

## Closure versus non-closure of hernia defect during laparoscopic ventral hernia repair with mesh

M. S. Zeichen · H. J. Lujan · W. N. Mata ·  
V. H. Maciel · D. Lee · I. Jorge · G. Plasencia ·  
E. Gomez · A. M. Hernandez

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### Abstract

**Purpose** Laparoscopic ventral hernia repair with mesh versus laparoscopic ventral hernia defect closure with mesh reinforcement. The primary end-point was recurrence.

**Methods** Retrospective review of patients who underwent laparoscopic ventral hernia repair for small- and medium-sized hernias between July 2000 and September 2011. These patients were divided: (1) repair with mesh alone (non-closure group) and (2) those with hernia defect closure and mesh reinforcement (closure group). The closure group was further divided by technique: percutaneous versus intracorporeal closure of the defect.

**Results** 128 patients were studied: 93 patients (72.66 %) in the non-closure group and 35 patients (27.34 %) in the closure group. Follow-up was available in 105 patients (82.03 %) at a mean of 797.2 days (range 7–3,286 days). In the non-closure group there were 14 patients (15.05 %) with postoperative complications and 8 patients (22.86 %) in the closure group, four of which were seromas. Fourteen patients (19.18 %) developed recurrent hernias in the

non-closure group with an average time to presentation of 23.17 months (range 5.3–75.3). Two patients (6.25 %) developed recurrent hernias in the percutaneous group with an average time to presentation of 12.95 months (range 9.57–16.33). There have been no recurrences in patients whose defect was closed intracorporeally.

**Conclusion** Although our study demonstrated a difference in recurrence rates of 19.18 % in the non-closure group versus 6.25 % in the closure group, the difference did not reach statistical significance. A larger series with longer follow-up may demonstrate clinical significance.

**Keywords** Ventral hernia · Laparoscopic · Closure · Mesh

### Background

Ventral hernias are a challenge for surgeons and patients. Approximately 5 million Americans are affected with a cost of 3 billion dollars for every 250,000 ventral hernia repairs performed each year in the United States [1, 2]. 150,000 incisional hernias arise from 1.3 million laparotomies performed annually (11 %), but other authors report a higher percentage between 11 and 20 % [3]; Furthermore, this rate is increasing with every post-operative year (12.3 % at 5 years and 23 % at 13 years) [4–6]. Flum et al. [4] described progressively shorter intervals between each additional hernia repair.

Laparoscopic ventral hernia repair (LVHR) was introduced in 1993 [7]. In this technique the mesh was placed over the defect without closing it. This “tension-free” repair was shown to be a safe and feasible alternative to open ventral hernia repair with mesh. Many authors reported better outcomes with this technique, less

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M. S. Zeichen (✉) · H. J. Lujan · W. N. Mata · G. Plasencia  
Miami International Surgical Services at Jackson South  
Community Hospital, 9195 SW 72nd St # 230,  
Miami, FL 33173, USA  
e-mail: mzeichen@hotmail.com

V. H. Maciel · I. Jorge  
General Surgery, Mount Sinai Medical Center, 9195 SW 72nd St  
# 230, Miami, FL 33173, USA

D. Lee  
9195 SW 72nd St # 230, Miami, FL 33173, USA

E. Gomez · A. M. Hernandez  
Jackson South Community Hospital, 9195 SW 72nd St # 230,  
Miami, FL 33173, USA

recurrence, fewer complications, shorter operative time, shorter hospitalization, reduced need of analgesic drugs and faster return to normal activities compared with open ventral hernia repair [8–12]. A Cochrane meta-analysis from Germany with 880 patients compared laparoscopic versus open hernia repair and concluded that laparoscopic repair is a safe technique with promising results such as less wound infection and hospital stay; nevertheless, long-term follow-up is needed to assess recurrence rate and complications [13].

The use of mesh is now widely accepted because it has contributed to a dramatic reduction in recurrence [14–16]. In 2000, Luijendijk et al. published a prospective, randomized clinical trial comparing open primary repair with mesh repair of defect smaller than 6 cm. They reported recurrence rates of 46 and 23 % respectively, thus, demonstrating the utility of prosthetic reinforcement [15]. A 10-year follow-up of this data demonstrated a recurrence rate of 63 % in the primary repair group and 32 % for the mesh group [16]. Another Cochrane meta-analysis showed that the use of mesh during open ventral hernia repair is superior to suture repair in terms of recurrences, but inferior when considering wound infection [17]. Despite the use of mesh, the recurrence rates of ventral hernia repair are high. Most authors recommend 3- to 5-cm overlap in order to account for mesh migration and decrease recurrence [18, 19].

