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Conversions related to adhesions in abdominal surgery. Robotic versus laparoscopic approach: a multicentre experience.

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Abstract

Background: An advantage of robotic surgery over laparoscopy is the lower rate of unplanned conversion. One of the implicated reasons for conversion is adhesions from Previous Abdominal Surgeries (PAS).

Methods: A comparative analysis of 98 patients with history of open PAS treated by laparoscopic or robotic surgery was performed. Primary endpoint was the rate of conversion to open surgery related to adhesiolysis. Secondary endpoints were short-term outcomes and complications.

Results: Conversion rate specifically related to adhesiolysis was significantly lower in robotic group (13 for LG versus 2 for RG; $p = 0.046$). Conversions occurred during adhesiolysis were significantly related to severity of adhesions expressed by PAI score ($p < 0.001$), number of abdominal areas involved by adhesions ($p < 0.001$) and severity of PAI into the target area of surgical intervention ($p = 0.021$).

Conclusions: Benefits of robotic surgery are more noticeable in performing procedures with increasing technical difficulties.

Keywords: robotic surgery; conversions; adhesions; adhesiolysis; previous abdominal surgery.

Introduction

Since the introduction of Robotic Minimally Invasive Surgery in the early 2000s, several studies have demonstrated its safety and feasibility of minimally invasive surgery in various complicated procedures including esophageal [1,2], gastric [3,4], colorectal [5-8] and hepatobiliopancreatic surgery [9-11], gynaecological [12-13] and urological [14-16] procedures for both benign and malignant pathologies.

Evidence of benefits of robotic surgery over laparoscopic surgery have been implemented even if, to our knowledge, there is no unequivocal consensus to declare superiority of robotic over laparoscopic surgery [17-18], except in robot-assisted radical prostatectomy [19]. So the best application of robotic surgery is far to be identified.

Nevertheless, one of the major benefits of robotic abdominal surgery already demonstrated is the lower rate of unplanned conversion to open surgery when compared to laparoscopic approach. [20-22]

It is important to highlight that one of the implicated reasons for conversion is abdominal and pelvic adhesions from Previous Abdominal Surgeries (PAS), due to the increased surgical difficulties in performing adhesiolysis.

We hypothesized a lower rate of conversions related to adhesiolysis in robotic surgery over laparoscopic approach and to demonstrate this advantage in performing adhesiolysis we designed a comparative study between laparoscopic and robotic procedures performed in patients with open PAS.

Materials and methods

Institutional Review Board approval was obtained before reviewing any patient material. Using a prospective database, all patients with history of open Previous Abdominal Surgery treated for different surgical pathologies were included in this study. Informed consent was obtained from all patients prior to surgery.

Study population

We performed a comparative analysis of 98 patients with history of open Previous Abdominal Surgery treated by laparoscopic or robotic surgery for different surgical pathologies in two high volume of activity institutions between January 2017 and March 2020. Laparoscopic or robotic intervention was performed according to the clinical advice of each surgeon. Concerning robotic procedures, in both institutions the surgeons used the da Vinci ® Xi platform.

A propensity score matching was performed to exclude any bias related to the surgeons' personal choice of method. The predicted probability of undergoing one of the two procedures was estimated for each patient using a multivariate logistic regression model in which the surgical procedure was the dependent variable and patient's characteristics (age, gender, BMI, ASA score, diagnosis, Previous Abdominal Surgery, and timing from PAS) were the independent variables. The two groups were matched for the analysed characteristics, thereby no propensity matching was needed for further analysis.

Study outcomes

Primary endpoint was to investigate the rate of conversion to open surgery related to adhesiolysis in particular, after laparoscopic or robotic surgery among patients with PAS.

According to literature [23-24], conversion from laparoscopic or robotic procedures to open surgery was performed when there was lack of operative progress or technical difficulties or for prolonged operative time in high risk patients (ASA class 3 or 4) or for complications such as bleeding or organ injury due to a poor visualization of anatomical structures.

Peritoneal adhesions are defined as pathological post-inflammatory or post-operative scar tissues between the omentum, small and large bowels, abdominal wall and other intra-abdominal organs.

