Surgical complications associated with robotic urologic procedures in elderly patients

Antonio Cusano, BS, Peter Haddock, PhD, Ilene Staff, PhD, Max Jackson, BA, Fernando Abarzua-Cabezas, MD, Ryan Dorin, MD, Anoop Meraney, MD, Joseph Wagner, MD, Steven Shichman, MD, Stuart Kesler, MD

Urology Division, Hartford Healthcare Medical Group, Hartford, Connecticut, USA

CUSANO A, HADDOCK P, STAFF I, JACKSON M, ABARZUA-CABEZAS F, DORIN R, MERANEY A, WAGNER J, SHICHMAN S, KESLER S. Surgical complications associated with robotic urologic procedures in elderly patients. *Can J Urol* 2015;22(1): 7607-7613.

Introduction: *Urologic malignancies are often diagnosed at an older age, and are increasingly managed utilizing robotic-assisted surgical techniques. As such, we assessed and compared peri-postoperative complication rates following robotic urologic surgery in elderly and younger patients.*

Materials and methods: *A retrospective analysis of IRB-approved databases and electronic medical records identified patients who underwent robotic-assisted urologic surgery between December 2003-September 2013. Patients were grouped according to surgical procedure (partial nephrectomy, radical cystectomy, radical prostatectomy) and age at surgery (≤ 74 or ≥ 75 years old). Associations between age, comorbidities, Charlson comorbidity index (CCI), and patient outcomes were evaluated within each surgery type.*

Results: *97.5% and 2.5% of patients were ≤ 74 or ≥ 75 years old, respectively. Cystectomies, partial nephrectomies and prostatectomies accounted for 3.5%, 9.5% and 87.1% of surgeries, respectively. Within cystectomy, nephrectomy and prostatectomy groups, 24.4%, 12.5% and 0.6% patients were ≥ 75 years old. Within each surgical type, elderly patients had significantly elevated CCI scores. Length of stay was significantly prolonged in elderly patients undergoing partial nephrectomy or prostatectomy. In elderly cystectomy, partial nephrectomy and prostatectomy patients, 36.7%, 14.3% and 5.9% suffered ≥ 1 Clavien grade 3-5 complication, respectively. Major complications were not significantly different between age groups. A qualitatively similar pattern was observed regarding Clavien grade 1-2 complications.*

Conclusions: *The risks of robotic-assisted urologic surgery in elderly patients are not significantly elevated compared to younger patients.*

Key Words: partial nephrectomy, prostatectomy, elderly, robotic, surgery, cystectomy

Introduction

Over the last three decades, improvements in healthcare and surgical technologies have greatly increased the average life expectancy for individuals in the United States – a trend that is expected to continue.[1] For the majority of surgical procedures, an open approach has been the traditional, gold standard surgical paradigm. However, laparoscopic and minimally invasive surgical techniques have steadily gained recognition and are now routinely utilized in both younger and elderly populations. The DaVinci robotic surgical system has emerged as a credible alternative to open surgical treatment and has been shown to be associated with superior preservation of organ function, shorter operative times, equivalent oncological efficacy and reduced morbidity.[2,3] However, there are limited published data comparing the use, success, and peri/postoperative complication rates associated with robotic surgery in the elderly population compared to a younger patient cohort. In the industrialized world, the life expectancy of a 75-year-old is currently more than 10 years.[4-6] As such, the risk management of robotic surgical procedures is of clinical relevance, especially when conservative management is not an option.

In the present study, we assessed the utilization of robotic surgery in patients aged either ≤ 74 or ≥ 75 years undergoing three different urological procedures at our clinical center. Our aim was to ascertain whether robotic urological surgery is associated with significantly elevated risks for elderly patients. We utilized a dichotomy of patient ages, rather than assessing the impact of age over a continuous scale.

