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ORIGINAL ARTICLE

# Long-term outcomes of repa for ventral hernias and diastasis: recurrence risk and aesthetic challenges

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## Abstract

**Purpose** To evaluate outcomes of the REPA technique in patients with midline ventral or incisional hernias and associated diastasis during long-term follow-up, complemented with computed tomographic (CT) imaging.

**Methods** A retrospective study including patients who underwent REPA surgery between November 2017 and April 2024 was performed. Demographic data, operative times, postoperative complications, and hospital stay were analyzed. Functional and aesthetic outcomes were assessed using the EHS quality-of-life score. Patients with more than one year since surgery underwent a CT. Based on CT results, patients were divided into two groups to compare (recurrence/no recurrence).

**Results** A total of 142 patients underwent REPA. The associated diastasis had a mean size of 33.8 ± 13.3 mm. The median follow-up time was 47.9 ± 23.97 months. 62 patients completed the EHS-QoL questionnaire. Regarding aesthetics, the general shape of the abdomen had a mean score of 5.66 (± 3.55) and the hernia site and scar scored 3.37 (± 3.58). Among the 33 patients who underwent follow-up CT scans, recurrence was identified in 9 cases (27.3%). Statistically significant differences were observed in BMI (26.01 ± 5.45 vs. 30.52 ± 4.99 kg/m$^2$, $p = 0.04$) and diastasis size (30.3 ± 8.95 vs. 56.6 ± 17.4 mm, $p < 0.001$) between patients with and without recurrence.

**Conclusion** Our findings suggest a higher risk of recurrence in patients with diastasis > 5 cm and obesity, highlighting the need for careful patient selection. Furthermore, overall abdominal shape may be unsatisfactory despite minimal scarring. Overweight and obesity should be considered exclusion criteria to optimize functional and aesthetic outcomes.

**Keywords** REPA · Recurrence · Rectus diastasis · Ventral hernia · Long-term outcomes

## Introduction

The diastasis of the rectus muscles in the anterior abdominal wall refers to the separation of the linea alba or midline, caused by the loosening of the interconnected fibers that form the aponeurosis of these muscles. This condition can manifest various symptoms, from aesthetic concerns to functional issues in the abdominal wall. These functional problems may include disruptions in pelvic floor functions—such as gynecological, urological, or intestinal difficulties—and persistent low-back pain [1].

However, other perspectives suggest that both rectus diastasis (DR) and pelvic floor dysfunction may have a common origin, such as dysfunction of the transversus abdominis (TA) muscle, rather than a direct causal relationship. The TA is involved in multiple functions. In addition to providing stability to the spine, the TA contributes to respiration and regulating intra-abdominal pressure. A primary function of the TA is to tighten the posterior abdominal fascial sheath, including the rectus abdominis fascia and the linea alba. From this perspective, suppression of TA activation may contribute to the development and worsening of DR [2].

In addition, rectus diastasis is a significant risk factor for midline defects of the anterior abdominal wall, as it leads to the thinning and stretching of connective tissue, increasing the likelihood of hernia development. When RD coexists with primary ventral hernias, such as umbilical or epigastric

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hernias (present in up to 50% of cases) the risk of recurrence following hernia repair rises substantially, particularly when the weakened linea alba is not addressed. Simultaneous corrective surgery for RD and associated hernias is considered the most effective approach [3, 4].

Minimally invasive techniques for repairing hernias and midline defects are gaining popularity as promising alternatives to traditional open hernia repair methods. These advanced procedures prioritize preserving the anatomical myofascial continuity of the ventral abdominal wall and result in minimal scarring [5]. In the classic laparoscopic approach, the mesh is placed intra-abdominally and fixed to the peritoneum, carrying risks such as adhesions, visceral damage, and nerve injury. Despite advancements in mesh technology to reduce adhesion risks, the potential complications of foreign material in the abdominal cavity remain [6].

The Pre-Aponeurotic Endoscopic Repair (REPA) technique involves preaponeurotic dissection, closure of the linea alba and associated defects, and onlay mesh placement. This fully endoscopic approach avoids accessing the abdominal cavity, thereby reducing the risks associated with traditional laparoscopic methods. Reported recurrence rates range from 0% to 12.5% [7], but most studies focus on short- to mid-term outcomes, with only one reporting a mean follow-up of two years [8]. Consequently, long-term data is still limited.

The present study aimed to evaluate the clinical outcomes of the REPA technique in patients with midline ventral or incisional hernias and associated RD during long-term follow-up. It was complemented by tomographic imaging to provide objective follow-up data on recurrence rates.

