



# Effects of different types of hysterectomies on postoperative urodynamics and lower urinary tract symptoms

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**Purpose:** To evaluate the effects of different hysterectomies—simple hysterectomy (SH) and radical hysterectomy (RH) with or without radiation therapy (RT) on urodynamics and lower urinary tract symptoms (LUTS).

**Materials and Methods:** Among patients who underwent urodynamic study between 2009 and 2019, those with RH history due to cervical cancer and SH for uterine myoma were included. Clinical parameters were compared after adjusting clinically significant baseline variables with multivariate regression.

**Results:** A total of 289 patients (RH-only, n=57; RH+RT, n=72; SH, n=160) were included. Age at hysterectomy, gap between urodynamic study and hysterectomy, body mass index, hypertension and vaginal delivery history were adjusted. Stress urinary incontinence was more likely to occur in SH group ( $p<0.001$ ), while urgency urinary incontinence was more prevalent in patients with history of RH (odds ratio [OR] 6.4, 95% confidence interval 2.171–18.855;  $p=0.001$ ). There was no difference in OR of mixed urinary incontinence. Higher proportion of RH patients complained of recurrent urinary tract infection and voiding symptoms requiring intermittent catheterization. On urodynamic study, RH groups had lower maximal flow rate, larger post-void residual, decreased bladder sensation and impaired detrusor contractility (all  $p<0.001$ ) than SH group. Adjuvant RT resulted in decreased compliance and decrease in volume of the first sense to void.

**Conclusions:** Predominant LUTS differed among patients after different types of hysterectomy. RH resulted in inefficient bladder emptying, leading to recurrent urinary tract infection and voiding symptoms requiring intermittent catheterization. Adjuvant RT exacerbated bladder compliance and increased bladder sensation.

**Keywords:** Hysterectomy; Lower urinary tract symptom; Urinary incontinence

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## INTRODUCTION

Hysterectomy is one of the most common surgical procedures performed in women for various benign and

malignant gynecological diseases. The prevalence of voiding dysfunction after hysterectomy varies among studies, but radical hysterectomy (RH) and hysterectomy for pelvic organ prolapse have higher incidence than simple hysterectomy.

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tomy (SH) for other benign conditions, for instance, uterine myoma and abnormal uterine bleeding [1]. One of the troublesome lower urinary tract symptoms among middle aged and elderly women is urinary incontinence. Vigorous attempts to investigate the role of hysterectomy on the development of urinary incontinence have been made, but due to the heterogeneous and multifactorial etiologies, no consensus was withdrawn [2-4].

RH with pelvic lymph node dissection is a primary treatment option for early-stage cervical cancer [5]. Postoperative urinary dysfunction rates were as high as 70% after traditional RH [6], but improvements in surgical techniques led to nerve-sparing RH which is now accepted as a new standard practice, with comparable oncological outcomes and decreased postoperative complications [7]. However, lower urinary tract dysfunction is one of the most common complications of RH and can significantly affect patients' quality of life, as 5-year survival rate for early-stage cervical cancer patients are reported to be high as 95% [8,9]. Along with RH, radiation therapy (RT) is also a principal therapy for cervical cancer and can be used in all stages as a primary or adjuvant option. Despite improvements in targeting and lowered dosage, RT induces fibrotic changes in the detrusor and decreases bladder compliance, resulting in high prevalence of storage symptoms such as frequency and urgency [10]. The exact prevalence of various lower urinary tract dysfunctions after RH with or without adjuvant RT varies among studies [11-13].

Sufficient information on postoperative changes in lower urinary tract symptoms is crucial for patient satisfaction and readiness of mind. Therefore, we evaluated the effects of different hysterectomies—SH for benign uterine myoma (except pelvic organ prolapse), RH with or without RT on lower urinary tract dysfunction, urodynamic parameters and the management. Secondly, we investigated the predictive factor for clean intermittent catheterization (CIC) in cervical cancer patients whose bladder function was evaluated at least one year and 5-years after RH.

