Hernia (2019) 23:387–396
https://doi.org/10.1007/s10029-019-01888-x

ORIGINAL ARTICLE

Laparoscopic repair of type III/IV giant para-oesophageal herniae with biological prosthesis: a single centre experience

A. K. Shrestha[1] · M. Joshi[1] · L. DeBono[2] · K. Naeem[3] · S. Basu[4,5]

Received: 27 September 2018 / Accepted: 9 January 2019 / Published online: 19 January 2019

Abstract

Purpose Repair of giant paraoesophageal herniae (GPEH) is technically challenging and requires significant experience in advanced foregut surgery. Controversy continues on suture versus mesh cruroplasty with the most recent systematic review and meta-analysis putting the onus on the operating surgeon. Study aim was to review whether the biological prosthesis (non-cross-linked bovine pericardium and porcine dermis) and the technique adopted for patients with GPEH had an influence on clinical and radiological recurrences.

Method A retrospective analysis of a prospectively collected data of 60 consecutive patients with confirmed 5 cm hiatus hernia and ≥ 30% stomach displacement in the thorax that were operated in the upper gastrointestinal unit of a large district general hospital between September 2010 and August 2017. Pre and post-surgery Gastro-Oesophageal Reflux Disease Questionnaire [(GORD-HRQOL)] and a follow up contrast study were completed.

Results 60 included 2 (3%) and 58 (97%) emergency and elective procedures respectively with a male: female ratio of 1:3, age 71* (Median) (42–89) years, BMI 29* (19–42) and 26 (43%) with ASA III/IV. Investigations confirmed 46* (37–88) mm and 42* (34–77) mm transverse and antero-posterior hiatal defect respectively with 60* (30–100)% displacement of stomach into chest. Operative time and length of stay was 180* (120–510) minutes and 2* (1–30) days respectively. One (2%) converted for bleeding and 2 (3%) peri-operative deaths. Five (8%), 5 (8%) and 4 (7%) have dysphagia, symptomatic and radiological recurrences respectively. GORD-HRQOL recorded preoperatively was 27* (10–39) dropping significantly postoperatively to 0* (0–21) ($P < 0.005$) with 95% patient satisfaction at a follow up of 60* (36–84) months.

Conclusions Our technique of laparoscopic GPEH repair with biological prosthesis is safe with a reduced symptomatic and radiological recurrence and an acceptable morbidity and mortality.

Keywords Giant paraoesophageal herniae · Cruroplasty · Anti-reflux procedure · Biological prosthesis · GORD-HRQOL score

Introduction

Giant paraoesophageal hernia (GPEH), which accounts for 5% of all hiatus hernia, is defined as 30–50% displacement of the stomach above the diaphragm [1, 2]. Surgery is the recommended treatment for the medically fit symptomatic patients as complications (volvulus, obstruction and strangulation of the stomach) can lead to high morbidity and even mortality (up to 30%) [3, 4]. The advent of minimally invasive technologies and technique have shifted the surgical approach from thoracic and open abdominal to laparoscopic surgery [3] that was first reported in the literature in 1992 [5] and now compromises approximately 50% of all antireflux surgery [2, 6].

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s10029-019-01888-x) contains supplementary material, which is available to authorized users.

✉ S. Basu
sanjoy.basu@nhs.net

1 Department of General Surgery, East Kent Hospitals University NHS Foundation Trust (EKHUFT), Ashford, Kent, UK

2 Department of Surgery, One Ashford Hospital, Willesborough, Ashford, Kent, UK

3 Department of Radiology, EKHUFT, Ashford, Kent, UK

4 Department of Surgery, EKHUFT, Ashford, Kent, UK

5 Department of Surgery, William Harvey Hospital, Ashford, Kent TN24 0LZ, UK

The benefits of laparoscopic surgery are very well documented in the literature, however, disadvantages are longer operative time, learning curve for the surgeons and higher recurrence (up to 42%) for patients only having primary suture cruroplasty [1, 3, 7]. Hiatal reinforcement with non-absorbable synthetic mesh has reduced recurrence (< 10%), but can cause serious complications that include infection, short and long-term dysphagia, ulceration, erosion, fistulation and even oesophageal strictures [8]. Emergence and use of biological mesh for complex hiatal surgery that retains the buttressing effect of the synthetic mesh and possibly excludes their complications have been reported with varying success [3, 4, 9]. However, Oelschlager and Watson et al. have recently reported no difference in the outcome for patients with GPEH having suture cruroplasty versus hiatal reinforcement with porcine submucosa (SIS, Cook Biotech) [9, 10]. Although, studies initially had reported reduced recurrence following hiatal reinforcement with biological prosthesis (porcine submucosa), long-term review of these patients has been disappointing [9]. A recent systematic review including the meta-analysis of mesh versus suture cruroplasty for repair of giant hiatus hernia is still inconclusive and puts the discretion for mesh use on the operating surgeon [11]. Thus, disagreement regarding the use and type of mesh and its configuration and the preferred technique for repair of giant hiatus hernia continues amongst surgeons. This prompted authors to explore the use of biologics other than the porcine submucosa for hiatal reinforcement. Veritas, a bovine pericardium and Strattice, a porcine dermis, are both non-cross-linked extracellular matrix scaffolds meant to allow in situ soft tissue repair and regeneration [12]. They became available for clinical use in the United Kingdom in 2008 and 2010, respectively. Current evidence in primates/abdominal reconstruction states that following implantation; the mesh allows mild inflammatory reaction, vascularisation, cellular migration, regeneration and remodelling, and tissue integration. Non-cross-linked was preferred over cross-linked biologics based on the literature evidence of possible better remodeling and tissue integration, although having a higher risk of enzymatic degradation. Cross-linked meshes are also known to incite greater inflammatory reaction and could behave more like a synthetic mesh [12]. There is no published data as yet using these two materials for hiatal reinforcement for patients with GPEH including their long-term follow-up.

