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Article

Patterns and Predictors of Urinary Continence Recovery After Extraperitoneal Single-Port Robot-Assisted Radical Prostatectomy

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Abstract

Background/Objectives: Urinary continence recovery after robot-assisted radical prostatectomy (RARP) follows a progressive trajectory that is often simplified into binary outcomes. Modeling continence recovery as an ordered process may better reflect postoperative functional patterns and identify clinically relevant predictors. **Methods**: We retrospectively analyzed 180 patients undergoing extraperitoneal single-port RARP. At 6 months, continence recovery was classified into three ordered categories: early continence, late continence, and persistent incontinence. Multivariable ordinal logistic regression was used to identify independent predictors of continence recovery. The primary model included nerve-sparing (NS) status, postoperative complications, age, and prostate volume. Sensitivity analyses were performed by sequentially replacing prostate volume with body mass index, surgical case number, or preoperative prostate-specific antigen (PSA). An interaction between NS and age group was also tested. **Results**: NS surgery was the strongest independent predictor of favorable continence recovery ($p < .001$), followed by absence of postoperative complications ($p = .003$). Younger age and larger prostate volume were also independently associated with improved continence recovery. Sensitivity analyses confirmed the robustness of the primary model, as replacement of prostate volume with body mass index, surgical case number, or PSA did not improve model performance and did not alter the effect of NS surgery. No significant interaction between NS and age group was observed. **Conclusions**: Continence recovery after extraperitoneal RARP is primarily driven by NS surgery and an uncomplicated postoperative course, with age and prostate volume providing additional refinement. Modeling continence as an ordinal outcome offers a clinically meaningful framework for evaluating functional recovery after prostatectomy.

Keywords: robot-assisted radical prostatectomy; urinary continence; nerve-sparing surgery

1. Introduction

Radical prostatectomy is a standard curative option for clinically localized prostate cancer, and the widespread adoption of robot-assisted radical prostatectomy (RARP) has substantially improved perioperative and functional outcomes compared with open and pure laparoscopic approaches [1,2]. Nevertheless, post-prostatectomy urinary incontinence remains one of the most relevant determinants of postoperative quality of life, with reported continence rates at 12 months ranging from approximately 70% to 95%, depending on the definition of continence and the assessment method used [2,3]. Early urinary incontinence within the first weeks after surgery is particularly frequent, and although most patients ultimately regain satisfactory continence, a non-negligible proportion experience persistent symptoms that may require additional treatment [4].

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Multiple patient- and surgery-related factors have been implicated in continence recovery after RARP, including age, comorbidities, prostate volume, and adjuvant therapies, as well as technical aspects such as bladder neck preservation, posterior and anterior reconstruction, and periurethral suspension [3,5]. Among these, preservation of the neurovascular bundles through nerve-sparing (NS) techniques has consistently been associated with improved early and mid-term urinary continence, as well as better erectile function, without compromising oncological control in appropriately selected patients [1,6,7]. Recent systematic reviews and meta-analyses have shown that NS RARP is linked to higher continence rates up to 6–12 months postoperatively compared with non-nerve-sparing procedures, even when different reconstructive strategies are considered [5–7].

More recently, single-port (SP) robotic platforms and extraperitoneal approaches have been introduced to reduce invasiveness while maintaining oncologic and functional outcomes comparable to multiport transperitoneal RARP [8]. Early series of SP extraperitoneal RARP have reported favorable perioperative profiles and high early continence rates, suggesting that this technique may facilitate a rapid functional recovery [9,10]. However, data on the patterns and predictors of urinary continence recovery after extraperitoneal SP-RARP remain limited, and most available studies do not model continence as an ordered process that captures the full trajectory from early recovery to persistent incontinence [5,9]. In this context, the present study aims to characterize distinct patterns of urinary continence recovery after extraperitoneal SP-RARP and to identify independent predictors of early, late, and persistent incontinence using an ordinal modeling framework.

2. Materials and Methods

2.1. Patient Selection

We retrospectively reviewed the records of 180 consecutive patients who underwent Single-Port Robot-Assisted Radical Prostatectomy (SP-RARP) performed by a single surgeon between January 2019 and June 2025. The primary surgeon already had >10 years of experience and >100 cases of multi-port RARP. All procedures were performed using an extraperitoneal approach.

