



Open Access

ORIGINAL ARTICLE

Male Health

Contemporary trends in radical prostatectomy and predictors of recovery of urinary continence in men aged over 70 years: comparisons between cohorts aged over 70 and less than 70 years

Young Ju Lee¹, Jin-Woo Jung², Sangchul Lee¹, Sang Wook Lee³, Jeong Hyun Kim³, Sung Kyu Hong¹, Seok-Soo Byun¹, Sang Eun Lee¹, Seong Jin Jeong¹

We evaluated contemporary trends in radical prostatectomy (RP) in men aged >70 years and investigated associations of selected variables with recovery of urinary continence (UC) in two age groups: >70 and ≤70 years. A retrospective cohort of 2301 eligible patients attending our institution from 2004 to 2015 was reviewed. Patients were divided into two groups based on age at surgery (>70 years [$n = 610$] vs ≤70 years [$n = 1691$]) and four groups by year of surgery. Over the study period, the proportion of patients aged >70 years gradually increased up to 30.0%, and the rate of robot-assisted RP and neurovascular bundle (NVB) saving increased continually to 80.0% and 67.4% of older patients, respectively. Although the rate of recovery of UC within 12 months (3 months) in patients aged >70 years was lower than that in those aged ≤70 years (81.5% [52.6%] vs 88.6% [60.9%], respectively; both $P < 0.001$), the gap between age groups in the rate of recovery within 12 months narrowed from the second quarter of the study period. Among younger patients, age, robot-assisted RP, prostate volume, membranous urethral length (MUL), and NVB saving were predictors of recovery of UC within 3 or 12 months. In contrast, only age and MUL were predictors of recovery of UC within 3 and 12 months in patients aged >70 years. Therefore, unlike younger patients, only variables (age and MUL), possibly associated with the inherent function of the urinary sphincter, were predictors of recovery of UC in patients aged >70 years.

Asian Journal of Andrology (2020) 22, 280–286; doi: 10.4103/aja.aja_62_19; published online: 25 June 2019

Keywords: elderly; predictor; prostate cancer; radical prostatectomy; urinary incontinence

INTRODUCTION

The world's population is aging rapidly, and the proportion aged over 60 years is expected to increase up to 20% by 2050.¹ Furthermore, it is predicted that 19.6% of the US population will be >70 years by 2030.² With increasing life expectancy and the widespread adoption of prostate-specific antigen (PSA) testing, the incidence of prostate cancer (PCa) has been increasing in almost all countries, except for a few high-income countries.³

Several guidelines have suggested that a life expectancy of >10 years or 10–20 years, or simply reasonable life expectancy be a prerequisite for offering curative surgical treatment, such as radical prostatectomy (RP), for PCa.⁴ In the past, RP may not have been recommended to men with PCa aged >70 years because of uncertain survival benefits and unsatisfactory functional outcomes in this age group. However, the additional life expectancy of a 70–74-year-old man is currently reported to be around 15 years.^{4,5} A review of published reports found that older men may benefit from RP, especially when they have high-risk PCa.⁶ In addition, several studies have shown that selected healthy patients among those aged >70 years or >75 years

have good long-term overall survival after RP.^{7,8} Taken together, healthy older men aged >70 or >75 years with significant disease may derive oncological benefits from RP.

However, RP can be associated with some complications, including urinary incontinence (UI) and erectile dysfunction (ED). More than half of older men already have ED preoperatively and only 28% of men aged >70 years with moderate-to-severe ED care about it.⁹ Therefore, ED may have less impact on quality of life in this age group than in younger patients.

UI after RP is a matter of significant concern for both physicians and their patients,¹⁰ and, given that age at surgery has consistently been found to be a predictor for recovery of urinary continence (UC),¹¹ older men seem to be at relatively higher risk of UI after RP than younger men.¹² Reported rates of UI within 12 months after surgery range from 8% to 37% in patients aged ≥70 years who undergo RP,^{4,12–17} and the reported odds ratios of age for recovery of UC are 0.92–0.99 as a continuous variable.^{13,18} While many studies have assessed various predictors of recovery of UC, including age, body mass index, comorbidity index, lower urinary tract symptoms, and prostate volume,

¹Department of Urology, Seoul National University Bundang Hospital, Seongnam 13620, Korea; ²Department of Urology, Catholic Kwandong University International St. Mary's Hospital, Incheon 22711, Korea; ³Department of Urology, Kangwon National University School of Medicine, Chuncheon 24341, Korea.

Correspondence: Dr. SJ Jeong (urojsj@empal.com)

Received: 23 September 2018; Accepted: 25 April 2019

for patients of all ages undergoing RP,^{4,13,19,20} specific predictors for older patients have rarely been identified.

To improve understanding about recovery of UC and facilitate counseling of older men undergoing RP in particular, we investigated contemporary trends in RP in men aged >70 years and compared associations of each predictor with recovery of UC with those for patients aged ≤70 years over time.

PATIENTS AND METHODS

The present retrospective study was carried out in Seoul National University Bundang Hospital (Seongnam, Korea) and was processed in accordance with the principles of the Declaration of Helsinki. The Institutional Review Board of Seoul National University Bundang Hospital approved the study protocol (approval number B-1808-484-120). The requirement for informed consent was waived due to the retrospective nature of the study.