The primary objective of this study was to review whether the biological prosthesis (non-cross-linked bovine pericardium and porcine dermis) and the technique adopted for repair of symptomatic patients with GPEH had an influence on clinical and radiological recurrences. The secondary objectives were comparing pre and post- operative symptoms as well as complications associated with the repair.

Materials and methods

The local institutional review board approved the project. This was a retrospective review of a prospectively collected data from 60 consecutive patients who underwent surgical management of GPEH with biological prosthesis (Veritas and Strattice) between 2010 and 2014 in the upper gastrointestinal unit of a large district general hospital with a final clinical follow up in mid-2017 (September 2010 and August 2017). The median follow up for the symptomatic recurrence for this study was 60 months. Biological meshes used were from bovine pericardium [Veritas®—non-cross-linked (Synovis® Surgical Innovations, USA)] and porcine dermis [Strattice™—non-cross-linked (Lifecell)].

Study included patients that were symptomatic, medically fit and confirmed to have at least 5 cm of hiatus hernia in the cranio-caudal length (top of gastric folds to the crural pinch) and > 30% displacement of stomach in the thorax as determined by preoperative upper GI endoscopy (UGIE), barium swallow (BS) and computerised tomography (CT). Study excluded patients with previous history of surgery to the oesophago-gastric junction or stomach and those undergoing any other additional surgical procedure.

Patient demographics, body mass index (BMI), American Society of Anaesthesiologists (ASA), duration of symptoms, co-morbid conditions, investigations (UGIE, BS and CT) and operative details (number of hiatal sutures, intra and postoperative complications, operative duration and postoperative stay) were recorded.

A radiologist blinded for the study reported pre and postoperative barium and computerised tomography independently.

A standardised validated symptom and Health Related Quality of Life questionnaire for measuring symptom severity in Gastro-Oesophageal reflux disease (GORD-HRQOL) [13] was completed pre-operatively and at 6 months postoperatively by all patients. They were routinely followed in the surgical clinic at 8 weeks and via a telephone call every 6–2 months. GORD-HRQOL scale of 0–5, 6–10, 11–15 and more than 15 were graded as excellent, good, fair and poor, respectively as previously used by other researchers [13]. Patient's symptoms like bloating, flatulence, regurgitation, epigastric and chest pain, vomiting, weight loss, diarrhoea, coughing, wheezing and shortness of breath were documented both before and after surgery. Any presence of preoperative symptoms related to GPEH following surgery was deemed as symptomatic recurrence of the condition.

All patients were booked for a routine postoperative barium swallow/meal between 6 and 12 months post-surgery and were re-reviewed in the surgical clinic if there

were any concerns. They were also booked for UGIE, where deemed necessary. The left hemi diaphragm was taken as the height for the top of the wrap and any plication more than 2 cm (greatest vertical linear distance) above the left hemi-diaphragm was considered as recurrence of hiatus hernia in accordance with standard monitoring [9, 14]. However, for completeness we have also mentioned here about patients with < 2 cm migration of the wrap above the left hemi diaphragm. All patients were once again contacted in mid-2017 for a review including necessary investigations, where necessary, for completion of this data.

The first 30 consecutive patients had their hiatus reinforced with Veritas and the subsequent 30 consecutive patients underwent reconstruction with Strattice.

A single senior upper GI surgeon performed all procedures and the surgical technique that was standardised to treat GPEH with biological prosthesis in this study is detailed below [15, 16].

Patients receive a single dose of antibiotic prophylaxis (Augmentin 1.2 gm IV or Cefuroxime 1.5 gm IV) and Dexamethasone 4 mg IV on induction and 24-h 3 doses of 4 mg Ondansetron postoperatively. DVT prophylaxis of 40 mg subcutaneous Clexane is commenced 6-h after completion of the procedure.

Surgical technique [16]

The patient is placed in a reverse Trendelenburg Lloyd Davies position. The surgeon is stationed between the patient's legs. The procedure is performed with the placement of 10, 10, 5, and 5 mm ports in standard positions relevant for anti-reflux surgery (Fig. 1). Nathanson liver retractor is deployed following the induction of pneumoperitoneum to retract segments II and III of the liver.

The GPEH sac is dissected and freed from the mediastinum using the Harmonic scalpel, taking careful note to preserve the peritoneal covering of the crura and the vagi nerves. Extensive mediastinal dissection around the oesophagus allows ≥ 3 cm of intra-abdominal oesophagus without any tension followed by the excision of the hernial sac. The upper short gastric vessels are divided and haemostasis secured. The procedure is performed with gas pressure at 12 mmHg dropping to 8 mmHg only during suture cruraoplasty. Reduced intra-abdominal pressure to 8 mmHg allows suture cruroplasty to be completed under less tension and better preservation of the crural musculature. The diaphragmatic crura are juxtaposed posteriorly/anteriorly without tension with interrupted 0 polyester, braided sutures, e.g., Ethibond®. No releasing incisions are made on the diaphragm. A 3 cm, tennis-racquet-shaped transverse gap is created from the center of the shorter border of a 7 cm by 6 cm biological mesh (Fig. 2). The handle-end of the fashioned

