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RESEARCH

Lateral single-dock robot-assisted retro-rectus ventral hernia repair (rTARUP/rTARM): observational study on long-term follow-up

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Abstract

Robot-assisted surgery for ventral hernias has gained popularity among surgeons in hospitals equipped with robotic platforms, despite the limited availability of high-level prospective data. Moreover, research on long-term outcomes of ventral hernia repair remains particularly challenging. This study aims to evaluate the long-term outcomes of patients operated for a ventral hernia with a robot-assisted repair using a self-fixating retro-rectus synthetic mesh with a lateral docking transabdominal approach (rTARUP/rTARM). The study is a mono-centric cohort study of a consecutive series of patients with a midline ventral hernia, including both primary and incisional hernias, treated with a robot-assisted lateral approach utilizing a self-fixating retro-rectus mesh. The patients were identified from a prospective online registry database and subsequently contacted for follow-up assessment. Among the 526 ventral hernia repairs registered between September 2016 and December 2019, 198 patients met the inclusion criteria for this study. Long-term follow-up with valid data on recurrence was achieved in 162 patients (82%). Valid data from the EuraHS Quality-of-Life (QoL) questionnaire were available for 111 patients (56%). The recurrence rate after rTARUP, with a median follow-up of 4.5 years, was 3.7% in 162 patients with valid recurrence data. The rTARUP procedure can be performed with a low complication rate of 6.1% and favorable long-term results on QoL. The robot-assisted transabdominal retromuscular approach is a safe and effective surgical technique with a low recurrence rate and favorable QoL scoring over time. It combines the favorable retro-rectus mesh position with minimal invasive surgery, however care should be taken on adopting the technique too early in the robot-training pathway since it does pose some anatomic challenges and requires advanced robotic skills.

Keywords Umbilical hernia · Ventral hernia · Robotic surgery · Quality of Life · TARUP · Retromuscular · Retro-rectus

Introduction

Background and rationale

Robot-assisted surgery for ventral hernias has become popular among surgeons in hospitals where they have access to a robotic platform [1]. In the United States the number of robot-assisted ventral hernia repairs has surpassed those performed using conventional laparoscopic approaches, accompanied by a decline in open surgery procedures. The technological advantages of using wristed instruments to work on the anterior abdominal wall, the enhanced three-dimensional view, and the improved surgeon's ergonomics have initiated this increasing interest of surgeons, despite the current scarcity of high-level prospective data [2–5]. Moreover, the opportunity to adopt surgical techniques that position the mesh outside the intraperitoneal cavity, utilizing

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a preperitoneal or retromuscular placement, has been recognized as an important incentive to embark on robot-assisted ventral hernia repair [6]. In Europe, access to a robotic platform for the treatment of benign conditions such as ventral hernias remains limited. Nevertheless, for wide incisional hernias needing a component separation, the short-term advantages of robot-assisted surgery, with reduced hospital stays and lower complication rates compared to open surgery, have been acknowledged [7–10]. For smaller sized ventral hernias, recent studies from the Danish Nationwide Hernia Database have demonstrated a clear advantage in short-term outcomes for robot-assisted surgery compared to open surgery, as well as compared to laparoscopic surgery with intraperitoneal mesh (IPOM) placement [11, 12]. These findings indicate a favorable cost–benefit balance in favor of a robot-assisted approach [13]. However, as with all hernia repair techniques, the long-term outcomes, including recurrence rates and the risk of prolonged postoperative pain, are as important as the observed short-term benefits yet research on long-term outcomes remains considerably challenging [14, 15]. The collection of long-term follow-up data represents the "Achilles heel" of registries, primarily due to a lack of financial incentives and limited patient engagement and collaboration [16]. This study aims to evaluate the long-term outcomes of patients who underwent robot-assisted ventral hernia repair using a self-fixating retro-rectus synthetic mesh and a lateral docking transabdominal approach, referred to as the robotic TransAbdominal Retromuscular Umbilical Prosthesis (rTARUP) or robotic TransAbdominal RetroMuscular (rTARM) repair.

Objectives

To gather long-term follow-up data on recurrence rates and to assess patient-reported outcomes using the EuraHS Quality-of-Life (QoL) questionnaire following robot-assisted ventral hernia repair with retro-rectus mesh placement.

Methods

Study design

The study is a mono-centric cohort study involving a consecutive series of patients with a midline ventral hernia, including both primary and incisional hernias, treated by the rTARUP/rTARM technique. The patients were identified from a prospective online registry database and subsequently contacted to complete follow-up assessments.

