ΜΕΤΑΠΤΥΧΙΑΚΟ ΠΡΟΓΡΑΜΜΑ ΣΠΟΥΔΩΝ:
‘‘ΕΛΑΧΙΣΤΑ ΕΠΕΜΒΑΤΙΚΗ ΧΕΙΡΟΥΡΓΙΚΗ,
ΡΟΜΠΟΤΙΚΗ ΧΕΙΡΟΥΡΓΙΚΗ ΚΑΙ ΤΗΛΕΧΕΙΡΟΥΡΓΙΚΗ’’

ΕΘΝΙΚΟ ΚΑΙ ΚΑΠΟΔΙΣΤΡΙΑΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΑΘΗΝΩΝ
ΙΑΤΡΙΚΗ ΣΧΟΛΗ

ΔΙΠΛΩΜΑΤΙΚΗ ΕΡΓΑΣΙΑ

ΘΕΜΑ:

Laparoscopic repair of parastomal hernia. Review of the literature.

ΜΕΤΑΠΤΥΧΙΑΚΟΣ ΦΟΙΤΗΤΗΣ:
ΚΟΡΟΒΕΣΗΣ ΓΕΩΡΓΙΟΣ
Α.Μ.: 20120728

ΑΘΗΝΑ ΙΑΝΟΥΑΡΙΟΣ 2015

ΠΡΑΚΤΙΚΟ ΚΡΙΣΕΩΣ
ΤΗΣ ΣΥΝΕΔΡΙΑΣΗΣ ΤΗΣ ΤΡΙΜΕΛΟΥΣ ΕΞΕΤΑΣΤΙΚΗΣ ΕΠΙΤΡΟΠΗΣ
ΓΙΑ ΤΗΝ ΑΞΙΟΛΟΓΗΣΗ ΤΗΣ ΔΙΠΛΩΜΑΤΙΚΗΣ ΕΡΓΑΣΙΑΣ
Του Μεταπτυχιακού Φοιτητή Κοροβέση Γεώργιου

Εξεταστική Επιτροπή

- Ιωάννης Γκρινιάτσος, Αναπληρωτής Καθηγητής Χειρουργικής, **(Επιβλέπων)**
- Χρήστος Π. Τσιγκρής, Καθηγητής Χειρουργικής και Επιστημονικός Υπεύθυνος του Π.Μ.Σ.
- Θεόδωρος Διαμαντής, Καθηγητής Χειρουργικής

Η Τριμελής Εξεταστική Επιτροπή η οποία ορίσθηκε από την ΓΣΕΣ της Ιατρικής Σχολής του Πανεπιστημίου Αθηνών Συνεδρίαση της ....ης ..... 20.... για την αξιολόγηση και εξέταση του υποψηφίου κου Κοροβέση Γεώργιου, συνεδρίασε σήμερα .../.../....

Η Επιτροπή διαπίστωσε ότι η Διπλωματική Εργασία του Κου Κοροβέση Γεώργιου με τίτλο: "Laparoscopic repair of parastomal hernia. Review of the literature", είναι πρωτότυπη, επιστημονικά και τεχνικά άρτια και η βιβλιογραφική πληροφορία ολοκληρωμένη και εμπεριστατωμένη.

Η εξεταστική επιτροπή αφού έλαβε υπ' όψιν το περιεχόμενο της εργασίας και τη συμβολή της στην επιστήμη, με ψήφους ..... προτείνει την απονομή του Μεταπτυχιακού Διπλώματος Ειδίκευσης (Master's Degree), στον παραπάνω Μεταπτυχιακό Φοιτητή.

Στην ψηφοφορία για την βαθμολογία ο υποψήφιος έλαβε για τον βαθμό «ΑΡΙΣΤΑ» ψήφους ....., για τον βαθμό «ΛΙΑΝ ΚΑΛΩΣ» ψήφους ....., και για τον βαθμό «ΚΑΛΩΣ» ψήφους ..... Κατά συνέπεια, απονέμεται ο βαθμός «.....».

Τα Μέλη της Εξεταστικής Επιτροπής

- Ιωάννης Γκρινιάτσος, **(Επιβλέπων)** (Υπογραφή) _____
- Χρήστος Π. Τσιγκρής (Υπογραφή) _____
- Θεόδωρος Διαμαντής (Υπογραφή _____

TABLE OF CONTENTS

1.Introduction

Parastomal hernia, broadly defined as an incisional hernia located at or immediately adjacent to a stoma, is one of the most common complications following stoma creation and its prevalence is only expected to increase. A parastomal hernia develops in up to 78% of patients with a stoma and typically occurs within 2 years of ostomy creation but may develop as long as 20 or 30 years after surgery. The reported incidence varies from 3 to 39 % for colostomies and from 0 to 6 % for ileostomies(1). Goligher even went so far as to claim that some degree of parastomal herniation is inevitable given enough follow-up time. While there is little argument that parastomal hernia is a common complication, the literature contains a broad range of parastomal hernia rates (**Table 1.**) as a result of varying definitions, method of diagnosis, length of follow-up, and type of stoma. It often has direct result in the quality of life for patients due to discomfort, pain, cosmetic complaints, frequent ostomy appliance leakage, or peristomal skin irritation and can result in significantly increased healthcare costs. Most parastomal hernias are asymptomatic and therefore can be treated conservatively. Urgent treatment is indicated when incarceration or strangulation of hernia content occurs(1). Surgical technique for parastomal hernia repair has evolved significantly over the past two decades with the introduction of new types of mesh and laparoscopic procedures(2)(3). The preperitoneal, retromuscular, or intraperitoneal positions of meshes are biomechanically more attractive and therefore favored by most surgeons(1).

Table 1. Rates of parastomal hernia in current literature for different types of stomas

Type of stoma	Rates of parastomal hernia in the literature
Loop ileostomy	0–6.2%
Loop colostomy	0–30.8%
End ileostomy	1.8–28.3%
End colostomy	4–48.1%
Urostomy	5–28%

1.1 Types of parastomal hernia

The most common classification system describes four subtypes: type 1: interstitial hernia, type 2: subcutaneous hernia, type 3: intrastomal hernia and type 4: peristomal hernia (stoma prolapse). The interstitial type includes a hernia sac within the muscle and aponeurotic layers, the subcutaneous type contains a subcutaneous hernia sac, the intrastomal type contains a hernia sac between the intestinal wall and the everted

intestinal layer, and the peristomal type results in the prolapse of bowel through a circumferential hernia sac surrounding the stoma. However, these four subtypes are difficult to ascertain on clinical exam and, therefore, have not been useful for clinical studies or in clinical decision making(2).

1.2 Risk factors

Both patient and operative technique are the two major factors that have been implicated in the subsequent risk of parastomal hernia. Individual patient characteristics that have been shown to be independent risk factors for parastomal hernia development including older age, increased body mass index, increased waist circumference, respiratory comorbidity, connective tissue disorders (e.g. Ehlers–Danlos syndrome) and other disorders that predispose patients to wound infection (e.g. diabetes mellitus), cancer, increased intraabdominal pressure (due to chronic cough, constipation, benign prostatic hypertrophy or ascites), and the presence of other abdominal wall hernias. Other factors in the literature that have been suggested but not validated include malnutrition, smoking status, chronic coughing, chronic constipation, ascites, corticosteroid use, and postoperative wound sepsis. Technical aspects related to ostomy creation that have been suggested as risk factors for paratomal hernia include bringing the stoma out through the resection site(4), an intraperitoneal route as opposed to an extraperitoneal one(5), a laparoscopic approach(6), and increased aperture size (7) (2).

A risk-stratification scoring system that takes into account the presence and influence of any of these factors on the development of herniation might be a useful clinical tool, since it may allow different management strategies for patients at different levels of risk. Surgery-related factors include the diameter of the trephine, whether the stoma is constructed in an emergency setting and whether an intraperitoneal or extraperitoneal approach is used (8). Although there is insufficient evidence on the ideal trephine size, a defect of 3 cm or more was found to be associated with a higher incidence of herniation (9). For every millimetre increase in the aperture diameter, the potential herniation risk appears to increase by 10%(10). The average glove size of general surgeons, which is 7.5(11), results in an abdominal wall defect 3.5 cm in diameter, which has been found to be an independent predictor of hernia on multivariate analysis(12). Resnick first described the use of a mechanical device to ensure the correct size of abdominal stoma. This consists of three different sized disposable heads (17, 25 and 32 mm) with a cartridge containing an annular knife and conical anvils. Using this there was only one case of herniation out of 32 patients at a mean follow-up of 7 years(13). Others have since used a conventional circular stapler. Although the optimum diameter of the trephine is not known, an oversized defect may contribute in itself to herniation. Goligher first described extra-peritoneal colostomy in 1958 and reported a herniation rate of only 9% at a follow-up of at least 2 years(14). Similar results were reported by others, but only one demonstrated a statistically significant difference(15). A meta-analysis of 1071

patients comparing extra-peritoneal with intra-peritoneal permanent colostomy found parastomal herniation to be lower in the former(16). There is, currently, insufficient evidence to advocate the routine use of the extra-peritoneal technique, particularly since it is technically more difficult and time-consuming and requires further colonic mobilization to provide extra length for the extra-peritoneal course. Furthermore, it is impracticable in laparoscopic surgery and the functional outcome may be unsatisfactory with a tendency to obstruction. The trans-peritoneal approach has been the most popular method of stoma formation over the last two decades. Sjodahl et al. (17) reported parastomal herniation rates of 2.8 and 21.6%, respectively, in patients with a permanent stoma formed either directly through (n = 107) or lateral (n = 23) to the rectus muscle. Others have, however, not confirmed these findings. Furthermore, Stephenson and colleagues reported a 10% parastomal herniation rate at a median follow up of 23 (19–29) months when the stoma was positioned lateral to the rectus abdominis in 41 patients(18). Splitting and excessive stretching of the rectus fibres is likely to weaken the muscle which may be an important factor accounting for the high incidence of herniation. Epigastric nerve injury has been completely overlooked as a factor, but it may also be important since partial or complete nerve transection may lead to denervation of the rectus abdominis with resulting muscle atrophy and abdominal wall weakness(19). Emergency surgery is thought to increase the likelihood of parastomal herniation, partly because the trephine often needs to be larger where there is dilated bowel segment and partly because the finer technical aspects of stoma formation are not the priority when the stoma is formed in a life-threatening situation(20).

