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Original Article

Open *versus* robotic-assisted laparoscopic posterior component separation in complex abdominal wall repair

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Abstract

Background: Transversus abdominis release (TAR) is a surgical technique used in the treatment of complex ventral hernias. The aim of this study was to compare outcomes of open (oTAR) *versus* robotic-assisted (rTAR) posterior component separation by TAR.

Methods: Consecutive patients at two European hernia centres who underwent bilateral TAR were included. The primary endpoint was the duration of postoperative hospital stay.

Results: Data from 90 rTAR and 79 oTAR operations were evaluated. Patient demographics were similar between groups in terms of age, sex, BMI, and co-morbidities. There were more smokers, and hernias were larger in the oTAR group (width 8.7 cm *versus* 10.0 cm; $P = 0.031$, length 11.6 cm *versus* 14.1 cm; $P = 0.005$). Duration of postoperative hospital stay was significantly shorter in the rTAR group (3.4 days *versus* 6.9 days; $P < 0.001$). Short-term serious complications (Clavien–Dindo grade III and above) were more frequent (20.3 per cent *versus* 7.8 per cent; $P = 0.018$), and there were more surgical site infections (12.7 per cent *versus* 3.3 per cent; $P = 0.010$) in the oTAR group. During a median follow-up of 19 months in the rTAR group and 43 months in the oTAR group, reoperation (4.4 per cent *versus* 8.9 per cent; $P = 0.245$), and recurrence rates (5.6 per cent *versus* 5.1 per cent; $P > 0.009$) were similar.

Conclusion: Patients with ventral incisional hernias who undergo bilateral rTAR had significantly shorter postoperative hospital stays and fewer short-term complications compared with patients undergoing bilateral oTAR.

Introduction

The retrorectus position is often considered the most favourable plane for abdominal wall reconstruction[1,2]. Closure of the hernia defect is important[3], although some incisional hernias are too wide to perform a closure of the defect without additional surgical techniques. Component separation techniques of the lateral abdominal wall muscles increase the likelihood of medializing the edges of a midline hernia defect and achieving a tension-free defect closure[4]. When compared with open anterior component separation techniques, posterior component separation techniques (PCSTs) have the advantage that there is no need to create large subcutaneous skin flaps, minimizing additional morbidity[5]. In 2012, Novitsky *et al.* described the open technique of transversus abdominis release (TAR), that allows mesh placement in the retrorectus and retromuscular position behind all three lateral abdominal wall muscles, after creation of a large retromuscular and preperitoneal space[6]. More recently, TAR has been performed with minimally invasive laparoscopic techniques[7,8], but these complex abdominal wall reconstructions requiring TAR are technically challenging to perform with laparoscopic instruments, because of the limited workspace and restricted angulation of instruments. These limitations have been overcome by the introduction of robotic-assisted surgery[9]. Robotic-assisted TAR (rTAR) is similar to open TAR (oTAR) in terms of defect closure and retromuscular mesh position but adds the benefits of minimally invasive surgery. Detailed descriptions of the surgical technique of rTAR have been published[10,11]. rTAR has rapidly gained popularity in recent years. Short-term results have been described and a recent meta-analysis comparing early outcomes after rTAR and oTAR demonstrated fewer complications and shorter length of postoperative hospital stay (LOS) in favour of the robotic approach[12].

The aim of this study was to compare outcomes after oTAR and rTAR at two European hernia centres. The primary endpoint of the study was LOS. Secondary endpoints were intraoperative complications, in-hospital complications, overall and surgical site-related complications during the first 30 postoperative days, and overall and surgical site-related complications during the follow-up interval, including hernia recurrence.

Methods

Study design

This was a two-centre case–control study using a prospectively developed database (European Registry for Abdominal Wall Hernias (EuraHS)[13]) based on electronic clinical files from patients undergoing bilateral PCST (either open or robotic-assisted). The study protocol was sent for notification to the local ethics

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committee at Maria Middelares Hospital, Ghent, The Netherlands, on 21 December 2021 (reference no. MMS.2021.068). The study protocol was published online on 19 January 2022, at ClinicalTrials.gov identifier NCT05195957.

