A Collective Review on Mesh-Based Repair of Umbilical and Epigastric Hernias

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Abstract In accordance with the tension-free principles for other hernias, umbilical and epigastric hernia repair should probably be mesh-based. The number of randomized studies is increasing, most of them showing significantly less recurrences with the use of a mesh. Different devices are available and are applicable by several approaches. The objective of this review was to evaluate recent literature for the different types of mesh for umbilical and epigastric hernia repair and recurrences after mesh repair. A multi-database search was conducted to reveal relevant studies since 2001 reporting mesh-based repair of primary umbilical/epigastric hernia and their outcomes in adult patients. A total of 20 studies were included, 15 of them solely involved umbilical hernias, whereas the remaining studies included epigastric hernias as well. A median of 124 patients (range, 17–384) was investigated per study. Three quarters of the included studies had a follow-up of at least 2 years. Six studies described the results of laparoscopic approach, of which one reported a recurrence rate of 2.7 %; in the remaining studies, no recurrences occurred. Two comparative studies reported a lower incidence of complications and postoperative pain after laparoscopic repair compared to open repair. Seventeen studies reported results of open techniques, of which seven studies showed no recurrence. Other studies reported recurrence rates up to 3.1 %. A wide range of complication rates were reported (0–33 %). This collective review showed acceptable recurrence rates for mesh-based umbilical and epigastric hernia repair. A wide range of devices was investigated. A tendency toward more complications after laparoscopic repair was found compared to open repair.

Keywords Mesh herniorraphy · Mesh · Epigastric hernia repair · Umbilical hernia repair · Recurrence · Laparoscopy

Introduction

Umbilical hernias are the most common type of linea alba abdominis defects in adults, followed by epigastric hernia [1, 2]. They both represent 10–15 % of all primary hernias [3–5]. However, in contrast to all other primary hernias, there is no consensus whether the repair of umbilical and epigastric hernias should be mesh-based. Several randomized controlled trials (RCTs) as well as various cohort studies and a systematic review have pointed out the superiority of mesh over sutures in terms of recurrences [6–11]. Complication rates and postoperative pain after mesh repair are investigated for inguinal hernias, but are not reviewed for umbilical and epigastric hernias [12]. The purposes of this collective review were to focus on the different mesh devices placed in open and laparoscopic approach as well as evaluate reported recurrence as the primary outcome and complications and postoperative pain as the secondary outcome.

Pathophysiology

The pathophysiology of umbilical hernias in adults is still a matter of debate. These hernias do not persist from childhood, but arise *de novo* in adult life. Umbilical hernias in adults are indirect hernias, which herniate through the umbilical canal. The umbilical canal is bordered posteriorly by the umbilical fascia, anteriorly by the linea alba and medially by the two rectus sheaths. Therefore, these hernias tend to incarcerate and strangulate and do not resolve spontaneously like the direct infantile umbilical hernia [1]. Umbilical

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hernias are five times more common in women than men and usually occur after the age of 35 years [1, 5, 13]. Pregnancy is proposed to be a predisposing factor for umbilical hernias [14].

Epigastric hernias are related to extensive strain on the anterior wall of the aponeurosis. The midline aponeurotic area can be divided into an upper and lower abdominal wall, divided by the lowest tendinous intersection. Above the umbilicus, most aponeurotic fibres cross the midline and appear as superficial fibres of the opposite side. When crossing over from one side to the other side, these fibres decussate with the fibres of the opposite side [1]. Epigastric hernias protrude between these fibres. The definition of an epigastric hernia is a protrusion of extraperitoneal fat, with or without a peritoneal pouch, between the decussating fibres or through a perforating vessel lacunae of the linea alba abdominalis, occurring from the xyphoid to the umbilical ring, without the orifice in the linea alba being connected to the umbilical ring [15]. Uncoordinated tearing strains on the aponeurotic fibres of the linea alba, for instance in vigorous sports, coughing, or vomiting, will stretch the crossing fibres and allow the development of fatty protrusions between their bundles [1, 2]. Approximately 3–5 % of the population suffers from epigastric hernias. It is thought that epigastric hernias are two to three times more common in men, with a higher incidence in patients from 20 to 50 years [5, 14].

Methods

Search Strategy

The Medline database, CINAHL, Embase and Pubmed, including e-links to related articles, and the clinical trial registry of the Cochrane Collaboration were searched for relevant clinical studies reporting mesh treatment and the outcome of umbilical and epigastric hernias.

