcome? A meta-analysis and European survey study

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Abstract

Background

Synthetic mesh (SM) has been used in the laparoscopic repair of hiatus hernia but remains controversial due to reports of complications, most notably esophageal erosion. Biological mesh (BM) has been proposed as an alternative to mitigate this risk. The aim of this study is to establish the incidence of complications, recurrence and revision surgery in patients following suture (SR), SM or BM repair and undertake a survey of surgeons to establish a perspective of current practice.

Methods

An electronic search of EMBASE, MEDLINE and Cochrane database was performed. Pooled odds ratios (PORs) were calculated for discrete variables. To survey current practice an online questionnaire was sent to emails registered to the European Association for Endoscopic Surgery.

Results

Nine studies were included, comprising 676 patients (310 with SR, 214 with SM and 152 with BM). There was no significant difference in the incidence of complications with mesh compared to SR ($P = 0.993$). Mesh significantly reduced overall recurrence rates compared to SR [14.5 vs. 24.5 %; POR = 0.36 (95 % CI 0.17–0.77); $P = 0.009$]. Overall recurrence rates were reduced in the SM compared to BM groups (12.6 vs. 17.1 %), and similarly compared to the SR group, the POR for recurrence was lower in the SM group than the BM group [0.30 (95 % CI 0.12–0.73); $P = 0.008$ vs. 0.69 (95 % CI 0.26–1.83); $P = 0.457$]. Regarding surgical technique 503 survey responses were included. Mesh reinforcement of the crura was undertaken by 67 % of surgeons in all or selected cases with 67 % of these preferring synthetic mesh to absorbable mesh. One-fifth of the respondents had encountered mesh erosion in their career.

Conclusions

Both SM and BM reduce rates of recurrence compared to SR, with SM proving most effective. Surgical practice is varied, and there remains insufficient evidence regarding the optimum technique for the repair of hiatal hernia.

Keywords

Hiatal herniaMeshLaparoscopy

Laparoscopic repair of hiatus hernia has been widely adopted in the management of patients with symptomatic large hiatus hernia. The procedure commonly incorporates a laparoscopic dissection of the hernia sac from the mediastinum, reduction of herniated intra-abdominal organs, posterior repair of the crura and fundoplication. Although good clinical outcomes were reported with direct suture of the hiatus, clinical and/or radiological recurrences have been described in up to 66 % of patients [1]. Mesh has been suggested as a strategy to prevent recurrences, with a principle similar to groin hernia repair, initially by Frantzides et al. [2], and since then, the use of mesh in laparoscopic surgery of hiatus hernia has increased. However, the indications for mesh reinforcement and some technicalities including mesh type, shape and position are still debated. The major concern regarding the use of mesh is the long-term risk of mesh erosion into the esophagus and other adjacent vital structures. In order to avoid or reduce this risk, some surgeons chose to abandon synthetic mesh [e.g., polypropylene, polytetrafluoroethylene (PTFE), polyvinyl, Teflon] as originally described [2] in favor of the many currently available biological meshes (e.g., cadaveric human skin, porcine intestinal submucosa, bovine pericardium, cross-linked collagen) [3].
The European Association of Endoscopic Surgeons (EAES) consensus conference in 2014 stated that hiatal repair with mesh reinforcement may reduce hernia recurrence, although mesh-related complications have to be considered. As a consequence, the EAES recommended that indications for mesh should be limited to patients with weak crurae and a large hiatal defect [4]. SAGES guidelines on the management of hiatal hernia [5] acknowledged the controversy surrounding the use of mesh cruroplasty stating “There is inadequate long-term data on which to base a recommendation either for or against the use of mesh at the hiatus.” In a SAGES survey in 2007 [3], 10 % of respondents reported using mesh routinely and 46 % regarded a large hiatal defect as an absolute indication for mesh placement. Most commonly used mesh material from this previous survey were biomaterial (28 %), polytetrafluoroethylene (25 %) and polypropylene (21 %).
There is evidence that by reinforcing the crura with mesh the rate of hernia recurrence is reduced [5, 6], but the long-term outcomes (and complications) of these patients are not yet clarified and the abundance of case reports reporting complications from all types of mesh contributes to the current confusion. Previous literature reviews [6–8] have summarized available data surrounding mesh cruroplasty without a separate analysis between synthetic and biological mesh. With biological mesh possibly offering an improved safety profile, the different characteristics of synthetic and biological mesh require separate evaluation. The aim of this study was to: (1) undertake a systematic review and pooled analysis to compare clinical outcomes following laparoscopic repair of hiatus hernia using suture repair alone (SR), synthetic mesh (SM) and biological mesh (BM); and (2) generate a perspective of current surgical practice through a survey of EAES members.

Materials and methods

Systematic review

An electronic search of EMBASE, MEDLINE and Cochrane databases from 1966 to 2015 was performed. The search terms “hiatus hernia,” “laparoscopy” and “mesh” were used with the Boolean operator AND. Two authors independently performed searches in November 2015. The reference lists of articles obtained were also searched to identify further relevant citations. Titles and abstracts of the citations identifies in the search were then scrutinized by two of the authors (JRH and SRM) to determine eligibility for inclusion in the pooled analysis.
Publications were included if they were randomized controlled trials or comparative studies in which patients underwent a laparoscopic repair of a hiatus hernia with the use of mesh (synthetic or biological). Studies were excluded if they were non-comparative, without the use of mesh or surgery was performed for gastroesophageal reflux disease in the absence of a large hiatal hernia.

