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Stepwise transversus abdominis muscle release for the treatment of complex bilateral subcostal incisional hernias

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Abstract

Background:

Management of subcostal incisional hernias (SIHs) is particularly complicated due to their proximity to the costochondral limits in addition to the lack of aponeurosis on the lateral side of the abdomen. We present our results of posterior component separation (PCS) through the same previous incision as a safe and reproducible technique for these complex cases.

Methods:

We presented a multicenter and prospective cohort of patients diagnosed with bilateral SIHs on either clinical examination or imaging based on computed tomography (CT) from 2014 to 2020. The aim of this investigation was to assess the outcomes of abdominal wall reconstruction (AWR) for SIHs through a new approach. The outcomes reported were short- and long-term complications, including recurrence, pain, and bulging. Quality of life was assessed with the European Registry for Abdominal Wall Hernias Quality of Life (EuraHS-QoL) score.

Results:

A total of 46 patients were identified. All patients underwent PCS. Surgical site occurrences (SSOs) occurred in 10 patients (22%), with only 7 patients (15%) requiring procedural intervention. During a mean follow-up of 18 months (range, 6–62 months), 1 (2%) case of clinical recurrence was registered. Also, there were 8 (17%) patients with asymptomatic but visible bulging. The EuraHS-QoL score showed a statistically significant decrease in the three domains (pain, restriction, and cosmetic) of the postoperative scores compared with the preoperative score.

Conclusions:

PCS technique for the repair of SIHs through the same incision is a safe procedure that avoids injury to the linea alba. It is associated with acceptable morbidity, low recurrence rate, and improvement in patient’s reported outcomes.

Keywords: subcostal incisional hernia, transversus abdominis release, abdominal wall reconstruction, complex hernia, posterior component separation, liver transplantation

Abbreviations (in alphebetic order)

ASA – American Society of Anesthesiologists

AWR – abdominal wall reconstruction

BMI – body mass index

CeDAR – Carolina's Equation for Determining Associated Risks

COPD – chronic obstructive pulmonary disease

CT – computed tomography

e-TEP – extended totally extraperitoneal

EHS – European Hernia Society

EuraHSQoL – European Abdominal Wall Hernia Quality of Life Scores

ICU – intensive care unit

IH – incisional hernia

IO – internal oblique

PCS – posterior component separation

QoL – quality of life

SIH – subcostal incisional hernia

SPSS – Statistical Package for the Social Sciences

SSI – surgical site infection

SSO – surgical site occurrence

SSOPI – surgical site occurrence that required procedural intervention

STROBE – Strengthening the Reporting of Observational Studies in Epidemiology

TA – transversus abdominis

TAR – transversus abdominis release

VAS – visual analogue scale

VHWG – Ventral Hernia Working Group

Introduction

Treatment of complex incisional hernias (IHs) can be a real challenge for surgeons, particularly those that appear after subcostal incisions due to their complexity and relatively low incidence. Subcostal laparotomies are conventionally used for hepatobiliary and esophagogastric open procedures. Although the incidence of IH seems to be less than that of the midline defects, it has been described that the incidence of subcostal incisional hernias (SIHs) is about 4.8%–31.3%, with few studies focusing on this subject [1,2]. However, up to 40% of incidence have been reported in liver transplantation patients [3]. Therefore, it has probably been underestimated. Furthermore, outcomes after repair of SIHs present rates of recurrence as high as 25% [4], and they have been classified as complex by a group of experts [5].

Regarding the anatomy, subcostal defects represent the drawback of their proximity to costochondral limits in addition to the lack of aponeurosis on the lateral side of the abdomen, making dissection difficult. In addition, repair of these SIHs could cause weakness or laxity, producing a bulge without an obvious fascial defect, due to a denervation injury secondary to transection of the intercostal nerves or its branches [6,7].

