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HOW-I-DO-IT

Lateral approach totally extraperitoneal (TEP) robotic retromuscular ventral hernia repair

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Abstract

Background The enhanced (or extended) view total extraperitoneal (TEP) access that was initially described for laparoscopic inguinal hernia repair has been applied to first laparoscopic and now robotic retromuscular ventral hernia repair (RRVHR). However, a 'dynamic' port setup that is based on the area of interest is preferred by most surgeons. In this study, we present our center's early operative outcomes after utilizing a lateral approach TEP-access RRVHR with and without transversus abdominis release (TAR).

Method An evaluation of a prospectively maintained database of hernia patients was conducted identifying patients who underwent a lateral approach TEP-access RRVHR between February 2013 and April 2019. The lateral approach TEP-access RRVHR was described. Patient demographics, intraoperative and postoperative variables were reviewed. Preoperative and postoperative results were presented according to recommended classification systems by European Hernia Society.

Results Fifty-two patients who underwent a lateral approach TEP-access RRVHR were included in this study. A lateral dock setup was utilized for all patient who had a midline defect, as well as a lateral defect. The mean console time was 121.6 min., skin-to-skin time was 138.5 min. There was no intraoperative complication or conversion. The mean hospital length of stay was 0.71 day. During the mean 6.5 months follow-up period, no hernia recurrence arose.

Conclusion The lateral approach TEP-access RRVHR with and without TAR is a reproducible technique. Feasibility of this approach needs to be demonstrated by other surgeons familiar with retromuscular hernia repair in addition to long-term follow up.

Keywords Robotic ventral hernia repair · Totally extraperitoneal · eTEP · Robotic retromuscular repair · Incisional hernia

Introduction

Various abdominal layers are utilized in current practice for the placement of the mesh in ventral hernia repair (VHR), including the retromuscular position. Originally, retromuscular hernia repair was described by René Stoppa as a 'giant retroparietal prosthetic repair' for the inguinal hernia repair (IHR) [1] and evolved for VHR over time. Before the era of minimally invasive approaches for ventral hernia repair, optimal access for an open retromuscular repair (Rives-Stoppa) could only be accomplished with a large incision [2].

Totally extraperitoneal robotic retromuscular ventral hernia repair (TEP-access RRVHR) is a relatively new technique. The enhanced view-totally extraperitoneal technique (eTEP) was first described by Deas [3] for IHR, but later Belyansky et al. applied this method to laparoscopic VHR [4] and robotic VHR (RRVHR) [5]. In the original description, the port setup was defined as a 'dynamic' configuration, in accordance with hernia localization. For example, in an upper midline hernia, trocars were placed below the level of the umbilicus and the dissection was carried out in a caudocranial direction [5].

The aim of our study was to describe the lateral approach TEP-access RRVHR and to report the early outcomes of this technique.

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Methods

Study population and design

The data for this study were obtained from a prospectively collected, Institutional Review Board approved database of robotic cases performed between February 2013 and April 2019, which has been retrospectively reviewed. From this database, only patients who had undergone TEP-access RRVHR were included in this study. Other mesh positions (IPOM, TAPP) and retromuscular repairs with transabdominal access were excluded from the study.

The database included the patients' demographics (age, sex, body mass index (BMI)), preoperative risk factors, hernia characteristics (etiology, localization, dimensions), operative variables (console time, skin-to-skin time, estimated blood loss (EBL), intraoperative incidences), and early postoperative outcome notes (hospital length of stay, postoperative complications). Hernia characteristics, including localization, measurement, and classification were described in accordance with recommendations of the European Hernia Society (EHS) [6]. Defect size (cm^2), was calculated by area of an ellipse ($\pi \times$ (length (cm)/2 $\times$ width(cm)/2). Mesh size (cm^2) was calculated by area of an ellipse ($\pi \times$ (length (cm)/2 $\times$ width(cm)/2) or rectangle (length(cm) $\times$ width(cm)). The ratio of mesh size to defect size (M/D ratio) was calculated by dividing the respective areas. The modified Ventral Hernia Working Group (VHWG) grading system was used in collaboration with the hernia-patient-wound (HPW) staging system to assess patients' wound risk stratification [7]. The detailed review on postoperative complications was performed by reviewing follow-up visits of the patients with the surgeon, as well as the medical records and clinical charts of the patients. All complications were categorized according to the Clavien-Dindo classification system [8]. Surgical wound complications were further categorized according to the previously published classification system. In brief, surgical site events (SSEs) include all surgical site infections (SSIs) and clinically relevant surgical site occurrences (SSOs) [7]. Any SSO that required procedural intervention, such as percutaneous drainage, opening a wound, placing a drain, or reoperation qualified as an SSOPI. The Morales-Conde classification was utilized for seroma complication if present [9]. The Comprehensive Complication Index (CCI®, University of Zurich, Zurich, Switzerland) was used as a continuous scale to measure the morbidity score [10].

Surgical technique

Preoperative consideration

Careful physical examination and preoperative imaging are paramount to a successful VHR, especially when any degree of complexity is anticipated. Modifiable risk factors that can affect the wound healing process (diabetes mellitus, obesity, malnutrition, smoking) should be investigated and corrected before the elective operation, if possible. To appropriately delineate the extent of the hernia, an up-to-date cross-sectional abdominal imaging with computed tomography (CT), which includes both the abdomen and pelvis may be beneficial.

Patient preparation

Standard operative protocols are utilized. The patient is positioned supine on the operating table and the bed is flexed slightly to open the space between the iliac crest and subcostal margin to minimize collision of the robotic arms. Relevant anatomy is marked, including the xiphoid process, bilateral subcostal margins, symphysis pubis, iliac crests, linea alba, rectus muscle, and semilunar lines. Before the induction of general anesthesia, an examination with Valsalva maneuver may help identifying the hernia borders and rectus muscles in patients with a wide incisional hernia or diastasis recti.