Setting

The study was conducted at AZ Maria Middelares Hospital in Ghent, Belgium, using the daVinci Xi robotic system (dV Xi, Intuitive, Sunnyvale, CA, US). All procedures were performed by a single surgeon with specific interest in abdominal wall surgery (FM). A prospective registration of all abdominal wall surgeries is maintained using the online EuraHS database [17], from which consecutive eligible study patients were identified. Since the initiation of the robot-assisted hernia program at the hospital in 2016, the study includes all eligible patients treated between September 2016 and December 2019. Follow-up visits were performed between July 2023 and July 2024. While clinical follow-up was preferred, phone interviews and email exchanges of questionnaire were utilized when necessary. The study was approved by the ethics committee of AZ Maria Middelares hospital in March 2023, with the Belgian trial registration number B0172023000002. The study protocol was registered on ClinicalTrials.gov (NCT05939206) prior to the start of the study in July 2023.

Participants

Inclusion criteria

Adult patients who underwent repair of a primary or incisional midline ventral hernia (EHS classification M1–M5) [18] using a robot-assisted transabdominal approach by lateral docking and a self-fixating polyester mesh (Progrip™, Medtronic, USA) with retro-rectus mesh placement.

Exclusion criteria

Patients operated via open or conventional laparoscopic approaches. Additional exclusions included lateral hernias (EHS classification L1–L4), parastomal hernias, combined medial and lateral hernias, combined ventral and groin hernias, repairs with the mesh placed in the intraperitoneal or preperitoneal position, totally extraperitoneal approaches (eTEP), component separation techniques, and operations using other meshes than the self-fixating polyester mesh.

Follow-up

All patients were contacted by phone and invited for a clinical outpatient follow-up visit with the surgeon. To maximize patient participation, a highly flexible schedule was implemented, including options for weekend or evening appointments. A total of three phone-call attempts were made to reach each patient. If phone contact was unsuccessful, up to two email invitations were sent, provided an email address was available. In cases where patients declined to attend a clinical visit, they were asked to complete the questionnaires by email correspondence.

Clinical follow-up was performed by the first surgeon (FM), who obtained informed consent, recorded the patient's history since the operation, and completed the EuraHS-QoL questionnaire. Subsequently, a separate clinical examination was performed by a surgical resident (MV) with the patient both standing and supine, including a Valsalva maneuver. Findings were recorded on a paper Case Report Form (CRF), and the data were entered to the Excel file derived from the prospective EuraHS database.

Surgical technique

The surgical technique has been previously described, and a drawing of the technique is shown in Fig. 1 [19]. Patients are positioned supine with both arms tucked alongside the body. The robotic system is placed at the right side of the patient, and the trocars are inserted on the left side. Pneumoperitoneum is established at 12 mmHg using a Veress needle at Palmer's point. An 8-mm trocar is placed subcostal along the anterior axillary line, and two additional 8-mm trocars are inserted at least 7 cm apart in the left flank along the same vertical line. The ipsilateral posterior rectus sheath is opened to access the retro-rectus plane. Retro-rectus dissection is performed laterally to medially until the medial border of the rectus muscle is reached. A longitudinal incision is made in the ipsilateral posterior rectus fascia, just lateral to the junction of the anterior and posterior rectus fascia. Dissection continues in the preperitoneal plane behind the linea alba, and the hernia content is reduced. The contralateral posterior rectus fascia is then incised, and a contralateral retro-rectus dissection is performed. The hernia defect is closed with a 2/0 barbed suture (V-Loc™ 2/0, Medtronic, Minneapolis, MN, US) after decreasing the intra-abdominal pressure