2.2. Surgical Procedure

The technique for extraperitoneal SP-RARP has been previously described [1]. In brief, patients are positioned in the supine position, and an 18/20Ch Foley catheter is placed to empty the bladder. A 3–4 cm suprapubic incision is made 3 fingerbreadths up from the pubic bone. After incision of the rectus fascia, finger dissection is used to develop the extraperitoneal space. The Da Vinci SP access kit with an 8 mm assistant port is positioned and after insufflation with the valveless AirSeal (ConMed, Utica, NY, USA), the robot is docked and the instrument inserted. For suction and irrigation, the ROSI (Vascular Technology Incorporated, Nashua, New Hampshire) is inserted through the assistant port. After dissection of the retropubic extraperitoneal fat of the Retzius space, the prostate and anterior bladder neck are reached. From this point, radical prostatectomy is carried out following the standard surgical steps, following a NS approach when applicable, and performing a pelvic lymphadenectomy when deemed necessary following international guidelines. For the reconstruction part, a modified Rocco stitch [11] for posterior reconstruction is employed, using a 3.0 V-Loc™ suture (Covidien, Mansfield, MA, USA); the same suture is used to start the anastomosis from 6 o'clock location in a clockwise fashion. A second 3.0 V-Loc™ (Covidien, Mansfield, MA, USA) suture is employed in a counterclockwise fashion to complete the anastomosis.

2.3. Statistical Analysis

The statistical analyses were performed using IBM SPSS Statistics version 30.0.0.0 (IBM Corp., Armonk, NY, USA). Continuous variables were reported as mean and standard deviation (SD) for normally distributed variables, or median and interquartile range (IQR) for non-normally distributed data. Categorical variables were reported as frequencies and percentages. Normality of distribution was assessed using the Shapiro–Wilk test.

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Patients were classified into three ordered continence recovery patterns at 6 months:

- Early continence recovery: pad-free status at 30 days and maintained at 6 months.
- Late continence recovery: incontinent at 30 days with recovery within 6 months.
- Persistent incontinence: incontinent at both 30 days and 6 months.

Continence was defined as a complete pad-free status.

Comparisons across continence groups were performed using the one-way ANOVA or Kruskal–Wallis test for continuous variables and the chi-square or Fisher's exact test for categorical variables, as appropriate.

Given the ordinal nature of the outcome, multivariable ordinal logistic regression models (proportional odds models) were used to identify independent predictors of continence recovery. The primary multivariable model was deliberately kept parsimonious due to the limited number of patients in the smallest outcome category and included NS status, postoperative complications, age, and prostate volume. Continence recovery was treated as an ordered outcome ranging from persistent incontinence to late continence and early continence, with higher categories representing more favorable recovery patterns. NS status was coded as a binary variable, with non–NS surgery serving as the reference category. The proportional odds assumption was assessed using the test of parallel lines.

Sensitivity analyses were performed to assess the robustness of the primary model by sequentially replacing prostate volume with other clinically relevant covariates, including body mass index, surgical case number (log-transformed), and preoperative PSA, while keeping NS status, postoperative complications, and age constant. An additional model tested the interaction between NS and age group (<65 vs ≥65 years). Results are reported as odds ratios (ORs) with 95% confidence intervals (CIs). A two-sided p-value < .05 was considered statistically significant.

3. Results

3.1. Baseline Characteristics by Continence Group

A total of 180 patients were included in the analysis and stratified into three continence recovery groups: early continence (41 patients, 22.8%), late continence (67 patients, 37.2%), and persistent incontinence (72 patients, 40%). Baseline characteristics according to continence recovery patterns are reported in Table 1.

Patients with persistent incontinence were significantly older compared with those achieving early or late continence recovery (mean age 65.0 vs 61.7 and 64.2 years, respectively; $p = .03$). No significant differences were observed among groups in terms of body mass index, previous abdominal surgery, operative time, estimated blood loss, or total opioid consumption on postoperative day 0.

NS surgery was performed more frequently in patients who achieved early and late continence recovery compared with those with persistent incontinence (82.9% and 79.1% vs 45.8%, respectively; $p < .001$). Similarly, postoperative complications within 30 days were significantly more common in patients with persistent incontinence compared with the other groups ($p < .001$). Readmission rates showed a borderline significant difference across continence groups ($p = .05$), whereas complication severity according to Clavien–Dindo classification did not differ significantly. A detailed breakdown of postoperative complication types according to the continence recovery group is provided in Appendix A (Table A1).