Initial access and ports position for midline hernias

A total of three trocars for this technique are used; one trocar is for a camera, the other two trocars are for instruments. The initial retrorectus dissection is performed via standard laparoscopy. The first trocar is inserted using either a 'cutdown' technique or via optical trocar entry; we prefer the latter. A 5 mm laparoscopic 0° camera is inserted into a 5 mm optical trocar (Kii Fios® First Entry, Applied Medical, CA, USA), which is connected to carbon dioxide (CO_2) insufflation on high flow, set at 15 mmHg pressure. An incision is made in the left upper quadrant, just medial of the linea semilunaris and the trocar is then slowly advanced (Fig. 1a). Subsequently, the subcutaneous tissue and the anterior rectus sheath are penetrated under direct visualization (Fig. 1b). Once the muscle fibers are visualized, the direction of trocar advancement is angled inferiorly to not penetrate the posterior rectus sheath, which is visible as a glistening white layer (Fig. 1c). Blunt dissection is performed using the laparoscope and high-pressure CO_2 insufflation (Fig. 2a) to obtain a reasonable amount of space to insert the other trocars. We use two 8.5 mm da Vinci trocars (Intuitive Surgical Inc.,

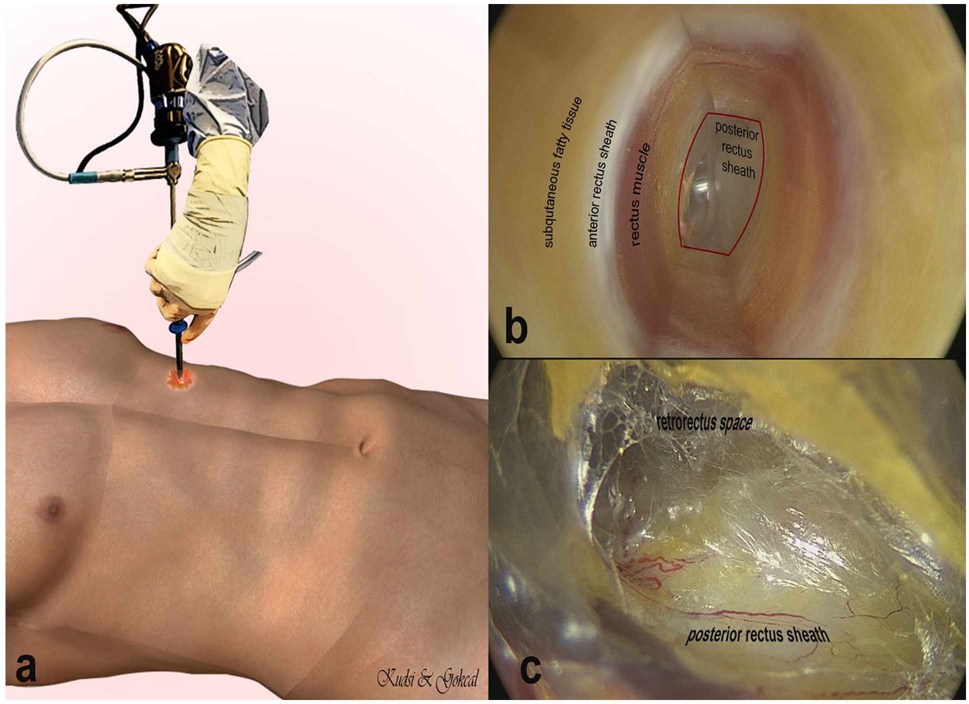

Fig. 1 **a** Optic trocar entry at left upper quadrant and **b**, **c** advancement of the optic trocar till posterior rectus sheath is visualized

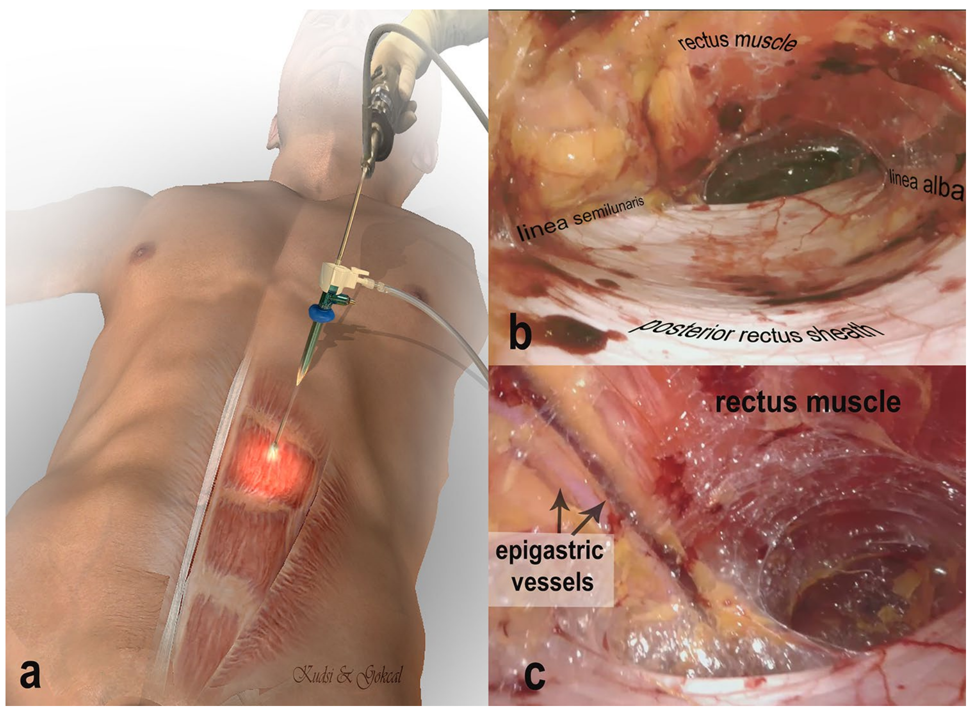

Fig. 2 **a** Blunt dissection with the help of the camera in addition to a high-pressure CO_2 insufflation, **b** anatomical landmarks of left retrorectus space, **c** left epigastric vessels

Sunnyvale, CA, USA) (Fig. 2b). In this step, performing a gentle blunt dissection is crucial to prevent inadvertent bleeding (Fig. 2c). A lateromedial and angled advancement is recommended to insert the da Vinci trocars, providing a distance of at least 8 cm from one another to minimize the mechanical interference of the robotic arms with each other. The initially placed 5 mm trocar is then switched to 8.5 mm da Vinci trocar (Intuitive Surgical Inc., Sunnyvale, CA, USA) (Fig. 3a–c).