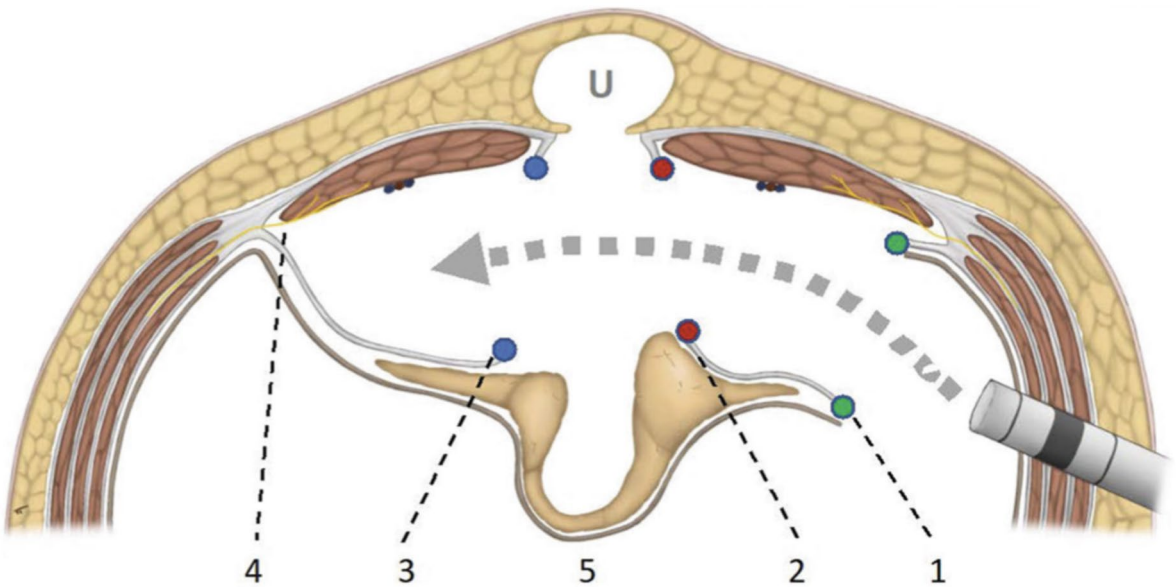

Fig. 1 An anatomic illustration depicting the minimally invasive transabdominal retro-rectus umbilical hernia repair (TARUP) technique, with trocars positioned on the left lateral side. The gray arrow indicates the path of dissection. U represents the umbilical hernia. *Step 1:* Opening the left posterior rectus sheath (green dots). *Step 2:* Medial opening of the posterior rectus sheath about 5 mm from the junction between the posterior and anterior rectus fascia (red dots). *Step 3:* Crossover to the right side by opening the right posterior rectus sheath (blue dots). *Step 4:* Contralateral retro-rectus dissection, ensuring preservation of the lateral neurovascular bundles for the rectus muscle. *Number 5* represents the mobilized hernia sac, including the median peritoneal bridge between both posterior rectus sheaths. Republished from Baur, J., Meir, M. Narbenhernien: minimalinvasive Operationsverfahren. Chirurgie 95, 20–26 (2024). https://doi.org/10.1007/s00104-023-02000-x (published under Creative Commons License CC BY 4.0 http://creativecommons.org/licenses/by/4.0/deed.de)

to 8 mmHg. A self-fixating mesh with rounded corners (Progrip™ Self-Fixating Mesh, Medtronic, Minneapolis, MN, US) is placed with the grips towards the rectus muscles. The ipsilateral posterior rectus fascia is closed using a barbed suture 3/0 (V-Loc™ 3/0). Postoperatively, patients were advised to avoid lifting heavy objects for approximately 3 weeks, while maintaining maximum mobility and resuming activities as tolerated based on their level of postoperative discomfort.

Variables

The primary endpoint of this study was the recurrence rate observed during follow-up. The secondary endpoint were the assessment of the hernia-specific QoL, measured using the EuraHS QoL score, as well as the complication rata.

Data measurement

For patients attending a clinical follow-up, the patient was examined in a standing position while also performing Valsalva maneuver, as well as in a lying position with palpation of the abdominal wall.

Quantitative variables

The EuraHS QoL score is a hernia-specific questionnaire consisting of nine questions that can be scored by the patient on an 11-point scale ranging from 0 to 10. The questions are categorized into three domains: "Pain" (score range 0—30), "Restriction of activities" (score range 0–40) and "Esthetical discomfort" (score range 0—20). The total score ranges from 0 to 90, with lower scores indicating a more favorable outcome.

Bias

The diagnosis of recurrence was primary assessed by clinical examination without the use of additional imaging modalities. This was done by a surgeon other than the one who performed the original operations. Clinical examination may underestimate the number of recurrences, as subclinical recurrences detectable through imaging may go unnoticed during clinical assessment. Despite efforts to maximize follow-up data collection, some patients either chose not to participate in the study or could not be reached. The study sample was consecutive, including all eligible patients who met the inclusion criteria and were not excluded based on the above-mentioned criteria. It also encompassed all patients from the initiation of the robotic hernia program, thereby including those operated on during the "learning curve" phase.

Study size

The study period was determined based on an initial screening of the prospective robotic hernia database, which estimated that approximately 200 patients would meet the eligibility criteria and could potentially undergo long-term follow-up within the planned follow-up timeframe.

Statistical methods

Distributions of baseline characteristics were summarized using means or medians, standard deviations or interquartile ranges and proportions. Categorical data were compared using the Fisher's exact test and for continuous variables the Kruskal–Wallis was used. A type I error level of $\alpha = 0.05$ was used to indicate statistical significance. All data analyses were undertaken using SAS statistical software, release 9.4 (SAS Institute Inc, Cary, NC).