Preoperative oncological characteristics, including ISUP grade, PSA levels, and prostate volume, were comparable among the three groups. In contrast, adverse pathological features were more frequently observed in patients with persistent incontinence, including higher pathological T stage ($p = .003$), nodal involvement ($p < .001$), and positive surgical margins ($p = .005$).

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Table 1. Baseline characteristics by continence group.

	Early continent	Late continent	Persistent incontinent	p-value
Number (%)	41 (22.8%)	67 (37.2%)	72 (40%)	
Age (yr.), mean ± SD	61.7 ± 7.5	64.2 ± 5.8	65 ± 6.6	**.03**
BMI (kg/m²), median (IQR)	28.9 (26.4-34.8)	27.9 (24.2-32.2)	28.3 (25.2-32.9)	.21
Previous abdominal surgery, n° (%)				
No	34 (82.9%)	48 (71.6%)	52(72.2%)	.36
Yes	7 (17.1%)	19 (28.4%)	20 (27.8%)	
Operative time (min.), mean ± SD	235.9 ± 40	231.3 ± 41.8	237.4 ± 39	.66
EBL (ml), median (IQR)	100 (50-200)	100 (50-200)	100 (50-100)	.39
Nerve-sparing, n° (%)				
No	7 (17.1%)	14 (20.9%)	39 (54.2%)	< **.001**
Yes	34 (82.9%)	53 (79.1%)	33 (45.8%)	
Postop. complications, n° (%)				
No	39 (95.1%)	46 (68.7%)	42 (58.3%)	< **.001**
Yes	2 (4.9%)	21 (31.3%)	30 (41.7%)	
Readmission, n° (%)				
No	39 (95.1%)	56 (86.6%)	56 (77.8%)	**.05**
Yes	3 (7.3%)	11 (16.4%)	16 (22.2%)	
Post-operative complication CD, n° (%)				
< 2	2 (66.7%)	14 (66.7%)	22 (71%)	.82
≥ 2	1 (33.3%)	7 (33.3%)	9 (29%)	
Preoperative ISUP grade, n° (%)				
< 3	27 (65.9%)	41 (61.2%)	37 (51.4%)	.59
≥ 3	14 (34.1%)	26 (38.8%)	35 (48.6%)	
Preoperative PSA (ng/ml), median (IQR)	7.7 (4.7-9.7)	8.5 (6.1-14.6)	8.4 (6-16.7)	.18
Prostate volume (ml), median (IQR)	44 (37-69)	47 (40-58)	49 (37-58.5)	.99
Postoperative ISUP grade, n° (%)				
< 3	28 (68.3%)	35 (52.3%)	27 (37.5%)	.14
≥ 3	13 (31.7%)	32 (48.7%)	55 (62.5%)	
Total opioid dose POD0 (ME), mean ± SD	19.1 ± 7.5	17.9 ± 7.3	19.0 ± 7.3	.25
Pathological T, n° (%)				
pT2	30 (73.2%)	42 (62.7%)	31 (43.1%)	**.003**
pT3a	8 (19.5%)	17 (25.4%)	18 (25%)	
pT3b	3 (7.3%)	8 (11.9%)	23 (31.9%)	
Pathological N, n° (%)				
pNx	20 (48.8%)	30 (44.8%)	21 (29.2%)	**< .001**
pN0	21 (51.2%)	33 (49.3%)	34 (47.2%)	
pN1	/	4 (6%)	17 (23.6%)	
Margin status, n° (%)				
R0	27 (65.9%)	47 (70.1%)	32 (44.4%)	**.005**
R1	14 (34.1%)	20 (29.9%)	30 (55.6%)	

IQR, interquartile range; SD, standard deviation; BMI, body mass index; EBL, estimated blood loss; CD, Clavien-Dindo; ISUP, International Society of Urological Pathology; PSA, prostate-specific antigen; ME: milligram equivalent; POD, post-operative day.

A detailed description of urinary continence status and pad use at different postoperative time points is provided in Appendix A (Table A2).

