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Outcomes of abdominal wall reconstruction in patients with the combination of complex midline and lateral incisional hernias

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ABSTRACT

Background: The best treatment for the combined defects of midline and lateral incisional hernia is not known. The aim of our multicenter study was to evaluate the operative and patient-reported outcomes using a modified posterior component separation in patients who present with the combination of midline and lateral incisional hernia.
Methods: We identified patients from a prospective, multicenter database who underwent operative repairs of a midline and lateral incisional hernia at 4 centers with minimum 2-year follow-up. Hernias were divided into a main hernia based on the larger size and associated abdominal wall hernias. 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 score.
Results: Fifty-eight patients were identified. Almost 70% of patients presented with a midline defect as the main incisional hernia. The operative technique was a transversus abdominis release in 26 patients (45%), a modification of transversus abdominis release 27 (47%), a reverse transversus abdominis release in 3 (5%), and a primary, lateral retromuscular preperitoneal approach in 2 (3%). Surgical site occurrences occurred in 22 patients (38%), with only 8 patients (14%) requiring procedural intervention. During a mean follow-up of 30.1 ± 14.4 months, 2 (3%) cases of recurrence were diagnosed and required reoperation. There were also 4 (7%) patients with asymptomatic but visible bulging. The European Registry for Abdominal Wall Hernias Quality of Life score showed a statistically significant decrease in the 3 domains (pain, restriction, and cosmetic) in the postoperative score compared with the preoperative score.
Conclusion: The different techniques of posterior component separation in the treatment of combined midline and lateral incisional hernia show acceptable results, despite the associated high complexity. Patient-reported outcomes after measurement of the European Registry for Abdominal Wall Hernias Quality of Life score demonstrated a clinically important improvement in quality of life and pain.
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Introduction

Incisional hernias (IHs) are frequent long-term complications after laparotomies. Midline IH may occur in 5% to 50% of patients after midline laparotomies in the general patient population.[1-3] Owing to their high frequency, many improvements in the operative treatment have been developed in the last 3 decades, including methods of components separation for the larger, more complicated cases.

Lateral IHs are assumed to be less frequent, although there is a wide range of incidence rates varying from 8% to 57%, depending on the types of incision, the definition of a "hernia" versus "bulge," and the etiology.[4-7] The most frequent lateral IHs are those developed

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Table I
Slater classification of severity of complex abdominal wall hernia[25]

Minor	Moderate	Major
Only 1 wound healing factors*	2 or more wound healing impairing risk factors* Hernia >10 cm with or without primary closure without component separation Loss of domain >20% Parastomal, lumbar, lateral, and subcostal hernias Full-thickness defects, loss of substance, distorted anatomy, or multiple hernia defects Skin grafts, wound ulcers, and nonhealing wounds Omphalocele COPD, obesity History of wound dehiscence or wound/mesh infection Intraperitoneal mesh removal Emergency operation with bowel resection	2 or more wound healing impairing risk factors* and 1 or more "moderate" class criteria Surgical wound class III (contaminated) or IV (dirty) Open (burst) abdomen Necrotizing fasciitis Current mesh infection Enterocutaneous fistula present

COPD, chronic obstructive pulmonary disease.
* Obesity, diabetes, steroid use, smoking, old age, and poor nutritional state (albumin <30 g/dl). Modified from Slater et al.[25]

after flank or lumbotomy incisions,[7] subcostal or transverse incisions after hepato-bilio-pancreatic surgery,[8] trocar incisions,[9-11] tumor resections, and iliac incisions.[12] Another group of patients at risk of lateral IHs are those undergoing liver or kidney transplantation.[13,14]

One of the main problems of lateral IHs is their proximity to the costochondral margin and the iliac crest, which limits the dissection beyond these bony limits. Also, on the lateral side of the abdomen, outside the myo-aponeurotic limit of external oblique muscles, no aponeurosis reinforces the abdominal wall; in fact, the muscles on the lateral side are only covered by their investing fascias. Furthermore, these IHs are associated in the vast majority of cases with a substantial element of denervation related to transection of the thoracoabdominal nerves during the actual incision, creating muscular weakness, which increases the problem.[7,15]

Treatment of lateral abdominal wall hernias is controversial, and multiple techniques have been described via laparoscopic or open approaches. The intramural, retromuscular sublay repair has emerged as a safe and durable approach.[13,16-18]

When a midline IH is associated with a lateral IH in the same patient, there are multiple alternative approaches to treatment. Most surgeons experienced with abdominal wall reconstruction (AWR) would probably try to repair them in a 1-stage operation. Nonetheless, the combined approach of both hernia defects has been described only rarely in the literature.[19-21] There is no consensus on what is the best method of approach. Posterior component separation (PCS) has been described as an appropriate surgical procedure for complex midline IHs[21,22] and for lateral IHs.[13] Our hypothesis was that PCS is a suitable operative approach for AWR in patients with simultaneous complex midline and lateral incisional hernias (MLIHs).

Methods

The main objective of the study was to evaluate the results of AWR for MLIHs. Recurrences and bulging were primary endpoints. The secondary objectives were to analyze the short- and longer term complications. The study report was written following the STROBE statement[23] and recommendations for reporting outcomes in abdominal wall hernias.[24]

After obtaining approval by our Institutional Review Board and using a prospective, international database of complex abdominal wall repair in 4 hospitals, all patients treated for simultaneous MLIHs between December 2011 and December 2017 were identified. Only adult patients with IHs defined as complex, using the criteria published by Slater et al were included in the database.[25] The 4 hospitals involved in the study are recognized referral centers for AWR.

The diagnosis of IH was based on clinical examination and imaging from a computed tomography (CT) with a Valsalva maneuver. Hernias have been classified according to the criteria established by the European Hernia Society (EHS).[26] We only included patients with combined midline (M1–M5 EHS classification) and lateral (L1–L4 EHS classification) IHs. As a result, we excluded patients with primary, nonincisional hernias such as those patients in whom the midline or lateral hernias were primary midline ventral hernias (umbilical and epigastric hernias) or primary lateral hernias (Spiegel, Grynfelt, and Petit hernias). We also excluded 8 patients in whom the LIH was a parastomal hernia, and restoration of intestinal continuity was not planned during the AWR.

All 58 consecutive patients identified were evaluated in a multidisciplinary unit specialized in the treatment of abdominal wall hernias. Patient demographics included age, sex, body mass index, comorbidities, number of previous hernia operations, and cause of the first operation.

The hernias were divided into main and associated ones based on the larger IH (length and width of the defect), regardless of whether it was medial or lateral.

To improve the quality of classification according to their degree of complexity, different classifications are currently being used in our database, such as Slater's classification,[25] the Ventral Hernia Working Group classification,[27] and the Ventral Hernia Staging System classification[28] (Tables I and II). To predict the risk of operative complications related to repair of the hernia, we used the Carolinas Equation for Determining Associated Risks.[29]

All patients followed a similar, preoperative optimization program, which included endocrinologic and nutritional evaluations, abstinence from smoking, weight loss, and respiratory physiotherapy. Smoking cessation 1 month before operation was mandatory. Weight loss was encouraged but without any compulsory prerequisite. Botulinum toxin injection and preoperative pneumoperitoneum were used in combination on 1 patient with loss of domain. Botulin toxin alone was also used in 2 additional patients.

Operative technique

The incision used in the repair was made depending on which was considered the main IH.

Incision through previous midline scar

This approach was performed through the midline in the following situations: when the main defect was a midline IH, in

Table II
Ventral Hernia Staging System[27] and Ventral Hernia Working Group classifications[28]

Ventral Hernia Staging System (VHSS)	
Stage I	<10 cm, clean
Stage II	10–20 cm, clean
	<10 cm, contaminated
Stage III	>20 cm, clean
	>10 cm, contaminated
Ventral Hernia Working Group classification	
Grade I	Low risk of complications
	No history of wound infection
Grade II	Smoker
	Obese
	Diabetic
	Immunosuppressed
	COPD
Grade III	Previous wound infection
	Stoma present
	Violation of the gastrointestinal tract
Grade IV	Infected mesh
	Septic dehiscence

Modified from Breuing et al[27] and Petro et al.[28]
COPD, chronic obstructive pulmonary disease.

cases in which the size of both hernia defects was similar, or when the linea semilunaris was involved in the lateral IH. The hernia sac was dissected by dividing it longitudinally into 2 halves and preserving the sac until the end of the operation to be used if necessary when it was impossible to approximate the midline. Previously implanted meshes were only removed in case of infection, fistula, lack of integration, or intense adhesions preventing appropriate dissection of the space for mesh implantation.