1.3 Presentation and Diagnosis

Unfortunately, not only is development of a parastomal hernia after ostomy creation quite common, but roughly three-quarters of patients suffer from clinical symptoms related to their hernia. For these patients that are symptomatic, they most often will present with complaints of peristomal bulging when coughing, pain, or discomfort around the stoma, and difficulty keeping the stoma appliance in place with subsequent leakage. Peristomal bulging is a result of increased intra-abdominal pressure resulting in abdominal contents protruding through the fascial defect. Pain and discomfort is generally caused by stretching of the abdominal wall and adjacent skin. Difficulty with maintaining a seal between the ostomy appliance and the stoma is secondary to periodic peristomal bulging(21). As a result, leakage around the stoma appliance may be frequent, resulting in significant peristomal dermatitis especially in ileostomy and difficulty concealing the ostomy under clothing. Skin irritation is more prevalent with ileostomies and urostomies due to their respective effluent. Inquiring about levels of peristomal pain or discomfort, frequency of leakage and appliance change, and degree of skin irritation can be helpful in determining the severity of symptoms(22).

On physical examination, similar to other incisional hernias, a bulging adjacent to the stoma may be apparent upon Valsalva maneuver in the standing position.

Additionally, a fascial defect adjacent to the stoma may be palpable. However, clinical diagnosis has been found to be challenging with poor inter-observer reliability(23). It can be difficult to distinguish between an abdominal bulge and a true parastomal hernia on clinical exam alone. Although there is no gold standard for diagnosis, a CT scan of the abdomen has been the traditional imaging modality to confirm the diagnosis or obtain better characterization of the parastomal hernia.

A numerical classification system for parastomal hernia based upon CT findings exists, which includes type I (hernia sac containing stoma loop), type II (hernia sac containing omentum), and type III (hernia sac containing a spare loop other than the stoma) parastomal hernias(24). However, some hernias may be missed on a CT scan due to the inability of the patient to lie at the supine position. Abdominal ultrasonography can make a dynamic diagnosis of parastomal hernia without the necessity of the patient lying supine and can discriminate parastomal from simple abdominal bulging. However, this technique has not been well described in the literature. Intrastomal ultrasonography has gained recent interest as a potentially superior imaging modality as it is dynamic and avoids the use of radiation. Preliminary studies testing feasibility and accuracy have been promising with demonstration of a relatively low learning curve and good inter-observer reliability(25). Using a rectal setting on the ultrasound probe with a frequency of 9 MHz, the different underlying structures such as fascia, rectus muscle, bowel, and implanted mesh when present can be recognised. Bowel appears as five different hypoechogenic or hyperechogenic layers, similar to the rectal wall layers seen on endorectal ultrasound, and parastomal hernia can be diagnosed by visualizing an opening in the adjacent fascia and/or penetration of intestine and peritoneum into the subcutaneous fat. A learning curve of approximately 30 patients has been suggested(25)(26). However, more studies are needed to make it the imaging modality of choice(2)(27).

1.4 Management

The best treatment for parastomal hernia is to restore continuity of the intestine, thereby removing the stoma clearly, this is not always possible. Most hernias can be managed conservatively, with or without the use of a stomal supporting device. Intervention is required for strangulation or obstruction and may also be considered when there is difficulty maintaining the seal of the appliance around the stoma. Recurrent peristomal pain and cosmesis are also relative indications for repair. When revision of the stoma is required for another reason, such as stenosis or prolapse, then simultaneous repair of the hernia is clearly sensible. The surgical options are many, sadly, the literature suggests that the results are less than satisfactory. The techniques for repair fall into three categories: local tissue repair, stoma relocation and repair with prosthetic material, either intraperitoneally, extraperitoneally (subfascial) or as a fascial onlay(8).

Current treatment options include non-operative management, stoma relocation and repair of the enlarged fascial defect, with or without mesh. Traditional repairs for

parastomal hernia have been unsatisfying. Relocation of the stoma understandably results in high recurrence rates, given that nothing has been done to alter the risk factors that led to the hernia in the first place. Additionally, the old stoma site is then at rather high risk for development of an extra incisional hernia(28).

There are currently three types of mesh fascial repair determined by the level in the abdominal wall where the mesh is placed. Onlay repair places the mesh subcutaneously, fixed on top of the fascia of the anterior rectus sheath. Sublay mesh technique places the mesh between the rectus abdominis muscle and posterior rectus sheath. The underlay technique places the mesh intraabdominally, fixed to the peritoneum, with the stoma emerging through the mesh (keyhole technique) or laterally to the mesh (Sugarbaker technique). In asymptomatic patients, a conservative approach tends to be the preferred. This is because surgical repair can be challenging, with no guarantee of success. Where surgery is required, there is no clear guidance as to which surgical technique is the most effective(29).

The laparoscopic approach is appealing for many reasons. It avoids stoma relocation. Because the stoma bud is not manipulated and the incisions are small, wound infections and wound-related complications should be low. In addition, the minimal-access approach should provide the benefits of less postoperative pain, a lower analgesic requirement, reduced morbidity, a shorter hospital stay and an earlier return to full activity and work(30).

The two laparoscopic approaches most cited in the literature are the keyhole and modified Sugarbaker technique, although it has not been established which technique offers the lowest recurrence rate. Historically, the keyhole technique was described in 1977 by Rosin and Bonardi (31)(32) and consists of using an intraperitoneal mesh with a central hole or slit, allowing bowel to pass through the mesh to the stoma site. A potential disadvantage of this approach is the inherent weakness in the mesh that results from the slitting necessary to allow bowel to pass through(33). Sugarbaker reported his technique in 1985 and described placing a single uncut piece of mesh as an intraperitoneal patch and then lateralizing the bowel so as to allow the stoma site to be covered by the mesh(28).

Indications for surgical treatment are absolute only in the presence of complications obstruction, strangulation, the rest need an accurate assessment of risk. The main techniques used are fascial repair, stoma relocation and prosthetic mesh repair by laparotomy or laparoscopic intra-peritoneal mesh repair. Fascial repair and stoma relocation have a high rate of complications (24-88%) and a high rate of recurrence (46-100%)(8)(34). Mesh repair is considered to be a safe procedure with low risk of mesh infections. Prosthetic mesh repair has a recurrence rate of up to 28%(35). The advantage of intra-peritoneal mesh placement by laparoscopic approach is that it is a sterile procedure with a probable lower risk of infection. Laparoscopic correction with expanded polytetrafluoroethylene (ePTFE) has a promising recurrence rate of 2-8%, but still presents a high rate of complications, of 30%: risk of iatrogenic bowel damage, bowel erosion, ileus by adhesion formation, colic stenosis or stoma stenosis(36)(37).

Despite the abundance of meshes currently available, the ‘‘ideal mesh’’ that should

combine rapid ingrowth in the abdominal wall, offer high resistance to infections, and completely lack adhesion to the intestine is not yet available. Meshes made of expanded polytetrafluoroethylene (ePTFE) cause only few adhesions, are soft and pliable, and anchor to the abdominal fascia when fixed with sutures or tacks(36, 38).

1.5 Prevention

Parastomal hernia represents a major surgical problem. There is no uniform definition of parastomal hernia at follow-up, and the true rate in surgical practice is therefore difficult to establish, although it is reportedly at least 30% in most series. The only method that has reduced the incidence of parastomal hernia in a randomized trial is the use of prophylactic prosthetic mesh. Large-pore, low-weight mesh with reduced polypropylene content and a high proportion of absorbable material placed in a sublay position at the primary operation significantly reduces the incidence of parastomal hernia. Recurrence rates after surgical treatment of parastomal hernia are high unless mesh is used. Relocation of the stoma with prophylactic sublay mesh at the new site and sublay mesh repairing the incisional hernia at the primary site is the standard method for treating of parastomal hernias(39).

Two different surgical procedures (the onlay and sublay techniques) of how to place the mesh at the primary stoma formation have been described. As far as the onlay technique, the mesh is positioned on the exteral rectus fascia, on the other hand sublay technique where the mesh can be positioned in different ways, either inside the abdomen, pre-peritoneal, or between the rectus muscle and the posterior rectus seath. (**Figure 1.**) The goal is to reinforce the abdominal wall that surrounds the stoma, and, thereby, prevent herniation. The trephine is made in the middle of the mesh, and the size of the trephine is described as having a diameter approximately 0.5 cm larger than the bowel diameter(40). There is no consensus on how big the mesh overlap should be, but most reports from hernia repair surgery have a minimum of 5–6 cm overlap in all directions(41)(40). By placing a prosthetic mesh during the primary operation, the operation will be prolonged by approximately 15 min independent of the technique(40, 42).