Accepted for publication November 2014

Address correspondence to Dr. Peter Haddock, Hartford Healthcare Medical Group, Urology Division, Hartford Hospital, 85 Seymour Street, Suite 416, Hartford, CT 06106 USA

Materials and methods

We undertook a retrospective analysis of patients who underwent robotic-assisted urologic surgical procedures between December 2003 and September 2013 at our large, urban clinical urology practice. Data were retrieved from IRB-approved, prospectively-managed institutional databases, inpatient hospital electronic medical records, and outpatient electronic and paper physician-recorded medical charts. The robotic-assisted urological procedures included in the study were cystectomies, partial nephrectomies and prostatectomies performed by urology surgeons at our large, urban clinical center at Hartford Hospital. Patients in all groups had a minimum follow up of 90 days. However, some patients were tracked for longer periods of up to 5.7 years (69 months).

Patient demographics (gender, age and body mass index), comorbidities (specific comorbidities and Charlson Comorbidity Index (CCI)) and perioperative information (estimated blood loss; EBL, operative time and length of stay; LOS) were collected for each patient. The major outcome measure was the incidence of postoperative complications.

Patients were initially grouped based on the type of robotic surgical procedure (partial nephrectomy, radical cystectomy or radical prostatectomy). Within each surgical group, patients were further stratified based on their age at surgery (≤ 74 or ≥ 75 years old). Associations between age at the time of surgery, comorbidities, CCI score, and patient outcomes were evaluated within each surgery type.

Unfortunately, data regarding which surgeon performed each surgery was not available for every surgery subtype. Nonetheless, stratifying by surgeon would significantly have diminished the statistical power. As such, we did not stratify our data by surgeon.

The severity of complications was assessed using the Clavien classification system (grades 1-5). Complications graded as Clavien grade 1-2 were classed as 'minor', while Clavien grade 3-5 complications were termed as 'major'. Primary preoperative parameters assessed in this study included patient age, gender, body mass index (BMI) and comorbidities. Specific complications were categorized by system (e.g. cardiac, pulmonary, genitourinary, gastrointestinal).

Data related to each of the surgical procedures were analyzed separately. Differences between the two age groups for the presence and severity of complications were analyzed using chi-square tests of proportions. BMI, CCI and operative time were analyzed with independent group t-tests. LOS and EBL, due to the nature of their distribution, were analyzed with the Wilcoxon Ranked Sum test.

Results

Overall patient demographics

A total of 3541 patients (3404, 96.1% male; 137; 3.9% female) underwent urologic robotic surgery procedures between December 2003 and September 2013 and were initially stratified on the basis of their age at surgery (≤ 74 or ≥ 75 years old). Of these, 3452 (97.5%) and 89 (2.5%) of patients were ≤ 74 or ≥ 75 years old, respectively, at the time of undergoing their robotic surgical procedure. When further stratified by surgery type, cystectomy, partial nephrectomy and prostatectomy accounted for 123 (3.4%), 335 (9.5%) and 3083 (87.1%) of cases across all patient ages, respectively.

The stratification of patient demographics by age at time of cystectomy, partial nephrectomy or prostatectomy is detailed in Table 1.

Patients undergoing robotic cystectomy

A total of 123 patients (97 male, 79.9%; 26 female, 21.1%) underwent robotic cystectomy of which 93 (75.6%) and 30 (24.4%) were ≤ 74 and ≥ 75 years old, respectively. Elderly patients (≥ 75 years old) had significantly elevated CCI scores compared to patient's ≤ 74 years old (5.5 ± 1.5 versus 3.7 ± 1.6; $p < 0.001$). ASA scores were not significantly elevated in elderly compared to young patients ($p = 0.071$, Table 1). BMI was significantly elevated in patient's ≤ 74 years old (25.7 ± 3.5 versus 28.7 ± 5.1 kg/m^2, $p = 0.007$). EBL and LOS were not significantly different between the two age groups (EBL: 400 (IQR: 275-800) versus 500 (IQR: 300-700) mL, $p = 0.356$; LOS: 8 (IQR: 6-17.25) versus 8 (IQR: 7-11) days, $p = 0.897$; Table 1). Operative time was significantly shorter in older compared to younger patients (492.1 ± 92.0 versus 575.8 ± 159.9 min; $p < 0.004$, respectively). Demographics and perioperative surgical indices are summarized in Table 1.