There are different techniques available for laparoscopic ventral hernia repair; Chowbey et al. [20] published a technique with laparoscopic extraperitoneal placement of a mesh to minimize adhesions and fistula formation. Other authors have advocated closure of the defect prior to laparoscopic mesh placement to recreate the abdominal wall [18, 19, 21–27]. Other advantages cited included: increased mesh overlap, improved functional results, better cosmesis, less seroma and decreased recurrence. In theory, closing the defect will increase mesh overlap. But, fascial closure can be challenging and time consuming and is not routinely performed [21, 23, 25]. Furthermore, very few studies comparing closing the hernia defect versus not closing in laparoscopic repair with mesh exist. The purpose of this study was to review our experience with laparoscopic ventral hernia repair and compare our results with “non-closure” or use of mesh alone against laparoscopic sutured hernia defect “closure” with mesh reinforcement.

## Methods and materials

Between July 2000 and September 2011, patients diagnosed with hernias greater than 3 cm and smaller than 20 cm in diameter underwent laparoscopic ventral hernia

repair with mesh. A standard, tension-free, on-lay mesh repair was used as described by LeBlanc et al. and others. In 2004, Franklin et al. [19] reported their 11 years’ experience with laparoscopic ventral hernia repair and possible advantages associated with defect closure. Later, similar reports and anecdotal experience suggested an association with defect closure and decreased recurrence rates [21, 22, 25, 27]. We, therefore, modified our repair accordingly. We started routinely closing the hernia fascial defect in 2008, and it became our preferred approach.

During the study period, 128 consecutive patients underwent laparoscopic ventral hernia repair with mesh. Ninety-three patients did not have defect closure (non-closure) and 35 patients had the defect closed prior to mesh placement (closure group). The following data were collected for each patient: age, sex, body mass index (BMI), previous hernia repairs, American Society of Anesthesiologists (ASA) classification, size and location of the fascial defect, size and type of prosthetic mesh implanted, operative time, estimated blood loss, co-morbidities, length of hospital stay, complications, conversion rate, recurrences and follow-up.

Patients were included in the study if they were 18 years or older presenting with hernias greater than 3 cm and smaller than 20 cm in diameter. Patients were capable of understanding and giving signed consent for laparoscopic treatment of ventral hernia. Patients undergoing open ventral hernia repair, paracolostomy hernias, drainage tube site hernias, umbilical hernias and hernias with defects <1 cm were excluded.

## Surgical techniques

### *Non-closure*

The patient was placed on the table in the supine position. After adequate general anesthesia was obtained, the abdomen was prepped and draped in the usual sterile manner. Pneumoperitoneum was established by veress needle when possible or open “Hasson” technique when surgical scars present. The position of the trocars varied depending on the size, location and number of existing hernia defects. In general, two 5-mm and one 12-mm trocars were placed along the left lateral abdomen as shown in Fig. 1. Adhesions to the anterior abdominal wall surrounding the hernia were lysed and the hernia contents reduced. The peritoneal sac is left in situ. After completion of the dissection, the hernia defect was measured, and a mesh chosen to overlap all margins of the defect by at least 3–5 cm. For larger hernias, 0-prolene stay sutures were placed at four corners of the mesh and retrieved individually with a suture passer to provide fascial fixation. The mesh was placed through the 12-mm trocar and inserted



**Fig. 1** Port placement

into the abdominal cavity. A centering stitch was used in most of the cases; the mesh was serially fixed to the abdominal wall circumferentially at 1-cm intervals with the hernia tacker. A second crown of tacks was placed and additional tacks were placed as necessary. The trocars were removed under direct vision. In several cases, the 12-mm trocar was placed through the skin at the defect for mesh introduction. These sites were covered by mesh and, therefore, were not routinely closed. The fascia for any exposed 12-mm port site was routinely closed with 0-Vicryl suture; skin incisions were closed in subcuticular fashion.