A retrorectus dissection was performed in all cases, according to Rives-Stoppa concept.[30] When the anterior layer of the midline defect was considered able to be approximated completely, then a PCS was employed on the side of the lateral IH. When the anterior layer could not be restored by a unilateral Rives-Stoppa dissection, a bilateral PCS was carried out to maximize the possibility of restoring midline fascial approximation.

A classic transversus abdominis release (TAR)[31] or a modification of the TAR,[32] which avoids cutting the fibers of the transversus abdominis, were performed as described previously. The lateral dissection continues to the extent of the defect of the lateral IH (Fig 1). After reducing the hernia sac of the lateral defect, the retromuscular preperitoneal plane is dissected further laterally to the posterior axillary line to find the psoas muscle and quadratus lumborum. Cranially, the dissection reaches the central tendon of the diaphragm and caudally to Cooper's ligaments. Then, in most cases, the posterior layer can be closed with absorbable monofilament sutures to allow placement of the mesh intramurally rather than intraperitoneally.

For the reconstructive part of the operation, a combination of meshes, absorbable and permanent, were used in all cases.[33] An absorbable mesh of 20 x 30 cm (GORE BIO-A Tissue Reinforcement; WL Gore & Associates, Inc, Flagstaff, AZ) and a large 50 × 50 cm permanent, macroporous, polypropylene mesh (Bulevb; Dipro Medical Devices SRL, Torino, Italy). This is a mid-weight, large pore, polypropylene mesh with a minimum 1.36 mm pore size; 26.8 N/cm transversal, 34.2 N/cm longitudinal tensile strength; and 48 g/m^2 density (mid-density). Both meshes were trimmed to fit the dissected space. The absorbable mesh helped to make the 3-dimensional (3-D) configuration placement of the permanent synthetic mesh for IH M4–M5 and L3, as Stoppa described.[30,33] The absorbable mesh was also used to make what we call the 3-D "taco" configuration of the posterior abdominal wall, as described for lateral IHs.[34] The permanent was secured caudally and posteriorly with slowly absorbable sutures of poly-4-hydroxybutyrate (Monomax, USP 00; B. Braun, Melsungen, Germany) to Cooper's ligaments. No other lateral or transparietal fixation of the meshes was performed. Usually, drains were placed between the polypropylene mesh and the muscles.

The closure of the anterior layer was completed with slowly absorbable sutures (Monomax, USP 1 or 0; B. Braun).[31] When the closure of the anterior layer (linea alba) was not possible, the edges of the anterior fascia were sewn to the mesh, leaving a bridge that was covered with the remains of sacs or fibrous tissues whenever possible.[20] In a similar way, the anterior layers of the lateral defect were also closed whenever possible; here a bridged repair was necessary when approximation of the fascial edges of the lateral defect was not possible.

Incisions through the previous lateral scar

If the main hernia is lateral, and the linea semilunaris is not involved, we start with an incision over the lateral defect, after positioning the patient in 30° degree lateral decubitus with the aid of a rolling or bean bag.

After excising the previous scar, we first try to identify the sac, which is often partially covered by atrophic fibers of both oblique muscles. Then we continue the dissection around the hernia sac in order to help visualize an approach to the retromuscular

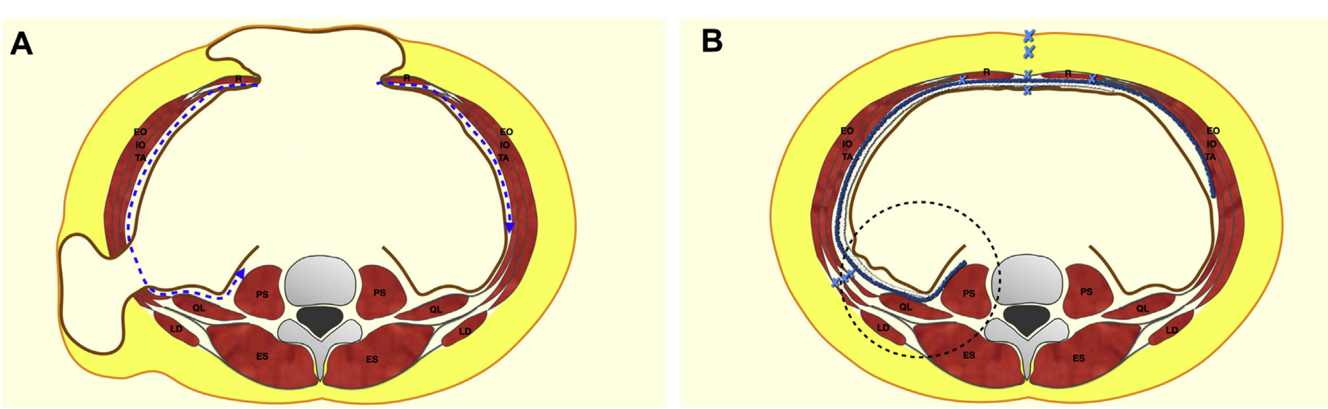

Fig 1. Schematic representation of a midline approach. (*A*) Schematic representation of steps of dissection in case of the combination of large midline IH and lateral IH. After PCS on both sides through midline incision, the lateral retromuscular preperitoneal plane is developed to reach the lateral defect and continue posteriorly over the quadratus lumborum reaching the psoas muscle. (*B*) Schematic representation of AWR in the case of (*A*), with the combination of absorbable (white line) and polypropylene mesh (blue line). Absorbable mesh helps to make the "taco" posterior configuration of the polypropylene mesh without any fixation of the mesh (dotted circle). Blue line: polypropylene mesh; white line: absorbable mesh; blue X: lines of sutures. (Color version of the figure is available online.) *EO*, external oblique muscle; *ES*, erector spinae muscle; *IO*, internal oblique muscle; *LD*, latissimus dorsi; *PS*, psoas muscle; *QL*, quadratus lumborum; *R*, rectus muscle; *TA*, transversus abdominis muscle.

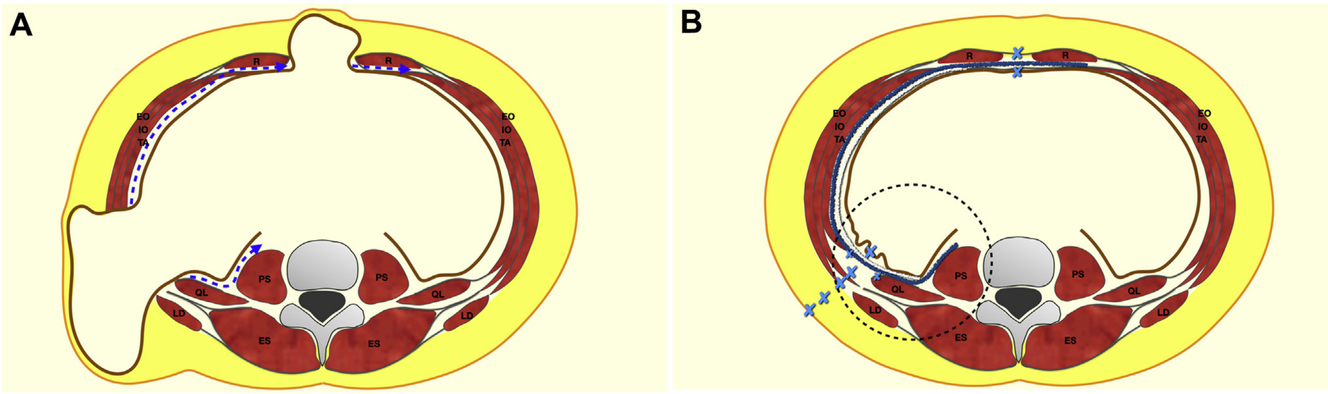

Fig 2. Schematic representation of a lateral approach. (*A*) Schematic representation of steps of dissection in case of the combination of large lateral IH and a midline IH. After a lateral incision and reducing of the sac, the dissection reaches posteriorly to the quadratus lumborum and psoas muscle. Medially, the retromuscular preperitoneal plane is reached to find the linea semilunaris. When peritoneum is very thin medially, a reverse TAR is made to access the retromuscular Rives plane and crossing over the contralateral side. (*B*) Schematic representation of AWR in the case of (*A*) with the combination of absorbable (white line) and polypropylene mesh (blue line). Absorbable mesh helps to make the “taco” posterior configuration of the polypropylene mesh without any fixation of the mesh (dotted circle). Blue line: polypropylene mesh; white line: absorbable mesh; blue X: lines of sutures. (Color version of the figure is available online.) *EO*, external oblique muscle; *ES*, erector spinae muscle; *IO*, internal oblique muscle; *LD*, latissimus dorsi; *PS*, psoas muscle; *QL*, quadratus lumborum; *R*, rectus muscle; *TA*, transversus abdominis muscle.

