Journal of Robotic Surgery (2020) 14:275–281
https://doi.org/10.1007/s11701-019-00979-2

ORIGINAL ARTICLE

Robotic ventral hernia repair in octogenarians: perioperative and long-term outcomes

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Received: 6 February 2019 / Accepted: 25 May 2019 / Published online: 29 May 2019

Abstract
Very few studies have documented perioperative outcomes of ventral hernia repair in octogenarians. The aim of this study is to report the perioperative and the long-term outcomes of robotic ventral hernia repair (RVHR) in aged 80–89 years patients. From a prospectively maintained database, aged 80–89 years patients who underwent robotic procedures between 2013 and 2018 were analyzed retrospectively including perioperative outcomes and long-term follow-up. Complications were assessed with validated grading systems and index. 21 octogenarians with average age 83.48 were included. Intraperitoneal onlay mesh repair, transabdominal preperitoneal repair, retromuscular repair with or without transversus abdominis release technique were performed without conversion. The average operating time was 150 min. The mean hospital length of stay of all cohorts was 1.24 day. There was a strong correlation between operating time and hospital length of stay. The median follow-up was 23.5 months. According to Clavien–Dindo classification, grade-I and grade-II complications were observed in 23.8% and 28.6% patients, respectively; major complications (grade-III and IV) were not observed. The maximum Comprehensive Complication Index® score was 29.6. None of the patients experienced hernia recurrence or chronic pain. To our best knowledge this study is the first to present perioperative as well as long-term outcomes of octogenarian patients who underwent RVHR. The results indicate the safety and efficacy of RVHR in octogenarians.

Keywords Robot-assisted laparoscopy · Robotic ventral hernia repair · Incisional hernia · Octogenarians · Oldest-old · Elderly

Introduction

Surgeons are encountering the effects of an aging population. The prevalence of individuals living beyond 80 is increasing and is expected to more than triple over the next 30 years [1]. Continuing breakthroughs in medical technology, public health, and evolving minimally invasive techniques, has expanded the utility of surgical intervention, allowing an increasing number of elderly patients' consideration for even complex surgical procedures [2]. A faster return to one's baseline status is prioritized by patients universally, but this becomes particularly important in elderly patients where re-establishing their daily routine quickly after surgery can be of pivotal importance to preserving their mental orientation and functional status [3]. In this context, selecting the appropriate surgical approach becomes increasingly meaningful [4].

Recent studies on laparoscopic ventral hernia repair (LVHR) in the elderly, stress the preference of a minimally invasive approach in these patients [5–7]. There are two studies of note that specifically focus on the outcomes of patients over the age of 80 undergoing ventral hernia repair (VHR) [8, 9]. Although the safety and feasibility of robotic surgery in elderly patients has been well documented for a 'variety of surgical procedures [10–13], however, robotic ventral hernia repair (RVHR) in elderly patients remains underrepresented in the surgical literature. Recently, robotic techniques for VHR are increasing in popularity [14]. Accordingly, to better establish the utility of this repair in an older cohort, we present our experience with RVHR in octogenarians and aim to describe the postoperative outcomes of this population.

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Materials and methods

Study population

The data for this study was obtained from a prospectively collected database of cases preformed between February 2013 and November 2018, which has been retrospectively reviewed. The variables collected included demographics (age, sex), the presence of comorbidities, body mass index (BMI), American Society Anesthesiology (ASA) Score, the type of hernia (ventral, incisional, primary, or recurrent), the location of the hernia (midline, off-midline or a combination), the capability of the surgeon to close the anterior fascial defect of the hernia robotically (yes/no), the type of mesh used; the appliance of fixation materials (suture/tacker) to secure the mesh (yes/no), the dimensions of the hernia defect and of the mesh itself, the requirement of extensive adhesiolysis (more than 45 min), the operative time in minutes [console time and skin-to-skin time (the time of first incision to completed skin closure)], the estimated blood loss (EBL), and postoperative discharge day.

