

# A stepwise approach based on a rational use of components separation and double mesh prosthesis for incisional hernia repair

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## Abstract

**Purpose** We aimed to evaluate the results of a protocol for a tension-free reconstruction of the abdominal wall in midline incisional hernia repair, based on the rational association of components separation and prosthesis, independently of the hernia size.

**Methods** A total of 100 consecutive patients with midline incisional hernias were prospectively included in the study. Three groups according to the transverse diameter of the defect [group A (<4 cm,  $N = 18$ ), group B (4–10 cm,  $N = 59$ ), and group C (>10 cm,  $N = 23$ )] were identified.

**Results** Components separation was necessary in 54 % of the patients: 16.7 % (3/18) in group A, 59.3 % (35/59) in group B, and 69.6 % (16/23) in group C. Complete tension-free reconstruction was achieved in 87 % of the patients: 94.4 % (17/18) in group A, 91.5 % (54/59) in group B, and 69.6 % (16/23) in group C. Overall morbidity rate was 21 % (21/100) [group A 16.7 % (3/18), group B 22 % (13/59), and group C 21.7 % (5/23)]. Hospital length of stay was  $3.7 \pm 3.3$  days (group A  $1.83 \pm 1.43$  days, group B  $3.05 \pm 2.11$  days, and group C  $6.91 \pm 4.45$  days). Median follow-up was 25 months (interquartile range 12.25–55.25) with overall recurrence of 2 %.

**Conclusion** A tension-free abdominal wall reconstruction can be achieved in most cases of small and large midline incisional hernia repair, by a stepwise approach based on a rational association of components separation and double mesh prosthesis, with a low morbidity and recurrence rates.

**Keywords** Components separation · Incisional hernia · Tension-free hernioplasty

## Introduction

Incisional hernia is a frequent complication after laparotomy. Prospective studies have reported an incidence of up to 11 % of the operated patients [1, 2]. These hernias could be associated with serious morbidity, ranging from bowel incarceration and strangulation requiring emergency abdominal surgery to important disabilities, with lifestyle and employment changes resulting in a significant economic burden [3].

Another major concern in incisional hernias is the poor outcomes after surgical repair. The introduction of meshes during the last decades has broadened the possibility for improving the results [4]. However, randomized controlled trials [5] have found very high recurrence rates after mesh and suture repairs, up to 24 and 43 %, respectively. Moreover, some authors have suggested [6] that mesh does not reduce the incidence of recurrent incisional hernias and only increases the interval of time until the new recurrent hernia is detected.

Double mesh technique for incisional hernia repair, although not well documented, seems to be more commonly used in practice than described in the literature [7]. First introduced by Usher in several papers between 1960 and 1971, it has undergone several modifications and only few variants are published so far [8–11]. Generally, the deep mesh could be placed intraperitoneally, in the preperitoneal or retromuscular space. The superficial mesh could be placed in the retromuscular space or most commonly in the preaponeurotic/subcutaneous space. Midline closure is variably used by different authors, but

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generally it is applied when components separation is performed. Although no formal comparison has been made to date, it has been highlighted in several papers the notably low recurrence rate with these techniques [8, 10, 12].

Plastic surgeons have described techniques for reconstruction of large abdominal wall defects. In 1990, Ramirez et al. [13] introduced the “Components Separation Technique”, based on translation of the muscular layer of the abdominal wall without the use of prosthetic material. This technique enlarges the surface of the abdominal wall and provided the closure of the defect at the midline. This method, however, creates weak areas in the abdominal wall, which can lead to the origin of new hernias.

Recently, the combination of components separation techniques and mesh prosthesis seems to be gaining an increased importance in the incisional hernia repair. The purpose of this prospective study is to evaluate a protocol for a tension-free reconstruction of the abdominal wall during incisional hernia repair, based on a rational association of components separations and

double polypropylene mesh, independently of the hernia size.

