Robotic-assisted Gynecological Surgery in Older Patients – a Comparative Cohort Study of Perioperative Outcomes

Robotisch assistierte gynäkologische Chirurgie bei älteren Patientinnen – eine komparative Kohortenstudie zum perioperativen Verlauf

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ABSTRACT

Study design Because of current demographic developments, a hypothesis was proposed whereby older female patients aged > 65 years can be safely operated using minimally invasive, robotic-assisted surgery, despite having more preoperative comorbidities. A comparative cohort study was designed to compare the age group ≥ 65 years (older age group, OAG) with the age group < 65 years (younger age group, YAG) after robotic-assisted gynecological surgery (RAS) in two German centers.

Patients and methods Consecutive RAS procedures performed between 2016 and 2021 at the Women's University Hospital of Jena and the Robotic Center Eisenach to treat benign or oncological indications were included in the study. The age groups were compared according to their preoperative comorbidities (ASA, Charlson comorbidity index [CCI], cumulative illness rating scale – geriatric version [CIRS-G]) and perioperative parameters such as Clavien-Dindo (CD) classification of surgical complications. Analysis was performed using Welch's *t*-test, chi^2 test, and Fisher's exact test.

Results A total of 242 datasets were identified, of which 63 (73 ± 5 years) were OAG and 179 were YAG (48 ± 10 years). Patient characteristics and the percentage of benign or oncological indications did not differ between the two age groups. Comorbidity scores and the percentage of obese patients were higher in the OAG group: CCI (2.7 ± 2.0 vs. 1.5 ± 1.3; p < 0.001), CIRS-G (9.7 ± 3.9 vs. 5.4 ± 2.9; p < 0.001), ASA class II/III (91.8 % vs. 74.1 %; p = 0.004), obesity (54.1 % vs. 38.2 %; p = 0.030). There was no difference between age groups, even grouped for benign or oncological indications, with regard to perioperative parameters such as duration of surgery (p = 0.088; p = 0.368), length of hospital stay (p = 0.786; p = 0.814), decrease in Hb levels (p = 0.811; p = 0.058), conversion rate (p = 1.000; p = 1.000) and CD complications (p = 0.433; p = 0.745).

Conclusion Although preoperative comorbidity was higher in the group of older female patients, no differences were found between age groups with regard to perioperative outcomes following robotic-assisted gynecological surgery. Patient age is not a contraindication for robotic gynecological surgery.

ZUSAMMENFASSUNG

Studiendesign Im Kontext der demografischen Entwicklung wurde die Hypothese aufgestellt, dass ältere Patientinnen ≥ 65 Jahre trotz höherer präoperativer Komorbidität sicher minimalinvasiv robotisch assistiert operiert werden können. Im Design einer komparativen Kohortenstudie erfolgte der Vergleich der Altersgruppen ≥ 65 Jahre („older age group“, OAG) vs. < 65 Jahre („younger age group“, YAG) nach robotisch assistierter gynäkologischer Chirurgie (RAS) in 2 deutschen Zentren.

Patientinnen und Methoden Es wurden konsekutive RAS zwischen 2016 und 2021 mit benignen oder onkologischen Indikationen an der Universitätsfrauenklinik Jena und am Robotischen Zentrum Eisenach eingeschlossen. Der Altersgruppenvergleich erfolgte hinsichtlich präoperativer Komorbidität (ASA, „Charlson Comorbidity Index“, CCI, „Cumulative Illness Rating Scale – Geriatric Version“, CIRS-G) und perioperativer Parameter einschließlich Clavien-Dindo-(CD-)Komplikationen. Es wurden Welch's t-Tests, Chi^2-Tests und exakte Tests nach Fisher durchgeführt.