Peritoneal Adhesion Index (PAI) according to Coccolini et al. [25] has been used to classify adhesions. Abdomen has been divided into 10 areas (A-L) and to each area has been ascribed an adhesion grade score ranging from the absence to the presence of very strong and vascularized adhesion (0-3). The sum of the scores from 0 to 30, results in the PAI.

To minimize any selection bias, only procedures performed by two expert surgeons that performed more than 100 minimally invasive procedures of major surgery using a standardized surgical technique were included in the study. Intervention in which laparoscopic adhesiolysis was performed before a robotic procedure were excluded. Postoperative management was homogeneous in all patients.

To further exclude other bias related to patients' characteristics or disease-related characteristics , age, gender, Body Mass Index (BMI), American Society of Anaesthesiologists risk class (ASA score), diagnosis, Previous Abdominal Surgery (PAS), timing from PAS, surgical procedure performed, Peritoneal Adhesion Index (PAI) were evaluated.

Secondary endpoints evaluated were short-term outcomes including operative time, intraoperative and postoperative complications according to Clavien-Dindo classification [26] after laparoscopic or robotic surgery among patients with PAS.

All adverse events that occurred within 30 days after surgery were considered complications, such as surgical wound infection, pneumonia, atrial fibrillation, respiratory failure, bowel obstruction. Postoperative ileus was defined as a temporary delay in gastrointestinal motility > 4 days. Any bleeding was considered if blood transfusion was required. The terms anastomotic leakage, jejunal or pancreatic fistulae involved all conditions of clinical or radiological dehiscence, with or without the need of surgical revision. Pain, nausea and vomiting were considered if rescue analgesia or antiemetics were needed.

Recovery outcomes as mobilization, time to first flatus and Length Of hospital Stay (LOS) were also analysed.

Statistical analysis

Statistical analysis was performed using the SPSS 23 System (SPSS Inc., Chicago, IL, USA). Continuous data were expressed as the mean ± SD; categorical variables were expressed as %. To compare continuous variables, an independent sample *t* test was performed. The Wilcoxon test for paired samples was employed as a nonparametric similar of the paired samples *t* test used for continuous variables. The Chi-square test was employed to analyse categorical data. When the minimum expected value was < 5, the Fisher's extract test was used. All the results were presented as 2-tailed values with statistical significance if *p*-values < 0.05.

Results

Ninety-eight patients who undergone at least one previous abdominal intervention from 3 to 876 months before surgery and received laparoscopic or robotic intervention for different surgical conditions were analysed in this study.

There were 50 males and 48 females, with a mean age of 66.71 ± 13.10 years and a mean BMI of 25.98 ± 5.99 kg/m^2. Venous thromboembolism prophylaxis [27], perioperative management of antiplatelet and anticoagulant therapy [28-29] and antibiotic prophylaxis [30] were set up according to literature.

Thirty-six patients (36.7%) were treated by robotic approach and sixty-two (63.3%) received a laparoscopic intervention.

No statistically significative differences were identified for patients' demographics and diseases characteristics as reported in Table 1.

Concerning the type of surgical procedures performed, there were: 19 right hemicolectomies (14 in Laparoscopic Group and 5 in Robotic Group), 16 left hemicolectomies (11 in LG and 5 in RG), 14 Total Mesorectal Excisions (six of which robotics) and 1 laparoscopic Partial Mesorectal Excision, 10 subtotal gastrectomies (two of which robotics) and 2 total gastrectomies (one of which robotic), 9 reversal Hartmann procedures (6 in LG and 3 in RG), 8 cholecystectomies (5 in LG and 3 in RG), 6 abdominoperineal amputations (4 in LG and 2 in RG), 3 ventral rectopexies (2 in LG and 1 in RG), 3 liver resections (2 of which robotics), 2 right adrenalectomies (1 with robotic and 1 with laparoscopic approach), 1 robotic left adrenalectomy associated with TME for simultaneous rectal cancer, 1 robotic distal pancreatectomy with spleen preserving, 1 laparoscopic duodenal wedge resection, 1 laparoscopic hepatic and gastric wedge resection, 1 laparoscopic splenectomy.