The strategy was by free text words: *hernia and epigastric* or umbilic* and repair or treatment or surgery or operation or laparosc* or mesh*. Medical subject headings were used whenever possible. Those studies considered for full critical appraisal were published between March 2001 and December 2012. The search was limited to human studies, and only English articles were included. Two reviewers independently reviewed the publications (JP/SN). All references were cross-checked for literature that was not found in the database. The following data were extracted from full articles only: study design, number of included and evaluated patients, type of hernia and diameter, procedure of mesh placement, type of mesh material, length of follow-up, recurrence rate, complications and postoperative pain.

Selection Criteria

All retrospective cohort studies, prospective cohort studies, case-control studies and RCTs, which reported outcomes of mesh-based repair of epigastric or umbilical hernias, were included. Paediatric studies were excluded for analysis. Articles studying all types of ventral hernias without presenting recurrence rates in subgroups for primary epigastric and primary umbilical hernias were excluded. Studies were also excluded if the type of mesh material used was not reported. A minimum of ten mesh-operated patients and at least a mean or median follow-up of 4 months were requirements for inclusion. Description of the primary outcome measure recurrence was required. Secondary outcome measures as complications and postoperative pain rates were not required for inclusion.

Quality Assessment

The quality of the included RCTs was judged on the quality of randomization, blinding, baseline characteristics, loss to follow-up and intention-to-treat analysis. The quality of cohort studies was assessed by investigating baseline characteristics, selection bias, method of intervention, blinding, follow-up, selective loss to follow-up and confounding factors. These factors were namely used as a guide to evaluate the RCTs and the cohort studies. No studies were excluded because of poor quality.

Data Analysis

Some included studies investigated not only mesh repair but also tissue or Mayo repair. All mesh-operated patients were extracted and pooled. Total recurrence, complications and postoperative pain rates were calculated. A weighted mean follow-up was calculated for the total of the mesh-operated patient group. Mean follow-up or median follow-up figures were extracted or calculated. Means were also calculated for the included hernia size and actual operated hernia size.

The type of mesh material used was noted per study. Subjects treated with the same device were pooled for subgroup analysis. Recurrence rates were extracted or calculated for the pooled mesh-type subgroups. The same was done for complications and postoperative pain if reported separately for primary epigastric and umbilical hernia and separate for mesh material.

In subgroup analysis, the patients were once more pooled into a laparoscopic mesh placement group and open mesh placement group. The recurrence, complications and postoperative pain outcome were also extracted for these two groups.

Results

Description of the Studies

The cumulative search in the databases identified 649 publications based on the title and abstract. Thirty-four articles were potentially relevant and underwent critical appraisal on full text. Twenty studies fulfilled the selection criteria and were included for this collective review.

All included studies were graded by the standards for the quality of evidence. For grading the level of evidence, the Australian National Health and Medical Research Council Evidence Hierarchy was used [16]. All included RCTs were also separately graded by a score first described by Jadad et al. [17].

Seven of the included studies were prospective studies [6–8, 18–21]. Four of them were graded level II evidence [6, 7, 19, 20], one level III-1 [18], and two studies were graded level III-2 evidence [8, 21]. Some of the remaining retrospective studies were also graded level III-2 evidence [9, 10, 22–29] or level IV [30–32].

The Jadad score (scale 0–5) was different for the four RCTs: score 5 [20], score 3 [6], score 2 [7] and score 1 [19].

The quality of the observational studies was inferior to the RCTs, with unclear reporting of several secondary outcomes, like complications and postoperative pain. All studies reported recurrence rates in a relatively uniform fashion, although sometimes this was not reported for the mesh subgroups. The characteristics of the included RCTs and observational studies are summarized in Table 1.

The 20 included studies describe 2,484 patients, with a mean patient group of 124 patients. The patient groups extracted for mesh repair only consisted of 1,380 patients, with a mean of 69 mesh-operated patients per study. The weighted mean follow-up of the included studies was 40.3 months (range, 4.5–65 months). Thirteen studies reported the number of female and male patients [6–9, 18, 19, 21, 22, 25–28, 30, 32]. When pooling the data, the calculated mean female–male ratio for the extracted mesh operated group was 1:1.

