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DYNAMIC MANUSCRIPT

Cranial approach for preperitoneal/pretransversalis enhanced-view totally extraperitoneal (PeTEP) hernia repair: a novel technique description and early outcomes

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Abstract

Background Minimally invasive techniques are widely used to treat abdominal wall defects. This study describes a cranial approach for performing the total preperitoneal/pretransversalis enhanced-view totally extraperitoneal (PeTEP) technique and presents early outcomes for treating primary ventral hernias (PVH), midline trocar site incisional hernias (IHs), both associated with rectus diastasis, as well as lateral IHs.

Methods An observational study was conducted from October 2023 to September 2024, identifying cases where the cranial PeTEP technique was employed, using data from a multicentric prospectively maintained database. The cranial approach involved dissection of the preperitoneal fatty rhomboid, extending the dissection across the preperitoneal and transversalis fascial plane to the semilunar lines laterally and the pubis caudally. For lateral defects, the dissection extended beyond the ipsilateral semilunar line, surpassing the lateral edge of the defect.

Results Twenty-four patients underwent elective endoscopic hernia repair: 62.5% PVH, 29.2% midline IH, and 8.3% lateral IH. The mean defect area was 6.32 ± 6.13 cm^2, and the average mesh size was $497.21.41 \pm 202.71$ cm^2. The surgical site occurrences rate was 8.3%, with no surgical site infections or recurrences at a mean follow-up of 5.3 months.

Conclusions The cranial PeTEP technique was a safe, effective, and reproducible method for repairing PVH and small-medium IHs associated with rectus diastasis in a selected cohort of patients. It facilitated large preperitoneal mesh placement without entering the retromuscular plane and avoided posterior component separation in lateral defects. Larger studies with extended follow-up are needed to confirm these promising results.

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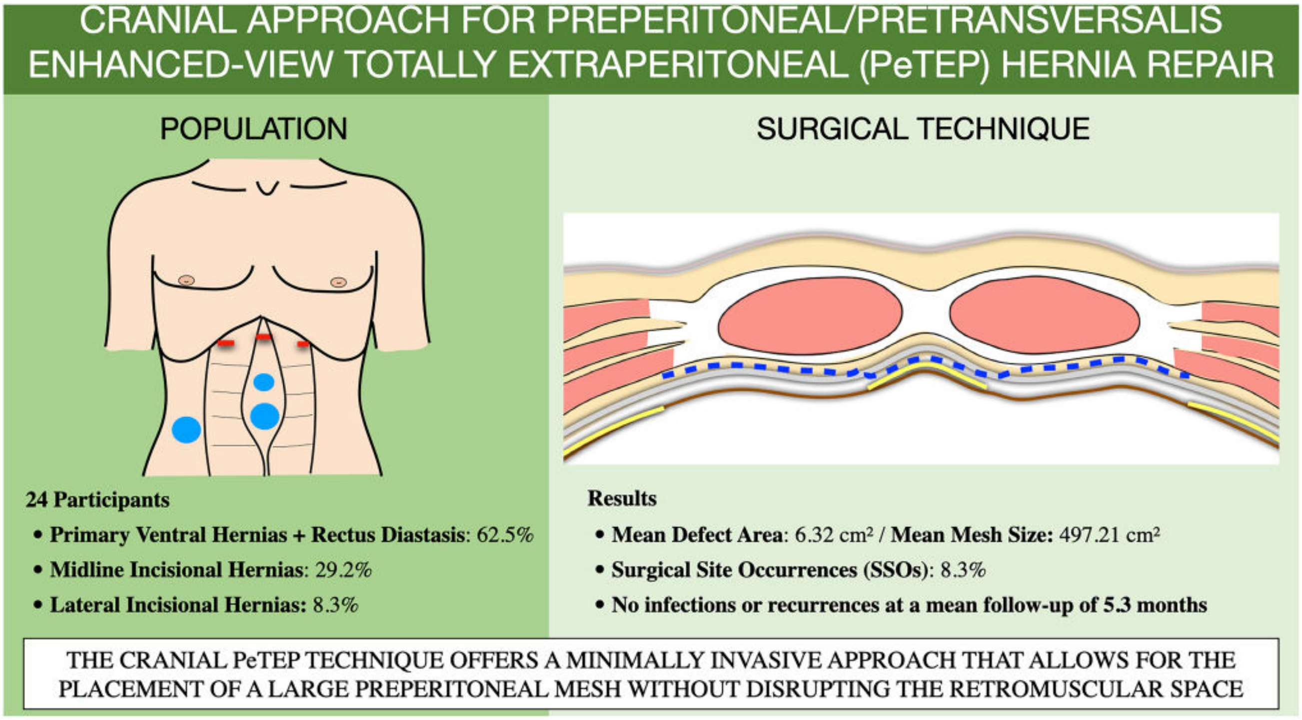
Graphical Abstract



Keywords Preperitoneal approach · Cranial PeTEP · Hernia repair · Rectus diastasis · Endoscopic surgery · Incisional hernia

Abbreviations

ASA	American society of anesthesiologists
BMI	Body mass index
CeDAR	Carolina's equation for determining associated risks
COPD	Chronic obstructive pulmonary disease
EHS	European hernia society
EMILOS	Endoscopic mini/less open sublay
eTEP	Enhanced-view totally extraperitoneal
eTPA	Endoscopic totally preperitoneal approach
ICAP	International classification of abdominal wall planes
IH	Incisional hernia
IPOM	Intraperitoneal onlay mesh
IRB	Intraperitoneal onlay mesh
PCS	Posterior component separation
PeTEP	Preperitoneal enhanced-view totally extraperitoneal
PVH	Primary ventral hernias
SCOLA	Subcutaneous onlay laparoscopic approach
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
STROCSS	Strengthening the reporting of cohort studies in surgery
TAP Block	Transversus abdominis plane block
TAPP	Trans-abdominal preperitoneal
rTARUP	Robotic-trans abdominal retromuscular umbilical prosthesis
TEA	Endoscopic totally extraperitoneal approach

There are multiple treatment options for primary ventral hernias (PVH) or trocar site incisional hernias (IHs) along the midline, including open, laparoscopic or robotic approaches. In open surgery, placing a mesh in the preperitoneal or intraperitoneal planes is often the preferred method, utilizing flat polypropylene meshes or dual-layer meshes suitable for the intraperitoneal space. The open preperitoneal approach is recommended in the joint guidelines of the European Hernia Society and the Americas Hernia Society [1].