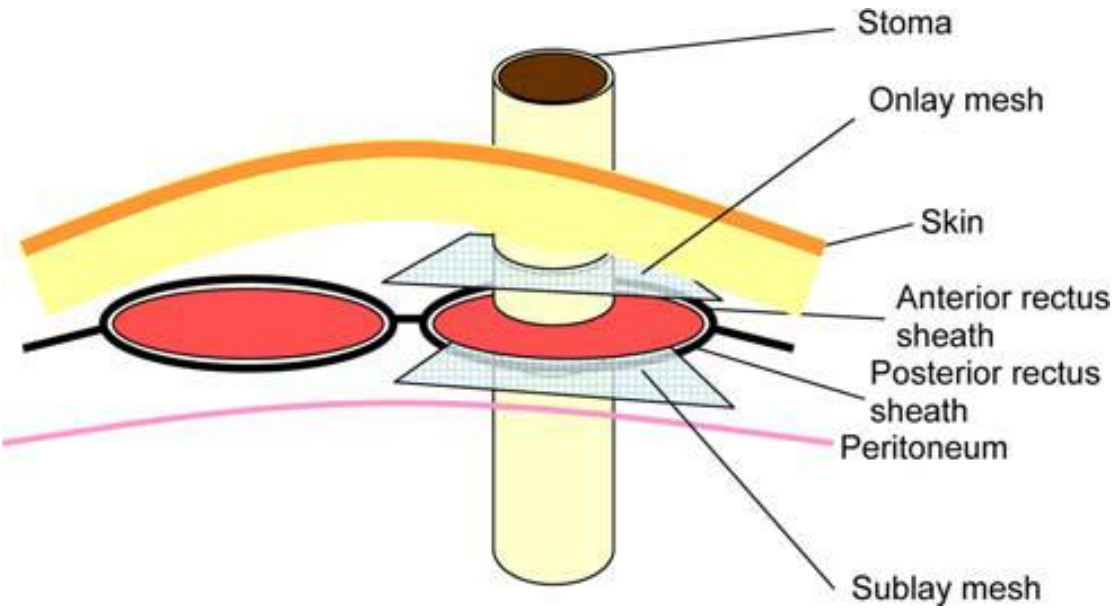


Figure 1. Schematic drawing of where to position a mesh in order to prevent parastomal hernia.

1.6 Techniques

Instrument/Monitor Positioning

The primary surgeon will usually stand on the patient's side opposite the stoma or between the patient's legs (**Figure 2**.) The primary monitor is placed on the patient's side that contains the stoma near the level of the patient's hip. A secondary monitor can be placed at the patient's shoulder or at an alternate site viewable by the assistant or surgical technician. Insufflation tubing, suction tubing, cautery power cord, laparoscopy camera wiring, and a laparoscope light cord are brought off the patient's side. A 10-mm laparoscope with a 30-degree lens is preferred.

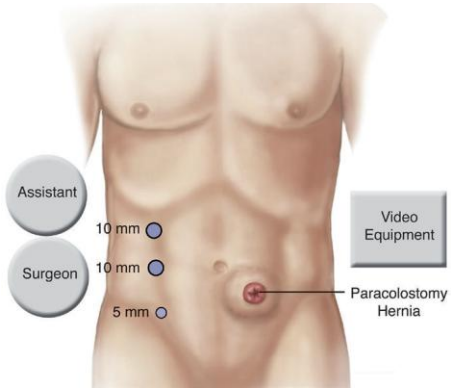


Figure 2. Trocars and surgeons position.

Port Selection and Placement

A 10/11-mm port with a balloon is placed using an open (modified Hasson) technique in the lateral abdomen on the side opposite the ostomy and hernia. A vertical skin incision with a scalpel is followed by dissection down to the fascia. If a balloon trocar is not used, a purse-string of 2-0 polyglycolic acid suture is placed, and the fascia is incised inside this suture. Muscles are split, and the peritoneum is opened sharply. Once entry into the peritoneal cavity is obtained, a 10/11-mm trocar is inserted, and the purse-string is tightened. Laparoscopic inspection of the peritoneal cavity rules out unsuspected pathology and identifies the patient with dense extensive adhesions that would make a laparoscopic approach problematic. If the abdomen is suitable, additional ports are placed under laparoscopic visualization at the locations described. Unless a quality 5-mm camera and mesh fixation device (tacker) are available, one of the other ports needs to be at least 10-mm in diameter. The remaining ports can be 5-mm trocars. The exact location will vary depending on adhesions and the location and size of the hernia. In general they are placed a hand's width apart and on the side of the abdomen opposite the hernia. If the stoma is located on the right side of the abdomen, the trocar placement locations are reversed.

Operative technique

Adhesions to the anterior abdominal wall are divided with sharp dissection and traction. This can often be tedious and has the potential for bowel injury. This is especially true if previous repairs have used mesh. Extensive dense adhesions may require conversion to an open technique. Bowel loops are gently reduced from the hernia using traction and careful division of adhesions. Alternate energy sources, such as Enseal (Ethicon Endosurgery, Cincinnati, Ohio), may be helpful for some vascular adhesions, but they are not a substitute for careful dissection. When all the bowel has been reduced, the bowel leading to the stoma will remain. The peritoneal sac is left in place. The underlay techniques require that the bowel have adequate laxity to allow the bowel to track between the mesh and the abdominal wall. Reduction of the hernia will usually provide adequate laxity. If that does not, additional mobilization of the bowel may be necessary to allow adequate lateralization of the bowel. The ostomy bowel is pulled intra-abdominally to reduce any prolapse. The ostomy bowel is then pulled to the lateral or superior edge of the hernia defect. Some surgeons will then suture the ostomy bowel serosa to the peritoneum with absorbable sutures at the edge of the defect. The abdominal wall is also inspected for additional hernias that need repair. A piece of mesh is selected that will cover the hernia defect with a 5-cm overlap. It is often helpful to compare the mesh on the abdominal wall, but to minimize the risk of contamination, the mesh should not touch the stoma itself, and contact with the skin should be avoided. Several types of mesh have been used, including nonabsorbable, absorbable, partly absorbable, and acellular collagen matrix meshes. Early authors used a polypropylene mesh. Subsequently, composite meshes

were used, and more recent authors have expressed a preference for biologic meshes. Whatever mesh is chosen, it must be thin enough to allow tacking of the mesh to the posterior abdominal wall. If peripheral tacking sutures will be used, they are placed at the edges of the mesh. The mesh is then tightly rolled (**Figure 11. and Figure 12.)** and inserted through one of the larger trocars into the abdomen. Here it is unrolled and moved toward the stoma and hernia and oriented. After orienting the mesh, the traction sutures are extracted with a "suture passer" technique through small separate skin incisions. The sutures are tied down to the anterior abdominal fascia, creating transabdominal fixation. Authors have used a variable number of these traction/fixation sutures, ranging from a suture every 5cm to just 4 sutures. As tacking devices have improved, the number of traction/fixation sutures has been reduced or eliminated. After the traction/fixation sutures are secured, further fixation is done with a mechanical fixation device (e.g., SorbaFix or ProTack) at the margin of the mesh and along the bowel tract and edge of the fascial defect. Care is taken to produce appropriate tension on the mesh and to avoid putting the tackers into the ostomy bowel or mesentary and to allow enough laxity for the ostomy bowel to exit the mesh. After mesh fixation, the bowel is again inspected to exclude any unsuspected injury or bowel compression. Another technique uses a keyhole piece of mesh. Mesh of appropriate size is cut with a central or slightly offcenter opening and a slit (**Figure 3**). The size of the mesh and location of the "central" opening should again allow a 5 cm overlap from the edges of the hernia. The central opening should be large enough to accommodate the bowel. If nonbiologic mesh is used, most authors have made the opening large enough that the mesh edges are not in direct contact with the bowel wall. With this technique, less laxity of the bowel leading to the stoma is required. After cutting the mesh, it is inserted into the abdomen as described previously and maneuvered into place. The four traction sutures are placed through the abdominal wall and secured. The edges of the mesh are tacked to the fascia as described previously (**Figure 4.**). The fascia of larger trocar sites is closed with absorbable sutures, and the sites are infiltrated with local anesthetic (bupivacaine or bupivacaine liposome injectable suspension).

More recently, a laparoscopic sandwich technique was introduced by Berger et al(43) with excellent results. The sandwich repair is a combination of the keyhole and Sugarbaker techniques utilizing two pieces of mesh. First, a piece of mesh is incised in a keyhole fashion, placed around the stoma, and fixed to the abdominal wall with staples. Next, an additional larger piece of mesh covers the stoma site, and the stoma loop is lateralized between the slit mesh and larger mesh for at least 5 cm. In their observational study of 47 patients, a recurrence rate of only 2.1% was noted(2)(44).

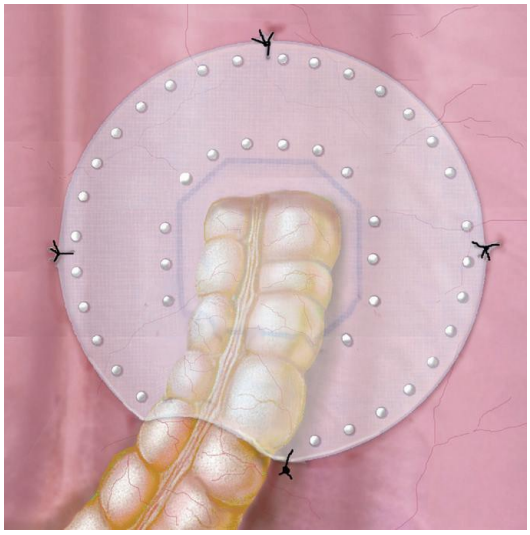


Figure 3. Fixation of mesh in a laparoscopic hernia repair.

