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ORIGINAL ARTICLE

Impact of COVID-19 on clinical outcomes of robotic retromuscular ventral hernia repair

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Abstract

Background The COVID-19 pandemic disrupted the healthcare sector and forced hospitals to limit the number of elective procedures with the goal of reducing overcrowding of wards and thus viral transmission. Recent trends for ventral hernia repair have shifted towards retromuscular techniques, which normally require a longer length of stay. Therefore, the aim of this study is to investigate the impact of the COVID-19 pandemic on clinical outcomes of robotic retromuscular ventral hernia repair (rRVHR).

Methods Patients who underwent rRVHR up to 600 days before and after March 10, 2020, were included in this retrospective study and assigned to the pre- or post-COVID group depending on the date of their procedure. Pre-, intra-, and postoperative variables including patients' demographics, hernia characteristics, complications, and hernia recurrence were compared between both groups.

Results 153 (46% female) and 141 (51% female) patients were assigned to the pre- and post-COVID groups respectively. Median age was statistically different between both groups [pre-COVID: 57 (48–68) vs. post-COVID 55 (42–64) years, $p=0.045$]. Median hospital length of stay (LOS) was 0 day (0–1) in both groups, and same day discharge were 61% pre-pandemic and 70% post-pandemic ($p=0.09$). Mean postoperative follow-up was 39.2 (4.1–93.6) months. In total, 26 pre-COVID patients had postoperative complications, out of which 7 were pulmonary complications, whereas 23 complications were recorded in the post-COVID group, with only 3 pulmonary complications ($p=0.88$). Rate of surgical-site events was comparable between both groups, and no recurrences were recorded.

Conclusion This is the first study to describe the impact of the COVID-19 on rRVHR. Hospital LOS was comparable between both groups. Rates of medical and hernia specific complications were not altered by the pandemic.

Keywords COVID-19 · Robotic · Retromuscular · Ventral hernia · Outcomes

The COVID-19 pandemic disrupted the healthcare system and forced hospitals to limit electives procedures in an effort to minimize unnecessary admissions and exposure to the virus [1]. In response to the unprecedented crisis, the Governor of Massachusetts declared a state of emergency on March 10, 2020. Elective surgeries were postponed, with the purpose of reallocating the resources to fight the pandemic [2]. Across different specialties, several interventions were progressively performed in an outpatient setting to avoid overcrowding the hospitals by reducing the length of stay [3, 4]. Gastrointestinal surgeries have been affected differently, depending on the procedure [5]. For ventral hernia repair (VHR), minimally invasive surgery (MIS) was proven to reduce the hospital length of stay and wound morbidity [6], and to offer an outpatient setting in most unselected cases [7–9]. However, complex techniques such as retromuscular repair would normally require an overnight stay, with a shorter LOS for robotic repairs in comparison to the open approach [10].

With the healthcare sector suffering from the pandemic, this study aimed to evaluate the impact of the COVID-19 virus on midterm outcomes of robotic retromuscular ventral hernia repair (rRVHR). We hypothesized that clinical

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outcomes for rRVHR would not differ after the COVID-19 pandemic.

Materials and methods

Patient selection and study groups

A single center, single surgeon, retrospective review of a prospectively collected database of VHRs performed between February 2013 and December 2021 was performed. March 10, 2020, the date of declaration of a state of emergency in Massachusetts, was set as a cutoff date to separate the cohort into two groups. Patients who underwent robotic retromuscular VHR up to 600 days before the cutoff date were assigned to the pre-COVID group, whereas patients who underwent rRVHR after that date formed the post-COVID group.

Variables

Preoperative variables included patient demographics such as age, sex, body mass index (BMI), comorbidities, and risk factors, the modified Ventral Hernia Working Group (VHWG) grade, and the hernia-patient-wound (HPW) stages [11]. As for procedure-related variables, operative time, estimated blood loss (EBL) and intraoperative complications were recorded. Hernia and mesh related characteristics such as hernia size, and mesh type, size, and method of repair were also recorded. Postoperatively, a Verbal Rating Scale (VRS) graded from 0 to 10 was used to assess pain in the post-anesthesia care unit (PACU). Morphine milligram equivalent (MME) was also collected. Hospital readmission within a 30-day post-operative period and post-op complications were also recorded.

Hernia dimensions were reported according to the European Hernia Society (EHS) recommendations [12]. Hernia defect area, mesh area, and mesh-to-defect ratio were calculated based on intraoperative measurements, using previously described mathematical formulas [13]. Operative time was defined as the time between skin incision and closure.