Results

Participants

A patient flow diagram is shown in Fig. 2. Of the 526 ventral hernia repairs registered between September 2016 and December 2019, 198 patients met the inclusion criteria for eligibility in the study. Long-term follow-up with valid clinical recurrence data was achieved in 162 patients (82%). Valid data from the EuraHS QoL questionnaire were available for 111 patients (56%).

Descriptive data

Patient characteristics and short-term outcomes of the study cohort are summarized in Table 1. The cohort includes a substantial number of younger patients under 55 years of age (46%) and a notable percentage of patients with a Body Mass Index (BMI) over 30 kg/m^2 (44%). The majority of cases involved primary ventral hernias (62%), with a mean hernia size of around 2.8 (SD 1.41) cm in width and 3.0 (SD 2.80 cm) in length. The mean mesh

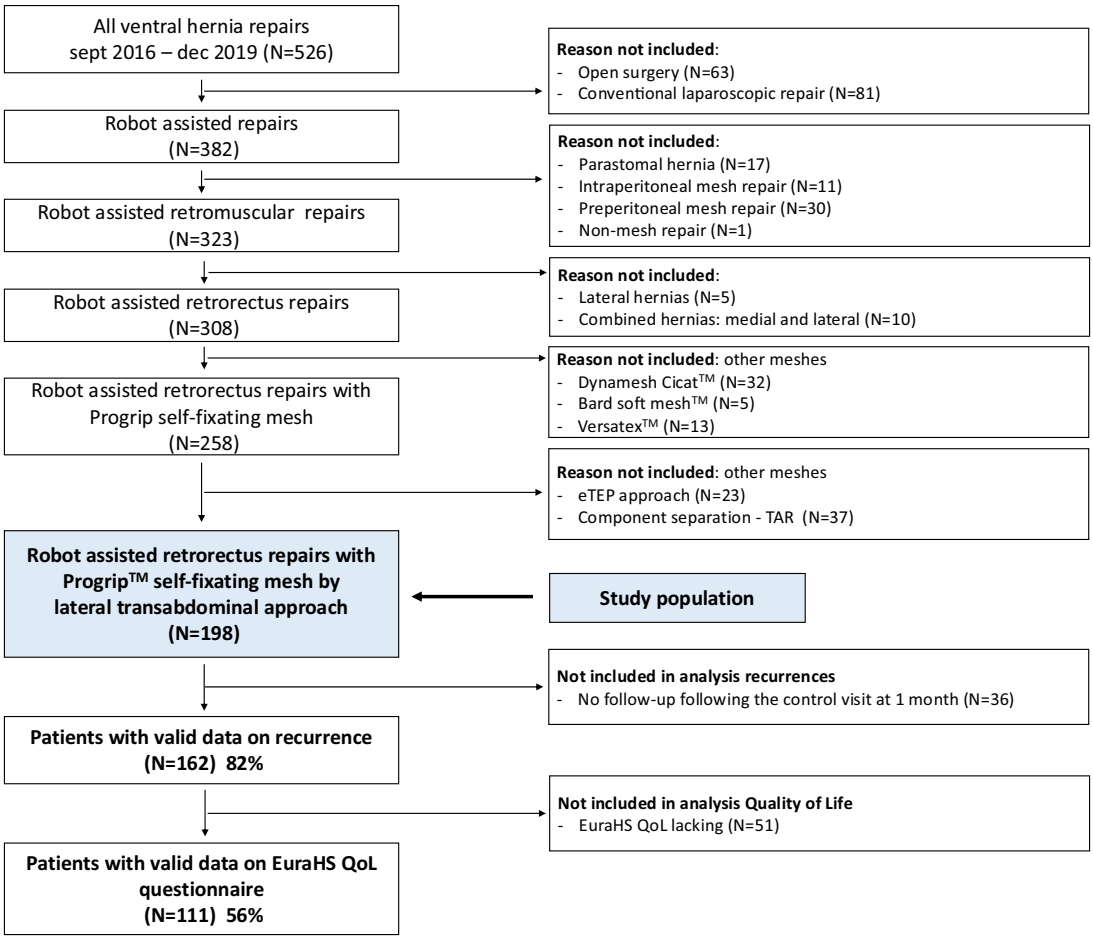

Fig. 2 Patient flow diagram of an observational cohort study involving patient treated for a midline ventral hernia using a robot-assisted lateral single-docking retro-rectus mesh repair (rTARUP). Of the 526 ventral hernia repairs registered between September 2016 and December 2019, 198 patients met the inclusion criteria, and long-term follow-up with valid recurrence data was achieved in 162 patients (82%)

dimensions used were 15 (SD 0.8) cm in width and 19 (SD 5.6) cm in length.