Three groups were compared in the analysis: patients who underwent a crural repair without mesh (SR), patients who had crural repair with synthetic mesh reinforcement (SM) and patients who underwent crural repair with absorbable or biological mesh (BM) reinforcement.
Data from eligible trials were entered into a computerized spreadsheet for analysis. Statistical analysis was performed using StatsDirect 2.5.7 (StatsDirect, Altincham, UK). Three comparative analyses were undertaken: combined mesh group versus SR, SM versus SR and BM versus SR. Pooled odds ratios (PORs) were calculated for the effect of synthetic or biological mesh on discrete variables. All pooled outcome measures were determined using random-effects models as described by DerSimonian–Laird [9]. Heterogeneity among trials was assessed by means of the Cochran Q statistic, a null hypothesis in which $P < 0.05$ is taken to indicate the presence of significant heterogeneity [10]. The Egger test was used to assess the funnel plot for significant asymmetry, indication of possible publication or other biases.

EAES survey

A survey comprising 21 questions was designed (see Appendix 1) that included multiple choice and free text responses. The survey was conducted on a Web-based survey platform (Qualtrics, Provo, Utah, USA). An invitation to participate with an explanation of the subject of the study and link to the survey was sent by electronic mail to all registered addresses in the European Association for Endoscopic Surgery and other interventional techniques (EAES) directory. This included members and non-members with the society including members from all surgical disciplines and therefore not specific to upper gastrointestinal surgeons. A reminder was sent at 2 weeks, and all responses were collected in February and March 2015. Following this period, survey responses were collated for analysis. Survey responses were only included in the analysis if the full survey was completed.

Results

Systematic review

The literature search identified four randomized controlled trials [1, 14–16] and five comparative studies [17–21]. Figure 1 shows the PRISMA flowchart for the literature search. Three studies were excluded from the pooled analysis as long-term outcome data had been subsequently published from the same patient group and was included in this analysis. In total 676 patients were included, 310 with SR, 214 with SM and 152 with BM. Table 1 describes basic demographic data from each study including patient age, male–female ratio and inclusion criteria for study. Table 2 describes the type, shape, position and fixation technique used for the mesh reinforcement. Table 3 describes the outcome measures including complications, recurrence and the need for revision surgery. Reported complications are summarized in Table 4; no mesh erosions were reported in any of the included studies. Reported subjective outcomes were not been included in the pooled analysis due to the heterogeneity of data making summative analysis impossible.

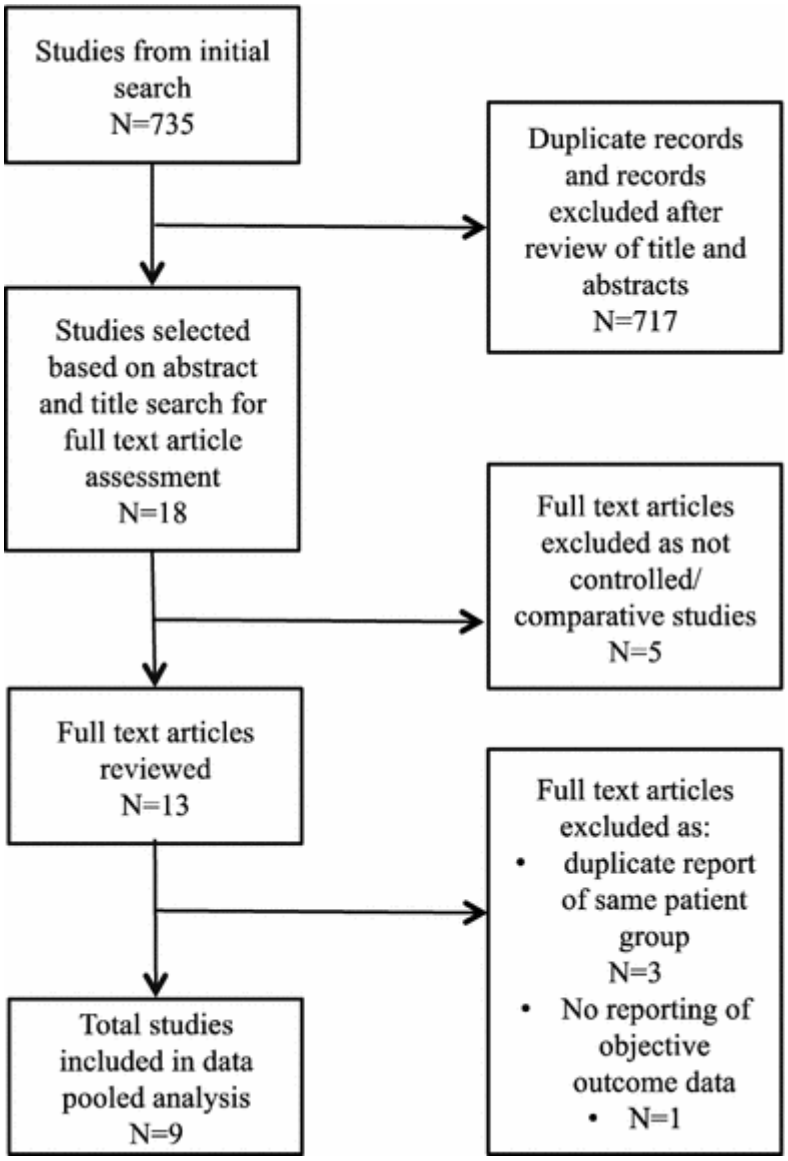

Fig. 1
PRISMA flowchart describing literature search strategy

Table 1
Study type, demographics, inclusion criteria and follow-up of studies included in pooled analysis

