

Is Robotic-Assisted Surgery Safe in the Elderly Population? An Analysis of Gynecologic Procedures in Patients ≥ 65 Years Old

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ABSTRACT

Background. The elderly population is expanding worldwide but is underrepresented in clinical trials. We sought to assess the safety of robotic gynecologic surgery in an elderly cohort and to identify factors associated with unfavorable outcomes.

Methods. All patients ≥ 65 years who underwent a robotically assisted procedure at a single institution between May 2007 to December 2016 were divided into three age groups: 65–74 (Group 1); 75–84 (Group 2); ≥ 85 (Group 3). Perioperative outcomes were recorded in patients who did not require conversion to laparotomy. We compared clinical variables among groups and performed multivariate logistic regression to detect variables associated with major complications (\geq Grade 3) or 90-day mortality.

Results. We retrospectively identified 982 cases: 685 in Group 1; 249 in Group 2; 48 in Group 3. Median age = 71 years. Median BMI = 28.9. Malignancy was documented in 72.8% of cases; the majority were endometrial cancer (61.8%). Thirty-four patients (3.5%) were readmitted within 30 days. Seventy-seven (7.8%) had a postoperative complication, and 23 (2.3%) had a major complication. Ninety-day mortality was 0.5%. There was significant difference between groups with respect to body

mass index ($P = 0.026$), ECOG PS ($P \leq 0.001$), > 5 comorbidities ($P = 0.005$), hospital stay ($P < 0.001$), major complications ($P = 0.001$), and 90-day mortality ($P < 0.001$). On multivariable logistic regression, age ≥ 85 years was associated with major complications. Body mass index, age ≥ 85 years, and major complications were significantly associated with 90-day mortality.

Conclusions. Robotic-assisted surgery appears to be safe in an elderly cohort. The incidence of overall and major complications is consistent with those reported in the literature. Patients ≥ 85 years old appear to be at higher risk of unfavorable outcomes.

In the past few decades, we have observed an increase in life expectancy and, consequently, in the elderly population worldwide. According to World Health Organization data, the number of individuals older than 65 years increased by 140 million between 1975 and 1995, and it is projected that the elderly will constitute 10% of the world population by 2025.¹ This poses a unique challenge to physicians, both medically and surgically. The challenges are especially significant in cancer care, because elderly patients present with more medical comorbidities and pose a greater risk for postoperative complications.^{2,3} Data have shown that older age is an independent risk factor for worse perioperative outcomes. For this reason, surgical treatment in the elderly often is less aggressive than in younger patients and may even be deferred.^{4–13}

Therefore, it is of interest to investigate minimally invasive surgical (MIS) approaches in this population. MIS approaches may result in fewer complications without

TABLE 1 Cases converted to laparotomy ($N = 78$)

Reason for conversion	<i>N</i>	%
Adhesions	44	56.4
Extent of disease	18	23.1
Uterine size	7	8.9
Specimen removal	3	3.8
Limited visualization	2	2.6
Complex procedure	2	2.6
Intraoperative complication	2	2.6

compromising surgical aggressiveness when needed. As an alternative to laparotomy, laparoscopy represents a valid and well-studied MIS approach. It is associated with lower rates of complication, less blood loss, reduced postoperative pain, shorter hospital stay, and quicker return to normal activities.^{14–18} These benefits hold true for both young and elderly patients.¹⁹ A robotic surgical platform was approved in 2005 by the Food and Drug Administration (FDA); since then it has been used with increasing frequency, especially in oncologic surgery. The robotic platform also offers potential benefits for the surgeon compared with traditional laparoscopy—including a three-dimensional view, greater magnification, and absence of hand tremor—without any loss of the advantages offered by laparoscopy.^{20–23}

The advantages of the robotic-assisted MIS approach may be particularly critical in elderly patients, who present with higher burdens of physical restriction and comorbidities, and are considered at increased surgical risk.^{2, 3} Unfortunately, there is very limited data regarding MIS in the elderly population, especially in those older than age 80 years.^{24–26} Many surgeons and anesthesiologists are reluctant to perform laparoscopic or robotic surgery for patients in this age group, due to concerns about the effects of Trendelenburg position and hypercapnia in a population with increased risk of cardiopulmonary complications.²⁷ We sought to examine the perioperative outcomes in a cohort of elderly patients undergoing elective robotic-assisted gynecologic surgery at our institution.