Docking and instruments

Once a proper trocar placement is achieved, the patient side cart of the da Vinci surgical system (model Xi, Intuitive

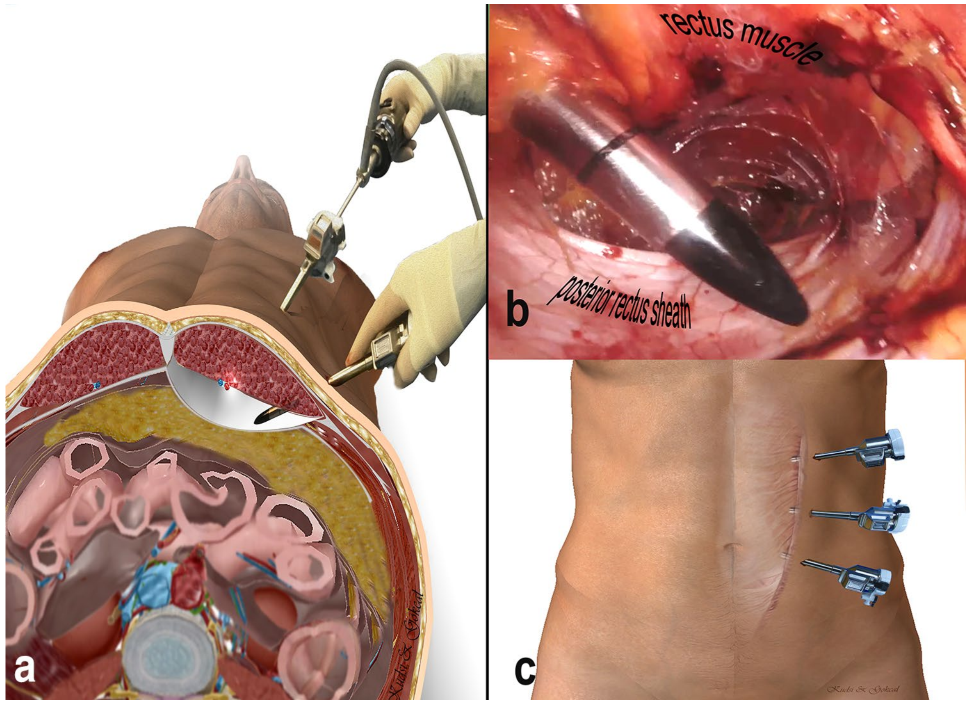

Fig. 3 **a**–**c** Trocar entry under direct visualization and position of the trocars for lateral dock setup

Surgical Inc., Sunnyvale, CA, USA) is docked where the patient's side is(Fig. 4). The EndoWrist® (Intuitive Surgical Inc., Sunnyvale, CA, USA) instruments are used as follows: first a bipolar fenestrated Maryland forceps and monopolar curved scissors; later the scissors are switched to a suture cut large needle driver. The 30° scope is pointed to the target anatomy and the system will automatically position the boom to ensure an optimal arm configuration for the procedure. On average, we use a total of three robotic instruments per case.

Retromuscular dissection and crossover

After completion of the ipsilateral retrorectus dissection, the medial edge of the rectus sheath is incised (Fig. 5a) to reach the contralateral rectus sheath. This can be accomplished provided that the peritoneum and preperitoneal fat, which are posterior to the linea alba, is kept intact (Fig. 5b). The TEP technique where one retrorectus space is dissected and joined to its contralateral counter counterpart without entering the peritoneal cavity is called "crossover" [5] (Fig. 5c, d). At the posterior aspect of the linea alba, the preperitoneal fat is relatively thick, because of the contribution of the falciform ligament (superiorly) and umbilical ligaments (inferiorly). In case of very thin preperitoneal layer, there may be a violation of the posterior layer resulting in peritoneal tears that will need to be sutured later.

It is recommended to start the crossover in an area, where the tissue has not been previously violated. This is especially true in an incisional hernia where one may encounter difficulties during the dissection of the tissue adjacent to the hernia, because the layers surrounding the neck of the sac can be fused and hard to differentiate. Although it is not possible to always completely separate the hernia sac from the subcutaneous tissue, it is important for the hernia sac to be kept intact. Otherwise, undesired tissue loss might require performing an unplanned transversus abdominis release (TAR). In the scenario of an incarcerated hernia, the hernia sac is opened to reduce the visceral contents under direct visualization.

When the crossover is complete, the two rectus sheath compartments are merged to form one compartment that is enclosed by the linea semilunaris on both sides. In most cases, this merged space (bilateral retrorectus areas) can provide enough space for the recommended 3–5 cm mesh overlap of the hernia. However, to reconstruct the posterior midline under no tension and obtain more space for larger meshes, performing a posterior component separation may be needed TAR (Fig. 6a–d).

Technical considerations

A violation of the posterior layer is a challenging intraoperative event during TEP hernia repair. Any violation of the posterior layer may result in pneumoperitoneum, which may reduce the working space. This situation might occur mainly at two stages: (1) during trocar insertion, (2) during crossover dissection.

For the first scenario, a Veress needle or a 5 mm port may be inserted into the abdomen away from the surgical