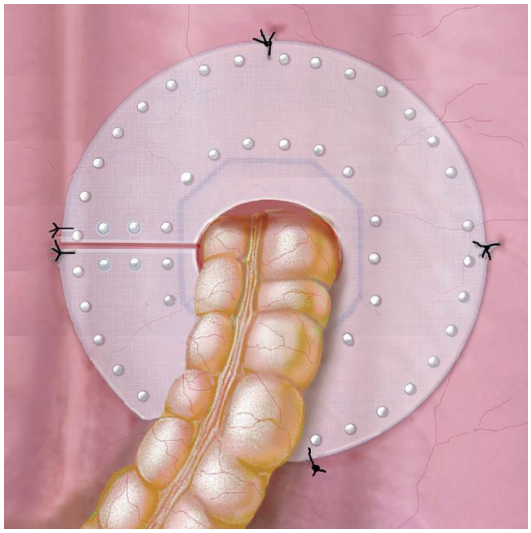


Figure 4. Keyhole mesh.

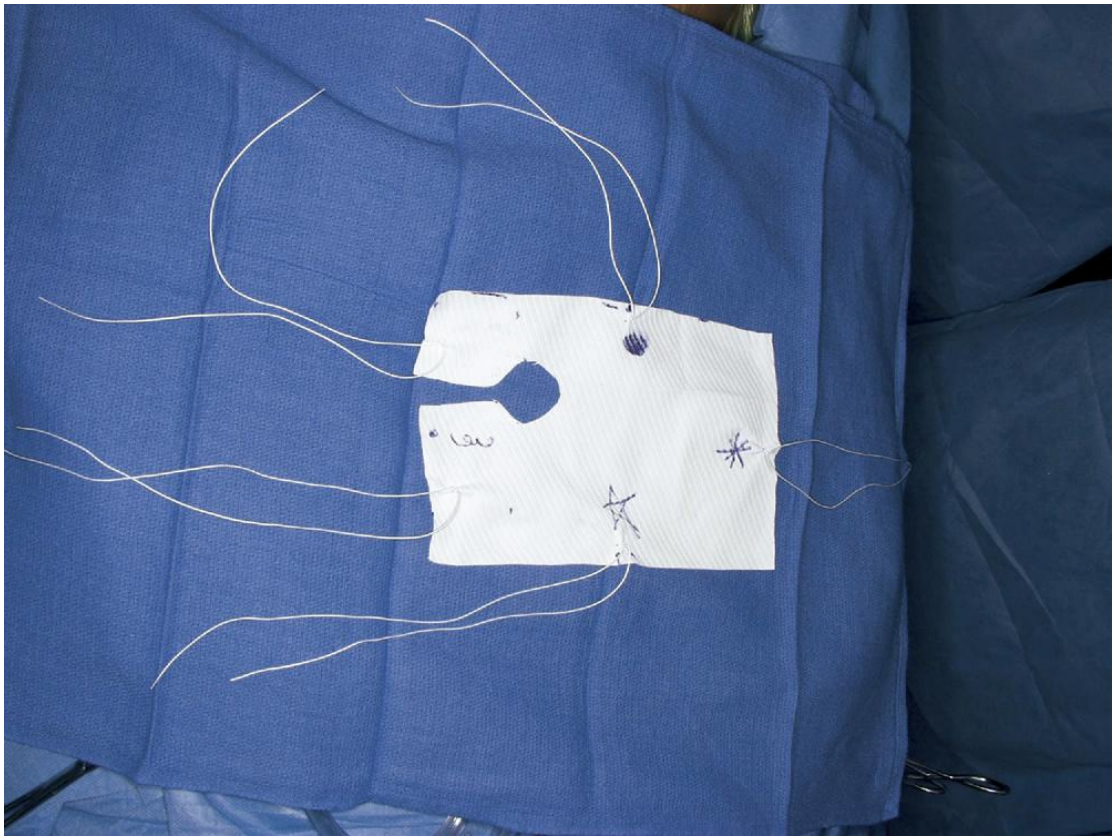


Figure 5. A 2 to 3cm keyhole defect created in the mesh to accommodate the ostomy.

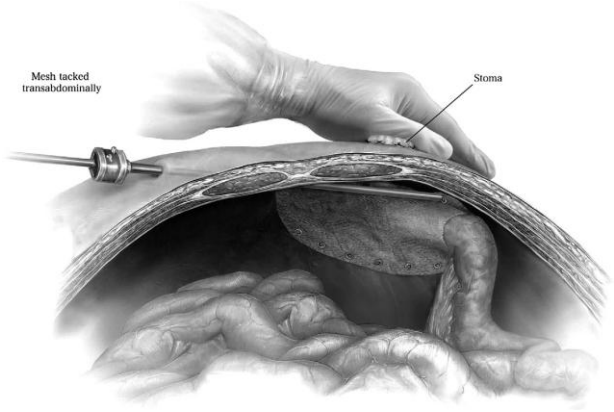


Figure 6. Sugarbaker technique: The mesh is tacked circumferentially with a spiral tacker. The surgeon uses the opposite hand for abdominal wall traction.

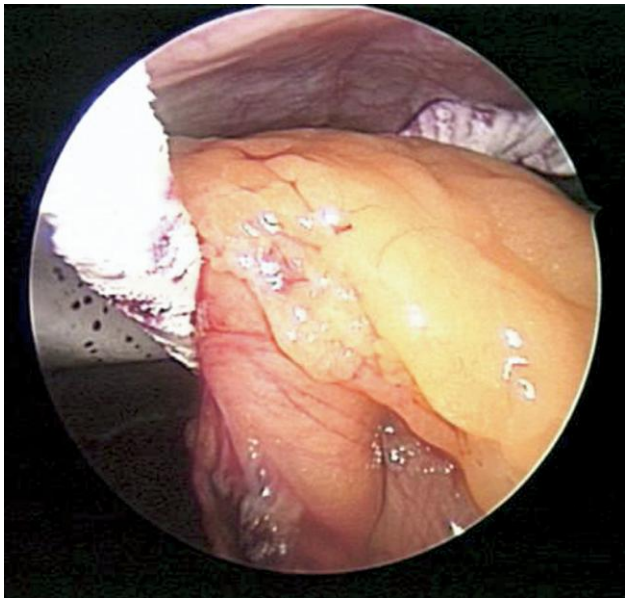


Figure 7. Sugarbaker technique: Laparoscopic view of bowel exiting over the side of the mesh.

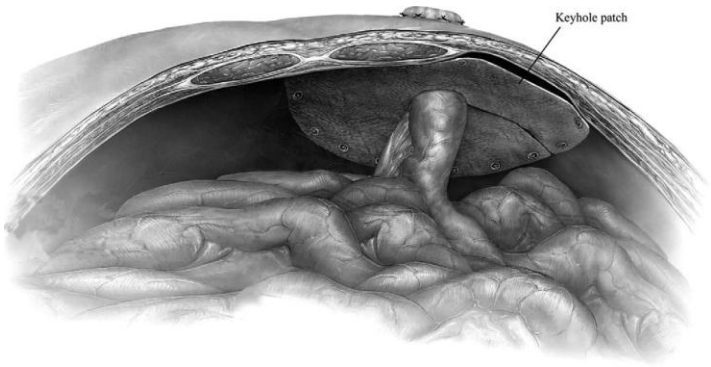


Figure 8. Keyhole technique: Final appearance of mesh and ostomy.

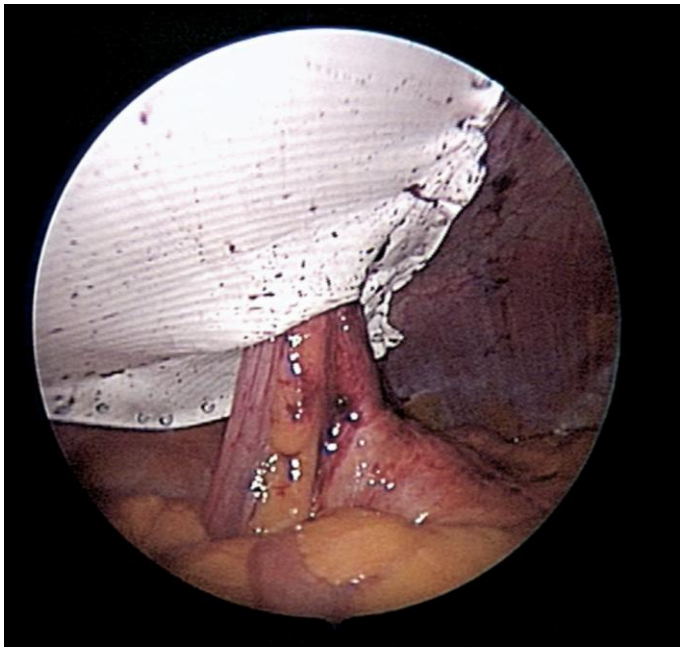


Figure 9. Keyhole technique: Laparoscopic view of the final appearance of mesh and ostomy.