However, in patients with obesity or rectus diastasis, the meshes' sizes that can be used with this approach may be considered insufficient, or it may require enlarging the hernia defect to properly implant the mesh.

Traditionally, the main laparoscopic option has been the *laparoscopic Intraperitoneal Onlay Mesh (IPOM)* [2, 3]. Several innovative techniques have been developed to avoid placing meshes in the peritoneal cavity. These include Trans-abdominal Preperitoneal (TAPP) technique [4], Endoscopic Mini/Less Open Sublay (EMILOS) technique [5], robotic-TransAbdominal Retromuscular Umbilical Prosthesis (rTARUP) [6] or Subcutaneous Onlay Laparoscopic Approach (SCOLA) [7]. Nevertheless, since the popularization of the enhanced-view totally extraperitoneal (eTEP) technique described by Belyansky et al. in 2018 [8], many patients have been treated using this approach [9, 10]. This technique involves placing the mesh in the retromuscular space, allowing for the placement of large meshes that cover the entire diastatic midline. Despite its advantages, some critics argue that this approach may lead to overtreatment [11, 12], as it involves disrupting the retromuscular plane, potentially complicating future surgeries in the event of a recurrence.

The insights gained from the eTEP approach, along with a better anatomical understanding of the distribution of fatty tissue in the preperitoneal plane [13], have paved the way for a novel preperitoneal approach. In 2020, Li et al. published a series of 28 patients with primary ventral hernias (PVH) treated using the Endoscopic Totally Extraperitoneal Approach (TEA) [14]. The following year, the same group described the identical surgical technique but with a subxiphoid approach [15]. Later, in 2024, Valenzuela et al. published a study on patients with umbilical hernias and diastasis, also utilizing an endoscopic totally preperitoneal approach. They accessed the preperitoneal space through the Retzius space, achieving excellent results and contributing to the popularization of the preperitoneal technique [16]. Nonetheless, accessing the Retzius space can be particularly challenging in patients with previous Pfannenstiel incisions or concurrent inguinal hernias. The presence of associated hernias in individuals with abdominal wall defects is not uncommon and could be explained by the theory of a genetic or acquired predisposition to hernia development, often referred to as "herniosis" or "systemic hernia disease" [17–20].

The purpose of this study is to describe the total preperitoneal/pretransversalis enhanced-view totally extraperitoneal (PeTEP) technique using a cranial approach and to present the early outcomes achieved with this method for treating midline PVH and trocar site IHs, both associated with rectus diastasis, as well as lateral IHs, without the need for posterior component separation (PCS) techniques.

Methods

Study design and data collection

A multicenter retrospective cohort study was conducted using a prospectively maintained database from two university hospitals specialized in complex abdominal wall reconstruction. All patients undergoing a totally endoscopic preperitoneal abdominal wall with a cranial approach repair between October 2023 and September 2024 were identified.

Inclusion criteria included patients with PVH, midline trocar site incisional hernias (IHs) associated with rectus diastasis, small (less than 4 cm) midline IHs, and small-to-medium (less than 6 cm) lateral IHs suitable for minimally invasive repair. Exclusion criteria encompassed patients with symptomatic supraumbilical diastasis requiring complete linea alba plication after resolution of the underlying cause (obesity, pregnancy), prior extensive abdominal surgeries limiting access to the preperitoneal space (e.g., xiphopubic scars), incisional hernias larger than 4–6 cm (depending on location), patients with previous large preperitoneal mesh repair, the presence of ostomies, active infections, severe comorbidities contraindicating surgery, and patients younger than 18 years.

In all cases, the selection of this technique was made through a shared decision-making process between the patient and the surgeon.

Hernias were classified according to the European Hernia Society (EHS) classification [21].

Rectus diastasis was defined as a widening of the linea alba exceeding 2 cm in accordance with EHS guidelines, detectable by clinical examination, ultrasound imaging, or CT scan [22].

The results were reported following the recommendations for reporting outcomes in abdominal wall hernias [23], adhering to the STROCSS criteria [24], the STROBE statement [25], and the International Classification of Abdominal Wall Planes (ICAP) [26].

This study was conducted following approval by the Institutional Review Board (IRB) of Puerta de Hierro University Hospital, approval number (PI 175/24), in compliance with the Declaration of Helsinki.

Data on demographics, patient comorbidities, hernia characteristics, along with intraoperative and postoperative details, were collected.

All postoperative surgical site occurrences (SSOs) such as surgical site infections (SSI) and those SSOs that required procedural intervention (SSOPI) were recorded [27, 28]. Systemic complications were also documented.

Long-term complications, such as recurrence, bulging, or chronic infection, were systematically monitored using previously established definitions [29–31]. Chronic pain was defined as pain or discomfort lasting more than 3 months after abdominal wall repair that required analgesic treatment.

Preoperative optimization

All patients underwent a standardized preoperative optimization program, which included endocrinological and nutritional assessments for those with obesity or malnutrition, respiratory physiotherapy, and smoking cessation at least four weeks before and after surgery. Weight loss and smoking cessation were strongly recommended, although some exceptions were made.

Surgical technique

The surgical team includes the main surgeon, initially positioned on the patient's left side at shoulder level, one assistant, and one scrub nurse positioned on the opposite side (Fig. 1). This positioning may change if addressing a concomitant unilateral inguinal hernia, with the main surgeon positioned contralaterally to the hernia. In cases of concomitant bilateral hernias, the main surgeon and assistant may switch positions as necessary.

General anesthesia is required for the procedure. To minimize postoperative pain, a preoperative ultrasound-guided transversus abdominis plane (TAP) block is administered.

Antibiotic prophylaxis should be administered prior to the intervention. We routinely use 2 g of cefazolin, and for patients allergic to penicillin, we use vancomycin.

All patients received prophylaxis for deep venous thrombosis, which included subcutaneous administration of enoxaparin and the application of compression devices to both lower extremities.

The patient is placed in a supine position with both arms tucked at the sides, and the operating table flexed at approximately 12–15 degrees. (Fig. 2).

The surgical field extends from the mammary line to the pubis and laterally to the anterior axillary line. This area should be disinfected with 2% alcoholic chlorhexidine. A bladder catheter is recommended during the procedure and should be removed postoperatively to facilitate early patient mobilization.