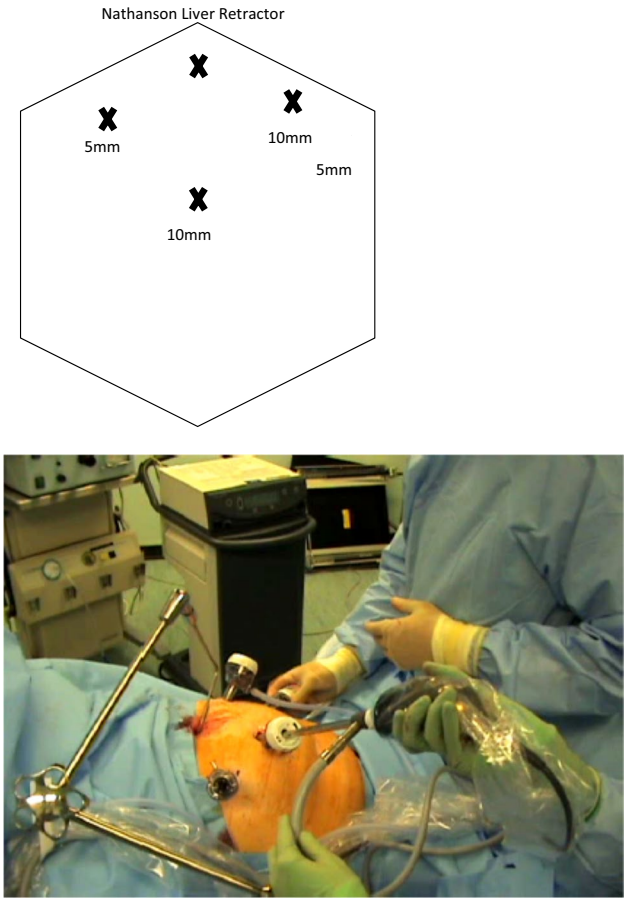

Fig. 1 Standard port placement

mesh is introduced from the right towards the left crus that bridges, if any, remnant hiatal defect and simultaneously accommodates the oesophagus loosely. The two loose ends of the mesh are kept apart (0.25–0.5 cm) on the left crus, thus, preventing full cerclage of the oesophagus and fixed to the diaphragm and crura with 5 interrupted, 0 polyester, braided sutures. Veritas is relatively easy to suture intracorporally laparoscopically, however, pliable Strattice being tougher still requires dedicated puncture (Nettleship instrument used) wounds at pre-determined sites for intracorporeal suturing (Fig. 2).

A 360° loose fundoplication is achieved with three interrupted 0 polyester, braided sutures (no bougie used) and then the anterior gastropexy is completed by securing the wrap to the diaphragm, mesh and the right crus with another five interrupted 0 polyester, braided sutures.

Postoperative care

After surgery, all patients are managed in the first 24–48 h in the high dependency unit and are allowed free fluids or soft diet the same day. This was increased to solids as tolerated the

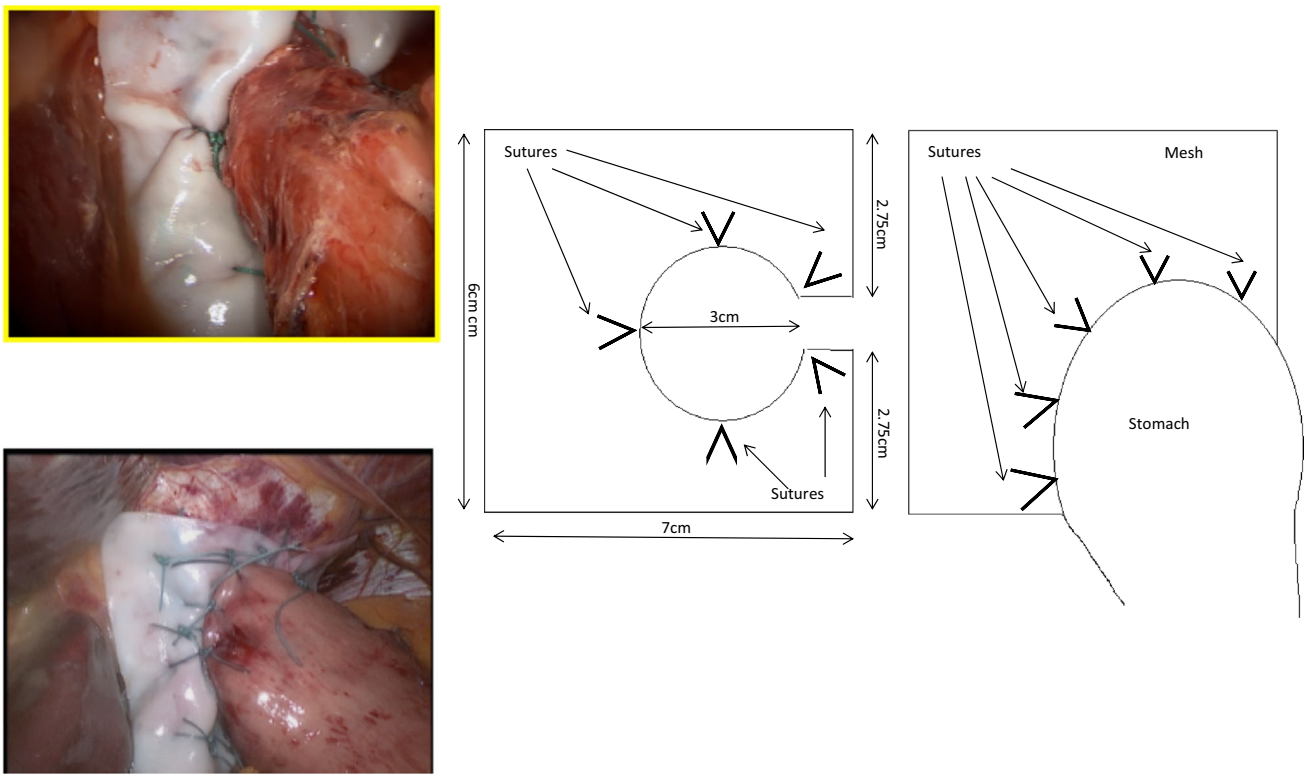

Fig. 2 Mesh placement and anterior gastropexy

following day. Patients are able to commence normal activities on discharge, however, are cautioned against any strenuous workouts till reviewed in clinic at 8 weeks. Routine contrast studies are not performed.