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3.2. Multivariable Ordinal Logistic Regression

To account for the ordered nature of continence recovery, an ordinal logistic regression model was constructed. The proportional odds assumption was satisfied (test of parallel lines, $p > .05$). In the multivariable model, NS surgery (OR ~0.22 for absence of NS), absence of postoperative complications (OR ~2.7), younger age (OR ~0.95 per year), and larger prostate volume (OR ~1.02 per mL) were independently associated with a more favorable continence recovery profile (Table 2). The model showed good overall fit (Nagelkerke $R^2 = .23$). Although the effect size for prostate volume was modest, its association remained statistically significant after adjustment for the main covariates, suggesting a potential role of prostate size in shaping continence recovery patterns in this cohort.

BMI, surgical case number, and PSA were not independently associated with continence recovery, and sensitivity analyses replacing prostate volume with these variables did not improve model performance or alter the association between NS surgery and continence recovery (Appendix B, Tables B1–B3). We deliberately did not include tumor-related variables such as ISUP grade or pathological stage in the multivariable model, as these factors directly influence the decision to perform NS surgery and could introduce collinearity or overadjustment. Likewise, no statistically significant interaction between NS and age group was observed ($p = .81$; Appendix B, Table B4). Predicted probability plots derived from the ordinal regression model showed a markedly higher likelihood of early continence recovery in patients undergoing NS surgery, with consistent effects across age groups (Figure 1).

Table 2. Ordinal logistic regression of continence recovery.

	OR	95% CI	p-value
Nerve-sparing	0.22	0.12-0.38	**< .001**
Post-operative complications	2.75	1.40-5.40	**.003**
Age (yr.)	0.95	0.92-0.99	**.02**
Prostate volume (ml)	1.02	1.00-1.03	**.012**

Odds ratios > 1 indicate higher odds of belonging to a more favourable continence recovery category (persistent incontinent → late continent → early continent). For binary variables, odds ratios are reported relative to the reference category.

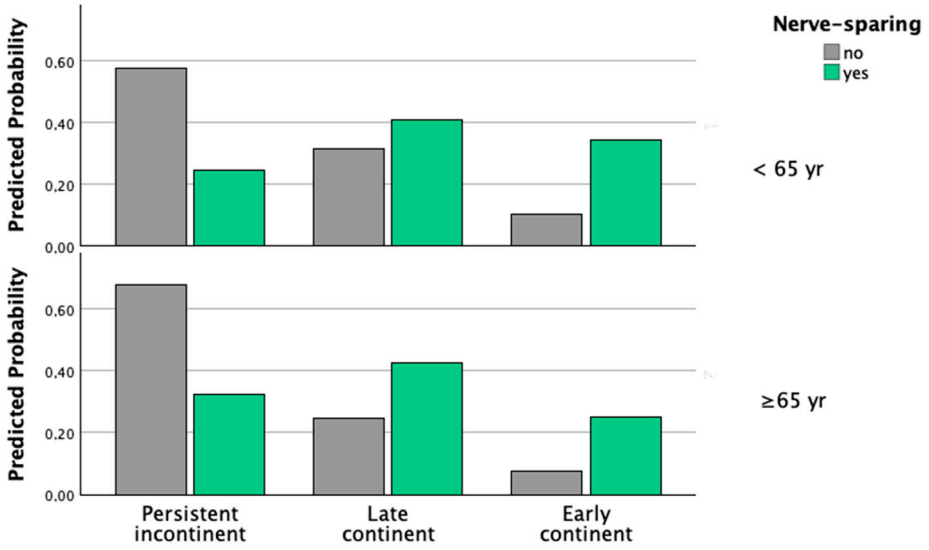

Figure 1. Predicted probabilities of continence recovery according to nerve-sparing status and age group derived from the multivariable ordinal logistic regression model.

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4. Discussion

Urinary continence recovery after RARP is reported with substantial variability across studies, largely because definitions (e.g., strict 0-pad vs "security pad") and follow-up time points are heterogeneous, which complicates direct cross-study comparisons [3,12].

Our study demonstrates that NS surgery is the strongest independent predictor of favorable urinary continence recovery after extraperitoneal SP-RARP, followed by the absence of postoperative complications, younger age, and larger prostate volume. By modeling continence as an ordered outcome, we captured nuanced recovery patterns not evident in binary assessments, with 22.8% achieving early continence, 37.2% late, and 40% with persistent incontinence at 6 months. The longitudinal distribution of continence status and pad use (Appendix A, Table A2) further supports the progressive nature of functional recovery after extraperitoneal SP-RARP, showing not only increasing pad-free rates over time but also a gradual reduction in incontinence severity among non–pad-free patients.