Patient selection

Between January 2004 and December 2015, 2779 consecutive men underwent open retropubic, pure-laparoscopic, or robot-assisted RP for clinically localized or locally advanced PCa in our institution. Among these patients, we excluded those who were incontinent or who had a possible neurogenic bladder before RP ($n = 50$ patients), had received neoadjuvant therapy ($n = 19$), had received pelvic irradiation before achieving recovery of UC ($n = 80$), had been followed for <12 months after surgery ($n = 124$), for whom had no information regarding time to achieve UC was available ($n = 159$), and had developed a neurogenic abnormality that influenced micturition function within 12 months after surgery ($n = 4$). In addition, given that only 42 (1.5%) patients had undergone pure-laparoscopic RP during the study period, we excluded these cases. Thus, 2301 patients were enrolled for analysis.

Surgical procedure and follow-up

Most surgeries (96.2%) were performed by three experienced surgeons (SEL, SSB, and SKH) at our institution. Surgery was performed via an open retropubic or robot-assisted transperitoneal approach based on the physician's and patient's discretion. Some patients underwent posterior and anterior reconstruction²¹ or bladder neck preservation²² during open retropubic RP during the study period. Robot-assisted RP was introduced in our institution in late 2007 and some patients undergoing this procedure underwent puboprostatic ligament sparing,²³ restoration of the Denonvilliers' musculofascial plate, or retropubic suspension stitching. The neurovascular bundle (NVB) was spared regardless of preoperative erectile function unless this procedure violated oncological principles. Postoperatively, all patients were taught to perform pelvic floor muscle exercises, but did not participate in an established rehabilitation program.

Follow-up consisted of physical examination including digital rectal examination, periodic PSA testing, completion of validated questionnaires concerning functional outcomes, patient-reported continence and erection status, number of pads used per day, and imaging studies at the physician's discretion. Patients were followed up 2 weeks, 1 month, 3 months, 6 months, and 12 months after surgery and yearly thereafter. Intraoperative and postoperative complications were documented.

Collected data and variable definitions

Clinical data with regard to relevant patient characteristics, surgical procedure, pathological findings, surgical complications, and results of follow-up tests were prospectively recorded in our computerized database. Age at surgery, body mass index, Charlson comorbidity index

(CCI),²⁴ type of surgical approach, PSA, prostate volume calculated in transrectal ultrasound, membranous urethral length (MUL) measured by magnetic resonance imaging,²⁵ NVB-saving status (nonsaving vs unilateral/bilateral-saving), and pathological T stage and Gleason score sum were extracted from the database.

Functional outcomes, such as UC and erectile function, were assessed periodically by a physician or certificated research assistant and were documented in the database. Achievement of UC was defined as wearing no pads or an occasional security pad by patient-reported daily pad usage. Our definition was adapted from the fifth item (number of pads used per day) of the Expanded Prostate Cancer Index Composite – urinary assessment. "Using an occasional security pad" meant that patients did not actually have incontinence but used a security pad occasionally for protection because of concerns about possible incontinence. On the contrary, patients who used a security pad daily for slight urine leakage were classified as wearing one pad daily. Once an individual patient had recovered UC, he was regarded as being continent thereafter; recurrence of UI after achievement of UC was ignored in the current analyses. For patients who did not visit the hospital regularly, UI status was assessed with a telephone interview.

Patients were divided into four groups by year of surgery (2004–2006, 2007–2009, 2010–2012, and 2013–2015) to evaluate contemporary trends in RP in older men and were classified into two groups on the basis of age at surgery (>70 years vs ≤70 years) to compare predictors of recovery of UC between the two age groups.

Statistical analyses

The proportion of patients aged >70 years was examined, and clinicosurgical characteristics were compared between patients aged >70 years and ≤70 years in accordance with year of surgery. In addition, changes in clinicosurgical characteristics over the study period were assessed within patients aged >70 years. Comparisons between the two age groups were analyzed by the Pearson's Chi-square test or Student's *t*-test depending on the type of variable, and a linear-by-linear association was used to assess changes in clinicosurgical characteristics over the study period.

The recovery rates of UC within 3 and 12 months after RP were compared between the two age groups in accordance with year of surgery. The clinical factors related to the recovery of UC within 3 and 12 months were identified using univariate and multivariable logistic regression analyses and were compared between the two age groups. The significance level of two-tailed $P < 0.05$ in univariate analysis was a reference point for the candidate to enter into the multivariable logistic regression. Finally, the effect of each predictor on the recovery of UC within 12 months was compared between the two age groups. All statistical analyses were carried out with SPSS software package version 20.0 (IBM Corp., Chicago, IL, USA), and a two-tailed $P < 0.05$ was set to indicate statistical significance.

RESULTS

Changes of clinicosurgical characteristics over the study period in patients aged >70 years

Patients aged >70 years accounted for 26.5% (610/2301) of the cohort during the whole study period. Overall, compared with patients ≤70 years, those aged >70 years had significantly more comorbidities ($P < 0.001$), higher PSA ($P = 0.004$), larger prostate volume ($P = 0.002$), higher pathologic Gleason score ($P < 0.001$), and more extensive disease ($P = 0.002$). NVB-saving was performed more in patients aged ≤70 years ($P < 0.001$).