Outcome data

The mean operation time was 84 (SD 32.5) min. No intraoperative complications were registered, and 6.8% of the patients experienced intrahospital complications, with only one major complication (Clavien–Dindo Grade IIIb) [20]. This involved a patient who was readmitted due to major postoperative retro-rectus hematoma, which was drained laparoscopically. Minor complications included urinary retention in seven patients, postoperative nausea and vomiting in two patients, and single cases of atrial fibrillation and a superficial wound infection. Among the patients, 41% were discharged on the same day, another 41% stayed for one night, and 18% remained hospitalized for more than one night.

Main results

Long-term follow-up of 162 patients, with a median duration of 4.5 years (IQR 1.0–5.6 years), detected six patients with a recurrence, resulting in an overall recurrence rate of 3.7%. Among these, two patients experienced a recurrence below the mesh after treatment for an epigastric hernia. These cases were managed with an IPOM in one patient and a new rTARUP procedure in the other. Two patients presented with asymptomatic epigastric swelling after umbilical hernia repair, which required no further intervention. Additionally, two central mesh failures were observed: one patient experienced a symptomatic recurrence requiring IPOM repair, and another patient, during adhesiolysis for small bowel obstruction, was found to have a small asymptomatic recurrence.

Table 1 Descriptions of patient characteristics and perioperative outcomes for 162 patients who underwent rTARUP ventral hernia repair, with long-term follow-up data available

	rTARUP $N=162$ (%)
Age at operation (years), mean (SD)	53.7 (9.8)
< 55 years	46.3%
55–64 years	30.9%
≥ 65 years	22.8%
Gender, Female	30.2%
Body Mass Index (kg/m^2), mean (SD)	29.0 (4.3)
< 25 kg/m^2	19.1%
25–29.9 kg/m^2	36.4%
≥ 30 kg/m^2	44.4%
Hernia type	
Epigastric hernia (primary ventral)	15.4%
Incisional ventral hernia	38.3%
Umbilical hernia (primary ventral)	46.3%
Diabetes mellitus	9.3%
Cardiac disease	6.8%
Arterial hypertension	16.7%
Pulmonary disease	12.3%
Hepatic disease	2.5%
Renal disease	1.2%
Active smoker	15.4%
Anticoagulation therapy	12.3%
Width of hernia (cm), mean (SD)	2.78 (1.41)
Length of hernia (cm), mean (SD)	3.04 (2.80)
Surface area of hernia (cm^2), mean (SD)	8.48 (12.74)
Operation duration (mins), mean (SD)	84.3 (32.5)
Width of mesh (cm), mean (SD)	14.9 (0.8)
Length of mesh (cm), mean (SD)	18.9 (5.6)
Surface area of mesh (cm^2), mean (SD)	281.2 (83.6)
Indication, emergency	1.9%
Intraoperative complications	0.0%
Intrahospital complications	6.8%
Length of hospital stay (nights)	
0	41.4%
1	40.7%
≥ 2	17.9%
Clavien–Dindo classification	
Grade 0	93.2%
Grade I	4.3%
Grade II	1.9%
Grade IIIb	0.6%
Grade IVa	0.0%

Table 2 Relation between the occurrence of recurrent hernias and patient characteristics in 162 patients who underwent rTARUP ventral hernia repair, with long-term follow-up data available

	% Recurrence $N=162$
Overall	3.7% (6/162)
Age at operation (years)	
< 55 years	4.0% (3/75)
55–64 years	6.0% (3/50)
≥ 65 years	0.0% (0/37)
	P = 0.42
Gender	
Women	4.1% (2/49)
Men	3.5% (4/113)
	P = 0.99
Body Mass Index (kg/m^2)	
< 25 kg/m^2	3.2% (1/31)
25–29.9 kg/m^2	1.7% (1/59)
≥ 30 kg/m^2	5.6% (4/72)
	P = 0.58
Hernia type	
Epigastric hernia (primary ventral)	8.0% (2/25)
Incisional ventral hernia	4.8% (3/62)
Umbilical hernia (primary ventral)	1.3% (1/75)
	P = 0.17
Surface area of hernia (cm^2)	
< 3.8 cm^2	2.5% (2/81)
≥ 3.8 cm^2	5.3% (4/76)
	P = 0.43
Operation duration (mins)	
< 77 min	2.5% (2/81)
≥ 77 min	5.3% (4/76)
	P = 0.43
Surface area of mesh (cm^2)	
< 225 cm^2	3.1% (3/98)
≥ 225 cm^2	4.7% (3/64)
	P = 0.68
Recurrent hernia after previous repair	
No	4.0% (6/149)
Yes	0.0% (0/13)
	P = 0.99
Clavien–Dindo classification	
Grade 0	2.6% (4/151)
Grade I	14.3% (1/7)
Grade II	0.0% (0/3)
Grade IIIb	100.0% (1/1)
Grade IVa	–
	P = 0.016

Other analyses

The relation between patient or hernia characteristics and the occurrence of recurrence was investigated and is presented in Table 2. A higher tendency for recurrence was observed in patients with a BMI exceeding 30 kg/m^2.