In patients who underwent radical cystectomy a total of 46/123 (37.4%) patients received a continent urinary diversion (33 Neobladder and 13 Indiana Pouch). Of these, 1/30 (3.3%) of patients ≥ 75 years old received a continent diversion (1 Neobladder), and 45/93 (48.4%) patients ≤ 74 years old received a continent diversion (32 Neobladder, 13 Indiana Pouch).

In cystectomy patients, there was no significant difference in the incidence of any individual comorbidity between age groups, Table 2. However, elderly patients were significantly more likely to have an elevated number of comorbidities ($p = 0.03$; Table 3).

TABLE 1. **Patient demographics and clinical indices (†t-test for equality of means; §Wilcoxon Ranked Sum test)**

	Cystectomy			Nephrectomy			Prostatectomy		
	≤ 74 yrs	**≥ 75 yrs**	**p value**	**≤ 74 yrs**	**≥ 75 yrs**	**p value**	**≤ 74 yrs**	**≥ 75 yrs**	**p value**
# of patients	93 (75.6)	30 (24.4)	-	293 (87.5)	42 (12.5)	-	3066 (99.4)	17 (0.6)	-
Age (yrs) (mean; range)	62.5±7.8 (38-74)	80.0±3.7 (75-86)	-	57.6±9.9 (28-74)	77.8±2.2 (75-83)	-	59.7±6.5 (36-74)	75.5±0.7 75-77	-
# of males (%)	70 (75.3)	27 (90.0)	-	196 (66.9)	28 (66.7)	-	3066 (100)	17 (100)	-
Mean BMI (kg/m^2)	28.7±5.1	25.7±3.5	0.007†	29.7±5.7	27.2±4.2	0.001†	28.1±4.3	27.1±4.7	0.347†
ASA score (median; IQR)	3 (2-3)	3 (3-3)	0.071§	2 (2-3)	3 (2.75-3)	< 0.001§	-	-	-
Mean CCI score	3.7±1.6	5.5±1.5	< 0.001†	2.7±1.5	5.2±1.2	< 0.001†	2.8±1.0	4.7±0.9	< 0.001†
EBL (mL) (median; IQR)	500 (300-700)	400 (275-800)	0.356§	200 (100-350)	300 (200-700)	< 0.001§	200 (125-350)	200 (100-262.5)	0.212§
Mean operative time (min)	575.8±159.9	492.1±92.0	< 0.004†	218.2±66.1	230.4±63.6	0.265†	204.3±54.7	195.9±43.7	0.526†
LOS (days) (median; IQR)	8 (7-11)	8 (6-17.25)	0.897§	3 (3-4)	3 (3-4)	0.022§	1 (1-2)	2 (1-2)	0.04§
Hospital readmission (n; %)	19 (20.4)	6 (20)	0.96	2 (0.7)	0 (0)	0.59	79 (2.6)	0 (0)	0.50

BMI = body mass index; CCI = Charlson Comorbidity Index; EBL = estimated blood loss; LOS = length of stay

In addition, the number of elderly patients with ≥1 comorbidity was significantly greater compared to younger patients (p = 0.05; Table 3).

There was no difference observed in regards to the incidence of individual complications between age groups, Table 4. While it did not achieve statistical significance, the incidence of cardiac events was also elevated in patients > 75 years of age undergoing either robotic cystectomy (p = 0.059; Table 4). There was no significant difference in number of patient's ≥ 1 complication between the two age groups (p = 0.052, Table 5). When divided in terms of severity, there was also no significant difference in the incidence of minor (Clavien 1-2) or major (Clavien 3-5) complication rates between the two age groups (p = 0.577 and p = 0.052, respectively; Table 5).

