EVALUATION OF THE INTRAPERITONEAL (ONLAY) AND THE PREPERITONEAL (INLAY) TECHNIQUES IN LAPAROSCOPIC VENTRAL HERNIA REPAIR A REVIEW OF LITERATURE.

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ABSTRACT

Ventral hernias refer to fascial defects of the anterolateral abdominal wall through which intermittent or continuous protrusion of abdominal tissue or organs may occur. They are either congenital or acquired. In adults more than 80% of ventral hernias result from previous surgery hence the term incisional hernias. They have been reported to occur after 0-26% of abdominal procedures. Although these hernias mostly become clinically manifest between 2 to 5 years after surgery, studies have shown that, the process starts within the first postoperative month. They are said to occur as a result of a biomechanical failure of the acute fascial wound coupled with clinically relevant impediments to acute tissue repair and normal support function of the abdominal wall.

Historically, incisional hernias have been repaired with either primary suture techniques or placement of a variety of prosthetic materials. Before the 1960's, most ventral hernias were repaired primarily with suture and a few with metallic meshes. Even with some modifications, recurrence rates with the primary suture repair ranged from 24-54%. The introduction of polypropylene mesh repair by Usher in 1958 opened a new era of tension-free herniorrhaphy. Recurrence rates with prosthetic mesh decreased to 10-20%. Subsequentely, it was realized that the placement and fixation of the mesh was more crucial in determining the outcome of the repair. The placement of the mesh in the preperitoneal, retromuscular position with a wide overlap of at least 5 cm over the hernia defect in all directions was introduced in the late 1980's. The refinement of this method decreased the recurrence rates to as low as 3.5% making it to be declared the standard of care of ventral hernias. However implantation of the mesh by open techniques requires wide dissection of soft tissue contributing to an increase in wound infection and wound- related complications.

Initially described in 1992, laparoscopic repair of incisional hernias has evolved from an investigational procedure to one that can safely and successfully be used to repair ventral hernias. The well-established benefits of laparoscopy repair are less postoperative pain, reduced hospital stay and recovery time, low complication and recurrence rates based on numerous reports, meta-analysis and few randomised trials. Conventionally, the laparoscopic ventral hernia repair (LVHR) entails the intraperitoneal placement and fixation of the prosthetic mesh. An alternative technique has been tried in a few studies and proposed and to be an advancement of the conventional approach.

The objective of this review was to compare the efficacy and safety of these two LVHR techniques by analysing the evidence in available literature. It has suggested that, the proposed laparoscopic

preperitoneal placement of prostheses seems to negate most of the positive attributes of the intraperitoneal approach to LVHR in most ways. The proposed new technique may be advantageous in small primary hernias, in a highly selected patients population. However, it may not be of benefit to the majority of patients that usually present with this structural disability.

KEY WORDS:

Ventral Hernia; Laparoscopic repair; Intraperitoneal (onlay); Pre / Extraperitoneal (inlay)

INTRODUCTION:

Ventral hernias refer to fascial defects of the anterolateral abdominal wall through which intermittent or continuous protrusion of abdominal tissue or organs may occur [1, 2]. They have commonly being classified into congenital, traumatic or incisional. Chevrel (3) classified ventral hernias according to the anatomical localization, size of the defect and the number of previous repairs. A functional classification based on the expected level of endoscopic intraoperative difficulty has been proposed. According to this proposed classification, all abdominal wall hernias are graded from I to VI, on the basis of aetiology, reducibility, clarity of the defect margins, contents of the sac and clinical presentation. Higher grades correspond to increasing levels of intraoperative difficulty for endoscopic repair [4].

The far most common is the secondary or incisional hernia developing at a site of previous abdominal surgical incision (Grades V&VI). This occurs as a result of a biomechanical failure of the acute fascial wound coupled with clinically relevant impediments to acute tissue repair and normal support function of the abdominal wall during the postoperative period [2,5]. Although incisional hernias become clinically manifest between 2 to 5 years after surgery, studies have shown that, the process starts within the first postoperative month. These defects remain small and quiescent for years, progressively gaining size allowing for the protrusion of abdominal contents and visible bulging, and complaints (1,6). Factors associated with formation of incisional hernias are grouped into those that impair wound healing such as wound infection, diabetes, corticosteroids use, smoking, connective tissue disorders, malignancies, radiotherapy, multiple surgeries and advanced age; conditions that increase intraabdominal pressure like obstructive airways diseases, constipation, lower urinary tract obstruction, pregnancy and ileus; and surgical factors such as type of incision, suture type and technique (2,5,7).

Incisional hernia has been a frequent complication of abdominal surgery for a long time, with a current incidence of 2-20 % in most series (8-12). It is a problem of immense magnitude to the surgeon, the patient and the healthcare socio-economics. In the United States and the Netherlands for example, 200,000 and 3900 incisional hernia repairs are performed per year respectively (7). In Australia, an under-estimate of 9804 ventral hernias was repaired in the first six months of the year 2003(9). Data from these countries, and probably in general population indicate that, 4 % of patients undergoing a laparotomy will undergo an additional surgery to repair an incisional hernia later (7,10). These figures have a high negative impact on the cost-effectiveness of surgery and result in an unacceptably high frequency of co-morbidity. Until techniques for prevention of hernia are established, the efficacy of incisional hernias repair will remain a concern of major importance to all abdominal surgeons (6,7,13).