The proportion of patients aged >70 years gradually increased from 17.5% in 2004–2006 to 30.0% in 2013–2015 (Figure 1, $P < 0.001$). Table 1 shows comparisons of clinicosurgical characteristics between the two age groups according to year of surgery. For most of the study period, patients aged >70 years had lower body mass index, more comorbidities, larger prostate volume, and lower rate of NVB-saving than those aged ≤70 years. In addition, pathologic stage was more advanced and Gleason score sum was higher in patients aged >70 years, at least during some periods. The mean MUL was almost identical in the two age groups over the study period. While the use of robot-assisted RP increased over time in both age groups, the older age group underwent robot-assisted RP significantly less frequently than the younger age group in the last quarter of the study period. Figure 2 depicts changes in clinicosurgical characteristics over the study period in patients aged >70 years. The rates of robot-assisted RP and NVB-saving increased, and pathologic Gleason score sum became increasingly higher over the study period (all $P < 0.001$). On the other

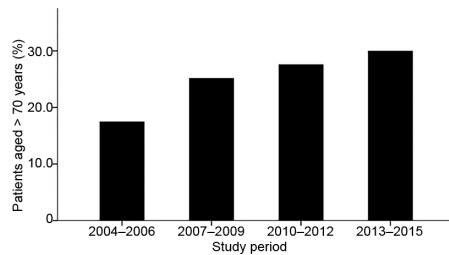


Figure 1: Change of the proportion of patients aged >70 years over the study period among all the patients who underwent radical prostatectomy ($P < 0.001$; linear-by-linear association).

hand, prostate volume and MUL decreased over the study period in this age group ($P = 0.035$ and $P < 0.001$, respectively).

Comparison of the rate of recovery of UC between both age groups

The median duration of follow-up was 58 months (range: 12–148 months). Overall, 60.9% and 88.6% of patients aged ≤70 years and 52.6% and 81.5% of those aged >70 years recovered UC within 3 and 12 months after surgery, respectively ($P < 0.001$; between both groups). Figure 3 depicts changes in the rates of recovery of UC within 3 and 12 months over the study period in both age groups. Patients aged >70 years had a significantly lower recovery rate than those aged ≤70 years during most of the study period, whereas the recovery rate improved in accordance with year of surgery in both age groups ($P < 0.001$). From the second quarter of the study period, the gap between the two age groups in the recovery rate within 12 months narrowed significantly ($P < 0.001$), whereas the gap within 3 months remained constant over time ($P = 0.347$).

Comparisons of the predictors for the recovery of UC between both age groups

Table 2 shows associations of each predictor with recovery of UC according to multivariable logistic regression analysis. Among patients aged ≤70 years, age at surgery, robot-assisted RP, prostate volume, and MUL were predictors of recovery of UC within both 3 and 12 months after RP. In addition, CCI and NVB-saving were identified as affecting only recovery of UC within 12 months. In contrast, only age at surgery and MUL were found to be predictors of recovery within both 3 and 12 months among patients aged >70 years. CCI also had an effect on recovery within 3 months in this age group.

Figure 4 shows comparisons of the effects of each predictor on recovery of UC within 12 months between both age groups in

Table 1: Clinicosurgical characteristics of patients aged >70 and ≤70 years according to year of surgery

Variable	2004–2006		P	2007–2009		P	2010–2012		P	2013–2015		P
	≤70 years	>70 years		≤70 years	>70 years		≤70 years	>70 years		≤70 years	>70 years	
Patient, n (%)	245 (82.5)	52 (17.5)		418 (74.8)	141 (25.2)		491 (72.4)	187 (27.6)		537 (70.0)	230 (30.0)	
Age (year), mean±s.d.	62.7±6.3	72.8±1.8	<0.001	63.1±5.7	73.4±2.0	<0.001	63.6±5.5	73.3±2.0	<0.001	62.6±5.7	73.4±2.0	<0.001
BMI (kg m ⁻²)	24.6±2.9	23.4±2.4	0.011	24.2±2.5	24.1±2.7	0.699	24.6±2.8	23.7±2.7	<0.001	24.6±2.9	23.8±3.0	0.001
Charlson comorbidity index, n (%)			0.916			0.003			0.006			0.010
	0	181 (73.9)	37 (71.2)	282 (67.5)	89 (63.1)	376 (76.6)	121 (64.7)	424 (79.0)	158 (68.7)			
	1	52 (21.2)	12 (23.1)	107 (25.6)	29 (20.6)	93 (18.9)	51 (27.3)	100 (18.6)	63 (27.4)			
	≥2	12 (4.9)	3 (5.8)	29 (6.9)	23 (16.3)	22 (4.5)	15 (8.0)	13 (2.4)	9 (3.9)			
Surgical approach, robot-assisted ^a , n (%)	NA	NA	NA	252 (60.3)	90 (63.8)	0.455	396 (80.7)	139 (74.3)	0.071	474 (88.3)	184 (80.0)	0.003
PSA (ng ml ⁻¹), mean±s.d.	9.6±8.5	13.2±12.9	0.061	11.8±15.4	12.3±14.0	0.745	12.2±13.2	13.5±16.6	0.272	11.7±13.0	14.1±22.9	0.130
Prostate volume (ml), mean±s.d.	40.3±16.3	43.4±17.8	0.220	37.5±13.9	41.0±16.9	0.027	35.4±16.4	38.5±16.6	0.028	35.5±14.8	37.3±15.3	0.117
Membranous urethra length (mm), mean±s.d.	13.2±2.4	13.0±2.2	0.699	13.0±2.6	12.7±2.6	0.398	11.8±3.1	12.2±2.9	0.116	11.5±3.1	11.4±3.0	0.699
NVB-saving ^b , n (%)	180 (73.5)	30 (57.7)	0.023	249 (59.6)	42 (29.8)	<0.001	362 (73.7)	115 (61.5)	0.002	398 (74.1)	155 (67.4)	0.040
Pathologic stage, n (%)			0.043			0.342			0.016			0.419
	≤T2	204 (83.3)	37 (71.2)	285 (68.2)	90 (63.8)	366 (74.5)	122 (65.2)	389 (72.4)	160 (69.6)			
	≥T3	41 (16.7)	15 (28.8)	133 (31.8)	51 (36.2)	125 (25.5)	65 (34.8)	148 (27.6)	70 (30.4)			
Pathologic Gleason score sum, n (%)			0.099			0.012			0.297			0.290
	≤6	93 (38.0)	13 (25.0)	85 (20.3)	17 (12.1)	34 (6.9)	7 (3.7)	24 (4.5)	9 (3.9)			
	7	144 (58.8)	35 (67.3)	301 (72.0)	104 (73.8)	402 (81.9)	159 (85.0)	453 (84.4)	186 (80.9)			
	≥8	8 (3.3)	4 (7.7)	32 (7.7)	20 (14.2)	55 (11.2)	21 (11.2)	60 (11.2)	35 (15.2)			