Statistical analysis

All data were collected in a well-structured proforma. Continuous data were expressed as a median with a range. Wilcoxon-sign rank test was used for analysis for paired categorical nonparametric data to compare clinical symptom and GORD-HRQOL scores outcome before and after surgery evaluate for any significant changes. Mann–Whitney *U* test and Chi-square test were used to compare non-parametric and qualitative data. *p* values $<0{\cdot}05$ was considered statistically significant. Statistical analysis was done with SPSS version 20 (IBM® SPSS® Statistics 20).

Results

60 patients underwent laparoscopic repair of GPEH with biological prosthesis between 2010 and 2014 with 2 (3%) and 58 (97%) as emergency and elective procedures respectively with a clinical review in mid-2017 (Table 1). 26 (43%) patients were over the age of 70 years with *M:F* ratio of 1:3 (approximately). 28 (47%) patients had BMI of 30 and over and 26 (43%) had ASA recorded at III and over.

All patients had UGIE performed by the operating surgeon. The procedure could not be completed in 11 (18%) patients due to extremely altered anatomy (Table 2).

20 (33%) and 52 (87%) had undergone barium study and oral contrast CT following their UGIE for confirmation of diagnosis and formulation of the management plan. 14 (23%) patients had undergone both investigations.

Preoperative investigations confirmed 46* (Median) (37–88) mm and 42* (34–77) mm transverse and antero-posterior hiatal defect, respectively, with 60* (30–100)% displacement of stomach into chest (Table 2). Operative time and length of stay was 180* (120–510) minutes and 2* (1–30) days, respectively (Table 3).

Tension free hiatal closure was achieved through anterior and posterior hiatal sutures in 58 (97%) and 60 (100%) patients, respectively, followed by the hiatal reinforcement with biological prosthesis. As part of anti-reflux procedure, all underwent a full 360° loose wrap followed by anterior gastropexy to the diaphragm, mesh and right crus. One (2%) underwent conversion for bleeding from the margin of the excised sac.

Table 1 Demographics

Total		Veritas (30)	Strattice (30)	*p* value	60 Patients
Age—(years) (range)		71[a] (42–89)	70[a] (49–85)	0.853◇	71[a] (42–89)
70+		15	11	0.45**	26 (43%)
Sex male:female		6:24	8:22	0.542**	14 (23%) 46 (77%)
BMI (range)		29[a] (19–42)	30[a] (23–39)	0.152◇	29[a] (19–42)
ASA Grade				0.099**	
I		2	3		5 (8%)
II		17	12		29 (48%)
III		10	14		24 (40%)
IV		1	1		2 (3%)
Type of admission					
Emergency	1		1		2 (3%)
Elective	29		29		58 (97%)

◇Mann–Whitney *U* test, **Chi-square test

[a]Median

Table 2 Investigations

Total	Veritas (30)	Strattice (30)	*p* value	60 Patients
OGD findings				
Z line (cm)	32[a] (26–41)	33[a] (25–40)	0.239◇	33[a] (25–41)
Oesophagitis	8	11	0.154**	19 (32%)
Hiatus Hernia (cm)	7[a] (5–9)	7.5[a] (5–10)	0.931◇	7[a] (5–10)
Incomplete	6	5	0.754**	11 (18%)
CT findings				
% Stomach in chest	60[a] (30–95)	60[a] (30–100)	1◇	60[a] (30–100)
Height above diaphragm (cm)	7.7[a] (45–114)	7.5[a] (44–115)	0.8◇	7.5[a] (44–115)
Transverse defect (cm)	4.8[a] (39–88)	4.6[a] (37–80)	0.8◇	4.6[a] (37–88)
Antero-posterior defect (cm)	4.5[a] (35–77)	4.2[a] (34–76)	0.7◇	4.2[a] (34–77)

◇Mann–Whitney *U* Test, **Chi-square test

[a]Median

Table 3 Perioperative findings

	Veritas (30)	Strattice (30)	*p* value	Total (60)
Anterior stitch	3[a] (0–5)	3[a] (0–6)	0.36◇	3[a] (0–6)
Posterior stitch	4[a] (1–7)	4[a] (1–8)	0.832◇	4[a] (1–8)
Combined stitch	7[a] (5–10)	7[a] (5–12)	0.4◇	7[a] (5–12)
360° Wrap	All	All		All
Duration (min)	180[a] (135–330)	180[a] (120–510)	0.621◇	180[a] (120–510)
Complications	1	0		1
Mortality	2	0		2
Length of stay (days)	2[a] (1–10)	2[a] (1–30)	0.247◇	2 (1–30)

◇Mann–Whitney *U* test, **Chi-square test

[a]Median

Both the mesh groups were evenly matched in terms of their sample size, demographics, hiatal defect size, operative findings (hiatal stitches and duration of surgery) and length of stay without any significant differences.