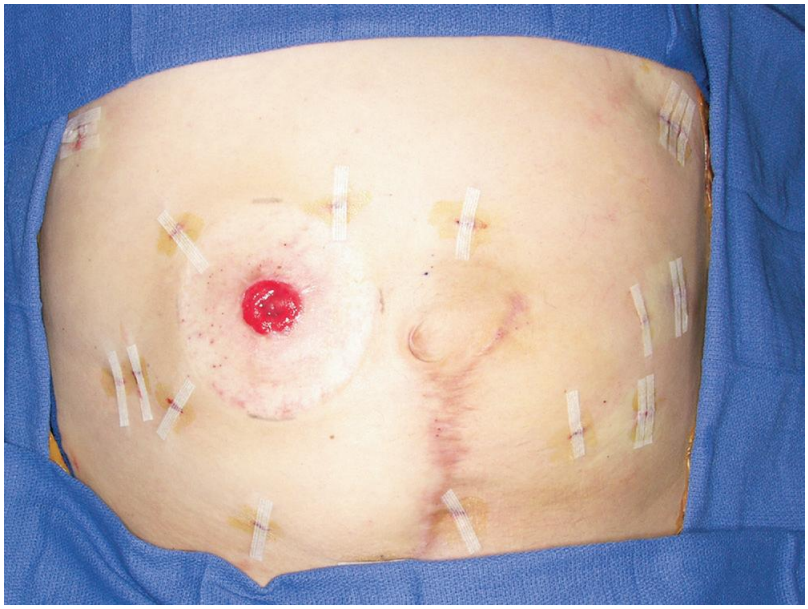


Figure 10. Abdomen with ostomy after a finished laparoscopic parastomal hernia repair.

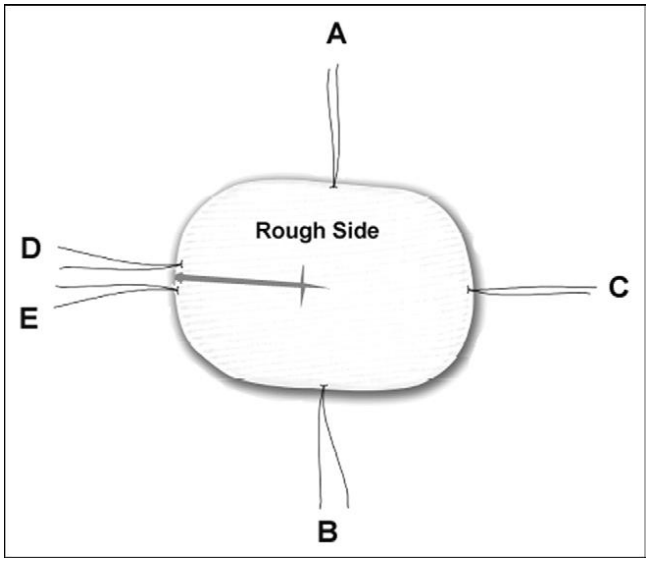


Figure 11. A cruciate incision is made at the junction of one third and two thirds of

the mesh. A long suture is placed at each corner of the mesh.

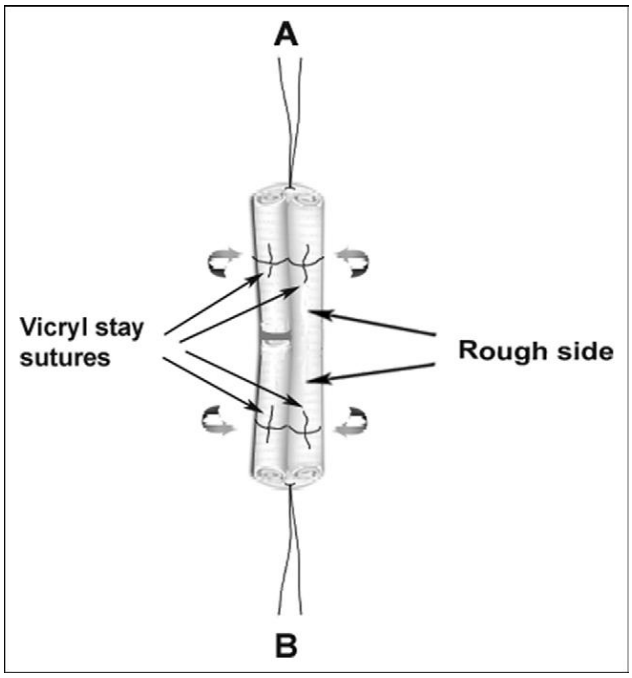


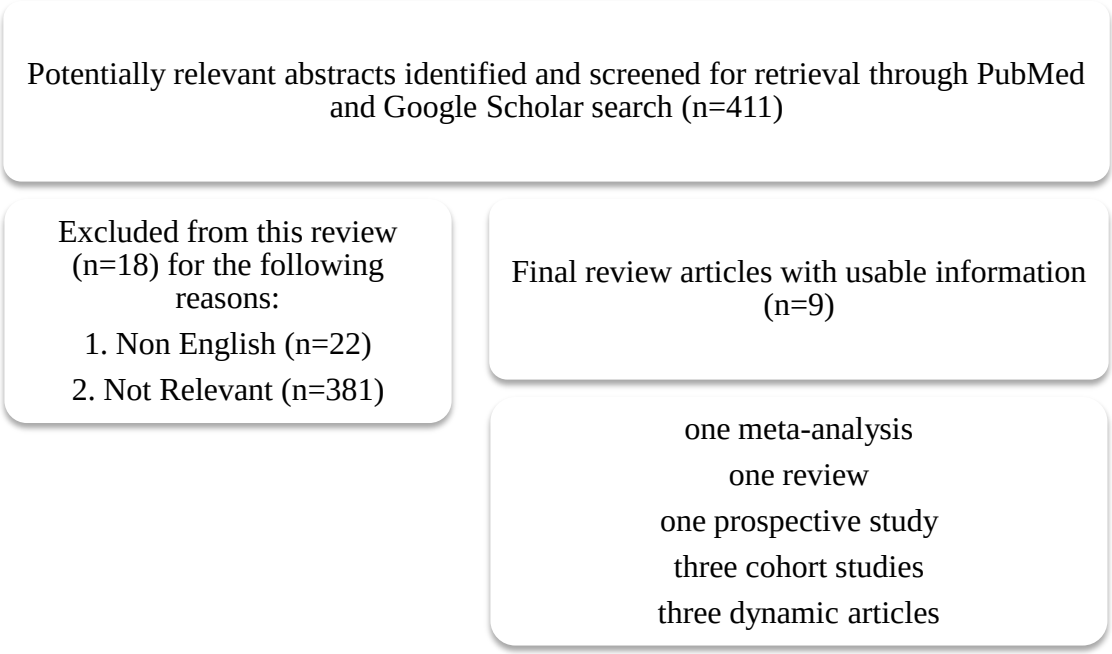
Figure 12. A technique how to wrap the mesh. The mesh is rolled tightly from each side to the middle and stay sutures are placed to keep the mesh rolled. Sutures C, D and E are now inside the rolled mesh.

2. Literature review

2.1 Review methodology

The literature review employed the PubMed and Google scholar database up to 2014 and applied the search words "laparoscopic", "parastomal hernia", "Sugarbaker", "keyhole", "complications" and "recurrence" in various compinations. The review included all the relevant publications in the English literature. For authors or institutions who republished their results with larger series, only the most recent and larger where included. Potentially relevant abstracts identified and screened were n=412 excluded 403 for the following reasons: 1. Non English (n=22), 2. Not relevant (n=381). The final studies, with usable information, included were 9: one meta-analysis, one review, one prospective study, three cohort studies and three dynamic articles (**Figure 13.**).

Figure13. Flow chart outlining the search history for published series of laparoscopic parastomal hernia repair.



3. Discussion

Many techniques for the repair of parastomal hernias have been described in recent decades. Generally, the techniques fall into one of three categories: local tissue repair, stoma relocation, or repair with prosthetic material. Although clinical trials to compare one technique with the others have never been performed, it is now commonsense to regard techniques using local tissue repair as outdated because of high recurrence rates in most studies(36).

Laparoscopic ventral hernia repair has consistently been proven superior to open ventral hernia repair. It is becoming the gold standard for incisional hernia repair as more surgeons gain experience. The laparoscopic technique is associated with fewer postoperative complications and a recurrence rate of 4.7% compared with 16.5% for open repair. Recently, the laparoscopic approach to incisional hernias has been applied to parastomal hernias. This has been associated with a decreased length of stay and earlier return to activities of daily living(45).

With the rising popularity over the last two decades of laparoscopic surgery, its use has spread to the treatment of parastomal hernia. The rationale is that the laparoscopic approach is associated with minimal additional injury to the abdominal wall and potentially offers a superior view of the defect allowing more precise repair and reinforcement of the abdominal wall with mesh but it could be argued hat it may increase the risk of iatrogenic intestinal laceration because parastomal hernia repair is by definition a reoperation, making disturbed anatomy and multiple dense adhesions

very common(36). Several investigators have reported their experience with laparoscopic parastomal hernia repair with variable success rates (**Table 2**).

Tracy Hull et al presented a laparoscopic prosthetic mesh parastomal hernia repair technique. The advantages of the laparoscopic method for mesh repair of nonparastomal ventral hernias include reduced analgesic requirements, reduced length of hospital stay, minimized abdominal wall trauma, and more rapid recovery. Decreased rates of wound and mesh infections have been reported previously. Uniquely for parastomal hernias, an important theoretical consideration would be to avoid an incision close to the stoma where bowel contents could potentially seep through the wound onto the underlying mesh with predictably disastrous results. Although nonabsorbable prosthetic mesh such as polypropylene has been reported to result in pain, obstruction, and erosion, this has not occurred in any of the study's patients, possibly because in this technique tailored the size of the mesh aperture to provide a correct fit around the stoma(27).