## Methods

Between 2002 and 2012, 100 consecutive patients were operated on midline incisional hernias by the same team, applying a carefully designed protocol for a tension-free reconstruction of the abdominal wall based on the rational use of components separation and polypropylene mesh. According to the classification established by the European Hernia Society [14], three groups of patients were identified based on the transverse diameter of the defect as follows: group A (<4 cm), group B ( $\geq 4$ –10 cm), and group C ( $\geq 10$  cm). General patient characteristics are given in Table 1.

Skin preparation was performed following a standard protocol [15]. Antibiotics were administered preoperatively, and postoperatively if indicated when accidental bowel perforation or long surgical time occurred. Standard

**Table 1** Patient characteristics by groups ( $N = 100$ )

	Groups			Statistical significance
	<4 cm $N = 18$	$\geq 4$ –10 cm $N = 59$	$\geq 10$ cm $N = 23$	
Female sex, $N$ (%)	8 (44.4)	38 (64.4)	12 (52.2)	NS
Age (years), mean (SD)	62.6 (14.7)	59.9 (12.4)	62.2 (13.2)	NS
Body mass index ( $\text{kg}/\text{m}^2$ ), mean (SD)	28.7 (5.0)	29.8 (3.9)	31.2 (6.5)	NS
Diabetes, $N$ (%)	3 (16.7)	6 (10.2)	3 (13)	NS
Chronic respiratory disease, $N$ (%)	1 (5.6)	10 (16.9)	2 (8.7)	NS
Hernia type (recurrent), $N$ (%)	2 (11.1)	7 (11.9)	4 (17.4)	NS
Type of anesthesia				NS
General	9 (50)	43 (72.9)	22 (95.7)	
General + local	4 (22.2)	7 (11.9)	0 (0)	
General + regional	0 (0)	1 (1.7)	0 (0)	
Regional	4 (22.2)	6 (10.2)	1 (4.3)	
Regional + local	1 (5.6)	2 (3.4)	0 (0)	
Location				NS
Supraumbilical	8 (44.4)	18 (30.5)	8 (34.8)	
Umbilical	5 (27.8)	14 (23.7)	2 (8.7)	
Infraumbilical	4 (22.2)	15 (25.4)	5 (21.7)	
Suprainfraumbilical	1 (5.6)	12 (20.3)	8 (34.8)	
Mean size of hernia defect (cm), mean (SD)	1.9 (1.0)	5.5 (1.5)	12.0 (2.2)	
Number of drains (SD)	1.0 (0.3)	1.3 (0.5)	1.7 (0.5)	<0.001
Duration of drainage (days), mean (SD)	3.8 (4.0)	6.7 (5.6)	8.7 (6.1)	0.003
Hospital length of stay (days), mean (SD)	1.8 (1.4)	3.0 (2.1)	6.9 (4.5)	<0.001
Mean operative time, minute (SD)	55 (21)	76 (33)	129 (31)	<0.001

NS not statistically significant

perioperative anticoagulant protocols were followed according to the risk assessment for deep venous thrombosis.

### Surgical technique

The abdominal wall was opened through a midline incision except for the cases with associated dermolipectomy, in which a transverse elliptical incision was made. Bowel was freed from the peritoneum, and the hernia sac from the subcutaneous tissue. The medial border of the rectus muscle was located, and its anterior surface freed from the subcutaneous tissue up to its lateral border.

Our approach was based on few main principles that we consider crucial for the correct abdominal wall reconstruction:

1. Intention to close the edges of the defect at the midline
2. Components separation on demand, independently of the hernia size
3. Double mesh hernioplasty is preferred