The procedure begins with a 1 cm transverse incision along the midline, positioned 1–2 cm below the xiphoid process. The fascia of the linea alba is exposed and incised to access the preperitoneal plane. Blunt dissection is then performed with a finger until enough fatty rhomboid is dissected. A Hasson trocar is inserted, and pneumoperitoneum insufflation is initiated with a pressure of 12 mmHg and a flow rate of 3 L per minute, maintained throughout the surgery.

Using the optical device, blunt dissection continues for approximately 6–8 cm on each side until the myoaponeurotic boundary of the transversus abdominis muscle within the posterior rectus sheath is visualized and surpassed.

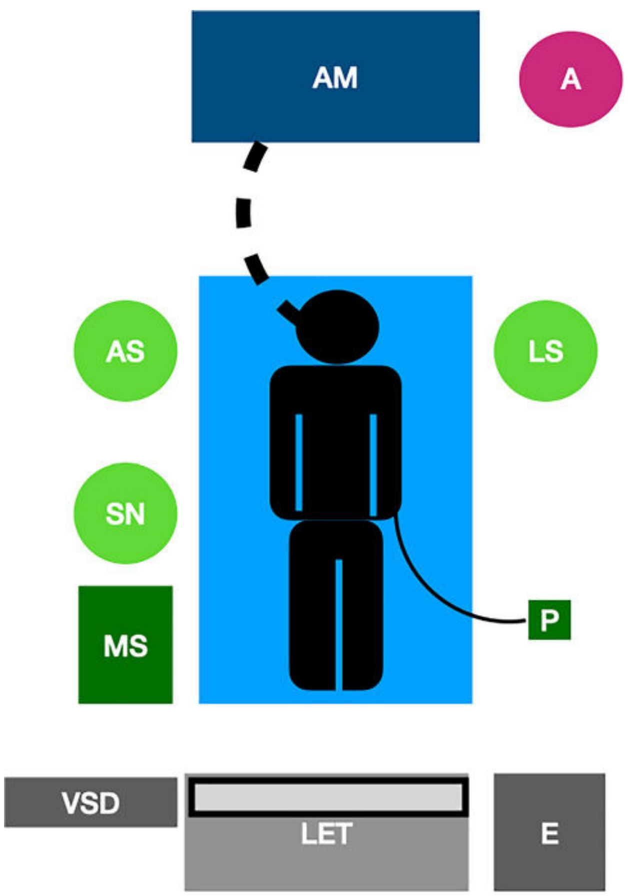


Fig. 1 Diagram of the operating room setup. *AM* anesthesia machine, A anesthesiologist, *LS* lead surgeon, *AS* assistant surgeon, *SN* scrub nurse, *P* intravenous pole, *LET* laparoscopic equipment tower, *E* energy-based surgical instruments tower, *MS* Mayo stand, *VSD* vacuum suction device

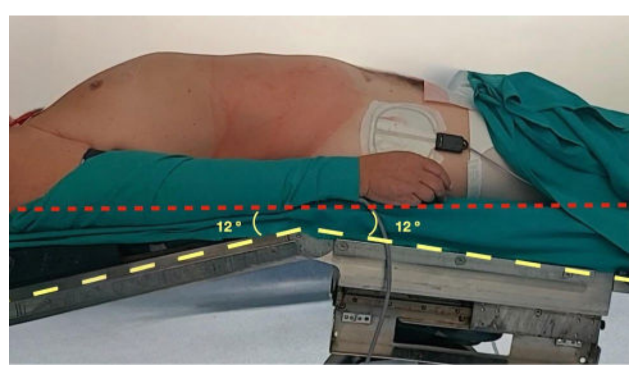


Fig. 2 Patient positioned with both arms tucked at the sides and the operating table flexed at a 12-degree angle

Next, a 5 mm trocar is inserted on the left side and an 11 mm trocar on the right side, approximately 6–8 cm from the initial incision. The 11 mm trocar on the right side allows for switching the optical device to improve ergonomics depending on the surgical stage (Fig. 3A).

After completing the dissection of the fatty rhomboid in the subxiphoid region, dissection of the preperitoneal fatty tissue along the midline below the linea alba continues (Fig. 5A). As caudal dissection progresses, lateral dissection below the posterior rectus sheath is performed until reaching the semilunar line, which serves as the lateral boundary for midline defects. Due to the absence of preperitoneal fat tissue beneath the posterior rectus sheath, making dissection of the preperitoneal plane more challenging, it is recommended to switch to the transversalis fascial plane to avoid peritoneal tears (Fig. 4) The transversalis fascia is thicker in the epigastric region and becomes more robust laterally, so it is suggested to access the transversalis fascial plane at the level of epigastric area, where the transversus abdominis muscle extends more medially, and continue caudally.

During the creation of the preperitoneal and transversalis space, meticulous blunt dissection was performed to separate

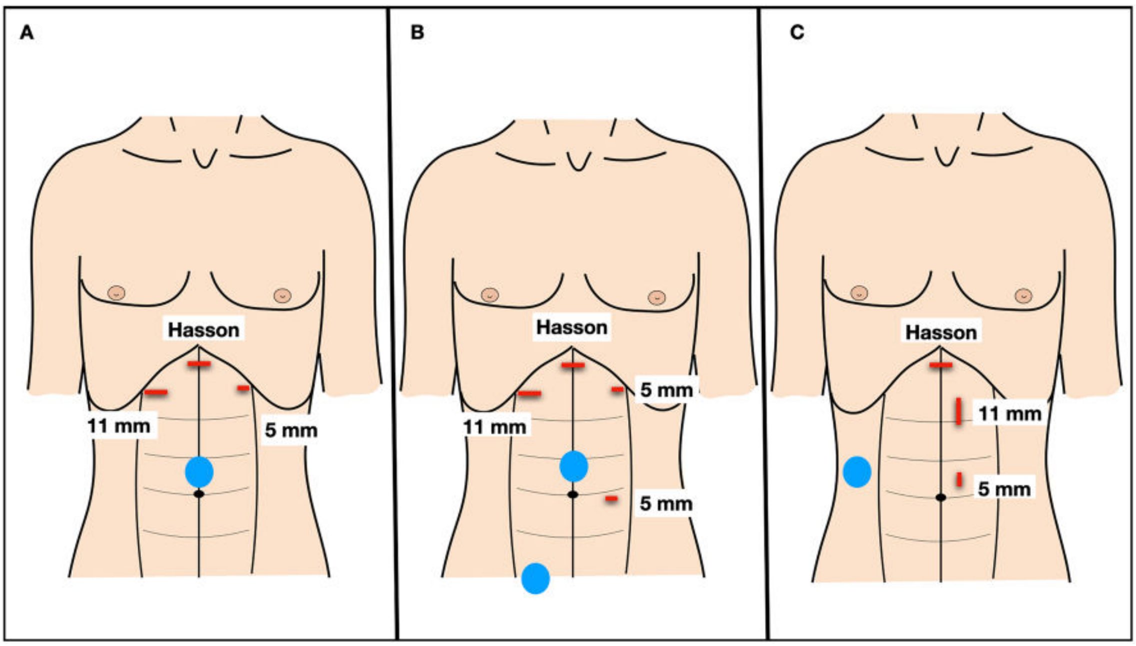


Fig. 3 Trocar positions. **A** Trocar positions for midline defects. **B** Trocar position for midline defects and associated inguinal hernia. **C** Trocar position for lateral defects. *Blue oval* location of the defect (Color figure online)