Recurrence, Complications and Postoperative Pain After Mesh Repair

Of all the mesh-operated patients ($n=1,380$), recurrence rates were reported in all included studies. Nine studies reported no patients with hernia recurrence after mesh repair [6, 9, 19–21, 26, 27, 30, 32]. Hernia recurrence occurred in 28 patients (2.0 % of the total), with a weighted mean of 2.0 % per study.

Complications after mesh repair were reported in 15 studies, with a total of 978 mesh-operated patients [6–10, 18–20, 22, 23, 25, 27, 28, 30, 32]. Complications were described in

121 cases (12.4 %). In these 15 studies, the reported complications were relatively similar, including seroma, wound infections and haematoma. Some studies additionally reported intolerance to prosthesis, urinary retention, pneumonia, phlebitis, thrombosis, fistula formation and cardiac arrhythmia. Postoperative pain was noted separately and not included in the complication rate. Postoperative pain was described in seven studies, of which only four studies were suitable for analysis [7, 18–22, 27]. The other three studies reported only mean pain scores after surgery; the number of patients suffering from postoperative pain was not reported [19]. These median pain scores were not measured at comparable moments after surgery, so this outcome was not suitable for analysis. The five included studies describe 502 patients. In 42 patients, postoperative pain was reported (9.0 %). Further study-specific outcome rates are shown in Table 1.

Different Types of Mesh Devices Used

Five studies investigated differences types of mesh within their study [6, 18, 19, 25, 27, 28]. All used mesh devices were noted and divided into five groups (Table 2): flat and/or plug polypropylene, flat expanded polytetrafluoroethylene (ePTFE), Ventralex™, Prolene Hernia System™ (PHS™) and Parietex™.

Patients in whom Vypro™ was used were included in the flat and/or plug polypropylene group. Vypro™ is a flat polypropylene mesh with a vicryl stitch in the middle, which is only used in one included study [18]. Flat polypropylene and plug polypropylene were combined as only one study reported a recurrence rate for plug separately. No complications and postoperative pain rates were reported for plug repair only. The ratio of plug/flat mesh in the polypropylene group was 0.3:1.

The recurrence rate was lowest in the PHS™ and Parietex™ groups (0.0 %), followed by the flat and/or plug polypropylene group (1.7 %). The flat ePTFE and Ventralex™ groups showed higher recurrence rates of 2.5 and 3.4 %, respectively.

The lowest complication rate was seen in the Ventralex™ group (4.1 %). In the other groups, the complication rates were higher: 11.4 % (flat ePTFE group), 11.8 % (PHS™ group), 12.7 % (flat and/or plug polypropylene group) and 73.7 % (Parietex™).

No postoperative pain was seen in patients after hernia repair with ePTFE (0.0 %). The Ventralex group and the flat and/or plug polypropylene group showed postoperative pain rates of 5.0 and 12.1 %, respectively. Postoperative pain rate was reported for Parietex™, however not suitable for analysis as only the mean