Of interest, no significative differences were identified between laparoscopic and robotic group for surgical procedure performed (p = 0.653), PAI score (p = 0.635), severity of PAI into the target area of surgical intervention (p = 0.981) and number of abdominal areas involved by adhesions (p = 0.502).

a significative difference (p =0.046) in terms of conversions related to adhesiolysis was identified (13 for LG versus 2 for RG).

In details, conversions related to adhesiolysis were due to technical difficulties in performing safely adhesiolysis in nine patients (14.52%) from laparoscopic group; bleeding in three patients (4.84%) from LG and one (2.78%) from RG; bowel perforation in one patient (1.61%) treated by laparoscopic approach; inability to tolerate pneumoperitoneum in a high-risk patient (2.78%) from robotic group.

There were other four additional procedures converted to open surgery due to intraoperative complications occurred after complete adhesiolysis was successfully performed: two laparoscopic procedures (3.23%) were converted for intraoperative bleeding (1.61%) and inability to tolerate pneumoperitoneum in high risk patient (1.61%). The other two robotic procedures (5.55%) were converted to open surgery for bleeding (2.78%) and bowel perforation (2.78%).

Furthermore, additionally evaluating associations between conversions related to adhesiolysis and PAS no significant differences were found. In details, type of previous abdominal intervention (p = 0.112) and timing from PAS (275.53 ± 229.36 months for LG versus 207.73 ± 211.24 month for RG; p = 0.289) were analysed.

Among the thirteen laparoscopic procedures converted for technical difficulties during adhesiolysis two patients had a previous history of open cholecystectomy, three of right and two of left hemicolectomy, two of hysterectomy, one of appendectomy, one of sigmoidectomy, one of hysteroannessiectomy, one of subtotal gastrectomy. Regarding the two robotic procedures converted to open surgery for adhesiolysis-related difficulties, both patients have undergone a previous subtotal gastrectomy.

Of interest, a statistically significant correlation between conversion and adhesions' characteristics was described: severity of adhesions expressed by PAI score (p < 0.001), number of abdominal areas involved by adhesions (p < 0.001) and severity of PAI into the target area of surgical intervention (p = 0.021) were separately analysed. In details, all patients with adhesion-related conversion had a PAI ≥

5 (one PAI = 5; one PAI = 6; three PAI = 8; one PAI = 9; one PAI = 11; two PAI = 12; two PAI = 13; two PAI = 14; one PAI = 15; one PAI = 16); number of abdominal areas involved by adhesions ≥ 3 (three patients with 3 areas involved; three with 4 areas; five with 6 areas; three with 7 areas and one with 8 areas) and they all had a severity of PAI into the target area of surgical intervention of 3, except one patient that had 2.

(Fig. 1); (Fig. 2); (Fig. 3)

Additionally, no differences in terms of complication and an advantage for recovery after surgery were identified as shown in Table 2.

Finally, post-operative complications have been described classified according to the Clavien-Dindo classification as shown in Table 3.

Two patients (1 for the LG and 1 for the RG) had surgical site infection without necessity of antibiotic therapy. Two patients with postoperative ileus conservatively treated were described in the laparoscopic group. Two patients with nausea and vomiting treated by antiemetics and one patient who complained pain that required supplementary analgesia were described in the robotic group. Two bleedings from the laparoscopic group required blood transfusion. One ileus in the LG, one surgical site infection and one ileus associated with wound infection from RG were also described. Antibiotic treatment was administered in all cases. One pancreatic fistula conservative managed with the maintenance of the drain placed during the intervention and one pneumonia treated by antibiotics was identified in the robotic group, while one atrial fibrillation treated with pharmacological therapy was described in the laparoscopic group. Three anastomotic leakages (2 in LG versus 1 in RG) were treated by reoperation. One bowel obstruction that required surgical intervention and one respiratory failure that necessitated intensive care unit management were identified, both in the laparoscopic group. There was one death in the laparoscopic group associated with a jejunal fistula.