Post-operative complications were collected from follow-up visits, medical records, and clinical charts, and were categorized according to the Clavien-Dindo classification system [14]. The morbidity score was measured using the Comprehensive Complication Index (CCI®, University of Zurich, Zurich, Switzerland) [15]. Surgical site events (SSE) were defined as surgical site infections (SSI) and surgical site occurrences (SSO). SSIs were further classified as cellulitis, superficial, deep, and organ space infections. SSOs included sterile fluid collections such as hematomas and seromas. Any occurrence of infection that required a procedural intervention (bedside wound exploration, percutaneous emptying to reduce symptoms, or reoperation) was described as an SSO/I-PI.

Statistical analysis

Patient demographics, hernia characteristics, operative variables, and post-operative outcomes were compared between the two groups. Chi-square test or Fisher's exact test were used for categorical variables. Student *t*-test or Mann–Whitney U test were used for continuous variables as appropriate. Categorical variables are presented in terms of frequency (n and/or %), while continuous variables were reported as the mean ± the standard deviation (SD) for normal distributions or the median with interquartile range (IQR) for non-normal distributions.

Results

In total, 294 patients were included in the study, with 153 rRVHR in the pre-COVID group and 141 in the post-COVID group. A comparison of patient demographics of the two groups is shown in Table 1. No differences were seen in the setting of the operation (139 vs. 132 elective procedures, 14 vs. 9 urgent procedures, in pre- and post-COVID groups respectively, $p = 0.38$).

Hernia characteristics and operative variables are compared in Table 2. Etiology of the ventral hernia between both groups did not significantly differ, with comparable rates of primary and incisional hernias (pre-COVID: 55% incisional vs post-COVID: 51%, $p = 0.19$). Operative time was similar between both groups. None of the procedures were converted to conventional open or laparoscopic approaches, and hybrid procedure rates were comparable between both groups ($p = 0.72$).

An intraoperative complication occurred in 5 patients in the entire cohort, 4 of which were in the pre-COVID group ($p = 0.37$). There were no differences between the two groups in terms of median (IQR) post-operative pain scores and MME [median (IQR) pain score: pre-COVID 5 (3–6) vs post-COVID 5 (4–6); median (IQR) MME: pre-COVID 10 (3.4–15) vs post-COVID 10 (2.5–15); $p = 0.58$ and $p = 0.75$, respectively]. The median (IQR) LOS was 0 (0–1) days with a maximum LOS of 11 days for both groups. Similar same-day discharges were seen pre- and post-COVID (61% vs. 70%, respectively, $p = 0.09$).

Thirty-day readmissions (5.9% pre-COVID vs 3.6% post-COVID, $p = 0.35$) and emergency visits within 30 days were also comparable (7.2% pre-COVID vs. 6.4% post-COVID, $p = 0.78$) The distribution of post-operative complications between the two groups is presented in Table 3. A total of 10 pulmonary complications were recorded, out of which 7 occurred in the pre-COVID group. For the post-COVID

Table 1 Comparison of patient demographics between the two groups

	Pre-COVID ($n=153$)	Post-COVID ($n=141$)	p-value
Age, year, median (IQR)	57 (48—68)	55 (42—64)	**0.045**
Sex, female, *n* (%)	71 (46)	72 (51)	0.42
BMI, kg/m^2, median (IQR)	31 (28–36)	33 (29–38)	0.07
ASA score, median (IQR) ASA I, *n* (%)	5 (3.3)	5 (3.5)	0.064
ASA II, *n* (%)	56 (36)	73 (52)	
ASA III, *n* (%)	90 (59)	62 (44)	
ASA IV, *n* (%)	2 (1.3)	1 (0.7)	
Comorbidities			
HT, *n* (%)	79 (52)	72 (51)	0.92
CAD, *n* (%)	15 (9.8)	9 (6.4)	0.28
MI, *n* (%)	3 (2.0)	4 (2.8)	0.71
Pulmonary, *n* (%)	62 (41)	61 (43)	0.63
Smoking, *n* (%)	30 (20)	28 (20)	0.96
DM, *n* (%)	32 (21)	24 (17)	0.40
Immunosuppression, *n* (%)	4 (2.6)	1 (0.7)	0.37
History of wound infections, *n* (%)	25 (16)	8 (5.7)	**0.004**

BMI Body Mass Index, *ASA* American Society of Anesthesiologists, *HT* Hypertension, *CAD* Coronary Artery Disease, *MI* Myocardial Infarction, *COPD* Chronic Obstructive Pulmonary Disease, *DM* Diabetes Mellitus. Values in bold indicate a p value < 0.05

group, 2 cases of aspiration pneumonias were recorded during the immediate postoperative hospital course, and 1 after discharge. Median follow-up was 33 months for the pre-COVID group, and 13 months for the post-COVID group. No patients reported contracting the COVID-19 virus within two weeks postoperatively (the virus incubation period).