## Methods

This retrospective cohort study was conducted at a tertiary care academic center between 2017 and 2023, including all consecutive patients who underwent REPA for midline hernias and associated RD. The indication for REPA was rectus diastasis associated with midline defects (primary or incisional hernias) in patients without contraindications. Exclusion criteria included large hernia defects, loss of domain, extensive dermal flaps, active skin infections, complicated acute hernias, or contraindications to general anesthesia.

Data collected included demographic variables such as age, sex, body mass index (BMI), surgical risk according to the American Society of Anesthesiology (ASA) classification, and hernia type and size assessed using the European Hernia Society (EHS) classification [9]. Operative variables included operating time, mesh size, and the type of suture used for rectus plication. Postoperative variables included hospital stay, time to drain removal (defined as $<30$ cc/24 h), and complications such as seroma, wound infection, skin necrosis, and hematoma.

All patients underwent surgery under general anesthesia, with preoperative antibiotic prophylaxis using cefazolin 2 g or clindamycin 300 mg for patients allergic to penicillin. During the procedure, patients were positioned supine with open legs. The surgeon stood between the patient's legs, the assistant on the surgeon's right, and the surgical nurse on the left. Access was achieved via a 10 mm suprapubic midline incision or through a previous cesarean scar to avoid additional aesthetic concerns. A space was created between the subcutaneous tissue and the superficial aponeurosis of the linea alba using scissors, followed by a 10 mm optical trocar. Two additional 5 mm trocars were placed under direct vision, approximately 5 cm from the optical trocar. $CO_2$ insufflation at 8 mmHg was used to maintain a working space. The supra-aponeurotic dissection was performed using monopolar energy. The umbilicus is freed above the hernial sac, reintroducing this into the intra-abdominal compartment and the supraaponeurotic dissection is resumed above the umbilicus until the subxiphoid region. The midline and associated defects were closed with a continuous barbed suture or polypropylene suture (No. 1), ensuring complete plication from the subxiphoid to the suprapubic region. A macroporous polypropylene mesh was placed onlay and fixed with Prolene 2–0 sutures. The umbilicus was reinserted and secured with Vicryl sutures, and a subcutaneous drain was placed through one of the 5 mm trocar sites. Figure 1 shows the key steps of the REPA procedure. Postoperatively, patients wore an abdominal elastic band for one month to provide compression. Follow-up visits were conducted at 15 days, 30 days, and six months postoperatively. At six-month follow-up, patients were discharged from routine care if no complications or problems were identified.

All patients were contacted by telephone one year after surgery, using the contact information from their medical records, to assess functional, aesthetic, and recurrence outcomes. Functional and aesthetic outcomes were evaluated using the EHS quality-of-life score (EHS-QoL) [10]. This is a hernia-specific questionnaire with nine questions that can be scored by the patient on an 11-point scale from 0 to 10 (0 = best outcome, 10 = worst outcome). The EHS-QoL questions are divided into three domains: "Pain" (range 0–10), "Restriction of activities" (range 0–10,"X"for activities not performed postoperatively), and "Esthetical discomfort" (range 0–10).

Additionally, patients were asked to undergo an abdominal computed tomography (CT) scan to assess recurrence. Diastasis was defined as a rectus muscle separation greater than 25 mm in the supraumbilical region, greater than 15 mm in the infraumbilical region, and/or the appearance of a new hernia. Based on CT results (recurrence/no recurrence), patients were divided into two groups to compare and analyze potential risk factors associated with recurrence using this technique.