When components separation was necessary for a tension-free closure of the edges of the defect, discharge incisions were made bilaterally in the posterior and/or the anterior rectus sheath, in a first stage, and adding incisions in the external oblique aponeurosis [16, 17], if necessary. When the posterior rectus sheath was longitudinally incised, anatomical planes were prepared to locate the “underlay” (prefascial retromuscular) polypropylene prosthesis. For repairs without components separation, the “underlay” prosthesis was placed in the preperitoneal plane. When necessary, the omentum and peritoneum [17] were used with the rectus sheath, to isolate the prosthesis from the abdominal viscera. Since 2009, composite prosthesis (Parietex™ Composite (PCO) Mesh, Covidien, Mansfield, USA) was used when the former could not be obtained. The “underlay” prosthesis was placed overlapping the abdominal wall up to the lateral border of the rectus, with transmural 2/0 polypropylene sutures, preserving the epigastric vessels, for later tying them over the “onlay” prosthesis. Then, the hernia defect was tension-free closed, suturing their edges with a continuous 0/0 polypropylene suture. Thus, the abdominal wall was considered “completely reconstructed.” In cases where the apposition of the edges was not possible without tension throughout all their length, the fascia was partially closed and the segment of the free edges were sutured to the “underlay” prosthesis, considering the abdominal wall “incompletely reconstructed.” Lastly, an “onlay” mesh was located at the preaponeurotic space and tied with the transmural sutures previously placed. When components separation is performed for tension-free reconstruction, we consider the meshes would substitute the fascia (“mesh

fascial substitution”). When components separation was not necessary, both meshes would reinforce the fascia (“mesh fascial reinforcement”). One or two closed-suction drains were placed under the subcutaneous tissue, which was closed with a continuous absorbable suture.

### Follow-up

Hospital discharge was given after oral intake. Subcutaneous drains were removed when the daily output was under 30 ml. Postoperative complications were clearly defined as follows: Seroma is a subcutaneous collection of fluid, appearing after removal of the drains, with spontaneous drainage or needing aspiration; hematoma is a subcutaneous blood collection with spontaneous drainage or requiring clot removal; skin necrosis is a necrotic loss of skin requiring debridement; and wound infection is discharge of pus with a positive bacterial cultures. After discharge, the patients were followed by a surgical nurse till the removal of the drains or till the complete resolution of the complication if such occurred. Outpatient follow-up by the operating surgeon was done at 1, 6, and 12 months, and yearly thereafter or more frequently as needed. Recurrence was diagnosed by physical examination, as a hole defect at the edges of the previous repair with abdominal contents in the subcutaneous plane. CT or MRI was performed only for patients with any concerns for recurrence or discomfort during physical examination.

### Statistical analysis

Statistical analysis was performed using Chi-square or Fisher’s exact test for qualitative variables and Mann–Whitney or Kruskal–Wallis test for quantitative variables since data did not show normality. In order to determine the effect of hernia size and discharge incisions on postoperative morbidity, a logistic regression analysis was performed. SPSS version 20 statistical package (SPSS Inc, Chicago, IL) was used for all analysis.

### Results

The approach was done through a vertical midline incision in 96 patients. A lower transverse incision was used in four cases, with associated dermolipectomy. Components separation was necessary in 54 % of the patients by discharge incision made in one or more of the aponeurotic planes (Table 2). In 6 % (6/100) of the patients, only the “onlay” prosthesis was used as no anatomical plane could be achieved to separate an “underlay” mesh from the abdominal viscera. Complete reconstruction of the abdominal wall was possible in 87 % of the patients:

**Table 2** Components separation technique

	Groups		
	<4 cm N = 18	≥4–10 cm N = 59	≥10 cm N = 23
No discharge incision	15 (83.3 %)	25 (43.1 %)	7 (30.4 %)
Discharge incision	3 (16.7 %)	34 (58.6 %)	16 (69.6 %)
AS	2 (11.1 %)	14 (24.1 %)	4 (17.4 %)
PS	0 (0 %)	2 (3.4 %)	0 (0 %)
AS + PS	0 (0 %)	11 (19 %)	5 (21.7 %)
EO	0 (0 %)	4 (6.9 %)	0 (0 %)
EO + AS	0 (0 %)	1 (1.7 %)	1 (4.3 %)
EO + PS	0 (0 %)	1 (1.7 %)	2 (8.7 %)
EO + AS + PS	1 (5.6 %)	0 (0 %)	4 (17.4 %)