Table 1 Characteristics of the included RCTs and observational studies

Study reference	Mesh-operated patients	Mesh type	Mean operated and included defect size (cm)	Mean ^a follow-up (months, range)	Recurrence (%)	Complications (%)	Postoperative pain (%)
[6] ^b	21	PP (flat mesh)	4.7, incl. 3–6	16 (6–24)	0.0	28.6	NR
[7] ^b	100	PP (flat mesh/plug, 32/68)	NR, incl. all sizes	64 (21–80)	1.0	11.0	5.0
[22]	213	PP(flat-mesh/plug, 70/143)	NR, incl. all sizes	64 (21–80)	0.9	11.3	15.0
[29]	132	PP (flat mesh/plug/PHS TM)	NR, incl. >1	NR	3.0	NR	NR
[31] ^c	31	ePTFE (GT)	NR, incl. NR	45 (12–84)	9.7	NR	NR
[18]	116	Vypro TM (Eth.) or Ventralex TM (Dav., 56/60)	1.24, incl. ≤3	39.6 (24–56)	6.0	6.0	4.3
[20] ^b	38	PX (Cov.) or PX (Cov.)	NR, incl. 1.5–5	16	0.0	73.7	NR, only mean pain scores
[8]	48	PP (flat mesh)	5.94, incl. for mesh ≥3	37 (6–66)	2.1	16.7	NR
[23]	65	PP (flat mesh) or PTFE*** (61/4)	NR for mesh group only	19.9 (1–57)	1.5	1.5	NR
[24]	138	PP, Surgisis, Gore-Tex, Composite	NR, incl. NR	47.1 (1–141)	1.4	NR	NR
[25]	52	PP (flat mesh) or ePTFE (20/32)	17.85, incl. all sizes	23.2	7.7	15.4	NR
[26]	12	PP (flat mesh)	NR, incl. NR	Median 32 (10–67)	0.0	NR	NR
[30]	17	PP (flat mesh)	1.96, incl. 1–3	36.2 (13–62)	0.0	17.6	NR
[21]	89	PP (flat mesh)	3.1, incl. 1–10	17 (5–41)	0.0	NR	NR
[27]	35	PP (flat mesh) or ePTFE (9/26)	1.95, incl. NR	24 (12–84)	0.0	20.0	0.0
[32]	88	Ventralex TM (Dav.)	NR, incl. NR	4.5 (0.3–4.6)	0.0	4.5	NR
[19] ^b	32	PP (PHS TM /flat mesh, 17/15)	NR, incl. <4	22 (6–44)	0.0	15.6	NR, only mean pain scores
[9]	39	PP (flat mesh/plug, 6/33)	96.7 % <5, incl. NR	Median 54 (12–96)	0.0	0.0	NR
[10]	64	PP (flat mesh/plug, 52/12)	2.6, incl. NR	52.9 (8–60)	3.2	7.8	NR
[28]	50	PP (flat mesh) or ePTFE (GT, 20/30)	26.4, incl. NR	25	2.0	4.5	NR

PP polypropylene, PX ParietexTM, GT Gore-Tex Dual Mesh, NR not reported, Eth. Ethicon, Dev. Devol Inc. Cov. Covidien, Incl. included size, PHSTM Prolene Hernia System, ePTFE = expanded polytetrafluoroethylene, PTFE polytetrafluoroethylene

^a Unless otherwise specified as median

^b Randomized controlled trial

^c One Spigelian hernia included

scores were given. Postoperative pain rate was not reported for the PHSTM group.

A subgroup analyses was performed for recurrence, complications and postoperative pain between the level 1

Table 2 Performance of mesh devices used

Mesh type	Recurrence (%), CI (n/N)	Complications (%), CI (n/N)	Postoperative pain (%), CI (n/N)
Flat and/or plug polypropylene	1.7, 0.9–2.6 (15/861)	12.7, 10.1–15.3 (79/622)	12.1, 8.5–15.7 (39/322)
Flat ePTFE	2.5, 0.0–5.3 (3/119)	11.4, 4.7–18.0 (10/88)	0.0, 0.0–11.5 (0/26)
Ventralex TM	3.4, 0.5–6.3 (5/148)	4.1, 0.9–7.2 (6/148)	5.0, 0.0–10.5 (3/60)
Parietex TM	0.0, 0.0–7.9 (0/38)	73.7, 59.7–87.7 (28/38)	NR
PHS TM	0.0, 0.0–7.6 (0/17)	11.8, 0.0–27.1 (2/17)	NR

N = total of which recurrence/complications/postoperative pain rate was noted

NR not reported

evidence-rated studies and the level 2 evidence-rated studies. No significant differences were seen between the two evidence groups.

Laparoscopic Mesh Repair Versus Open Mesh Repair

Seven studies investigated only laparoscopic mesh repair or compared laparoscopic placement to open mesh repair or open suture herniorrhaphy [20, 24, 25, 27, 28, 30, 31]. The other 12 studies investigated open mesh placement or compared open mesh to suture herniorrhaphy [6–10, 18, 19, 21–23, 26, 29, 32]. The pooled results of the laparoscopic studies show a recurrence rate of 1.0 % compared to 2.6 % in the pooled open mesh repair group (Table 3).

The reported complication rate shows a large contrast compared to the open placement group. In the laparoscopic group, a mean complication rate of 25.2 % was calculated compared to a complication rate of 10.2 % in the open mesh repair group (Table 3).

No patients reported postoperative pain in the laparoscopic mesh repair group, or the mean pain scores were not usable for analysis. In the open mesh placement group, 9.8 % of the patients suffered from postoperative pain.

Thirteen studies reported operation time in mean or median [6, 7, 18–20, 22, 24, 25, 27, 28, 30–32]. Mean operative time was used; in one study, only the median operation time was reported [27]. The mean operation time for laparoscopic mesh repair was 77.5 min compared 60.7 min for open mesh repair.