## MATERIALS AND METHODS

The Institutional Review Board of the center approved this study (approval number: 2019-1693) and waived the requirement for informed consent due to the retrospective study design.

Among cervical cancer patients with history of RH, those with available oncological data and urodynamic studies performed between January 2009 and December 2019 were included. Patients with underlying neurological conditions—Parkinson's disease, multiple system atrophy, multiple sclerosis, and spinal lesions, previous pelvic organ prolapse repair or dye test-proven genitourinary fistula were excluded. For better comprehension of lower urinary tract symptoms and urodynamics after RH with or without RT (RH+RT, RH-only), patients who underwent urodynamic study during the same period with a history of SH for uterine myoma were

**Table 1.** Baseline demographics and clinical characteristics of patients

Variable	SH (n=160)	RH only (n=57)	RH+RT (n=72)	p-value
Age at operation (y)	44.1±7.2	48.8±10.1	51.3±10.6	<0.001
Age at evaluation (y)	59.7±9.2	56.3±11.9	55.4±11.3	0.006
Gap (mo)	166.8 (8.0–549.7)	66.2 (2.3–301.9)	34.7 (0.9–227.6)	<0.001
BMI (kg/m <sup>2</sup> )	24.7±3.1	23.9±3.8	23.4±3.2	0.024
Diabetes	20 (12.5)	7 (12.3)	4 (5.6)	0.262
Hypertension	50 (31.3)	14 (24.6)	9 (12.5)	0.010
Vaginal delivery	144 (95.4)	46 (83.6)	59 (85.5)	0.010
Frequency	91 (56.9)	23 (40.4)	35 (48.6)	0.085
Urgency	113 (70.6)	23 (40.4)	41 (56.9)	<0.001
SUI only	69 (43.1)	8 (14.0)	5 (6.9)	<0.001
UUI only	8 (5.0)	9 (15.8)	13 (18.1)	0.003
MUI	60 (37.5)	11 (19.3)	28 (38.9)	0.029
Weak stream	26 (16.3)	42 (73.7)	55 (76.4)	<0.001
Residual urine sense	42 (26.3)	44 (77.2)	54 (75.0)	<0.001
Hesitancy	21 (13.1)	38 (66.7)	50 (69.4)	<0.001
Urinary tract infections	21 (13.1)	14 (24.6)	27 (37.5)	<0.001

Values are presented as mean±standard deviation, median (range), or number (%).

SH, simple hysterectomy; RH, radical hysterectomy; RT, radiation therapy; BMI, body mass index; SUI, stress urinary incontinence; UUI, urgency urinary incontinence; MUI, mixed urinary incontinence.

set as the control group.

After an initial interview regarding lower urinary tract symptoms, patients were asked to submit a 3-day voiding diary; cervical cancer patients who complained of ambiguous incontinence underwent cystoscopy with dye test to rule out the presence of genitourinary fistula. Urodynamic studies were performed by a skilled nurse practitioner using an Aquaris TT instrument (2009, LABORIE, Mississauga, ON, Canada). Medication was prescribed based on the patients' subjective symptoms, voiding diary, and urodynamic study results. For patients with ineffective bladder emptying (larger residual volume than voided volume), CIC was recommended and additional workup for upper tract evaluation was performed. In patients who were recommended catheterization, the catheterized volume of residual urine was documented serially to determine the number of catheterizations per day.

Baseline demographics, clinical symptoms, and urody-

dynamic parameters were compared among the SH, RH-only, and RH+RT groups. The predictive factors for CIC were analyzed in patients who had their bladder function evaluated at least 5 years after RH with no evidence of cancer recurrence.