Ergebnisse Es konnten n = 242 Datensätze mit OAG n = 63 (73 ± 5 J.) and YAG n = 179 (48 ± 10 J.) identifiziert werden. Patientencharakteristika und Anteil an benignen bzw. onkologischen Indikationen unterschieden sich in den Altersgruppen nicht. Komorbiditäts-Scores inkl. Adipositasanteil waren in der OAG höher: CCI (2,7 ± 2,0 vs. 1,5 ± 1,3; p < 0,001), CIRS-G (9,7 ± 3,9 vs. 5,4 ± 2,9; p < 0,001), ASA-Klasse II/III (91,8 % vs. 74,1 %; p = 0,004), Adipositas (54,1 % vs. 38,2 %; p = 0,030). Weder bei benignen noch bei onkologischen Indikationen unterschieden sich die Altersgruppen hinsichtlich perioperativer Parameter wie Operationsdauer (p = 0,088; p = 0,368), stationärem Aufenthalt (p = 0,786; p = 0,814), Hb-Abfall (p = 0,811; p = 0,058), Konversionsrate (p = 1,000; p = 1,000) und CD-Komplikationen (p = 0,433; p = 0,745).

Schlussfolgerung Bei höherer präoperativer Komorbidität in der Gruppe der älteren Patientinnen waren in den untersuchten Kohorten keine Unterschiede im perioperativen Verlauf nach robotisch assistierter gynäkologischer Chirurgie zwischen den verglichenen Altersgruppen zu finden. Das Patientinnenalter stellte keine Kontraindikation für robotische gynäkologische Chirurgie dar.

Abbreviations

ASA	risk classification of the American Society of Anesthesiologists
BMI	body mass index
CCI	Charlson comorbidity index
CD	Clavien-Dindo classification
CIRS-G	cumulative illness rating scale – geriatric version
ICU	intensive care unit
MIS	minimally invasive surgery
OAG	older age group
OAS	open abdominal surgery
RAS	robotic-assisted surgery
SD	standard deviation
UTI	urinary tract infection
WHO	World Health Organization
YAG	younger age group

Introduction

As disproportionate aging of populations is taking place in almost all industrial countries, healthcare systems are facing increasing numbers of older and very old patients who are entitled to comprehensive healthcare services and who expect to be socially independent. For this reason, surgical therapeutic options – if indicated – should not be questioned based only on patient age.

The use of robotic-assisted surgical systems, which represents a technological advance in minimally invasive surgery, is becoming increasingly popular among gynecological surgeons in Europe [1]. While robotic assistance is already widely used in gynecological-oncological surgery [2, 3], it is now increasingly being used in the surgical treatment of complex benign gynecological diseases, for procedures requiring extensive suturing [4], in obese female patients, or in patients who have had multiple previous abdominal operations [5, 6]. The use of high-precision instruments, excellent imaging of the anatomy, and good ergonomics mean that the risk of minimally invasive approaches requiring conversion in cases with advanced disease is decreasing and this approach can even be used in cases with complex constraints. Compared to open surgery, minimally invasive procedures reduce postoperative morbidity and require shorter hospital stays [7, 8, 9, 10, 11], which can have a positive impact both economically and for the individual patient.

It is known that comorbidity increases the risk of surgical complications in elderly female patients [12, 13]. Although minimally invasive pelvic surgery has been safely carried out in very old female patients [14], anesthesiologists and gynecologists are often cautious when considering the use of the Trendelenburg position and hypercapnia in a group of patients who is at higher risk of cardiopulmonary complications [15]. While the use of a surgical robot during a minimally invasive approach to treat increasingly complex entities may avoid the disadvantages of open surgery, it will often be necessary to allow for longer operation times.

This comparative cohort study aimed to evaluate consecutively generated perioperative datasets obtained after robotic-assisted gynecological pelvic surgery (RAS) for complex benign and oncological indications and to compare outcomes for the age groups "patients ≥ 65 years of age" and "patients < 65 years of age". We hypothesized that older female patients ≥ 65 years of age could be safely operated using minimally invasive robotic-assisted surgery despite their higher preoperative comorbidity scores.

Patients and Methods

Patient groups and data

The study had a retrospective comparative design and evaluated all datasets of consecutively treated female patients who underwent robotic-assisted surgery (RAS) for complex gynecological benign or oncological indications at the Women's University Hospital of Jena and the Robotic Center of the Academic Teaching Hospital St. Georg Klinikum Eisenach between 2016 and 2021. All RAS procedures were carried out by a team trained in robotic surgery. The complexity of disease or procedure was evaluated at both centers as part of routine clinical practice, but patient age was not considered an inclusion or exclusion criterion for RAS.