The study was performed at the departments of surgery at Oulu University Hospital, Oulu, Finland (OUH) and Maria Middelares Hospital, Ghent, Belgium (MMH). Patients were operated by a single surgeon in MMH and by two surgeons at OUH. An additional search of surgical logbooks was conducted at OUH to identify bilateral TAR patients not included in the database. The study included all consecutive patients undergoing bilateral PCST between December 2011 and October 2019 at MMH hospital, where the rTAR technique was introduced in October 2016, and consecutive patients undergoing bilateral PCST between August 2017 and May 2021 at OUH. After the introduction of the rTAR technique at OUH, the choice between a robotic-assisted or open approach was mainly guided by the availability of the robotic platform. All patients had a follow-up visit during the first 3 months after surgery. At MMH, a routine clinical follow-up visit 1 year after surgery was performed. Hernia recurrence was based on clinical evaluation, with supplementary CT if there was clinical uncertainty.

Study population

All patients undergoing bilateral PCST for the treatment of their ventral incisional hernia, either open, or robotic assisted, were considered eligible. Patients undergoing only unilateral PCST and patients with a stoma or parastomal hernia were excluded. The technique of rTAR was similar in both centres, as both surgeons at OUH were trained and proctored for their first cases by the participating surgeon from MMH. The robotic-assisted surgical procedures were performed with the DaVinci Xi or Si system (Intuitive Surgical, Sunnyvale, California, USA). The variables on which data were collected are added as *Table S1*.

Statistical analysis

Data analysis was carried out with Microsoft® Excel and SPSS® Statistics (IBM, Armonk, New York, USA). Continuous variables are presented as mean(s.d.) Categorical data are presented as percentages and proportions. Statistical analysis was performed according to the intention-to-treat principle. For normally distributed continuous variables, an independent samples *t* test was used. When a normal distribution could not be assumed, a Mann–Whitney *U* test was used. A chi-squared or Fisher's exact test was used to compare categorical data. Additionally, a logistic regression and linear regression analyses were performed for the outcome parameters 'serious postoperative complications' (Clavien–Dindo grade III and above) within 30 days after surgery, and 'duration of postoperative hospital stay'. In both models smoking and hernia width were used as adjusting factors. Results of the logistic regression analysis are presented as OR with a 95 per cent confidence interval (c.i.), and as regression coefficient with a 95 per cent confidence interval for the linear regression analysis.

A two tailed *P* value of less than 0.005 was considered statistically significant.

Results

A total of 90 patients in the rTAR group and 79 patients in the oTAR group were included. Patient demographics are summarized in *Table 1*. No differences between patient groups were noted regarding age, sex, BMI, or co-morbidities. There were significantly more smokers in the oTAR group. Hernias were larger in the oTAR group in both width and length of fascial defect (width 8.7 cm *versus* 10.0 cm; $P = 0.031$, length 11.6 cm *versus* 14.1 cm; $P = 0.005$).

Intraoperative data are shown in *Table 2*. Skin-to-skin operative time was longer in the rTAR group (242 *versus* 188 min; $P < 0.001$).

Table 1 Description of patient characteristics at baseline of a case–control study comparing robotic-assisted transversus abdominis release and open transversus abdominis release

	rTAR $n = 90$	oTAR $n = 79$	P*
Age (years), mean(s.d.)	66 (11)	63 (14)	0.075
Women	57 (63.3)	42 (53.2)	0.181
BMI (kg/m²), mean(s.d.)	8.5 (31)	5.3 (30)	0.350
Current smoker	15 (16.7)	23 (30.3)	0.038
Co-morbidities			
Cardiac disease	21 (23.3)	19 (24.1)	>0.009
Diabetes mellitus	17 (18.9)	13 (16.5)	0.680
Hepatic disease	1 (1.1)	0 (0)	0.261
Previous malignancy	23 (25.6)	23 (29.1)	0.604
Pulmonary disease	10 (11.1)	6 (7.6)	0.582
Renal disease	10 (11.1)	4 (5.1)	0.229
Hernia characteristics			
Recurrent incisional hernia	21 (23.3)	14 (17.7)	0.369
Hernia width (cm), mean(s.d.)	8.7 (3.2)	10.0 (4.4)	0.031
Hernia length (cm), mean(s.d.)	11.6 (5.3)	14.1 (6.2)	0.005

rTAR, robotic-assisted transversus abdominis release; oTAR, open transversus abdominis release. Values are n (%) unless otherwise indicated.
*For normally distributed continuous variables, an independent samples *t* test was used. When a normal distribution could not be assumed, a Mann–Whitney *U* test was used. The chi-squared and Fisher's test were used to compare categorical data. A *P* value of less than 0.05 was considered statistically significant.