Several hernia repair methods have been described. Traditionally, primary repair entailed a laparotomy and suture approximation of fascia on each side of the defect. Recurrence rates after this type of repair range from 30-55% on long term follow up (8,13,14,15). The introduction of polypropylene mesh repair by Usher (16) opened a new era of tension-free herniorrhaphy (15, 16,17). The mesh, which was modified in 1962, gained popularity over 30 years and currently popular polypylene meshes are commercially available. Polyester mesh was introduced in Europe in the 1950's. Rives (18) and Stoppa (19) employed polyester mesh in their landmark article describing preperitoneal technique for abdominal wall hernia repair in 1989 (19). This technique has become the standard by which all abdominal hernia repair methods are measured (20-23).The expanded Polytetrafluoroetylene(ePTFE) initially used as a vascular graft was adapted for ventral hernia repair in 1983 by Goore et al (24) and has been modified severally in the 1990's. Unlike polypylene and polyester meshes, which were associated with severe intraabdominal adhesions leading to small bowel erosion, obstruction and fistulation, there are no reports of these complications with ePTFE. It is now well established that mesh repair significantly reduce the incidence of recurrence (8,7,25-27) to 10- 25% (7,11,14,28) regardless of mesh type and operative technique (29). However implantation of the mesh by open techniques requires wide dissection of soft tissue contributing to an increase in wound infection and wound-related complications (8, 10,13, 24) in addition to the complications associated with the older mesh materials.

Since the first report of laparoscopic ventral hernia repair in 1993 (30), the technique has been refined and has gained sufficient popularity within the surgical fraternity to be considered the standard procedure for ventral hernia repair (13,31,32). In this conventional technique, the contents of the hernial sac are reduced and a prosthetic mesh is placed intraperitoneally extending far beyond the borders of the fascial defect and held in place by sutures and /or staples, intra-abdominal pressure and later by fibrinous growth (1,30,31,33). The reliability and security of this onlay repair has been extensively reviewed (8,13,22,26,30,34-36) as well as the well-established benefits in terms of less postoperative pain, reduced hospital stay and recovery time and low complication and recurrence rates (12,15,20,26,37-40). Some controversial areas such as extent of adhesiolysis, choice of mesh and fixation technique are continuously being addressed (41-43).

An alternative laparoscopic ventral hernia repair technique is the inlay method in which the prosthetic mesh is placed and fixed in the preperitoneal space. This space has been approached trasnsabdominally (44-48) or through a totally extrapertoneal approach (TEP) (48-50). This new technique takes advantage of immediate mesh fixation by the peritoneal sac and avoids direct interaction of the mesh prosthesis and the intraperitoneal viscera and the TEPP avoids the abdominal cavity altogether with the attendant potential complications. It is supposed that formation of adhesions with this technique will be less (31,46,50) and thus, it has been suggested to be advancement over the intraperitoneal mesh placement of ventral hernia repair in selected patients (44).

AIM:

The aim of this review is to compare the efficacy and safety of the conventional intraperitoneal (onlay) and the preperitoneal (inlay) laparoscopic ventral hernia repair (LVHR) techniques from the available

literature and to determine whether a prospective randomised controlled study comparing them are warranted.

MATERIALS AND METHODS:

A literature search was performed using search engine Google, Pubmed, High Wire, Online Springer library facility available at The Laparoscopy Hospital, New Delhi, India. The following Boolean search terms were used: "Ventral / incisional hernia repair", "laparascopic ventral hernia repair", "laparoscopic extraperitoneal/ in-lay ventral hernia repair", "laparoscopic intraperitoneal/onlay ventral hernia repair". Further references were obtained by cross-referencing the bibliography in some selected papers.

1.Diagnosis and patient selection.

2.Techniques and operative care for laparoscopic ventral hernia repair.

3.Operation time.

4.Intraoperative complication.

5. Duration of hospital stay.

6. Postoperative pain.

7.Postoperative morbidity including recurrence.

8. Quality of life analysis/ patient centered outcomes

CLINICAL PRESENTATION:

The signs and symptoms of a ventral hernia are due to congestion and stretching of the viscera in the sac, intermittent bowel obstruction, ischaemia of the overlying skin and eventual loss of domain of the contents of the hernia. Stretching the attachments of the bowel mesentery occurs as abdominal contents rush into the hernia sac during any effort or straining that increases the intra-abdominal pressure (1,2).

SYMPTOMS:

A typical ventral hernia appears as a diffuse bulge in the anterior abdominal wall, the bulge appearing in a portion of a healed incision in case of an incision hernia. Stretching of the viscera results in dull, gnawing discomfort occasionally associated with nausea and pain. Quite often the discomfort and pain are associated with specific activities or movements, which the patient tends to avoid (2). Steady enlargement of the hernia sac causes atrophy and displacement of the subcutaneous fat and stretching of the skin over the hernia. Ischaemic skin necrosis may ensue due to overstretching. Loss of domain occurs when unreduced viscera are present over a relatively long period. The abdominal cavity accommodates to a smaller volume of residual contents. Bowel obstruction may be due to incarceration of the bowel within the hernial sac but more often, it is due to adhesions around the hernial orifice. This happens in about 6-15% and is more common in large hernias with small fascial defects. In about 2% strangulation and ischaemic necrosis of the viscera occurs necessitating emergency surgery.

CLINICAL SIGNS:

In the supine position, there is usually a visible or palpable bulge in the vicinity of a surgical scar in case of an incisional hernia. Fascial defect is often but not always palpable. The bulge increases with maneuvers that raise the intra-abdominal pressure. Difficulties may arise in evaluating obese patients. Particular discomfort with pressure over a suspected hernia with Valsalva maneuver should increase suspicion in these cases but is not diagnostic. Reducibility, size of the defect, proportion of abdominal contents involved and overlying skin changes are important factors.

DIAGNOSTIC TESTS:

Imaging is unnecessary when diagnosis by physical examination is certain. However when the nature of the bulge is unclear like in large, irreducible hernias or small, poorly defined hernias in an obese abdomen, ultrasound is often used. When ultrasound is inconclusive CT scan and MRI offer superior but more expensive diagnostic imaging.