preperitoneal plane posterior to the transversus abdominis muscle. We extend this blunt dissection cranially to find the subdiaphragmatic plane by peeling the diaphragmatic fascia off the diaphragmatic muscle caudally to reach Bogros space[35] (the lateral preperitoneal space at the iliac fossa above the inguinal ligament) and the space of Retzius (the retropubic preperitoneal space). Posteriorly, the quadratus lumborum and psoas muscles are identified with careful preservation of the nerves involved (Fig 2). Finally, we continue our dissection medially to the linea semilunaris. At this point, in the cases when the peritoneal layer can be preserved and the midline IH is not huge, we extend the dissection beyond the linea alba, thereby reducing the midline hernia sac. In contrast, when the peritoneal layer is torn, entering the peritoneal cavity, or if a Rives-Stoppa is necessary owing to the size of the midline defect, the lateral border of the ipsilateral posterior rectus sheath (made of the different anatomic components depending on the level of the abdomen, see Fig 3) is incised, and the retromuscular plane is dissected from lateral to medial (a so-called “reverse TAR”), usually starting at the arcuate line. Then, a crossover to the contralateral side is made by transecting the medial insertion of the posterior rectus sheaths with the linea alba and then reducing the midline sac.[36] Afterwards, our midline extension must cranially reach the subxiphoid region and caudally the Retzius space; if the midline hernia defect does not extend all the way to the xiphoid or the pubis, the continuity of the linea alba should be carefully preserved.

Now, the reconstructive phase will follow the same as in the midline approach. We do not use fixation to the costal margin. One

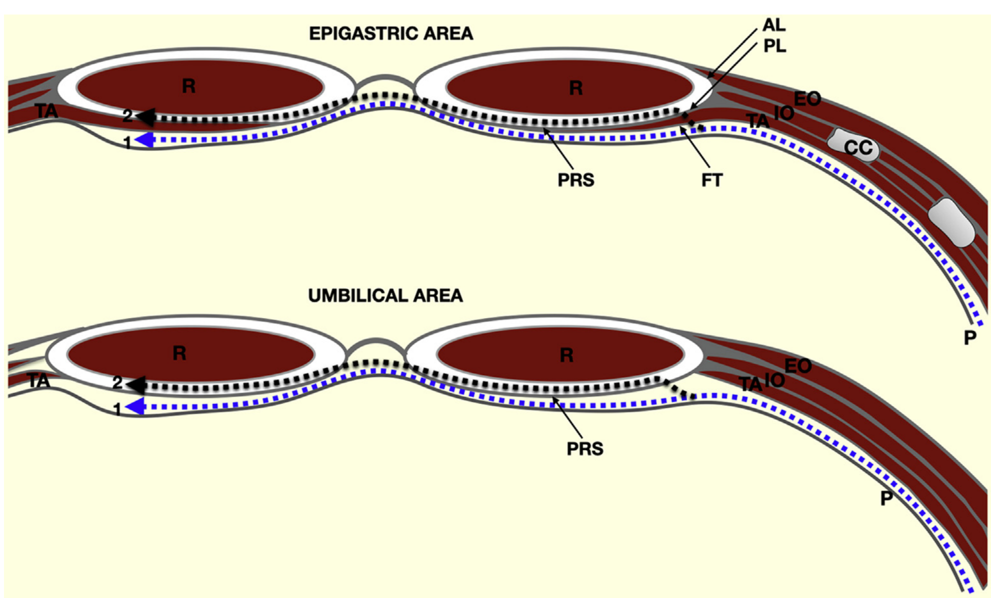

Fig 3. Schematic representation of the “reverse” TAR. Coming from the lateral preperitoneal dissection to the midline, the dissection may follow 2 layers: (1) a complete preperitoneal dissection reducing the midline sac (blue dotted line) and (2) making an incision on the posterior rectus sheath or transversus abdominis muscle and posterior lamella of the internal oblique (depending of the level of anatomy) to access the retrorectus Rives space (black dotted line). After reducing the midline sac, the contralateral retrorectus Rives space can be reached (crossover). (Color version of the figure is available online.) *AL*, anterior lamella of internal oblique muscle; *CC* costochondral joints; *EO*, external oblique muscle; *FT*, fascia transversalis; *IO*, internal oblique muscle; *P*, peritoneum; *PL*, posterior lamella of internal oblique muscle; *PRS*, posterior rectus sheath; as muscle; *R*, rectus muscle; *TA*, transversus abdominis muscle.

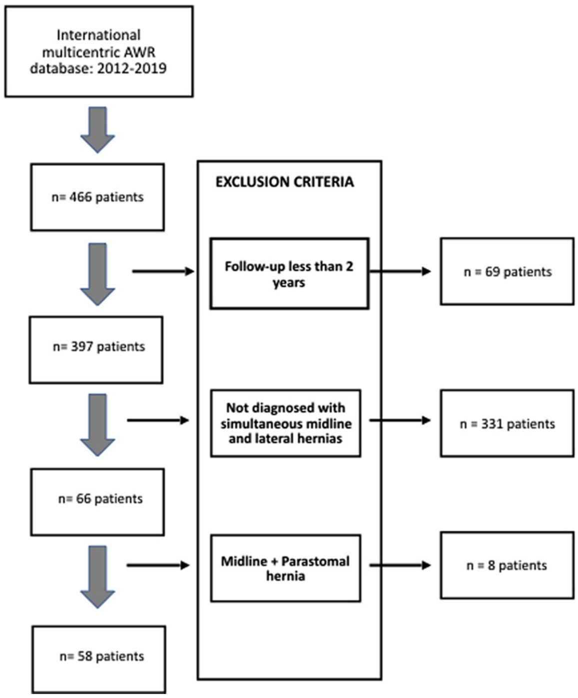

Fig 4. Flow chart of patient selection.

of the authors uses sutures to the periosteum of the iliac crest to support the lateral and posterior extension of polypropylene mesh. We do not use bone anchor fixation or sutures through the bone of the iliac crest.

In 1 exceptional circumstance, when the size of both the midline IH and the lateral IH defects were extremely large, 2 separate incisions were made (a midline and a lateral incision) to allow adequate visualization for the dissection and deployment of meshes.

Follow-up

Postoperative data comprised both local and systemic complications. All postoperative surgical site occurrences (SSOs) were included: surgical site infection (SSI), hematoma, seroma, skin necrosis or dehiscence, and those SSOs that required procedural intervention, as defined previously,[37] using the definitions of SSI of the Centers for Disease.[38] Seroma was defined as a mass or swelling in the wound caused by the localized accumulation of clear serum without signs of SSI.[39]

To assess the effectiveness of the treatment, a standardized follow-up was carried out, including physical examination with outpatient clinical visits at 6 weeks, 3 months, 6 months, and then annually. In case of any doubt of recurrence during the clinical exam or any abdominal discomfort, an abdominal CT was requested. We were especially interested in long-term complications, such as chronic pain, chronic infection, and mesh explantation, recurrence, and bulging. Recurrence was defined as "a protrusion of the contents of the abdominal cavity or preperitoneal fat through a defect in the abdominal wall at the site of a previous repair of an abdominal wall hernia." Recurrence was confirmed by CT after clinical suspicion. Bulging was defined as an "area of weakness or asymmetry in the inspection or exploration of the patient's abdominal wall, without defects confirmed in a CT." Chronic pain was defined as "pain or discomfort that lasted greater than 3 months after the repair of the abdominal wall that required analgesic treatment to control the symptoms."