Follow up (Table 4)

Patients were contacted and/or reviewed either by telephone or at the outpatient clinics with a final review in mid-2017

that showed a symptomatic recurrence of 8% at the median follow up of 60 (36–84) months [Veritas Group 71* (60–84) months versus Strattice Group 50* (36–60) months]. In this study, no patients were lost to the follow up. Radiological recurrence of more than 2 cm was 7% with equal distribution amongst both groups.

Three (60%) of the 5 symptomatic recurrences, 3 (75%) of the 4 > 2 cm radiological recurrences and 7 (70%) of the 10 < 2 cm radiological recurrences had BMI > 30 recorded at the time of their operative interventions.

Symptom and Quality of Life Questionnaire (Table 5)

Presenting symptoms that included heartburn, regurgitation, dysphagia, chest pain, retrosternal discomfort, shortness of breath, and vomiting had significantly reduced/disappeared at 8 weeks after surgery and this was maintained at the median follow up of 60 months. Five (8%) patients had recurrence of their preoperative symptoms, although, much less in severity requiring maintenance dose of proton pump inhibitors. Two (4%) patients complained of chest pain at 8-weeks post surgery. Five (8%) patients complained of mild dysphagia (Grade I) at their subsequent follow up visits. Contrast studies showed slow transit in all with one patient showing oesophageal narrowing that required two episodes of dilatation with the subsequent contrast study being unremarkable. UGIE in the remaining four were normal. One patient has continued to complain of shortness of breath although all her other pre-surgery symptoms have settled completely. Two patients (3%) have bloating and another two (3%) have post-surgery diarrhoea. Two (3%) patients complained of inability to eat appropriately and fullness and recorded delayed gastric emptying in the contrast study requiring pyloric dilatations with an uneventful recovery.

The GORD-HRQOL was recorded as poor (> 15) in 55 (92%) patients with a median score of 27 before surgery. Following the repair GORD-HRQOL score was recorded as excellent in 58 (97%) patients with only a single patient (1.5%) having a poor GORD-HRQOL score. There was highly significant reduction in postoperative GORD-HRQOL with median score recorded as 0.

Table 4 Follow up

	Veritas (30)	Strattice (30)	*p* value	Total (60)
Barium study (6–12 months)				
Recurrence				
< 2 cm	5	5	1**	10 (17%)
> 2 cm	2	2	1**	4 (7%)
Delayed emptying	2	3	0.9**	5 (8%)
Follow up[a] (months)	71[a] (60–84)	50[a] (36–60)		60[a] (36–84)
Symptomatic recurrence				5 (8%)

◇Mann–Whitney *U* test, **Chi-square test

[a]Median

Mortality (Table 3)

The 30-day mortality was 3%. The first patient was an 83-year old man, with previous history of multiple pulmonary embolism [PE (on Warfarin)], died from myocardial infarction on the 2nd POD. The second was an 89-year-old woman who suffered from severe chronic obstructive pulmonary disease (COPD), PE, chronic renal failure and hypertension died on the 4th POD from massive gastrointestinal bleeding on commencement of therapeutic anticoagulation.

Reoperation

One patient (1.5%) with a symptomatic > 2 cm recurrent hiatus hernia underwent hiatal reoperation with strattice having previously undergone a hiatal reconstruction with Veritas for an uneventful recovery.

Discussion

Various surgical techniques have evolved over the years including the use of synthetic and biological meshes for hiatal reinforcement for patients with GPEH with no technique achieving or announcing a technical superiority over other [4, 17]. A meta-analyses of non-randomised series of laparoscopic PHH repair of 965 cases puts the overall recurrence rate at 10.2% [18]. However, a formal evaluation with barium swallow identifies recurrence at 25.5%. Various studies during their follow-up investigations have reported similar findings of radiological recurrence exceeding the symptomatic recurrence [9]. This study shows a 8% symptomatic and 7% radiological recurrence of > 2 cm following hiatal reconstruction with combined polyester suture cruroplasty reinforced with biological non-cross-linked extracellular matrix meshes of bovine and porcine origin for GPEH at a median follow up of 60 months.

Survey (2010) amongst SAGES members have shown a preference for biological mesh (67%) for those using mesh for hiatal reinforcement and mesh reinforcement (46%) for hiatal defect of 5 cm [19]. Prosthetic material implantation has routinely been proposed for large hiatal defects to reduce the recurrence rate to below 10% [20]. Result of hiatal reinforcement with biological prosthesis (porcine submucosa) although initially promising has proved disappointing with recurrence as high as 54% in the longer term compared to 59% recurrence for patients undergoing suture cruroplasty

Table 5 Symptoms and Quality of Life Questionnaire

Symptoms	Veritas (30)			Strattice (30)			Total (60)			*p* value❖
	Pre	Post	FU (m)	Pre	Post	FU (m)	Pre	Post	FU (m)	
		8 weeks	71* (60–84)		8 weeks	50* (36–60)		8 weeks	60* (36–84)	
Number of patients (%)										
Duration (years)	4* (1–40)			5* (1–30)			5* (1–40)			
Heartburn	24	2	3	25	1	2	49 (82%)	3 (5%)	5 (8%)	0.0004
Vomiting	15			12			27 (45%)			0.0039
Dysphagia	13	2	2	13	3	3	26 (43%)	5 (8%)	5 (8%)	0.005
Chest pain*	13	1		12	1		25 (42%)			0.004
Regurgitation	12			14			26 (43%)			0.0013
Retrosternal discomfort	14			14			28 (47%)			0.0013
Epigastric pain	6			5			11 (18%)			0.0016
Shortness of breath	8	1	1	7			15 (25%)		1	0.0014
Weight loss	7			6			13 (22%)			0.0014
Anaemia	5			6			11 (18%)			0.0034
Haematemesis	0			0			0			
Use of PPI	24	2	3	26	1	2	50 (83%)	3 (5%)	5 (8%)	0.0006
Gas bloat			2						2	NA
Diarrhoea						2			2	NA
Gastric outlet obstruction						2			2	NA