OPERATIVE TREATMENT:

All ventral hernias should be repaired surgically. Repair is done upon diagnosis in order to avoid the technical and physiological consequences and complications that occur with delay, such as loss of domain, incarceration, bowel obstruction and similar events (1).

PATIENT'S SELECTION:

Indications of laparoscopic ventral hernia repair include:

i) Size of the defect: Defects larger than 3 cm and smaller ones in obese patients, recurrent hernias and special types of hernias such as the spigelian hernia, are best treated laparoscopically (1). There are no objectively defined selection criteria for the upper limit but some experts have suggested limiting LVHR to cases where transverse separation of the fascial edges is 10 cm (29). However there are many reports in the literature of LVHR of far much larger hernias.

ii) Obese patients and recurrent hernias.

iii) "Swiss-cheese" defects.

b) Contra indications

i) Extremely large hernias

ii) End-stage cardiac, liver and pulmonary disease

iii) Extremely dense adhesions like in previous multiple laparotomies, peritonitis or end stage renal disease with peritoneal dialysis, as there may be obliteration of the peritoneal cavity for placement of cannulas and the attendant increased risk of enterotomy.

iv) Liver cirrhosis and portal hypertension.

v) General contraindications to laparoscopy e.g. coagulopathy and ascites.

vi) Paediatic age group due to the potential of mesh migration.

vii) Strangulated hernias.

viii) Lack of abdominal domain. This refers to patients with insufficient space in the abdomen to accommodate the contents of the hernia that are also at great risk for pneumoperitoneum.

ix) Hernias in which the fascial edges extend lateral to the midclavicular line may make trocar placement lateral to the defect impossible. Defects in close proximity to the bony margins of the abdomen, especially those near the xiphoid, pose significant challenges for mesh fixation, though this is also true with open incisional herniorrhaphy.

EQUIPMENT:

As the wide variety of mesh materials currently available suggests, there is no one ideal mesh. Meshes may be divided into two categories: (1) polymeric meshes and (2) meshes made of specially prepared connective tissue (animal or human). The polymeric meshes are biocompatible materials made of either polypropylene, polyester, expanded polytetrafluoroethylene (ePTFE), or laminates of these. Most ePTFE meshes are engineered so that one side is porous to encourage tissue ingrowth and the other is smooth to resist adhesion formation. They may also be coated with an adhesion-resisting absorbable material. Because laparoscopic incisional hernia repair leaves the mesh exposed to the intraperitoneal cavity, concerns have been expressed about the risk of adhesion formation and fistulization if polypropylene mesh is used. Polytetrafluoroethylene (PTFE) mesh has been demonstrated to have a reduced propensity for adhesion formation.

Additional special equipment used for incisional hernia repair includes a suture passer, a 5 mm spiral tacker (or other tacking device), and 2-0 monofilament sutures. Several tacking devices and suture placement devices have been developed to facilitate mesh fixation.

OPERATIVE TECHNIQUES:

The intraperitoneal (onlay) and extraperitoneal (inlay) techniques of LVHR differ in dissection of the peritoneum, position of mesh placement and the closure of the peritoneum beneath the mesh thus separating it from the contents of the abdominal cavity.

PREOPERATIVE PREPARATION:

Patient should be counseled on expected outcome particularly on cosmesis and possible complication especially, the expectant management of seroma if it occurs.

Bowel preparation is necessary to increase the size of the abdominal cavity and to prepare for bowel surgery should an enterotomy occur intraoperatively.

Prophylaxis for DVT and respiratory dysfunction in high-risk patients, and prophylactic antibiotics at the induction of general anaesthesia.

OT ROOM, ANAESTHESIA, PATIENT AND SURGICAL TEAM SET UP:

- Patient is placed on the operating table in supine position.
- General anesthesia with muscle relaxation, endotracheal intubation and usual monitors for laparoscopic procedures.
- Naso/oro-gastric intubation and urinary catheterization.
- Abdomen is prepped and draped in a sterile fashion preferably with an Ioban adhesive dressing.
- Surgeon stands on the left of the patient with the assistant on either side depending on the location of the ventral hernia.

ACCESS AND PORTS PLACEMENT:

Closed method with the Veress needle or open (Hasson's) technique depending on risk analysis is the most commonly used access methods. Optical trocar can also be used.

Most preferred site is the Palmer's point. Alternative sites include the right hypochondrium and the iliac fossae. Ultimately, the trochar position is determined by the location of the hernia.

Pneumoperitoneum is created and the defect localized during diagnostic laparascopy. An angled (usually 30 degrees) scope is essential because dissection and repair are done on the undersurface of the anterior abdominal wall, which cannot be adequately visualized with a zero degree scope.

The baseball diamond concept is followed in port placement depending on the location of the defect. Three trocars are usually adequate for small to moderate hernias with at least one 10/12 mm for insertion of the mesh and tack applicator.

Complete adhesiolysis of the anterior abdominal wall is performed including release of the round ligament where necessary preferably with sharp and blunt dissection and avoiding energy sources as much as possible.

The content of the hernia sac(s) are reduced; the number of the defect(s) confirmed and their extents mapped on the skin of the anterior abdominal wall.

MESH PLACEMENT AND FIXATION:

The prosthetic mesh is tailored to overlap the defect by 3-5 cm. In cases of incisonal hernias the whole of the incision is covered by the prosthesis. More than one sheet of mesh may be needed depending on the locations of the defects and the size of the patient.

Four sutures are placed extracorporeally at cardinal points of the mesh, marked on the skin and on the prosthesis. The side of the mesh to face the viscera is marked appropriately.

All necessary precautions are taken to avoid mesh contamination with skin pathogens.

The mesh is rolled, introduced into the abdomen through a 10/12 mm port and unrolled.