The advantages of mesh repair combined with minimally invasive surgery have led to the development of different laparoscopic techniques. Laparoendoscopic single-site surgery made its debut in 2010. The high incidence of parastomal hernia and the controversy surrounding its repair make its prevention an area of intense research. It has been experimentally shown that elastic polyvinylidene fluoride (PVDF) mesh material grows inward, prevents intestinal adhesions, and shows less shrinkage tendency. On the basis of these results, Gernot Kohler et al, chose to use this implant not only for prevention but also for parastomal hernia repair. It offers the following advantages 3-D funnel meshes can be used either in laparoscopic or open surgery. The parstomal hernia defect can be locally covered, with wide overlap to all sides. The skin and fascial incision can be minimized, which exceeds no other visually controlled laparoscopic port insertion, which is in any case recommended to avoid injuries due to potential adhesions. Wound complications such as hematoma and infections might potentially be decreased, because the abdominal wall layers need not be separated. The implant can be easily and quickly placed. By using a second flat mesh, a preexisting midline incision can be well covered to treat concomitant incisional hernias or avoid their occurrence. The frequently coexisting stoma prolapse can sufficiently be removed by relocation of the shortened bowel, and prolapse reoccurrence can effectively be prevented by the tightly fitting dome of the 3-D mesh(46).

Study	Number of patients	Technique	Blood loss (cc)	Conversion (%)	Complications (%)	Operating time (m)*	Length of stay (d)**	Recurrence (%)	Follow-up (m)***
Tracy Hull et al	3	Keyhole	50	0,0	0	43 (32-60)	-	0	8-16 m (12)
Genrot Kohler et al	9	single port 3D textile implant	-	0,0	11,1%	126,6	6 - 12	16	0,5-4,25 m
Mizrahi et al	29	Keyhole	-	6,9	3,4%	-	-	0	12-53m (30)
Wara et al	66	Keyhole	-	4,0	3%	-	-	46,4	6-132 m (36)
Hansson et al	54	Keyhole	-	14,5	0,9%	-	-	3	12-72 m (36)
Pastor et al	12	keyhole / Sugarbaker	-	8,3	8%	172±10	-	37	(13,9) m
Muysoms et al	24	keyhole / Sugarbaker	-	0,0	0%	-	3,1±0,4	33,3	4-54 m (21,1)
Zacharakis et al	4	Keyhole	-	0,0	0%	-	-	41,7	(9) m
Berger et al	66	Sugarbaker / sandwich	-	1,5	2,25%	-	-	25	3-72 m (24)
Craft et al	21	keyhole / Sugarbaker	-	0,0	2,4%	-	-	12	3-36 m (14)
Mancini et al	25	Sugarbaker	-	0,0	2%	-	-	4,7	2-38 m (19)
Le Blanc et al	12	keyhole / Sugarbaker	-	0,0	0%	-	-	4	3-39 m (20)

Study	Number of patients	Technique	Blood loss (cc)	Conversion (%)	Complications (%)	Operating time (m)*	Length of stay (d)**	Recurrence (%)	Follow-up (m)***
Safadi et al	9	keyhole / slit	-	0,0	0%	-	-	8,3	6-33 m
Kozlowski et al	4	modified Sugarbaker	-	0,0	0%	-	-	44,4	2-33 m
Voitk et al	4	Sugarbaker	-	0,0	0%	-	-	0	2-12 m
Hansson et al	55	GORTEX Dual mesh funnel shaped	20 (0-500)	8,0	10,8%	120 (40-315)	2-20	0	1,5m
Asma et al	33	keyhole / Sugarbaker	-	0,0	39,4%	-	5,1-6,4	1,8	21,5 m
Kevin et al	21	keyhole / Sugarbaker	-	0,0	9,5%	210 (99-326)	-	33,3	1-17 m
Hansson et al	61	modified Sugarbaker	-	0,0	18%	111,9 (55-295)	5 (1-21)	6	26 m
Alan et al	3	scroll technique-keyhole	-	0,0	33%	184 (150-122)	2	6,6	6-24 m

(m)* minutes, (d)** days, (m)***

Table 2.

In this review the conversion rates vary between 0 and 14,5%. Most laparoscopic repair studies report low wound infection rates of 0–5% with low mesh explantation rates of up to 10%. The most popular mesh in the laparoscopic studies was polytetrafluoroethylene which may account for the very low rate of erosion between 0 and 1.5%. Although polytetrafluoroethylene is a soft, inert material with minimum reactivity that does not adhere to the bowel(38), its major drawback appears to be its tendency to shrink(36), (47) which accounts for the disappointing recurrence rates of up to 46,4%. The shrinking of polytetrafluoroethylene mesh is thought to be due to the small pore size of the mesh which prevents tissue ingrowth and incorporation(48). Hansson et al. (47) reported that in almost all patients in their series who were re-operated for a recurrent parastomal hernia, the mesh appeared smaller with a wider central opening which was likely to be the cause of the recurrence. This is clearly an important observation, since their series is one of the largest with a median follow-up of 36 months. The ability of the polytetrrafluoroethylene mesh to provide effective, long-term treatment for parastomal hernias is in doubt and warrants further investigation. Other investigators have used instead of the 'keyhole' technique, variations of the 'Sugarbaker' technique that avoids creating a central hole with a slit in the mesh. Mancini et al. (49) reported recurrence rates of 4,7% with this technique whereas Pastor et al. (50) reported recurrence rates of 29% using the modified Sugarbaker technique and 67% using a keyhole technique. Similarly, Berger and Bientzle (50) reported eight recurrences in 41 patients (19.5%) using the modified Sugarbaker technique which they thought was disappointing. Subsequently, they used a two-mesh sandwich technique in the next 25 patients with no reported recurrences but the median follow-up was only 12 months. In conclusion, the laparoscopic approach appears attractive in view of the theoretical advantages of a more precise repair, minimal injury to the abdominal wall and faster postoperative recovery with decreased postoperative pain, although patients may occasionally complain of pain from the tacking sutures or clips to the abdominal wall. Laparoscopic parastomal hernia repair is associated with similar results to open repair and, hence, the benefit of this approach is unclear in terms of the longevity of repair considering the reported problems with mesh shrinkage and surgical repair technique. If a laparoscopic approach is selected then Sugarbaker / modified Sugarbaker or 'sandwich' techniques should be the preferred therapeutic options, since, at the present time, they appear to be superior to the keyhole technique(20).

Hansson et al reported accidental full-thickness enterotomy occurred in six patients (11%) despite the presence of an experienced laparoscopic surgeon. However, this still compares favorably with the 19% rate for inadvertent enterotomies during 270 relaparotomies in open surgery, as reported by van der Krabben et al.(51). The laparoscopic technique in itself should thus not be regarded as a risk factor for iatrogenic bowel injury. A risk factor may be the presence of a recurrent hernia because the percentage of inadvertent intestinal damage and reoperation is higher for these patients than for those with primary hernias. This may be explained by the disturbed anatomy and fibrosis caused by the previous operations, but it must be

realized that the number of patients studied is too small for definitive conclusions to be drawn. Four of the six bowel perforations were recognized during the initial procedure, which resulted in conversion to an open procedure. In two of these patients, further complications developed in the early postoperative period: an abscess on the mesh requiring its removal on the postoperative day 12 and an early recurrence. In two patients, full-thickness enterotomy was recognized only at the time of relaparotomy for signs of peritonitis, and although the patients eventually recovered completely, the hospital stay was prolonged and one mesh had to be removed because of infection. On the basis of the results from the current study, which represents by far the largest patient series available to date, it is concluded that laparoscopic parastomal hernia repair is feasible, even in cases of recurrent parastomal hernia. However, every possible precaution should be taken to prevent perioperative full-thickness enterotomy because this puts the patient at risk for serious infectious complications in the early postoperative period(36).

The slit-mesh technique or keyhole repair, has resulted in less than satisfactory results in the literature, and Asma Asif et al in their study confirm unsatisfactory recurrence rates (28). Any slit mesh technique carries the potential for herniation through the slit, and in the case of parastomal hernias, the stoma itself can act as a lead point for recurrent herniation through the defect created in the mesh. A modified laparoscopic Sugarbaker technique appears promising for repair of these challenging hernias as it allows for the proven advantages of laparoscopic ventral hernia repair, namely generous mesh overlap and less wound complications when compared with open repairs. By lateralizing the bowel over intraperitoneally placed mesh, the flap valve created is able to withstand increased abdominal pressure. One theoretical concern would be that lateralizing the bowel could lead to severe bowelobstructing angulation. One of the keys to this technique is the use of mesh that results in adequate coverage without resulting in bowel erosion or other obstruction. Several authors have documented the safety of expanded polytetrafluoroethylene as compared with other types of mesh (e.g. polypropylene), which led us to its use on a regular basis. At the moment, expanded polytetrafluoroethylene is the most frequently used prosthetic material for parastomal hernia repair. It is soft and pliable and causes less severe adhesions to the viscera compared to polypropylene meshes. If adhesions occur, the bowel can be easily dissected free from the prosthesis(1). To date, there have been no mesh related complications such as erosions or fistulas in our series(28).

Kevin et al have performed 21 laparoscopic parastomal hernia repairs (9 urostomy, 7 ileostomy, and 5 colostomy). The Sugarbaker technique was found to be technically less demanding, associated with decreased operative times and decreased recurrence rates. All repairs were successfully completed laparoscopically. Mean operative time was 210 minutes (99-326 minutes). A potential complication of this procedure is mesh obstruction of the enterostomy. This can occur if the flap valve around the bowel is created too small. One patient required laparoscopic re-operation for urostomy obstruction because of this problem. The surgeon needs to be cognizant of this while securing the mesh. Two patients required mesh removal for infection. Follow-up ranged from 1 to 17 months (mean 6 months). There have been no

recurrences(45).