### Closure

It was similar to the technique described above for non-closure. The only difference was that we performed a primary approximation of the fascial edges of the hernia defect with polyester sutures (Ethibond excel, Ethicon, Johnson & Johnson) prior to mesh placement using one of three techniques. (1) The hernia defect was closed percutaneously using a suture-passer as has been described [19]. Intracorporeal defect closure was performed using (2) a needle and standard laparoscopic needle drivers or (3) an Endo Stitch™ (Covidien) suturing device (Fig. 2a–d). Several interrupted figure of eight sutures were placed, and then, tied with a knot pusher. After closing the defect primarily, an appropriately sized mesh was tailored to overlap all margins of the defect by 3–5 cm.

Patients were examined postoperatively at 1 week, 3 months, 1 year, and thereafter as clinically indicated. Complete current follow-up was achieved in 105 patients (82.03 %, 73 patients of non-closure group and 32 of closure group) with a mean of 797.20 days (range

7–3,286 days). Follow-up was achieved by reviewing medical records of clinic visits, and a structured phone interview performed by two reviewers. All patients with a minimum of 7-day follow-up were included in the analysis for follow-up results.

The Institutional Review Board approved the database. Statistical analysis of recurrence rate, operative time and postoperative complications was performed using survival analysis, linear regression and logistic regression, respectively. A  $p$  value  $<0.05$  was considered statistically significant.

## Results

Between July 2000 and September 2011, 128 patients presented with hernias greater than 3 cm and smaller than 20 cm in diameter. All cases were approached laparoscopically. We classified the patients into two different groups: non-closure and closure, the second group was further divided by technique: percutaneous suture closure of the defect with a suture passer versus intracorporeal suture closure of the defect.

### Patient characteristics

The demographic features and perioperative data of the 128 patients undergoing laparoscopic ventral hernia repair are listed in Table 1.

In the non-closure group there were 93 patients (72.66 %), 38 males and 55 females. Mean age was 63 years (range 26–91). The average BMI was 30 (range 20–52). The average ASA was 2.3 (range 1–4). Eleven patients (11.83 %) were undergoing the repair for a recurrence of ventral hernia.

In the closure group there were 35 patients (27.34 %), 15 males and 20 females. Mean age was 63 years (range 27–80). The average BMI was 32 (range 21–71). The average ASA was 2.24 (range 1–4). Six patients (17.14 %) were undergoing the repair for a recurrence of ventral hernia.