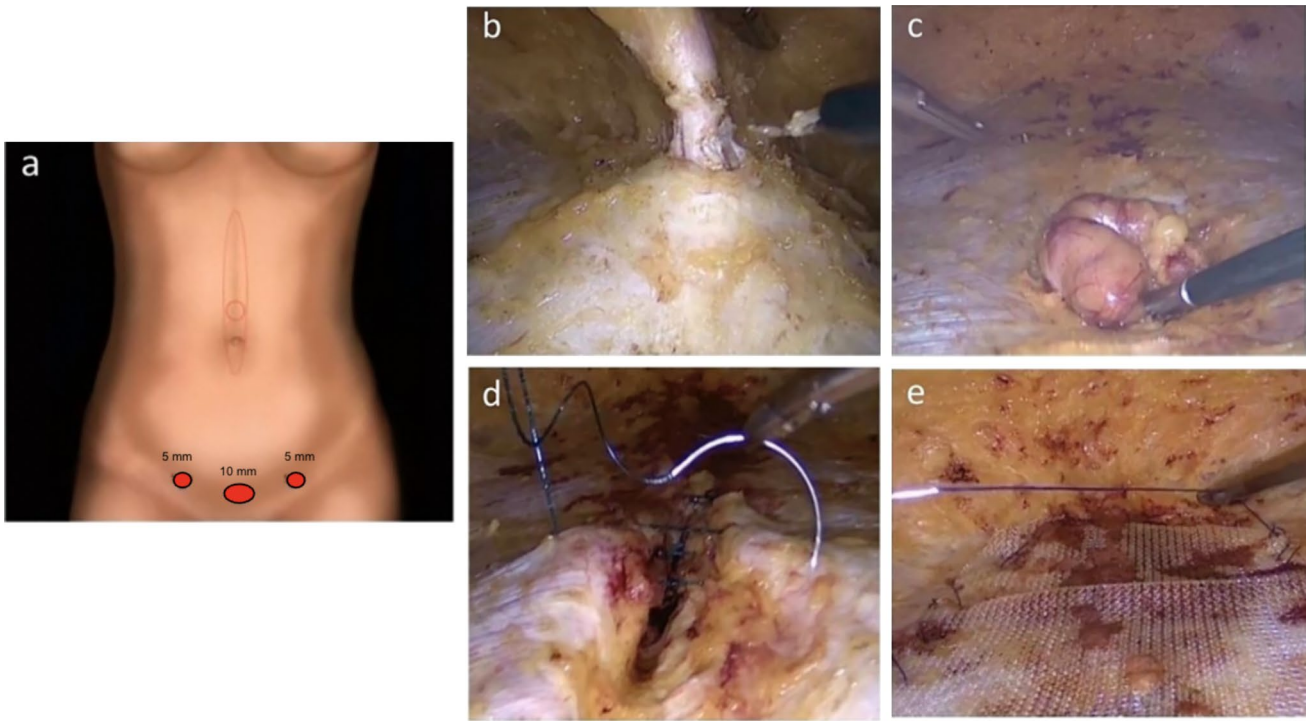


**Fig. 1** **a** Trocar placement. **b** Subcutaneous dissection. **c** Hernia reduction. **d** Defect closure. **e** Mesh placement

Data was analyzed using IBM SPSS Statistics for Windows, version 25 (IBM Corp., Armonk, N.Y., USA). The quantitative variables were compared using the Student t-test for independent samples or the nonparametric Mann–Whitney test as appropriate. The qualitative variables were compared using the chi-square test. Statistical significance is indicated by P values that are less than or equal to 0.05.

## Results

A total of 142 patients underwent REPA for midline hernias and associated RD. 73% were women, the mean age was 47.9 years, and the majority were classified as ASA 2 (69%). The mean BMI was 27.37 ± 4.58 kg/m$^2$. 71.1% of the wall defects were primary ventral hernias ($n = 101$) predominantly umbilical (69.4%) and medium-sized (85.7%). The remaining 28.9% ($n = 41$) were incisional hernias, 75.6% were classified as M3 (umbilical), and 82.9% as W1 (medium) according to the EHS classification. The associated diastasis had a mean size of 33.8 ± 13.3 mm (Table 1).

The total median operative time was 106.17 ± 35.66 min. The median mesh length was 15.48 ± 2.91 cm, and the median mesh width was 11.16 ± 3.45 cm. Polypropylene suture plication was performed in 53.5% ($n = 76$) of cases, followed by barbed suture plication in 43.7% ($n = 62$). The median duration for the subcutaneous drain permanence was 10.06 ± 4.98 days and the median length of hospital stay was 0.64 days (range 0—3). The most common complication was seroma, occurring in 30.3% ($n = 43$) of patients (Table 2).

**Table 1** Patients' main preoperative characteristics

| | $n = 142$ |
|---|---|
| Age (years) | 47.9 (24—84) |
| Female | 105 (73%) |
| IBM (kg/m$^2$) | 27.37 ± 4.58 |
| ASA 1 | 42 (29%) |
| ASA 2 | 98 (69%) |
| ASA 3 | 3 (2%) |
| Primary ventral hernia | 101 (71.1%) |
| umbilical hernia | 73 (72.2%) |
| epigastric hernia | 18 (17.8%) |
| umbilical and epigastric hernias | 10 (9.9%) |
| small (< 2 cm) | 11 (10.8%) |
| medium (2–4 cm) | 88 (87.1%) |
| large (> 4 cm) | 2 (1.9%) |
| Insicional hernia | 41 (28.9%) |
| M2 (epigastric) | 10 (24.4%) |
| M3 (umbilical) | 31 (75.6%) |
| W1 (< 4 cm) | 34 (82.9%) |
| W2 (4–10 cm) | 7 (17.1%) |
| Size of the diastasis (mm) | 33.8 ± 13.3 |