Laparoscopic parastomal hernia repair is a safe and feasible procedure. Conversion to open repair is rare. Hansson et al reported at their study that reasons for conversion were multiple dense adhesions in six patients, intraoperative full-thickness bowel injury in six patients, and an inaccessible abdomen in one patient. Iatrogenic intraoperative bowel lesions were reported in 4.1%. Conversion rate (1.6%) and inadvertent enterotomy rate (1.6 %) were lower in this study probably because all procedures were done by experienced laparoscopic surgeons. Also, the complications were similar: wound infection in 3.3%, mesh infection in 2.7%, and other complications in 12.7%. Most complications resolve without further consequences however, mesh infection often results in mesh removal and a recurrent hernia. In this study, all repairs were done using an expanded polytetrafluoroethylen patch. The overall recurrence rate in our series was 6.6 %. Laparoscopic parastomal hernia repair using the Sugarbaker technique with an expanded polytetrafluoroethylen mesh is safe and feasible in experienced hands. This study shows an overall morbidity of 19 % and a recurrence rate of 6.6 % after a mean follow-up of 2 years(1).

Saber et al used scroll technique in 3 patients, the mean surgical time was 184 minutes (range 150–222 min). Remarkable is the fact that lysis of adhesions was the most challenging and time-consuming part of the procedure. The average time for mesh placement was about 30 minutes. The mean length of stay was 2 days. Apart from 1 patient who developed a transient postoperative seroma, there were no intraoperative or postoperative complications. With a mean follow-up period of 12 months (range, 6–24 mo), there was no evidence of recurrence(52).

In all the studies of this review blood loss was indicated only in two and it was between 20-500cc. As far as the length of stay it was between 2-21 days.

4. Conclusion

Various techniques have been advocated for surgical repair of parastomal hernias. The advantages of mesh repair combined with minimally invasive surgery have led to the development of different laparoscopic techniques. Laparoscopic repair of ventral hernias is increasing in popularity. This may be attributed to the advantages of such a minimally invasive approach: small incisions, less postoperative pain with fast recovery, and minimal wound complications. In addition, the use of mesh has decreased the recurrence rate of ventral hernias. The fundamental components of a sound hernia repair are maintained when the repair is performed laparoscopically, wide mesh overlap of the defect is used, and transabdominal sutures are the primary mechanism to secure the mesh in position. The use of laparoscopic repair combines the low recurrence rate of the mesh repair with the dramatically reduced risk of incisional hernia. In addition, patients receive the benefits of minimally invasive surgery including decreased analgesic requirements, reduced length of stay, lessened abdominal wall trauma, quicker recovery, and decreased wound and mesh infection. It also enables the surgeon to repair any associated incisional hernias without additional incisions. The high incidence of parastomal hernia and the controversy surrounding its

repair make its prevention an area of intense research(46).

The laparoscopic approach involves minimally invasive access to the abdominal cavity and intraperitoneal placement of prosthetic material with or without narrowing the trephine opening. Generally, three to four trocars are used for access. Adhesiolysis, reduction of the hernia sac content, and placement and fixation of the prosthesis are the key steps of the procedure. Similarly to the open intraperitoneal mesh repair both the Sugarbaker, the keyhole and a combination of both (ie, sandwich), are used. When performing intraperitoneal repair, the choice can be made between the keyhole and Sugarbaker repair. The recurrence rate is significantly lower with laparoscopic repair using the Sugarbaker compared to the keyhole technique. There is as yet insufficient evidence to show whether this holds true for open intraperitoneal repair of parastomal hernias. With the keyhole technique, it is difficult to estimate the size of the hole to "snugly" accommodate passage of the colon. Also, shrinkage of the mesh may result in enlargement of the central hole, which is often noted as the site of reherniation. One laparoscopic study reported on a sandwich repair using polyvinylidenefluoride (PVDF) prostheses combining both the Sugarbaker and keyhole techniques resulting in the lowest recurrence rate(3).

The majority of the literature about treatment of parastomal hernia consists of retrospective studies and case series with only small numbers of patients. There have been no randomized clinical trials published to date. The study populations are diverse with different types of stomas and some series also include rerepairs. The outcome parameters are ill defined, and the method of follow-up to detect postoperative complications or recurrent hernias differs between series(3).

5. Abstract

Backround Parastomal hernia is one of the most common complications following stoma creation and its prevalence is only expected to increase. Most parastomal hernias are asymptomatic and therefore can be treated conservatively. Advances in operative techniques and technology have facilitated laparoscopic repair of parastomal hernia. The surgical techniques has evolved over the past two decades with the introduction of mesh and laparoscopic procedures.

Methods All parastomal hernia repairs were attempted laparoscopically. The literature was reviewed. Two techniques were compared keyhole technique with Sugarbaker technique.

Results Between 2004 and 2014, n=515 patients underwent laparoscopic repair of parastomal hernia with the following techniques keyhole and Sugarbaker. The complicatios, conversion and recurrence were 6%, 3,7% and 17% respectively and the mean follow-up range between 8 and 33 months. The mean of median operating time in 7 studies was 138 minutes with a range between 32 and 326 minutes. As far as the length of stay in 6 of the studies range between 2 and 20 days.

Conclusion Laparoscopic repair of ventral hernias is increasing in popularity. This may be attributed to the advantages of such a minimally invasive approach: small

incisions, less postoperative pain with fast recovery, and minimal wound complications. When performing laparoscopic intraperitoneal repair, the choice can be made between the keyhole and Sugarbaker repair. The recurrence rate is significantly lower with laparoscopic repair using the Sugarbaker compared to the keyhole technique. Futhermore Sugarbaker is techniqually less demanding.

6. Περίληψη

Οι κήλες παρά την στομία είναι μια συνήθης επιπλοκή σε ασθενείς που φέρουν στομία. Εμφανίζονται σχεδόν στα δύο τρίτα των ασθενών σε διάστημα δύο ετών αλλά μπορεί και πολύ αργότερα μετά απο 20 ή και 30 χρόνια. Τις περισσότερες φορές είναι ασυμπτωματικές και η αντιμετώπιση τους είναι συντηρητική. Ο πόνος, ο ερεθισμός του δέρματος γύρω από τη στομία και η προπαίτεια του τοιχώματος είναι κύριοι λόγοι που οδηγούν τον ασθενή στο χειρουργείο. Οι παράγοντες κινδύνου για την δημιουργία κήλης αφορούν στην τεχνική που ακολουθήθηκε καθώς και τα ιδαίτερα σωματομορφικά χαρακτηρηστικά και τα συνοδά νοσήματα του ασθενούς. Υπάρχουν πολλές τεχνικές αποκατάστασης των κηλών παρά την στομία τοσο ανοικτής χειρουργικής όσο και λαπαροσκοπικής. Η συγκεκριμένη ανασκόπηση επικεντρώνεται σε δύο λαπαροσκοπικές τεχνικές την "keyhole" και την "Sugarbaker". Όλοι οι ασθενείς χειρουργήθηκαν λαπαροσκοπικά. Στην δεκαετία 2004 εώς 2014 χειρουργήθηκαν 515 ασθενείς με την πρώτη ή τη δεύτερη τεχνική. Οι επιπλοκές, η μετατροπή σε ανοικτή χειρουργική επέμβαση και οι υποτροπές ήταν 6%, 3,7% και 17% αντίστοιχα σε χρονικό διάστημα παρακολούθησης 8 εώς 33 μήνες. Η μέση τιμή της διάρκειας του χειρουργείου σε 7 μελέτες ήταν 138 λεπτά με διακύμανση 32 εώς 326 λεπτά. Όσον αφορά την διάρκεια νοσηλείας στο νοσοκομείο σε 6 μελέτες κυμαινόταν απο 2 εώς 20 ημέρες. Η αποκατάσταση των κηλών λαπαροσκοπικά στις μέρες μας αυξάνει σε δημοτικότητα γεγονός που αποδίδεται στα πλεονεκτήματα της ελάχιστα επεμβατίκης προσέγγισης, των μικρών τομών, του μικρότερου μετεγχειρητικού πόνου, της γρήγορης ανάρρωσης και των λιγότερων επιπλοκών. Οι επιλογές για την λαπαροσκοπική αποκατάσταση των κηλών παρά την στομία είναι κατά κύριο λόγω δύο, η τεχνική "keyhole" και η τεχνική "Sugarbaker", με την δεύτερη να υπερτερεί έναντι της πρώτης όσον αφορά τα ποσοστά υποτροπής και την ευκολότερη εκτέλεση της τεχνικής.

7. References:

1. Hansson BM, Morales-Conde S, Mussack T, Valdes J, Muysoms FE, Bleichrodt RP. The laparoscopic modified Sugarbaker technique is safe and has a low recurrence rate: a multicenter cohort study. Surg Endosc. 2013 Feb;27(2):494-500.