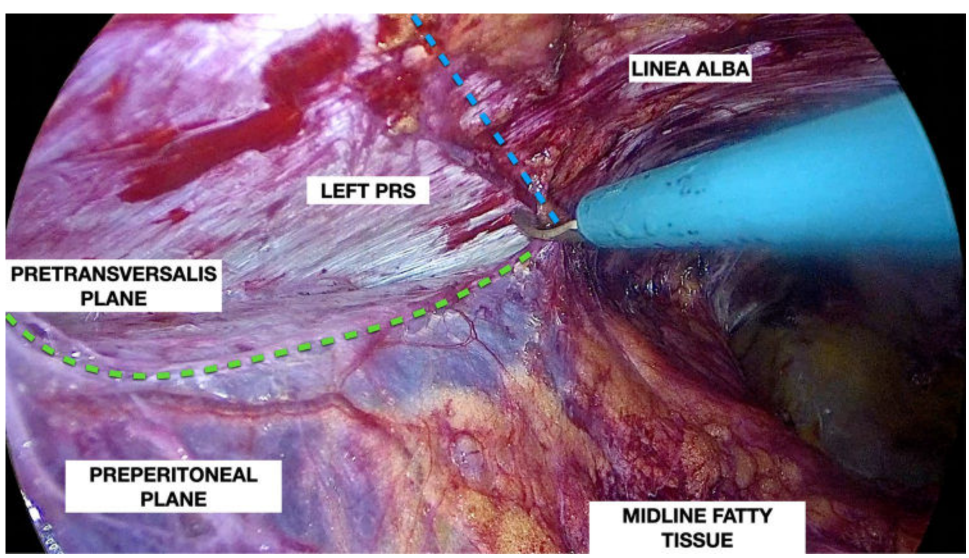


Fig. 4 Detail of the transition between the preperitoneal plane and the transversalis fascial plane in the epigastric area. *PRS* posterior rectus sheath, *Green dotted line* line of transition between the preperitoneal plane and the transversalis fascial plane, *Blue dotted line* medial border of the left rectus sheath (Color figure online)

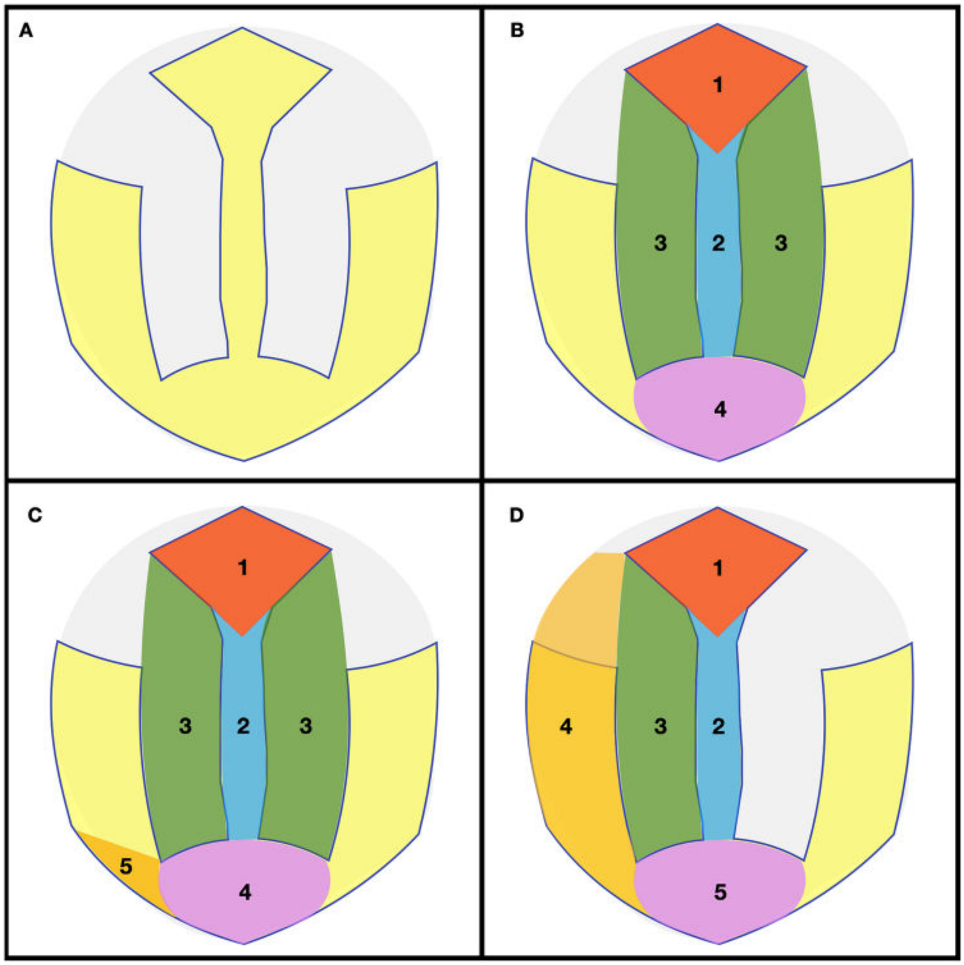


Fig. 5 Schematic order of dissection of the preperitoneal plane. **A** Preperitoneal fatty trident scheme. **B** Schematic order of dissection for midline defects. **C** Schematic order of dissection for midline defects and associated inguinal hernia. **D** Schematic order of dissection for lateral defects

the peritoneum and transversalis fascia from the posterior rectus sheath, minimizing the risk of visceral injury. Scissors without electrocautery were employed for most maneuvers, reserving the use of monopolar or advanced bipolar energy devices to control minor bleeding in the abdominal wall when necessary. This technique allowed for precise dissection with optimal thermal control, significantly reducing the possibility of thermal damage to visceral organs.