Table 3 EuraHS Quality-of-Life scores in 111 patients with rTARUP repair, after a median follow-up of 4.5 years

	Overall score	Domains		
		Pain	Restrictions	Cosmetic
Overall	0 (0–3)	0 (0–0)	0 (0–0)	0 (0–2)
Age at operation (years)				
< 55 years	2 (0–6)	0 (0–1)	0 (0–2)	0 (0–4)
55–64 years	0 (0–1)	0 (0–0)	0 (0–0)	0 (0–0)
≥ 65 years	0 (0–1)	0 (0–0)	0 (0–0)	0 (0–1)
	P = 0.0014	*P = 0.042*	*P = 0.0011*	*P = 0.083*
Gender				
Women	0 (0–7)	0 (0–0)	0 (0–1)	0 (0–3)
Men	0 (0–2)	0 (0–0)	0 (0–0)	0 (0–2)
	P = 0.16	*P = 0.14*	*P = 0.19*	*P = 0.18*
Body Mass Index (kg/m^2)				
< 25 kg/m^2	2 (0–10)	0 (0–1)	0 (0–1)	0 (0–4)
25–29.9 kg/m^2	0 (0–4)	0 (0–0)	0 (0–0)	0 (0–2)
≥ 30 kg/m^2	0 (0–2)	0 (0–0)	0 (0–0)	0 (0–0)
	P = 0.043	*P = 0.25*	*P = 0.38*	*P = 0.16*
Hernia type				
Epigastric hernia (primary ventral)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)
Incisional ventral hernia	2 (0–9)	0 (0–1)	0 (0–2)	0 (0–4)
Umbilical hernia (primary ventral)	0 (0–2)	0 (0–0)	0 (0–0)	0 (0–0)
	P = 0.0030	*P = 0.0013*	*P = 0.14*	*P = 0.0015*
Surface area of hernia (cm^2)				
< 3.8 cm^2	0 (0–2)	0 (0–0)	0 (0–0)	0 (0–1)
≥ 3.8 cm^2	1 (0–6)	0 (0–0)	0 (0–2)	0 (0–3)
	P = 0.040	*P = 0.078*	*P = 0.031*	*P = 0.17*
Operation duration (mins)				
< 77 min	0 (0–2)	0 (0–0)	0 (0–0)	0 (0–2)
≥ 77 min	0 (0–6)	0 (0–0)	0 (0–1)	0 (0–2)
	P = 0.21	*P = 0.14*	*P = 0.20*	*P = 0.61*
Surface area of mesh (cm^2)				
< 225 cm^2	0 (0–2)	0 (0–0)	0 (0–0)	0 (0–2)
≥ 225 cm^2	1 (0–8)	0 (0–1)	0 (0–2)	0 (0–3)
	P = 0.041	*P = 0.015*	*P = 0.027*	*P = 0.23*
Recurrent hernia after previous repair				
No	0 (0–2)	0 (0–0)	0 (0–0)	0 (0–2)
Yes	7 (2–11)	1 (0–1)	0 (0–3)	3 (0–6)
	P = 0.010	*P = 0.013*	*P = 0.18*	*P = 0.024*
Clavien–Dindo classification				
Grade 0	0 (0–3)	0 (0–0)	0 (0–0)	0 (0–2)
Grade I	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)
Grade II	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)
Grade IIIb	–	–	–	–
Grade IVa	–	–	–	–
	P = 0.54	*P = 0.90*	*P = 0.88*	*P = 0.76*

The outcomes of the EuraHS QoL scores are detailed in Table 3, along with a sub-analysis based on patient and hernia characteristics. Given that many patients reported an overall score of 0 or domain scores of 0, an additional analysis was conducted focusing on patients with scores greater than zero, both overall and for each domain. These findings are summarized in Table 4. The analysis revealed a lower QoL in younger patients, patients with lower BMI, those with incisional hernias, and those with larger hernias.