^aRobot-assisted RP has been introduced at our institution since late 2007; ^bNVB-saving is classified into nonsaving and unilateral/bilateral saving. NA: non-applicable; BMI: body mass index; PSA: prostate-specific antigen; NVB: neurovascular bundle



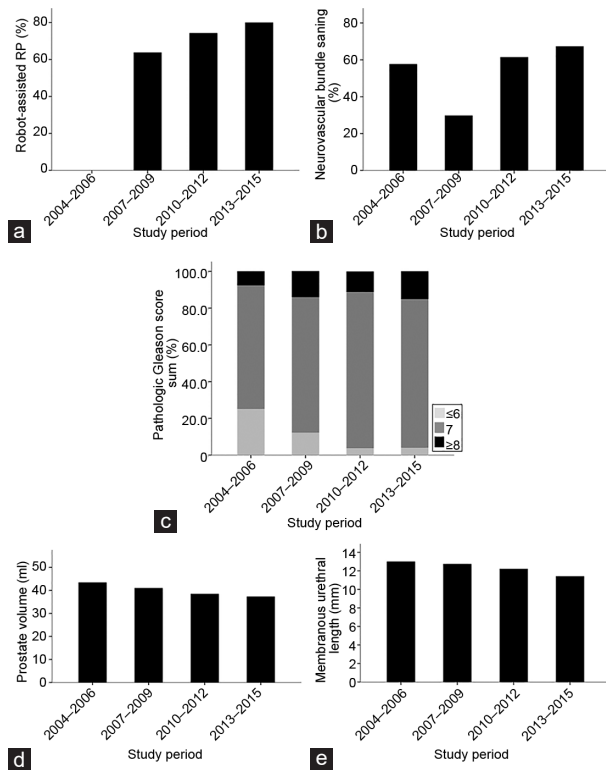


Figure 2: Changes in clinicosurgical characteristics over the study period in patients aged >70 years. (a) Robot-assisted RP ($P < 0.001$; linear-by-linear association). (b) Neurovascular bundle-saving ($P < 0.001$; linear-by-linear association). (c) Pathologic Gleason score sum ($P < 0.001$; linear-by-linear association). (d) Prostate volume ($P = 0.035$; one-way analysis of variance). (e) Membranous urethral length ($P < 0.001$; one-way analysis of variance). RP: radical prostatectomy.

accordance with year of surgery. Robot-assisted RP, NVB-saving, lower CCI, and smaller prostate volume had a positive effect on recovery during some study periods in the younger age group; however, recovery in patients aged >70 years was not affected by these predictors throughout the study period. In the younger age group, robot-assisted RP had a positive impact on recovery during the recent period, whereas NVB-saving, CCI, and prostate volume did not affect the recovery rate during that period. Age at surgery was significantly lower in patients who recovered UC within 12 months during the first two quarters of the study period in the younger age group and also significantly lower in patients who recovered UC during the third quarter of the study period in the older age group. MUL was significantly longer in patients who recovered UC over the study period, except for the first quarter in both age groups.

DISCUSSION

Decision-making about treatment for localized PCa may be complicated, especially in older individuals. In the past, many clinicians were hesitant about offering RP as curative treatment for PCa to men aged >70 years because of their relatively short life expectancy, lack of proven benefit of curative surgery, and fear of troublesome complications such as UI; men in this age group were also reluctant to undergo RP. However, the increased life expectancy after age 70 years^{4,5} and advances in surgical techniques and modalities is now challenging previous age limits for RP.

UI remains the most distressing complication after RP, having a critical impact on postoperative quality of life, especially in older individuals. Although some studies with a reference point of 70 years found that age had