The size of the hernia defect was measured based on the guidelines of the European Hernia Society [15]. Additionally, transverse mesh overlap was defined by the shortest radial distance between the edge of the defect and the edge of the mesh. The defect area (cm^2), the mesh area (cm^2), and the ratio of mesh size to defect size (*M*/*D* ratio) were also calculated, according to the formula of round (or oval), rectangular (or oval), and division, respectively. The modified Ventral Hernia Working Group (VHWG) grading system was used to represent the hernia grades [16]. VHWG grades were used to guide the choice of repair material [17]. For grade 1 patients (low-risk), repair material was selected by surgeon preference and patient factors. For grade 2 risk patients, which includes co-morbid situations such as diabetes mellitus, chronic obstructive pulmonary disease (COPD), smoking, obesity, and immunosuppression, permanent synthetic repair materials which have macropores, or a biologic repair material was utilized. For grade 3 risk patients, which defines potentially contaminated cases, a biologic repair material was utilized depending on choice of technique (IPOM vs extraperitoneal), or synthetic materials which have large pore sizes were preferred. Additionally, synthetic meshes with antiadhesive coatings were utilized for IPOM repair. Accordingly, medium weight polypropylene and polyester repair materials were used for low-risk patients. Polytetrafluoroethylene repair materials were used for co-morbid patients. Biosynthetic materials were used for potentially contaminated cases.

Postoperative pain scores were documented by the anesthesiologist using the 0–10 numeric rating scale system (0: no pain, 10: the worst pain). The last pain score was determined at the time point just before the patient left the post anesthesia care unit (PACU). The total amount of narcotic-analgesic received while in PACU was also calculated. In patients who stayed overnight following surgery, the pain score at postoperative day 1 (POD-1) was also reviewed, as documented by the unit nurse. The hospital length of stay (LOS) in days was defined as the difference in time between the date of the operation and the date of hospital discharge. Any emergency department (ED) visit within 30 days postoperatively was classified as a re-visit. Patients presenting to the ED requiring inpatient admission were classified as a re-admission.

Postoperative complications were reviewed as documented in follow-up visits of the surgeon, as well as the medical records and clinical charts of the patients. All complications were categorized according to Clavien–Dindo classification system [18]. Of these, surgical wound complications were further categorized according to the previously published classification of surgical site occurrences [16]. The Morales–Conde classification algorithm was utilized to describe the severity of a seroma complication [19]. To measure the morbidity score, the Comprehensive Complication Index (CCI®, University of Zurich, Zurich, Switzerland) was used as a continuous scale [20]. Long-term outcomes were assessed by phone survey. Patients or their surrogates were asked if they had required further hernia operations after their index repair. Patients were then assessed for recurrence via the criteria of the ventral hernia recurrence inventory [21].

Surgical technique and postoperative plan

The patients were placed in the supine position. Following appropriate preparation, the trocars were inserted in suitable places and the patient side cart of the da Vinci surgical robotic system (Intuitive Surgical, Sunnyvale, CA) was docked. Adhesiolysis was performed if necessary.

Robotic intraperitoneal onlay mesh (rIPOM) VHR

The peritoneum surrounding the defect was dissected. After defect measurement, primary closure of the hernia defect was performed by running a long-lasting absorbable suture. The mesh was introduced and secured to the posterior fascia using absorbable sutures.

Robotic transabdominal preperitoneal (rTAPP) VHR

The preperitoneal plane was entered and dissected at least 5 cm circumferentially around the defect to provide space for adequate mesh deployment. After closing the hernia defect,

the mesh was secured to the posterior fascia. The peritoneal flap was closed with an absorbable suture.