Patients undergoing robotic partial nephrectomy

A total of 335 patients (224 male, 66.9%; 111 female, 33.1%) underwent robotic partial nephrectomy of which 293 (87.5%) and 42 (12.5%) were ≤ 74 and ≥ 75 years old, respectively. Elderly patients (≥ 75 years old) had significantly elevated CCI scores compared to patients who were ≤ 74 years old (CCI: 5.2 ± 1.2 versus 2.7 ± 1.5, p < 0.001). ASA scores were also significantly elevated in elderly patients (p < 0.001; Table 1). BMI was significantly lower in elderly compared to younger patients (27.2 ± 4.2 versus 29.7 ± 5.7 kg/m^2, p = 0.001). In addition, EBL and LOS were significantly greater in elderly compared to patients who were ≤ 74 years old, Table 1. There was no significant difference in operative time between the two age groups.

At time of surgery, there was a greater incidence of overall comorbidities in older patients (p < 0.001, Table 3). A significantly greater number of older patients also presented with ≥ 1 comorbidity (p < 0.001; Table 3). In terms of specific comorbidities, elderly patients presented with a significant increase in the incidence of coronary artery disease (CAD), renal insufficiency, cerebrovascular attack (CVA), myocardial infarction (MI) and connective tissue-related comorbidities, Table 2.

The incidence of cardiac events was elevated in patients > 75 years of age undergoing robotic nephrectomy (p = 0.026; Table 4), which may be related to an increased prevalence of CAD in this patient cohort (p < 0.001; Table 2). However, there was no significant difference in the incidence of any of the other specific peri/postoperative complications between the two age groups, Table 4. In patients undergoing partial

TABLE 2. **Patient comorbidities stratified by surgery type and age (†Pearson Chi Square test; §Fisher's Exact test)**

Comorbidity	Cystectomy (n; %)			Nephrectomy (n; %)			Prostatectomy (n; %)		
	≤ 74 yrs	≥ 75 yrs	p value	≤ 74 yrs	≥ 75 yrs	p value	≤ 74 yrs	≥ 75 yrs	p value
Diabetes	17 (18.3)	8 (26.7)	0.321†	53 (18.1)	9 (21.4)	0.602†	221 (7.2)	2 (11.8)	0.351§
CAD	13 (14)	8 (26.7)	0.108†	28 (9.6)	13 (31)	< 0.001†	0 (0)	0 (0)	-
COPD/ pulmonary	15 (16.1)	4 (13.3)	1.0§	9 (3.1)	3 (7.1)	0.18§	217 (7.1)	1 (5.9)	1.0§
Renal insufficiency	5 (5.4)	5 (16.7)	0.063§	3 (1)	3 (7.1)	0.028§	72 (2.3)	2 (11.8)	0.061§
PVD	3 (3.2)	2 (6.7)	0.595§	7 (2.4)	2 (4.8)	0.314§	193 (6.3)	0 (0)	0.621§
CVA/stroke	4 (4.3)	2 (6.7)	0.633§	3 (1)	4 (9.5)	0.006§	61 (2)	1 (5.9)	0.293§
CHF	2 (2.2)	0 (0)	1.0§	5 (1.7)	2 (4.8)	0.215§	10 (0.3)	0 (0)	1.0§
Peptic ulcer	2 (2.2)	0 (0)	1.0§	2 (0.7)	0 (0)	1.0§	184 (6)	1 (5.9)	1.0§
Lymphoma	2 (2.2)	1 (3.3)	0.571§	2 (0.7)	0 (0)	1.0§	0 (0)	0 (0)	-
Connective tissue	7 (7.5)	5 (16.7)	0.163§	22 (7.5)	9 (21.4)	0.008§	0 (0)	0 (0)	-
Liver disease	0 (0)	0 (0)	-	11 (3.8)	0 (0)	0.371§	0 (0)	0 (0)	-
Myocardial infarction	3 (3.2)	3 (10)	0.155§	1 (0.3)	2 (4.8)	0.042§	131 (4.3)	2 (11.8)	0.165§
Leukemia	0 (0)	0 (0)	-	1 (0.3)	1 (2.4)	0.235§	0 (0)	0 (0)	-

CAD = coronary artery disease; COPD = chronic obstructive pulmonary disease; PVD = peripheral vascular disease; CVA = cerebrovascular accident; CHF = congestive heart failure

nephrectomy, there was no difference between the incidence of minor (Clavien 1-2) complications and major (Clavien 3-5) complications in the two age groups, Table 5. There was also no difference in the number of patients with ≥1 complication between age groups, Table 5.