Discussion

After the declaration of the COVID-19 pandemic, the healthcare sector suffered a tremendous shortage of material and personnel, especially with the scarcity of personal protective equipment. To limit the nosocomial transmission of the virus, hospitals initially reduced the number of unnecessary admissions and procedures, in particular elective surgeries. Subsequently, with the recuperation of resources, activity in surgical wards and operation rooms progressively returned to normal. Different strategies were explored to prevent uncontrolled transmission of the virus, and all surgeries in COVID-19 negative patients were performed. Recently, retromuscular VHRs have become more appealing for surgeons, thanks to their superior outcomes in comparison to other techniques [16]. However, their learning curve might be steeper than other repairs in order to achieve acceptable outcomes [17, 18].

In this single center retrospective study, we aimed to evaluate the impact of the COVID-19 virus on the postoperative course of patients undergoing rRVHR by comparing the clinical outcomes before and after the pandemic. Patient demographics did not differ between both groups, except for age, with the post-COVID group showing a lower median age of two years. Older patients, who are at higher risk for COVID-19 complications, might be reluctant to undergo elective VHR and therefore would postpone their surgery. Medical comorbidities did not seem to hinder the willingness of the surgeon to perform the procedures as their specific rates were comparable between both groups.

In a study comparing the rates of hernia repair before and after the pandemic, Kollatos et al. reported an increase in emergent ventral hernia repairs with a decrease of planned procedures [19]. Lima et al. originally expected a similar result, only to find that the rate of emergent cases was lower during the pandemic [20]. In our study, the comparable rates of procedure setting can be explained by the larger selected timeframe.

Retromuscular repairs typically require an extended hospital LOS, especially when performed via an open approach [21]. In contrast, the robotic platform offers reduced patient morbidity and LOS with studies reporting a mean hospital course of one day for rRVHR [10, 22]. However, in our study, more than 60% of all patients were discharged on the same day of their surgery and median hospital LOS was of 0 days. Additionally, post-COVID same day discharge rate was 9% higher than the pre-COVID era but did not significantly differ.

At the beginning of the pandemic, minimally invasive surgery was believed to increase risk of viral transmission due to the aerosolization of the virus through the smoke escaping from the trocars. However, these claims were unfounded and

Table 2 Comparison of hernia characteristics and operative variables between the two groups

	Pre-COVID ($n=153$)	Post-COVID ($n=141$)	p-value
HPW			0.91
Stage 1, *n* (%)	21 (14)	22 (16)	
Stage 2, *n* (%)	103 (67)	95 (67)	
Stage 3, *n* (%)	25 (16)	22 (16)	
Stage 4, *n* (%)	4 (2.6)	2 (1.4)	
Modified VHWG			0.90
Grade 1, *n* (%)	25 (16)	24 (17)	
Grade 2, *n* (%)	125 (82)	113 (80)	
Grade 3, *n* (%)	3 (2.0)	4 (2.8)	
Hernia location, midline only, *n* (%)	133 (87)	133 (94)	0.08
Recurrent hernia, *n* (%)	52 (34)	31 (22)	**0.022**
LOA, (> 30 min.), *n* (%)	14 (9.2)	12 (8.5)	0.85
Multiple defects, *n* (%)	3 (2.0)	15 (11)	**0.002**
Hernia defect length, cm, median (IQR)	5 (4–12)	6 (5–12)	0.50
Hernia defect width, cm, median (IQR)	4 (4–8)	4 (4–8)	0.16
Hernia defect area, cm^2, median (IQR)	16 (13–88)	21 (16–79)	0.23
Mesh area, cm^2, median (IQR)	300 (225–600)	300 (300–600)	**0.002**
Mesh-to-defect ratio, median (IQR)	13 (6.6–18)	13 (6.3–18)	0.80
Mesh materials			
Polypropylene, *n* (%)	92 (60)	34 (24)	
Polyester, *n* (%)	0 (0)	1 (0.7)	
Hybrid, *n* (%)	61 (40)	105 (74)	
Absorbable, *n* (%)	0 (0)	1 (0.7)	
Operative time, min., median (IQR)	101 (64–178)	100 (80–202)	0.22
Repair technique			0.055
Rives-Stoppa, *n* (%)	83 (54)	92 (65)	
Transversus Abdominis Release, *n* (%)	70 (46)	49 (35)	
EBL, mL, median (IQR)	5 (5–10)	5 (5–10)	0.47
Drain, *n* (%)	5 (3.3)	9 (6.4)	0.21