Table III
Demographics and characteristics of patients

Variables	*n* (%)
Sex	
Male	35 (60%)
Female	23 (40%)
Age, mean ± DS	62 ± 11.5
BMI, mean ± DS	29 ± 4 kg/m^2
Obesity (BMI >30)	23 (40%)
Comorbidities	
Smoking	27 (47%)
Anticoagulation	16 (28%)
Diabetes	16 (28%)
Immunosuppression	8 (14%)
COPD	10 (17%)
Hypertension	28 (48%)
Neoplasia	18 (31%)
Cardiac disease	14 (24%)
Renal disease	5 (9%)
Liver disease	8 (14%)
CeDAR; median (min–max)	32.6 (9–78)
<30%	33 (57%)
30–60%	22 (38%)
>60%	3 (5%)
ASA	
I	6 (10%)
II	31 (53%)
III	20 (35%)
IV	1
Prior history of hernias:	23 (40%)
Primary hernias (inguinal, umbilical…)	10 (17%)
Incisional hernias	13 (22%)
Number of previous hernia repairs, median (min–max)	1 (0–12)
Etiology of main IH (type of operations)	
Digestive tract	32 (55%)
Liver-pancreatic	8 (14%)
Urology	5 (9%)
Trauma	4 (7%)
Abdominal wall	2 (3%)
Gynecology and obstetrics	4 (7%)
Cardiac	1
Others	2 (3%)

ASA, American Society of Anesthesiologists; *BMI*, body mass index; *CeDAR*, Carolinas Equation for Determining Associated Risks; *COPD, chronic* obstructive pulmonary disease.

To evaluate patient-reported outcomes, a quality of life assessment was measured preoperatively and at 1- and 2-year follow-up, using the European Registry for Abdominal Wall Hernias Quality of Life (EuraHS-QoL) score, a hernia-specific tool developed by the European Hernia Society.[40]

Statistics

The description of variables and the statistical analysis were performed using the Statistical Package for the Social Sciences program, version 19.0 for Windows (SPSS, Inc, Chicago, IL). In an intention-to-treat analysis, quantitative variables were expressed as mean/median and standard deviation/quartiles and categorical variables as absolute numbers and percentages.

We used the EuraHS-QoL to compare the evolution in patients by pain, restriction, and cosmetic domains between the preoperative and postoperative periods. We analyzed these differences in preoperative and postoperative periods by correlating scores obtained prior to AWR and at 12 and 24 months postoperatively using the Spearman correlation coefficients.

Results

Demographics and characteristics of patients

During this time interval (December 2011 to December 2017), 58 patients underwent an open, AWR with a diagnosis of

Table IV
Characteristics of IH

	n (%)
EHS classification of main IH	
Medial	40 (69%)
M1–M3	5 (9%)
M1–M5	29 (50%)
M3–M5	6 (10%)
Lateral	18 (31%)
L1	6 (10%)
L2	1
L3	5 (9%)
L4	6 (10%)
EHS classification of associated IH	
Medial	18 (31%)
M1–M3	8 (14%)
M1–M5	8 (14%)
M3–M5	2 (3%)
Lateral	40 (69%)
L1	8 (14%)
L2	6 (10%)
L3	21 (36%)
L4	5 (9%)
Maximum horizontal size (cm) of main IH; median, (min–max)	8 (3–20)
Maximum vertical size (cm) of main IH; median, (min–max)	10 (4–25)
W EHS of the main IH	
W1 (<4 cm)	2 (3%)
W2 (4–10 cm)	31 (53%)
W3 (>10 cm)	25 (44%)
Slater's classification of main IH[25]	
Grade 1	0
Grade 2	39 (67%)
Grade 3	19 (33%)
VHWG* classification of main IH	
Grade 1	8 (14%)
Grade 2	38 (65%)
Grade 3	12 (21%)
Grade 4	0
VHSS† classification of main IH	
Grade 1	27 (47%)
Grade 2	24 (41%)
Grade 3	7 (12%)

* Ventral Hernia Working Group hernia classification.[27]
† Ventral Hernia Staging System classification.[28]

Table V
Operative data

Variables	n (%)
Type of operation	
Elective	57 (98%)
Urgent	1
Wound classification	
Clean	47 (81%)
Clean-contaminated	9 (16%)
Contaminated	2 (3%)
Dirty	0
Operative technique	
Posterior component separation	
TAR	26 (45%)
Modification of TAR	27 (47%)
Reverse TAR	3 (5%)
Retromuscular preperitoneal	2 (3%)
Bridging of posterior layer in midline IH	2 (3%)
Bridging of anterior layer in midline IH	14 (24%)
Maximum diameter of bridging in cm: mean (min–max)	
Horizontal	0.86 (0–5)
Vertical	1.12 (0–10)
Other operative procedures associated with the IH repair	
None	15 (26%)
Adhesiolysis	34 (59%)
Intestinal resection	2 (3%)
Closure of bowel opening	1
Another abdominal surgery	6 (10%)
Operative time (min), mean (range)	202 (120–420)

simultaneous MLIHs during the study period and a minimum of 2 years postoperative surveillance (Fig 4) (Table III).

Hernia characteristics

Almost 70% of patients presented with a midline defect as the main IH, with a M1–M5 type being the most frequent (50%). When the main IH was the LIH, the incidence was more uniformly distributed: 10% L1, 4% L2, 9% L3, and 10% L4. There were 10 patients (17%) who presented with a concomitant inguinal hernia that was repaired during the main procedure.

The median maximum horizontal aponeurotic defect was 8 (3–20) cm and a vertical length of 10 (4–25) cm. Most patients had a main IH greater than W1 (97%) and 44% were W3. One-third of the patients presented with a severe degree according to Slater's classification, and more than 50% were grades 2 and 3 according to the Ventral Hernia Staging System (Table IV).

Operative details

Preoperative interventional optimization techniques were performed only rarely: pneumoperitoneum in 1 patient and botulinum toxin injection in 3. Most cases were classified as clean and clean-contaminated wounds. According to the characteristics of the MLIH, 53 patients (91%) were approached through the midline defect and 5 (9%) through the lateral defect. Only 1 case of a midline approach needed an accessory lateral incision to help with the repair. In only 2 cases was a retromuscular preperitoneal approach required; the majority of patients underwent a PCS for the AWR (97%) (Table V).

In 14 cases (24%), the anterior fascial layer of the midline defect was bridged by the mesh without the possibility of complete fascial closure.[20] In only 2 cases (3%), a bridge was required using the absorbable mesh as a patch for a defect in the peritoneum.[41]

Postoperative complications

The overall incidence of SSOs was 38% (Table VI). SSI developed in 16% of patients: superficial in 5 patients (9%), deep in 1, and an organ/space SSI in 3 (5%); the 3 organ/space infections were secondary to 2 intestinal anastomotic dehiscences and 1 inadvertent enterotomy. The rest of the SSOs were noninfectious wound complications: 9 (16%) seromas and 8 (14%) hematomas. There were 8 SSOs that required procedural intervention (14%): 4 superficial SSIs, 2 symptomatic seromas, and 2 hematomas required bedside treatments by opening of the wound, with debridement or excision of subcutaneous sutures. A case of suspected deep SSI appeared 3 weeks after discharge; CT revealed inflammation of the repaired abdominal wall without any fluid collection and was treated conservatively with antibiotics during readmission.

Regarding abdominal complications, there were 3 cases (5%) of postoperative ileus, 1 of intestinal obstruction, and 3 (5%) of intestinal anastomotic dehiscence. Regarding these 3 cases, 1 occurred in a patient who underwent takedown of a stoma associated with AWR and was able to be conservatively treated. The other 2 cases were inadvertent small bowel injuries and required reoperation on the second and fourth postoperative days, respectively, with a postoperative favorable evolution and without the need to remove any implanted mesh. There was no postoperative mortality.