Patients undergoing robotic prostatectomy

A total of 3083 male patients underwent robotic prostatectomy of which 3066 (99.4%) and 17 (0.6%) were ≤ 74 and ≥ 75 years old at time of surgery, respectively. Elderly patients (≥ 75 years old) had significantly

TABLE 3. **Comorbidities stratified by surgical procedure and age**

# of comorbidities	Cystectomy (n; %)			Nephrectomy (n; %)			Prostatectomy (n; %)		
	≤ 74 yrs	≥ 75 yrs	p value	≤ 74 yrs	≥ 75 yrs	p value	≤ 74 yrs	≥ 75 yrs	p value
0	47 (50.5)	9 (30)		185 (63.1)	14 (33.3)		2192 (71.5)	10 (58.8)	
1	28 (30.1)	11 (36.7)		79 (27)	13 (31)		703 (22.9)	5 (29.4)	
2	10 (10.8)	5 (16.7)		20 (6.8)	13 (31)		136 (4.4)	2 (11.8)	
3	7 (7.5)	3 (10)	-	8 (2.7)	1 (2.4)	-	27 (0.9)	-	-
4	1 (1.1)	2 (6.7)		1 (0.3)	1 (2.4)		7 (0.2)	-	
> 5	-	-		-	-		1 (< 0.1)	-	
Median # of comorbidities/ patient (IQR)	0 (0-1)	1 (0-2)	0.033	0 (0-1)	1 (0-2)	< 0.001	0 (0-1)	0 (0-1)	0.22
Number of patients with ≥ 1 comorbidity (%)	46 (49.4)	21 (70)	0.05	108 (36.8)	28 (66.6)	< 0.001	874 (28.5)	7 (41.2)	0.282

TABLE 4. **Peri/postoperative complications stratified by surgical type and age (†Pearson Chi Square test; §Fisher's Exact test).**

Complication	Cystectomy (n; %)			Nephrectomy (n; %)			Prostatectomy (n; %)		
	≤ 74 yrs	≥ 75 yrs	p value	≤ 74 yrs	≥ 75 yrs	p value	≤ 74 yrs	≥ 75 yrs	p value
Infection	33 (35.5)	12 (40)	0.655†	13 (4.4)	1 (2.7)	1.0§	55 (1.8)	0 (0)	1.0§
Genitourinary	14 (15.1)	4 (13.3)	1.0§	34 (11.6)	2 (4.8)	0.284§	174 (5.7)	1 (5.9)	1.0§
Vascular	22 (23.7)	4 (13.3)	0.229†	17 (5.8)	2 (4.8)	1.0	64 (2.1)	0 (0)	1.0§
Gastrointestinal	18 (19.4)	10 (33.3)	0.112†	15 (5.1)	3 (7.1)	0.482§	79 (2.6)	0 (0)	1.0§
Respiratory	8 (8.6)	2 (6.7)	1.0§	18 (6.1)	2 (4.8)	1.0§	7 (0.2)	0 (0)	1.0§
Surgical	3 (3.2)	0 (0)	1.0§	1 (0.3)	0 (0)	1.0§	49 (1.6)	0 (0)	1.0§
Nausea	5 (5.4)	2 (6.7)	0.678§	2 (0.7)	1 (2.4)	0.332§	0 (0)	0 (0)	-
Cardiac	3 (3.2)	4 (13.3)	0.059§	6 (2)	4 (9.5)	0.026§	10 (0.3)	1 (5.9)	0.059§
Other	3 (3.2)	1 (3.3)	1.0§	2 (0.7)	0 (0)	1.0§	0 (0)	0 (0)	-
Death	1 (1.1)	2 (6.7)	0.147§	0 (0)	0 (0)	-	1 (< 0.1)	0 (0)	1.0§
Misc. medical	10 (10.8)	2 (6.7)	0.729§	7 (2.4)	1 (2.4)	1.0§	24 (0.8)	0 (0)	1.0§