Upon locating the midline defect, which may be single or multiple, it is reduced, with primary hernias being easier to address. As caudal dissection advances, the arcuate line is reached and surpassed, continuing until the pubis, with dissection extending into the Retzius space (Fig. 5B).

For patients with concomitant inguinal hernias, whether unilateral or bilateral, one or two additional 5 mm trocars are typically required for inguinal region dissection (Fig. 3B). The dissection is extended toward the Bogros space on the affected side, continuing until a critical view of the myopectineal orifice is achieved [32] (Fig. 5C).

When treating lateral IHs, the procedure begins with the placement of a subxiphoid trocar and blunt dissection of the fatty rhomboid and the most cranial portion of the preperitoneal fat in the midline. After establishing the working space, 2 or 3 trocars are inserted into the linea alba or slightly lateralized toward the side opposite to the defect. (Fig. 3C). Dissection of the transversalis fascial space is then performed, followed by continuation of the preperitoneal dissection, surpassing the semilunar line without the need for component separation, as the EIT ambivium boundary is not encountered as it is in the retromuscular space [33] (Fig. 5D).

Upon completion of the dissection (Fig. 6), any peritoneal tears are closed with 3–0 absorbable barbed suture, and fascial defects are closed with 0 absorbable barbed suture. For symptomatic diastasis in the periumbilical region, a plication is performed using the inverted suture technique as described by Inan [34].

To facilitate closure, especially of peritoneal defects, it is recommended to reduce the insufflator pressure to 6–8 mmHg.

Finally, the dissected space is measured, and a medium-weight, wide-pore polypropylene mesh is cut to size and placed (Fig. 7). Ensuring that the mesh lies completely

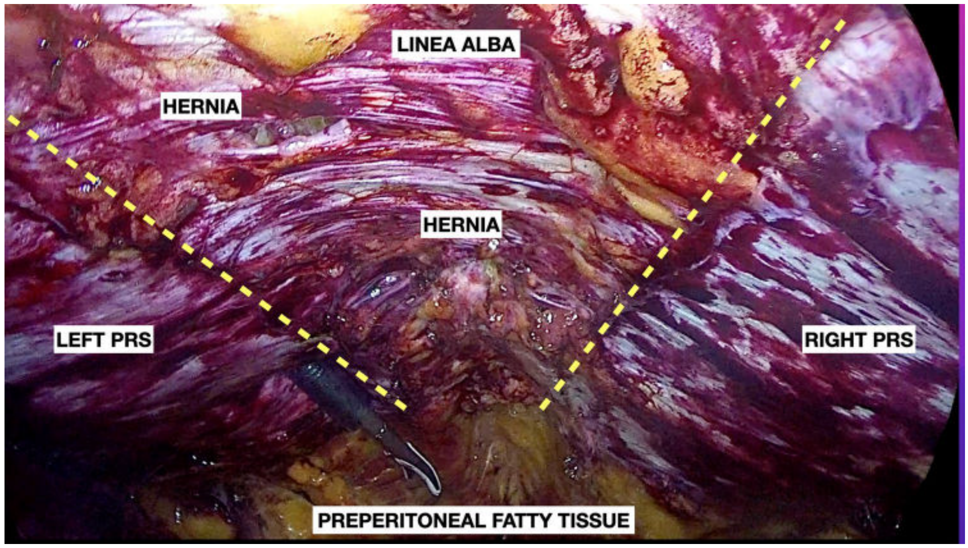


Fig. 6 Detail of midline defects and diastasis of the linea alba and the integrity of the posterior rectus sheath after dissection. *PRS* posterior rectus sheath, *Yellow dotted line* medial border of the rectus sheath (Color figure online)

flat without wrinkles is crucial to prevent adhesions of intraperitoneal viscera. No fixation is used for the mesh.

For concomitant inguinal hernias, two meshes are preferred: an anatomical mesh for inguinal hernia treatment (Dextile™ anatomical mesh 15×10 cm, Medtronic, Minneapolis, MN, USA) and the previously described mesh in the created subfascial space.

Once the mesh is deployed, the CO_2 inlet is closed, and CO_2 is slowly evacuated through the trocars under direct