Author	Study type	Patient number			Age (years)[a]			Male gender			Inclusion criteria	Follow-up (months)[a]
		SR	SM	BM	SR	SM	BM	SR	SM	BM		
Watson [19]	RCT	43	42	41	67.8	68.1	68.0	14	10	16	>50 % stomach	12
Frantzides [2]	RCT	36	36	0	63	58					>8 cm	40 ± 20
Granderath [20]	RCT	50	50	0	48.7 (24–73)	48.3 (22–71)		30	32		Symptomatic	12
Oelschlager [17]	RCT	57	0	51	64 ± 13		67 ± 11	14		13	>5 cm and sig symptoms	58 (40–78)
Zaninotto	Retrospective	19	35	0	65	64		2	8		Type III	36 (IQR

Author	Study type	Patient number			Age (years)[a]			Male gender			Inclusion criteria	Follow-up (months)[a]
		SR	SM	BM	SR	SM	BM	SR	SM	BM		
[21]	case–control				(59–67)	(59.5–69.5)						12–73)
Morino [22]	Retrospective case–control	14	37	0							>6 cm or >50 % stomach	
Leeder [18]	Prospective case–control	37	14	0	71 (45–92)	72 (61–85)		11	3		Type II or III	
Ringley [23]	Prospective case–control	22	0	22	52.3 (33–75)		57.8 (34–75)	13		11	>5 cm	6.7 in mesh group, 12.2 in SR group
Schmidt [24]	Retrospective case–control	32	0	38	41		51	12		17	1–5 cm	12

[a]Presented as median (range) or mean□ ± □standard deviation (*IQR* interquartile range)

Table 2

Type of mesh, shape of mesh, position of mesh and method of fixation adopted in studies included in pooled analysis

Author	Mesh properties			
	Type	Shape	Position	Fixation
Watson [19]	TiMesh, Surgisis	Rectangular	Posterior	Sutures or ProTack
Frantzides [2]	PTFE	Oval with keyhole	Circular	Straight hernia stapler
Granderath [25]	Polypropylene	Rectangular	Posterior	Sutures
Oelschlager [17]	Porcine SIS	U-shape	Posterior	Sutures
Zaninotto [21]	Goretex handsewn over polypropylene	Square with keyhole	Circular	Staples
Morino [22]	Polypropylene or PTFE	U-shape		Sutures
Leeder [18]	Polypropylene	U-shape	Anterior	Staples
Ringley [23]	Alloderm	U-shape	Posterior	Sutures
Schmidt [24]	Human acellular dermal matrix mesh	U-shape	Posterior	Sutures

Table 3

Complications, recurrence rates and revision surgery rates following suture repair, synthetic mesh cruroplasty and biological mesh cruroplasty

Author	Complications *n*(%)	Recurrences *n*(%)	Revisions *n*(%)

	SR	SM	BM	How assessed (definition)	SR	SM	BM	SR	SM	BM
Watson [19]	8 (18.6)	5 (11.9)	3 (7.3)	EGD and barium meal at 6 months (evidence of stomach above the level of diaphragm)	9 (20.9)	5 (11.9)	12 (29.2)	5 (11.6)	4 (9.5)	0 (0)
Frantzides [2]	1 (2.8)	2 (5.6)		3-month EGD and barium swallow. Ba swallow repeated each 6 months (not defined)	8 (22.2)	0 (0)		5 (13.9)	0 (0)	
Granderath [25]	0 (0)	0 (0)		3 months and 1 year manometry, 24 h pH, barium swallow and symptom evaluation (intra-thoracic wrap migration)	13 (26)	4 (8)			2 (4)	
Oelschlager [17]	12 (21)		12 (23.5)	Barium swallow and EGD at 2 to 4 weeks and 6 months (vertical height of greater than 2 cm from the diaphragm to the top of the wrap)	20 (35)		14 (27.5)	2 (3.5)		0 (0)
Zaninotto [21]				Barium swallow at 1 month, endoscopy at 12/12 and every 24/12 (intra-thoracic gastric migration or wrap migration)	8 (42.1)	3 (8.6)				
Morino [22]	0 (0)	0 (0)		Barium swallow at 3 months or later (any evidence denoting herniation of the stomach above the level of the diaphragm)	10 (71.4)	13 (35.1)		5 (35.7)	5 (13.5)	
Leeder [18]	3 (8.1)	3 (21.4)		Barium swallow (not defined)	1 (2.7)	2 (14.2)		1	1	
Ringley [23]	4 (18.2)		4 (18.2)	Barium swallow and EGD (herniation of wrap)	2 (9.1)		0 (0)			
Schmidt [24]	0 (0)		0 (0)	Barium swallow ± EGD at 12/12 (presence of >2 cm vertical height of stomach/wrap above the hiatus)	5 (15.6)		0 (0)	2 (6.2)		0 (0)

EGD esophagogastroduodenoscopy

Table 4

Summary of reported perioperative complications in included studies by group

	SR *n*(%)	SM *n*(%)	BM *n*(%)
Pneumothorax	9 (3.0)	0 (0.0)	12 (7.9)
Bleeding	1 (0.3)	0 (0.0)	1 (0.7)
Tight hiatal repair	1 (0.3)	2 (1.1)	0 (0.0)
Acute hiatus hernia	3 (1.0)	1 (0.6)	0 (0.0)
Visceral perforation	3 (1.0)	0 (0.0)	3 (2.0)
Splenic injury	1 (0.3)	1 (0.6)	0 (0.0)
Pneumonia	0 (0.0)	1 (0.6)	0 (0.0)
Dysphagia	1 (0.3)	1 (0.6)	1 (0.7)
Urinary retention	1 (0.3)	1 (0.6)	0 (0.0)
Atelectasis	1 (0.3)	0 (0.0)	0 (0.0)
Unexplained fever	0 (0.0)	0 (0.0)	2 (1.3)
Undefined	4 (1.4)	3 (1.7)	0 (0.0)
Death	3 (1.0)	0 (0.0)	0 (0.0)
Total	28 (9.6)	10 (5.6)	19 (12.5)