There is little evidence for the recommendations of the ideal surgical technique to repair SIHs. There are few specific references on repair, but it seems that retromuscular repair could improve onlay repair not only in terms of recurrence but also in terms of morbidity, mainly associated with surgical site occurrences (SSOs) [8,9]. Abdominal wall reconstruction (AWR) surgery with transversus abdominis muscle release (TAR) offers the possibility of placing a big mesh in the completely retromuscular preperitoneal plane, as it has been described to be an appropriate

alternative in large flank defects [10], lateral IHs after kidney transplant [11], simultaneous midline and lateral IHs [12], and liver transplantation IHs through a midline access [13].
We hypothesized that PCS with TAR through the same previous subcostal scar is a suitable operative technique without increasing the morbidity related to a new wound incision. We present the experience and outcomes of a multicenter, prospective study providing a stepwise approach based on our clinical experience and cadaver laboratory dissections.

Methods

We presented a multicenter and prospective cohort of patients diagnosed with SIH on either clinical examination or imaging based on computed tomography (CT) with Valsalva maneuver. Only L1 cases according to the European Hernia Society (EHS), involving both sides, were included [14]. All data were obtained from a prospectively maintained database from January 2014 to January 2020. Hospitals involved in the study were recognized referral centers for complex abdominal wall surgery. All patients were informed, and their consent was obtained prior to surgery. Ethical and Institutional Review Board approval were obtained before study onset.
The aim of the investigation was to assess the outcomes of AWR for SIHs through a new approach. We considered the incidence of recurrence of SIH and patient-reported outcomes as the main objectives, and development of short-term and long-term complications were the secondary endpoints. The study followed the STROBE statement [15] and the recommendations of the EHS for reporting the outcomes. We also used the nomenclature recommended in the recently published international classification of abdominal wall planes [16].

Registered preoperative clinical data included demographic data, risk factors, comorbidities and several hernia classifications[5,17–19].

All patients underwent a similar preoperative optimization program, which included endocrinologic and nutritional evaluations, abstinence from smoking, weight loss, preoperative respiratory physiotherapy, and antibiotic prophylaxis. In patients with body mass index (BMI) > 25, preoperative weight loss was encouraged, although surgical treatment was not contraindicated in any case for not achieving this objective.

Operative procedure

The operative procedure starts incising through the previous scar, and trying to identify the sac that is usually covered by atrophic muscle fibers. Previously implanted meshes are only removed in case of infection, fistula, lack of integration, or intense adhesions. It is mandatory to transversally open the sac as soon as possible to remove visceral adhesions to the abdominal wall. Both halves of the sac, superior and inferior, are preserved until the end of the operation. Dissection of the subcutaneous tissue is never extended beyond the defect to reduce the associated morbidity. Then, we continue the dissection over the hernia sac to achieve the retromuscular preperitoneal plane that will be our landing zone for reconstruction with a mesh. A step-by-step approach is made according to the different anatomical areas involved in the retromuscular dissection. Our recommended order is as follows: subdiaphragmatic (cranial), lateral preperitoneal (lateral and posterior), retromuscular over the posterior rectus sheath (caudal anterior), and midline preperitoneal (midline and caudal).

We start cranially to identify the subdiaphragmatic plane. In most circumstances of subcostal incisions, the posterior rectus sheath and the rectus muscle are usually obliterated or retracted. Some fibers from the transversus abdominis (TA) still persist and need to be identified. Then, a pretransversalis plane between the fascia transversalis and TA muscle is developed to identify the diaphragm. Later, the diaphragmatic fascia is peeled off the diaphragm, and then the pretransversalis plane becomes the “pre-fascia diaphragmatica” plane. The superior extent of this dissection reaches the central tendon of the diaphragm. The next step is the lateral preperitoneal plane. Subsequently, the layer under the remaining fibers of the TA muscle are dissected laterally in a pretransversalis or preperitoneal plane, depending on the integrity of the peritoneum. This plane can be extended from the linea semilunaris to the level of the posterior axillary line. Then, inferiorly, the posterior rectus sheath is separated from the rectus muscle, and the Rives plane is exposed as far as the linea arcuata. Then, the lateral preperitoneal plane and the retromuscular plane need to be joined by the PCS technique, incising the fibers of the TA muscle and the lateral posterior border of the posterior rectus sheath (Figure 1). This TA release can be made safely from lateral to medial (reverse TAR). Similar steps are taken on the contralateral side. At this moment, only the midline still remains attached to the peritoneum. Then, a crossover to the contralateral side is made by transecting the medial insertion of the posterior rectus sheath on the linea alba, taking care to preserve its integrity. The dissection can be extended to identify the Retzius and Bogros spaces and both Cooper ligaments.