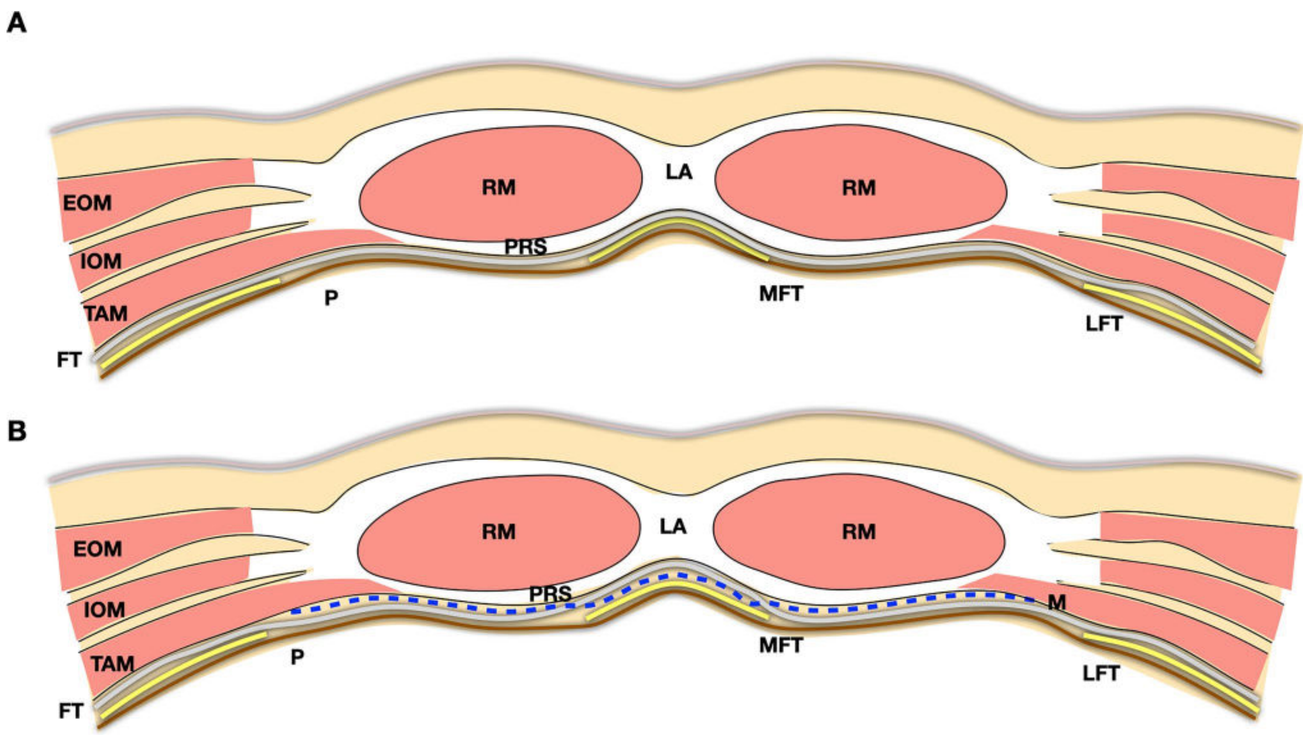


Fig. 7 Schematic representation of the abdominal wall planes, dissected area, and mesh placement. **A** Schematic representation of the abdominal wall planes. **B** Schematic representation of the dissected area and the mesh placement in the preperitoneal and the transversalis fascial spaces. *RM* rectus muscle, *LA* linea alba, *PRS* posterior rectus sheath, *EOM* external oblique muscle, *IOM* internal oblique muscle, *TAM* transversus abdominis muscle, *FT* fascia transversalis, *P* peritoneum, *MFT* midline fatty tissue, *LFT* lateral fatty tissue, *M* Mesh (blue dotted line) (Color figure online)

vision to confirm correct mesh placement. Drains are typically not placed in the dissected preperitoneal space.

Follow-up

Patients were advised to stay physically active while refraining from intense exercise for the first 4 weeks post-surgery. Standardized outpatient follow-ups were scheduled for all patients, with physical examinations at 2 weeks, 1 month, 3 months, 6 months, and annually thereafter. During these follow-ups, if there was any suspicion of hernia recurrence, bulging, or persistent pain, an abdominal CT scan with Valsalva maneuver was performed.

Outcomes

The primary outcome was the recurrence rate following hernia repair. Recurrence was defined as the protrusion of abdominal cavity contents or preperitoneal fat through a defect in the abdominal wall at the site of a previous hernia repair [35]. This was monitored during follow-up visits in the outpatient clinic.

Secondary outcomes included both short- and long-term complications, such as SSOs, SSOPI, bulging, chronic pain, and mesh infection.

Statistics

The description of variables and statistical analysis were conducted using the Statistical Package for the Social Sciences (SPSS) software (IBM Corp. Released 2017. IBM SPSS Statistics for Macintosh, Version 25.0. Armonk, NY: IBM Corp.). Quantitative variables were presented as mean or median with standard deviation or quartiles, while categorical variables were reported as absolute frequencies and percentages.

Results

Demographics and patient baseline characteristics (Table 1)

Between October 2023 and September 2024, 24 patients underwent elective endoscopic hernia repair using a cranial PeTEP approach for PVH and trocar site IHs, both associated with rectus diastasis, as well as for lateral IHs. Of these patients, 15 were male, with a mean age of 59.17 ± 11.76 years. The mean BMI was 27.89 ± 3.88 kg/m^2. Four patients were diabetic, three were immunosuppressed, and three were smokers.

Table 1 Demographics and patient baseline characteristics

Variables	Total (n = 24) n (%)
Sex	
Male	15 (62.5%)
Female	9 (37.5%)
Age, mean ± DS (years)	59.17 ± 11.76
BMI*, mean ± DS (kg/m^2)	27.89 ± 3.88
Obesity (BMI > 30)	6 (25%)
Comorbidities	
Smoking	3 (12.5%)
Anticoagulation	0
Diabetes	4 (16.7%)
Immunosuppression	3 (12.5%)
COPD†	4 (16.7%)
Hypertension	5 (20.8%)
Neoplasia	1 (4.2%)
Cardiac disease	2 (8.3%)
Renal disease	1 (4.2%)
Liver disease	0
Collagen disease	0
CeDAR ‡, mean ± DS	10.94 ± 5.73
< 10%	16
11–20%	6
> 20%	2
ASA §	
I	6 (25%)
II	15 (62.5%)
III	2 (8.3%)
IV	1 (4.2%)
Prior history of hernias:	3 (12.5%)

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

Hernia characteristics and operative features (Table 2)

The incidence rates were 62.5% for primary umbilical hernia, 29.2% for midline IH, and 8.3% for lateral IHs in our series. Eleven patients (45.8%) presented with a concomitant hernia (other midline or inguinal hernia), with more than one associated hernia in four of these cases. All defects were repaired during the main procedure.

The mean defect area was 6.32 ± 6.13 cm^2. The mean width of rectus diastasis among patients was 4.2 ± 0.8 cm, predominantly located in the epigastric and supraumbilical region.

Peritoneal tears were documented during every procedure. In our series, minor peritoneal rents were observed in 16 out of 24 cases (66.6%), with an average of 2 defects per case and a mean diameter of 1.4 ± 0.7 cm. These tears