Combined mesh group versus suture repair

All but one study reported a consistent lower recurrence rates in patients treated with mesh: 14.5 % in the combined mesh group versus 24.5 % in SR. The only study with a different outcome used the mesh to bridge the hiatus defect without any direct suture on the crura. The pooled analysis confirmed a significant reduction in recurrence in the combined mesh group (POR = 0.36; 95 % C.I. 0.17–0.77; $P = 0.009$) (Fig. 2). There was significant statistical heterogeneity (Cochran $Q = 17.43$; $P = 0.026$; $I^2 = 54.1$ %) but no evidence of bias (Egger = −1.426; $P = 0.227$).

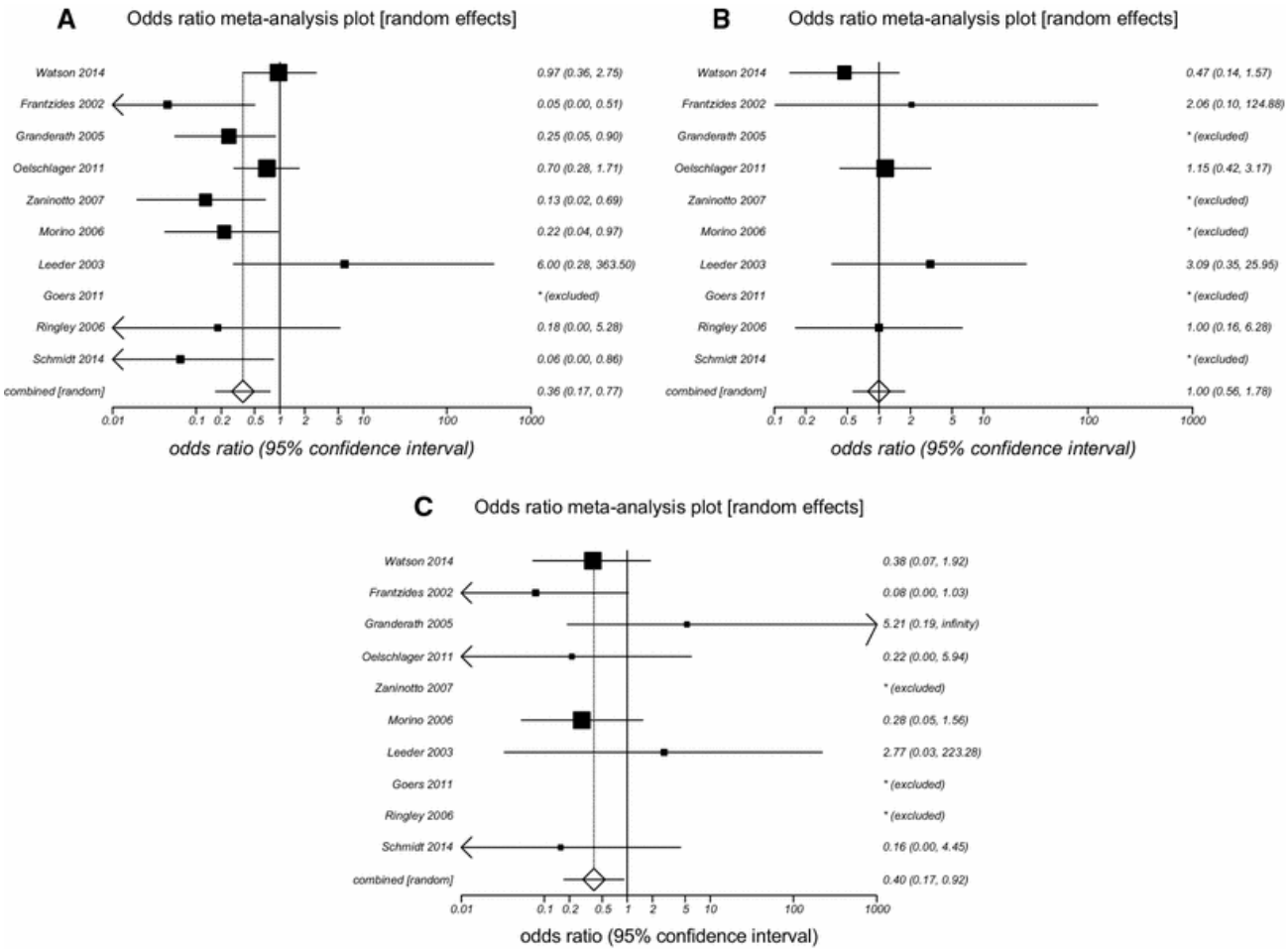

Fig. 2
Forest plots demonstrating a significant reduction in hernia recurrence (**A**) and rate of revision surgery (**C**) with the use of mesh but no significant reduction in complications (**B**)

Eight studies reported perioperative complications rates that were 9.6 and 8.8 % in the SR and combined mesh groups, respectively. Pooled analysis showed no significant difference in complications between the combined mesh group and SR group (POR = 1.00; 95 % CI 0.56–1.78; P = 0.993) (Fig. 2). There was no evidence of significant statistical heterogeneity (Cochran $Q = 4.04$; $P = 0.401$; $I^2 = 0.9$ %) or bias (Egger = 1.49; $P = 0.35$).