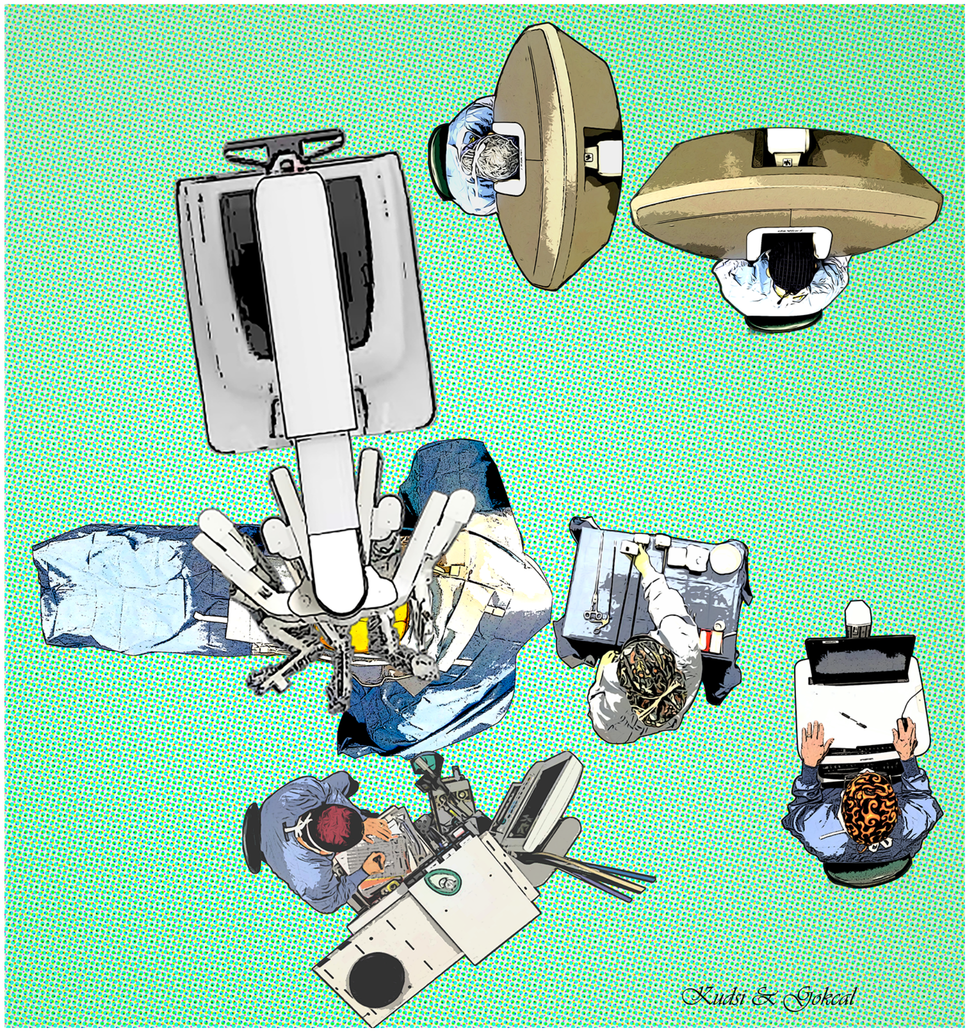

Fig. 4 Operating room setup

site to evacuate intraabdominal CO_2. As mentioned before, once the fibers of the rectus muscle are visualized during optical trocar insertion, the direction of the trocar advancement is angled so that the port is located nearly parallel to the muscle fibers and superficial to the posterior layer. If a complete transabdominal entry has occurred, conversion to a 'cut-down' technique can be considered for the closure of the posterior opening with an absorbable suture. During the initial dissection, a meticulous blunt dissection is crucial to avoid disrupting the posterior layer. Starting to the crossover dissection from anatomically distorted region may cause pneumoperitoneum, and consequently impair surgical working space. To optimize visualization and facilitate the reduction of the hernia sac, we use a circumferential approach, which develops a large space surrounding the hernia defect. A wide dissection on the contralateral side allows for a large space. The wide dissection allows us to continue even in cases, where the posterior layer is breached.

Fascial reconstruction, mesh deployment (Fig. 7a–d)

Once retromuscular dissection is completed, the next step is closure of the hernia defect followed by mesh insertion. The purpose of the hernia defect closure is twofold; the abdominal wall anatomy is restored to closer approximate to native anatomy and abdominal wall function is improved. Furthermore, closing the defect may prevent undesired postoperative pseudohernia bulging, by equalizing the pressure and tension along with the mesh and the abdominal wall. The choice of suture material may vary, but in our practice, primary closure of the hernia defect is accomplished by running a long-lasting absorbable barbed suture (Stratafix™ 0 on CT-1 needle, Ethicon, Somerville, NJ, USA). A small bite technique is used based on the guidelines for laparotomy closure consisting of taking 5–8 mm bites of the fascia and placing stitches every 5 mm in a shoelace fashion [11]. Reducing the CO_2 pressure also facilitates closure. A large distal sac may be left in place and used to plicate the cavity

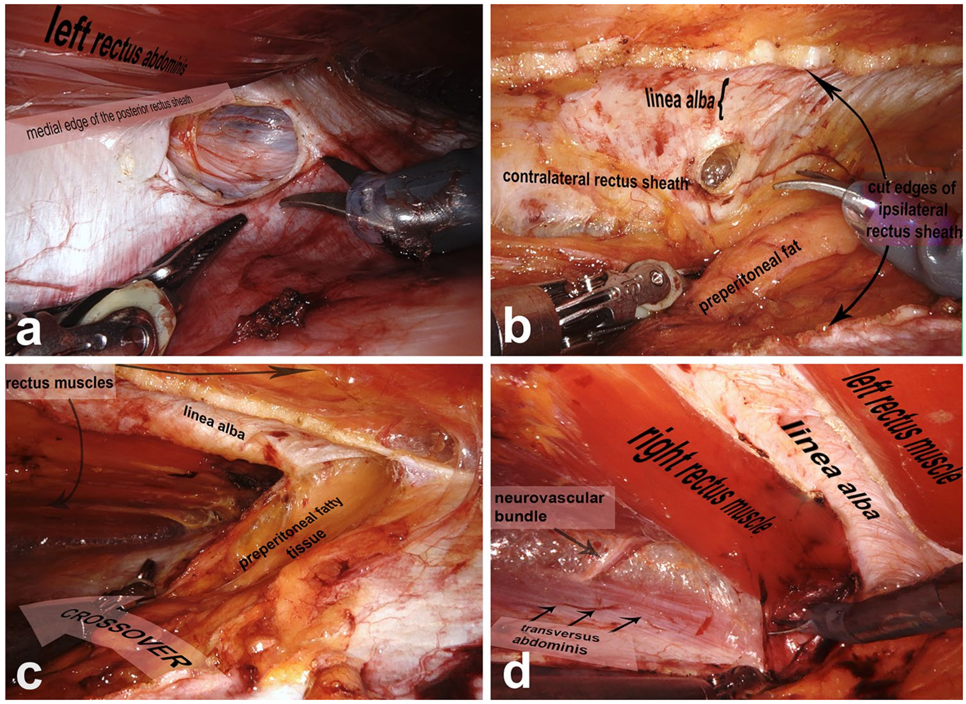

Fig. 5 **a** Dissecting the medial edge of the left posterior rectus sheath, **b** contralateral dissection while keeping peritoneum intact, **c**, **d** completion of the crossover