Table 2 Characteristics of hernias and operative data

Variables	Total (n = 24) n (%)
Type of Hernia	
Primary ventral hernia	15 (62.5%)
Midline Incisional Hernia	7 (29.2%)
Lateral Incisional hernia	2 (8.3%)
Type of Primary Midline Hernia (EHS*)	n = 15
Epigastric	4 (26.7%)
Small (< 2 cm)	2 (13.3%)
Medium (≥ 2–4 cm)	2 (13.3%)
Large (≥ 4 cm)	0
Umbilical	11 (73.3%)
Small (< 2 cm)	3 (20%)
Medium (≥ 2–4 cm)	7 (46.7%)
Large (≥ 4 cm)	1 (6.7%)
Type of Incisional Hernia (EHS)	n = 9
Midline	7 (77.8%)
M2	1 (11.1%)
M3	4 (44.5%)
M2–M3	1 (11.1%)
M3–M5	1 (11.1%)
Lateral	2 (22.2%)
L1	1 (11.1%)
L3	1 (11.1%)
W EHS (For Incisional Hernias)	n = 9
W1 (< 4 cm)	6 (66.7%)
W2 (4–10 cm)	3 (33.3%)
W3 (> 10 cm)	0
Maximum horizontal size of defect (cm), mean ± sd†	2.58 ± 1.05
Maximum vertical size of defect (cm), mean ± sd	2.70 ± 1.54
Maximum horizontal size of rectus diastasis (cm), mean ± sd	4.21 ± 0.83
Area defect (cm^2) mean ± sd	6.32 ± 6.13
Concomitant hernia	
Yes	11 (45.8%)
No	13 (54.82%)
Type of concomitant hernia	
Umbilical	4 (16.7%)
Epigastric	6 (25%)
Intraparietal hernia	2 (8,3%)
Inguinal unilateral	1 (4.2%)
Inguinal bilateral	2 (8,3%)
Mesh type	
Bulevb 30 × 30 cm (*Dipro Medical Devices SRL, Torino, Italy)*	9 (37.5%)
Bulevb 50 × 50 cm (*Dipro Medical Devices SRL, Torino, Italy)*	1 (4.2%)
Optilene mesh 26 × 36 cm *(B. Braun, Melsungen, Germany)*	14 (58.3%)
Mesh vertical size (cm), mean ± sd	30.25 ± 6.15
Mesh horizontal size (cm), mean ± sd	15.93 ± 4.19
Mesh area (cm^2), mean ± sd	497.21 ± 202.71
Operative time (minutes), mean ± sd	136.67 ± 47.07

*EHS European Hernia Society, †Standard Deviation were more frequently observed in cases involving incisional hernias or patients with a history of prior laparotomies.

In all cases, a polypropylene mesh was used, trimmed to fit the preperitoneal dissected space after closing the fascial defect. The average mesh size was 497.21 ± 202.71 cm^2. In one case of a lateral hernia with abdominal wall denervation, a 50 × 50 cm polypropylene mesh was trimmed to fully cover the defect and surrounding denervated tissue, ensuring optimal reinforcement.

The mean operative time was 137 ± 47 min.

Postoperative outcomes (Table 3)

The overall incidence of surgical site occurrences (SSOs) was 8.3%, with no surgical site infections (SSIs) reported. Non-infectious SSOs included one hematoma and one trocar wound dehiscence. There were no surgical site occurrences requiring procedural intervention (SSOPIs). One patient with a prior kidney transplant experienced acute renal insufficiency, which was managed with fluid therapy. The patient with the L3 lateral incisional hernia also presented with bulging, which did not improve following the correction of the incisional hernia. A postoperative CT scan with Valsalva maneuver was performed, revealing persistent bulging consistent with denervation but without IH recurrence. Nevertheless, the patient reported functional improvement.

The median length of hospitalization was 1 day, with no readmissions within the first 30 postoperative days. With a mean follow-up of 5.3 months, no hernia recurrences, mesh infections, or chronic pain were reported.

Table 3 Postoperative outcomes

Variable	Total (n = 24) n (%)
SSO*	
Any SSO*	2 (8.3%)
SSOPI†	0
SSI‡	0
Hematoma	
No hematoma	16 (95.8%)
No requiring intervention	1 (5.8%)
Seroma	0
Skin/wound dehiscence	1 (4.2%)
Fascial disruption/evisceration	0
Systemic complications	
Paralytic ileus	0
Urinary infection	0
Venous line infection	0
Respiratory insufficiency	0
Renal insufficiency	1 (4.2%)
Pneumonia	0
Cardiac complications	0
Hemoglobin difference on the first postoperative day, mean ± DS (g/dl)	1.08 ± 0.69
C-reactive protein on the first postoperative day, mean ± DS (mg/L)	14.60 ± 5.18
Pain > 48 h requiring opioids	0
Length of hospitalization (days), median, (min–max)	1 (1–3)
Readmission	0
Months of Follow-up	5.32 ± 2.63
Clinical and /or CT§ recurrence	0
Mesh infection	0
Chronic seroma	0
Pain	0
Bulging	1 (4.2%)

*Surgical site occurrence, † Surgical site occurrence that required procedural intervention, ‡ Surgical site infection, §: Computed Tomography

Discussion

In accordance with the EHS clinical guidelines, we consider the preperitoneal plane to be ideal for treating PVH [1]. Based on the clear benefits observed with the eTEP technique and its evolution into the preperitoneal plane with the PeTEP technique described by Valenzuela, as well as the TEA and the subxiphoid top-down endoscopic totally preperitoneal approach (eTPA*)* both introduced by Li et al. [14, 15], we present a technical modification that also utilizes a cranial approach, similar to the eTPA technique. Our improved understanding of fatty tissue distribution in the preperitoneal plane led us to confirm that the fatty rhomboid in the subxiphoid region could serve as an access point to the preperitoneal plane, similar to the Retzius space in the original technique [13]. We agree with Li et al. that this approach facilitates access in patients with previous Pfannenstiel scars, which can complicate entry without undesired peritoneal openings. Additionally, this technique allows us to treat patients with synchronous inguinal hernias and midline defects through the preperitoneal plane, avoiding the issues inguinal hernias might pose for proper access from a caudal approach.

A key advantage of the cranial approach is the ease of trocar insertion, which eliminates the risk of iatrogenic damage to the epigastric vessels. This approach also offers better ergonomics and easer dissection and suturing, as the patient's legs do not interfere with the surgeon's movements.

However, a significant drawback is that this modification does not allow for complete plication of the linea alba in cases of symptomatic supraumbilical diastasis. Our protocol does not routinely perform plication of rectus diastasis in asymptomatic male patients or obese patients (regardless of sex) with a BMI over 30 kg/m^2. We believe that if the underlying cause of diastasis, such as obesity, has not been corrected, performing a plication could result in suboptimal outcomes and may further compromise the integrity of the linea alba. Instead, we prioritize reinforcing the weakened area with a mesh to prevent recurrences or metachronous hernias. Even without plication of rectus diastasis, we believe that patients with PVH and associated diastasis should have the entire linea alba reinforced with a prosthesis to reduce recurrences, address small hidden defects, and prevent potential metachronous ventral hernias.

For symptomatic patients requiring a complete plication of the linea alba, we recommend the original caudal approach as described by Li or Valenzuela [14, 16]. Another minimally invasive approach for rectus diastasis is the SCOLA technique [7], which involves extensive dissection of subcutaneous tissue, with a consequent risk of seroma and mesh placement in the supra-aponeurotic space.