HPW Hernia-Patient-Wound, *VHWG* Ventral Hernia Working Group, *LOA* Lysis of Adhesions, *EBL* Estimated Blood Loss. Values in bold indicate a p value < 0.05

were considered as excessive [23]. Moreover, most pulmonary complications recorded in our database were seen in the pre-COVID group, with no cases of COVID-19 diagnosed after the pandemic. In a study comparing postoperative morbidity in the immediate pre- and post-COVID era for emergent gastrointestinal procedures including ventral hernia, Cano-Valderrama et al. noted a similar result to ours, with comparable respiratory complications [24].

Finally with a median follow-up of a year achieved in both groups, no significant hernia related complications were noted. Surgical site events were comparable, and no recurrences were noted in both groups. These results can be attributed to both the robotic platform and retromuscular repair technique.

This study has several limitations. First, it is a retrospective cohort conducted at a single center in the United States. These factors limit the generalizability of our findings, as the COVID-19 virus affected regions and hospitals differently across the world. Second, surgeon's experience played a significant role in the clinical outcomes as reflected by the short LOS for rRVHR and most patients discharged on the same day of their surgery. A longer LOS might increase the risk of exposure and thus contraction of the COVID-19 virus.

In conclusion, this is the first study to describe the impact of the COVID-19 on rRVHR through a comparison of clinical outcomes before and after the declaration of the pandemic. Hospital LOS was comparable between both groups. Rates of medical and hernia specific complications were not altered by the pandemic.

Table 3 The comparison of postoperative outcomes

	Pre-COVID ($n=153$)	Post-COVID ($n=141$)	p-value
CCI®, mean ± *SD*	3.4 (8.6)	3.0 (8.6)	0.66
Clavien-Dindo			0.12
Grade-I, *n* (%)	17 (11.1)	15 (10.6)	
Grade-II, *n* (%)	10 (6.5)	4 (2.8)	
Grade-IIIa, *n* (%)	3 (2.0)	2 (1.4)	
Grade-IIIb, *n* (%)	1 (0.6)	1 (0.7)	
Grade-IVa, *n* (%)	2 (1.3)	3 (2.1)	
Grade-IVb, *n* (%)	0 (0)	1 (0.7)	
SSEs, yes, n (%)	15 (9.8)	16 (11)	0.67
SSIs, yes, *n* (%)	5 (1.9)	4 (5.3)	0.45
Cellulitis, *n* (%)	0 (0)	2 (1.4)	
Superficial, *n* (%)	3 (2.0)	1 (0.7)	
Deep, *n* (%)	2 (1.3)	1 (0.7)	
SSOs, yes, *n* (%)	11 (7.2)	13 (9.2)	0.53
Seroma, *n* (%)	8 (5.2)	9 (6.4)	
Hematoma, *n* (%)	2 (1.3)	3 (2.1)	
Wound dehiscence, *n* (%)	1 (0.7)	1 (0.7)	
SSO/I-PI, *n* (%)	6 (3.9)	3 (2.1)	0.50
Recurrence, *n* (%)	0 (0)	0 (0)	N/A

CCI® Comprehensive Complication Index (University of Zurich, Zurich, Switzerland), *SSEs* Surgical Site Events, *SSIs* Surgical Site Infections, *SSOs* Surgical Site Occurrences, *SSO/I-PI:* Surgical Site Occurrence or Infection requiring Procedural Intervention

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Declarations

Disclosures Drs. Georges Kaoukabani, Naseem Bou-Ayash, Allison S. Crawford, and Fahri Gokcal have no conflicts of interest or financial ties to disclose. Dr. Omar Yusef Kudsi has received teaching course, grant funding, and/or consultancy fees from Intuitive Surgical, Bard, and W.L. Gore outside the submitted work.

Ethical approval The database used for this study approved by the Institutional Review Board.

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

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

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