**Table 2** Operative data and patient's outcomes

| | $n = 142$ |
|---|---|
| Operative time (min) | 06.17 ± 35.66 1 |
| Width of mesh (cm) | 11.16 ± 3.45 |
| Length of mesh (cm) | 15.48 ± 2.91 |
| Polypropylene suture plication | 76 (53.5%) |
| Barbed suture plication | 62 (43.7%) |
| Other suture | 4 (2.8%) |
| Time of subcutaneous drain (days) | 10.06 ± 4.98 |
| Lenght of hospital stay (days) | 0.64 días (0—3) |
| Seroma | 43 (30.3%) |
| Wound infection | 2 (1.4%) |
| Skin necrosis | 0 |
| Haematoma | 5 (3.5%) |

After contacting all patients, 62 completed the EHS-QoL questionnaire, and 33 underwent follow-up CT scans to assess recurrence. The median follow-up time was 47.9 ± 23.97 months, equivalent to 3.99 ± 1.9 years. The EHS-QoL results were as follows: abdominal pain at rest had a mean score of 2.82 (± 2.68), during activities 3.61 (± 2.87), and for the worst pain experienced in the past week 2.31 (± 2.87) (Fig. 2a). Activity limitations scored a mean of 3.35 (± 3.17) for daily activities at home, 3.64 (± 3.12) for activities outside the house, 5.95 (± 3.45) for sports activities, and 5.98 (± 3.46) for heavy activities (Fig. 2b). Regarding aesthetics, the general shape of the abdomen had a mean score of 5.66 (± 3.55) and the hernia site and scar scored 3.37 (± 3.58) (Fig. 2c).

Among the 33 patients who underwent follow-up CT scans, recurrence was identified in 9 cases (27.3%) (Fig. 3). Of these cases, 1 (11.1%) was a hernia, 1 (11.1%) was diastasis, and 7 (77.7%) involved both hernia and diastasis, with 7 (77.7%) presenting symptoms. Patients were divided into two groups based on recurrence as assessed by CT. The comparison of the two groups is summarized in Table 3. Statistically significant differences were observed in BMI (26.01 ± 5.45 vs. 30.52 ± 4.99 kg/m$^2$, $p = 0.04$) and diastasis size (30.3 ± 8.95 vs. 56.6 ± 17.4 mm, $p < 0.001$). No significant differences were found in other characteristics between patients with and without recurrence.

## Discussion

Patients with umbilical or epigastric hernias benefit from mesh-based repairs, especially when RD is present, as it increases recurrence risk and worsens aesthetic outcomes. Open surgery often requires extensive incisions, leading to undesirable cosmetic results and wound complications like hematoma, seroma, necrosis, hypertrophic scars, and infections. However, open abdominoplasty with dermolipectomy is recommended for patients with significant fatty skin excess. Minimally invasive techniques are preferable for patients without skin excess or those avoiding large incisions. These approaches prevent longitudinal incisions in the superior abdomen for diastasis plication, often associated with suboptimal aesthetic outcomes [5]. While various minimally invasive methods have been proposed, there is no consensus, and the ideal technique remains under debate [11].

The classic laparoscopic approach for ventral hernia repair with intraperitoneal mesh (IPOM) has demonstrated benefits over open methods, such as reduced recurrence rates, shorter hospital stays, lower complication rates, and a faster return to normal activity. However, it also presents risks related to abdominal cavity access, intracavity prostheses, fixation techniques, and higher material costs [6, 12]. In this context, endoscopic techniques that avoid abdominal cavity access could offer additional advantages. Hybrid techniques like endoscopic-assisted linea alba reconstruction plus mesh augmentation (ELAR plus), described by Kockerling et al. [13], and endoscopic mini/less open sublay technique (eMILOS), described by Reinpold et al. [14], are variations of the classical open hernia repair that preserve the anatomical continuity of the ventral abdominal wall, minimize scarring, and reduce the risk of incisional hernias and complications associated with intra-abdominal access. However, these techniques are not exempt from complications such as umbilical necrosis, seromas and aesthetic dissatisfaction with the umbilical scar [13, 14]. REPA offers the benefits of significantly smaller and less visible incisions, in addition to the lower risk of surgical site wounds and periumbilical cutaneous necrosis.