The data search was done using paper or computer-based patient files. All patients gave their informed consent.

The data of the group of patients aged ≥ 65 years (older age group, OAG) was compared with that of the group of patients aged < 65 years of age (younger age group, YAG). Patient characteristics such as age, parity, obesity class (WHO), preoperative comorbidity based on BMI, ASA, the Charlson comorbidity index (CCI) and the cumulative illness rating scale – geriatric version (CIRS-G), as well as perioperative and postoperative parameters such as indication, previous open abdominal surgery, concomitant adhesiolysis, the conversion rate, duration of surgery, Hb decline, in-patient days, and surgical complications graded using the Clavien-Dindo (CD) classification were compared and analyzed, also according to subgroups of benign and oncological indications.

Grading of surgical complications was performed using the standard Clavien-Dindo (CD) system, in which a complication is defined according to the need for medication or surgical intervention. The evaluation interval included the time spent in hospital plus a 48-hour readmission interval.

All procedures were carried out using the surgical robot daVinci Si, X or Xi (Intuitive Surgical, Sunnyvale, CA, USA).

Statistical analysis

Data analysis was carried out using SPSS (Statistical Package for the Social Sciences; version 27.0; SPSS Inc., Chicago, IL, USA). Mean values of continuous variables were analyzed irrespective of homogeneity of variance using Welch's *t*-test, which does not require normal distribution for sample sizes > 30. Descriptive analysis of categorical data was carried out using chi^2 test or Fisher's exact test.

Results

The datasets of 242 consecutive robotic-assisted surgical procedures to treat complex benign or oncological indications were found. Four patients required conversion to open abdominal surgery (OAS), which corresponds to a rate of 1.6 % for the total cohort treated with robotic-assisted surgery (cervical cancer n = 2; endometrial carcinoma n = 1; deep infiltrating endometriosis n = 1). In these cases, conversion was required due to additional factors such as extensive abdominal adhesions combined with obesity.

The OAG consisted of 63 female patients aged 65 years or older; the YAG included 179 female patients below the age of 65 years. Patient characteristics are listed in ▶ **Table 1**. The mean age of the OAG was 73 ± 5 years; the oldest patient was 88 years old. Nine of the patients who underwent robotic-assisted surgery were more than 80 years old; the mean age of the YAG was 48 ± 10 years; the youngest patient was 27 years old.

With the exception of parity, which was higher in the OAG (p = 0.001), there were no differences between groups with regard to patient characteristics (▶ **Table 1**). All preoperative comorbidity scores were higher for the OAG (▶ **Table 2**): CCI (2.7 ± 2.0 vs. 1.5 ± 1.3; p < 0.001), CIRS-G (9.7 ± 3.9 vs. 5.4 ± 2.9; p < 0.001), ASA class II/III (91.8% vs. 74.1%; p = 0.004) and obesity using the WHO definition (54.1% vs. 38.2%; p = 0.030); concomitant adhesiolysis was needed more often in the OAG (p = 0.008; ▶ **Table 1**). There was no difference between the age groups regarding the rates of benign or oncological indications (▶ **Table 3**; p = 0.068). No severe complications were recorded for the very old patients above the age of 80 years.

▶Table 1 Basic characteristics of the study population; total study population (n = 242), Group 1 (≥ 65 y; n = 63), Group 2 (< 65 y; n = 179).