elevated CCI scores compared to patients ≤ 74 years old (4.7 ± 0.9 versus 2.8 ± 1.0; p < 0.001). BMI was not statistically different between younger and elderly patients (28.1 ± 4.3 versus 27.1 ± 4.7 kg/m^2, p = 0.347; Table 1). There was no statistical difference in EBL or operative time between the two age groups, Table 2. While LOS was significantly extended in ≥ 75 year old patients compared to those ≤ 74 (2 (IQR: 1-2) versus 1 (IQR: 1-2) days, p = 0.04; Table 1), this relatively short increase in LOS is not considered clinically relevant.

There was no significant difference in the incidence of overall comorbidities or in the incidence of any individual comorbidity between patient groups, Tables 2 and 3. There was also no difference in the number of patients with ≥ 1 complication between age groups, Table 5.

Further, there was no significant difference in the incidence of specific peri/postoperative complications between the two age groups of patients, Table 4. While it did not achieve statistical significance, the incidence of cardiac events was elevated in patients > 75 years of age undergoing either robotic prostatectomy (p = 0.059; Table 4. There was no significant difference in the incidence of minor (Clavien 1-2) and major (Clavien 3-5) complication rates between the elderly and younger cohort of patients, Table 5.

In general, readmission rates were relatively low particularly in nephrectomy and prostatectomy patients. Readmission rates in cystectomy patients were relatively higher. This may be related to the fact that cystectomy patients typically carry a burden of

TABLE 5. **Distribution and frequency of postoperative complications**

	Cystectomy			Nephrectomy			Prostatectomy		
	≤ 74 yrs	≥ 75 yrs	p value	≤ 74 yrs	≥ 75 yrs	p value	≤ 74 yrs	≥ 75 yrs	p value
# of patients	93	30	-	293	42	-	3066	17	-
Patients with ≥ 1 minor (Clavien 1-2) complication (n;%)	63 (67.7)	16 (53.3)	0.152	68 (23.2)	9 (21.4)	0.798	264 (8.6)	1 (5.9)	1.0
Patients with ≥ 1 major (Clavien 3-5) complication (n;%)	29 (31.2)	11 (36.7)	0.577	39 (13.3)	6 (14.3)	0.862	176 (5.7)	1 (5.9)	1.0
Number of patients with ≥ 1 complication	75 (80.6)	19 (63.3)	0.052	97 (33.1)	14 (33.3)	0.977	398 (13)	2 (11.8)	1.0

significant comorbidities, have been heavy smokers, in addition to the surgery itself being associated with significant complications. Reasons for readmission of cystectomy patients included a failure to thrive, dehydration, electrolyte imbalance, ileus nausea, vomiting, bowel obstruction, fever, chills, urinary obstruction and sepsis. Notably, readmission rates were not significantly different between the two patient age groups for each surgery type, Table 1.

Discussion

With an expanding proportion of elderly patients, assessing the safety and efficacy of minimally-invasive surgical techniques in this population is of increasing relevance. Elderly patients have been previously classified as those ≥ 75 years old, with a 90 day perioperative mortality rate as high as 11%.[7] While morbidity is associated with advanced age, ASA scores ≥ 3, BMI and surgical blood loss are also useful outcome indicators.[8] Compared to open surgical techniques, robotic surgery has been associated with improved perioperative morbidity and, as such, can be a preferential surgical option for elderly patients.[9] Coward et al reported no significant increase in complication rates in patients ≥ 70 years of age compared to younger patients.[10] Similarly, Donat et al reported on a series of octogenarians who had similar rates of minor and major complications as their younger counterparts.[11]