AS rectus anterior sheath, PS rectus posterior sheath, EO external oblique aponeurosis

94.4 % (17/18) in group A, 91.5 % (54/59) in group B, and 69.6 % (16/23) in group C. An incomplete reconstruction, but with important reduction in the defect was achieved in the rest of the cases. Other aspects of the operations and patient characteristics are shown in Tables 1 and 2. Overall morbidity rate was 21 % (21/100): 16.7 % (3/18) in group A, 22 % (13/59) in group B, and 21.7 % (5/23) in group C, due to hematoma (11 %), seroma (6 %), skin necrosis (2 %), and infection (6 %). There were no postoperative reoperations or mesh losses. In a logistic regression model, neither hernia size (OR 1.06; CI 95 % 0.93–1.20;  $p = 0.40$ ) nor components separation (OR 0.51; CI 95 % 0.18–1.41;  $p = 0.19$ ) increased the risk of postoperative complications. Hospital length of stay was  $3.7 \pm 3.3$  days ( $1.83 \pm 1.43$  days in group A,  $3.05 \pm 2.11$  days in group B, and  $6.91 \pm 4.45$  days in group C). Median follow-up was 25 months (interquartile range 12.25–55.25). Overall recurrence was 2 % (2/100), 1.7 % (1/59) in group B (a patient without components separation), and 4.3 % (1/23) in group C (at the level of the oblique muscle releasing site in a patient with bilateral components separation of the anterior and posterior rectus sheath and external oblique muscle aponeurosis).

## Discussion

Components separation as first described by Ramirez et al. [13] and modified by others authors [11, 18–22] has been the preferred approach for the repair of large abdominal wall defects. Retrorectus mesh repair has been widely employed and considered the standard prosthetic repair of ventral hernias [23, 24]. Complex incisional hernias have also been repaired with mesh, bridging the defect without approximation of the edges [10]. However, the addition of

components separation to mesh prosthesis as a rational method for a complete tension-free reconstruction of the abdominal wall during incisional hernia repair, independently of the size of the defect, has rarely been studied.

Furthermore, although no prospective comparative study has been performed to date, some authors have found associating double mesh technique with components separation to be the best combination for incisional hernia repair. For example, in a recent paper, these authors observed 11 % of recurrences, with a great variability of mesh techniques used [25]. Interestingly, the lowest recurrence rate was found with the double mesh technique and components separation (approximately 9 %), compared to a single mesh with components separation (approximately 15 %). In another paper, it was found that double mesh and components separation were both and independently related to fivefold decrease in recurrences [26].

Anatomical and physiological reasons exist to use the above-proposed approach of reconstruction of the abdominal wall during incisional hernia repair. Askar described in 1977 [27] the digastric pattern among the muscles of both sides of the abdominal wall and the importance of the rectus sheath for its physiology. Anterior and posterior rectus sheaths are formed by the strata of tendons coming from the aponeurosis of muscles of both sides of the abdomen. The mobility between the described tendinous fibers is possible because of a loose areolar tissue binding them, which allows change in the shape and dimensions during movements of the trunk and the abdominal wall with respiration. In the middle aponeurotic zone or “linea alba,” fibers from all the strata of the anterior and posterior rectus sheaths decussate with fibres from the opposite side.

The abdominal wall dysfunction due to fascial desinsertion has several consequences in patients with incisional hernias, especially in those with chronic respiratory obstructive disease [28]. Indeed, recent studies have demonstrated that internal oblique muscles express a pattern of atrophy and fibrosis consistent with those seen in chronically unloaded skeletal muscles, decreasing abdominal wall compliance [29]. Experimental and clinical studies suggest the reversibility of the abdominal wall atrophy and fibrosis after a tension-free reconstruction [30]. Anatomical and physiological reconstruction must theoretically be an important condition for an adequate repair of incisional hernias, especially large ones. Review articles have recently appeared grading the incisional ventral hernias and giving recommendations regarding the technique of repair. One of the conclusions is that reapproximation of the rectus muscles along the midline for ventral hernia repair creates a true dynamic repair without undue tension [31]. Therefore, we always aim to completely reconstruct

the abdominal wall or at least decrease the size of the defect.