Variable	Total population (n = 242)	Group 1 (≥ 65 y) (n = 63)	Group 2 (< 65 y) (n = 179)	p
Age (years; mean ± SD)	54 ± 14 (n = 242)	73 ± 5 (n = 63)	48 ± 10 (n = 179)	< 0.001[1]
Age (years; Min–Max)	27–88	65–88	27–64	
Parity (mean ± SD)	1.67 ± 1.15 (n = 235)	2.08 ± 1.06 (n = 59)	1.53 ± 1.16 (n = 176)	0.001[1]
BMI (kg/m^2; mean ± SD)	28.9 ± 6.7 (n = 234)	29.8 ± 5.9 (n = 61)	28.6 ± 6.9 (n = 173)	0.174[1]
BMI of obese patients (kg/m^2; mean ± SD)	35.0 ± 5.5 (n = 99)	33.8 ± 4.8 (n = 33)	35.6 ± 5.7 (n = 66)	0.111[1]
Previous open abdominal surgeries	131/240 (54.1 %)	37/63 (58.7 %)	94/177 (53.1 %)	0.441[2]
Concomitant adhesiolysis	181/242 (74.8 %)	55/63 (87.3 %)	126/179 (70.4 %)	0.008[2]

[1] Welch's *t*-test, [2] chi^2 test. BMI = body mass index; SD = standard deviation; y = years.

▶Table 2 Preoperative comorbidity, total study population (n = 242), Group 1 (≥ 65 y; n = 63), Group 2 (< 65 y; n = 179).

Variable	Total population (n = 242)	Group 1 (≥ 65 y) (n = 63)	Group 2 (< 65 y) (n = 179)	p
CCI (mean ± SD)	1.8 ± 1.6 (n = 239)	2.7 ± 2.0 (n = 62)	1.5 ± 1.3 (n = 177)	< 0.001[1]
CIRS-G (mean ± SD)	6.55 ± 3.71 (n = 239)	9.7 ± 3.9 (n = 62)	5.4 ± 2.9 (n = 177)	< 0.001[1]
Obesity (n; WHO def.)	99/234 (40.9 %)	33/61 (54.1 %)	66/173 (38.2 %)	0.030[2]
Obesity class II/III	51/99 (51.5 %)	12/33 (36.4 %)	39/66 (59.1 %)	0.033[2]
ASA class II/III	176/223 (78.9 %)	56/61 (91.8 %)	120/162 (74.1 %)	0.004[2]

[1] Welch's *t*-test; [2] chi^2 test. ASA = risk classification of the American Society of Anesthesiologists; CCI = Charlson comorbidity index; CIRS-G = cumulative illness rating scale – geriatric; SD = standard deviation; y = years.

▶Table 3 Benign and oncological indications for RAS, total study population (n = 242), Group 1 (≥ 65 y; n = 63), Group 2 (< 65 y; n = 179).

	Total population (n = 242)	Group 1 (≥ 65 y) (n = 63)	Group 2 (< 65 y) (n = 179)	p
Benign	166 (68.6 %)	49 (77.8 %)	117 (65.4 %)	0.068
Oncological	76 (31.4 %)	14 (22.2 %)	62 (34.6 %)	

Chi^2 test. RAS = robotic-assisted surgery; y = years.

Benign indications

Benign indications for RAS included deep infiltrating endometriosis, complex pelvic floor defects of all three compartments, enlarged uterine myoma, complex adnexal findings, sepsis from pelvic abscesses, as well as additional complicating factors such as obesity or a history of multiple open abdominal surgeries. The investigated procedures also included four deep anterior rectum resections, a partial cystectomy carried out as part of the therapy of deep infiltrating endometriosis, and 11 multiple myoma enucleations with uterine reconstruction using a modified Osada procedure in women wanting to have children as well as 61 sacrocolpopexies. The mean uterine weight was 265 ± 278 g, with the highest weight recorded as 1840 g after robotic-assisted hysterectomy for uterine myoma (n = 73; ▶ **Table 4**). Concomitant adhesiolysis was more common in the OAG (p < 0.001), while the duration of surgery (p = 0.088), in-patient days (p = 0.786), blood loss (p = 0.811), conversion rate (p = 1.000), and the CD complication rate (p = 0.433) did not differ between the age groups (▶ **Table 4**). CD II complications (minor) requiring medication in the group of older female patients (Group 1) consisted of a hypertensive crisis treated with urapidil (n = 1), leg swelling of unclear origin treated with ibuprofen and cortisone after exclusion of leg vein thrombosis (n = 1), UTI treated with antibiotics (n = 1), persistent decrease in O_2 saturation treated by administering oxygen. CD III(b) complications (major) in the OAG which required an intervention under general anesthesia were port hernias after uterine morcellation using a morcellator in two prolapse patients with significant connective tissue weakness on the 2nd and 4th postoperative day, respectively.