Discussion

To the best of our knowledge, this is the first study investigating conversions related to adhesiolysis in robotic versus laparoscopic surgery. We demonstrated that conversion rate specifically related to adhesiolysis was significantly lower in the robotic group than in the laparoscopic one.

Peritoneal adhesions are pathological post-inflammatory or post-operative scar tissues between the omentum, small and large bowels, abdominal wall and other intra-abdominal organs.

As we know from literature [31-33] one of the common sequelae of open prior abdominal operations is abdominal and pelvic adhesions [34-35]. Several studies demonstrated that pelvic adhesions occur after 70% to 90% of abdominal pelvic surgeries [36-37]. An autopsy study found that abdominal adhesions developed in 75% to 90% of patients with PAS, whereas they occurred only in 10% of patients without prior surgery [35]. The adhesions typically occurred at the operating site, but other areas could also be involved. In a clinical study, 83% of patients with PAS had adhesions along abdominal openings while only 7% of patients without PAS had adhesions [38].

According to Coccolini et al.[25] adhesions can be classified by the Peritoneal Adhesion Index (PAI), a score ranging from 0 to 30 based on the macroscopic appearance of adhesions and their extent to the different regions of the abdomen.

Abdominal and pelvic adhesions may distort the normal anatomy and make visualization more difficult, increasing surgical challenge. Adhesiolysis is potentially related to a higher risk of conversion from laparoscopic or robotic to an open procedure affecting perioperative outcomes, precluding potential benefits of MIS.

As we know from literature several benefits of robotic approach over laparoscopic surgery have been described, such as magnified 3D vision with a more stable operative field, preservation of natural eye-hand-instrument alignment, precisely controlled EndoWrist instruments with better ergonomics and reduced physiologic tremor. Over the past few years, new supplementary tools have been developed as FireFly system that combines a special video camera and a fluorescent dye (indocyanine green) injected intravenously during the intervention to give a detailed picture of the vessels and the biliary tract; Til Pro system that allows a simultaneous visualization of two image sources in the monitor (for example CT and intraoperative echography) for intraoperative studies on vascular anatomy [39].

Evidence of safety and feasibility of robotic surgery and its advantages over laparoscopy have been described [40-42] although, to our knowledge, there is no unequivocal consensus to identify best application of robotic surgery or declare its superiority over laparoscopic surgery [20,21], except in robot-assisted radical prostatectomy [22].

One of the most validated advantages of robotic abdominal surgery already described in literature is the lower rate of unplanned conversion to open surgery when compared to laparoscopic approach. [20,21,43]

Several experiences on the effect of PAS on robotic surgery outcomes have been reported [27, 44-46] but to our knowledge, no one specifically compared the impact of intra-abdominal and pelvic adhesions on conversion rates between robotic and laparoscopic surgery.

For this reason, an analysis to specifically investigate if robotic surgery could be a valid approach in performing safer adhesiolysis with decreased conversion rates in patients with adhesions from previous open abdominal surgery was conducted.

The results obtained from the analysis confirmed our hypothesis being demonstrated an advantage of robotic surgery in performing adhesiolysis. In fact, conversion rate specifically related to adhesiolysis was significantly lower in robotic group than in laparoscopic one

Additionally, it's important to underline that conversions occurred during adhesiolysis were significantly strictly related to severity of intra-abdominal and pelvic adhesions Analysing conversions data, severity of PAI into the target area of surgical intervention in converted procedures was similar between robotic and laparoscopic group but there was a lower rate of conversion in robotic group.

This report additionally confirmed that benefits of robotic surgery were more noticeable in performing procedures with increasing technical difficulties.

Furthermore, our findings also shown that robotic group was associated with better postoperative outcomes in terms of time to first flatus (p = 0.043) and mobilization (p = 0.046) in performing abdominal surgery complicated with adhesions while safety was similar between the two groups (1 intraoperative complication for LG versus 2 for RG; p = 0.552).