MATERIALS AND METHODS

This study was approved by the Institutional Review Board at Memorial Sloan Kettering Cancer Center (MSKCC). All consecutive patients ≥ 65 years old who were scheduled to undergo a planned robotic-assisted gynecologic procedure at MSKCC from May 1, 2007 to December 31, 2016 were identified. Perioperative characteristics were retrospectively recorded (indication for surgery, type of procedure, uterine size, estimated blood

loss, operative time, conversion rates, intraoperative and postoperative complications, length of hospital stay, and readmission rates within 30 days following surgery). All surgeries were performed by fellowship-trained gynecologic oncologists. Conversion rates were recorded; however, cases requiring laparotomy due to intraoperative conversion were not included in the final analysis. An institutional surgical secondary event grading system was used to assess complications occurring within 30 days of surgery. The rate of complications was assessed only in patients not requiring conversion to laparotomy. Any death that occurred within 90 days from surgery also was noted.

In general, “elderly” has been defined as a chronological age of 65 years or older. The elderly can be further divided into the following groups: those aged 65–74 years (“early elderly”), individuals 75 years and older (“late elderly”), and those aged 85 years and older (“very elderly”).²⁸ We decided to use age groupings based on these commonly accepted definitions. Thus, the patients in our study were divided into three corresponding age groups for analysis: Group 1 (65–74 years); Group 2 (75–84 years); and Group 3 (≥ 85 years).

Minor procedures were defined as any diagnostic procedure involving biopsies or adnexal surgery only. Major procedures were defined as any surgical procedure that included at least a hysterectomy and uni-/bilateral salpingo-oophorectomy. We considered a procedure to be safe if the overall incidence of complication was comparable to $\pm 10\%$ in the general population. Associations were tested using the Chi square test for categorical or ordinal variables and the Kruskal–Wallis test for continuous variables. Multivariate logistic regression analysis was performed to identify potential independently associated predictors of grade 3 or higher complications or of 90-day mortality. Statistical significance was set at $P > 0.05$. All of the statistical analysis was done using SPSS software.

RESULTS

We identified 1060 women, aged ≥ 65 years, who were scheduled to undergo a planned robotic-assisted procedure. Seventy-eight (7.4%) cases required conversion to laparotomy: 58 (5.5%) cases were converted before and 20 (1.9%) were converted after docking the robotic platform. Reasons for conversion are reported in Table 1; the most common were presence of adhesions (56.4%) and extent of disease (23.1%). These cases were not included in further analyses.

A total of 982 (92.6%) cases were completed robotically. Patients’ characteristics are shown in Table 2. The overall median age was 71 (range 65–96) years, and the median BMI was 29.8 (range 14.2–65.1) kg/m^2 . Most

TABLE 2 Characteristics of robotically completed cases and comparison of age groups