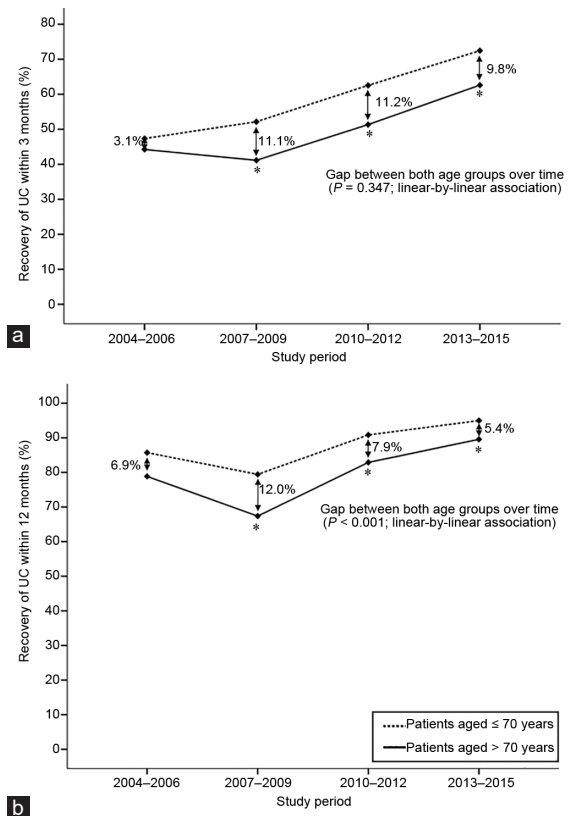


Figure 3: Changes in the rates of recovery of urinary continence over the study period in both age groups. (a) Within 3 months after RP and (b) within 12 months after RP. Patients aged >70 years had a significantly lower recovery rate than those aged ≤70 years during most of the study period, whereas the recovery rate improved in accordance with year of surgery in both age groups (both $P < 0.001$). From the second quarter of the study period, the gap between the two age groups in the recovery rate within 12 months narrowed significantly, whereas the gap within 3 months remained constant over time. * $P < 0.05$ between patients aged >70 and ≤70 years at the same study period. UC: urinary continence; RP: radical prostatectomy.

no significant effect on recovery of UC,^{14,15,20} most such studies have found that older age has a negative influence on recovery of UC.^{4,6,13} Furthermore, with increasing life expectancy, UI following RP may receive more attention when deciding on treatment, especially among older patients.

To improve understanding about recovery of UC and facilitate counseling of older men scheduled for RP, we focused on the predictors of recovery of UC after RP in men aged >70 years, evaluated contemporary trends in RP in this age group, and compared associations of each predictor with recovery of UC with those for younger patients over time. We found that the proportion of patients aged >70 years gradually increased up to 30.0% in 2013–2015 and that the use of robot-assisted RP and NVB-saving increased continuously in this age group. Similar to our findings, Kim *et al.*²⁶ investigated SEER data and found that about 40% of 16 348 men treated with RP in 2000 to 2007 were older than 70 years. In addition, Adejoro *et al.*²⁷ reported an increasing trend toward a minimally invasive approach to RP in all patients regardless of age. Therefore, considering these trends in patients with RP, urologists are more likely to be confronted with the challenge of deciding on the management of PCa with curative surgery in older men. In addition, robot-assisted approaches may be used more frequently in older patients in future; however, more long-term studies on this trend are needed.

Table 2: Associations of clinicosurgical variables with recovery of urinary continence within 3 and 12 months in each age group according to multivariable logistic regression analysis

Variable	Recovery of continence within 3 months		Recovery of continence within 12 months	
	Odds ratio (95% CI)	P	Odds ratio (95% CI)	P
Patients aged ≤70 years				
Age	0.96 (0.94–0.97)	<0.001	0.94 (0.90–0.97)	<0.001
Charlson comorbidity index (1 vs 0)	0.82 (0.64–1.05)	0.267 ^a	0.70 (0.49–1.01)	0.017 ^a
Charlson comorbidity index (≥2 vs 0)	0.88 (0.54–1.44)		0.47 (0.25–0.86)	
Surgical approach (robot-assisted)	1.64 (1.31–2.04)	<0.001	1.67 (1.21–2.32)	0.002
Prostate volume	0.99 (0.98–1.00)	0.039	0.99 (0.98–0.99)	0.009
Membranous urethral length	1.08 (1.05–1.12)	<0.001	1.08 (1.03–1.14)	0.003
NVB-saving	1.20 (0.95–1.51)	0.123	1.41 (1.01–1.98)	0.044
Patients aged >70 years				
Age	0.92 (0.84–0.99)	0.041	0.89 (0.80–0.99)	0.026
Charlson comorbidity index (1 vs 0)	0.64 (0.43–0.94)	0.034 ^a	NA	NA
Charlson comorbidity index (≥2 vs 0)	0.59 (0.32–1.10)		NA	NA
Surgical approach (robot-assisted)	0.99 (0.68–1.44)	0.967	1.33 (0.84–2.12)	0.224
Membranous urethral length	1.17 (1.10–1.24)	<0.001	1.18 (1.10–1.28)	<0.001
NVB-saving	1.10 (0.77–1.56)	0.607	1.27 (0.82–1.98)	0.286

^aP compared between Charlson comorbidity index (1 vs 0) and (≥2 vs 0). The significance level of two-tailed P<0.05 in univariate analysis is a reference point for the candidate to enter into the multivariable logistic regression. NA: non-applicable; CI: confidence interval; NVB: neurovascular bundle