By our results we can conclude that robotic adhesiolysis seems to be superior to laparoscopy giving a new possible target of selection criteria for robotic surgery. If an advantage in obtaining safer adhesiolysis in patients with history of open previous abdominal surgery will be further confirmed, these patients could be referred to a robotic approach.

However, some limitations must be addressed. The main limitation of this study lies in its design: the retrospective evaluation of a prospective database can lead to potential patients' selection bias, making it difficult to draw firm conclusions. Our analysis has to be considered a proof of concept and it provides the rationale for further ad hoc studies to confirm these results.

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Table 1. Demographics characteristics and PAS related data

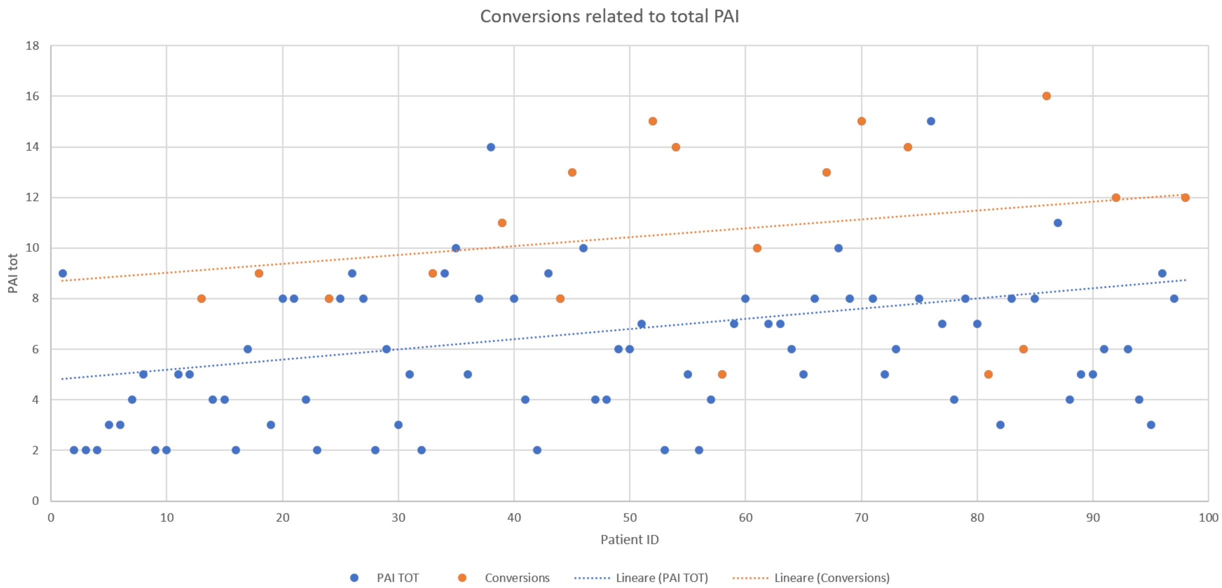
	LAPAROSCOPIC GROUP (n=62)	ROBOTIC GROUP (n =36)	*p* value
Age	67.69 ± 11.28	65.03 ± 15.8	0.254
Gender (male)	36	14	0.067
BMI	25.51 ± 5.9	26.77 ± 6.12	0.536
ASA score			
I	5 (8.06%)	6 (16.67%)	
II	32 (51.61%)	18 (50%)	
III	25 (40.33%)	12 (33.33%)	
IV	0 (0%)	0 (0%)	
Timing from PAS	266.66 ± 247.32	234.28 ± 195.01	0.503
PAS			0.436
Open appendectomy	12 (19.35%)	11 (30.55%)	
Open cholecystectomy	11 (17.74%)	5 (13.90%)	
Open hysterectomy	13 (20.97%)	7 (19.44%)	
Open prostatectomy	2 (3.23%)	0 (0%)	
Open sigmoidectomy	5 (8.06%)	5 (13.90%)	
Open hysteroannessiectomy	5 (8.06%)	0 (0%)	
Open left hemicolectomy	4 (6.45%)	0 (0%)	
Open right hemicolectomy	3 (4.85%)	2 (5.55%)	
Open cystectomy	1 (1.61%)	0 (0%)	
Open right ovariectomy	1 (1.61%)	2 (5.55%)	
Open subtotal gastrectomy	2 (3.23%)	3 (8.33%)	
Open splenectomy	2 (3.23%)	1 (2.78%)	
Open right nephrectomy	1 (1.61%)	0 (0%)	