Variable	Total (N = 982)	Group 1 (age 65–74) N = 685 (%)	Group 2 (age 75–84) N = 249 (%)	Group 3 (age ≥ 85) N = 48 (%)	P value
Age (y)					
Median (range)	71 (65–96)	69 (65–74)	78 (75–84)	86.5 (85–96)	< 0.001
Race					
American Indian/Alaskan Native	1	0	1 (0.4%)	0	0.128
White	831	576 (84.1%)	211 (84.7%)	44 (91.7%)	
Asian	28	22 (3.2%)	3 (1.2%)	3 (6.3%)	
Black	55	239 (5.7%)	16 (6.4%)	0	
Unknown	67	48 (7%)	18 (7.2%)	1 (2.1%)	
BMI (kg/m ²)					
Median (range)	28.9 (14.2–65.1)	29.2 (14.2–65.1)	28.9 (16–56.6)	26.65 (18.4–50)	0.026
ECOG					
0	726 (74%)	538 (78.5%)	163 (65.7%)	25 (52.1%)	< 0.001
1	206 (21%)	126 (18.4%)	63 (25.4%)	17 (35.4%)	
2	41 (4.2%)	20 (2.9%)	18 (7.3%)	3 (6.3%)	
3	7 (0.7%)	1 (0.1%)	3 (1.2%)	3 (6.3%)	
4	1 (0.1%)	0	1 (1.7%)	0	
5	0	0	1 (1.7%)	0	
5 or more comorbidities	182 (18.5%)	109 (15.9%)	62 (24.9%)	11 (22.9%)	0.005
Previous abdominal surgery	507 (51.6%)	365 (53.3%)	117 (47%)	25 (51.2%)	0.234
Indication for surgery					
Benign	64 (6.5%)	46 (6.7%)	15 (6%)	3 (6.3%)	0.261
Uterine hyperplasia	41 (4.2%)	30 (4.4%)	8 (3.2%)	3 (6.3%)	
Uterine cancer	607 (61.8%)	412 (60.1%)	167 (67.1%)	28 (58.3%)	
Breast cancer/risk-reducing	9 (0.9%)	7 (1%)	1 (0.4%)	1 (2.1%)	
Benign adnexal mass	147 (15%)	110 (16.1%)	34 (13.7%)	3 (6.3%)	
Ovarian/fallopian tube cancer	74 (7.5%)	48 (7%)	16 (6.4%)	10 (20.8%)	
Cervical dysplasia	6 (0.6%)	5 (0.7%)	1 (0.4%)	0	
Cervical cancer	22 (2.2%)	17 (2.5%)	5 (2%)	0	
2 Gynecologic primaries	4 (0.4%)	3 (0.4%)	1 (0.4%)	0	
Lymphoma	4 (0.4%)	4 (0.6%)	0	0	
Other	4 (0.4%)	3 (0.4%)	1 (0.4%)	0	
Procedure					
Minor	131 (13.3%)	96 (14%)	30 (12%)	5 (10.4%)	0.611
Major	851 (86.7%)	589 (86%)	219 (88%)	43 (89.6%)	
Estimated blood loss (cc)					
Median (range)	50 (0–800)	50 (0–800)	50 (0–450)	50 (10–200)	0.299
*Uterine size (gr)					
Median (range)	91 (27–740)	91.3 (6–740)	89.5 (28.5–410)	87.8 (29–229)	0.770
Operating room time (mins)					
Median (range)	159 (40–450)	155 (68–450)	149 (40–367)	141 (61–300)	0.418
Length of stay (days)					
Median (range)	0 (0–19)	0 (0–19)	0 (0–13)	1 (0–11)	< 0.001
Intraoperative complication	4 (0.4%)	3 (0.4%)	1 (0.4%)	0	0.899
Perioperative complication	77 (7.8%)	51 (7.4%)	20 (8.0%)	6 (12.5%)	0.449
Major (G3–5) complication	23 (2.3%)	12 (1.8%)	6 (2.4%)	5 (10.4%)	0.001
Readmission within 30 days	34 (3.5%)	22 (3.2%)	8 (3.2%)	4 (8.3%)	0.167
Death within 90 days	5 (0.5%)	1 (0.1%)	2 (0.8%)	2 (4.2%)	< 0.001

*Only 785 patients were evaluated for uterine size

TABLE 3 Complications (*N* = 83). Some patients had more than 1 complication

	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Total <i>N</i> (%)
Intra-operative (<i>N</i> = 4)						
Genitourinary	0	0	3	0	0	3 (75%)
Hematologic/vascular	0	0	1	0	0	1 (25%)
Postoperative (<i>N</i> = 79)						
Cardiovascular	1	2	1	0	1	5 (6.3%)
Gastrointestinal	3	5	6	0	0	14 (17.7%)
Genitourinary	18	1	0	0	0	19 (24%)
Hematologic/vascular	2	5	3	0	0	10 (12.7%)
Neurologic	1	1	1	0	1	4 (5.1%)
Intra-abdominal collection	0	2	4	0	0	6 (7.6%)
Pulmonary	1	0	0	0	0	1 (1.3%)
Wound/skin	18	0	2	0	0	20 (25.3%)