Symptom severity	Pre	Post (6–12 m)	Pre	Post (6–12 m)	Pre	Post (6–12 m)	
Heartburn	4* (0–5)	0* (0–2)	4* (0–5)	0* (0–3)	4* (0–5)	0* (0–3)	0.0001
Dysphagia	3* (0–5)	0* (0–2)	2* (0–5)	0* (0–4)	2* (0–5)	0* (0–4)	< 0.014
Odynophagia	3* (0–5)	0* (0–2)	2* (0–5)	0* (0–4)	2* (0–5)	0* (0–4)	< 0.01
Use of PPI	2* (0–5)	0* (0–2)	2* (0–5)	0* (0–2)	2* (0–5)	0* (0–2)	< 0.01

GORD- HRQOL Score	Veritas (30)		Strattice (30)		Total (60)		
Maximum 50	Number of patients (%)						
	Pre	Post (6–12 m)	Pre	Post (6–12 m)	Pre	Post (6–12 m)	
0–5	0	29 (97%)	0	29 (97%)	0	58 (97%)	
6 to 10	0	1 (3%)	1 (3%)	0	1 (1.5%)	1 (1.5%)	
11 to 15	3 (10%)	0	1 (3%)	0	4 (7%)	0	
> 15	27 (90%)	0	28 (94%)	1 (3%)	55 (92%)	1 (1.5%)	
Total Score	27* (12–39)	0* (0–7)	27* (10–37)	0* (0–21)	27* (10–39)	0* (0–21)	< 0.005

Post surgery	Patient feedback		
Satisfied	29 (97%)	28 (94%)	57 (95%)
Neutral	1 (3%)	2 (6%)	3 (5%)
Dissatisfied			

*Median, ❖Wilcoxon Sign rank test

[9]. Study by Watson et al. has also not exhibited any benefit for patients undergoing hiatal reinforcement with porcine submucosa showing a recurrence of 30.8% as compared to 23.1% following suture cruroplasty [10]. Historically, the unit had performed suture cruroplasty with 29% symptomatic recurrence further confirmed on contrast study for patients with giant PEH. This prompted the authors to explore other biologics available for hiatal reinforcement. Veritas, a non-cross-linked bovine pericardium, was used in the first 30 consecutive patients in the first 2 years (2010–2012) of the study. However, with the identification of clinical and radiological recurrence, although small, Strattice, another non-cross-linked porcine dermis, was chosen for the subsequent 30 consecutive patients for the next

2 years for an expected better outcome. The results show the two study groups to be comparable and evenly matched in terms of demographics, BMI, ASA, preoperative investigations, operative interventions, postoperative stay and their interval for postoperative investigations and even showed no significant difference in symptomatic and radiological recurrences. The only noticeable finding was the ease of intracorporeal suturing of Veritas over Strattice. The authors would like to state that the overall outcome here confirms a knee-jerk reaction that had prompted the switching of the mesh from veritas to strattice rather than an actual clinical indication. Overall, five (8%) symptomatically recurrent patients have significant improvement compared to their pre-surgery status and are only on maintenance doses of PPI's and the radiological recurrence > 2 cm was noted in only 4 (7%) patients. However, for completeness we mention here another 10 (16%) patients with < 2 cm recurrence. Only one of these ten patients has a symptomatic recurrence. Thus, the authors feel the contrast study that was routinely performed, as part of the study protocol should possibly be reserved only for patients presenting with a symptomatic recurrence after surgery. Higher incidence of both symptomatic and radiological recurrences was noted in patients with BMI > 30 recorded at the time of their operative interventions.

Postoperative dysphagia is reported between 0 and 34.3% with varied configuration in mesh placement [14, 20, 21] and there is evidence of oesophageal dysmotility in patients of long standing GPEH [22]. In this study, five (8%) patients continue to complain of mild dysphagia to solids and investigations have excluded a mechanical obstruction, thus, raising the possibility of functional dysphagia. Perihiatal scar formation is recognised following hiatal surgery [23] that could cause vagal dysfunction which was evident in four of our patients complaining of diarrhoea well controlled on low dose loperamide and slow gastric emptying responding to pyloric dilatation, respectively.

Crural repair is one of the key steps in the repair of hiatus hernia [4]. The most common method of primary repair is either a continuous or interrupted sutures on the hiatus. Meta-analyses from 2004, reported 14% recurrence for 1331 patients undergoing primary laparoscopic repair of PHH [21]. Most studies report only posterior hiatal sutures that can lead to distortion or angulation at the distal oesophagus contributing to dysphagia/odynophagia or otherwise could leave behind an anterior hiatal weakness. In our study, 97% patients required an anterior cruroplasty, which is well accepted [23], in addition to the posterior suture cruroplasty in all.

Leaving the hernial sac in the mediastinum especially in continuity with the intra-abdominal peritoneum gives rise to high recurrences [24]. True incidence of oesophageal shortening is once again unknown with figures reported between 0 and 60% for patients of GPEH. No preoperative investigation is completely reliable at predicting a shortened oesophagus [25]. Mobilisation and excision of hernia sac and extensive mediastinal dissection achieved at least 3 cm of intra-abdominal oesophagus in all our patients, thus, excluding the need for oesophageal lengthening and its associated serious complications (10%) [26].