In our study, patients of group A needed components separation in 16.7 % (3/18) of cases, group B in 59.3 % (35/59), and group C in 69.6 % (16/23) of cases. These results show that even small midline hernias would occasionally need the components separation in order to close the edge of the defect, so this technique should be done on demand, independently of the diameter, for a complete tension-free reconstruction of the abdominal wall.

Another important issue of components separation is the aponeurotic plane in which the discharge incision must be made. The anatomical study of Ramirez et al. [13] showed that each rectus muscle with the overlying rectus sheath and its attached internal oblique and transverse muscles can be advanced 3–10 cm toward the midline by section of the external oblique aponeurosis and 3–5 cm by the longitudinal section of the posterior rectus sheath. However, in the clinical application for giant ventral hernias, the Ramirez technique always begins with the external oblique aponeurosis section, before proceeding to other levels of discharge incisions. The gradual approach ensures a tailored treatment according to the hernia size. The technique we propose is a stepwise approach opposite to that described by Ramirez, leaving the oblique muscle incisions as a last step. We have shown that longitudinal discontinuous incisions on the anterior rectus sheath can also facilitate an advancement of the rectus muscles toward the midline similar to that obtained after the section of the posterior rectus sheath. A rational use of components separation, performing discharge incisions in one or both sheaths of the rectus and adding incisions in the external oblique aponeurosis when necessary, allows repairing of all sizes of hernia defects without overtreatment.

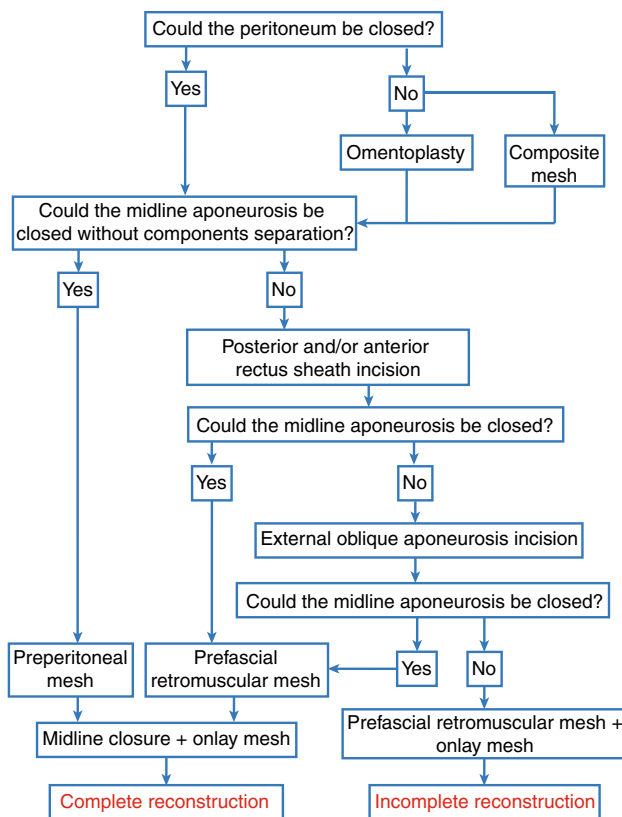
Components separation creates weakness areas where the aponeurosis is sectioned and breaks the functional unit of the abdominal wall described by Askar [27]. For this purpose, some authors have proposed a technique for components separation, based on undermining the anterior and posterior rectus sheet, achieving midline closure and preserving the semilunar line (avoiding external oblique aponeurosis desinsertion) [32]. According to our protocol, after the section of rectus sheaths, a double-layer prosthesis substitutes the fascias, and once the scar tissue integrates the aponeurosis with the mesh, it contributes to the enlarging of the tendinous fibers.