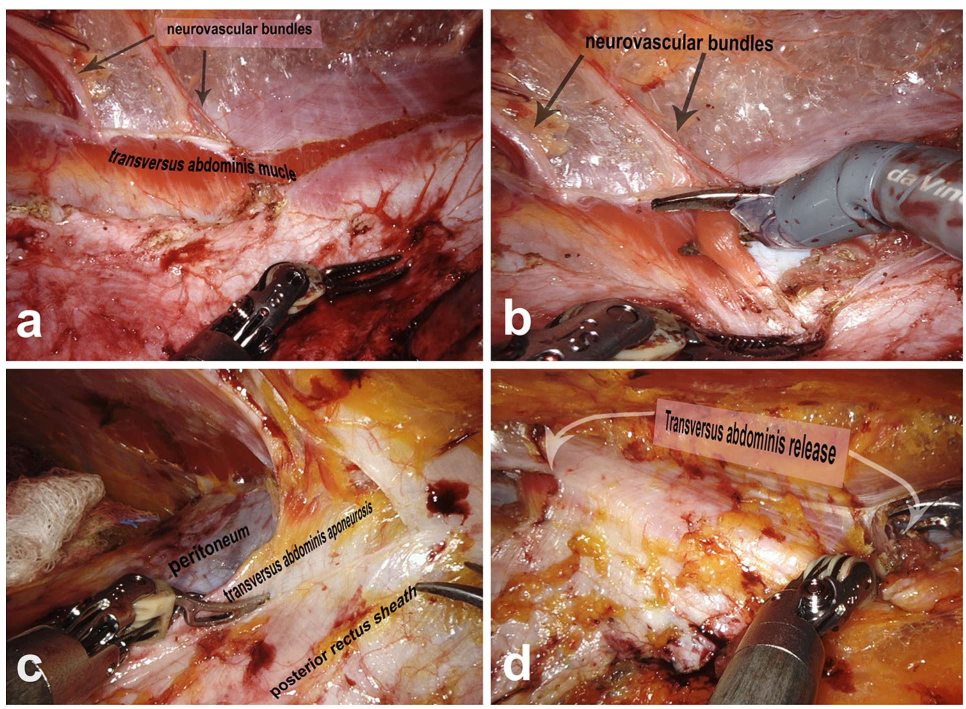

Fig. 6 **a**–**d** The steps of transversus abdominis release (TAR)

during fascial closure. If present, any tears in the peritoneum or posterior rectus sheaths are closed with a 2–0 absorbable suture on a GS-22 needle (V-Loc™ 180; Medtronic, Minneapolis, MN, USA).

In terms of mesh preferences, different brand name meshes within the same subtype are used interchangeably based on sizing needs and availability. However, it is apparent that it is unnecessary to use coated meshes. The preferred mesh is shaped to occupy the entire retromuscular dissected area and is placed against the anterior abdominal wall. Mesh fixation is usually not required, since physiological intraabdominal pressure will aid in maintaining the mesh in position. We prefer to place two

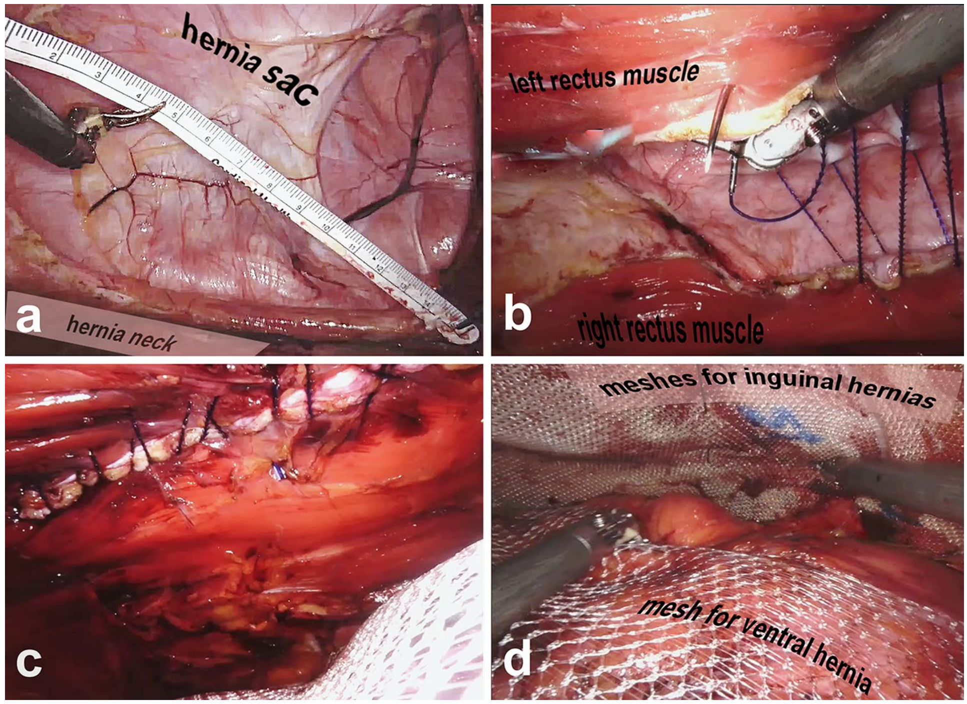

Fig. 7 a The measurement of the defect size, b, c defect closure with barbed suture, d mesh deployment in a case who had a bilateral inguinal hernia and ventral hernia

to three interrupted absorbable sutures to facilitate the deployment a large piece of mesh (with ≥ 30 cm).

Placement of a drain is generally not necessary. Pneumoperitoneum is released and trocars are removed. There is no need to close the fascial defect of the trocar sites, as each is covered by the posterior layer as well as the mesh. Skin incisions are closed after local anesthetic injection.