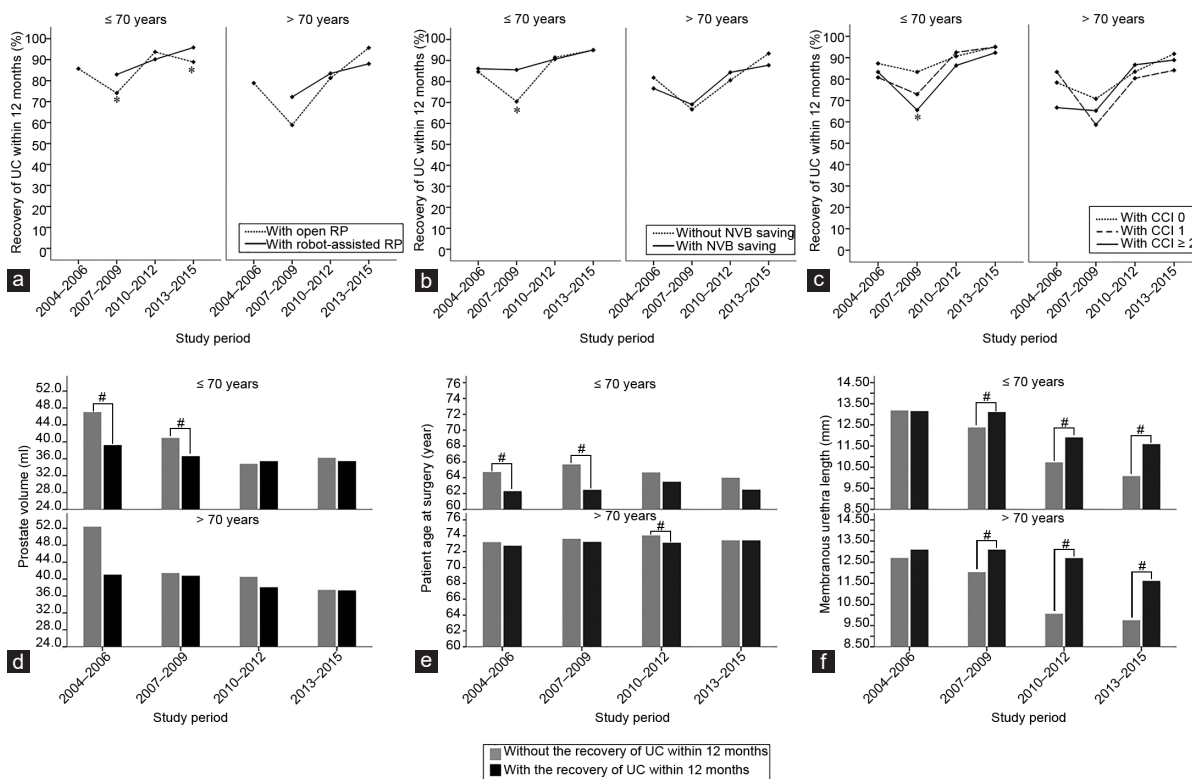


Figure 4: Comparisons of the effects of each predictor on recovery of UC within 12 months between patients aged ≤70 and >70 years in accordance with year of surgery. (a) Robot-assisted RP, (b) NVB-saving, (c) CCI, (d) prostate volume, (e) patient age at surgery, and (f) MUL. Robot-assisted RP, NVB-saving, lower CCI, and smaller prostate volume had a positive effect on recovery during some study periods in the younger age group; however, recovery in patients aged >70 years was not affected by these predictors throughout the study period. Patient age and MUL were significantly related with the recovery during some study periods in both age groups. *P < 0.05 according to the presence of the predictor. #P < 0.05 between patients with and without recovery within 12 months. UC: urinary continence; RP: radical prostatectomy; NVB: neurovascular bundle; CCI: Charlson comorbidity index; MUL: membranous urethral length.

As for the rate of recovery of UC in the present cohort, 60.9% and 88.6% of patients aged ≤70 years and 52.6% and 81.5% of those aged >70 years achieved UC within 3 and 12 months after RP, respectively, over the whole study period. More specifically, the rates of recovery of UC

within 3 and 12 months increased significantly from 44.2% to 78.8% in 2004–2006, to 62.6% and 89.6% in 2013–2015, respectively, in the older age group, despite being lower than those in the younger age group during most of the study period. In addition, the gap in the recovery rate



within 12 months between the two age groups decreased significantly over the study period, whereas the gap within 3 months remained constant. Our findings are similar to most of previous studies, which have reported rates of recovery of UC at 12 months of 81%–87% and lower rates in patients aged ≥ 70 years.^{4,12,16,17} However, a few other studies have reported insignificant differences in the rates of recovery between patients aged >70 years and ≤ 70 years.^{14,15,20,28} Mandel *et al.*⁴ suggested that the small sample size for older men or the use of dichotomous dividing of patient age in previous studies may have resulted in advanced age not being significantly associated with worse continence rates. Moreover, biological age might not be similar to calendar age. Taken together with our findings, there is strong evidence that older age is a risk factor for UI after RP; however, net continence rates in patients aged >70 years are within a reasonable range (81%–87%).

The rate of recovery of UC in our cohort showed an increasing trend in both age groups and the gap between them in the recovery rate within 12 months gradually decreased (**Figure 3**; from 12.0% in 2007–2009 to 5.4% in 2013–2015). While continence rate following RP may improve with more surgical volume, we cautiously postulate that the introduction of robot-assisted RP may have a positive effect on the rates of recovery of UC over time. As noted by Tewari *et al.*,²⁹ robot-assisted procedures have the advantages of providing more details of the pelvic anatomy with magnification, three-dimensional imaging, and improved hemostasis. We are unsure why there was a gradual decrease in the gap between age groups in the recovery rate within 12 months. One possible explanation for this may be that the increasing use of robot-assisted RP and NVB-saving over time affected the continence rate more in the older age group; however, robot-assisted RP and NVB-saving were not statistically significant predictors in that group and the implementation of these procedures has also increased over time in the younger age group. More research is needed to explain this finding.

In the present study, age and MUL were the only predictors of recovery of UC within 3 and 12 months in patients aged >70 years, whereas we could identify other clinicosurgical predictors of UC besides age and MUL in the younger age group. Previous studies that did not investigate older patients separately have identified patient age, body mass index, comorbidity index, lower urinary tract symptoms, MUL, and prostate volume as predictors of UC.^{4,13,19,20,30} However, in the present study, we found that predictors of continence after RP may differ between younger and older men. We found that CCI, robot-assisted RP, prostate volume, and NVB-saving predicted recovery more strongly in patients aged ≤ 70 years. In contrast, age and MUL were identified as predictors both in patients aged >70 years and in those aged ≤ 70 years. These findings suggest that, in older men undergoing RP, few clinicosurgical factors are associated with recovery of UC and the inherent function of the urinary sphincter complex may be the main factor. A longer MUL is associated with a greater amount of smooth muscle fibers and rhabdosphincter, potentially increasing the length of the urethral pressure profile. Pre- and postoperative conditioning of the rhabdosphincter may have optimal effects in individuals with a greater MUL and therefore, incorporating a greater volume of muscle for training further improves postoperative continence outcomes.³⁰ As for the surgical approach, we found that robot-assisted RP significantly improves the rate of recovery of UC in the younger age group. Therefore, younger patients had as good undergo robotic assisted instead of open RP.