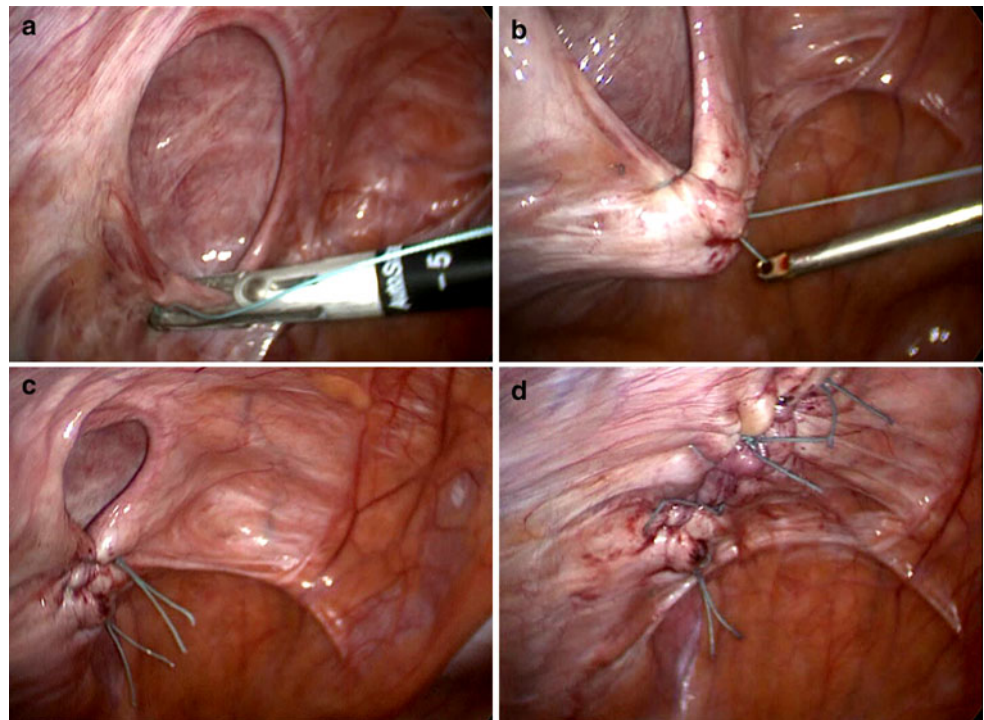
### Operative results

Characteristics of the hernias repaired are summarized in Table 2.

### Non-closure group

The most common hernia sites were periumbilical, left lower quadrant and midline. The average size of the hernia was 66.24 cm<sup>2</sup> (range 9–400). The average size of the prosthetic meshes were 190.16 cm<sup>2</sup> (range 81–675). The

**Fig. 2** **a** Intracorporeal defect closure using Endostitch suturing device. **b** Intracorporeal defect closure using Endostitch suturing device. **c** Intracorporeal defect closure using Endostitch suturing device. **d** Intracorporeal defect closure using Endostitch suturing device



**Table 1** Patient Characteristics

Characteristic	Non-closure	Closure
<i>n</i>	93	35
Male/female	38/55	15/20
Age in years (range)	63.08 (26–91)	63.43 (27–80)
BMI (range)	30.22 (20–52)	31.79 (20.92–70.86)
ASA	2.3 (1–4)	2.24 (1–4)
Previous hernia repair, <i>n</i> (%)	11 (11.83)	6 (17.14)

Values are mean (range) unless otherwise indicated

*BMI* Body Mass Index; *ASA* American Society of Anesthesiologists

mesh was fixed to the abdominal wall using a fixation device (ProTack™, SorbaFix™ or AbsorbaTack™) in 33 patients (35.48 %), suture (Vicryl or Prolene) in 23 patients (24.73 %) or both in 37 patients (39.78 %). The choice of fixation technique was surgeon dependent.

Mean operative time was 75.04 min (range 18–215 min). Postoperative hospital stay was 1.38 days (range 1–6 days). The most common reasons for staying overnight were pain control and bleeding. For the operative time and length of stay calculation, we only included 69 patients (74.2 %). These patients only had the ventral hernia repair performed. Twenty-four (25.8 %) patients had concomitant procedures performed.

Conversion to open surgery was necessary in 11 (11.83 %) of the 93 patients, for the following reasons: severity of adhesions (6), inability to reduce incarcerated intestine (1), need to resect strangulated intestine (1) and enterotomy (3).

### Closure group

The most common hernia sites were periumbilical and left lower quadrant. The average size of the hernia was 43.97 cm<sup>2</sup> (range 9–225). The average size of the mesh was 206.76 cm<sup>2</sup> (range 81–500) and the mesh was fixed to the abdominal wall using a fixation device (ProTack™, SorbaFix™, SecureStrap™ or AbsorbaTack™) in 25 patients (71.43 %), suture (Vicryl or Prolene) in 1 patient (2.86 %) or both in 9 patients (25.71 %). Mean operative time was 88.96 min (range 45–143 min). Postoperative hospital stay was 1.23 days (range 1–3 days). The most common reason for staying overnight was postoperative ileus. For the estimation of operative time and length of stay we only included 23 patients (65.7 %). These patients only had the ventral hernia repair performed. Twelve (34.3 %) patients had concomitant procedures performed.

Conversion to open surgery There were no conversions.

### Postoperative complications

Complications after surgery are shown in Table 3. Complications were recorded one per patient even if the patient had multiple complications.