Over the past years, several endoscopic sublay techniques—such as enhanced-view totally extraperitoneal (eTEP), transhernial retromuscular (THT), and totally endoscopic sublay abdominal repair (TESAR)—have emerged as effective and increasingly adopted alternatives for ventral hernia and rectus diastasis (RD) repair [15]. These approaches avoid intraperitoneal mesh placement, preserve anatomical planes, and offer good cosmetic and functional outcomes with low complication rates, especially seroma. eTEP is currently the most widely adopted technique, following the principles of the Rives-Stoppa open repair, which is considered the gold standard for open ventral hernia repair [16]. It has shown favorable outcomes in terms of infection, seroma, and recurrence rates; however, it requires significant expertise. Posterior extraperitoneal approaches operate within a single retromuscular plane, minimizing the risks of seroma and intra-abdominal injury, but they involve a steep learning curve and should be performed by well-trained hernia surgeons [15]. (reviewer #3, comment 1).

The main advantages of the REPA technique include minimally invasive endoscopic repair of both RD and hernia

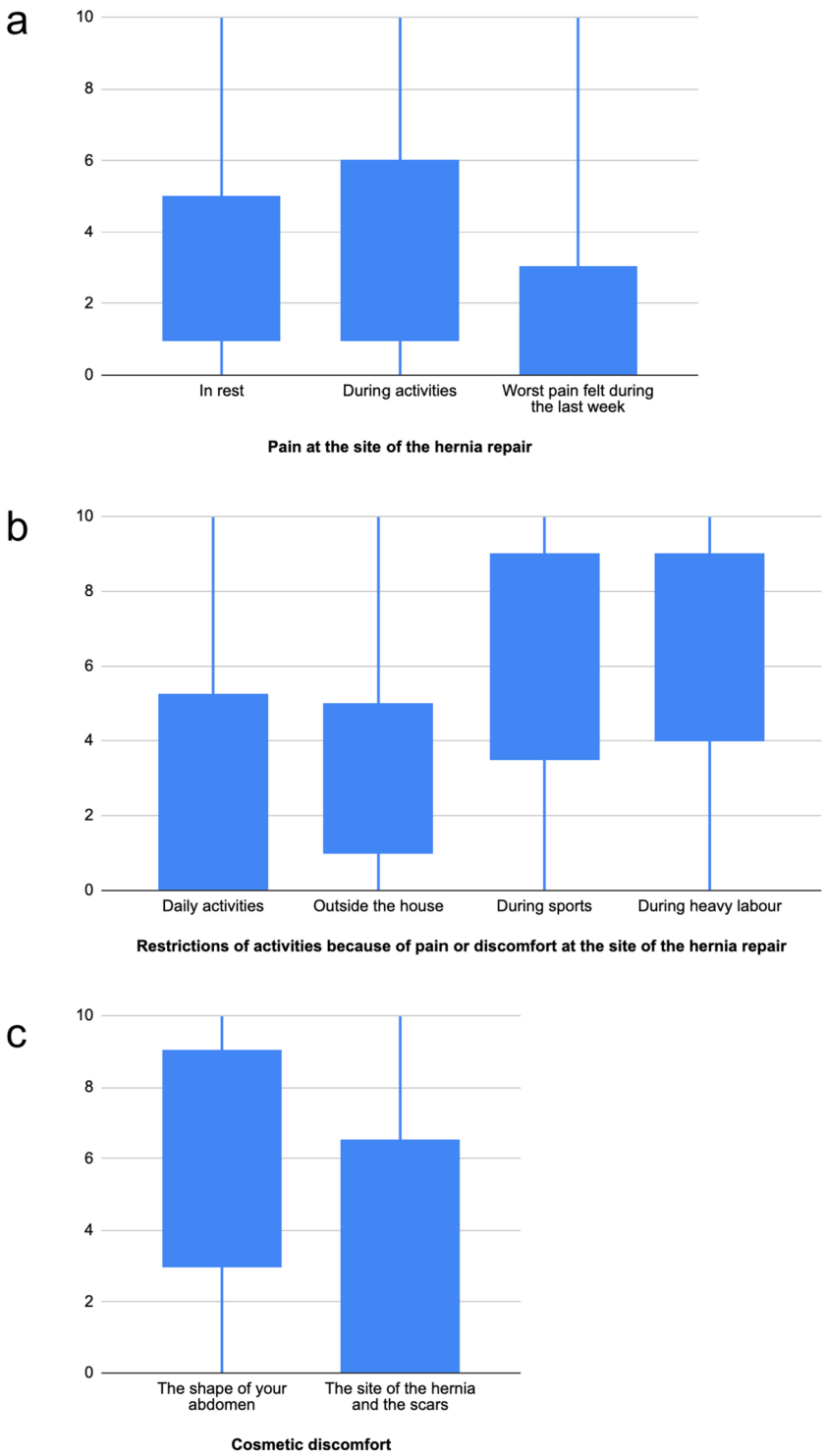


**Fig. 2** EHS-QoL results (0 = best outcome, 10 = worst outcome) in three domains: "Pain" (**a**), "Restriction of activities" (**b**) and "Cosmetic discomfort" (**c**) ($n = 62$)

without accessing the abdominal cavity, minimal incisions, favorable surgical ergonomics, ease of reproducibility, and a short postoperative stay that reduces costs [7]. We previously reported our short-term results from a 6-month follow-up of patients who underwent REPA ($n = 54$). Only one recurrence was reported during that period and favorable cosmetic and functional outcomes were demonstrated, with a mean aesthetic discomfort score of 1.2, mean postoperative pain of 2.25, and mean daily activity constraints of 2.63 in the EHS-QoL results [17].