patients were white (*n* = 831; 84.6%). An ECOG performance score of 0 or 1 was documented in 932 (95%) patients. One hundred eighty-two (18.5%) patients had more than 5 comorbidities, and 507 (51.6%) had undergone previous abdominal surgery. A diagnosis of malignancy was documented in 72.8% of the cases (*n* = 715); the majority were endometrial cancer (*n* = 607, 61.8%). Major procedures were performed in 851 (86.7%) patients.

Overall intra- and postoperative characteristics are depicted in Table 2. Four (0.4%) patients had intraoperative complications: three patients had a grade 3 urologic complication (2 involving the bladder, 1 involving the ureter), and one patient suffered injury to the inferior vena cava. Seventy-seven (7.8%) patients had at least one postoperative complication, 23 (2.3%) of which were major complications (\geq grade 3). The most common postoperative complications (grades 1–5) were wound- or skin-related (25.3%), followed by genitourinary complications (24%; Table 3). The incidence of major complications was 2.3%. The most common major complications were gastrointestinal (6 cases), all of which required surgical reintervention: one because of a postoperative bowel perforation, one for an incarcerated Richter’s hernia, and four for small bowel obstruction.

Thirty-four (3.5%) patients were readmitted within 30 days from surgery. The most common reasons for readmission were gastrointestinal issues. Of the 11 patients (30.6%) who were readmitted for a gastrointestinal complication, 8 had a bowel obstruction, 1 had a Clostridium Difficile infection, 1 experienced nausea refractory to oral medications, and 1 developed a fistula. Six patients were readmitted for wound or skin complications (16.7%) and five (13.9%) for bleeding or hematomas. Four women (11.1%) were readmitted for genitourinary issues and four (11.1%) for an intraabdominal collection requiring drainage. Two (5.6%) patients were readmitted due to a thromboembolic event, one (2.8%) patient was readmitted for pneumonia, two for neurologic issues (5.6%), and one for a

vaginal cuff dehiscence (2.8%). Five (0.5%) patients died within 90 days from surgery; one of these patients died before discharge from the hospital due to a massive stroke. The other causes of death were: occlusion of the right coronary artery in one patient; a cancer-related death in one patient; and unknown cause of death in two patients.

There were 685 patients in Group 1, 249 in Group 2, and 48 in Group 3. Characteristics of the three groups are depicted in Table 2. There were no significant differences between the three groups with respect to race, previous abdominal surgery, indication for surgery, type of surgical procedure performed, estimated blood loss, uterine size, operative times, overall intraoperative or postoperative complications, and readmission rates within 30 days. Median body mass index (BMI) was 29.2 (range 14.2–65.1) kg/m² in Group 1, 28.9 (range 16–56.6) kg/m² in Group 2, and 26.7 (range 18.4–50) kg/m² in Group 3 (*P* = 0.026). A major perioperative complication occurred in 12 (1.8%) of the patients in Group 1, 6 (2.4%) in Group 2, and 5 (10.4%) in Group 3 (*P* = 0.001). Table 4 summarizes the univariable and multivariable analyses of factors associated with major perioperative complications. ECOG status was not included in the multivariable analysis, because it was multicollinear with age. Age \geq 85 years was the only factor associated with development of a major perioperative complication on univariate analysis and retained an independent association after adjusting for presence of five or more comorbidities, prior abdominal surgery, and whether or not a major procedure was performed (adjusted hazard ratio [HR] 5.92 (95% confidence interval [CI] 1.95–17.96, *P* = 0.002).