Table 4 EuraHS Quality-of-Life scores > 0 in 111 patients with rTARUP repair, after a median follow-up of 4.5 years

	Overall score > 0	Domain score > 0		
		Pain	Restrictions	Cosmetic
Overall	40.5% (45/111)	16.2% (18/111)	19.8% (22/111)	29.7% (33/111)
Age at operation (years)				
< 55 years	57.7% (30/52)	25.0% (13/52)	34.6% (18/52)	38.5% (20/52)
55–64 years	25.6% (10/39)	5.1% (2/39)	7.7% (3/39)	20.5% (8/39)
≥ 65 years	25.0% (5/20)	15.0% (3/20)	5.0% (1/20)	25.0% (5/20)
	P = 0.0026	*P = 0.032*	*P = 0.0014*	*P = 0.17*
Gender				
Women	48.3% (14/29)	24.1% (7/29)	27.6% (8/29)	37.9% (11/29)
Men	37.8% (31/82)	13.4% (11/82)	17.1% (14/82)	26.8% (22/82)
	P = 0.38	*P = 0.24*	*P = 0.28*	*P = 0.34*
Body Mass Index (kg/m^2)				
< 25 kg/m^2	54.5% (12/22)	27.3% (6/22)	27.3% (6/22)	40.9% (9/22)
25–29.9 kg/m^2	46.3% (19/41)	17.1% (7/41)	22.0% (9/41)	31.7% (13/41)
≥ 30 kg/m^2	29.2% (14/48)	10.4% (5/48)	14.6% (7/48)	22.9% (11/48)
	P = 0.077	*P = 0.18*	*P = 0.43*	*P = 0.30*
Hernia type				
Epigastric hernia	16.7% (3/18)	5.6% (1/18)	11.1% (2/18)	5.6% (1/18)
Incisional ventral hernia	56.4% (22/39)	33.3% (13/39)	28.2% (11/39)	48.7% (19/39)
Umbilical hernia	37.0% (20/54)	7.4% (4/54)	16.7% (9/54)	24.1% (13/54)
	P = 0.014	*P = 0.0019*	*P = 0.27*	*P = 0.0019*
Surface area of hernia (cm^2)				
< 3.8 cm^2	32.7% (18/55)	10.9% (6/55)	12.7% (7/55)	25.5% (14/55)
≥ 3.8 cm^2	50.0% (26/52)	23.1% (12/52)	28.8% (15/52)	34.6% (18/52)
	P = 0.080	*P = 0.12*	*P = 0.055*	*P = 0.40*
Operation duration (mins)				
< 77 min	36.2% (21/58)	12.1% (7/58)	15.5% (9/58)	27.6% (16/58)
≥ 77 min	45.8% (22/48)	22.9% (11/48)	25.0% (12/48)	33.3% (16/48)
	P = 0.33	*P = 0.19*	*P = 0.23*	*P = 0.53*
Surface area of mesh (cm^2)				
< 225 cm^2	35.2% (25/71)	9.9% (7/71)	14.1% (10/71)	26.8% (19/71)
≥ 225 cm^2	50.0% (20/40)	27.5% (11/40)	30.0% (12/40)	35.0% (14/40)
	P = 0.16	*P = 0.029*	*P = 0.051*	*P = 0.39*
Recurrent hernia				
No	37.9% (39/103)	13.6% (14/103)	18.4% (19/103)	27.2% (28/103)
Yes	75.0% (6/8)	50.0% (4/8)	37.5% (3/8)	62.5% (5/8)
	P = 0.060	*P = 0.023*	*P = 0.19*	*P = 0.049*

Discussion

Key results

The recurrence rate following rTARUP/rTARM, with a median follow-up of 4.5 years, was 3.7% in 162 patients with valid recurrence data. The procedures can be performed with a low complication rate of 6.1% and yields favorable long-term QoL outcomes.

Limitations

Despite extensive efforts to encourage patient participation in long-term follow-up, valid recurrence data were obtained for 82% of patients. Various reasons contributed to the loss to follow-up, including patient deaths, inability to contact patients, refusal to participate, and language barriers. Refusal to participate could indicate that the patient either experienced no issues and saw no value in participating

or, conversely, was dissatisfied and therefore declined to engage. Analysis revealed no systematic differences in patient or hernia characteristics between the overall group of 198 patients and the 162 patients with valid follow-up data.