Seven studies reported revision surgery rates that were 7.4 and 3.9 % in the SR and combined mesh groups retrospectively. Median follow-up ranged from 12 to 58 months. Pooled analysis showed a significant reduction in the rates of revisional surgery in the mesh group (POR = 0.40; 95 % CI 0.17–0.92; $P = 0.032$) (Fig. 2). There was no evidence of significant statistical heterogeneity (Cochran $Q = 6.40$; $P = 0.38$; $I^2 = 6.2$ %) or bias (Egger = 0.53; $P = 0.666$).

Synthetic mesh versus suture repair

Six studies reported a reduced recurrence rate in SM (24.6 and 12.6 % for the SR and SM groups, respectively). Pooled analysis confirmed a significant reduction in recurrence in the SM group (POR = 0.30; 95 % CI 0.12–0.73; $P = 0.008$) (Fig. 3). There was no significant statistical heterogeneity (Cochran $Q = 9.52$; $P = 0.09$; $I^2 = 47.5$ %) or bias (Egger = 0.43; $P = 0.85$).

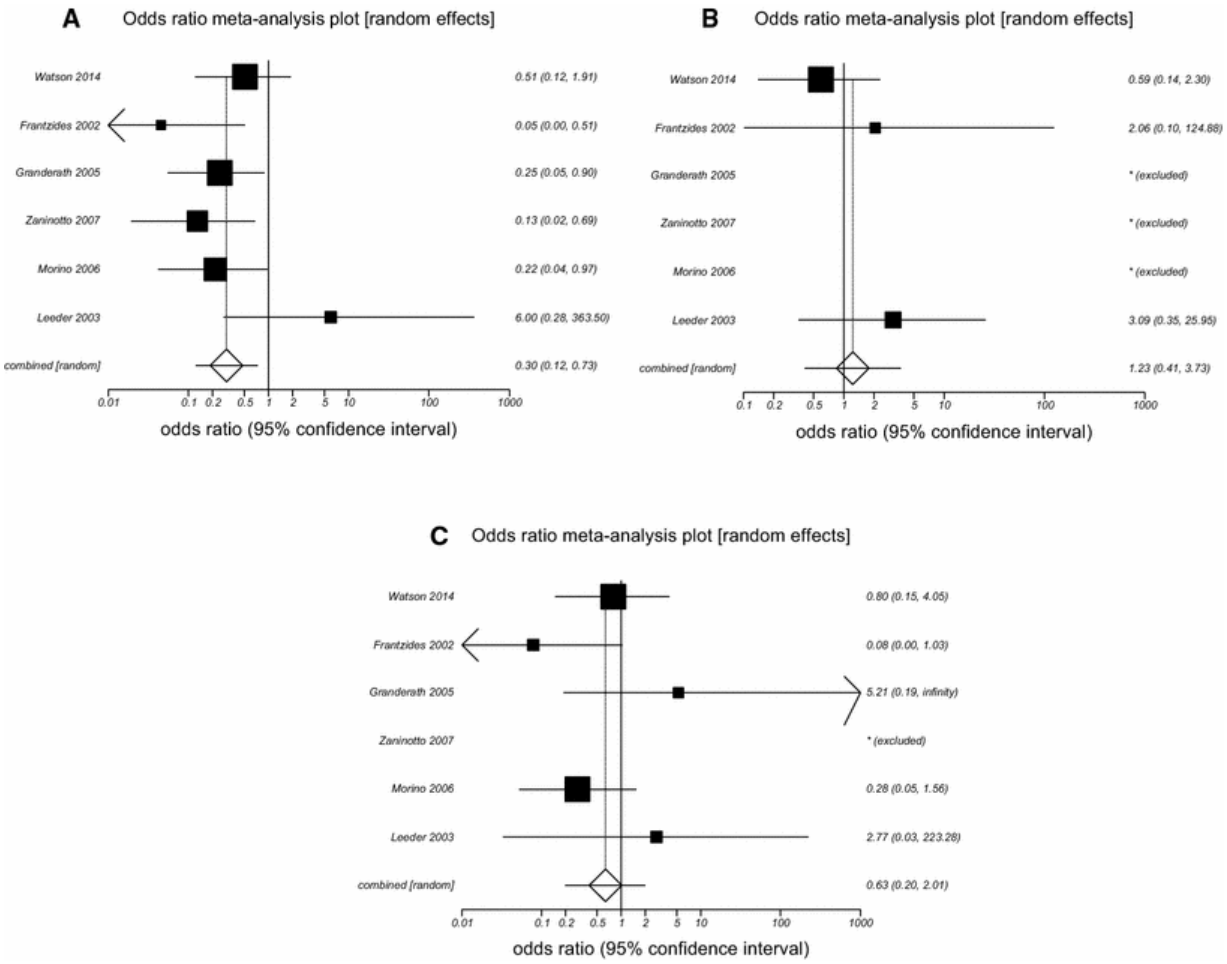

Fig. 3
Forest plot demonstrating a significant reduction in hernia recurrence (**A**) with the use of synthetic mesh but no significant reduction in complications (**B**) or need for revision surgery (**C**)

Five papers reported complication rates that were 6.7 and 5.6 % for the SR and SM groups, respectively. There was no significant difference in complications between the SM and SR group (POR = 1.23; 95 % CI 0.41–3.73; $P = 0.712$) (Fig. 3). Pooled analysis showed no evidence of significant statistical heterogeneity (Cochran $Q = 2.62$; $P = 0.27$; $I^2 = 23.7$ %). Bias indicators were not undertaken due to the number of included studies.