Immediately, all the real retromuscular preperitoneal plane is exposed and ready for a very big mesh placement as giant reinforcement of the visceral sac. This plane encompasses a surface similar to that obtained with conventional TARs for complex midline IHs, bound from the central tendon of the diaphragm to both Cooper ligaments and, posteriorly, from the psoas muscle on one side to its contralateral counterpart on the other side.

Afterward, the posterior layer is closed. This layer comprises the peritoneum, fascia transversalis, fascia diaphragmatica, both posterior rectus sheaths, and one of the flaps of the peritoneal sac that was previously preserved (Figure 2).

For the reconstructive part of the operation, a combination of meshes, absorbable and permanent, are used as previously described [12,20,21]. An absorbable mesh of 20 x 30 cm (GORE® BIO-A® Tissue Reinforcement, WL Gore & Associates, Inc. Flagstaff, AZ, USA) and either a large 50 x 50 cm permanent, macroporous, polypropylene mesh (Bulevb®, Dipro Medical Devices SRL, Torino, Italy) or a large 45 x 60 cm permanent, polyvinylidene difluoride (PVDF) mesh (Dynamesh®-CICAT, FEG Textiltechnik, Aachen, Germany) are used. The initial rigidity of the absorbable mesh placed transversely supports the extension of a large permanent mesh placed in a diamond shape. The permanent mesh is fixed to both Cooper ligaments caudally and, eventually, to the central tendon of the diaphragm cranially. We do not use fixations to the costal margin or bone anchor fixations. After mesh placement, the medial border of the layer made of the internal oblique (IO) and TA muscles are reimplanted to the permanent mesh to provide continuity to these inner muscle layers, using long-term absorbable material (poly-4-hydroxybutyrate, Monomax®). The anterior layer is then closed with interrupted or running long-term absorbable sutures. The anterior layer is bridged with the mesh when complete anterior closure cannot be achieved. Low-suction drains are set between the mesh and the muscle layer.

Follow-up

All postoperative SSOs were included in the analysis. They mainly comprised seroma, hematoma, surgical site infection (SSI), and ischemia/necrosis of the skin or soft tissue, and those SSOs that required procedural intervention (SSOPI) [22]. Centers for Disease Control and Prevention definitions of SSI were used [23]. Seroma was defined as a mass or swelling in the wound caused by localized accumulation of clear serum liquid without SSI signs. Chronic pain was defined as any pain lasting more than 12 weeks [24]. Visual analogue scale (VAS) score > 2 and the need for analgesia were considered as pain. Hernia recurrence and mortality were registered as the main outcomes during long-term follow-up. Recurrence was defined as a new abdominal wall defect in the operated area, identified by physical examination or imaging. Bulging was defined as an area of weakness or asymmetry on inspection or exploration of the patient's abdominal wall, without defects confirmed on CT.

Follow-up consisted of a physical examination in the outpatient clinic at 4 weeks, 3 months, 6 months, 1 year, and then annually thereafter. Patients underwent an abdominal CT scan when needed to rule out doubts of recurrence or oncologic patients.

We used also the European Abdominal Wall Hernia Quality of Life Scores (EuraHSQoL) to compare evolution in patients on the pain, restriction, and cosmetic domains between the preoperative and postoperative periods (1 and 2 years after surgery).

Statistics

The description of variables and statistical analysis were performed using the Statistical Package for the Social Sciences (SPSS) program (version 19.0 for Windows). Comparative analysis for qualitative variables was performed with the Student's *t* test or the x2 test. Spearman's correlation coefficient was also used to measure the strength of the relationship between paired data of EuraHS-QoL scores. Statistical significance was accepted at $p < 0.05$.

Results

Patient demographics and characteristics

Between 2014 and 2020, 46 patients who underwent AWR for complex bilateral SIHs were included. Demographics and characteristics of the patients are shown in Table 1.

Hernia characteristics

Hernia features are summarized in Table 2. In 12 (26%) cases, there was an associated IH related to the main SIH in the following distribution: 1 (2%) lumbar, 7 (15%) midline supraumbilical (M1-3 EHS classification), and 4 (9%) midline xyphopubic (M1-5 EHS classification). There were 5 (11%) patients who presented with a concomitant inguinal hernia that was repaired during the main procedure: 2 (4%) unilateral and 3 (7%) bilateral.