CD II complications (minor) in the YAG (Group 2) consisted of minimal persistent bleeding without indications for revision, postoperative anemia requiring blood transfusion, one patient treated with antibiotics for paraclinical signs of infection after hysterectomy of a uterus weighing 1840 g, two patients treated with antibiotics for paraclinical signs of infection and fever of unclear origin, one patient requiring iron substitution due to an Hb of 6.1 mmol/l, four patients treated with antibiotics either for UTI or pneumonia, and one patient treated with antibiotics for hematoma of the apical vagina after hysterectomy of a uterus weighing 660 g without indications for revision. In Group 2, complications classified as CD III(b) (major) included laparoscopic revision for postoperative hemorrhage after surgical remediation of endometriosis (ASRM IV), multiple myoma enucleations, and uterine flap-plasty procedure in a patient wanting to have children.

Oncological indications

RAS was performed to treat oncological indications such as cervical (n = 45), endometrial (n = 18) or (early/borderline) ovarian cancer (n = 10) and used to carry out radical hysterectomies (n = 37), pelvic (n = 45) and para-aortic (n = 16) lymphadenectomies and omentectomies (n = 9), as indicated. No difference was found between patients in the different age groups treated for oncological indications with regard to concomitant adhesiolysis (p = 0.438), duration of surgery (p = 0.368), in-patient days (p = 0.814), blood loss (p = 0.058), conversion rate (p = 1.000), and CD complication rates (p = 0.745; ▶ **Table 5**).

CD II complications (minor) requiring drug therapy in the OAG included blood transfusion for postoperative anemia and antibiotic therapy for paraclinical signs of infection and fever. No CD III–V complications occurred after RAS for oncological indications in the OAG.

In the YAG, CD II complications (minor) treated with drug therapy included three patients with blood transfusion, one patient with iron substitution for postoperative anemia, one hypertensive crisis requiring drug therapy, two UTIs and one bladder voiding disorder treated with distigmine. One lymphocele puncture performed under local anesthesia (bed side) and one trocar hernia revision carried out under general anesthesia were classified respectively as CD IIIa and IIIb. In the YAG, one morbidly obese patient (BMI 58) had to be transferred to the ICU for one day for prolonged postoperative artificial respiration after RAS hysterectomy for endometrial cancer and was therefore classified as CD IV(a).

Discussion

The results of our study show that female patients above the age of 65 years can be safely treated using robotic-assisted gynecological surgery despite higher preoperative comorbidity scores and risk parameters (CCI, CIRS-G, ASA, BMI) and despite a higher rate of concomitant adhesiolysis, with no differences in the perioperative course compared to a younger comparison group.

Age and basic Characteristics

Use of a minimally invasive surgical approach in older female patients with oncological and benign indications for surgery has been investigated by several different working groups [14, 16, 17, 18, 19]. Although studies have shown that this approach is both feasible and safe in older patients, there are still concerns regarding the Trendelenburg position, insufflation pressure, hypercapnia, and duration of surgery [20, 15]. In clinical studies of surgical outcomes, old age is defined by most authors as 65 years or older [18, 21, 22]. Other studies on gynecological surgical strategies, for example, to treat endometrial cancer or reconstructive pelvic surgery, use a cut-off of 70 or 80 years [14, 23, 24, 25, 26, 27, 28]. Whether robotic-assisted surgery (RAS) can be safely carried out in older patients was recently investigated in urology [29, 30] and gastric and colorectal surgery [18, 31]. There are almost no clinical data available for the wide range of gynecological indications in older and very old female patients. Evaluation of perioperative parameters in a frail older population of patients aged ≥ 65 years found longer stays in hospital and more surgical complications [21]. Geriatric scoring systems such as CCI and CIRS-G or a standardized use of the definition and systematic classification of surgical complications using the Clavien-Dindo system [32, 33, 34] were not used [21]. In another study, the same working group of Aloisi et al. found less favorable outcomes following robotic surgery in patients over the age of 85 years [35]. We included female patients above the age of 65 years in the OAG of our study and found that this group also included nine very old patients aged ≥ 80 years in whom robotic-assisted gynecological procedures could also be safely and feasibly carried out. Because of the size of this subgroup, findings are not presented in detail.