The sutures at the cardinal points are pulled transabdominally using a suture passer and knotted in a prefascial level. Additional transfascial sutures are placed around the prosthesis at 5 cm intervals. Further fixation is done with spiral tacks in a ‘double crown’ technique. A recent technique of fixing the mesh with a proline suture with the help of a suture passer or looping with a Veress needle has been described (391.

An intraabdominal drain has been used in cases of extensive adhesiolysis (33).

Final exploration for possible injuries is performed, all ports removed under direct vision. The pneumoperitoneum is released. The fascia at any trocar site 10 mm in diameter or larger is closed. Careful closure of the site used for open insertion of the first trocar is mandatory to prevent trocar site hernia. The skin is then closed with subcuticular sutures and a compressive bandage applied for 2-7 days depending on the size of hernia.

SPECIAL SITUATIONS:

SUPRAPUBIC HERNIA:

For hernial defects that extend to the pubic bone, a three-way Foley catheter is inserted. After adhesiolysis, the patient is placed in the Trendelenburg position, and the bladder is distended with methylene blue in saline. The bladder is dissected off the pubic bone until Cooper's ligament is reached. The mesh is then placed so that it extends behind the bladder and is tacked to the pubic bone, to Cooper's ligament, or to both.

SUBXIPHOID OR SUBCOSTAL HERNIA:

A hernia in which there is no fascia between the hernia and the ribs or the xiphoid (e.g., a poststernotomy hernia) poses significant challenges for fixation. Because of the risk of intrathoracic injury, the mesh is not tacked to the diaphragm. Although some surgeons perform mesh fixation to the ribs, this measure is often associated with significant postoperative pain and morbidity. In these situations, the falciform ligament is taken down the mesh laid along the diaphragm above the liver, placing tacks and sutures up to but not above the level of the costal margin. Taking down the falciform ligament may be a helpful step for all upper abdominal wall hernia repairs. The recurrence rates for subxiphoid and subcostal hernias are higher than those for hernias at other locations.

PARASTOMAL HERNIAS:

As many as 50% of stomas are complicated by parastomal hernia formation, and 10% to 15% will require operative intervention for obstruction, pain, difficulty with stoma care, or unsatisfactory cosmesis. The intestine is centralized in the mesh by cutting an appropriately sized hole in the middle of the mesh sheet, along with a slit to allow it to be placed around the intestine. This step is repeated on a second piece of mesh, but with the slit oriented to the opposite side. The mesh is fixed with sutures and tacks in such a way that it overlaps the defect by at least 3 cm (more commonly, 5 cm) on all sides, as in other ventral hernia repairs. This method appears to minimize the risk of mesh prolapse and bowel herniation alongside the stoma. Laparoscopic parastomal hernia repair appears to be a viable alternative to laparotomy or stoma relocation, but long-term multicenter evaluation is necessary for full assessment of this technique's value in this setting.

THE PREPERITONEAL (INLAY) REPAIR:

This method differs in the positioning and mesh placement in the preperitoneal retromuscular space.

In the totally extraperitoneal (TEP) approach, the first trochar is inserted in the retromuscular level; this is followed by blunt dissection of the preperitoneal space by a balloon catheter, identification and reduction of the sac and insertion of the mesh with considerable overlap of the defect. (48-50).

The transabdominal approach (TAP) proceeds like the onlay method. After reduction of the sac contents and adhesiolysis intraperitoneally, a large flap of peritoneum (with extraperitoneal fat, fascia and posterior rectus sheath where present) is raised to accommodate a suitably sized polypropylene mesh, which is then covered again with the peritoneal flap at the end of the procedure. The mesh is fixed to the retromuscular fascia with spiral tacks at a distance of 1-2 cm with a 'double crown' technique (44-46). Reperitonization by re-placing the peritoneal flap created earlier is performed by spiral tackers or by continuous intracorporeal suture thus making the mesh entirely extraperitoneal.

POSTOPERATIVE CARE:

The Foley catheter is removed at the end of the procedure. Unless adhesiolysis was minimal, patients are admitted to the hospital. Oral intake is begun immediately. Patients are discharged when oral intake is tolerated and pain is controlled with oral medication. Patients are informed that fluid may accumulate at the hernia site and are asked to report any fever or redness or severe pain. Finally, patients are instructed to resume all regular activities as soon as they feel capable.

PERIOPERATIVE DATA / RESULTS:

(A) THE INTRAPERITONEAL (ONLAY) APPROACH:

Several series of LVHRs with intraperitoneal (onlay) placement of the mesh have been reported. The number of patients, duration of hospital stay, mean follow-up period, and complication and recurrence rates are summarized in Table 1. Published articles not giving the 75% of the variables analyzed were excluded.

Table I: Published Series Obtained for Intraperitoneal LVHR:

	Year of Study	No. of patients	Complication rate (%)	Duration of hospital stay (days)	Mean period of follow up (months)	Recurrence rate (%)
Saiz et al	1996	10	20	<l	13.5	0
Costanza et al	1998	15	13.3	2.0	18	6.7
Park et al	1998	56	18	3	24	ll
Toy et al[65]	1998	144	24	2	7	4