The rate of recovery of UC in patients aged >70 years has significantly increased over time, reaching almost 90% in the last quarter of our study period, which may be considered acceptable as the recovery rate. Therefore, surgical management of PCa with curative purpose should not be rejected purely on the basis of patient age, provided a

patient has a life expectancy of >10 years and tolerable health status. However, given that the recovery rate in patients aged >70 years is still lower than that in those aged ≤ 70 years, during preoperative counseling of older patients, we should inform them that they may have a higher risk of postoperative UI than younger men. Similarly, other researchers recommend that older patients be clearly informed that they are at higher risk of UI after RP than younger men; however, it is considered that the rate of recovery of UC in older patients is reasonable.⁶

Our study has several limitations that deserve discussion. First, an inevitable selection bias for the older patients may exist because most men in the older age group might be different to general older cohort with PCa, with regard to general health and willingness to be actively treated. In addition, the risk profile of the cohort or surgical experience of the surgeons might have been changed over the period studied and these might inadvertently affect our results. Second, we categorized patient's continence status based on the number of pads used, not pad weight per day. However, measurement of pad weight per day has been reported to be the most accurate estimation,³¹ although the recovery of UC is the lack of a universally accepted definition. We applied a method for pad weight assessment to some outpatients, but the response rate was too low to perform sufficient analysis. Third, we did not include relevant questionnaires such as the International Consultation on Incontinence Questionnaire-Short Form (ICIQ-SF) into the analyses. A couple of questionnaires were used to assess the changes of symptoms and bothersomeness after surgery; however, these were not mentioned in the results due to the amount of the missing data. Finally, we tried to identify the predictors for the recovery of UC in older patients aged >70 years. Even so, older age group just had a mean age of 73.3 years; thus, additional studies of the cohort with the more advanced age are needed to prove more definite association of age with the recovery of UC after RP. Despite these limitations, the present study may add further information to our knowledge on the recovery and predictor of UC following RP, particularly in patients aged >70 years.

CONCLUSIONS

In our contemporary RP series, the proportion of patients aged >70 years gradually increased to 30.0% over 12 years, and robot-assisted RP and NVB-saving were increasingly frequently implemented in this age group. Although the rate of recovery of UC within 3 and 12 months improved significantly over time in patients aged >70 years, it still remained lower than that in younger patients. While several clinicosurgical characteristics, such as NVB-saving and robot-assisted RP, were associated with the recovery of UC in younger patients, only age and MUL, possibly reflecting the inherent function of the urinary sphincter, were significant predictors in those aged >70 years. This information about contemporary trends in the recovery of UC and its predictors in older patients may be helpful in counseling individuals of this age group who are considering undergoing RP.

AUTHOR CONTRIBUTIONS

YJL, JWJ, and SJJ carried out substantial contributions to conception of the study, data acquisition, statistical analysis, and drafting the manuscript. SL, SWL, and JHK helped gather the data and draft the manuscript. SKH, SSB, and SEL helped interpret the findings and revise the manuscript. YJL wrote the draft of the manuscript and SJJ supervised the process. All authors read and approved the final manuscript.

COMPETING INTERESTS

All authors declared no competing interests.