### Non-closure group

There were a total of 14 patients with postoperative complications (15.05 %), 13 cases (92.86 %) developed during the first 30 days after the surgery. Seroma

**Table 2** Hernia characteristics and perioperative results

	Non-closure	Closure
Hernia location		
Periumbilical, <i>n</i> (%)	42 (45.16)	14 (40)
Midline, <i>n</i> (%)	21 (22.58)	2 (5.71)
Right upper quadrant, <i>n</i> (%)	4 (4.3)	3 (8.57)
Left upper quadrant, <i>n</i> (%)	2 (2.15)	0 (0)
Right lower quadrant, <i>n</i> (%)	9 (9.68)	5 (14.29)
Left lower quadrant, <i>n</i> (%)	11 (11.83)	11 (31.43)
Suprapubic, <i>n</i> (%)	4 (4.3)	0
Hernia type		
Primary ventral, <i>n</i> (%)	79 (84.95)	25 (71.43)
Incisional, <i>n</i> (%)	14 (15.05)	10 (28.57)
Hernia size in cm <sup>2</sup> (range)	66.24 (9–400)	43.97 (9–225)
Mesh size in cm <sup>2</sup> (range)	190.16 (81–675)	206.76 (81–500)
Operative Time in min (range)	75.04 (18–215)	88.96 (45–143)
Patients with concurrent procedures, <i>n</i> (%)	24 (25.81)	12 (34.29)
LOS in days	1.38 (1–6)	1.23 (1–3)
Conversions to open surgery, <i>n</i> (%)	11 (11.83)	0

Values are mean (range) unless otherwise indicated

LOS length of stay

formation was the most common occurring in 4 cases (4.30 %), only 1 case of seroma persisted 48 days after surgery. No long-term complications related to seroma formation were observed, whether they were aspirated or not. Other complications included anemia in two cases, one of these patients had a concurrent colectomy performed at the time of ventral hernia repair. Ileus occurred in 2 cases (2.15 %), and 2 cases (2.15 %) of partial small bowel obstruction (pSBO). One pSBO improved after medical treatment and the other required reoperation because of associated bowel perforation. One patient (1.08 %) had respiratory distress after surgery. There were three patients that suffered enterotomies (3.23 %) and required reoperation.

#### Closure group

There were a total of 8 postoperative complications (22.86 %). During the follow-up period, seroma formation was the most common occurring in 4 cases (11.43 %). Those seromas were self-limited and all had disappeared by 6 weeks postoperatively. Other complications included ileus in 1 case (2.86 %) and 1 case (2.86 %) of pSBO that improved after medical treatment.

One patient was readmitted to the hospital 8 days after the surgery with abdominal pain, hypotension, nausea and vomiting and accounts for the one mortality. A CT scan of

**Table 3** Postoperative complications

Complication	Non-closure	Closure
Death	0	1
Sepsis	1	0
Bowel obstruction	2	1
Seroma	4	4
Infectious colitis	1	0
Renal failure	1	0
Urinary retention	1	0
Ileus	2	1
Enterotomy	3	0
Respiratory distress	1	1
DVT	0	1
Anemia	2	1
Patients <sup>a</sup> <i>n</i> (%)	14 (15.05 %)	8 (22.86 %)

More than one patient had more than one complication

<sup>a</sup> Number of patients in which a complication occurred

the abdomen confirmed small bowel obstruction secondary to incarcerated small bowel between the anterior abdominal wall and the mesh. At surgery, a loop of bowel was found incarcerated, where the mesh had partially detached inferiorly, the mesh did not provide adequate overlap to cover the defect. This loop was easily reduced and it was viable with no evidence of strangulation. The mesh was reattached to the abdominal wall and reinforced with a second mesh in that area, although this patient expired 6 days after the second operation, intra-operative findings did not correlate with the patient's clinical deterioration.

#### Recurrence rate

Recurrence rates are shown in Table 4. Cumulative probabilities of recurrence are depicted in Fig. 3.

#### Non-closure group

During the follow-up period, 14 patients (19.18 %) developed recurrent hernias. The average time of recurrence to develop was 23.17 months.

#### Closure group

In the percutaneous group, the closure of the defect was performed with the use of Ethibond and a suture passer (18 patients), 2 patients (11.11 %) developed recurrent hernia with an average time onset of 12.95 months. In the intracorporeal group, the closure of the defect was performed with the Endo Stitch<sup>TM</sup> suturing device (17 patients). No recurrences have been recorded to date.