Operative features

Operative details are also presented in Table 2. All patients underwent an elective procedure under general anesthesia. Preoperative interventional optimization techniques were rarely performed: pneumoperitoneum in one patient and botulinum toxin injection in one patient. Antibiotic prophylaxis was used in all cases: 2 g of cefazolin was administered 1 h before surgery with repeated doses at 4 h when the operation was prolonged. Forty-two cases were classified as clean (91%), and 4 cases were classified as clean-contaminated wounds (9%). An epidural catheter was placed in 10 (22%) cases.

Posterior layer could be closed in all cases. In 18 patients (39%), the anterior fascial layer defect was bridged by the mesh without the possibility of complete fascial closure. In 40 (86.9%) cases, we completed a reimplantation of the layer of IO and TA muscles. Panniculectomy was performed in one case. Eleven (24%) patients were admitted to the intensive care unit (ICU) during the first 24 h postoperatively.

Postoperative complications

Postoperative complications are summarized in Table 3. Nine (20%) patients developed a seroma in the following distribution: 1 (2%) requiring a percutaneous drain, 4 (9%) superficial seromas (above muscle layers) not requiring any intervention, 2 (4%) superficial seromas requiring insertion of a drain, and the other 2 (4%) requiring a simple drain through skin. With respect to hematomas, there were 4 (9%) patients requiring minor intervention, and 1 (2%) patient requiring simple aspiration. SSIs were reported in four (9%) cases: 1 (2%) organ/space SSI and 3 (7%) deep SSIs. No superficial SSI was registered. In terms of systemic complications, there was 1 (2%) case of pneumonia with an associated respiratory insufficiency that required intensive care. No postoperative mortalities were registered.

Long-term postoperative complications

Long-term postoperative complications are shown in Table 3. Two patients were lost to follow-up during the study. After a mean follow-up of 18 months (range 6–62 months), 1 (2%) case of clinical recurrence was registered that had not been reoperated. There were 8 (17%) patients who presented with an asymptomatic bulging at follow-up. There were 3 (7%) patients with an occasional need for pain treatment, and 1 (2%) immunosuppressed patient who developed a chronic mesh infection by methicillin-resistant *Staphylococcus aureus* that required surgery for partial mesh removal. During follow-up, there were 6 (13%) dead patients, but mortality was not related to previous surgery in any case.

Quality of life

Progression over time in all domains of the EuraHS-QoL score is plotted in Figure 3. EuraHS-QoL score revealed a statistically significant decrease in all three domains assessed (pain, restriction, and cosmetic) in the postoperative score compared to the preoperative score. Differences were statistically significant between the preoperative and 1-year scores for pain ($p = 0.01$; Spearman 0.45, moderate correlation) and restriction ($p = 0.01$; Spearman 0.47, moderate correlation) domains. The difference was also statistically significant in all three domains between 1 and 2 postoperative years: pain, $p = 0.01$, Spearman 0.79; restriction, $p = 0.01$, Spearman 0.73; cosmetic, $p = 0.01$, Spearman 0.88. There were all in sum with a very strong correlation.

Statistics

Bivariate analytical studies were carried out with the aim of relating variables with postoperative (short and long-term) outcomes, including development of bulging or IH recurrence. We only found differences in the relationship between the anterior bridge and development of SSOs ($p = 0.03$).

Discussion

Incidence of SIHs has been reported in the literature, with a rate of up to 20% [25,26]. However, its surgical treatment has only been rarely described [13,27–29]. In the surgical treatment of these complex SIHs, the preperitoneal retromuscular layer dissected during TAR seems to be the ideal zone to lay the mesh for reconstruction [13]. The myofascial mobilization achieved develops a unique plane that comprises the following: the superior surface with the “pre-diaphragmatic” fascia and pretransversalis layer, the lateral retromuscular preperitoneal area, the retromuscular Rives layer, the midline preperitoneal fat and finally, the Retzius and Bogros preperitoneal caudal spaces (Figures 1 and 2).