These findings align with extensive literature confirming NS as a cornerstone for functional preservation in RARP [5,7,13,14]. Bilateral NS consistently yields superior continence rates versus unilateral or none, with multivariable analyses showing odds ratios (OR) for favorable recovery ranging from 0.22–0.45 [15]. In our cohort, NS rates were markedly higher in early/late recovery groups (82.9%/79.1% vs. 45.8% in persistent; $p < .001$), mirroring large series where NS independently predicted pad-free status at 3–12 months (OR 2.1–4.5) [6,7,13]. Notably, our extraperitoneal SP approach preserved this benefit without transperitoneal caveats, consistent with early SP-RARP reports of 80–95% continence at 6 months [1,2].

In our analysis, postoperative complications emerged as the second strongest predictor, a novel emphasis in SP-RARP contexts [1,15,16]. However, prior evidence suggests that postoperative morbidity, including early surgical complications such as anastomotic leakage and lymphoceles, can negatively impact early functional outcomes, including urinary continence [17]. Additionally, comprehensive reviews of post-prostatectomy urinary incontinence emphasize the multifactorial nature of functional recovery, involving patient-, surgical-, and perioperative factors [18]. In this context, our findings further suggest that postoperative complications may represent an important and potentially modifiable factor associated with delayed continence recovery.

Age behaved as an independent predictor in our model, and this direction agrees with multiple RARP series in which increasing age is associated with lower odds of early pad-free continence and/or slower time-to-continence recovery [7,12,19].

Although predicted probability plots suggested lower absolute continence recovery rates in older patients (Figure 1), no statistically significant interaction between nerve-sparing and age group was observed (Appendix B, Table B4). This indicates that while age influences baseline continence recovery, the relative benefit of NS surgery remains consistent across age strata. These findings support the use of NS techniques whenever oncologically appropriate, even in older patients, as age alone does not appear to modify the effect of nerve preservation on continence recovery.

The association we observed for prostate volume should be interpreted against a mixed literature: large registry data (CaPSURE) suggest baseline prostate volume predicts urinary function recovery after radical prostatectomy, with larger glands showing lower continence scores up to 1–2 years [20], whereas other RARP cohorts found prostate weight/volume not independently predictive once age and symptoms are accounted for [12].

For BMI, our null finding is consistent with multivariable RARP analyses where BMI did not independently predict early pad-free status [12], but longer-term evidence remains conflicting because some studies/meta-analytic syntheses report higher 12-month incontinence odds in obese patients [21], while other cohorts show similar continence outcomes between obese and non-obese men when the technique is standardized [22].

Preoperative PSA was not independently associated with continence recovery in our cohort. This finding is consistent with previous RARP series showing that PSA primarily reflects tumor

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burden and oncologic risk, rather than functional recovery, once age, surgical technique, and NS status are accounted for [11,13].

The lack of an association between surgical case number and continence recovery likely reflects prior surgeon expertise. The adoption of the SP platform preserves the same anatomical landmarks and NS principles, potentially minimizing platform-related learning effects on continence outcomes. As a matter of fact, early functional outcomes reported in initial series of SP-RARP appear favorable even during the early adoption phase [16].

Limitations include the retrospective design and tertiary single-center nature, introducing selection/performance bias despite surgeon experience. We lacked membranous urethral length (MUL) measurements [23] or detailed anastomotic features, precluding nuanced analysis. Moreover, incontinence-complication correlations were aggregate, not granular by type, limiting causality insights. Finally, a six-month endpoint may underestimate very late recovery.

5. Conclusions

Continence recovery after extraperitoneal SP-RARP is driven primarily by NS surgery and the absence of postoperative complications, with age and prostate volume providing additional refinement. These results support a surgical strategy focused on functional preservation and complication avoidance to optimize postoperative continence outcomes.

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Informed Consent Statement: Patient consent was waived due to the retrospective nature of the study and the use of anonymized electronic health record data.

Data Availability Statement: The raw data supporting the conclusions of this article will be made available by the authors upon reasonable request.

Conflicts of Interest: Simone Crivellaro is a consultant for Intuitive. Other authors have nothing to disclose.