Robotic retromuscular (rRM) VHR

The posterior rectus fascia was cut along the medial edge of the rectus muscle after performing adhesiolysis, as necessary. The dissection plane was carried out laterally towards the linea semilunaris. Transversus abdominis release (TAR) was added as required. Neurovascular bundles of the rectus muscle were found and preserved during the TAR and the dissection plane was extended approximately to the anterior axillary line. The same steps were performed for the contralateral side if necessary. After completion of the dissection, primary closure of the anterior fascial defect was accomplished by running a long-lasting absorbable barbed suture. The opening of posterior rectus sheath was closed using absorbable suture. The mesh was then deployed. Skin incisions were closed with absorbable sutures. Those patients who required overnight inpatient stay, often secondary to deconditioning or other co-morbidities, were able to be discharged based primarily on safety criteria, specifically with respect to an assessment of fall risk and home support. All of the patients were prescribed Oxycodone-Acetaminophen 5–325 mg/30 tablets at the time of discharge.

Statistical analysis

All statistical analyses were performed using SPSS software (Statistical Package for Social Sciences for Windows Version 22). Categorical variables were represented in terms of frequency [*n* (%)], 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. Spearman's rho test was utilized to compare continuous variables. A *p* value of less than 0.05 was considered statistically significant.

Results

A total of 21 octogenarian patients were included from a total of 468 patients who underwent robot assisted laparoscopic ventral hernia repair in the aforementioned timeframe. The mean age of these selected patients was 83.48 ± 2.69 years (range 80–89). 10 (47.6%) patients were female, 11 (52.4%) patients were male. The mean body mass index (BMI) was 29.44 ± 2.92 kg/m^2. 3 (14.3%) patients were American Society of Anesthesiologists (ASA) class-2 and 18(85.7%) patients were ASA class-3. All patients but one had one or more comorbidities (95.2%), including cardiovascular comorbidities in 20 (95.2%), pulmonary comorbidities in 10 (47.6%), endocrine comorbidities in 8 (38.1%), and neuropsychiatric comorbidities in 2 (9.5%). Hernia etiology consisted of: a primary ventral hernia in 8 (38.1%) patients and an incisional hernia in 13 (61.9%) patients. Of patients who had incisional hernias, 5 (38.5%) patients had a recurrent hernia. For 4 (19%) patients, surgery was performed in an emergent setting. At the time of repair, 14 (66.7%) patients had an incarcerated hernia. Of these, incarcerated viscera included; omentum in 9 (42.9%) patients, small bowel in 6 (28.6%), and colon in 2 (9.5%). Extensive adhesiolysis was needed in 8 (38.1%) patients. The details of hernia characteristics and procedures were represented in Table 1.

In terms of mesh position, it was placed as an intraperitoneal onlay (IPOM) in 8 (38.1%) patients, preperitoneal (TAPP) in 3 (14.3%), and retromuscular in 10 (47.6%). 7 of 10 retromuscular hernia repairs were performed with the addition of a transversus abdominis release (TAR). Mesh types were represented in Table 2. 7 (33.3%) patients in all cohorts underwent concomitant surgery in addition to VHR; unilateral inguinal hernia ($n=4$), bilateral inguinal hernia repair($n=1$), cholecystectomy ($n=1$), and colostomy takedown ($n=1$).

None of the procedures were converted to open or conventional laparoscopy. A segmental transverse colon resection was required in one patient (4.8%). In another patient (4.8%), the small bowel was injured while performing the lysis of adhesions, and subsequently repaired without spillage of enteric content.

Table 1 Hernia characteristics and operative variables for patients

Hernia etiology, *n* (%)	
Primary ventral	8 (38.1)
Incisional	13 (61.9)
Hernia location, *n* (%)	
Midline	15 (71.4)
Off-midline	5 (23.8)
Both	1 (4.8)
Multiple hernia defects, *n* (%)	3 (14.3)
Modified VHWG hernia grade, *n* (%)	
Grade 1	5 (23.8)
Grade 2	12 (57.1)
Grade 3	4 (19)
Hernia defect area, cm^2, median (IQR)	23.56 (4.71–32.98)
Mesh area, cm^2, median (IQR)	300 (150–500)
Mesh overlap, transverse, cm, median (IQR)	5 (4–8)
Mesh/Defect ratio, median (IQR)	18.89 (6.63–30.83)
Primary defect closure, *n* (%)	19 (90.5)
Console time, min., mean ± SD	132.48 ± 90.35
Skin-to-skin time, min., mean ± SD	150.52 ± 93.87
Estimated blood loss, mL, median (IQR)	5 (5–15)