In this study, we analyzed the long-term outcomes of REPA, with a median follow-up time of 47.9 months. The mean pain score at rest was 2.82, while the score during activities was 3.61. These results suggest mild pain at rest

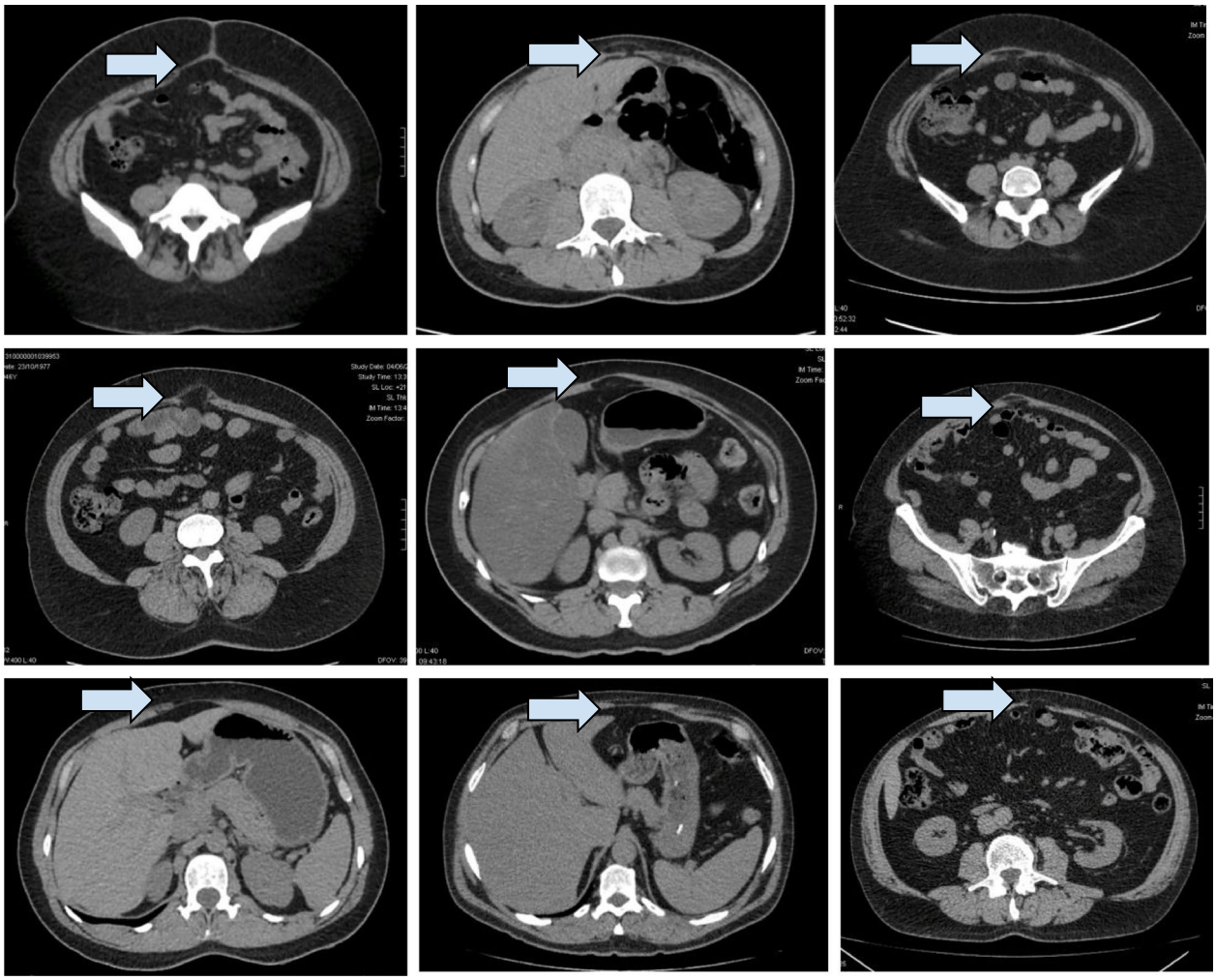

**Fig. 3** Results of CT scans in the 9 patients who presented recurrence. The arrow indicates the site of the recurrent wall defect