Five studies reported rates of revision surgery that were 8.9 and 6.7 % in the SR and SM groups, respectively. Median follow-up duration was reported in three of these studies (Table 1) and ranged from 12 to 40 months. Pooled analysis showed no significant difference in the rates of revision surgery between the two groups (POR = 0.63; 95 % CI 0.2–2.01; $P = 0.438$) (Fig. 3). There was no evidence of significant statistical heterogeneity (Cochran $Q = 6.1$; $P = 0.192$; $I^2 = 34.4$ %) or bias (Egger = 0.94; $P = 0.629$).

Biological mesh versus suture repair

Four studies showed a trend toward a reduced recurrence rate (23.4 and 17.1 % in the SR and BM groups, respectively). Pooled analysis, however, showed no significant difference in recurrence between the groups (POR = 0.69; 95 % C.I. 0.26–1.83; $P = 0.457$) (Fig. 4). There was no significant statistical heterogeneity (Cochran $Q = 5.25$; $P = 0.15$; $I^2 = 42.8$ %) or bias (Egger = −1.72; $P = 0.267$).

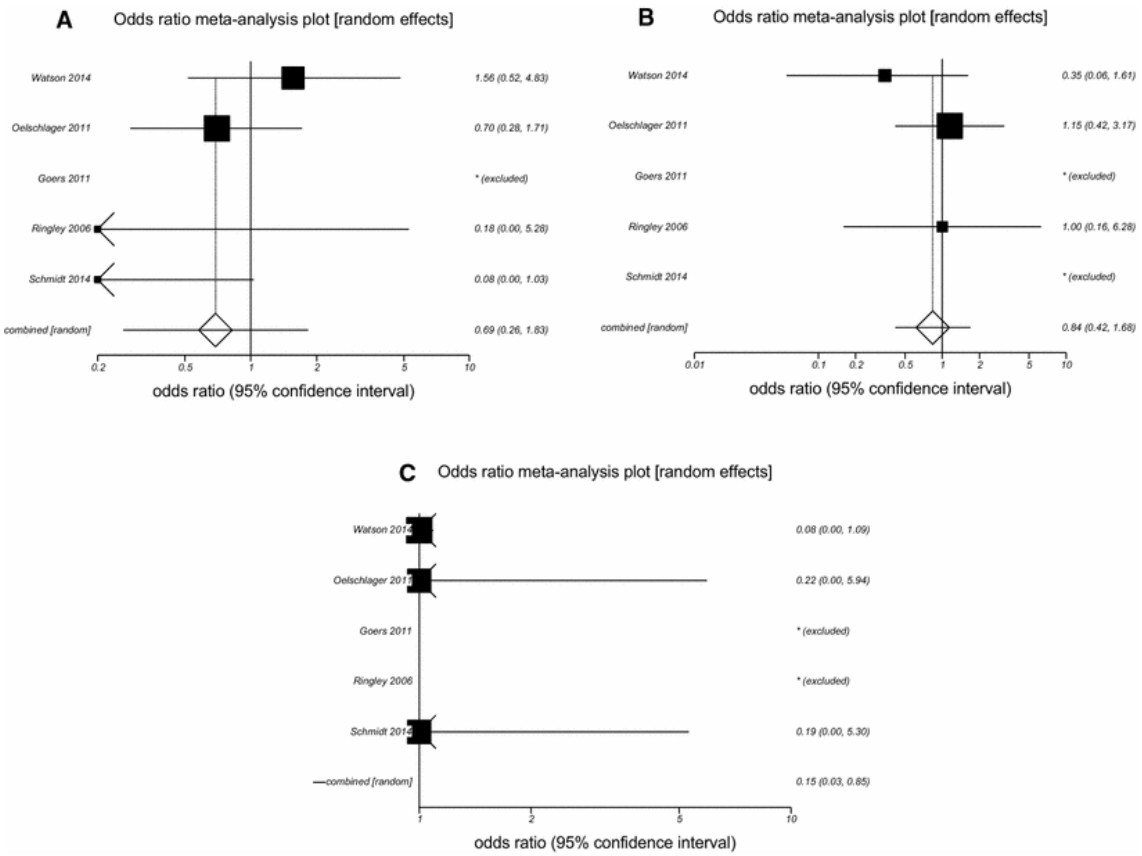

Fig. 4

Forest plot demonstrating no significant difference in hernia recurrence (**A**), complications (**B**) or need for revision surgery (**C**) with the use of biological mesh

Four studies reported complication rates that were 15.6 and 12.5 % in the SR and BM groups, respectively. Pooled analysis showed no significant difference in 30-day complications between the BM and SR group (POR = 0.84; 95 % CI 0.42–1.68; $P = 0.621$) (Fig. 4). There was no evidence of significant statistical heterogeneity (Cochran $Q = 2.06$; $P = 0.36$; $I^2 = 3.1$ %). Bias indicators were not undertaken due to the number of included studies.

Three studies reported rates of revision surgery that were 6.8 and 0 % in the SR and BM groups, respectively. Median follow-up ranged from 12 to 58 months. Pooled analysis showed a significant reduction in the rates of revisional surgery in the BM group (POR = 0.15; 95 % CI 0.03–0.85; $P = 0.032$) (Fig. 4). There was no evidence of significant statistical heterogeneity (Cochran $Q = 0.23$; $P = 0.89$; $I^2 = 0$ %). Bias indicators were not undertaken due to the number of included studies.

EAES survey

The survey was undertaken by 854 participants with a response rate of 15.7 %. Of these, 145 (17 %) participants do not undertake laparoscopic repair of hiatus hernia and were excluded from further questions. A further 206 (24 %) respondents were excluded as they did not complete the survey and demographic data were not provided. Therefore, 503 survey responses were included in the analysis (9.3 % of invited surgeons). Respondent characteristics are shown in Table 5.