REFERENCES

- 1 United Nations Population Division. World Population Ageing 1950–2050. New York: United Nations Publications; 2001. p48–9.
- 2 Kumar A, Samavedi S, Bates AS, Giedelman Cuevas CA, *et al*. Age stratified comparative analysis of perioperative, functional and oncologic outcomes in patients after robot assisted radical prostatectomy – a propensity score matched study. *Eur J Surg Oncol* 2015; 41: 837–43.
- 3 Center MM, Jemal A, Lortet-Tieulent J, Ward E, Ferlay J, *et al*. International variation in prostate cancer incidence and mortality rates. *Eur Urol* 2012; 61: 1079–92.
- 4 Mandel P, Graefen M, Michl U, Huland H, Tilki D. The effect of age on functional outcomes after radical prostatectomy. *Urol Oncol* 2015; 33: 203.e11–8.
- 5 Korean Statistical Information Service. Complete Life Tables, 2015–2065. Available from: http://kosis.kr/eng/statisticsList/statisticsListIndex.do?menuId=M_01_01&vwcd=MT_ETITLE&parmTabId=M_01_01&statId=1994042&themald=#SelectStatsBoxDiv. [Last accessed on 2018 Mar 04].
- 6 Mandel P, Chandrasekar T, Chun FK, Huland H, Tilki D. Radical prostatectomy in patients aged 75 years or older: review of the literature. *Asian J Androl* 2019; 21: 32–6.
- 7 Mandel P, Kriegmair MC, Kamphake JK, Chun FK, Graefen M, *et al*. Tumor characteristics and oncologic outcome after radical prostatectomy in men 75 years old or older. *J Urol* 2016; 196: 89–94.
- 8 Kim JK, Cho SY, Jeong CW, Lee SB, Ku JH, *et al*. Patients aged more than 70 had higher risk of locally advanced prostate cancers and biochemical recurrence in Korea. *BJU Int* 2012; 110: 505–9.
- 9 Corona G, Lee DM, Forti G, O'Connor DB, Maggi M, *et al*. Age-related changes in general and sexual health in middle-aged and older men: results from the European Male Ageing Study (EMAS). *J Sex Med* 2010; 7: 1362–80.
- 10 Stanford JL, Feng Z, Hamilton AS, Gilliland FD, Stephenson RA, *et al*. Urinary and sexual function after radical prostatectomy for clinically localized prostate cancer: the Prostate Cancer Outcomes Study. *JAMA* 2000; 283: 354–60.
- 11 Tan GY, El Douaihy Y, Te AE, Tewari AK. Scientific and technical advances in continence recovery following radical prostatectomy. *Expert Rev Med Devices* 2009; 6: 431–53.
- 12 Nilsson AE, Schumacher MC, Johansson E, Carlsson S, Stranne J, *et al*. Age at surgery, educational level and long-term urinary incontinence after radical prostatectomy. *BJU Int* 2011; 108: 1572–7.
- 13 Shikanov S, Desai V, Razmaria A, Zagaja GP, Shalhav AL. Robotic radical prostatectomy for elderly patients: probability of achieving continence and potency 1 year after surgery. *J Urol* 2010; 183: 1803–7.
- 14 Greco KA, Meeks JJ, Wu S, Nadler RB. Robot-assisted radical prostatectomy in men aged ≥ 70 years. *BJU Int* 2009; 104: 1492–5.
- 15 Basto MY, Vidyasagar C, te Marvelde L, Freeborn H, Birch E, *et al*. Early urinary continence recovery after robot-assisted radical prostatectomy in older Australian men. *BJU Int* 2014; 114 (Suppl 1): 29–33.
- 16 Kundu SD, Roehl KA, Eggener SE, Antenor JA, Han M, *et al*. Potency, continence and complications in 3,477 consecutive radical retropubic prostatectomies. *J Urol* 2004; 172: 2227–31.
- 17 Catalona WJ, Carvalhal GF, Mager DE, Smith DS. Potency, continence and complication rates in 1,870 consecutive radical retropubic prostatectomies. *J Urol* 1996; 162: 433–8.
- 18 Novara G, Ficarra V, D'elia C, Secco S, Cioffi A, *et al*. Evaluating urinary continence and preoperative predictors of urinary continence after robot assisted laparoscopic radical prostatectomy. *J Urol* 2010; 184: 1028–33.
- 19 Ficarra V, Novara G, Rosen RC, Artibani W, Carroll PR, *et al*. Systematic review and meta-analysis of studies reporting urinary continence recovery after robot-assisted radical prostatectomy. *Eur Urol* 2012; 62: 405–17.
- 20 Kunz I, Musch M, Roggenbuck U, Klevecka V, Kroepfl D. Tumour characteristics, oncological and functional outcomes in patients aged ≥ 70 years undergoing radical prostatectomy. *BJU Int* 2013; 111: E24–9.
- 21 Rocco F, Carmignani L, Acquati P, Gadda F, Dell'Orto P, *et al*. Early continence recovery after open radical prostatectomy with restoration of the posterior aspect of the rhabdosphincter. *Eur Urol* 2007; 52: 376–83.
- 22 Walsh PC, Marschke PL. Intussusception of the reconstructed bladder neck leads to earlier continence after radical prostatectomy. *Urology* 2002; 59: 934–8.
- 23 Deliveliotis C, Protogerou V, Alargof E, Varkarakis J. Radical prostatectomy: bladder neck preservation and puboprostatic ligament sparing—effects on continence and positive margins. *Urology* 2002; 60: 855–8.
- 24 Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis* 1987; 40: 373–83.
- 25 Coakley FV, Eberhardt S, Kattan MW, Wei DC, Scardino PT, *et al*. Urinary continence after radical retropubic prostatectomy: relationship with membranous urethral length on preoperative endorectal magnetic resonance imaging. *J Urol* 2002; 168: 1032–5.
- 26 Kim PH, Pinheiro LC, Atonia CL, Eastham JA, Sandhu JS, *et al*. Trends in the use of incontinence procedures after radical prostatectomy: a population based analysis. *J Urol* 2013; 189: 602–8.
- 27 Adejoro O, Gupta P, Ziegelmann M, Weight C, Konety B. Effect of minimally invasive radical prostatectomy in older men. *Urol Oncol* 2016; 34: 234.e1–11.
- 28 Grivas N, van der Roest R, Schouten D, Cavicchioli F, Tillier C, *et al*. Quantitative assessment of fascia preservation improves the prediction of membranous urethral length and inner levator distance on continence outcome after robot-assisted radical prostatectomy. *Neurourological Urodyn* 2018; 37: 417–25.
- 29 Tewari A, Peabody JO, Fischer M, Sarle R, Vallancien G, *et al*. An operative and anatomic study to help in nerve sparing during laparoscopic and robotic radical prostatectomy. *Eur Urol* 2003; 43: 444–54.
- 30 Mungovan SF, Sandhu JS, Akin O, Smart NA, Graham PL, *et al*. Preoperative membranous urethral length measurement and continence recovery following radical prostatectomy: a systematic review and meta-analysis. *Eur Urol* 2017; 71: 368–78.
- 31 Bauer RM, Gozzi C, Hübner W, Nitti VW, Novara G, *et al*. Contemporary management of postprostatectomy incontinence. *Eur Urol* 2011; 59: 985–96.

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

©The Author(s)(2019)