Statistical analysis was performed using IBM SPSS Statistics for Windows, version 21.0 (IBM Corp., Armonk, NY, USA). Differences with  $p < 0.05$  were considered statistically significant. Student's t-tests and one-way analysis of variance (ANOVA) were used to compare parametric continuous variables, and chi-square tests were used to compare non-parametric categorical variables. Under the review of statistician, we adjusted baseline variables which were significantly different among groups with linear log regression. To adjust baseline variables which were significantly different among groups, we performed multivariable linear regression for continuous variables and multivariable logistic regression for binary variables. The right-skewed variables were

**Table 2.** Odds ratio of postoperative lower urinary tract symptoms

LUTS	Category	Unadjusted			Adjusted		
		Odds ratio	95% CI	p-value	Odds ratio	95% CI	p-value
Frequency	SH	1		0.084	1		0.325
	RH only	0.513	0.277–0.948	0.033	0.627	0.321–1.227	0.173
	RH+RT	0.717	0.410–1.253	0.243	0.996	0.510–1.945	0.990
Urgency	SH	1		<0.001	1		0.009
	RH only	0.281	0.150–0.528	<0.001	0.352	0.178–0.696	0.003
	RH+RT	0.520	0.292–0.925	0.026	0.731	0.366–1.458	0.373
SUI only	SH	1		<0.001	1		<0.001
	RH only	0.215	0.096–0.484	<0.001	0.170	0.071–0.408	<0.001
	RH+RT	0.098	0.038–0.257	<0.001	0.072	0.025–0.205	<0.001
UUI only	SH	1		0.003	1		0.001
	RH only	3.562	1.303–9.744	0.013	5.538	1.721–17.823	0.004
	RH+RT	4.186	1.651–10.617	0.003	8.051	2.327–27.850	0.001
MUI	SH	1		0.022	1		0.030
	RH only	0.399	0.192–0.828	0.014	0.496	0.226–1.089	0.081
	RH+RT	1.061	0.599–1.879	0.840	1.475	0.729–2.985	0.280
Weak stream	SH	1		<0.001	1		<0.001
	RH only	14.431	6.997–29.762	<0.001	15.627	6.978–34.995	<0.001
	RH+RT	16.674	8.387–33.150	<0.001	18.991	8.202–43.974	<0.001
Residual urine sense	SH	1		<0.001	1		<0.001
	RH only	9.509	4.666–19.379	<0.001	10.373	4.773–22.544	<0.001
	RH+RT	8.429	4.448–15.972	<0.001	9.472	4.418–20.306	<0.001
Hesitancy	SH	1		<0.001	1		<0.001
	RH only	13.238	6.464–27.111	<0.001	15.698	6.880–35.815	<0.001
	RH+RT	15.043	7.623–29.685	<0.001	19.418	8.153–46.247	<0.001
UTI	SH	1		<0.001	1		<0.001
	RH only	2.155	1.010–4.598	0.047	2.945	1.251–6.933	0.013
	RH+RT	3.971	2.049–7.699	<0.001	6.222	2.627–14.739	<0.001

LUTS, lower urinary tract symptoms; CI, confidence interval; SH, simple hysterectomy; RH, radical hysterectomy; RT, radiation therapy; SUI, stress urinary incontinence; UUI, urgency urinary incontinence; MUI, mixed urinary incontinence; UTI, urinary tract infection.

analyzed after log transformation.

## RESULTS

A total of 289 patients (RH-only, n=57; RH+RT, n=72; SH, n=160) were included. SH group underwent hysterectomy at the youngest age but required urological evaluation at the oldest age, while the gap between operation and hysterectomy was the shortest in RH+RT group (oldest at operation, but youngest at evaluation). SH group had highest body mass index (BMI), more prevalent hypertension and vaginal delivery history. Prevalence of various lower urinary tract symptoms significantly varied among groups (Table 1).

To identify the effect of hysterectomy on various lower urinary tract symptoms, age at operation, gap between the operation and evaluation, BMI, presence of hypertension and vaginal delivery history was adjusted with SH group set as a reference group. Stress urinary incontinence (SUI) only was more prevalent in SH group while urgency urinary incontinence (UUI) only was more prevalent in RH and RH+RT group. There were no significant differences in mixed urinary incontinence and frequency of micturition among groups. Voiding symptoms including weak stream, residual urine sense and hesitancy were more prevalent in

RH and RH+RT group leading to higher risk of urinary tract infection (Table 2).