Franklin et al[66]	1998	112	5.1	6.5	30	1.1
Ramshaw et al	1999	79	19	1.7	21	2.5
Sanders et al	1999	II	0		12.5	8.3
Koehler and Voeller	1999	32	15.6	1.9	20	9.4
Kyzer et al [67]	1999	53	11.3	3.3	17	1.9
Heniford and Ramshaw[52].	2000	100	14	1.6	23	3
Heniford et al [22]	2000	407	13	1.8	23	3.4
Nguyen et al [68]	2000	16	0	<l	5.9	0
Chowbey et al [52]	2000	202	2.4	1.8	34.8	1
LeBlanc et al [69]	2001	96	4.1	-	51	9.3
Moreno-Egea et al [70]	2001	20	0	-	10	0
Kannan [51]	2003	20	10.0	4.0	14.9	5
Musyoms et al [33]	2004	49	18.4	5.9	14.3	2.0
Karimyan et al [71]	2004	32	6.7	1.8	-	6.7
Holland et al [10]	2004	25	4	-	20	12
Heineford et al [8]	2003	850	13.2	2.3	20.2	4.7
Yafuz et al [72]	2005	150	8.6	2.5	32	3.0
Benhaim et al [34]	2000	100	21	-	19	2

Bower et al [64]	2004	100	15.2	-	18	2
Mc Greevy et al [61]	2003	65	1	1.1	-	8
Rosen et al [62]	2002	100	16	1.8	-	17
Carbajo et al [40]	2003	270	14.07	1.5	44	4
Misra et al [74]	2006	33	6	1.5	13.8	6
Kyzer et al [75]	2004	25	0	2.7	47	0
Holzmann et al [73]	1997	18	23	1.6	24	10
Lomanto et al [76]	2006	50	24	2.7	21	2

The mean operative time ranged from 82-97 minutes. Intraoperative complications were not reported uniformly in all studies. There were reported cases of conversion into a laparotomy mainly due to severe adhesions with a range of 3-9.9 % (8,10,33,53,54), inadvertent enterotomies, (56-60), bleeding, morbid obesity preventing trocars from accessing the abdominal wall (62) and malignancy requiring oncological resection (33). There are also reported cases of enterotomies, which were managed laparoscopically without the need of conversion and where a minilaparotomy was performed for bowel repair, and the hernia repair completed laparoscopically (57).

The duration of hospital stay range from < 1 to 6.5 with a mean of 2.5days, mean follow up period range from 7-32 months, overall complication rates range from 0-24% with a mean range of 3.6-5.4(51,52) and a recurrence rate of 0-9.4% with a mean range of 3.8-4.3% during the follow-up periods reported.

The main post operative complications documented include enterotomies, hematoma and post-operative bleeding, urinary retention and urinary tract infection, post-operative fever of unknown origin, prolonged ileus, wound and mesh infection, prolonged pain (>6 months) and prolonged seroma (8 months) (2,8,12,33,55). Cobb et al (13) analyzed 19 large series of LVHR incooperating a total of 3276 patients and found the following complication rates; Fistula 3(0.1%), wound infection 35 (1.1%); mesh infection 20 (0.6%) and seroma 363(11.4%). Rare events included intraabdominal abscess (61), pulmonary embolism (39,62) prolonged ileus (63) and pancreatitis (64).

(B) THE PREPERITONEAL (INLAY) APPROACH

Only three series of the inlay method were obtained; one TAPP (44) and one TEPP (49) and one had both (48). The others publications are case reports (45-47,50), or isolated cases in a series of patients undergoing intraperitoneal repairs, which are not discussed (41,51).

In the TAPP series, Chobey (44), there were 34 patients, 18 with primary and 16 with incisional hernia. Intraoperatively there were a total of 24 iatrogenic peritoneal tears mainly at the site of the previous scar with considerable exposure of the mesh. Median duration of hospitalization was 1 day. One patient (2.9%) had an infected mesh removed 8 months after surgery and there was 1 (2.9%) case of recurrence at 4 months after surgery. Duration of follow up is not given.

In the TEP series, Miserez et al (49) had 15 patients. Complete reduction of the sac was accomplished in five while in the others; the peritoneum was excised at the hernia neck. The meshes were fixed with a circumferential tacker. Hospital stay duration is not given. There was no complication seen but there was one (6.6%) recurrence at 5.5 months with a median follow up of 4.5 months.

Moreno-Egea et al (48) had 8 patients in TEP and 3 in onlay method. Operative time averaged 42 minutes for either approach and the duration hospital stay was <1 day. All patients were observed for some hours and then discharged. There was no intraoperative or postoperative complication reported and no recurrence in the follow-up period.

There is no complication or recurrence reported in the case reports.

DISCUSSION:

Despite its significant prevalence and associated morbidity, there is little in the way of evidence- based guidelines regarding the timing and method of repair of ventral and particularly, incisional hernias (6,7). Several large studies on laparoscopic ventral hernia repair (LVHR) have been reported (8,22, 34, 40,52, 65,72). This technique has proven to be a safe and feasible alternative to open mesh repair. Although many are retrospective series and a few comparative studies, only two completed randomized trials comparing open versus laparoscopic mesh repair have been published (9,14,26,37,48). Based on these studies, LVHR has been found to have shorter operating time depending on the surgeon's experience, shorter hospital stay, lower complication rates especially wound and mesh infections and lower recurrence rate during the follow up period. This evidence has led to the suggestion that now; it would be unethical to conduct a prospective randomized controlled trial comparing LVHR and open approach (4,13,41,78).

LVHR techniques are based on the fundamental principles of the open preperitoneal repair described by Stoppa (19) and Rives (18). The placement of a large mesh in the preperitoneal location allows for an even distribution of forces along the surface area of the mesh, which may account for the strength of the repair and the decreased recurrence associated with it. The repair capitalizes on the physics of Pascal's principle of hydrostatics by using the forces that create the hernia defect to hold the mesh in place (8,13,26). For this to attain maximum effect, there has to be a wide mesh overlap over the defect and adequate, secure fixation. In the open approach, attaining an overlap of 3-5 cm required extensive soft tissue dissection, with the resultant increase in wound complications. Larger defects should require more overlap and smaller ones theoretically less. The laparoscopic approach not only allows clear definition of the defect margins but also the identification of additional defects that may not have been clinically apparent preoperatively.