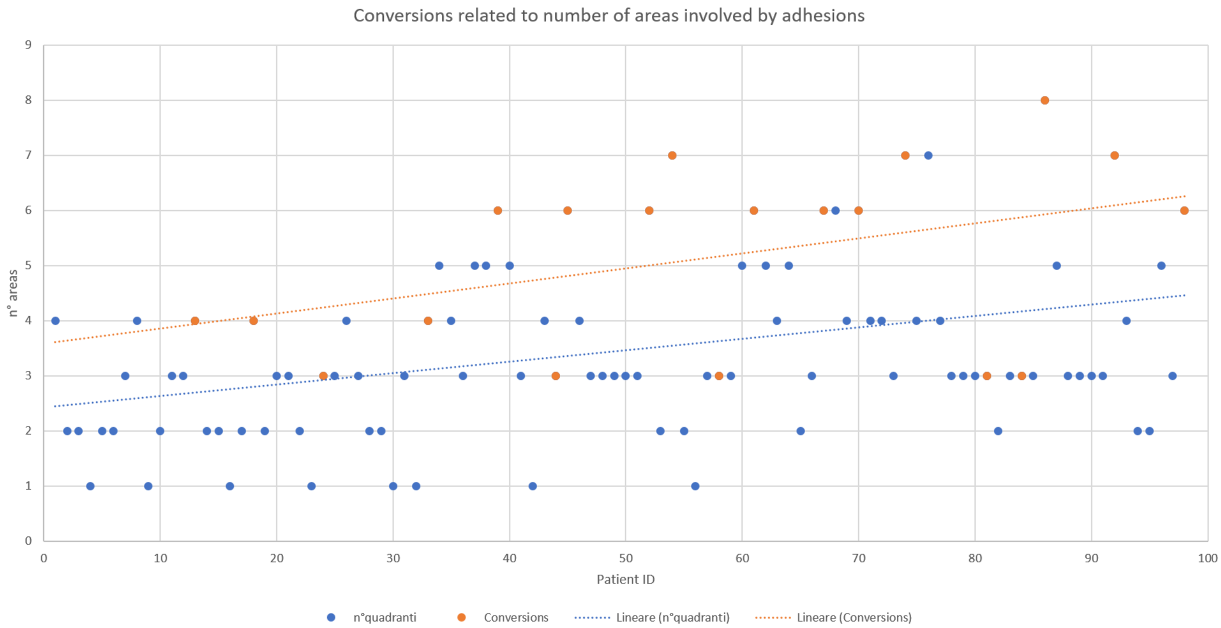
Table 2. Short-term outcomes.