One of the main difficulties with this high transverse IHs is the location of a pretransversalis plane, as the TA muscle and the posterior rectus sheaths are usually retracted or obliterated in the superior edge of the scar. The differentiation between TA muscle and the diaphragm at their intersections is really complicated but not necessary, as we just extend our dissection in the plane between the fasciae and muscles, peeling off the diaphragm and TA as described [30–32]. This layer is stronger than a pure preperitoneal plane (between the peritoneum and the fascia transversalis/diaphragmatica), where the tears of the peritoneum would make it extremely difficult. The nude exposed muscles are the landmarks of a right plane achieved (Figure 1). We also insist on following the dome shape of the diaphragm muscle to avoid an iatrogenic Morgagni hernia [33], instead of following a retroxyphoid dissection parallel to the sternum that would detach the physiological insertions of the diaphragm. The cranial limit of this dissection is the central tendon where the fascia diaphragmatica fuses with the aponeurotic tendon, and only the peritoneum lies underneath (Figure 4).

Related to operative technique, making a new midline incision, where the TAR technique would be easier, has been described [13]; however, with our dissection, we can avoid a new midline skin scar, and the incision that is performed along the entire linea alba is not necessary with this approach. All the dissection provides an entire preperitoneal retromuscular surface between the visceral sac and the abdominal wall to be strengthened by a very large mesh. This reconstruction allows the application of the Stoppa's concept of giant reinforcement of the visceral sac, not only to the hypogastric area but also to the whole abdominal wall. This large reinforcement requires the use of a very large mesh to avoid use of quilted mesh [34].

The distance between both posterior limits of dissection is usually longer than 50 cm. This is the main reason for implanting the 50 x 50 or 60 x 45 cm meshes in a romboid or diamond shape that adapts better to the retromuscular dissection obtained [35] (Figure 5). The absorbable mesh reinforces the posterior layer and provides physical support for the extension of permanent meshes under the convexity of the abdominal wall [12]. We have recently reported the clinical and pathologic findings when using both meshes [36].

In these bilateral subcostal defects, despite the TAR, complete closure of TA and IO may be difficult. When this approximation cannot be accomplished, we usually reimplant the lateral borders of the muscles to the permanent synthetic mesh (Multimedia 1). The anterior layer was not completely closed in 39% of cases. We consider that this is due to two reasons: the big size of the defects and the fact that the vertical approximation might not be increased significantly after PCS, as PCS allows mainly medial (horizontal) approximation but not vertical.

TAR has been used to repair hernias after different incisions on the abdominal wall with encouraging results. Indications of lateral TAR are presented in Table 4; regarding reported outcomes of SIHs in literature there are only four series that included patients with specific SIHs [13,27–29]; three of them included liver transplant patients. The remaining series included a heterogeneous diversity of complex lateral IHs, making it difficult to assume specific conclusions for SIHs [4,9,28,37–45]. The onlay technique was performed in two of the four studies, and laparoscopy was used in the other study. These four articles present recurrence rates between 4.1% and 25%, somewhat higher than those obtained in our series, and all of them had a lower number of treated patients. In the remaining articles, only one described laparoscopic repair of SIHs with high recurrence rate [4]. Tastaldi et al. [13] described an interesting series of 44 liver transplantation patients who underwent a retromuscular repair by the PCS-TAR technique. In this article, a 25% recurrence rate was recorded, which was mainly caused by central mesh failure probably influenced by the quality of the mesh used. There are several studies comparing laparoscopic access with open approach in abdominal wall surgery. Laparoscopic repair of hernias extending to the xyphoid and costal margins is challenging as cranial mesh fixation into the diaphragmatic surface is not recommended due to the risk of chronic pain or pericardial injuries [13]. Therefore, there are no data that definitely favor a laparoscopic approach, although we would consider it in small or unilateral subcostal hernias using an extended totally extraperitoneal (e-TEP) approach. We also believe that these hernia defects are not a good indication for onlay repairs.

Although our recurrence rate is low, the number of patients who presented with bulging is quite significant (17%), but it can be apparently attributed to the denervation made when making an incision parallel to the costal margin, in which the terminal branches from 8th to 10th intercostal nerves are systematically cut [7]. Nonetheless, this bulging is asymptomatic, and none of the patients reported chronic pain on surveillance.