Table 2 Description of intraoperative variables of a case–control study comparing robotic-assisted transversus abdominis release and open transversus abdominis release

	rTAR $n = 90$	oTAR $n = 79$	P*
Skin-to-skin operative time (min), mean(s.d.)	242 (82)	188 (90)	<0.001
Wound contamination class†			0.465
Clean	87 (96.7)	73 (92.4)	
Clean contaminated	2 (2.2)	4 (5.1)	
Contaminated	1 (1.1)	2 (2.5)	
Dirty	0 (0)	0 (0)	
Antibiotic prophylaxis	64 (71.1)	79 (100)	<0.001
Mesh type used			0.526
Polyester	68 (75.6)	61 (77.2)	
Polyvinylidene	17 (18.9)	17 (21.5)	
Polypropylene	2 (2.2)	1 (1.3)	
Unknown	3 (3.3)	0 (0)	
Mesh size (cm²), mean(s.d.)	980 (354)	1344 (460)	<0.001
Hernia defect closure	89 (98.9)	74 (93.7)	0.119
Combined surgical procedure	1 (1.1)	15 (19.0)	<0.001
Intraoperative complications	8 (8.9)	13 (16.5)	0.137

rTAR, robotic-assisted transversus abdominis release; oTAR, open transversus abdominis release. Values are n (%) unless otherwise indicated.
*For normally distributed continuous variables, an independent samples *t* test was used. When a normal distribution could not be assumed, a Mann–Whitney *U* test was used. The chi-squared and Fisher's test were used to compare categorical data. A *P* value of less than 0.05 was considered statistically significant.
†According to the Center for Disease Control and Prevention (CDC) classification[15].

In case of oTAR, all patients received prophylactic antibiotics before surgery, compared with 71.1 per cent in the rTAR cases. Several large-pore synthetic non-absorbable meshes were used (*Table 2*). The mean size of the mesh used was significantly larger in the oTAR group. Hernia defect closure rates were comparable between groups. Patients of the oTAR group underwent simultaneous operations more frequently (19.0 per cent *versus* 1.1 per cent; $P < 0.001$). These included panniculectomy ($n = 9$), colostomy closure ($n = 2$), oncological colorectal resections ($n = 2$), lymph node removal ($n = 1$), and adrenalectomy ($n = 1$). One patient in the rTAR group underwent simultaneous scar removal.

There were 8 intraoperative complications in the rTAR group and 13 in the oTAR group ($P = 0.137$), the most frequent being bowel injury ($n = 16$). Four of these were full-thickness injuries, with one requiring bowel resection with anastomosis. Three severe bleeding complications occurred: one from the liver, one from the abdominal wall, and one from the femoral vein. One patient had a small pleural injury.

There were eight conversions from rTAR to oTAR (8 of 90; 8.9 per cent) related to adhesions ($n = 8$), severe bleeding ($n = 2$), small bowel injury ($n = 1$), and full-thickness stomach injury ($n = 1$).

Table 3 Description of outcome variables of a case–control study comparing robotic-assisted transversus abdominis release and open transversus abdominis release

	rTAR $n = 90$	oTAR $n = 79$	P*
Duration of postoperative hospital stay (days), mean(s.d.)	3.4 (0.4)	6.9 (1.6)	<0.001
In-hospital complications			
Overall complications	8 (8.9)	21 (26.6)	0.002
Surgical site-related complications	6 (6.7)	6 (7.6)	0.815
30-day complications†			
No complications	63 (70.0)	39 (49.4)	0.003
Grade I	10 (11.1)	7 (8.9)	
Grade II	10 (11.1)	16 (20.3)	
Grade III	4 (4.4)	7 (8.9)	
Grade IV	1 (1.1)	7 (8.9)	
Grade V (mortality)	2 (2.2)	2 (2.5)	
30-day surgical site-related complications			
SSI	3 (3.3)	10 (12.7)	0.010
Superficial infection	1	3	
Deep infection	-	6	
Mesh infection	2	1	
SSO	18 (20.0)	19 (24.1)	0.512
SSOPI	6 (6.7)	12 (15.2)	0.071
30-day readmission rate	4 (4.4)	6 (7.6)	0.386
Follow-up time (months), mean(s.d.)	19 (14)	43 (32)	<0.001
Reoperation rate during follow-up	4 (4.4)	7 (8.9)	0.246
Hernia recurrence during follow-up	5 (5.6)	4 (5.1)	>0.9

rTAR, robotic-assisted transversus abdominis release; oTAR, open transversus abdominis release; SSI, surgical site infection; SSO, surgical site occurrence; SSOPI, surgical site occurrence requiring procedural intervention. Values are n (%) unless otherwise indicated.
*For normally distributed continuous variables, an independent samples *t* test was used. When a normal distribution could not be assumed, a Mann–Whitney *U* test was used. A chi-squared and Fisher's test were used to compare categorical data. A *P* value of less than 0.05 was considered statistically significant.
†According to the Clavien–Dindo classification[16].