While obesity is a known indication for using a surgical robot in minimally invasive procedures, the mean BMI in the OAG in our study was higher than in a previously investigated cohort of very old female patients who underwent minimally invasive pelvic surgery [14]. ▶ **Table 2** shows that although the patients in the OAG were more often obese according to the definition of obesity, the obesity class of obese patients tended to be higher in the YAG (corresponding to WHO class II/III). None of the patients included in our study had a BMI of less than 20 kg/m^2, which is a known indicator of frailty in geriatric patients and is associated with postoperative morbidity from wound infections and falls [36].

The difference in parity between the age groups reflects the percentage of women still wanting to have children who underwent robotic-assisted procedures to treat myomas or endometriosis in the YAG.

▶Table 4 RAS for benign indications (n = 166): perioperative parameters, Group 1 (≥ 65 y; n = 49), Group 2 (< 65 y; n = 117).

Variable	Total (n = 166)	Group 1 (≥ 65 y) (n = 49)	Group 2 (< 65 y) (n = 117)	p
Concomitant adhesiolysis	136/166 (81.9 %)	48/49 (98.0 %)	88/117 (75.2 %)	< 0.001[1]
Conversion to open surgery	1/166 (0.6 %)	0/49	1/117 (0.9 %)	1.000[1]
Duration of surgery (min; mean ± SD; all procedures)	159 ± 98 (n = 165)	144 ± 44 (n = 49)	165 ± 112 (n = 116)	0.088[2]
CD complications, total	26/166 (15.7 %)	6/49 (12.2 %)	20/117 (17.1 %)	0.433[3]
CD III–IV (major)	3/166 (1.8 %)	2/49 (4.1 %)	1/117 (0.9 %)	0.208[1]
Duration of stay in hospital (mean ± SD)	4.02 ± 1.63 (n = 163)	3.96 ± 1.94 (n = 48)	4.04 ± 1.50 (n = 115)	0.786[2]
Hb delta (mmol/l; mean ± SD)	-0.96 ± 0.65 (n = 158)	-0.94 ± 0.52 (n = 47)	-0.97 ± 0.70 (n = 111)	0.811[2]
Uterine weight (g)*	265 ± 278 (n = 73)	222 ± 192 (n = 7)	270 ± 287 (n = 66)	0.569[2]

[1] Fisher's exact test, [2] Welch's *t*-test, [3] chi² test
* After hysterectomy for uterine myoma.
CD = Clavien-Dindo; Hb = hemoglobin; SD = standard deviation; y = years.
Definition of CD interval: postoperative stay in hospital plus a 48-hour interval for readmission.

▶Table 5 RAS for oncological indications (n = 76): perioperative parameters, Group 1 (≥ 65 y; n = 14), Group 2 (< 65 y; n = 62).

Variable	Total (n = 76)	Group 1 (≥ 65 y) (n = 14)	Group 2 (< 65 y) (n = 62)	p
Concomitant adhesiolysis	45/76 (59.2 %)	7/14 (50 %)	38/62 (61.3 %)	0.438[1]
Conversion to open surgery	3/76 (3.9 %)	0/14	3/62 (4.8 %)	1.000[2]
Duration of surgery (min; mean ± SD; all procedures)	389 ± 165 (n = 76)	346 ± 196 (n = 14)	398 ± 157 (n = 62)	0.368[3]
CD complications, total	22/76 (28.9 %)	3/14 (21.4 %)	19/62 (30.6 %)	0.745[2]
CD III–IV (major)	3/76 (3.9 %)	0/14	3/62 (4.8 %)	1.000[2]
Duration of stay in hospital (mean ± SD)	6.95 ± 2.71 (n = 75)	7.14 ± 3.57 (n = 14)	6.90 ± 2.50 (n = 61)	0.814[3]
Hb delta (mmol/l; mean ± SD)	− 1.39 ± 0.74 (n = 76)	− 1.11 ± 0.55 (n = 14)	− 1.46 ± 0.76 (n = 62)	0.058[3]