Table 5

Summary of respondent demographics

Characteristic	**Number of respondents (%)**
Number of years practicing laparoscopic surgery	
Less than 2	12 (2)

Characteristic	Number of respondents (%)
2–5	43 (9)
5–10	86 (17)
Greater than 10	362 (72)
Trainee	97 (19)
Number of procedures performed per year	
Greater than 30	91 (18)
10–30	157 (31)
5–10	167 (33)
Less than 5	88 (17)
Country of surgeon	
Albania	2 (0.4)
Austria	11 (2.2)
Belgium	31 (6.2)
Bosnia	2 (0.4)
Bulgaria	9 (1.8)
Croatia	3 (0.6)
Cyprus	1 (0.2)
Czech Republic	10 (2.0)
Denmark	3 (0.6)
Estonia	3 (0.6)
Finland	2 (0.4)
France	18 (3.6)
Germany	18 (3.6)
Greece	16 (3.2)
Hungary	1 (0.2)
Iceland	1 (0.2)
Italy	47 (9.3)
Lebanon	1 (0.2)
Lithuania	3 (0.6)
Luxemburg	2 (0.4)
Macedonia	1 (0.2)
Moldova	1 (0.2)
Netherlands	24 (3.2)
Norway	2 (0.4)
Poland	5 (1.0)
Portugal	5 (1.0)
Romania	29 (5.8)

Characteristic	Number of respondents (%)
Russia	15 (3.0)
Serbia	2 (0.4)
Slovakia	2 (0.4)
Spain	21 (4.2)
Sweden	6 (1.2)
Switzerland	14 (2.8)
Turkey	11 (2.2)
UK	43 (8.5)
Ukraine	8 (1.6)
Rest of the World	136 (27.0)

Many respondents cited more than one country of practice; all have been included in table

Mesh reinforcement of the crura was used by 7 % of surgeons in all cases and 60 % of surgeons in selected cases, and 33 % of surgeons never used mesh. Of those that used mesh in selected cases the top indication for mesh reinforcement was a large defect (37 %); other indications included tension in the sutures, weak crural muscles and recurrent hernia. The majority of surgeons using a mesh used an onlay technique after suturing the crura (75 %) with 19 % opting for a tension free repair without suturing the crura. Other less common techniques included imbedding the mesh in the repair (mesh-crura-crura-mesh stitches). Synthetic mesh is used by 67 % of surgeons using mesh with 29 % preferring biological mesh. The size and shape of mesh used generated heterogeneous responses. Size varied from 2 × 1 cm rectangles up to 25 cm. Most surgeons used a rectangular mesh (34 %) with 22 % cutting a keyhole or U-shaped mesh; other shapes included square (9 %), round (4 %) or tailoring to the characteristics of the defect (18 %). Suture fixation was the most common method of securing the mesh with 60 % of surgeons adopting this technique, and 30 % used staples with other options including fibrin glue (4 %) or combination techniques (5 %). The use of pledgets was less common than mesh with 5 % of surgeons using them routinely and 37 % in selected cases with indications mirroring that of mesh use.

Regarding complications, mesh erosion had been encountered by 21 % of respondents, esophageal stenosis by 25 %, pericardial tamponade by 2 % and mesh infection by 7 %. Most surgeons (58 %) had not changed their practice in the last 5 years with cited reasons for change including recurrence rates, complications and improved technology.

Discussion

The use of mesh significantly reduced the recurrence rate after a mesh cruroplasty for large Hiatal Hernia compared to sutured repair from 24.5 to 14.5 % on combined mesh analysis. The rate of revision surgery was also significantly reduced with the use of mesh. When SM and BM groups were separately analyzed, synthetic and biological meshes showed a trend toward reduction of recurrence, although this trend only reached statistical significance in the SM group. This finding may be due to the type of BM used as in the four studies comparing SR to BM, all recurrences in the BM group were reported in the two studies that used porcine small intestine submucosa mesh and therefore the benefits of other BM types may be masked.

The EAES survey shows that in Europe two-third of the surgeons use meshes to repair the hiatus defect when the defect is large, there is a tension in the sutures or the muscle is weak. The most used meshes are the synthetic one, as it was in the American survey of 8 years ago: It is possible that the higher costs of BM may affect this choice; other factors might be the better pliability and easy suturing of the synthetic mesh.

Despite the demonstrated benefits of mesh, a third of surgeons do not use mesh to reinforce the crura. This is likely to be due to concerns regarding the potential complications, most notably mesh erosion. There were no reports of esophageal erosion in the included studies, although this may be due to the short follow-up period (Table 1) that most of these studies reported. Despite having a reported incidence of only 0.2 % [6], esophageal erosion had been encountered by 21 % of survey respondents and is feared given the management challenge, morbidity and mortality it precipitates, usually necessitating specialist management, reoperation and often esophageal or gastric resection. Proponents of BM have suggested that the use of absorbable mesh reduces or eliminates the chance of mesh erosion and therefore offer improved patient safety. However, case reports of both esophageal erosion and dysphagia secondary to excessive scarring around biological mesh do appear in the literature. In their recent systematic review [11], Stabihuber et al. describe 28 mesh-related complications that followed laparoscopic hiatus hernia repair: 21 following placement of SM (12 PTFE, 8 Polypropylene and 1 Dualmesh) and 7 following placement of BM (5 Surgisis, 1 Alloderm and 1 Biomesh). Such reports continue to be regularly published describing the rare but significant complications from the use of both synthetic and biological mesh including mesh erosion [12, 13] and esophageal stenosis [14, 15].