Both the inlay and onlay placements of prosthetic mesh embrace these fundamental principles of hernia repair. The onlay and the transabdominal inlay methods, allow for adequate diagnostic laparoscopy to clearly define the margins and the number of the hernia defects including the occult ones. The TEP approach has the same draw back as the open method in detecting subclinical hernias. The TAP method requires the dissection of a large flap of peritoneum with extraperitoneal fat, fascia and posterior rectus sheath where present to accommodate a suitably sized mesh (44,47). The extent of dissection will thus be proportional to the size and the number of the defects. Dissection of the peritoneum has also been found to be quite difficult in recurrent and incisional hernias (13,26,59). Furthermore, the minimal reduction and resection of the hernia sac has been suggested to increase the incidence of seroma formation (20). The TEP approach also entails considerable tissue dissection albeit with a balloon catheter. This is even more marked in the obese, with a thick layer of subcutaneous tissue fat. Any amount of dissection albeit minimal entails creation of an additional wound in tissues, which in incisional and recurrent hernias may already be unhealthy due to previous surgical insults.

In comparing these two methods therefore, two issues needs to be considered regarding the dissection; One, the ease of achieving the adequate overlap of the hernia defect of 3-5 cm. The balloon catheter allows for blind dissection while raising peritoneal flaps would require a considerable dissection especially for larger defects. Two, the wound and mesh related complications due to extensive dissection of the open repair method have been partly attributed to tissue damage hematoma formation and devascularization (13). Thus in as far as adequate overlap of all hernia defects and preservation of intact tissue physiology are concerned, the intraperitoneal approach is the most ideal particularly for large, incisional and recurrent hernias, as well as for the obese and other patients occult defects.

One of the critical technical points that significantly impact on any method of hernia mesh repair is adequate mesh fixation (8,13,43). The mesh is held in position by sutures and /or staples, clips, tacks, intra-abdominal pressure and later by fibrinous growth (1,33). The most widespread technique in onlay approach involves fixation of mesh with tacks and transabdominal permanent sutures. Some surgeons have tried to reduce the operating and possibly postoperative discomfort by reducing or eliminating the use of sutures (29,40,79). The physics of mesh fixation do not support the sole placement of tacks. Majority of the meshes used are about 1mm thick. A perfectly placed tack can be expected to penetrate only 2 mm beyond the mesh thus tacks will not give the same holding strength as full thickness abdominal wall suture (9,33,41,42,57). Furthermore, the mesh is placed against the peritoneum, so any ingrowth is most likely into the peritoneum and not into the fascia (13,22,26).

Detachment of tacks has also been attributed to some recurrence of hernia (80). Postoperative recurrence of ventral hernia repair is reported to be as high as 13% when only a stapling, clipping or the tacking device is used for mesh fixation (69). Proper use of the transfascial fixation sutures in combination with staples decreased the recurrence rate to as low as 2 %. Therefore the current recommendation for mesh fixation is that a transfascial suture should be placed at a distance of 5 cm each along the perimeter of the mesh and tacking devices be used to affix the edge of the mesh at 1 cm intervals (8,69,71). The preperitoneal approach mesh fixation differs in that, there is immediate and continued fixation by the intact peritoneal sac and whether tacks or sutures or both are used, they fix the mesh directly onto the fascia. Sharma et al (47) emphasized that the primary concern of the peritoneal flap in the inlay technique is to achieve secure fixation of the mesh to the underlying fascia. The fibrinous ingrowth is from the fascia and not the peritoneum. Furthermore the preperitoneal positioning confers with the original design of Stoppa (19).

Perhaps the most compelling advantage of the preperitoneal placement of the mesh in the inlay approach is the avoidance of direct interaction between the mesh and the intraabdominal viscera. Contact of the viscera with foreign material such as the prosthesis may lead to an inflammatory response and adhesion formation which can induce chronic pain, intestinal obstruction, enterocutaneous fistula and infertility (29). In addition adhesions complicates any future intraabdominal surgery (28,58). The peritoneal covering also allows the use of conventional meshes, which have been associated with intense inflammatory response, and adhesion formation by some workers (15,58,81,82). The choice of the mesh used in LVHR may be the most contentious issue, particularly when financial cost is a major consideration (42).

The biomaterials available for ventral hernia repair have undergone many changes over the last several years. There are new products that have either been recently introduced or are in developmental stages. All seek to achieve two goals; rapid and permanent in-growth into the body wall and diminution of the risk of intestinal adhesions while maintaining its tensile strength (82-85, 88).The visceral side should be smooth, nonerosive antiadhesive and not easily susceptible to infection (29). This visceral barrier should be present for at least one week because this is the time frame in which adhesions forms (5,29,81,85). The ventral side should be macroporous allowing for fibroblast in growth and a foreign body reaction may be necessary for incorporation and high tensile strength.

Polypropylene (prolene) mesh, introduced by Sir Francis Usher in 1958 and modified in 1962 has gained widespread popularity and several types are commercially available today. Polyester mesh was introduced in Europe in the 1950s. Stoppa (19) used the polyester mesh in their landmark article describing preperitoneal repair of ventral hernia in 1989. Prolene mesh is currently the most widely used because it is relatively inexpensive, easy to handle, has a memory and is firmly incorporated in the abdominal wall due to its ability to induce an intense inflammatory reaction (29,85,). A 2-5% fistula rate has been reported with polypropylene mesh used intraabdominally (58) leading to the suggestion the great care must be taken to separate it from the bowel if it has to be used at all (20). However some studies do not support this view. Bingener et al (86) found no association of visceral adhesion when prolene was used with adequate omental interposition between it and the bowel. In another study involving 136 patients, Vrijland et al (87) concluded that enterocutaneous fistula appears to be very rare after prolene mesh repair regardless of intraperitoneal placement, omental coverage or closing the peritoneum.