IQR interquartile range, *SD* standard deviation

Table 2 The mesh types which were used in all procedures

Brand name	*n* (%)
ProGrip™*	6 (28.6)
Symbotex™*	5 (23.8)
Parietene™*	4 (19)
Phasix**	2 (9.5)
Bard® Soft Mesh**	2 (9.5)
Synecor Pre™***	1 (4.8)
Versatex™*	1 (4.8)

*Medtronic, Minneapolis, MN, USA

**Bard Davol Inc., Warwick, RI, USA

***W.L. Gore & Associates Inc., Newark, DE, USA

Table 3 Postoperative complications in the study group

Complications	*n* (%)
Pain/discomfort	6 (28.6)
Nausea	5 (23.8)
Urinary	4 (19)
Cardiac	1 (4.8)
Deep vein thrombosis	1 (4.8)
Clostridium difficile colitis	1 (4.8)
SSEs	3 (14.3)
SSIs* (cellulitis)	2 (9.5)
SSO (seroma**)	1 (4.8)
SSOPI	0 (0)
Recurrence	0 (0)

SSEs surgical site events, *SSIs* surgical site infections, *SSO* surgical site occurrence, *SSOPI* surgical site occurrence procedural intervention

*Occurred at trocar site

**Morales-Conde classification type-0b [19]

Immediately after the operation, 33.3% of patients did not require any pain medication. 66.7% of patients were given fentanyl with the median (IQR) dose of 112.5 mcg (100–175 mcg). The median (IQR) of the last pain score before leaving PACU was 2 (0–3) and POD-1 pain score (*n*: 12) was 3 (IQR 1–4).

The mean hospital the length of stay (LOS) inclusive of all cohorts was 1.24 days [min–max: 0–5, median:1 (IQR 0–2)]. 9 (42.5%) patients were discharged on the same day of surgery. 7 (33.3%) patients stayed in the hospital for more than 1 day. ED re-visit was required in three patients (14.2%) within 30 days of surgery due to pain/discomfort, nausea, and falls; however, none of them did not require further inpatient treatment.

The mean postoperative follow-up was 23.5 months. There were no major complications according to Clavien–Dindo grading system (grade III–IV). While grade-I complications were observed in 5 (23.8%) patients, grade II complications were observed in 6 (28.6%) patients. The median CCI® score was 8.7 (IQR 0–12.2). 1 (4.8%) patient expired during the follow-up period. This was secondary to a ruptured aortic aneurysm at PO-15 months. The details of postoperative complications and SSEs are presented in Table 3.

Discussion

Advanced age has been shown to be an independent risk factor for postoperative morbidity and mortality [22, 23]. Consequences of the physiologic changes that accompany aging, such as decreased reserve capacity, can become more apparent in periods of increased metabolic demand, such as surgical stress [3, 24]. Furthermore, a particular concern for older patients who may be candidates for minimally invasive surgery, are the potentially negative effects of increased intraabdominal pressure secondary to carbon-dioxide pneumoperitoneum [3, 25]. As anticipated, geriatric patients, especially those older than 80, usually have several comorbidities and higher ASA scores [2]. Additionally, they frequently require postoperative monitoring in an ICU setting [5]. Abovementioned factors naturally place this population at a greater risk of postoperative complications; commonly including cardiac, pulmonary, and urinary complications [2].