Based on the results of Salido et al.'s study on obese patients undergoing abdominal wall repair using the eTEP approach [36], we also consider the PeTEP technique to be suitable for obese patients who have not achieved the targeted weight reduction after the prehabilitation period. This approach may provide a viable alternative for those patients, ensuring effective hernia repair despite the challenges associated with obesity.

We also adhere to the recommendations for adequate mesh overlap, ensuring that the mesh area-to-defect area ratio is at least 16:1 [37, 38]. Achieving this recommended overlap through a small primary ventral defect via an open approach can be challenging, often leading to peritoneal defects and demanding an increase in defect size to avoid these complications. In our study the average mesh size was 497.21 cm^2. This larger mesh size was intentionally chosen to reinforce not only the hernia defect but also the weakened abdominal wall due to rectus diastasis and multiple small midline defects. This approach aligns with the recommended mesh-to-defect ratio to minimize recurrence and prevent future herniation.

The use of separate meshes for concomitant inguinal and ventral hernia repairs ensures proper placement and prevents displacement. To address ergonomic challenges in retroinguinal space access, increasing optical zoom or adding accessory trocars can improve visualization and surgical precision.

The introduction of the eTEP technique offers a solution for achieving adequate dissection through a minimally invasive approach. This technique allows for the placement of appropriately sized meshes that cover the entire linea alba with sufficient lateral overlap, thereby avoiding the supra-aponeurotic and intra-abdominal planes. Nevertheless, concerns emerged regarding potential overtreatment, specifically the division of the posterior rectus sheath and the disruption of the retromuscular plane for small defects. The endoscopic preperitoneal approach, whether cranial or caudal, mitigates these issues by avoiding disturbance of the retromuscular plane. This approach minimizes the risk of damaging lateral neurovascular bundles during dissection and provides adequate control of the preperitoneal plane, preventing unnoticed peritoneal defects and facilitating the placement of a sufficiently sized mesh.

Another advantage of endoscopic dissection of the preperitoneal and transversalis fascial plane beneath the posterior rectus sheath is the ability to treat lateral IHs through a minimally invasive approach, without the need for PCS as previously described in open approaches [39, 40]. To further explore this advantage, patients with lateral hernias were included in the study, despite the small sample size, to assess the adaptability of the cranial PeTEP technique beyond midline defects. This approach aligns with techniques like the Carolinas crossover, which explore alternative preperitoneal access to the lateral abdominal wall [41].

It is important to note that repairing lateral IHs often involves more than addressing the hernia defect alone. In many cases, nerve injury leads to denervation of the abdominal wall, resulting in persistent bulging. In fact, in one of the patients in our series, lateral incisional hernia repair was complicated by abdominal wall denervation. This condition cannot be corrected with mesh placement alone, and some degree of bulging may persist [40].

Due to the anatomical distribution of preperitoneal fat, the most challenging area for endoscopic approach is beneath the posterior rectus sheath, where the risk of peritoneal tears is significantly higher. This represents a key distinction from the eTPA technique described by Li et al. In our modified approach, we emphasize the importance of transitioning the dissection plane in this region by carefully separating the transversalis fascia from the posterior rectus sheath, providing greater consistency to the peritoneal layer as a result of its marked cellularity, which is distinct from the aponeurosis layer, as shown in Bendavid's studies [42]. If defects still occur, they can be sutured at the end of the dissection, and if the tear enlarges along the lateral border of the dissection and further dissection to correct the defect is not desirable, a flap of the posterior rectus sheath can be fashioned and sutured to bridge the peritoneal defect.

Ensuring the closure of all peritoneal defects is critical to prevent postoperative complications such as intraparietal hernias. These hernias can lead to bowel incarceration, resulting in significant morbidity and requiring reoperation. Furthermore, preventing direct contact between abdominal contents and reticulated meshes is essential to minimize the risk of adhesions and enteroatmospheric fistulas.

Regarding potential long-term issues, it remains to be determined whether this technique, by placing the mesh on a thinner layer than the posterior rectus sheath, causes intra-abdominal adhesions. To date, no patients with this problem have been identified; however, it is crucial to ensure the mesh does not fold in any area.

When comparing our study to the eTPA technique, several key differences emerge despite certain similarities. Our study involved a more diverse patient population, including both primary ventral hernias and small to medium-sized incisional hernias, whereas the eTPA study focused exclusively on primary defects. Additionally, the mean operative time in our series was longer (136 min) compared to the eTPA study (105 min). This discrepancy may be attributed to the inclusion of incisional hernias and multiple defects, including inguinal hernias, in our study cohort.

Another notable difference is the larger average mesh size used in our study (497 cm^2 vs. 206 cm^2), reflecting a more extensive dissection. This broader dissection could be possible due to the more structurally robust transversalis plane laterally, enabling more comprehensive reinforcement of the abdominal wall.

Despite these differences, both studies demonstrated comparable short-term outcomes, reinforcing the efficacy and safety of the preperitoneal/pretransversalis approach.

The learning curve for the cranial PeTEP technique may be steeper than for more commonly practiced procedures like eTEP or IPOM. However, we believe that the advantages, such as the preservation of the retrorectus space and avoiding intra-abdominal meshes, justify the additional training required. To facilitate the adoption of this technique, we recommend that surgeons first gain proficiency in other minimally invasive abdominal wall surgeries.

This study has remarkable limitations, primarily due to its descriptive nature, the small patient sample, and the need for longer-term follow-up. Another significant limitation of this study is the heterogeneity of the hernia types included, ranging from small umbilical hernias to lateral incisional hernias. Due to the limited sample size, subgroup analysis was not feasible. Future studies with larger cohorts are needed to allow for robust subgroup comparisons.

Moreover, the absence of a comparative group using other surgical techniques, such as open, laparoscopic or robotic approaches like onlay or underlay reinforcement, limits our ability to draw definitive conclusions. Consequently, we cannot affirm that our repair technique is the optimal approach for managing PVH or midline trocar site IHs with associated rectus diastasis and for lateral IHs. To address these limitations, it is essential to increase the patient sample and extend the follow-up duration. Furthermore, conducting well-designed clinical trials that compare our technique with existing methods is necessary to validate our findings.

Conclusions

The cranial PeTEP technique was a safe, effective, and reproducible method for repairing PVH and small-medium IHs associated with rectus diastasis in a selected cohort of patients. It facilitated large preperitoneal mesh placement without entering the retromuscular plane and avoided posterior component separation in lateral defects. Larger studies with extended follow-up are needed to confirm these promising results.

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