A study comparing the biomaterials used in LVHR found polyester to have the highest incidence of infection, fistulization and recurrence(58).The expanded polytetrafluoroethylene(ePTFE) has the longest history in the use for these hernias repair. The original description of the procedure used an early generation of the ePTFE product. The current product has one smooth surface with 3 microns ePTFE interstices, while the other side has 22 microns interstices to facilitate fibroblastic ingrowth for firm fixation. Other modifications of this product involve incorporation of antimicrobials on the visceral surface (31,83). All of the composite prostheses have ePTFE and prolene or polyester but differ in the number and attachment of them together. There are no reports of intestinal fistulization or obstruction with ePTFE (20,57,89) though it has also been found to induce inflammation and fibrosis in laboratory animals (90).

However, the use of synthetic materials is not without problems. As a foreign material, the repair site is subjected to inflammation, susceptibility to infection and pain as a foreign body response. Encapsulation could affect the elastic function of the abdominal wall and aesthetic outcome of the repair (31,58). This has stimulated the search for natural biological prostheses like surgisis, collagen, glycosaminoglycans from porcine intestinal submucosa and alloderm (31,42,83). The financial cost to clinical-benefit ratio for use of the substantially expensive composite meshes is unquantified and is likely to remain as such because, given the widespread acceptance of composite products, a randomized, clinical comparison with prolene is unlikely to occur. Therefore, in selected circumstances, it may be acceptable to use a

simple mesh, if this can be excluded from the bowel by tissue interposition be it omentum or peritoneum. A composite mesh should be considered as the current standard of care (20,42).

The extraperitoneal placement of the prostheses would in principle diminish the intraabdominal complications associated with formation of adhesions. It would also allow the safe use of the conventional meshes like prolene, which has high intrinsic tensile strength, good memory, and cheaper (37). In addition the peritoneal coverage over the entire mesh provides additional security of fixation and a better mechanical advantage (15,20,29,77). As such it can be seen as an advance over the onlay approach. However, the placement is technically demanding as evidenced by the high iatrogenic peritoneal tears in the largest series (44) and it may not be feasible in the scarred abdomen of incisional and recurrent hernias, which constitute the bulk and seems to benefit most, from LVHR. Thus the issue of limitation of patient population amongst the technical feasibility and adequacy of defect coverage are issues of great concern before the method is accepted as an additional procedure for LVHR.

The good results and the attributed safety of LVHR are based on the large number of studies mainly utilizing the intraperitoneal approach. The generalization of the procedure has resulted in multiple variations of techniques (8,21,22). Overall, fewer complications are reported after LVHR than after open mesh repair especially in relation to wound and mesh infection. The efficacy of the inlay approach as an advancement of the conventional repair needs to be evaluated in terms of the several specific complications that are of particular relevance in laparoscopic procedures.

Probably the most dreaded complication is bowel injury and particularly if it is missed intraoperatively. It is a potentially lethal complication. The overall incidence of bowel injury does not differ significantly between open repair and laparoscopic repair and is generally low with either approach (1% to 5% when serosal injuries are included)(55). Pneumoperitoneum may hinder the recognition of bowel injury at the time of operation. There have also been reports of late bowel perforation secondary to thermal injury with laparoscopic repair (56,57). One study reported two bowel injuries that were not discovered until sepsis developed; these late discoveries resulted in multiple operations, removal of the mesh, prolonged hospital stay, and, in one patient, death. The incidence of bowel injury is likely to be higher with less experienced surgeons (35,55,57) and in patients who require extensive adhesiolysis (33). In one series describing a surgeon's first 100 cases, four of six inadvertent enterotomies were made in the first 25 cases (40,55). Enterotomies and severe adhesions are also the major causes of failed LVHR necessitating conversion to open surgery (8,34,35,55).

Minimizing the use of electrocauterization and ultrasonic dissection markedly reduces the risk of bowel injury. The visualization afforded by the pneumoperitoneum place adhesions between the abdominal wall and the bowel under tension. The high intensity light source and the magnification inherent in the laparoscopy facilitate identification of the least vascularized planes. As far as possible, direct grasping the bowel should be avoided preferring simply to push it or to grasp the adhesions themselves to provide counter traction. External pressure on the hernia may also help. Larger vessels in the omentum or adhesions are controlled with clips. Some degree of oozing from the dissected areas is tolerated; such oozing almost always settles down without specific hemostatic measures (31,55).

In cases of dense adhesions it is preferable to divide the sac or the fascia rather than risk injury to bowel. Densely adherent polypropylene mesh is best excised the abdominal wall rather than attempting to separate it from the serosa of the bowel. If bowel injury is suspected immediate and thorough inspection should be carried out. It may be difficult or impossible to find the exact site of injury later once the bowel has been released and freed of its attachments. Once the injury is recognized, it is the surgeon's level of comfort with laparoscopic suture repair determines the best approach. With minimal spillage of bowel contents, the injury may be treated with either laparoscopic repair or open repair; the latter usually can be carried out through a minilaparotomy over the injured area. Whether the mesh prosthesis is put primarily or later depends on the degree of contamination. More significant bowel injuries necessitate conversion to open repair. Missed injuries manifest postoperatively mandating re-exploration (34) with occasional removal of the mesh and immediate recurrence of the hernia (8,39).