Initial access and ports position for lateral hernias

Depending on the hernia location, partial tilt or lateral decubitus may be of help. Each step except the position of the trocars is the same for lateral hernias. For small-sized lateral hernias, a TEP-access can be performed by entering the ipsilateral rectus sheath from a point immediately lateral to the linea alba (Fig. 8a). For larger lateral hernias, which involve the ipsilateral linea semilunaris, a TEP-access entry using a point on the contralateral rectus sheath may be helpful to obtain a better view of angle (Fig. 8b). A crossover dissection beneath the linea alba is mandatory in these types of approaches. Of note, in lateral hernias, TAR is usually necessary as an adjunct to retromuscular dissection [12].

Postoperative course

The majority of patients who underwent TEP-access RRVHR were discharged home on the same day. Patients who require an overnight hospital stay were typically those with preexisting comorbidities that needed monitoring after general anesthesia. Patients were encouraged to resume regular activity after the operation. They were advised to avoid lifting heavy objects and participating in strenuous activities for 4–6 weeks.

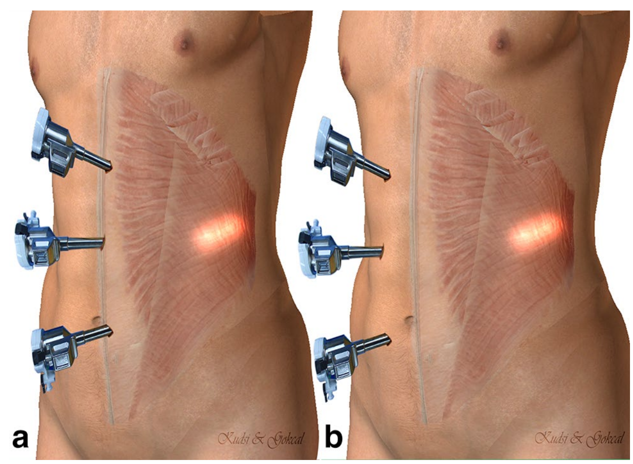

Fig. 8 **a** Ipsilateral trocar setup for a lateral hernia requires transversus abdominis release, **b** contralateral trocar setup requires a crossover dissection as well as transversus abdominis release

Statistical analysis

Categorical variables were presented as a percentage (%) and continuous variables as mean ± standard deviation (SD), or median (interquartile range, IQR) concerning their distributions. Also, some variables were presented with full range (min–max) to reflect extreme values and to be easily interpreted. The histogram graph, the Shapiro–Wilk test, or the Kolmogorov–Smirnov test was used to determine the evaluation of the normal distribution function of the variables. Statistical assessments and graphical illustrations were performed using SPSS (Statistical Package for Social Sciences for Windows, Version 22.0, Armonk, NY, USA: IBM Corp.) and MATLAB (R2015a, Natick, MA, USA; MathWorks, Inc.) software packs, respectively.

Results

Fifty-two patients who underwent a TEP-access RRVHR among a total of 518 RVHR were evaluated in this study. Patients' demographics, hernia grades, and HPW stages were given in Table 1. While 48 (92.3%) patients had undergone surgery in an elective setting, four (7.7%) patients underwent surgery in an emergency setting. All TEP-access RRVHRs were performed with a lateral docking. A TEP-access retrorectus (Rives-Stoppa) repair was performed for 30 (57.6%) patients; a unilateral TAR was required in 11 (21.1%) patients, whereas a bilateral TAR was required in nine (17.3%) patients. Accordingly, a double docking was needed in nine (17.3%) patients. In 12 (23.1%) patients, an inguinal hernia repair [unilateral in eight (15.4%); bilateral in four (7.7%) patients] was performed concomitantly with index procedures. The median defect width was 4 cm (min–max 2–15 cm). The median defect length was 5 cm (min–max 2–20 cm). Intraoperative variables were summarized in Table 2. The most frequent hernia localization was M3 (88.5%). Figure 9 represents the heatmap visualization of all repaired hernias, displaying their frequency.

All hernias repairs used non-coated meshes. The distribution of mesh types was as follows: 53.8% Bard® Soft Mesh (Bard-Davol Inc., Warwick, RI, USA), 19.2% Synecor Pre™ (W.L. Gore & Associates Inc., Newark, DE, USA), 13.5% ProGrip™ (Medtronic, Minneapolis, MN, USA), 13.5% Parietene™ (Medtronic, Minneapolis, MN, USA).

Intraoperative complication did not occur in any patients. One (1.9%) suction drain was placed in a patient who had ascites secondary to a known history of liver cirrhosis, with a MELD score of 8. None of the procedures were converted to open or conventional laparoscopy. In the PACU, the patient's assessed median (IQR) verbal 0–10 scaled pain score was 4 (3–6). The mean length of hospital stay was 0.71 day (range 0–6 days).

The mean postoperative follow-up was 6.4 (range 1–21.5) months. Complications were frequently low grade (Clavien-Dindo grade-I and grade-II). A grade-IVa complication was occurred in one (1.9%) patient who had a history of hepatic cirrhosis and presented to the emergency department, secondary to altered mental status and was subsequently admitted to the ICU with suspicion of hepatic encephalopathy. The median CCI® score was 0 (min–max 0–42.4). In terms of SSEs, seroma occurred in two (3.8%) patients; according to Morales-Conde classification [9], they were of type-0b and type-1. One (1.9%) patient experienced hematoma due to blunt trauma (fall) and presented to the emergency department. Two patients (3.8%) were readmitted through the emergency department within 30 days of surgery as mentioned above, neither of whom required an interventional procedure nor a blood transfusion. None of the procedures were complicated with SSIs. All complications were summarized in Table 3. No patients have experienced a hernia recurrence during the follow-up period.