Long-term postoperative complications

During surveillance, 5 patients died owing to unrelated causes, and 1 patient was lost to follow-up. Only 4 patients (7%) needed

Table VI
Postoperative complications

Variable	*n* (%)	Clavien-Dindo
SSO		
Any SSO	22 (38%)	
SSOPI	8 (14%)	
SSI	9 (16%)	
• Superficial	5 (9%)	Grade I: 4 (6.8%) bedside treatments
• Deep	1	Grade II: 1 antibiotic treatment
• Organ/space	3 (5%)	Grade II: 1 case; Grade IIIb: 2 cases
Hematoma	8 (14%)	Grade I: 2 (3%) bedside treatments
Seroma	9 (16%)	Grade I: 2 (3%) bedside treatments
Skin/wound dehiscence	3 (5%)	Grade I: 2 (4%)
Fascial disruption/evisceration	0	
Abdominal complications		
Paralytic ileus	3 (5%)	Grade I: 3 (5%) drug treatment
Intestinal obstruction	1	Grade I: 1 drug treatment
Intestinal dehiscence	3 (5%)	Grade II: 1 antibiotic treatment; IIIb: 2(3%) reintervention
Systemic complications		
Urinary infection	1	Grade II: 1 (1.7%) antibiotic treatment
Venous line infection	1	Grade I: 1 (1.7%) removal of catheter
Respiratory insufficiency	0	
Renal insufficiency	0	Grade II: 1 (1.7%) antibiotic treatment
Pneumonia	1	Grade I: 1 (1.7%) diuretic treatment
Cardiac complications	1	
DVT/PE	0	
Pain >48 h requiring opioids	11 (19%)	
Length of hospitalization, median, (min−max)	7 (1−54)	
30-day mortality	0	
Readmission	5 (9%)	

DVT/PE, deep venous thrombosis/pulmonary thromboembolism; *SSOPI,* SSOs that required procedural intervention.

occasional treatment with nonopioid analgesics. One patient developed a chronic mesh infection from *Staphylococcus aureus* that required partial mesh explantation in the fifth postoperative month. After a mean 30 ± 14 months follow-up, there were 2 recurrences of midline HIs at 9 and 19 months; both required reoperations. Both were epigastric recurrences: 1 was treated by an anterior component separation at 25 months, and the second was treated by retromuscular mesh reinforcement at 35 months. No recurrences of lateral IHs were observed, but there were, however, 4 cases of lateral asymptomatic large bulging (Table VII).

Quality of life

Progression over time in all domains of the EuraHS-QoL score is plotted in Fig 5. The EuraHS-QoL score revealed a statistically significant decrease in all 3 of the domains assessed (pain, restriction, and cosmetic) in the postoperative score compared with the preoperative score. The difference between preoperative and 1-year postoperative periods revealed moderate to strong correlation: pain, (Spearman 0.65), restriction (Spearman 0.49), and cosmetic (Spearman 0.50). Similarly, comparison between 1- and 2-year postoperative periods also showed differences in all domains: pain (Spearman 0.81), restriction (Spearman 0.84) and cosmetic (Spearman 0.97).

Discussion

It is increasingly common to find patients who have undergone different operations for diverse diseases via different incisions. Due to the increase in longevity, it is not so infrequent to find patients who develop multiple defects in the abdominal wall. A combined approach for midline IHs associated with a lateral abdominal wall defect from a previous flank or lumbotomy incision can be a real challenge. First, the surgeon must assess the possibility of using a single approach for the simultaneous treatment of both defects or an individualized procedure for each IH, deciding to correct it in 1 step or via staged consecutive operations, laparoscopic or open. We suggest trying to repair all defects during the same procedure via a single incision whenever possible to avoid additional operations and hospitalizations. To date, there are no clinical data on which is the best way to approach this combination of defects. Another potential alternative could be the use of the laparoscopic approach to treat both defects or the possibility of using the combination of open and laparoscopic approaches.

To achieve the best results for each patient, every case should be individualized, studying the patient's characteristics such as age and weight, associated comorbidities, smoking history, and respiratory function. The characteristics of both of the IHs is also mandatory, such as the size and distance between defects as well as the previous operations and techniques used; all prior operative notes should be obtained to be certain which tissue planes were dissected and whether mesh was placed at the prior operation. An abdominal CT with the Valsalva maneuver to better characterize all these factors is essential.

Apart from the size of the defects involved, the main anatomic landmarks to consider when choosing the best incision for the operative approach are the lateral border of the posterior rectus sheath and the linea semilunaris. When these structures are involved within the previous lateral incision, we prefer to approach the repair of these MLIHs from the midline for 2 reasons: first, the extension of the mesh should reach the contralateral side in order to obtain more than 5 cm overlap, and second, it is the safer lateral division of the posterior rectus sheath[31] for the TAR without injuring the neurovascular bundles.

By following these principles, we propose a specific approach regarding the characteristics of IHs (Fig 6). When the main defect is a midline IH and in cases where the size of both defects is similar or when the linea semilunaris is involved in the LIH, we recommend a midline approach. Lessons learned with PCS techniques and work with cadavers have taught us that lateral defects can also be reached and treated through the midline (Fig 7). After the

Table VII
Long-term postoperative complications

Complications	*n* (%)
Clinical recurrence	2 (3%)
CT control	
No CT performed	32 (55%)
No CT recurrence	18 (31%)
Yes CT recurrence	2 (3%)
Mesh infection	1 (1.7%)
Pain	
Discomfort	2 (3%)
Occasional need for pain treatment	4 (7%)
Daily treatment for pain	0
Interventional treatment for pain	0
Bulging	
No bulging	54 (93%)
Asymptomatic bulging	4 (7%)
Symptomatic bulging	0
Reoperation for recurrence or bulging	2 (3%)

retrorectal dissection, the lateral retromuscular preperitoneal plane is reached from the midline using the TAR approach to find the lateral defect[31,32] and dissected in a centripetal way from previously nondissected retromuscular preperitoneal areas toward the hernia defect. For example, in a lumbar hernia, we can dissect the subdiaphragmatic plane cranially, the preperitoneal Retzius and Bogros spaces caudally, and posterior to the transverse abdominus muscle medially before dissecting circumferentially and reducing the lumbar sac.

One of the advantages of following the retromuscular preperitoneal dissection laterally is the ability to extend the space far beyond the bone structures. Posteriorly, the lateral dissection of the retroperitoneum to the psoas muscle and quadratus lumborum allows enough overlap of the eventual placement the mesh. This maneuver implies creating a Stoppa 3-D configuration at the inguinal area[30] and a "taco" 3-D configuration of the mesh wrapping the visceral sac in the posterior abdominal wall.[34] This posterior wrapping of the visceral sac allows sufficient overlap of the mesh. The place where this overlap is more difficult to obtain is at the pubic area; that is the reason why we always fix the mesh to Cooper ligaments. We prefer not to secure to the pubis because mesh fixation to the pubic bone leads to an increased incidence of chronic pain.[42] Extending the plane beyond the costochondral junction by dissecting the plane between the fascia (and the underlying peritoneal covering) off the diaphragmatic muscle, one can obtain more than a 5 cm overlap.[34] In large IHs, even a 5 cm overlap may be insufficient; thus, based on the Stoppa concept of a large prosthetic reinforcement of the visceral sac and on Laplacés law, we always try to obtain a minimum of 10 cm overlap of the mesh in respect to the hernia defect. We also agree that sutures to the periosteum of the iliac crest, transparietal fixation, or the use of bone anchor fixation may also be helpful if an optimal overlap is not obtained.[43] In any case, whenever it is feasible, we prefer to obtain extension of overlap than mesh fixation.

Furthermore, we encourage attempting to use the modification of the TAR. This modification preserves the TA muscle and allows the possibility of reinsertion of the lateral border of posterior rectus sheath to the mesh[32] in an already weak lateral abdominal wall. In fact, nowadays, this technique is our preferred choice in PCS, when feasible.