In a study specifically designed to asses outcomes in patients over 80 using the ACS-NSQIP database, Spaniolas et al. [9] concluded that morbidity and mortality rates in the octogenarians who undergo VHR (both laparoscopic and open) are significantly higher compared with younger patients. When LVHR and open VHR were compared in patients aged 80 years and over, they determined that laparoscopic surgery was not associated with improved mortality or morbidity, except in the specific case of pulmonary complications and SSIs, where laparoscopic surgery was superior.

In a single center, retrospective study, aiming to evaluate the short-term outcomes and safety after LVHR in a total of 20 octogenarians, authors reported a minor complication rate of 50%, a major complication rate or 20%, and no perioperative mortality [8]. Urinary retention after surgery made up half of the reported minor complications (25%). Other minor complications included: pulmonary in 2 (10%) patients, ileus, hematoma, and cellulitis in three patients (5% for each). In our study, despite the high incidence of cardiovascular and pulmonary comorbidities, we encountered neither pulmonary complications nor the necessity of ICU admission post-operatively. Post-operative atrial fibrillation occurred in one patient, who had a known history, and

was treated successfully with β-blockade, and subsequently discharged at POD-5. We had two cases of post-operative urinary retention in our cohort, both with a history of benign prostate hypertrophy. Additionally, post-operative urinary tract infections were observed in two patients.

Blount et al. in their study on LVHR in octogenarians, report an average operating time in of 154.75 min [8], which was similar to our reported findings (mean: 150.52 min.). Worth noting, our cohort consisted of not only IPOM repairs which would be comparable to a laparoscopic approach, but also included retromuscular mesh placement. In a study examining postoperative LOS after robotic retromuscular VHR and open retromuscular VHR, with propensity score matching analysis, Carbonell et al. [26] determined that the average LOS was significantly shorter while the length of the operation was significantly longer in the RRVHR. The reported median LOS was 2 days, which is twice that of our series [LOS in day, median = 1 (IQR 0–2)]. Although the data of operative times was given as a categorical variable in this study [26], it is clearly recognized that more than 75% of the robotic retromuscular VHRs took longer than 180 min. This difference could be explained by a difference in anatomical complexity between cases included in our cohorts. The mean LOS of our cohort was shorter than other published studies on VHR in octogenarians (Table 4).

Patients who have chronic disease and multiple impairments are likely to have a longer inpatient LOS [27]. We found that there was a strong correlation between the length of the operation and the LOS. Patients who had surgery shorter than 90 min. were largely discharged on the same day (Fig. 1).

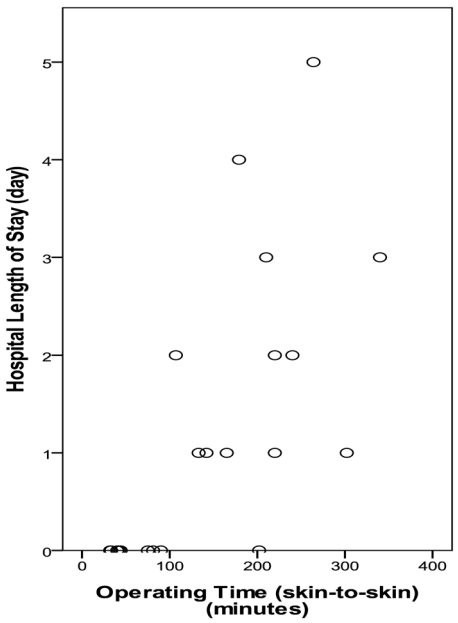

Fig. 1 Scatter-dot plot showing the correlation between operating time (skin-to-skin) and the hospital length of stay

Regarding hospital readmissions, in a nomogram developed and validated by Tevis et al. [28], bleeding disorders, prolonged procedure length, in-hospital complications, and dependent functional status and/or higher care at discharge

Table 4 Available studies on the outcomes of ventral hernia repair in octogenarians