More recent studies have illustrated that a higher incidence of perioperative complication in the elderly can be attributed to factors other than age. Nutritional deficiency has been observed to be predicative of increased mortality rates.[12] In addition, higher ASA scores can be related to longer hospital stays, an elevated incidence of cardiac dysfunction, and a higher susceptibility for intraoperative blood loss.[13]

While the efficacy of surgical intervention in elderly patients has been examined previously in the literature, to the authors' knowledge this is the first study that provides a comprehensive analysis across three different urological surgical procedures. Compared to their younger counterparts, our elderly population presented with a significantly higher number of comorbid conditions. Nonetheless, there was no difference in the total number of complications within patients undergoing cystectomy, partial nephrectomy, and prostatectomy ($p = 0.632$, $p = 0.798$, $p = 1.0$, respectively). A qualitatively similar trend was observed when complications were further stratified into minor (Clavien 1-2) and major (Clavien 3-5) complications. The incidence of cardiac events was elevated in patients > 75 years of age undergoing robotic nephrectomy ($p = 0.026$; Table 4), which may be related to an increased prevalence of coronary artery disease in this patient cohort ($p < 0.001$; Table 2). While it did not achieve statistical significance, the incidence of cardiac events was also elevated in patients > 75 years of age undergoing either robotic cystectomy or prostatectomy ($p = 0.059$; Table 4). As such, the consideration of pre-existing cardiac comorbidities should make a significant contribution to the preoperative counseling of patients, particularly those with small renal masses or prostate cancer.

Robotic surgeries are associated with lower overall complication rates, a finding that has previously been suggested to be associated with reduced surgical blood loss, decreased pain, faster recovery times and shorter hospital stays.[11,14] Aside from the physiological changes to the circulatory system associated with moving the patient in the Trendelenburg position for certain procedures, the robotic surgeries are tolerated well in elderly patients.[15,16] Our data suggest that patient age alone is not a contraindication for robotic surgical treatment, as age is not the most effective predictor of peri/post-operative complications. For robotic partial nephrectomy, the likelihood that an elderly patient suffered from a cardiac-related complication was significantly greater compared to the younger patient cohort. Nonetheless, when all patients who had cardiac-related comorbidities were excluded from analysis (i.e. those with coronary artery disease, congestive heart failure, or previous myocardial infarction), there was no statistical difference found in complication rates. This suggests that patient comorbidities, not age alone, may play a greater role in predicting the occurrence of peri/postoperative complications. Our study shows that robotic intervention represents a safe, effective, minimally-invasive surgical approach for elderly patients requiring urologic surgery. As more centers become facile with robotic surgery, it is likely to play a greater role in the treatment of the elderly.

Although this study illustrates that robotic surgery is a viable and safe surgical approach for managing patients ≥ 75, we recognize certain limitations. As a retrospective study there is potential selection bias in regards to who received surgical intervention. Patients with severe cardiac disease who did not undergo surgery were excluded from our study. This undoubtedly imposed a patient selection bias. We also accept that the complication rate in prostatectomy patients may have been impacted by selection bias, especially when there is a competing treatment modality that offers acceptable results. This may

also have been the case in nephrectomy patients, in which ablative therapy or active surveillance are other treatment options. There are also issues of sample size and power. The samples for cystectomy and partial nephrectomy are reasonable in size, while the sample of prostatectomy patients is more robust. However, the number of patients in the ≥ 75 year old group are limited, thereby potentially reducing statistical power. This imbalance in the sizes of the two groups is particularly evident in the prostatectomy sample. As a partial check on this issue, we repeated the prostate analysis using 70 years as the age cutoff. This resulted in a 10-fold increase in the size of the older group (175 versus 17) and a concomitant increase in available statistical power, offering sufficient power (80%) to detect a two to three fold change in relative likelihoods (odd ratios).

Our data indicate that patients ≥ 75 years old that undergo robotic urologic surgery are not statistically more likely to experience higher morbidity or complications compared to younger patients. Age alone should not be considered as a contraindication to robotic surgery. As such, urologic robotic-surgery is a safe and effective option for this expanding patient population.