In previous stoma site hernias associated with a midline IH, an ipsilateral PCS also offers the possibility of an appropriate overlap for both defects. In our series, we operated on 9 patients with concomitant midline and stoma site hernias. Similarly, in patients with both midline and parastomal defects who are going to be

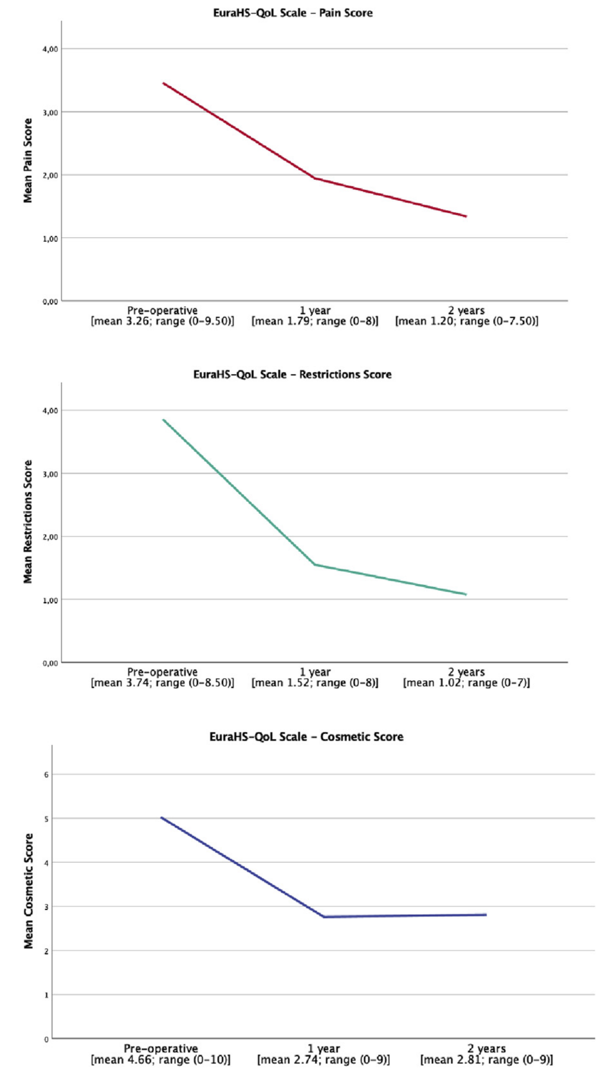

Fig 5. Plot of the evolution over time of the EuraHS-QoL score in patients undergoing an AWR for combined MLIH.

operated on for takedown of the stoma and restoration of intestinal continuity, a PCS also solves the problem, as in 4 patients in our series in whom the stoma takedown and the AWR were performed in the same operation.

If the main defect is a LIH and the linea semilunaris is not involved, we advise a lateral approach. Once the hernia sac has been dissected from its orifice and the preperitoneal dissection of the most lateral region is performed, we extend our incision toward the midline. We found 2 scenarios that are depicted in Fig 3. We can often complete a total preperitoneal approach, because the thickness of the peritoneal layer allows us to extend our dissection carefully without producing peritoneal tears. In contrast, however, in those cases where the peritoneum is too thin, once the linea semilunaris is reached, we must incise the lateral edge of the posterior rectus sheath to convert our dissection plane to the more anterior retromuscular plane. We usually start the incision on the lateral border of the posterior rectus sheath at the arcuate line, coming parallel to avoid damage of the neurovascular bundles and doing what may be named a "reverse" TAR (Fig 3). In the upper abdomen, this posterior rectus sheath is made of the fascia transversalis, the transversus abdominis, and the posterior lamella of the internal

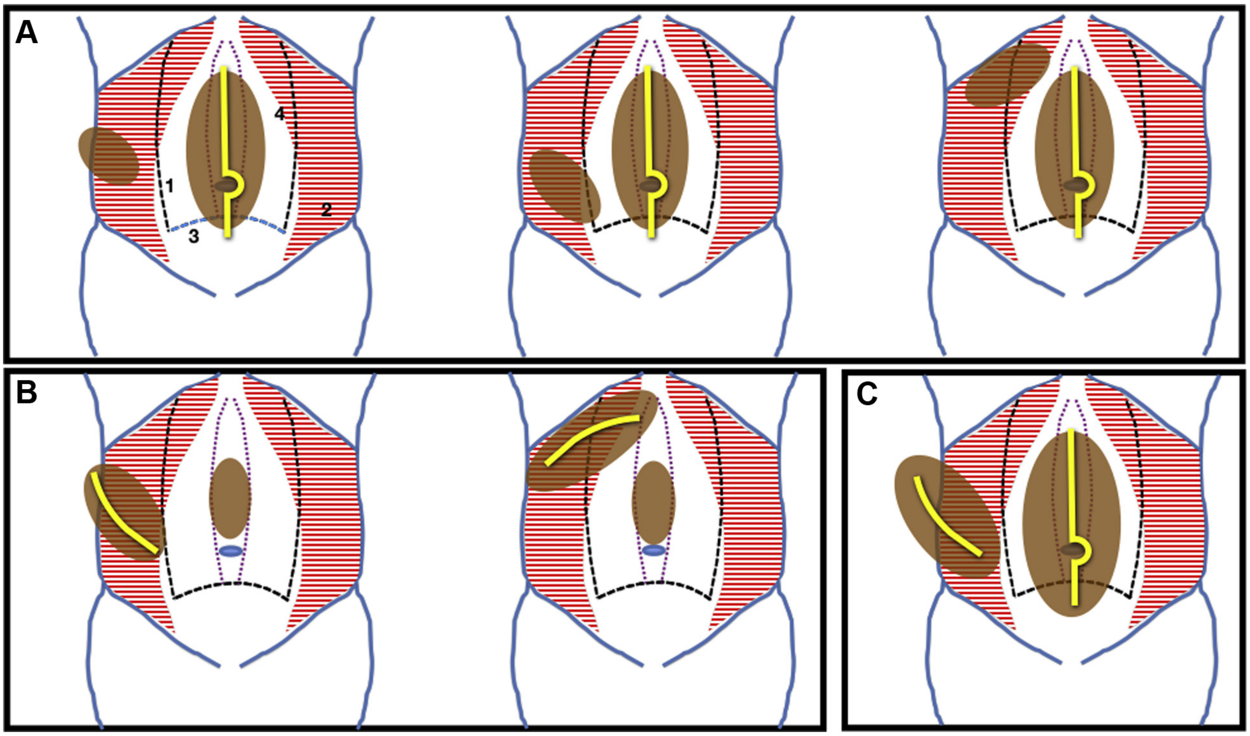

Fig 6. Schematic patterns of the operative approach in case of combined MLIH. (*A*) Patterns of the approach through the midline incision in the following circumstances: when the midline IH is more prominent than the lateral IH, or when the lateral IH involves the linea semilunaris in L1, L2, or L3 IHs. (*B*) Patterns of the approach through lateral incision when the lateral IH is bigger than the midline IH. (*C*) Pattern of the approach when both IHs are difficult to manage from only 1 incision.
1: ridge, lateral border of posterior rectus sheath; 2: transversus abdominis muscle; 3: linea arcuata; 4: linea semilunaris.

oblique; in the mid and lower abdomen, both the aponeurosis of insertion of transversus abdominis and the posterior lamella of the internal oblique contribute to form the posterior rectus sheath. When there are doubts about the location of our incision on the posterior rectus sheath, we use the electrocautery to touch the posterior rectus sheath to observe the contraction of the fibers of the rectus muscle in a cranio-caudal direction. Once we have advanced medially over the posterior rectus sheath, we sequentially cut the ipsilateral medial edge of the posterior rectus sheath and the contralateral medial edge where they fuse with the linea alba, to allow midline crossover in order to correct the midline defect and obtain adequate overlap of the mesh to be implanted (Figs 2 and 3).

In our series, it was only necessary in 1 case to perform 2 different incisions for the AWR because of the large volume of both defects. In these circumstances, we prefer to place the patient in a 30° modified lateral decubitus position and start with the midline IH to perform the modification of TAR before dissecting the lateral side and only then rotating the bed.