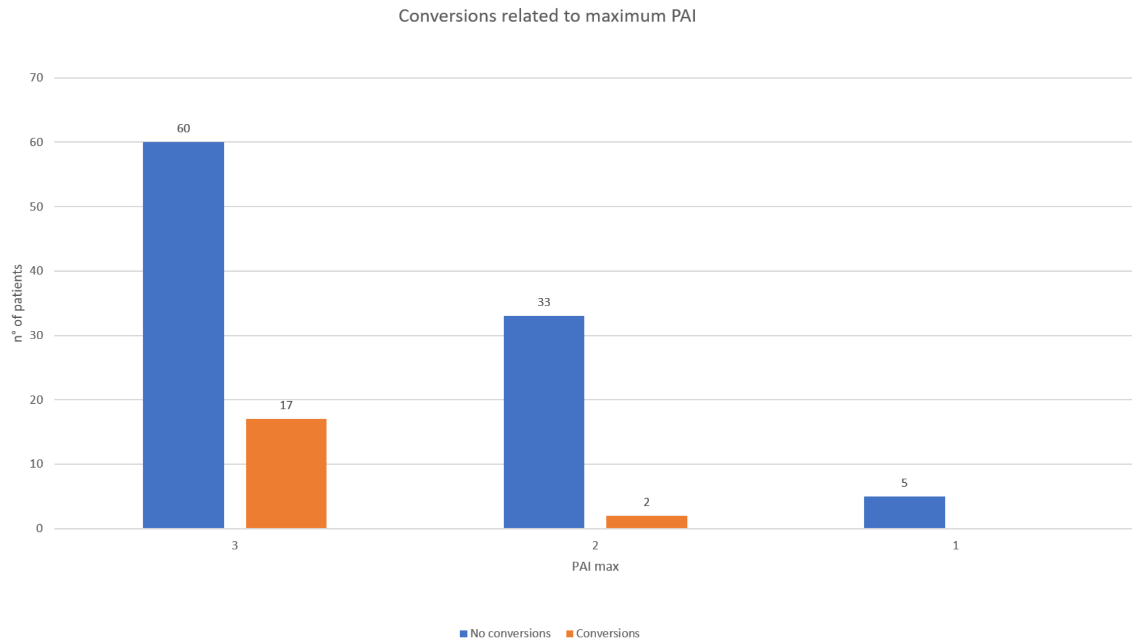
	LAPAROSCOPIC GROUP (n=62)	ROBOTIC GROUP (n =36)	*p* value
Operative time	185 ± 64.61	245.25 ± 95.71	0.001
Intraoperative complications	1 (1.61%)	2 (5.55%)	0.552
Postoperative complications	12 (19.35%)	9 (25%)	0.511
Clavien Dindo			0.646
0	50 (80.65%)	27 (75%)	
1	3 (4.84%)	4 (11.11%)	
2	4 (6.45%)	4 (11.11%)	
3a	0 (0%)	1 (2.78%)	
3b	3 (4.84%)	0 (0%)	
4	1 (1.61%)	0 (0%)	
5	1 (1.61%)	0 (0%)	
Time to first flatus	47.95 ± 23.12	38.87 ± 17.19	0.043
Mobilization	28.73 ± 19.44	22.05 ± 4.65	0.046
Length of hospital stay	8.5 ± 7.37	7.14 ± 4.77	0.323

Table 3. Post-operative complications according to the Clavien-Dindo classification.

GRADE	POSTOPERATIVE COMPLICATIONS	LAPAROSCOPIC GROUP (N=12)	ROBOTIC GROUP (N=9)
1	Ileus	2 (16.67%)	0 (0%)
	Wound infection	1 (8.33%)	1 (11.1%)
	Nausea and vomiting	0 (0%)	2 (22.2%)
	Pain	0 (0%)	1 (11.1%)
2	Bleeding	2 (16.67%)	0 (0%)
	Wound infection	0 (0%)	1 (11.1%)
	Ileus	1 (8.33%)	0 (0%)
	Ileus and wound infection	0 (0%)	1 (11.1%)
	Pneumonia	0 (0%)	1 (11.1%)
	Pancreatic fistula	0 (0%)	1 (11.1%)
	Atrial fibrillation	1 (8.33%)	0 (0%)
3	Anastomotic leakage	2 (16,67%)	1 (11.1%)
	Bowel obstruction	1 (8.33%)	0 (0%)
4	Respiratory failure	1 (8.33%)	0 (0%)
5	Jejunal fistula	1 (8.33%)	0 (0%)


Conversions related to total PAI
PAI tot
Patient ID
0
2
4
6
8
10
12
14
16
18
0
10
20
30
40
50
60
70
80
90
100
PAI TOT
Conversions
Lineare (PAI TOT)
Lineare (Conversions)


Conversions related to number of areas involved by adhesions
n° areas
Patient ID
n°quadranti
Conversions
Lineare (n°quadranti)
Lineare (Conversions)


Conversions related to maximum PAI
n° of patients
70
60
50
40
30
20
10
0
60
17
33
2
5
3
2
1
PAI max
No conversions
Conversions