Discussion and Conclusion

The aim of this review was to evaluate the recurrence of epigastric and umbilical hernias after mesh repair. Based on an analysis of 20 studies meeting our inclusion criteria, recurrence of an epigastric or umbilical hernia occurred in 2.0 % after mesh repair. This is regarded as an acceptable recurrence rate. In one study, it was found that the recurrence rate was decreased tenfold since the use of mesh [11].

The secondary outcomes of this review were the complication rate and the postoperative pain rate. When pooling the data, an overall complication rate of 12.4 % was shown. All studies included standard complications: seroma, wound infections and haematoma. A variety of additional complications

were reported in some studies. Despite its heterogeneity, all complications reported were pooled, creating an overall complication group.

Postoperative pain was reported in 9.0 % of the mesh-operated patients, which was presented in four articles. The moments of measurement remained unclear. In this review, a wide range of different mesh devices was used. Nevertheless, a subgroup analysis was performed focusing primarily on the recurrence rates and secondarily on the complication rates and postoperative pain rates. Table 2 shows a clear and complete overview of these factors for the different mesh devices. The most common used mesh devices for epigastric and umbilical hernias seemed to be included in this review. Although it could well be that in the selection process other mesh devices are excluded, the authors suggest that this is a rather complete overview of mesh devices.

PHSTM has the lowest recurrence rate of 0 %. The investigated patient group was small compared to the other mesh groups, but like other studies specific for PHSTM repair, a 0 % recurrence rate was reported [33]. In this review, no results were reported for postoperative pain in the PHSTM group. In other series, patients reported no postoperative pain after PHSTM repair for umbilical or epigastric hernias [33].

The flat and/or plug polypropylene group was largest and therefore had the biggest statistical power. The recurrence rate of 1.7 % as well as the 12.7 % complications and 12.1 % postoperative pain rates can be regarded as representative.

VentrexTM repair was associated with the highest recurrence rate. On the other hand, the lowest complication rate of 4.1 % was reported. Possibly, we have excluded other studies that investigated complications with VentrexTM in the selection process. However, in other series, which solely investigate VentrexTM repair in ventral hernias, similar or slightly higher recurrence rates were reported [34, 35]. Although Tollens et al. [35] investigated incisional hernia repair with VentrexTM as well, these result may not be representative for primary umbilical and epigastric hernias.

A 0 % postoperative pain rate was reported for the flat ePTFE group. It is likely that due to the small group, these findings are not representative. The specific benefits of the laparoscopic approach in postoperative pain have to be evaluated further. A clear benefit of the laparoscopic approach is

Table 3 Pooled results of the studies

Approach	Recurrence (%), CI (n/N)	Complications (%), CI (n/N)	Postoperative pain (%), CI (n/N)
Laparoscopic	1.0, 0.0–2.0 (3/312)	25.2, 18.1–32.3 (36/143)	0.0, 0.0–11.5 (0/26)
Open	2.3, 1.4–3.2 (25/1,068)	10.2, 8.1–12.2 (85/835)	9.8, 7.0–12.6 (42/429)

N = total of which laparoscopic or open recurrence/complication/postoperative pain rate was noted

that it allows the operating surgeon to perform a diagnostic laparoscopy to detect possible other defects. In addition, laparoscopy makes it easier to place a sizeable mesh in an intraperitoneal position with an adequate overlap of the borders of defect [11].

The result for complications in the pooled laparoscopic mesh placement group could be biased. One of the included studies is responsible for the high postoperative complication rate. Eriksen et al. report a complication rate of 73.7 % in their rather small group. If this study would be excluded, the complication rate would be 12.4 %. This is a more representative complication rate, but still slightly higher than in the open placement group. The results of the operation time of the laparoscopic approach could also be biased because in some studies, the included hernias in the laparoscopic group were significantly larger. Therefore, operation time can be longer in the laparoscopic repair group compared to the open repair group due to the difference in hernia size. Further studies are necessary to investigate the difference in operation time as a primary outcome, without significant differences in baseline characteristics.

Overall, this review gives a complete and clear picture of recurrence after umbilical and epigastric hernia repair with mesh. An acceptable overview is given for complications and postoperative pain after mesh repair. Nevertheless, further randomized studies with larger patient groups are necessary to gain more power for the evaluation of the best mesh device used for umbilical or epigastric hernias.

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