As a result, in most cases, the retromuscular plane of Rives in the midline and the retromuscular preperitoneal plane laterally are connected by means of the PCS and prepared as a unique “landing zone” on which to lay on the mesh. We use a 2-mesh technique in AWR based on the results of our previous experience.[33,44] The absorbable mesh does not work like a conventional mesh and should be considered as only tissue scaffolding to reinforce the posterior layer and to cover inadvertent tears in the peritoneum and not to be relied on as a permanent repair of the hernia defect. This absorbable mesh provides a temporary physical support for the extension of a very large permanent mesh without fixation and

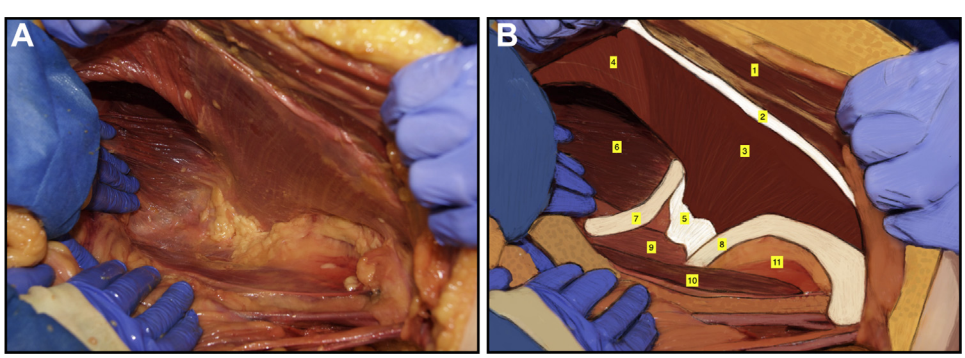

Fig 7. (*A*) Anatomic dissection of a frozen cadaver. A left posterior component separation has been made. The visceral sac is grabbed to the right within the surgeon’s hands. The anatomic relationships of the lateral and posterior abdominal walls are shown. This picture represents the muscle layers that are seen when the retromuscular preperitoneal plane is dissected laterally after the PCS technique. (*B*) Schematic drawing of figure 7A. 1: Left rectus muscle; 2: Lateral border of posterior rectus sheath; 3: Transversus abdominis covered by its investing fascia transversalis (preperitoneal plane); 4: transversus abdominis muscle without fascia transversalis (pretransversalis plane); 5: posterior aponeurosis of transversus abdominis; 6: diaphragm; 7: XII rib; 8: iliac crest; 9: quadratus lumborum; 10: psoas muscle; 11: iliopsoas muscle.

Fig 8. Comparative between preoperative and postoperative CTs after PCS for a simultaneous midline and lumbar defects.

allows creation of the 3-D configuration in the lateral and posterior abdominal walls. It also facilitates the safe reimplantation of the transversus abdominus muscle and lateral muscles when necessary, allowing the restoration of continuity of the posterior layers of the abdominal wall. The combined use of these meshes provide a durable result and low rate of bulging (7%), despite the muscle atrophy associated with lateral incisions, the occasional need of anterior bridging in 24%, and lack of transparietal or bone-anchored fixations (Fig 8).

To the best of our knowledge, this is the first report of a large series with the combination of MLIHs. We eventually classified the MLIHs in 2 groups involving the main defect and the associated defect depending on the size of the IHs involved. A midline IH was the more frequent main IH, probably because this group contains those patients who had an abdominal laparotomy via a midline incision and the creation of a diverting stoma and then developed both a stoma site hernia and a midline IH, a second hepatobiliary operation, and patients with parastomal hernias who underwent restoration of intestinal continuity at the time of takedown of their stoma and repair of a midline IH. The remaining patients comprised patients with the combination of digestive surgery and urologic, vascular, or trauma procedures approached via a flank or lumbotomy incision.

Regarding the EHS classification, we recognize that L2 IHs were found only rarely in our series. This lack of prevalence can be attributed to the lack of pararectal incisions in our series associated with midline incisions and that an enlarged L2 IH is difficult to differentiate from an L3 IH. Interestingly, almost 20% of patients had a concomitant inguinal hernia. This high rate could be explained by the theory of an hereditary or acquired predisposition to development of hernias in so-called "herniosis" or "systemic hernia disease,"[45,46] and the trauma related to previous incisions and previous attempts at repair.[47]

Although the morbidity of SSO was high (38%), the percentage of patients who needed therapeutic intervention or reoperation was only 13%. Our results with a minimum 2-year follow-up showed a recurrence rate of less than 4% and a symptomatic bulge rate of 7% despite the complexity of the combination of MLIHs. Furthermore, we did not have any patient with chronic pain needing regular treatment or any intervention for chronic pain. While some may argue that this lack of chronic pain could be explained by the lack of fixation methods used, we should recognize that other factors, such as level of preoperative pain, patient expectations, and psychological status, may also have an influence on pain and have not been analyzed. There may also be an important influence of the pain from the index operation for lateral scars, where in many cases the patients had pain owing to the denervation related with the transection of the neurovascular bundles by the flank/lumbotomy incision.

We also considered the necessity of evaluating the patient-reported QoL.[48] By performing an invasive operative procedure, our goal is to improve the patient's QoL. Although a permanent correction of all defects with the least possible number of associated complications is a basic objective after AWR, the improvement of the patient's QoL after surgery should also be essential. If an AWR causes chronic pain or restrictions in the patient's daily life, these effects can be very disabling. Therefore, patient-related outcomes have become increasingly important and require a validated QoL instrument. In our study, we verified through the EuraHS-QoL instrument, a validated tool in inguinal hernias, that there was improvement in all domains after the AWR.

This study does have some important limitations. Although it is a prospective multicenter study, there is no comparison group in our study or even in the previous literature. Therefore, we cannot conclude that the treatment of MLIHs via a 1-step approach using different PCS techniques is better than that of staged, consecutive operations or other approaches, but our study is the first to focus on the feasibility of using the PCS technique for the repair of the simultaneous midline and IHs through the same incision and provides what appear to be excellent results. Greater follow-up, of course, will be necessary to confirm the durability of the repair in terms of recurrence or bulging. Regarding the assessment of the QoL, the EuraHS-QoL tool has been validated only in a study for inguinal hernias, but it is the recommended instrument for QoL assessment in the ventral hernia register of the EHS.[40]

In summary, we have shown that using the different PCS techniques through the midline or lateral defect in a single procedure are safe and effective, with promising results, despite the associated high complexity.