**Table 4** Recurrence rate

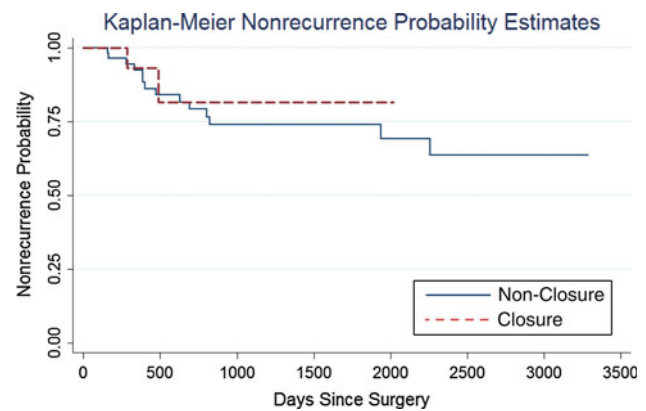
	Non-closure	Closure	
		Percutaneous	Intracorporeal
Recurrence rate, <i>n</i> (%)	14 (19.18)	2 (6.25)	0

## Discussion

In 2004, Franklin et al. [19] reported their 11 years' experience with laparoscopic ventral hernia repair. Their technique included primary closure of the defect before mesh placement. Benefits included lower recurrence rate (2.9 %) and fewer complications (10.1 %) at a mean follow-up of 47.1 months. Since then, different defect closure techniques have been described, and all have advantages and disadvantages. In 2011, we described our intracorporeal technique of hernia defect closure using the Endo Stitch™ suturing device [24]. Authors have reported good results using conventional needle and suture, laparoscopic needle driver, and knot pusher; others have reported a percutaneous technique using a suture passer to close the hernia defect [19, 21–27]. These reports are summarized in Table 5.

Several benefits have been proposed with hernia defect closure. For example, authors have suggested that by closing the defect, especially large ones, the repair is stronger and more reliable. It has also been suggested that by approximating the fascial edges, a more physiologic restoration of abdominal wall function is achieved. Greater mesh overlap and better cosmesis has also been suggested [21, 24]. A disadvantage cited with the laparoscopic “tension-free” technique without defect closure is a bulging phenomenon. The mesh bulges through the defect [28, 29]. Aside from cosmetic disadvantage, the mesh can also come in contact with the skin, especially in larger defects. Conversely, when the defect is closed, the mesh is never in contact with the skin because the abdominal wall muscle and fascia provide a physical barrier. This may also help prevent mesh erosion of the skin and subsequent infections [21, 25, 27]. Finally, a lower wound and mesh infection rate has been reported with defect closure [19, 21, 27].

Recurrence rate after laparoscopic ventral hernia repair are reported to range from 4.2 to 16.7 % [8, 9, 12, 26]. Authors have reported lower recurrence rates with defect closure from 0 to 2.9 [19, 21, 25–27]. A study of 736 patients described a laparoscopic sutured closure of the defect with mesh reinforcement and reported a recurrence rate of 0.55 % during a mean follow-up of 4.2 years [21]. We found a recurrence rate of 6.25 % in the defect closure group compared to 19.18 % in the non-closure group. Although this did not reach statistical difference in our study, a trend was demonstrated. Longer follow-up and a

**Fig. 3** Cumulative probabilities of hernia recurrence after laparoscopic repair

larger series may demonstrate a difference. Furthermore, no recurrences occurred in the intracorporeal sutured group compared to the percutaneous closure technique group.

Authors have also considered disadvantages of closing the defect. Percutaneous sutures were associated with abdominal discomfort (up to 6 months after surgery), pain and neuralgia [19, 30]. Pain, an important secondary end point, was not addressed by our retrospective study. We did not analyze immediate or intermediate term pain in the two groups. However, the authors did not notice a subjective difference in pain or postoperative recovery in either group, nor was a difference in readmission rates for pain control appreciated. Evaluation is further confounded by different practice patterns of the surgeons in our study. Recently, there is more liberal use of local anesthetics, intravenous acetaminophen and intravenous ketorolac. Finally, fixation techniques, whether tacks, sutures or a combination, and how many of each all probably play a role. Thus, we chose to evaluate only recurrence rates because this is arguably the most important outcome even if it were to be associated with more pain.

Intracorporeal suturing is generally considered technically demanding [21, 23]. Operative times have been reported as “prolonged” when using transfascial or intracorporeal suturing. However, authors rarely report their operative times or compare them to a control group. In Franklin’s study [19], the authors achieved an average OT of 68 min (range 14–405). Our operative times were similar with a mean of 75.04 min in the non-closure group and 88.96 min in closure group. No statistically significant difference was shown between these two groups in our study.