Fundoplication that anchors the stomach in abdomen was routinely performed and prevents reflux: is reported in as high as 65% patients not having an anti-reflux procedure for repair of paraoesophageal herniae [27]. Positive intra-abdominal and negative intra-thoracic pressure creates a cephalad force favouring thoracic migration of stomach. In this series, further anterior gastropexy in conjunction with fundoplication possibly prevented or reduced this migration.

Our operating time and hospital stay are comparable to previous studies [4, 14]. Literature reports morbidity of 25% and mortality ranging from 0.5 to 20% for open and laparoscopic repair of GPEH [9, 14, 28] and even higher for elderly patients with associated significant comorbidities [7, 29]. Current evidence suggests operative intervention to be based on three factors: patients overall medical status, symptomatic complaints and the risk of incarceration and strangulation [3]. Of the 60 patients, 26 (43%) were > 70 years and 26 (43%) were ≥ ASA III. In this series, 22% and 3% patients suffered from morbidity (5 dysphagia, 2 gas bloat, 2 diarrhoea, 2 gastric outlet obstructions and 2 chest infections) and peri-operative mortality respectively. Another routine death was reported during the follow up. Thus, a selective approach to surgery for only symptomatic medically fit patients is justified [30]. There were no mesh related complications and the study recorded 95% (57) patient satisfaction with significant improvement in all preoperative symptoms and GORD-HRQOL scores.

The hiatus is an extremely dynamic area (moving more than 21,000 times per day) and simple suture cruroplasty has a reported recurrence of up to 42% for patients with GPEH [1]. Synthetic meshes despite reducing recurrences (< 10%) have risks of serious complications and data on hiatal reinforcement with biological prosthesis (porcine submucosa) till date has been disappointing [9, 10]. Recent systematic review and meta-analysis puts the onus of hiatal mesh reinforcement on the operating surgeon [11]. This study shows global hiatal reinforcement in the form of incomplete cerclage with the biological mesh (non-cross-linked extracellular matrix) implantation provided acceptable morbidity and mortality and reduced symptomatic and radiological recurrence with significantly improved quality of life in the early and intermediate-term post-surgery follow up. There is a difference in follow up between the two groups, however, a median follow up of 50 months is a reasonable time period for the Group B patients to draw conclusions. We recognize here that this is a retrospective analysis of a prospectively collected study of a small sample size that would be

perceived as a limitation and a weakness. Since the results are encouraging, we recommend a multi-centric study with a standardised protocol for the adoption of this technique and use of non-cross-linked extracellular matrix scaffolds for hiatal reconstructions/reinforcement be performed with long-term follow-up to ensure a definite conclusion for this complex challenging surgical condition.

Compliance with ethical standards

Conflict of interest Authors would like to confirm here that there is no conflict of interest.

Ethical approval The study received approval from the local institutional review board. The meshes used were approved for use in the United Kingdom.

Human and animal rights All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Permission were obtained from patients for use in the article.