Conclusion

Our study presents data from young and elderly cohorts of patients who underwent robotic-assisted cystectomy, partial nephrectomy or prostatectomy procedures. These data indicate that patients ≥ 75 years of age undergoing these robotic-assisted surgeries are not at significant additional risk of experiencing a range of peri/postoperative complications when compared to a younger patient cohort. However, since cardiac complications were significantly elevated in elderly patients undergoing robotic nephrectomy (and bordering statistical significance in cystectomy and prostatectomy patients), the consideration of pre-existing cardiac comorbidities should make a significant contribution to the preoperative counseling of patients considering robotic-assisted surgery. The relationship between patient postoperative morbidity and preoperative patient characteristics (e.g. nutritional status, intraoperative blood loss, ASA and CCI scores, operative time, length of stay and surgeon's experience) warrants continued monitoring. □

References

1. Ahmed A, Tollefsbol T. Telomeres and telomerase: basic science implications for aging. *J Am Geriatr Soc* 2001;49(8):1105-1109.
2. Thomas AA, Aron M, Hernandez AV et al. Laparoscopic partial nephrectomy in octogenarians. *Urology* 2009;74(5):1042-1046.
3. Lane BR, Gill IS. 5-Year outcomes of laparoscopic partial nephrectomy. *J Urol* 2007;177(1):70-74.
4. Roos FC, Pahernik S, Melchior SW, Thuröff JW. Renal tumor surgery in the elderly patients. *BJU Int* 2008;102(6):680-683.
5. Arias E. United States life tables, 2003. *Natl Vital Stat Rep* 2006;54: 1-40.
6. Takao T, Tsujimura A, Kiuchi H et al. Urological surgery in patients aged 80 years and older: a 30-year retrospective clinical study. *Int J Urol* 2008;15(9):789-793.
7. Mendiola FB, Zorn KC, Gofrit ON et al. Cystectomy in the ninth decade: Operative results and long-term survival outcomes. *Can J Urol* 2007;14(4):3628-3634.
8. Malavaud B, Vaessen C, Mouzin M, Rischmann P, Sarramon J, Schulman C. Complications for radical cystectomy. Impact of the American Society of Anesthesiologists score. *Eur Urol* 2001;39(1): 79-84.
9. Ng CK, Kauffman EC, Lee MM et al. A comparison of postoperative complications in open versus robotic cystectomy. *Eur Urol* 2010; 57(2):274-281.
10. Coward RM, Smith A, Raynor M, Nielsen M, Wallen EM, Pruthi RS. Feasibility and outcomes of robotic-assisted laparoscopic radical cystectomy for bladder cancer in older patients. *Urology* 2011;77(5):1111-1114.
11. Donat SM, Siegrist T, Cronin A, Savage C, Milowsky MI, Herr HW. Radical cystectomy in octogenarians—Does morbidity outweigh the potential survival benefits? *J Urol* 2010;183(6):2171-2177.
12. Hollenbeck BK, Miller DC, Taub D et al. Identifying risk factors for potentially avoidable complications following radical cystectomy. *J Urol* 2005;174(4 Pt 1):1231-1237.
13. Al-Qudah HS, Rodriguez AR, Sexton WJ. Laparoscopic management of kidney cancer: updated review. *Cancer Control* 2007;14(3):218-230.
14. Porits AJ, Yan Y, Landman J et al. Long-term follow up after laparoscopic radical nephrectomy. *J Urol* 2002;167(3):1257-1262.
15. Harrell AG, Lincourt AE, Novitsky YW et al. Advantages of laparoscopic appendectomy in the elderly. *Am Surg* 2006;72(6): 474-480.
16. Mayol J, Martinez-Sarmiento J, Tamayo FJ, Fernández-Represa JA. Complications of laparoscopic cholecystectomy in the ageing patient. *Age Ageing* 1997;26(2):77-81.