When tension-free restitution of “linea alba” has been achieved without the need of components separation, the use of prosthesis reinforces the aponeurotic planes. This could be theoretically questioned as necessary, but it would be justified by the high recurrence rates described among patients who had suture repair of their hernias [5]. With our approach, the use of “underlay” and “onlay” prosthesis

secured by transmural sutures reinforces the rectus sheaths, secures the suture of the edges of the defect for reconstruction of “linea alba,” and prevents dislodgement of the prosthesis [4, 10].

An anatomical plane must separate the “underlay” mesh from the abdominal viscera and thus prevent from adhesions and intestinal fistulas. Usually, this plane is created with the posterior rectus sheath. When necessary, the omentum and peritoneum were used with the former, to isolate the “underlay” prosthesis from the abdominal viscera [17]. Creation of an anatomical separation plane for the “underlay” prosthesis was not possible in 6 % (6/100) patients, so only “onlay” prosthesis was placed. More recently, we have introduced the composite mesh as “underlay” prosthesis in these cases [33]. Despite components separation, closing the edges of the defects for a complete reconstruction of the “linea alba” was not achieved in 13 % (13/100) of the patients. In these cases, although the final diameters of their respective defects were not determined in our study, there was an important reduction in the areas of the original defects. Smaller defects remained bridged by the prosthesis and, consequently, physiological disturbance of the abdominal wall diminished [28]. As it could be observed from Table 1, the wider the hernia defect, the more necessary are the releasing incisions, and more frequent the use of external oblique incision. We have also observed that sometimes the posterior rectus sheet does not need to be incised as the deep mesh could be easily located preperitoneally (e.g., not always the internal mesh has to be placed on the Rives manner, retromuscular). As for the hernia size, we found that for the small size group (<4 cm), in most of the cases (83.3 %), a preperitoneal plane could be dissected for placement of the internal mesh, avoiding discharge incisions. Interestingly, even the large size hernias (>10 cm) could be repaired without releasing incisions in almost one-third of the cases in our series, questioning the routine use of components separation in this group. Logically, using the complete spectrum of releasing incisions was done mainly in the largest hernias. The medium size group (4–10 cm) is the most numerous and heterogeneous one in terms of need for releasing incisions. Most of these hernias could be repaired by releasing incisions at the levels of the anterior and/or posterior rectus sheet. However, we believe that this is the group where the stepwise approach we propose will have a greater importance and application in order to tailor the treatment.

Gathering the above-mentioned surgical principles for ventral hernia repair, we developed an algorithm for a stepwise approach of the tension-free repair based on the rational use of components separation technique and mesh prosthesis (see Fig. 1).



**Fig. 1** Ventral hernia repair algorithm

Overall morbidity (21 %) of the study is similar to that reported in the literature [3]. Our study does not show increased morbidity in the patients with components separation compared to those without, indicating that the addition of these surgical methods during repair of incisional hernias does not increase the rate of complications.

Skin edge necrosis in up to 20 % and seroma formation in up to 40 % have been reported after the original components separation technique due to the extensive flap formation to expose the external oblique aponeurosis [11, 21]. In our study, among the patients with components separation, there was no increased incidence in necrosis or seroma formation. We usually perform relaxing incision at the external oblique aponeurosis, through a cutaneous contra-incision, following the previously described technique [16], reducing the risk of flap devascularization and seroma formation. Recurrence appeared in one patient in group B (4 cm hernia) and in one patient in group C (10 cm hernia), with overall recurrence of 2 % in our study.

We conclude that a tension-free reconstruction of the abdominal wall can be achieved in most cases during small and large midline incisional hernia repairs, applying a stepwise approach (see Fig. 1) for a rational association of components separation and double mesh prosthesis, with a low morbidity and recurrence rates.

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**Compliance with ethical standards**

**Conflict of interest** The authors declare no conflict of interest.

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