Table 1 Patient demographics

	TEP-access RRVHR (*n* = 52)
Age, years, mean ± SD	57.7 ± 14.8
Sex, female, *n* (%)	20 (38.5)
BMI, kg/m^2, mean ± SD	30.8 ± 6.3
Cardiovascular comorbidities, *n* (%)	26 (50)
Hypertension, *n* (%)	24 (46.2)
Coronary artery disease, *n* (%)	5 (9.6)
Myocardial infarction, *n* (%)	2 (3.8)
COPD, *n* (%)	4 (7.7)
Smoking, *n* (%)	6 (11.5)
Diabetes, *n* (%)	10 (19.2)
History of wound infection, *n* (%)	5 (9.6)
ASA score	
ASA-I, *n* (%)	5 (9.6)
ASA-II, *n* (%)	19 (36.5)
ASA-III, *n* (%)	28 (53.8)
Modified VHWG grade, median (IQR)	2 (1–2)
HPW-stage, median (IQR)	2 (2–2)

TEP totally extraperitoneal, *RRVHR* robotic retromuscular ventral hernia repair, *BMI* body mass index, *COPD* chronic obstructive pulmonary disease, *ASA* American society of anesthesiologists, *VHWG* ventral hernia working group, *HPW* hernia-patient-wound, *SD* standard deviation, *IQR* interquartile range

Discussion

Throughout the history of hernia surgery, there has been an ongoing debate on the topic of the optimal surgical approach, mesh position, as well as the initial access to achieve the best results. In the United States, surgeons who already perform a minimally invasive approach to VHR are increasingly placing the mesh in the extraperitoneal (retromuscular/preperitoneal) space in an attempt to minimize adhesions due to a foreign body and potentially improve outcomes [13]. Similar efforts have been observing among

Table 2 Hernia characteristics and operative variables

	TEP-access RRVHR ($n=52$)
Hernia type	
Primary ventral, *n* (%)	31 (59.6)
Incisional, *n* (%)	21 (40.4)
Recurrent incisional, *n* (%)	6 (11.5)
Hernia localization	
Midline, *n* (%)	47 (90.4)
Off-midline, *n* (%)	5 (9.6)
Defect length (cm), median (IQR)	5 (4–9.5)
Defect width (cm), median (IQR)	4 (3–5)
Defect area (cm2), median (IQR)	15.7 (10.6–37.7)
Defect closure, yes, *n* (%)	52 (100)
Mesh area (cm2), median (IQR)	300 (225–612.5)
Transverse mesh overlap (cm), median (IQR)	6 (5.5–8.5)
Mesh/defect ratio, median (IQR)	17 (11.3–28.6)
Mesh fixation	
None/self-fix, *n* (%)	48 (92.3)
Interrupted suture, *n* (%)	4 (7.7)
Console time (min.), median (IQR)	99 (52.5–162.5)
Skin-to-skin time (min.), median (IQR)	116.5 (64.5–189)
Estimated blood loss (mL), median (IQR)	5 (5–15)
Drain placement, *n* (%)	1 (1.9)

TEP totally extraperitoneal, *RRVHR* robotic retromuscular ventral hernia repair, *IQR* interquartile range

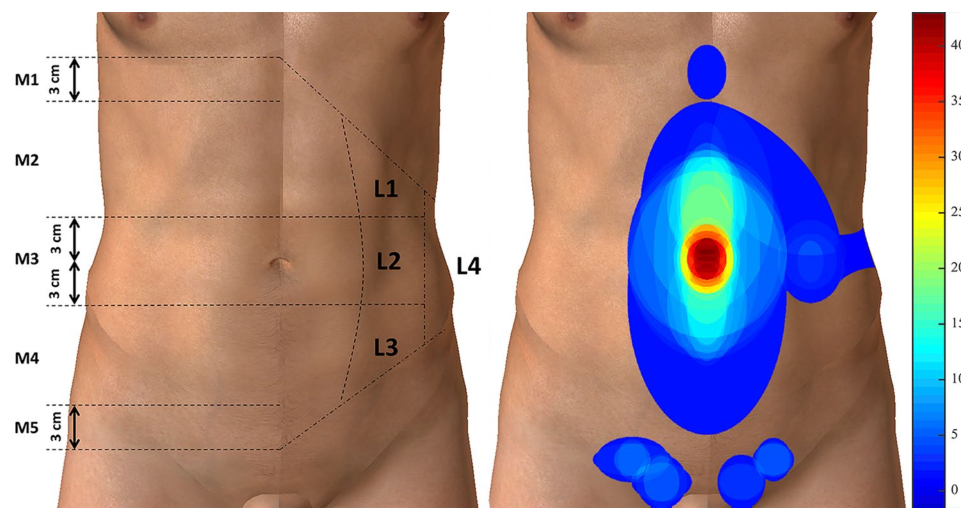

Fig. 9 Heatmap illustration of the frequency and sizes of all repaired ventral and inguinal hernias based on European Hernia Society's hernia classification [6]

surgeons in Europe [14]. Accordingly, in the current literature, the management of ventral hernia using extraperitoneal mesh placement has increased exponentially. A recent meta-analysis showed that mesh placed in a sublay location yields lower complication rates compared to other positions [15]. In a systematic review that aimed to provide a contemporary and comprehensive appraisal of surgical outcomes and complications following ventral hernia repair with various mesh position, the authors found that the anatomic location of mesh implantation appears to influence outcomes and a retromuscular or underlay mesh repair is associated with a lower recurrence rate [16].

In regard to the mesh position in robotic VHR, when we examine our 6-year timeline, there is a shift from intraperitoneal onlay mesh (IPOM) mesh placement to the extraperitoneal position (unpublished data). With the lack of long-term results, in a retrospective propensity score matching comparative study, we reported that robotic preperitoneal mesh placement might improve immediate postoperative outcomes, when compared to robotic IPOM repair in

Table 3 Postoperative complications profile

Overall complications	TEP-access RRVHR ($n=52$)
Pain/discomfort, *n* (%)	7 (13.3)
Nausea/vomiting, *n* (%)	2 (3.8)
Pulmonary complications, *n* (%)	3 (5.7)
Urinary complication (hematuria), *n* (%)	1 (1.9)
Hepatic encephalopathy, *n* (%)	1 (1.9)
Ileus, SBO, *n* (%)	0 (0)
CCI®, median (IQR)	0 (0–0)
Clavien-Dindo	
Grade-I, *n* (%)	8 (15.4)
Grade-II, *n* (%)	3 (5.8)
Grade-IVa, *n* (%)	1 (1.9)
SSEs, *n* (%)	3 (5.7)
SSI, *n* (%)	0 (0)
SSO, *n* (%)	3 (5.7)
Seroma, *n* (%)	2 (3.8)
Hematoma, *n* (%)	1 (1.9)
SSOPI, *n* (%)	0 (0)
Hernia recurrence, *n* (%)	0 (0)