[1] Chi² test, [2] Fisher's exact test, [3] Welch's *t*-test
CD = Clavien-Dindo; Hb = hemoglobin; SD = standard deviation; y = years.
Definition of CD interval: postoperative stay in hospital plus a 48-hour interval for readmission.

A history of previous open abdominal procedures predisposes patients undergoing repeat surgery to have concomitant adhesiolysis; they are also more likely to have longer surgery times, higher rates of conversion and more intraoperative complications [16, 35]. In our study, no differences were found between age groups with respect to previous open abdominal surgeries, even though the rates in our study were higher (58.7% and 53.1%) compared to the rates reported in the literature. Additional factors such as the occurrence of pelvic infections over the patient's lifespan could have led to the higher rate of concomitant adhesiolysis procedures in older patients (Group 1). Other studies did not differentiate between previous minimally invasive procedures and open abdominal interventions. Gitas et al. [37] reported a rate of 57% for patients with a history of prior surgical procedures in a cohort of 42 RAS hysterectomies but did not differentiate between open and minimally invasive procedures, which makes it more difficult to compare their results with our findings after gynecological pelvic surgery in 242 female patients. The high rates of previous open surgical procedures in our patient population could be the result of a specific local issue of the delayed introduction of minimally invasive gynecological, urological, and abdominal surgical techniques in the geographical region of western Thuringia.

Comorbidity and perioperative course

Age is an independent risk factor for surgical complications [38]. Nevertheless, the numerical age of an older patient should be less important than their health and biological fitness and should therefore be considered when deciding on a surgical treatment or the best surgical approach for benign or oncological entities. Geriatric scoring systems such as CCI [39] and CIRS-G [40, 41] are valid approved instruments for the standardized collection of information on comorbidities in older patients. Both indices should be used in clinical healthcare as reliable instruments for further examinations into the impact of comorbidities of older patients on (surgical) treatment outcomes [42]. Although the current scientific literature includes seven publications on RAS to treat endometrial cancer in older patients [22, 23, 24, 25, 26, 27, 28] and two studies on benign and oncological gynecological entities and RAS in old age [21, 35], only one of the studies used the CCI as the only validated score to register preoperative comorbidity in patients [22]. Guy et al. calculated a CCI of 2.6 for one RAS group of female patients aged over 65 years with endometrial cancer, which is identical to the CCI we found in our study. When the age groups were compared in our study, all preoperative comorbidity scores (CIRS-G, CCI, ASA class II/III) were higher in the OAG. Depending on the inclusion criteria, the CIRS-G scores in studies of geriatric patients were 19.7 [36], 5.5 [43], 2.4 [44] to 4.1 [14]. CIRS-G scores were lower in studies on elective surgery [44]. Our scores of 10 vs. 5.4 in the older vs. the younger age group show a high preoperative comorbidity burden in our older patients, also when compared to the results of studies on elective surgery [14, 44]. This reflects the philosophy of our center to use a robotic approach in patients with more complex primary diseases and comorbidities compared to less expensive laparoscopy.