Furthermore, we have also analyzed patient's reported outcomes using the EuraHS-QoL assessment. We agree that improvement in the patient's QoL should become a standard method of evaluating the results after AWR [46]. We can repair a huge incisional hernia and can obtain very good results in terms of recurrence and bulging, but disabling a patient causes movement restrictions or pain. Even, there are some situations where we can only expect to obtain bulging as a better result due to the preoperative impressive conditions of the patient due to previous attempts of repair and denervation.

Nevertheless, our series has some important limitations. Although it is a prospective multicenter study, there is no group for comparison. Therefore, we could not conclude that the treatment of SIHs via PCS techniques is better than other operative techniques. Regarding the follow-up, there were 10 patients who had not completed the first year of follow-up. However, we considered including them for the analysis of short-term complications. Longer surveillance is needed to better assess the long-term complications. Additionally, differentiation between recurrence and bulging could be difficult. In these IHs where the rectus muscle is completely atrophic or obliterated, radiological evaluation of a true hernia defect versus bulging may be complicated during the follow-up. Although we use a definition for bulging, we encourage hernia scientific societies to agree on a consensus definition, as this is a major concern regarding off-midline IHs where associated denervation is a common feature.

Conclusion

Our study focuses on the feasibility and safety of using the PCS technique for repair of these subcostal defects through the same incision, using a step-by-step explanation based on the anatomical structure of the abdominal wall. Thorough knowledge of the anatomy and previous experiences with TAR technique are essential before dealing with these challenging transverse IHs that should be operated upon in highly specialized centers of AWR.

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Tables

Table 1. Demographics and characteristics of patients

Variables	**N (%)**
Sex	
Male	38 (83%)
Female	8 (17%)
Age, mean ± DS	61 ± 11.85
BMI*, mean ± DS	28 ± 4.25 kg/m^2
Obesity (BMI > 30)	15 (33%)
Comorbidities	
Smoking	9 (20%)
Anticoagulation	6 (13%)
Diabetes	15 (33%)
Immunosuppression	12 (26%)
COPD†	6 (13%)
Hypertension	21 (46%)
Neoplasia	19 (41%)
Cardiac Disease	9 (20%)
Renal Disease	6 (13%)
Liver Disease	17 (37%)
CeDAR ‡; median (min-max)	25 (10–67)
< 30%	27 (59%)
30–60%	18 (39%)
> 60%	1 (2%)
ASA §	
I	2 (4.5%)
II	22 (48%)
III	20 (43%)
IV	2 (4.5%)
Previous abdominal wall hernia operations	16 (35 %)
Concomitant incisional hernia	12 (26%)
Etiology of IH (type of operations)	
Digestive tract	7 (15%)
Liver-pancreas	26 (57%)
Liver-transplantation	8 (17%)
Urology	1 (2%)
Abdominal wall	1 (2%)
Others	3 (7%)

*Body mass index; † Chronic obstructive pulmonary disease; ‡ Carolinas Equation for Determining Associated Risks; § American Society of Anesthesiologists.

Table 2. Characteristics of IHs and operative data

Variables	**N (%)**
Maximum horizontal size (cm) of IH; median, (min-max)	10 (8–30)
Maximum vertical size (cm) of IH; median, (min-max)	9 (3–20)
W EHS of the IH	
W2 (4–10 cm)	20 (43%)
W3 (> 10 cm)	26 (57%)
Slater's classification of IH	
Grade 1	0 (0%)
Grade 2	31 (67%)
Grade 3	15 (33%)
VHWG *classification of IH	
Grade 1	6 (13%)
Grade 2	36 (78%)
Grade 3	4 (9%)
Grade 4	0 (0%)
VHSS † classification of IH	
Grade 1	16 (35%)
Grade 2	21 (46%)
Grade 3	9 (19 %)
Bridging of posterior layer	0 (0%)
Bridging of anterior layer	18 (39%)
Maximum diameter of bridging in cm: mean (min-max):	
Horizontal	5.58 (2–20)
Vertical	7 (1–20)
Other operative procedures associated with the IH repair:	
None	16 (35%)
Adhesiolysis	24 (52%)
Intestinal resection	2 (4%)
Closure of bowel opening	1 (2%)
Another abdominal surgery	3 (7%)
Operative time (min), mean (range)	221 (95–510)

*Ventral Hernia Working Group hernia classification; † Ventral Hernia Staging System classification.