**Table 3** Comparison of patients with recurrence vs. no recurrence on CT

| | No recurrence $n = 24$ | Recurrence $n = 9$ | $p$ |
|---|---|---|---|
| Female | 20 (83%) | 7 (78%) | 0.9 |
| Age (years) | 47.63 ± 13.02 | 46.56 ± 13.32 | 0.8 |
| IBM (kg/m$^2$) | 26.01 ± 5.45 | 30.52 ± 4.99 | 0.04 |
| Primary ventral hernia | 18 (75%) | 7 (78%) | 0.9 |
| Insicional hernia | 6 (25%) | 2 (22%) | 0.9 |
| Size of the diastasis (mm) | 30.3 ± 8.95 | 56.6 ± 17.4 | < 0.001 |
| Width of mesh (cm) | 10.17 ± 10.05 | 11 ± 2 | 0.1 |
| Length of mesh (cm) | 15.37 ± 2.69 | 16.11 ± 2.2 | 0.3 |
| Polypropylene suture plication | 14 (71%) | 5 (56%) | 0.6 |
| Lenght of hospital stay (days) | 7 (29%) | 4 (44%) | 0.6 |
| Seroma | 11 (46%) | 6 (67%) | 0.4 |
| Follow-up (months) | 49.4 ± 24.64 | 43.95 ± 23.06 | 0.6 |

and moderate pain during activities, which is consistent with typical postoperative expectations. These scores for postoperative pain and also for limitations of daily activity (3.35) remained consistent with our previous study. However, regarding aesthetics, patients reported lower satisfaction with the shape of their abdomen, with a mean score of

5.66 [17]. It is well known that cosmetic impairment is a major reason why patients with rectus diastasis seek medical attention, making the cosmetic results of surgical interventions highly significant for this population. Bellido et al. [18], assessed the final esthetic results of the scars measured with a visual analogical scale (0 to 10, with 10 being very satisfied) and reported an average score of 8.3 with a mean follow-up of 20 months.

Minimally invasive techniques have the advantage of minimal scarring; however, plication maneuvers can leave a surplus of skin immediately after surgery, as described in the study by Sahoo et al. [19]. Due to the lack of cosmetic outcome measurements, no evidence-based conclusions regarding postoperative appearance can be drawn. Scar outcomes and the overall abdominal shape were evaluated finding unsatisfactory results in our study. This may represent a limitation of the technique in achieving long-term aesthetic outcomes. Although patients with significant skin excess were excluded from our study, as they are more appropriate candidates for laparo-abdominoplasty (reviewer #3, comment 2), patients had an average BMI of 27.37 kg/m$^2$, suggesting that REPA may not be the most effective option for patients with higher overweight, as the final aesthetic outcome might not be as favorable if the skin surplus after plication is not adequately managed. A posterior approach does not require direct handling of the abdominal skin, which could be beneficial for patients with excess skin or abdominal fat. Surgeons should provide comprehensive information about the procedure, including its outcomes and limitations, particularly regarding the final aesthetic results. Although the scars are minimal, the overall shape of the abdomen does not provide significant satisfaction in the long term after the procedure. It must be stressed that the main objective of REPA surgery is the anatomical restoration of the midline and the repair of hernias in this location, prioritizing functional outcomes over aesthetic considerations.

To the best of our knowledge, this is the first study analyzing recurrence using a CT scan with long-term follow-up. Most studies focus on short- and mid-term outcomes, and despite the ability of imaging to accurately characterize ventral hernia morphology and recurrence, it remains underutilized. In our previous study, only one case of recurrence was recorded, representing 1.85% of patients over a 6-month follow-up period [17]. Similarly, Claus et al. [20] reported a mean follow-up of 8 months in 48 patients with 2.1% of recurrence. Cuccomarino et al. [21], reported a 2.4% recurrence in 124 patients with a median follow-up of 18 months. Medina et al. [22], conducted ultrasound evaluations between the 8 th and 10 th postoperative month on 93.1% of 42 patients and none showed recurrence. Bellido et al. [18], reported no recurrence in 21 patients with clinical and ultrasound evaluation at a mean follow-up of 20 months. Muas et al. [23] conducted a multicenter study with the largest cohort to date, involving 215 patients. The average follow-up was 12 months with clinical examination in 100% and ultrasound in 58.6%, with no recurrences. The International Endohernia Society (IEHS) guidelines recommend CT imaging as superior to clinical examinations for identifying recurrences, seromas, and residual or bulging hernias due to its detailed anatomical resolution. An ultrasound investigation can help detect seromas but does not yield the necessary anatomic details as does the CT scan to enable a firm diagnosis of recurrence [24]. In addition, a CT scan provides an objective analysis in every case. Our recurrence rate for patients who underwent REPA was 27.3% ($n = 9$) among the 33 patients evaluated with follow-up CT scans over a median follow-up period of 47.9 months.