Surgical complications in our study were classified using the Clavien-Dindo system [32, 33, 34]. In studies on surgical problems, the analysis of any complications occurring is a key element of a patient-centered evaluation of surgical quality. In studies on surgical methods, our working group uses the Clavien-Dindo (CD) classification system to categorize surgical complications, as it defines a surgical complication as "any deviation from the ideal postoperative course that is not inherent to the procedure, and does not comprise failure to cure" [33]. The need for an intervention determines the class (I–V) of the complication [32]. This classification system was evaluated for potential limitations, e.g., different medical standards, in 6336 patients. The authors found a strong correlation between duration of hospital stay and class I–V complications ($p < 0.0001$, Spearman's rank correlation test) which affected the evaluation interval [32]. There was no difference between total postoperative morbidity or frequency of minor or major surgical complications between the age groups in our study. The use of standardized validated classifications and indices allow study results to be compared between centers and enables scientific discussion. Other authors have reported higher complication rates after surgical procedures in geriatric female patients [14, 25]. Zeng et al. compared three different age groups who underwent RAS (< 70; 70–80; > 80 years) and only found a higher rate of severe complications (CD III/IV) in persons above the age of 80 years [25]. We found no serious complications in our small subgroup of patients above 80 years of age. The low complication rates after RAS reported in our study are too small to permit any binary or multivariate regression analysis which could explore the cause-and-effect relationship with regards to the parameters "duration of surgery", "BMI", "concomitant adhesiolysis" and "preoperative comorbidity scores". Prospective studies of larger cohorts would be necessary to detect correlations between comorbidity scores and surgical complications graded used a standardized score, and would make it possible to make preoperative risk predictions regarding the use of a surgical robot in geriatric patients. This would also be useful when providing information to patients preoperatively.

The main outcome of our study was the finding that patients aged 65 years or older can safely undergo robotic-assisted gynecological pelvic surgery, even though this age group has a higher preoperative comorbidity burden. The perioperative parameters und surgical complications did not differ from those of the younger comparison group.

Weighing up whether to use a robot in gynecological surgery to treat a wide range of benign and oncological indications in older female patients requires careful preoperative assessment and extensive information of patients. The aim is an interdisciplinary cooperation between medical specialties such as anesthesia, geriatrics, and internal medicine with the surgical specialty in the interests of patient safety and to achieve an optimal surgical outcome.

Strengths and limitations

The strength of this study is the scientific use of valid standardized comorbidity scores (CCI, CIRS-G, ASA) and the systematic classification of surgical complications using the CD system. This allows results to be compared with those of other working groups who have carried out RAS in geriatric patients. To the best of our knowledge, this is the first study which uses these instruments and examines the research question whether gynecological robotic-assisted pelvic surgery can be safely carried out in a population of older female patients.

The limitations of the study include bias due to the retrospective nature of the study, such as a lack of certain information in medical files, e.g., for ASA, or a lack of standardized criteria for robot use versus laparoscopy. In most clinical situations, the term "complex" describes difficult concomitant circumstances such as obesity, previous open abdominal surgery, large findings, or difficult anatomical topography; it may also refer to the "complex" nature of a procedure requiring extensive suturing (e.g., sacrocolpopexy) or an oncological procedure (e.g., in systematic lymphadenectomy). In a prospectively designed study, the inclusion criteria could be defined more precisely.

A further limitation is the small subgroup of oncological patients aged ≥ 65 years, which would allow the results of our study to be verified in a larger cohort.

Conclusions

The data of our study show that age is not an exclusion criterion for robotic-assisted gynecological surgery. Despite higher comorbidity rates, higher obesity rates and the higher rates of concomitant adhesiolysis, robotic-assisted gynecological surgery can be safely used to treat a wide range of complex benign and oncological indications in patients aged more than 65 years without higher postoperative morbidity. No differences between the studied age groups were found with respect to the perioperative course. The results of this study can be used in complex situations to help decide about the surgical approach prior to gynecological pelvic surgery to treat benign and oncological indications.

Contributors' Statement

A. R. Mothes: protocol/project development, data collection and management, patient recruitment, surgery, manuscript preparation and revision. A. Kather: data analysis and statistical interpretation of data, manuscript revision. I. Cepraga: data collection and management, assistant surgeon. A. Esber: data collection and management, assistant surgeon. A. Kwetkat: protocol/project development, data collection, ideas, manuscript revision. I. B. Runnebaum: project development, patient recruitment, surgery, manuscript revision.

Conflict of Interest

ARM has received support for robotic training and lecture fees from Intuitive Surgical. IBR has attended robotic training from Intuitive Surgical at no charge. AKa, IC, AE and AKw declare that they have no conflict of interest.

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