Abbreviations

The following abbreviations are used in this manuscript:

RARP	Robot-Assisted Radical Prostatectomy
NS	Nerve-Sparing
SP	Single-Port
PSA	Prostate-Specific Antigen
BMI	Body Mass Index
ISUP	International Society of Urological Pathology
MUL	Membranous Urethral Length
OR	Odds Ratio
CI	Confidence Interval

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Appendix A

Table A1. Post-operative complications profile by continence group.

	Early continent	Late continent	Persistent incontinent
Urine leak, n° (%)	/	5 (23.9%)	4 (13.4%)
UTI and/or sepsis, n° (%)	1 (50%)	2 (9.5%)	7 (23.4%)
Hematuria, n° (%)	/	4 (19%)	9 (30%)
Urinary retention, n° (%)	/	3 (14.3%)	3 (10%)
Lymphocele, n° (%)	/	4 (19%)	5 (16.7%)
Pneumothorax, n° (%)	/	2 (9.5%)	/
Orchitis/epididymitis, n° (%)	/	1 (4.8%)	/
Hernioplasty mesh infection, n° (%)	/	/	1 (3.2%)
Abdominal pain, nausea, n° (%)	1 (50%)	/	1 (3.2%)

UTI, urinary tract infection.

Table A2. Urinary continence status and pad use at different postoperative time points.

	1 month	6 months	Last-follow-up
Continent, n° (%)	41 (22.8%)	108 (60%)	94 (74%[1])
Incontinent, n° (%)	139 (77.2%)	72 (40%)	33 (26%[1])
Pads/day, n° (%)			
1	66 (47.5%)	33 (45.8%)	15 (45.5%)
2	52 (37.4%)	28 (38.9%)	15 (45.5%)
> 2	21 (15.1%)	11 (15.3%)	3 (9%)

[1]At last follow-up, continence data were available for 127 patients. Continence was defined as a complete pad-free status.

Appendix B

Table B1. Ordinal logistic regression including Body Mass Index.

	OR	95% CI	p-value
Nerve-sparing	0.24	0.14-0.42	**< .001**
Post-operative complications	2.65	1.35-5.22	**.004**
Age (yr.)	0.95	0.90-0.99	**.04**
BMI (kg/m²)	0.99	0.94-1.05	.70
Nagelkerke R^2 = .207			

Odds ratios > 1 indicate higher odds of belonging to a more favourable continence recovery category (persistent incontinent → late continent → early continent). For binary variables, odds ratios are reported relative to the reference category.

Table B2. Ordinal logistic regression including the logarithm of the surgical case number.

	OR	95% CI	p-value
Nerve-sparing	0.25	0.14-0.44	**< .001**
Post-operative complications	2.58	1.33-5.24	**.005**
Age (yr.)	0.95	0.91-0.99	**.04**
Log. of surgical case number	0.99	0.81-1.29	.90
Nagelkerke R^2 = .206			

Odds ratios > 1 indicate higher odds of belonging to a more favourable continence recovery category (persistent incontinent → late continent → early continent). For binary variables, odds ratios are reported relative to the reference category.

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Table B3. Ordinal logistic regression including the Prostate Specific-Antigen value.

	OR	95% CI	p-value
Nerve-sparing	0.24	0.14-0.43	**< .001**
Post-operative complications	2.62	1.34-5.12	**.004**
Age (yr.)	0.95	0.91-0.99	**.04**
PSA (ng/ml)	1.01	0.98-1.04	.48
Nagelkerke R^2 = .209			

Odds ratios > 1 indicate higher odds of belonging to a more favourable continence recovery category (persistent incontinent → late continent → early continent). For binary variables, odds ratios are reported relative to the reference category.

Table B4. Ordinal logistic regression including interaction between nerve-sparing and age group.

	OR	95% CI	p-value
Nerve-sparing	0.24	0.12-0.46	**< .001**
Post-operative complications	2.61	1.33-5.15	**.005**
Age group[1]	0.89	0.46-1.74	.73
Nerve-sparing x age group	1.17	0.33-4.11	.81
Prostate volume (ml)	1.02	1.00-1.03	**.019**
Nagelkerke R^2 = .214			

[1] ≥ 65 yr. vs < 65 yr. Odds ratios > 1 indicate higher odds of belonging to a more favourable continence recovery category (persistent incontinent → late continent → early continent). For binary variables, odds ratios are reported relative to the reference category.

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