This study aimed to compare patients with and without recurrence after REPA to identify risk factors that have not been scientifically elucidated yet. When recurrence was objective on CT, a significantly higher mean BMI (30.52 kg/m$^2$) was associated compared with those without recurrence (mean BMI of 26.01 kg/m$^2$). It is already well-established that a BMI greater than 30 kg/m$^2$ significantly increases the risk of recurrence. Additionally, laparoscopic repair is strongly recommended for obese patients [25]. However, the guidelines do not specify which laparoscopic technique is most suitable for obese patients, as no studies have compared these techniques in this population [6, 12]. Given that anterior approaches, such as REPA, are generally not suggested for obese patients, our findings reinforce that this technique may not be the most effective in this group, likely due to the onlay mesh position and the potential risk of recurrence.

Dietz et al. demonstrated that the length of the hernial gap ($\leq 5$ vs. $> 5$ cm) is an independent prognostic factor for recurrence during follow-up [26]. However, no differences in hernia type or size were found between patients with and without recurrence in our experience. This may be related to the fact that most hernias were medium-sized (2–4 cm) and only a small number of cases had defects greater than 4 cm. Nevertheless, the mean size of diastasis was significantly larger in patients with recurrence (56.6 mm) compared to those without recurrence (30.3 mm), suggesting that diastasis size could be a risk factor for recurrence in REPA. Another potential factor influencing REPA outcomes is seroma formation, the most common complication of this technique, primarily resulting from subcutaneous dissection and onlay mesh placement [27]. In our study, seroma was the most frequently reported complication. However, no significant differences in seroma incidence were observed between patients with recurrence and those without. Nevertheless, the presence of this complication, may still contribute to the recurrence rate, and we believe further investigation into how this factor interacts with the technique and long-term outcomes is warranted.

The current literature supports that minimally invasive approaches for hernia repair are safe, feasible, and effective in the short term, and long-term studies are needed to establish the best treatment option [6, 12]. There is a paucity of data in the literature for many of these techniques and an absence of comparative data to establish superiority. The IEHS guidelines recommend REPA for ventral hernias with coexisting diastasis, but size or type were not specified [12]. A width limit has not been established for this technique. Considering our results, we concluded that defects greater than 5 cm and patients with obesity might be carefully considered for this approach, as they could have a higher risk of recurrence in the long term. Furthermore, since we consider RD a pathology rather than an aesthetic issue, and REPA a surgery focused on functional restoration, we did not recommend this procedure to patients with primary aesthetic goals.

This study has limitations. The retrospective nature of the analysis introduces the risk of incomplete data and potential bias. Additionally, the sample size of patients who underwent long-term follow-up is relatively small, and there may be a selection bias, as patients were contacted retrospectively by telephone. This follow-up may have tended to include patients who sought evaluation due to symptoms or suspicion of recurrence, and this might be especially true for the ones who performed the CT scan. Nevertheless, this is the first long-term study evaluating REPA using CT scans to assess recurrence. This publication may encourage further research, including comparative and prospective studies, to identify the most effective laparoscopic technique for the repair of ventral hernias and associated diastasis.

## Conclusion

REPA offers the advantages of minimally invasive surgery, such as low pain, rapid mobilization, and a short hospital stay. However, our findings indicate a high risk of recurrence in patients with diastasis greater than 5 cm and obesity, emphasizing the need for careful patient selection. The optimal indication for REPA might be midline hernias up to 4 cm. Furthermore, the overall abdominal shape may be unsatisfactory despite minimal scarring. Overweight and obesity should be considered exclusion criteria to optimize functional and aesthetic outcomes.

**Author contribution** All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Micaela Milagros Rossi, Digby Montechiari and Ignacio Portela. The first draft of the manuscript was written by Micaela Milagros Rossi and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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**Data Availability** The datasets used and analyzed during the current study are available from the corresponding author upon reasonable request.

## Declarations

**Ethical approval** This retrospective study involving human participants was in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

**Consent to participate** Informed consent was obtained from all study participants, as authorization for data analysis is included in each procedure form.

**Conflict of interest** Micaela Milagros Rossi, Digby Montechiari, Ignacio Portela, Santiago Andrés Flores, Alejandro Rossini, Franco José Signorini and Lucio Obeide declare no conflict of interest.

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