Outcome data on primary and secondary endpoints are in *Table 3*. LOS was significantly longer in the oTAR group (3.4 days *versus* 6.9 days; $P < 0.001$). As there were significantly more patients in the oTAR group that underwent simultaneous surgery, an additional analysis after exclusion of these patients still showed a significantly shorter LOS in the rTAR group (3.4 days *versus* 7.1 days; $P < 0.001$). In a linear regression analysis adjusting for the possible confounding factors 'smoking' and 'hernia width', the oTAR group had 3.4 days' (95 per cent c.i. 1.8 to 5.0, $P < 0.001$) longer duration of postoperative hospital stay.

In-hospital complications, overall complication rates, and surgical site infections (SSIs) during the first 30 postoperative days were significantly lower in the rTAR group, whereas surgical site occurrences (SSOs), surgical site occurrences requiring percutaneous intervention (SSOPIs), and readmission rates were similar.

Major postoperative complications (Clavien–Dindo grade III and above) were significantly higher in the oTAR group (7.8 per cent *versus* 20.3 per cent; $P = 0.018$). After adjusting for smoking and hernia width, the oTAR group had an OR of 2.4 (95 per cent c.i. 0.88 to 6.4; $P = 0.087$) for major postoperative complications. Two deaths occurred in each group within 30 days after surgery.

Follow-up was significantly longer in the oTAR group (43 *versus* 19 months; $P < 0.001$) and revealed a reoperation rate of 4.4 per cent in the rTAR group and 8.9 per cent in the oTAR group ($P = 0.246$). Hernia recurrence was similar between groups (5.6 per cent *versus* 5.1 per cent).

Discussion

In this series rTAR was associated with significantly shorter duration of postoperative hospital stay and fewer short-term postoperative complications compared with oTAR, at the expense of longer operative times. Hernia recurrence rates between groups were comparable, although the rTAR group had shorter follow-up.

Six cohort studies have reported outcomes of rTAR compared with oTAR[14–19]. Of these, two focused of hybrid robotic-assisted TAR[14,17], the remaining four had sample sizes varying between 26 and 114 patients[15–18]. All demonstrated a significant decrease in LOS after rTAR, consistent with the present results. Regarding overall complications, only two studies reported a significant decrease in overall complications after rTAR[14,16], although a recent meta-analysis identified a decrease in overall complications after pooling of results[12]. The significantly longer operative times when performing robotic-assisted TAR have been reported in all studies. With regard to short-term outcomes, only one study has reported outcomes beyond 30 days[15].

While the present study looked at late outcomes, follow-up periods were markedly different at 19 months in the rTAR group, and 43 months in the oTAR group. This is an important limitation to this study, reflecting its observational nature and the later introduction of rTAR. The comparable recurrence rates should be therefore viewed with caution. The choice of the surgical technique varied between centres. At MMH, the implementation of the robotic platform into practice led to a shift from open to robotic-assisted surgery. After the introduction of the robot, only nine open TARs were performed. This induced a potential selection bias, as patient, and hernia characteristics may have influenced the surgeon's choice. At OUH, the choice of surgical technique was mainly dependent on the availability of the robot, which again could have led to a selection bias. More complex patients, prone to intra-, and postoperative complications and longer operative times, may also have made

up a larger proportion of the oTAR patients. Hernias and meshes used were significantly larger in the oTAR group, although it is worth noting that after adjusting for smoking and hernia width, LOS was still shorter in the rTAR group. A learning curve may have been included, with a possible influence on final outcomes, although no clear reduction in either operative times or complication rates seemed apparent with time. Current recommendations advocate the use of CT to detect hernia recurrence[20]. In this study, hernia recurrence was evaluated principally by clinical examination, with CT used to resolve clinical uncertainty. The true recurrence rate may have been underestimated. This cohort study reports on data from two European high-volume hernia centres, so there remain questions about generalizability of these results.

Future investigations on this topic should have a prospective design and randomization between oTAR and rTAR. Recently, a proposal for a European multicentre randomized clinical trial has been presented at the Fourth Annual Symposium on Robotic Abdominal Wall Surgery (Gent, Belgium). On the basis of the current results, such a study seems both ethically safe, and timely.

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Disclosure

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Supplementary material

Supplementary material is available at *BJS Open* online.

Data availability statement

Data are available upon reasonable request.

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