Although mesh complications are perceived by surgeons as a relevant drawback to their use, given that mesh complications often require major surgery, the risk of reoperations for symptomatic recurrence should not be underestimated as it carries higher risk of morbidity and mortality, longer hospital stay and increased cost. In the short time span of the studies considered in the present analysis, there were no differences in the reoperation rate (as no or few mesh-related complications were reported), but it is possible that at least some of the patients who had recurrent hernia might progress to need further surgery.

Despite there being no significant difference between the groups in perioperative complications, the BM group demonstrated a higher incidence of both pneumothorax and bleeding. This may be due to the added difficulty in handling absorbable mesh, thereby provoking errors, especially during laparoscopic suture fixation of mesh.

A wide range of both SM and BM are commercially available. Different mesh types, particularly in the biological mesh group, likely offer alternative characteristics although there were insufficient data to undertake a meta-regression to evaluate this further in this study. The choice of mesh, shape and position is currently a matter of individual surgeon preference and varied considerably in survey responses. Given the number of permutations possible, a study to define an optimal combination is unlikely to be feasible and may not be appropriate as the alternative mesh configurations may suit particular characteristics and size of defects differently.

This present study is the first to undertake a separate pooled analysis of BM and SM groups and compare this to current practice. However, there are important limitations that must be acknowledged. The studies included in pooled analysis had a degree of heterogeneity. Inclusion criteria, the type of mesh and its size, shape and position all varied between studies. The follow-up period is short, less than a year in all but three included studies. This is relevant as the durability of BM cruroplasty may reduce with time, explaining why despite Oelschlager et al. [16] having initially reported a recurrence rate of only 9 % at 6 months in their BM group compared to 24 % in their SR group, later demonstrated no significant difference between the groups at 5 years [17]. Longer-term outcome data preferably from randomized controlled trials are required to address the controversies surrounding the use of mesh at the hiatus and trials have been registered and are already underway to address some of these issues. All studies used objective investigations to demonstrate hernia recurrence with at least a barium study and in most cases an endoscopy also. However, there was some variation in the definition of recurrence between studies (Table 3) and two studies did not include a definition of recurrence [2, 18].

Limitations of the survey include the response rate and the potential for duplications in responses from trainees reporting the practice of trainers.

The results of this study show that the use of mesh cruroplasty as part of laparoscopic hiatal hernia repair reduces recurrence rates but worldwide practice is varied. Frantzides et al. [2] concluded in their 2009 survey of SAGES members that there is insufficient evidence to make firm recommendations. This study highlights that the same holds true 6 years later with an up-to-date systematic review and survey of current practice showing a hiatus between the perception of surgeons on the possible severe long-term complications of mesh repairs and an absence of data in RCTs to demonstrate this. SM may offer advantages over BM at 1 year in terms of recurrence, reduced cost and ease of use. However, there remains the need for a new multicenter study or international registry to further evaluate this and assess the optimal technique for repair.

Appendix 1: European Association of Endoscopic Surgeons Questionnaire

Q1 The following questions will focus on surgical technique for laparoscopic repair of hiatus hernia.

Q2 Do you perform laparoscopic repair of hiatus hernia?
- ❍ Yes (1)
- ❍ No (2)

If No Is Selected, Then Skip To End of Survey

Q3 Approximately, how many laparoscopic repair of hiatus hernia procedures do you perform per year?
- ❍ Less than 5 (1)
- ❍ 5-10 (2)
- ❍ 10-30 (3)
- ❍ More than 30 (4)

Q4 Do you use pledgets to reinforce the crural sutures?
- ❍ Never (1)
- ❍ In selected cases (2)
- ❍ Always (3)

If Never Is Selected, Then Skip To Do you use a mesh to reinforce your c...If Always Is Selected, Then Skip To Do you use a mesh to re

Q5 What is your indication for the use of pledgets?

Q6 Do you use a mesh to reinforce your crural repair?
- ❍ Never (1)
- ❍ In selected cases (2)
- ❍ Always (3)

If Never Is Selected, Then Skip To Has your practice changed in the last...If Always Is Selected, Then Skip To How do you use mesh in

Q7 What is your indication for the use of mesh?

Q8 How do you use mesh in your repair?
- ❍ Onlay - after suturing the crura (1)
- ❍ Tension free repair - without suturing the crura (2)
- ❍ Other (Please specify) (3) _____

Q9 What type of mesh do you use?
- ❍ Biological (Please specify type) (1) _____
- ❍ Synthetic (Please specify type) (2) _____
- ❍ Other (Please specify) (3) _____

Q10 What size and shape mesh do you use?

Q11 Where do you place your mesh?

Q12 How do you secure your mesh?
- ❍ Suture (1)
- ❍ Staples (2)
- ❍ Other (Please Specify) (3) _____

Q13 Has your practice changed in the last 5 years?
- ❍ Yes (1)
- ❍ No (2)

If No Is Selected, Then Skip To Have you ever encountered any of the ...

Q14 How has it changed?

Q15 Why did you change your practice?

Q16 Have you ever encountered any of the following complications?

Mesh erosion (1)	❍	❍
Oesophageal Stenosis (2)	❍	❍
Pericardial Tamponade (3)	❍	❍
Mesh Infection (4)	❍	❍

If No Is Equal to 4, Then Skip To Are you a trainee?

Q17 Would you be happy for the research group to contact you further regarding the outcomes from these complications
- ❍ No (1)
- ❍ Yes (Please provide email address) (2) _____

Q18 Are you a trainee?
- ❍ Yes (1)
- ❍ No (2)

Q19 How many years have you been practising laparoscopic surgery?
- ❍ Less than 2 years (1)
- ❍ 2-5 years (2)
- ❍ 5-10 years (3)
- ❍ More than 10 years (4)

Q20 In what country do you practise?

Q21 Any other comments regarding laparoscopic repair of hiatus hernia?

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