2. Aquina CT, Iannuzzi JC, Probst CP, Kelly KN, Noyes K, Fleming FJ, et al. Parastomal Hernia: A Growing Problem with New Solutions. Dig Surg. 2014 Dec 13;31(4-5):366-76.
3. Hansson BM, Slater NJ, van der Velden AS, Groenewoud HM, Buyne OR, de Hingh IH, et al. Surgical techniques for parastomal hernia repair: a systematic review of the literature. Ann Surg. 2012 Apr;255(4):685-95.
4. Randall J, Lord B, Fulham J, Soin B. Parastomal hernias as the predominant stoma complication after laparoscopic colorectal surgery. Surg Laparosc Endosc Percutan Tech. 2012 Oct;22(5):420-3.
5. Leong AP, Londono-Schimmer EE, Phillips RK. Life-table analysis of stomal complications following ileostomy. Br J Surg. 1994 May;81(5):727-9.
6. Funahashi K, Suzuki T, Nagashima Y, Matsuda S, Koike J, Shiokawa H, et al. Risk factors for parastomal hernia in Japanese patients with permanent colostomy. Surg Today. 2014 Aug;44(8):1465-9.
7. Hotouras A, Murphy J, Power N, Williams NS, Chan CL. Radiological incidence of parastomal herniation in cancer patients with permanent colostomy: what is the ideal size of the surgical aperture? Int J Surg. 2013;11(5):425-7.
8. Carne PW, Robertson GM, Frizelle FA. Parastomal hernia. Br J Surg. 2003 Jul;90(7):784-93.
9. Etherington RJ, Williams JG, Hayward MW, Hughes LE. Demonstration of para-ileostomy herniation using computed tomography. Clin Radiol. 1990 May;41(5):333-6.
10. Pilgrim CH, McIntyre R, Bailey M. Prospective audit of parastomal hernia: prevalence and associated comorbidities. Dis Colon Rectum. 2010 Jan;53(1):71-6.
11. Keeling NJ, Ataullah CM, Wastell C. A survey of glove preferences of general and orthopaedic surgeons in North West Thames Regional Health Authority. J Hosp Infect. 1995 Aug;30(4):305-8.
12. Resnick S. New method of bowel stoma formation. Am J Surg. 1986 Nov;152(5):545-8.
13. Koltun L, Benyamin N, Sayfan J. Abdominal stoma fashioned by a used circular stapler. Dig Surg. 2000;17(2):118-9.
14. Goligher JC. Extraperitoneal colostomy or ileostomy. Br J Surg. 1958 Sep;46(196):97-103.
15. Marks CG, Ritchie JK. The complications of synchronous combined excision for adenocarcinoma of the rectum at St Mark's Hospital. Br J Surg. 1975 Nov;62(11):901-5.
16. Lian L, Wu XR, He XS, Zou YF, Wu XJ, Lan P, et al. Extraperitoneal vs. intraperitoneal route for permanent colostomy: a meta-analysis of 1,071 patients. Int J Colorectal Dis. 2012 Jan;27(1):59-64.
17. Sjodahl R, Anderberg B, Bolin T. Parastomal hernia in relation to site of the abdominal stoma. Br J Surg. 1988 Apr;75(4):339-41.
18. Evans MD, Thomas C, Beaton C, Williams GL, McKain ES, Stephenson BM. Lowering the incidence of stomal herniation: further follow up of the lateral rectus abdominis positioned stoma. Colorectal Dis. 2011 Jun;13(6):716-7.
19. Rozen WM, Tran TM, Barrington MJ, Ashton MW. Avoiding denervation of the rectus abdominis muscle in DIEP flap harvest III: a functional study of the nerves to the rectus using anesthetic blockade. Plast Reconstr Surg. 2009 Aug;124(2):519-22.

20. Hotouras A, Murphy J, Thaha M, Chan CL. The persistent challenge of parastomal herniation: a review of the literature and future developments. Colorectal Dis. 2013 May;15(5):e202-14.
21. Kald A, Juul KN, Hjortsvang H, Sjodahl RI. Quality of life is impaired in patients with peristomal bulging of a sigmoid colostomy. Scand J Gastroenterol. 2008;43(5):627-33.
22. Martin L, Foster G. Parastomal hernia. Ann R Coll Surg Engl. 1996 Mar;78(2):81-4.
23. Gurmu A, Matthiessen P, Nilsson S, Pahlman L, Rutegard J, Gunnarsson U. The inter-observer reliability is very low at clinical examination of parastomal hernia. Int J Colorectal Dis. 2011 Jan;26(1):89-95.
24. Moreno-Matias J, Serra-Aracil X, Darnell-Martin A, Bombardo-Junca J, Mora-Lopez L, Alcantara-Moral M, et al. The prevalence of parastomal hernia after formation of an end colostomy. A new clinico-radiological classification. Colorectal Dis. 2009 Feb;11(2):173-7.
25. Gurmu A, Gunnarsson U, Strigard K. Imaging of parastomal hernia using three-dimensional intrastomal ultrasonography. Br J Surg. 2011 Jul;98(7):1026-9.
26. Strigard K, Gurmu A, Nasvall P, Pahlman P, Gunnarsson U. Intrastomal 3D ultrasound; an inter- and intra-observer evaluation. Int J Colorectal Dis. 2013 Jan;28(1):43-7.
27. Hiranyakas A, Ho YH. Laparoscopic parastomal hernia repair. Dis Colon Rectum. 2010 Sep;53(9):1334-6.
28. Asif A, Ruiz M, Yetasook A, Denham W, Linn J, Carbray J, et al. Laparoscopic modified Sugarbaker technique results in superior recurrence rate. Surg Endosc. 2012 Dec;26(12):3430-4.
29. Al Shakarchi J, Williams JG. Systematic review of open techniques for parastomal hernia repair. Techniques in coloproctology. 2014 May;18(5):427-32.
30. Safadi B. Laparoscopic repair of parastomal hernias: early results. Surgical endoscopy. 2004 Apr;18(4):676-80.
31. Mirza B, Chand B. Laparoscopic repair of ileal conduit parastomal hernia using the sling technique. JSLS. 2008 Apr-Jun;12(2):173-9.
32. Berger D. [Laparoscopic repair of parastomal hernia]. Chirurg. 2010 Nov;81(11):988-92.
33. Sugarbaker PH. Prosthetic mesh repair of large hernias at the site of colonic stomas. Surg Gynecol Obstet. 1980 Apr;150(4):576-8.
34. Rieger N, Moore J, Hewett P, Lee S, Stephens J. Parastomal hernia repair. Colorectal Dis. 2004 May;6(3):203-5.
35. Amin SN, Armitage NC, Abercrombie JF, Scholefield JH. Lateral repair of parastomal hernia. Ann R Coll Surg Engl. 2001 May;83(3):206-8.
36. Hansson BM, de Hingh IH, Bleichrodt RP. Laparoscopic parastomal hernia repair is feasible and safe: early results of a prospective clinical study including 55 consecutive patients. Surg Endosc. 2007 Jun;21(6):989-93.
37. Tarcoveanu E, Vasilescu A, Cotea E, Vlad N, Palaghia M, Danila N, et al. Parastomal hernias -- clinical study of therapeutic strategies. Chirurgia. 2014 Mar-Apr;109(2):179-84.
38. Koehler RH, Begos D, Berger D, Carey S, LeBlanc K, Park A, et al. Minimal adhesions to ePTFE mesh after laparoscopic ventral incisional hernia repair: reoperative findings in 65 cases. JSLS. 2003 Oct-Dec;7(4):335-40.

39. Israelsson LA. Preventing and treating parastomal hernia. World J Surg. 2005 Aug;29(8):1086-9.
40. Gogenur I, Mortensen J, Harvald T, Rosenberg J, Fischer A. Prevention of parastomal hernia by placement of a polypropylene mesh at the primary operation. Dis Colon Rectum. 2006 Aug;49(8):1131-5.
41. Janes A, Cengiz Y, Israelsson LA. Preventing parastomal hernia with a prosthetic mesh: a 5-year follow-up of a randomized study. World J Surg. 2009 Jan;33(1):118-21; discussion 22-3.
42. Marimuthu K, Vijayasekar C, Ghosh D, Mathew G. Prevention of parastomal hernia using preperitoneal mesh: a prospective observational study. Colorectal Dis. 2006 Oct;8(8):672-5.
43. Berger D, Bientzle M. Laparoscopic repair of parastomal hernias: a single surgeon's experience in 66 patients. Dis Colon Rectum. 2007 Oct;50(10):1668-73.
44. Berger D, Bientzle M. Polyvinylidene fluoride: a suitable mesh material for laparoscopic incisional and parastomal hernia repair! A prospective, observational study with 344 patients. Hernia. 2009 Apr;13(2):167-72.
45. Craft RO, Huguet KL, McLemore EC, Harold KL. Laparoscopic parastomal hernia repair. Hernia. 2008 Apr;12(2):137-40.
46. Kohler G, Emmanuel K, Schrittwieser R. Single-port parastomal hernia repair by using 3-d textile implants. JSLS. 2014 Jul;18(3).
47. Hansson BM, Bleichrodt RP, de Hingh IH. Laparoscopic parastomal hernia repair using a keyhole technique results in a high recurrence rate. Surg Endosc. 2009 Jul;23(7):1456-9.
48. Simmermacher RK, van der Lei B, Schakenraad JM, Bleichrodt RP. Improved tissue ingrowth and anchorage of expanded polytetrafluoroethylene by perforation: an experimental study in the rat. Biomaterials. 1991 Jan;12(1):22-4.
49. Mancini GJ, McClusky DA, 3rd, Khaitan L, Goldenberg EA, Heniford BT, Novitsky YW, et al. Laparoscopic parastomal hernia repair using a nonslit mesh technique. Surg Endosc. 2007 Sep;21(9):1487-91.
50. Pastor DM, Pauli EM, Koltun WA, Haluck RS, Shope TR, Poritz LS. Parastomal hernia repair: a single center experience. JSLS. 2009 Apr-Jun;13(2):170-5.
51. Van Der Krabben AA, Dijkstra FR, Nieuwenhuijzen M, Reijnen MM, Schaapveld M, Van Goor H. Morbidity and mortality of inadvertent enterotomy during adhesiotomy. Br J Surg. 2000 Apr;87(4):467-71.
52. Saber AA, Rao AJ, Rao CA, Elgamal MH. Simplified laparoscopic parastomal hernia repair: the scroll technique. Am J Surg. 2008 Sep;196(3):e16-8.