One of the greatest benefits of LVHR is the reduction in wound and mesh infections. In a detailed analysis of wound complications from a pooled data of forty-five published series involving 5340 patients, Pierce et al (37) reported wound infection rates of 4.6-8 times fold higher in open versus LVHR. The number of mesh infections was also significantly higher with open approaches. Wound problems are strongly linked with soft tissue dissection required for retromuscular placement of large pieces of mesh (8,13, 22). The intraperitoneal approach obviates the need of this dissection that potentially devascularizes the fascia and cause haematoma formation, both of which contribute to infection. Although the incidence of mesh infection is very low the consequences are severe. Infections of prolene meshes can be managed locally with surgical drainage and excision of exposed, unincoporated segments but that of ePTFE require removal in most cases (8,39,40) due to it’s relatively low incorporation onto the body wall (55). Removal of the mesh results in return of the defect and its added morbidity. An analysis of all series with more than 50 patients indicated a mesh infection rate of 0.6%, cellulitis of the trochar sites that resolved on antibiotics alone in 1.1% and an overall wound and mesh complications of 1.7% (13). This has led to the widely perceived conclusion that the most compelling argument for LVHR is the minimization of soft tissue dissection and the associated reduction in the morbidity of local wound complications and potential infection of the implanted mesh .The high mesh infection rate reported in the inlay approach (44,49) could be related to the extensive dissection of the peritoneal flap.

Seroma formation is one of the most commonly reported complications in LVHR though it is not unique to laparoscopy(13,55). It occurs immediately after operation in virtually all patients. Most seromas develop above the mesh and within the retained hernia sac (13). The mean incidence of seroma in reported series at a range of 4-8 weeks is 11.4%. In the largest multi-institutional trial, seromas that were clinically apparent more than 8 weeks were considered a complication and occurred in 2.6% (8). Regardless of whether they are aspirated under sterile conditions or allowed to resolve, they rarely cause long-term morbidity. Aspiration may increase the risk of mesh infection but is recommended if they enlarge or persist before they reach their extremes. Patients sometimes mistake a tense seroma for recurring incisional hernia, but appropriate preoperative discussion should provide them with significant reassurance on this point.

Although Feldman (55) suggests that, seroma formation is not related to a particular type of mesh, Carbanjo (40) and Heniford(8) reported a higher incidence of seroma formation with ePTFE than

prolene based meshes. The low incidence in the latter meshes has been attributed to the large pores of the prolene-based meshes that allows more efficient resorption of wound secretions into the abdominal cavity than ePTFE meshes (91). The dissection of the preperitoneal space during the inlay method may lead to more seroma formation. This is supported by the fact that, in the classical description of the onlay technique, it is emphasized that no attempts should be made to reduce or resect the hernia sac. This have been established to be unnecessary and to increase the incidence of seroma formation(20) The peritoneum interposed barrier between the mesh and the abdominal cavity may hinder the direct drainage of this fluid regardless of the mesh used. Thus based on these facts, it seems plausible that the problem of seroma formation is expected to be higher in the inlay than the conventional onlay approach.

After LVHR, about 5% of patients complain of persistent pain and point tenderness at the transabdominal suture site which usually resolves spontaneously within 6-8 weeks(12). If it does not, injection of local anaesthetic into the area around the painful suture has good results (12,92). Since missed enterotomy is a grave concern in LVHR, particularly after a difficult adhesiolysis, correct interpretation of the significance of post-operative pain is an important issue. Whether or not to re-laparoscope a patient who experiences severe pain remains an important issue (42). A possible explanation of the common type of pain may be that, the transabdominal suture entraps an intercostal nerve as it courses through the abdominal muscles. Local muscle ischaemia may be another possibility (13). As such, it is an unavoidable adverse outcome of either approach so long as there is suture fixation of the prosthetic mesh. Whether it can be avoided by not using suture in the preperitoneal approach has to be weighed against the clinical- benefit ratio of such a repair.

The morbidly obese population represents a significant population of patients who present for ventral hernia repair (13). The advantages of minimal dissection, smaller wounds and decreased wound complications using the onlay methods has been concluded in a recent review (92) and all mitigates against the prepeitoneal dissection of the inlay approach.

The ultimate measure of the effectiveness of hernia surgery is the recurrent rate (39,55). Recurrence rates after LVHR range from 1.1% to 13%(39) whereas those after the open repairs ranged from 25% to 49%(15,22,39,81). In a multicenter series of 850 cases, the recurrence rate after a mean follow-up period of 20 months was 4.7% (8). The average recurrent rates using the onlay approach are approximately 4.2%(83) although rates as high as 17% have been reported (39).The critical technical points related with recurrence are inadequate mesh fixation particularly with sutures and prostheses that overlap the defect by less than 2 to 3 cm. Other factors associated with high recurrent rates include postoperative complications, previous repairs, missed hernias as in the “Swiss cheese” defects, longer operating time and obesity. The surgeon's level of experience plays a significant role in patient outcome, as demonstrated by a group that compared the outcomes for their first 100 laparoscopic incisional hernia repair patients, with those for their second 100. Recurrence rates after a mean follow-up period of 36 months dropped from 9% in the first 100 patients to 4% in the second 100. In addition, the second set of patients were an average of 9 years older, had a higher percentage of recurrent hernias, and exhibited more comorbidities, yet despite these added challenges, operating time was not lengthened, length of stay was similarly short, and the complication rate was no different (34,55). A multivariate

analysis of these variables indicated that prior failed hernia and increased estimated blood loss predicted recurrence while the other variables included; body mass index, defect size, size of the mesh did not have a positive correlation (39,62).

Although the results of large randomised trials are not available yet, the evidence to date suggests that the conventional onlay laparoscopic approach to the repair of ventral hernias is highly promising. The proposed laparoscopic preperitoneal placement of prostheses seems to negate most of the positive attributes of LVHR in most ways. This technique may be advantageous in small primary hernias, in a highly selected patients population. However, the widespread application of this approach or even the possibility of it being entered into a randomised trial appear dismal in the prevailing evidence, and the patients population that usually present with this structural disability.

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