Study, citation	Study type	Mean age (years)	Surgical approach	Number of patients	Operative time (min.)	Postoperative LOS (day)	Follow-up (months)	Morbidity	Perioperative mortality
Spaniolas et al. [9]	ACS-NSQIP database-driven, controlled	53.8*	Laparoscopic Open	586 4331	N/A	3.4	1 (study period)	9% (L, overall) 11.7% (O, overall)	0.9% (L) 1.8% (O)
Blount et al. [8]	Retrospective chart review, uncontrolled	82	Laparoscopic	20	154.75	4.8	3.1 (mean)	50% minor 20% major	0%
Present study	Prospective database retrospective review, uncontrolled	83.48	Robotic	21	150.52	1.24	23.5 (mean)	23.8% CD grade-I 28.6% CD grade II 0% CD grade III 0% CD grade IV	0%

CD Clavien–Dindo classification, *LOS* length of stay, *ACS-NSQIP* the american collage of surgeons national surgical quality improvement program, *N/A* not available, *L* laparoscopic, *O* open

*For both ≥ 80 age and < 80 age, the mean age of the octogenarians was not available

were statistically significant factors to predict postoperative readmission in patients who underwent general surgical procedures. A prolonged procedure was defined as longer than 133 min. for a minimally invasive surgery. Our study population had many of the above-mentioned predictive factors. In our study, while emergency visit observed in three patients, representing 14.2% of our entire cohort, none of them required hospital readmission. However, the evaluation of this nomogram in octogenarians would be another topic of study. A study examining reasons for 30-day readmission after VHR, suggests that prevention of failed discharges largely involves management and avoidance of nausea and emesis, which can be the sequela of general anesthesia [27]. From our cohort, while one patient was experienced the re-visit to ED for nausea, we encountered four additional patients with nausea at the post-operative course.

A number of subjective complaints such as nausea, pain or discomfort in the early postoperative period, are frequently assumed to be part of a normal postoperative course and can be overlooked, although these kinds of complaints can significantly affect a patient's quality of life. In our patient's charts, all complaints are recorded. Thus, we included any complaints in this study as a complication, which is defined as any deviation from the anticipated postoperative course. A number of assessment scales were used to objectively document these complaints.

When we examine our data in terms of mesh position in the time-line between 2013 and 2018; at first IPOM was the preferred approach followed by extraperitoneal approach (TAPP/RM ± TAR) at later time period. Eventually, extraperitoneal mesh placement has become the most common approach where author believes the advantage of robotic platform to enable placing non coated mesh in extraperitoneal location without the use of any tacking devices. In regards to approach selection, authors prefer TAPP approach for hernias less than 3–5 cm and if not feasible consider IPOM. For defects larger than 5 cm, authors prefer retromuscular approach ± component separation.

One drawback of our study is a lack of quality of life assessment data. Although pain assessments with certain scaling methods were performed in the hospital, pain reported at office visits was documented only subjectively, thus limiting our ability to quantify this for comparison. Complaints of pain or nausea in early postoperative course were assumed as a complication, thus our postoperative complication rate is likely higher than what might be clinically relevant. Another limitation is the lack of assessment of patient independence or functional status. Finally, an additional limitation is the small sample size of our cohort.

In conclusion, this study presents the perioperative and long-term outcomes of the first reported series of RVHR in octogenarians. We were able to exploit the layers of abdominal wall (rIPOM, rTAPP, rRM ± TAR) with reasonable operating time. The absence of conversion, perioperative mortality and recurrence confirm both the safety and the efficacy of RVHR in octogenarians.

Funding These authors have no support or funding to report.

Compliance with ethical standards

Conflict of interest Drs. Gokcal and Morrison have no conflicts of interest or financial ties to disclose. Dr. Kudsi receives teaching course and/or consultancy fees from Intuitive, Bard, Medtronic, Gore, Optecks, Medrobotic, outside the submitted work.

Ethical standards 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 The Institutional Review Board approved this study, and informed consent was obtained from all individual participants included in the study.

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