Interpretation

Since the first description of rTARUP in 2018, several case series have been published, although most with limited follow-up periods [21, 22]. As the abbreviation suggests, the rTARUP technique was initially developed for umbilical hernia repair. However, it is now also applied to epigastric hernia repair and incisional ventral hernia repair. Recently, we proposed a new algorithm to systematically categorize surgical procedures. Based on this classification, the robot-assisted laparoscopic transabdominal approach used in this series for ventral hernia repair is designated as rl-VRSpA (robotic laparoscopic-Ventral Retro-rectus/Retromuscular, Synthetic permanent mesh, Autofixating mesh) [23]. Recently, Garza et al. reported a case series of 101 patients, which, similar to our current study, included a somewhat longer follow-up [24]. 53.4% of their cases involved incisional hernias. They reported a 3.2% recurrence rate with a mean follow-up of 34 months. However, their study population was more heterogeneous, incorporating different mesh types, including synthetic non-absorbable and bioabsorbable meshes. Also, in 19% of their patients a transversus abdominis release was done. In contrast, our study excluded patients who had meshes other than self-fixating synthetic meshes or dissections beyond the boundaries of the rectus sheath. Moreover, follow-up in the study by Garza et al. was conducted by telephone questionnaires. Like our study, they used the EuraHS QoL questionnaire and reported favorable postoperative outcomes. Overall, our findings on recurrence rates and QoL evaluation align closely with those reported by Garza et al.

The preference for a retro-rectus repair is supported by a large systematic review published by Hartog et al. in 2022, which concluded that this approach yields excellent outcomes, either superior or comparable to other mesh positions, except for surgical site infections [25]. The use of a robotic platform enabled us to place the mesh in the retro-rectus position through minimally invasive surgery, thereby reducing concerns regarding surgical site infections. This is further exemplified by our own evolution in surgical techniques during the adoption of robot-assisted surgery between 2016 and 2019 [6]. During this period, we observed a decrease in open surgeries from 48 to 10% in favor of minimally invasive approaches and a shift in mesh positioning from 48% intraperitoneal placement to 8%. While similar outcomes may be achieved by some surgeons using conventional endoscopic techniques, such as eTEP, we believe that the technological advantages of the robotic platform significantly facilitate the transition to extraperitoneal mesh placement instead of intraperitoneal.

The use of robot-assisted surgery for ventral hernia repair now appears validated by recent data from the robust Danish Hernia Database, which demonstrates clear advantages over open surgery and laparoscopic IPOM repair [11–13], However, for smaller ventral hernias, currently available randomized controlled trials (RCTs) do not yet show a clear advantage [2, 3]. It is anticipated that data from this nationwide registry will drive further adoption of robot-assisted surgery for ventral hernias, thereby increasing the need for specialized training of hernia surgeons in using the robotic platform.

The adoption of robot-assisted abdominal wall surgery should follow a carefully structured training pathway, as outlined by the European Hernia Society [26]. A progressive case selection with increasing complexity is crucial, and rTARUP should likely be reserved for later stages of adoption. Surgeons are advised to first perform a series of anatomically simple procedures, such as inguinal hernia repair, preperitoneal ventral hernia repair (TAPP), or robot-assisted IPOM. The retro-rectus approach, whether performed using eTEP or a transabdominal technique, requires a solid understanding of the anatomic planes involved in the dissection.

During our follow-up, two cases of central mesh failure were documented. It remains unclear whether these failures were related to the technique, specifically the handling of the mesh with robotic instruments, or due to an intrinsic issue with the mesh structure. We strongly emphasize during training that meshes should be handled with utmost care when using robotic instruments to avoid compromising their integrity.

Generalizability

The operations in this study were performed by a surgeon specifically dedicated to abdominal wall surgery using the da Vinci Xi robotic system. It is uncertain whether the results are generalizable to rTARUP/rTARM procedures performed with other robotic systems or by less experienced surgeons. The rTARUP technique poses anatomic challenges and potential pitfalls for surgeons new to robot-assisted surgery, requiring advanced robotic skill acquisition. A structured training approach is recommended, with rTARUP considered unsuitable for the early.

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Author contribution MV and FM wrote the main manuscript text. ADT and EH collected the data. PP critically analyzed the data. All authors reviewed the manuscript.

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Data availability No datasets were generated or analysed during the current study.

Declarations

Conflict of interest Outside the study, Maaike Vierstraete reports no conflict of interest. Annabelle De Troyer benefitted from a fellowship grant from Intuitive Surgical. Filip Muysoms has been awarded research funding from Medtronic, Intuitive Surgical, and FEG Textiltechnik. Additionally, Filip Muysoms has received speaking fees from Medtronic, BD Bard, Intuitive Surgical, and WL GORE, as well as consulting fees from Medtronic, CMR Surgical, and has provided expert testimony for Sofradim. Filip Muysoms also serves as a proctor for Intuitive Surgical, Medtronic, and is an advisory board member for Medtronic. Ella Hermie reports no conflict of interest.

Study registration The study protocol was submitted at ClinicalTrials.gov (NCT05939206) before the start of the study.

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