Mesh fixation can be achieved using suture, tacks or a combination. The number, types and techniques vary significantly in the literature. In a meta-analysis, tackers when used alone were associated with shorter operative time and less postoperative pain, but similar perioperative

**Table 5** Published reports describing hernia defect closure prior to mesh placement during laparoscopic repair

References	Patients (n)	Follow-up (months)	Recurrence (%)	Complication (%)
Franklin [19]	384	47.1	2.9	10.1
Palanivelu [21]	721	50.4	0.55	15.8
Palanivelu [22]	17	9	5.8	29.4
Agarwal [25]	29	34	0	20.69
Clapp [26]	36	24	0	33.3
Chelala [27]	382	28	0.26	12.5
Present study (2012)	35	27	6.25	22.86
Sharma [23]	*Technique reported			
Jorge [24]	*Technique reported			

complications, length of hospital stay and hernia recurrence when compared with suturing fixation alone [31]. As described above, we used a combination of tacks and sutures. At least four corners of the mesh were secured with transfascial sutures and then tacks were liberally applied.

In the literature, rates of seroma formation range from 2 to 20 % [19, 21, 27]. We found a slightly higher incidence of seroma formation in the closure group, 11.4 % compared to 4.3 % in the non-closure group. This could be due to the inability of the fluid collecting in the sac to drain back into the peritoneal cavity. However, we did not find any clinical importance to the seroma formation. Similar to Franklin et al. who reported rates of 15–20 % for seroma formation, we found these seromas resolved without intervention in less than 6 weeks.

Our results did not find a statistically significant difference in recurrence rates between closure (6.25 %) and non-closure groups (19.18 %). However, we believe that by approximating the fascial edges prior to fixation of the mesh, a more physiologic and anatomic repair is achieved. It is likely that with longer follow-up and more patients, a difference will be demonstrated in the future. Larger comparative, long-term studies are needed to address this question. Furthermore, we still need to investigate the maximum defect size that can be closed and still retain purported benefits. It is possible that by combining defect closure with endoscopic component separation this technique will be applicable to larger defects.

There are significant limitations with our study and we must comment on the weakness of our methodology. First, it is a retrospective review and selection bias is possible. The closure and non-closure groups were not as similar as we would have liked. For example, in the closure group, despite

using the defect measurement as a guide with the intention of 3- to 5-cm overlap, mesh size chosen tended to be slightly larger (190 versus 207 cm<sup>2</sup>). Hernia sizes were also slightly larger in the non-closure group. Finally, the locations of the hernia were not evenly distributed in each group. These differences could favorably affect the closure group.

Second, the techniques were not standardized with respect to type of mesh or fixation. This is an almost universal problem with LVHR studies. Hernia repair is a rapidly evolving field where new meshes, new fixation devices and modifications in techniques are continuously being introduced. We could not standardize measurement, types of hernia, location, mesh characteristics, overlap or fixation. However, our surgeons follow similar guidelines, principles and techniques of laparoscopic ventral hernia repair. Finally, important secondary endpoints like pain and quality of life were not addressed by our study.

Closure of the hernia defect represents a major difference to conventional LVHR with mesh as reported in most studies and meta-analyses. No randomized, controlled trial has addressed the advantages or disadvantages of defect closure. Laparoscopic ventral hernia repair with mesh has only been evaluated when performed with a “tension-free” or sublay, conventional method. Despite recommendations to close the hernia defect in laparoscopic repair with mesh by some surgeons [19, 21–27], it is not widely being performed in LVHR and there are only a few published reports. Reasons for this may be the added time and difficulty presumed to be associated with closing the defect [21, 23]. Another reason may be that there is presumed to be no benefit and/or a lack of evidence to suggest an advantage. Our results are encouraging and demonstrate the safety and feasibility of hernia defect closure. We look forward to reporting a longer follow-up in this group of patients in 3–5 years. The very low recurrence rate (6.25 %) emphasizes the need for a randomized clinical trial addressing laparoscopic closure with standardized clinical protocol and better control of variables.

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**Conflict of interest** Drs. Plasencia, Lujan and Gomez are consultants for Ethicon-Endosurgery.

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