TEP totally extraperitoneal, *RRVHR* robotic retromuscular ventral hernia repair, *SBO* small bowel obstruction, *CCI*® Comprehensive Complication Index, *SSE* surgical site events, *SSI* surgical site infection, *SSO* surgical site occurrence, *SSOPI* surgical site occurrence requiring procedural intervention, *IQR* interquartile range

small-sized ventral hernias [17]. In a recent study that compared 27 endoscopic TEP procedures with 27 IPOM procedures in terms of postoperative outcomes, showed that the differences between the two procedures are the reduction in mean postoperative pain score and the longer operative time both in favor of TEP approach [18].

In terms of initial access, Miserez and Penninckx [19] in 2002 described direct access to the retromuscular plane in a small cohort of 15 VHR cases and named as 'endoscopic totally preperitoneal'. However, Belyansky et al. [4] popularized this access in laparoscopic VHR as an 'enhanced or extended view' modification by adopting eTEP-access inguinal hernia repair, which was first described by Dr. Jorge Daes [3]. The application of this eTEP-access retromuscular VHR to the robotic surgery has been demonstrated formerly by Belyansky et al. [5]. However, in the description of their robotic eTEP technique, it is stated that the initial retrorectus dissection is performed via standard laparoscopy, and then the dynamic port placement is performed based on the hernia localization, as in the previous description for laparoscopic technique. Accordingly, in upper midline defects, they prefer 'lower dock setup' with a total of four ports; the first one is entered at right upper quadrant to develop initial retrorectus space and later to use for assistance, other ports are positioned in a horizontal line below the umbilical level after obtaining enough space performing with a laparoscopic crossover. For lower midline defects, similar steps but in a mirror-fashion with an 'upper dock setup' has been described by the authors. A 'lateral dock setup' has been preferred for centrally located hernias. The crossover is achieved robotically, not laparoscopically with this lateral dock setup. In our practice, all TEP-access VHR cases, irrespective to M class, were completed fully robotically utilizing a 'lateral dock setup', as described above. Of note, a 'lateral dock setup' is already required for lateral (EHS class-L) hernias with or without crossover.

In the studies on laparoscopic TEP-VHR, the authors [18–21] prefer a dynamic port setup, which changes depending on the hernia localization, as explained by Belyansky et al. [4]. Relative contraindications for this set up for upper midline defects include a history of cesarean section, pelvic surgery, prostatectomy, or morbidly obese habitus with large pannus; for lower midline defects they include a history of upper midline surgeries or past Kocher or Chevron subcostal incisions [5]. However, most of the abovementioned factors are not prohibitive in the lateral approach TEP-access. Furthermore, this lateral setup is currently becoming the most common approach for robotic repair by Belyansky et al. [5]. In conventional laparoscopy to obtain better visualization and ergonomics, a dynamic set up is preferred over a constant/fixed port setup. This allows the surgeon utilizing straight instruments and two-dimensional vision to operate in a narrow space that one encounters, while working on the rectus sheath. On the contrary, in robotic surgery, EndoWrist® instrument technology and three-dimensional vision help with the surgeon's orientation and ability to complete the dissection in this narrow space.

The TEP-access RRVHR may also eliminate the need for closure of posterior fascia, which is usually required in the standard transabdominal (TA)-RRVHR. In a study which reviews the learning curve of robotic transabdominal retromuscular umbilical prosthetic repair (r-TARUP), Muysoms et al. [22] describe a lateral approach—single docking—to the retromuscular plane by opening the ipsilateral posterior rectus fascia and carrying out the dissection to contralateral retrorectus space. The dehiscence of the posterior closure after TA-RRVHR may result in subsequent complication such as interparietal hernias and intense adhesions between viscera [23, 24], which are similarly seen after TAPP inguinal hernia repair, although these are rare [25]. Furthermore, when utilizing the lateral approach TEP-access, concomitantly repair of inguinal hernia can be performed without additional trocar insertion. In the present study, we performed 15.4% concomitant unilateral IHR and 7.7% bilateral IHR.

In the case where a unilateral TAR is required, it can be achieved with single docking in the TEP-access RRVHR.

We previously reported that up to 10% of RRVHR cases might require unplanned TAR as an adjunctive step, especially in incisional hernias [12]. In the present study, we encountered an unplanned TAR in one case. There was a large gap in the posterior layer, so we had to add a unilateral TAR to obtain a tension-free reconstruction of posterior layers.

We are able to perform a TEP-access RRVHR with TAR to patients with significant midline defects (M2–M3–M4–M5), up to 20 cm long and up to 15 cm width, without any conversion to an open procedure. The width of the defect, as well as the width of the rectus sheath are important to determine TEP-access' limitations or relative contraindications.

There are several limitations of this study related to the lateral approach TEP-access RRVHR. Even though early postoperative outcomes are promising, the long-term results of TEP-access RRVHR are still unknown [5]. Although we prefer an RRVHR for the treatment of the patients at an increasing rate since 2017 (unpublished data), there are certainly selection biases among these cases, which patient will undergo TEP-access. For the successful completion of this technique, apart from the familiarity of using the robotic platform, a detailed knowledge of abdominal wall anatomy and experience with abdominal wall reconstruction is required. However, regarding the learning curve for this technique, well-designed studies are essential.

In conclusion, the lateral approach TEP-access RRVHR is a promising technique. We are optimistic that this approach will prove to be a valuable tool in ventral hernia repair. Feasibility of this approach needs to be demonstrated by other surgeons familiar with abdominal wall reconstruction.

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Compliance with ethical standards

Conflict of interest Dr. A receives a teaching course and/or consultancy fees from Intuitive, Bard, Gore, outside the submitted work. Dr. B has no conflicts of interest or financial ties to disclose.

Ethical approval The data of this study are obtained from approved database by the Institutional Review Board.

Human and animal rights All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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