Mortality within 90 days of surgery occurred in 1 (0.1%) patient in Group 1, 2 (0.8%) in Group 2, and 2 (4.2%) in Group 3 (*P* < 0.001). Univariable and multivariable analyses of factors associated with 90-day mortality are presented in Table 5. Age \geq 85 (adjusted HR

TABLE 4 Multivariable analysis of factors associated with major (G3–5) perioperative complications

Variable	Univariate		Multivariable	
	HR (95% CI)	<i>P</i> value	Adjusted HR (95% CI)	<i>P</i> value
Age group (years)				
65–74	Reference	–	Reference	–
75–84	1.38 (0.51–3.73)	0.520	1.29 (0.47–3.53)	0.612
85+	6.52 (2.19–19.35)	0.001	5.92 (1.95–17.96)	0.002
BMI (kg/m ²)	0.98 (0.92–1.04)	0.570	0.98 (0.92–1.04)	0.508
EGOC group				
0	Reference	–		
1–2	1.38 (0.56–3.43)	0.485		
3–4	6.77 (0.78–58.53)	0.082		
5 or more comorbidities				
No	Reference	–	Reference	–
Yes	1.57 (0.61–4.04)	0.349	1.66 (0.61–4.54)	0.321
Prior abdominal surgery				
No	Reference	–	Reference	–
Yes	1.22 (0.53–2.82)	0.635	1.31 (0.55\6–3.05)	0.537
Procedure				
Major	Reference	–	Reference	–
Minor	3.45 (0.46–25.81)	0.228	3.73 (0.49–28.54)	0.204

All variables were tested for multicollinearity. Clinically significant variables and variables with $P < 0.2$ on univariate analysis were included in the multivariable analysis

TABLE 5 Multivariable analysis of factors associated with 90-day mortality

Variable	Univariate		Multivariable	
	HR (95% CI)	<i>P</i> value	Adjusted HR (95% CI)	<i>P</i> value
Age group (years)				
65–74	Reference	–	Reference	–
75–84	2.76 (0.17–44.26)	0.474	2.18 (0.09–49.19)	0.623
85+	29.74 (2.65–334.1)	0.006	29.67 (1.42–617.6)	0.029
BMI (kg/m ²)	1.11 (1.01–1.22)	0.036	1.166 (1.03–1.32)	0.017
ECOG group				
0	Reference	–		
1–2	5.92 (0.53–65.55)	0.147		
3–4	103.57 (5.87–1826.7)	0.002		
5 or more preoperative comorbidities				
No	Reference	–	Reference	–
Yes	4.43 (0.62–31.68)	0.138	1.47 (0.15–14.22)	0.738
Procedure				
Minor	Reference	–	Reference	–
Major	0.46 (0.05–4.45)	0.503	0.17 (0.01–3.23)	0.239
Length of surgery (min)	1 (0.99–1.01)	0.608	1 (0.98–1.02)	0.924
Major complication				
No	Reference	–	Reference	–
Yes	45.57 (6.12–339.1)	<0.001	27.88 (1.88–414.11)	0.016

All variables were tested for multicollinearity. Clinically significant variables and variables with $P < 0.2$ on univariate analysis were included in the multivariable analysis

29.67, 95% CI 1.42–617.6, $P = 0.029$), BMI (adjusted HR 1.17, 95% CI 1.03–1.32, $P = 0.017$), and occurrence of a major perioperative complication (adjusted HR 27.88, 95% CI 1.88–414.11, $P = 0.016$) were significantly associated with 90-day mortality on multivariable analysis.

DISCUSSION

The elderly population is growing worldwide. As people live longer, we will continue to see an increase in surgical and medical care given to older individuals. Thus, there is growing interest in this subgroup of patients, who constitute a significant economic burden with respect to healthcare but often are inadequately treated due to concerns about their physical limitations and comorbidities.

MIS has become the standard of care for many patients with gynecologic cancers. However, although the elderly population represents the fastest-growing cohort of patients worldwide, they are significantly underrepresented in clinical studies involving robotic surgery. This is especially true for patients older than 80 years.^{24–26} In this study, we assessed the feasibility and safety of robotic-assisted surgery in the elderly population. To our knowledge, this is one of the largest case series ever reported that focuses on elderly women undergoing robotic-assisted surgery for benign and malignant gynecologic indications.