References

1. Hashemi M, Peters JH, DeMeester TR, Huprich JE, Quek M, Hagen JA, Crookes PF, Theisen J, DeMeester SR, Sillin LF, Bremner CG (2000) Laparoscopic repair of large type III hiatal hernia: objective followup reveals high recurrence rate. J Am Coll Surg 190(5):553–560 **(discussion 560–551)**
2. Mitiek MO, Andrade RS (2010) Giant hiatal hernia. Ann Thorac Surg 89(6):S2168–S2173. https://doi.org/10.1016/j.athoracsur.2010.03.022
3. Sheff SR, Kothari SN (2010) Repair of the giant hiatal hernia. J Long-term Effects Med Implants 20(2):139–148
4. Mori T, Nagao G, Sugiyama M (2012) Paraesophageal hernia repair. Ann Thorac Cardiovasc Surg 18(4):297–305. https://doi.org/10.5761/atcs.ra.12.01882
5. Cuschieri A, Shimi S, Nathanson LK (1992) Laparoscopic reduction, crural repair, and fundoplication of large hiatal hernia. Am J Surg 163(4):425–430
6. Engstrom C, Cai W, Irvine T, Devitt PG, Thompson SK, Game PA, Bessell JR, Jamieson GG, Watson DI (2012) Twenty years of experience with laparoscopic antireflux surgery. Br J Surg 99(10):1415–1421. https://doi.org/10.1002/bjs.8870
7. Luketich JD, Nason KS, Christie NA, Pennathur A, Jobe BA, Landreneau RJ, Schuchert MJ (2010) Outcomes after a decade of laparoscopic giant paraesophageal hernia repair. J Thorac Cardiovasc Surg 139(2):395–404. https://doi.org/10.1016/j.jtcvs.2009.10.005 **(404 e391)**
8. Hazebroek EJ, Leibman S, Smith GS (2009) Erosion of a composite PTFE/ePTFE mesh after hiatal hernia repair. Surg Laparosc Endosc Percutaneous Tech 19(2):175–177. https://doi.org/10.1097/SLE.0b013e3181a11926
9. Oelschlager BK, Pellegrini CA, Hunter JG, Brunt ML, Soper NJ, Sheppard BC, Polissar NL, Neradilek MB, Mitsumori LM, Rohrmann CA, Swanstrom LL (2011) Biologic prosthesis to prevent recurrence after laparoscopic paraesophageal hernia repair: long-term follow-up from a multicenter, prospective, randomized trial. J Am Coll Surg 213(4):461–468. https://doi.org/10.1016/j.jamcollsurg.2011.05.017
10. Watson DI, Thompson SK, Devitt PG, Smith L, Woods SD, Aly A, Gan S, Game PA, Jamieson GG (2015) Laparoscopic repair of very large hiatus hernia with sutures versus absorbable mesh versus nonabsorbable mesh. Ann Surg 261(2):282–289
11. Tam V, Winger DG, Nason KS (2016) A systematic review and meta-analysis of mesh vs suture cruroplasty in laparoscopic large hiatal hernia repair. Am J Surg 211(1):226–238. https://doi.org/10.1016/j.amjsurg.2015.07.007
12. Sun WQ, Xu H, Sandor M et al (2013) Process-induced extracellular matrix alterations affect the mechanisms of soft tissue repair and regeneration. J Tissue Eng 4:2041731413505305
13. Velanovich V, Vallance SR, Gusz JR, Tapia FV, Harkabus MA (1996) Quality of life scale for gastroesophageal reflux disease. J Am Coll Surg 183(3):217–224
14. Oelschlager BK, Pellegrini CA, Hunter J, Soper N, Brunt M, Sheppard B, Jobe B, Polissar N, Mitsumori L, Nelson J, Swanstrom L (2006) Biologic prosthesis reduces recurrence after laparoscopic paraesophageal hernia repair: a multicenter, prospective, randomized trial. Ann Surg 244(4):481–490. https://doi.org/10.1097/01.sla.0000237759.42831.03
15. Shrestha A, Kumar R, Yusuf M, Abbey Y, Basu S (2013) Repair of type III/IV giant para-oesophageal herniae with biological prosthesis: a 5-year single centre experience. Br J Surg 100(S7):32–33
16. Alubaidi K, Shrestha A, Joshi M, Basu S (2016) Type III/type IV giant para-oesophageal herniae: our technique of gastropexy with biological prosthesis. Surg Sci 7(5):226–229. https://doi.org/10.4236/ss.2016.75031. doi
17. Antoniou SA, Pointner R, Granderath FA (2011) Hiatal hernia repair with the use of biologic meshes: a literature review. Surg Laparosc Endosc Percutaneous Tech 21(1):1–9. https://doi.org/10.1097/SLE.0b013e31820ad56c
18. Rathore MA, Andrabi SIH, Bhatti MI, Najfi SMH, McMurray A (2007) Metaanalysis of recurrence after laparoscopic repair of paraesophageal hernia. JSLS J Soc Laparoendosc Surg Soc Laparoendosc Surg 11(4):456–460
19. Pfluke JM, Parker M, Bowers SP, Asbun HJ, Daniel Smith C (2012) Use of mesh for hiatal hernia repair: a survey of SAGES members. Surg Endosc 26(7):1843–1848. https://doi.org/10.1007/s00464-012-2150-6
20. Granderath FA, Schweiger UM, Kamolz T, Asche KU, Pointner R (2005) Laparoscopic Nissen fundoplication with prosthetic hiatal closure reduces postoperative intrathoracic wrap herniation: preliminary results of a prospective randomized functional and clinical study. Arch Surg (Chicago, Ill: 1960) 140(1):40–48. https://doi.org/10.1001/archsurg.140.1.40
21. Soricelli E, Basso N, Genco A, Cipriano M (2009) Long-term results of hiatal hernia mesh repair and antireflux laparoscopic surgery. Surg Endosc 23(11):2499–2504. https://doi.org/10.1007/s00464-009-0425-3
22. Chrysos E, Prokopakis G, Athanasakis E, Pechlivadides G, Tsiaoussis J, Mantides A, Xynos E (2003) Factors affecting esophageal motility in gastroesophageal reflux disease. Arch Surg 138(3):241–246
23. Watson DI, Jamieson GG, Devitt PG, Kennedy JA, Ellis T, Ackroyd R, Lafullarde TA (2001) A prospective randomised trial of laparoscopic Nissen fundoplication with anterior vs posterior hiatal repair. Arch Surg 136(7):745–751
24. Oddsdottir M (2000) Paraesophageal hernia. Surg Clin N Am 80(4):1243–1252

25. Madan AK, Frantzides CT, Patsavas KL (2004) The myth of the short esophagus. Surg Endosc 18(1):31–34. https://doi.org/10.1007/s00464-002-8611-6
26. Martin TR, Ferguson MK, Naunheim KS (1997) Management of giant paraesophageal hernia. Dis Esophagus 10(1):47–50
27. Ponsky J, Rosen M, Fanning A, Malm J (2003) Anterior gastropexy may reduce the recurrence rate after laparoscopic paraesophageal hernia repair. Surg Endosc 17(7):1036–1041. https://doi.org/10.1007/s00464-002-8765-2
28. Schauer PR, Ikramuddin S, McLaughlin RH, Graham TO, Slivka A, Lee KK, Schraut WH, Luketich JD (1998) Comparison of laparoscopic versus open repair of paraesophageal hernia. Am J Surg 176(6):659–665
29. Larusson HJ, Zingg U, Hahnloser D, Delport K, Seifert B, Oertli D (2009) Predictive factors for morbidity and mortality in patients undergoing laparoscopic paraesophageal hernia repair: age, ASA score and operation type influence morbidity. World J Surg 33(5):980–985. https://doi.org/10.1007/s00268-009-9958-9
30. Maziac D, Pearson F Massive (paraesophageal) hiatal hernia. Pearson's thoracic and esophageal surgery, 3rd edn. Churchill Livingstone, Philadelphia