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References

1. Veljkovic R, Protic M, Gluhovic A, Potic Z, Milosevic Z, Stojadinovic A. Prospective clinical trial of factors predicting the early development of incisional hernia after midline laparotomy. *J Am Coll Surg*. 2010;210:210–219.
2. Jairam AP, Timmermans L, Eker HH, et al, and the PRIMA Trialist Group. Prevention of incisional hernia with prophylactic onlay and sublay mesh reinforcement versus primary suture only in midline laparotomies (PRIMA): 2-year follow-up of a multicentre, double-blind, randomised controlled trial. *Lancet*. 2017;390:567–576.
3. Rhemtulla IA, Messa 4th CA, Enriquez FA, Hope WW, Fischer JP. Role of prophylactic mesh placement for laparotomy and stoma creation. *Surg Clin North Am*. 2018;98:471–481.
4. Gardner GP, Josephs LG, Rosca M, Rich J, Woodson J, Menzoian JO. The retroperitoneal incision. An evaluation of postoperative flank 'bulge'. *Arch Surg*. 1994;129:753–756.
5. Nanni G, Tondolo V, Citterio F, et al. Comparison of oblique versus hockey-stick surgical incision for kidney transplantation. *Transplant Proc*. 2005;37:2479–2481.
6. Purnell CA, Park E, Turin SY, Dumanian GA. Postoperative flank defects, hernias, and bulges: a reliable method for repair. *Plast Reconstr Surg*. 2016;137:994–1001.
7. Zhou DJ, Carlson MA. Incidence, etiology, management, and outcomes of flank hernia: review of published data. *Hernia*. 2018;22:353–361.
8. Blázquez Hernando LA, García-Ureña M, López-Monclús J, et al. Prophylactic mesh can be used safely in the prevention of incisional hernia after bilateral subcostal laparotomies. *Surgery*. 2016;160:1358–1366.
9. Azurin DJ, Go LS, Arroyo LR, Kirkland ML. Trocar site herniation following laparoscopic cholecystectomy and the significance of an incidental preexisting umbilical hernia. *Am Surg*. 1995;61:718–720.
10. Dincel O, Basak F, Goksu M. Causes of asymptomatic trocar site hernia: how can it be prevented? *North Clin Istanb*. 2015;2:210–214.
11. Sikar HE, Cetin K, Eyvaz K, et al. Lateral sided trocar site hernia following laparoscopic hernia repair: results of a long-term follow-up. *Hernia*. 2019;23:101–106.
12. Beltran MA, Cruces KS. Incisional hernia after McBurney incision: retrospective case-control study of risk factors and surgical treatment. *World J Surg*. 2008;32:596–601;discussion 602–603.
13. Petro CC, Orenstein SB, Criss CN, et al. Transversus abdominis muscle release for repair of complex incisional hernias in kidney transplant recipients. *Am J Surg*. 2015;210:334–339.
14. Tastaldi L, Blatnik JA, Krpata DM, et al. Posterior component separation with transversus abdominis release (TAR) for repair of complex incisional hernias after orthotopic liver transplantation. *Hernia*. 2019;23:363–373.
15. Kapur SK, Butler CE. Lateral abdominal wall reconstruction. *Semin Plast Surg*. 2018;32:141–146.
16. Kapur SK, Liu J, Baumann DP, Butler CE. Surgical outcomes in lateral abdominal wall reconstruction: a comparative analysis of surgical techniques. *J Am Coll Surg*. 2019;229:267–276.
17. Beffa LR, Margiotta AL, Carbonell AM. Flank and lumbar hernia repair. *Surg Clin North Am*. 2018;98:593–605.
18. Renard Y, de Mestier L, Cagniet A, et al. Open retromuscular large mesh reconstruction of lumbar incisional hernias including the atrophic muscular area. *Hernia*. 2017;21:341–349.
19. Veyrie N, Poghosyan T, Corigliano N, Canard G, Servajean S, Bouillot JL. Lateral incisional hernia repair by the retromuscular approach with polyester standard mesh: topographic considerations and long-term follow-up of 61 consecutive patients. *World J Surg*. 2013;37:538–544.
20. Alkhatib H, Tastaldi L, Krpata DM, et al. Outcomes of transversus abdominis release (TAR) with permanent synthetic retromuscular reinforcement for bridged repairs in massive ventral hernias: a retrospective review. *Hernia*. 2020;24:341–352.
21. Pauli EM, Wang J, Petro CC, Juza RM, Novitsky YW, Rosen MJ. Posterior component separation with transversus abdominis release successfully addresses recurrent ventral hernias following anterior component separation. *Hernia*. 2015;19:285–291.
22. Novitsky YW, Fayezizadeh M, Majumder A, Neupane R, Elliott HL, Orenstein SB. Outcomes of posterior component separation with transversus abdominis muscle release and synthetic mesh sublay reinforcement. *Ann Surg*. 2016;264:226–232.
23. von Elm E, Altman DG, Egger M, et al, and the STROBE Initiative. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *Ann Intern Med*. 2007;147:573–577.
24. Muysoms FE, Deerenberg EB, Peeters E, et al. Recommendations for reporting outcome results in abdominal wall repair: results of a consensus meeting in Palermo, Italy, 28-30 June 2012. *Hernia*. 2013;17:423–433.
25. Slater NJ, Montgomery A, Berrevoet F, et al. Criteria for definition of a complex abdominal wall hernia. *Hernia*. 2014;18:7–17.
26. Muysoms FE, Miserez M, Berrevoet F, et al. Classification of primary and incisional abdominal wall hernias. *Hernia*. 2009;13:407–414.
27. Ventral Hernia Working Group, Breuing K, Butler CE, et al. Incisional ventral hernias: review of the literature and recommendations regarding the grading and technique of repair. *Surgery*. 2010;148:544–558.
28. Petro CC, O'Rourke CP, Posielski NM, et al. Designing a ventral hernia staging system. *Hernia*. 2016;20:111–117.
29. Augenstein VA, Colavita PD, Wormer BA, et al. CeDAR: Carolinas Equation for Determining Associated Risks. *J Am Coll Surg*. 2015;221(Supplement 1):S65–S66.
30. Stoppa RE. The treatment of complicated groin and incisional hernias. *World J Surg*. 1989;13:545–554.
31. Gibreel W, Sarr MG, Rosen M, Novitsky Y. Technical considerations in performing posterior component separation with transverse abdominis muscle release. *Hernia*. 2016;20:449–459.
32. Robin-Lersundi A, Blazquez Hernando L, López-Monclús J, et al. How we do it: down to up posterior components separation. *Langenbecks Arch Surg*. 2018;403:539–546.
33. García-Ureña MA, López-Monclús J, Cuccurullo D, et al. Abdominal wall reconstruction utilizing the combination of absorbable and permanent mesh in a retromuscular position: A multicenter prospective study. *World J Surg*. 2018;43:149–158.
34. La Pinska MP, Rosen MJ. Open flank hernia repair. In: Rosen M, ed. *Atlas of Abdominal Wall Reconstruction, second ed.* Philadelphia (PA): Elsevier; 2016:183–194.
35. Hureau J. The space of Bogros and the interparietoperitoneal spaces. In: Bendavid RA, Abrahamson J, Arregui ME, Flament JB, Phillips EH, eds. *Abdominal Wall Hernias: Principles and Management*. New York: Springer; 2001:101–108.
36. Belyansky I, Daes J, Radu VG, et al. A novel approach using the enhanced-view totally extraperitoneal (eTEP) technique for laparoscopic retromuscular hernia repair. *Surg Endosc*. 2018;32:1525–1532.
37. Haskins IN, Horne CM, Krpata DM, et al. A call for standardization of wound events reporting following ventral hernia repair. *Hernia*. 2018;22:729–736.
38. Garner JS, Favero MS. CDC guidelines for the prevention and control of nosocomial infections. Guideline for handwashing and hospital environmental control, 1985. Supersedes guideline for hospital environmental control published in 1981. *Am J Infect Control*. 1986;14:110–129.
39. *The American Heritage Medical Dictionary*. Boston: Houghton Mifflin Co; 2007.
40. Muysoms F, Campanelli G, Champault GG, et al. EuraHS: the development of an international online platform for registration and outcome measurement of ventral abdominal wall hernia repair. *Hernia*. 2012;16:239–250.
41. Winder JS, Majumder A, Fayezizadeh M, Novitsky YW, Pauli EM. Outcomes of utilizing absorbable mesh as an adjunct to posterior sheath closure during complex posterior component separation. *Hernia*. 2018;22:303–309.
42. HerniaSurge Group. International guidelines for groin hernia management. *Hernia*. 2018;22:1–165.
43. Carbonell AM, Kercher KW, Sigmon L, et al. A novel technique of lumbar hernia repair using bone anchor fixation. *Hernia*. 2005;9:22–25.
44. Lopez-Monclus J, Munoz-Rodriguez J, San Miguel C, et al. Combining anterior and posterior component separation for extreme cases of abdominal wall reconstruction. *Hernia*. 2020;24:369–379.
45. Read RC. Metabolic factors contributing to herniation. A review. *Hernia*. 1998;2:51–55.
46. Oma E, Jorgensen LN, Meisner S, Henriksen NA. Colonic diverticulosis is associated with abdominal wall hernia. *Hernia*. 2017;21:525–529.
47. Arnbjornsson E. A neuromuscular basis for the development of right inguinal hernia after appendectomy. *Am J Surg*. 1982;143:367–369.
48. Muysoms FE, Vanlander A, Ceulemans R, et al. A prospective, multicenter, observational study on quality of life after laparoscopic inguinal hernia repair with ProGrip laparoscopic, self-fixating mesh according to the European Registry for Abdominal Wall Hernias Quality of Life Instrument. *Surgery*. 2016;160:1344–1357.