The risk of adverse events in similar age groups has been reported to be as great as 33%.^{23,29–38} The incidence of overall complications in our cohort was much lower (8.2%)—similar to that reported for the general population (approximately 9%) in a recent review and meta-analysis of the literature.^{39, 40} This indicates that robotic surgery in the elderly appears to be feasible, with acceptable morbidity. In our study, we found no increased risk of overall complications within the three age groups examined. We did note an increased incidence (10% vs. < 3%) of major complications (Grades 3–5) in patients aged 85 years or older. However, although we observed an unfavorable trend related to age, it is important to emphasize that the overall incidence of adverse events was comparable to that reported in the literature for similar age groups, as well as for the general population.^{23, 29–40}

Our multivariate analysis revealed that age ≥ 85 years is independently associated with 90-day mortality. However, the overall mortality rate remained low (0.5%) and was approximately 4% in patients aged 85 years or older. During the 9-year study period, 5 of 982 patients died within 90 days of surgery. Of these, 2 were among the 48 women aged 85 years or older. There were no intraoperative deaths. One patient died during her hospital stay, and one patient died within the first 30 days after surgery. It is important to contextualize these results, because patients

aged 85 years or older are at risk for death even if they are not undergoing surgery. In addition to age, the development of a major perioperative complication, and higher body mass index, also were associated with increased risk of mortality. Appropriate preoperative medical assessment and careful selection are required for all patients, especially those aged 85 years or older.

Several other findings from our analysis also are of interest. Operative times and blood loss were similar to those reported in other published data.^{23, 29–38} Hospital stay was similar to, if not shorter than, that reported in the literature. We recorded a median hospital stay of 0 days compared with the median range of 1–3 days reported in the literature.^{23, 29–38} Our analysis demonstrates that same-day and next-day discharge is quite possible for elderly patients undergoing robotic-assisted gynecologic surgery, even those aged 85 years or older. Additionally, these patients are not at higher risk of conversion to laparotomy compared with the general population, with approximately 7% of planned robotic cases requiring conversion.^{39, 40} Some physicians are reluctant to perform MIS in the elderly because of concerns related to the effects of Trendelenburg and hypercapnia in a population with an increased risk of cardiopulmonary complications or ischemic optic neuropathy.⁴¹ However, it is important to emphasize that no cases in the current study had to be converted or aborted due to a patient's inability to tolerate the Trendelenburg position, pneumoperitoneum, or cardiorespiratory complication; conversions were due only to anatomical and technical issues, such as adhesions or extent of disease. No visual loss was encountered in our analysis, and only 5 cardiovascular complications were registered for 982 patients—none of which occurred intraoperatively.

The strengths of this study include its large sample size, and the fact that all procedures were conducted by fellowship-trained gynecologic oncologists. Additionally, we captured all consecutive cases within the study period. Limitations include the retrospective nature of the study, which had the potential to result in an underreporting of complications. However, our institution has a robust complication assessment system, which has been adopted by others. A dedicated research assistant reviewed all surgical cases to identify any possible perioperative complications. The inclusion of robotic-assisted cases since the initial implementation of the robotic platform may have affected the outcomes, due to the learning curves of surgeons.

In summary, we found that robotic-assisted gynecologic surgery is feasible and safe in an elderly patient population. It should be considered when appropriate and offered to properly selected elderly patients—even the most elderly. Others also have concluded the same and have stressed the

importance of a multidisciplinary approach.³⁸ Conversion rates and incidences of overall and severe complications were low, consistent with the complication rates reported in other series of MIS in patients of all ages. Age \geq 85 years may be associated with a slightly longer hospital stay, increased 90-day mortality, and occurrence of major complications. In patients aged 85 or older, there are increased risks, as would be expected, but these appear acceptable. However, in elderly patients younger than 85 years, perioperative outcomes appear to be the same as in patients who are much younger. Our data provide important information to surgeons who must discuss the risks and benefits of surgery with their elderly patients. Robotic-assisted gynecologic surgery should not be withheld from elderly patients for whom the benefits of surgical intervention outweigh the risks.

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