Table 3. Postoperative and long-term outcomes

Variable	**N (%)**	**Clavien–Dindo**
SSO		
Any SSO	10 (22%)	
SSOPI	7 (15%)	
SSI	4 (9%)	
• Superficial	0 (0%)	
• Deep	3 (7%)	Grade I: 2; Grade II: 1.
• Organ/space	1 (2%)	Grade II: 1.
Hematoma	5 (11%)	Grade I: 4; Grade IIIa: 1.
Seroma	9 (20%)	Grade I: 6; Grade IIIa: 3.
Skin/wound dehiscence	0 (0%)	
Fascial disruption/evisceration	0 (0%)	
Abdominal complications		
Paralytic ileus	0 (0%)	
Intestinal obstruction	0 (0%)	
Intestinal anastomotic dehiscence	1 (2%)	Grade IVa: 1.
Systemic complications		
Urinary infection	0 (0%)	
Venous line infection	0 (0%)	
Respiratory insufficiency	1 (2%)	Grade IVa: 1.
Pneumonia	1 (2%)	Grade IVa: 1.
Cardiac complications	0 (0%)	
DVT/PE *	0 (0%)	
Pain > 48 h requiring opioids	10 (22%)	
Length of hospitalization, median, (min-max)	6 (2–34)	
30-day mortality	0 (0%)	
Readmission	3 (7%)	
Clinical recurrence	1 (2%)	
CT † control		
No CT performed	22 (48%)	
No CT recurrence	21 (45%)	
Yes CT recurrence	1 (2%)	
Bulging		
No bulging	36 (78%)	
Asymptomatic bulging	8 (17%)	
Symptomatic bulging	0 (0%)	
Mesh infection	1 (2%)	
Pain		
Discomfort	0 (0%)	

Occasional need for pain treatment Daily treatment for pain Interventional treatment for pain	3 (7%) 0 (0%) 0 (0%)	
Reoperation for recurrence or bulging	0 (0%)	

* Deep venous thrombosis/pulmonary embolism; † Computed tomography.

Table 4. Indications of TAR in lateral His

Type of defect	Author	N	Follow-up (months)	Recurrences N (%)
LATERAL				
Subcostal	Tastaldi L et al. [13]	44	13	11 (25%)
Iliac	Petro et al., 2015 [47]	11	12	1 (9%)
Parastomal	Raigani et al., 2014 [48] Pauli et al., 2016 [49]	46 3	13 5	5 (1%) 0 (0%)
MIDLINE + LATERAL				
Midline + lateral	Munoz-Rodriguez et al., 2020 [12]	58	30.1	2 (3%)

Figure legends

Figure 1:

A. Posterior component separation and midline crossover. Dotted line 1, transversus abdominis release; dotted line 2, medial release of the insertion of posterior rectus sheath on linea alba (crossover).

B. Final retromuscular preperitoneal dissection layers: A, diaphragm has been peeled off fascia diaphragmatica (between diaphragm and fascia diaphragmatica); B, transversus abdominis peeled off fascia transversalis (between transversus abdomins and fascia transversalis); C, retromuscular preperitoneal plane (between fascia transversalis and peritoneum); D, retromuscular prefascial plane (between rectus muscle and posterior rectus sheath/peritoneum; E, under undamaged linea alba (between linea alba and peritoneum/preperitoneal fat)

Figure 2:

Conformation of the posterior abdominal wall closure before mesh placement. The anterior abdominal wall including the last chondrocostal joints have been erased to expose the landing zone obtained after the posterior component separation: A, fascia diaphragmatica; B, flap of the peritoneal sac; C, fascia transversalis; D, posterior rectus sheaths; E, peritoneum and preperitoneal fat; F, Retzius space; G, Bogros space.

Figure 3:

Evolution over time of EuraHS-QoL: Pain, restriction and cosmetic domains.

Figure 4:

Picture taken in frozen cadaver showing the extension of the subdiaphragmatic dissection up to the central tendon of diaphragm.

Figure 5:

Mesh extension on the retromuscular preperitoneal plane as a giant reinforcement of the visceral sac.