Medication prescription showed similar trends as regards to patients' lower urinary tract symptoms. The prescription rates of alpha-blockers (SH:RH:RH+RT=17.5% vs. 68.4% vs. 55.6%,  $p<0.001$ ) and cholinergics (SH:RH:RH+RT=3.8% vs. 38.6% vs. 16.7%,  $p<0.001$ ) were highest in RH group, while antimuscarinics or beta 3 agonist were most frequently prescribed in RH+RT group (SH:RH:RH+RT=35.6% vs. 24.6% vs. 52.8%,  $p=0.003$ ). Anti-incontinence surgery (midurethral sling operation or suburethral injection) was commonly performed in SH group (SH:RH:RH+RT=68.8% vs. 14.0% vs. 4.2%,  $p<0.001$ ). Patients who underwent RH had higher rates of CIC than SH patients (SH:RH:RH+RT=4.4% vs. 49.1% vs. 50.0%,  $p<0.001$ ).

Comparison of urodynamic parameters after adjustment revealed that RH and RH+RT groups tended to fail in voiding on both free uroflowmetry and voiding cystometry. In cases of successful voiding, they had lower maximal flow rate, larger postvoid residual, and impaired detrusor contractility compared to those in the SH group. Filling and voiding cystometry showed that patients with RH history had higher proportions of absent voiding sense, decreased compliance, impaired contractility and higher proportion of detrusor

**Table 3.** Comparison of urodynamic parameters

Parameter	SH (n=160)	RH only (n=57)	RH+RT (n=72)	p-value <sup>a</sup>
Uroflowmetry				
Fail to void	5 (3.1)	13 (24.5)	16 (23.5)	<0.001
Voided volume (mL)	211.74±136.17	175.7±160.23	141.14±148.99	0.005
Qmax (mL/s)	19.76±11.03	12.35±10.61	10.24±10.69	<0.001
Postvoid residual (mL)	57.69±110.88	221.28±193.09	188.31±190.16	<0.001
Filling cystometry				
Presence of sense	150 (93.8)	25 (43.9)	28 (38.9)	<0.001
First sense to void (mL)	181.86±112.14	153.7±199.22	103.08±152.33	<0.001
Presence of DO	76 (47.5)	8 (14.0)	14 (19.4)	<0.001
DLPP	3 (1.9)	12 (21.1)	32 (44.4)	<0.001
Decreased compliance	4 (2.5)	32 (56.1)	59 (83.1)	<0.001
Maximal capacity (mL)	384.09±106.94	476.41±110.78	388.39±146.12	<0.001
Voiding cystometry				
Voided volume (mL)	344.6±154.54	270.08±186.36	200.68±169.37	<0.001
Qmax (mL/s)	19.28±10.64	12.27±8.62	10.71±7.99	<0.001
Postvoid residual (mL)	62.21±126.7	263.33±183.99	228.26±180.21	<0.001
PdetQmax	17.07±11.43	4.78±10.6	9.34±19.59	<0.001
WF Qmax	11.14±6.1	8.39±9.42	10.04±9.26	<0.001
BCI<100	66 (41.3)	50 (87.7)	59 (81.9)	<0.001

Values are presented as number (%) or mean±standard deviation.

SH, simple hysterectomy; RH, radical hysterectomy; RT, radiation therapy; Qmax, maximal flow rate; DO, detrusor overactivity; DLPP, detrusor leak point pressure; PdetQmax, detrusor pressure at maximal flow rate; WF, Watt factor; BCI, bladder contractility index.

<sup>a</sup>:Linear regression adjusted age at operation, gap between the operation and evaluation, body mass index, presence of hypertension and vaginal delivery history.

underactivity (DU) which is defined with bladder contractility index (BCI; detrusor pressure at maximal flow rate [PdetQmax]+5×maximal flow rate [Qmax])<100, while the SH group had a higher proportion of patients with detrusor overactivity (DO). RH group had larger maximal cystometric capacity (MCC) than SH and RH+RT group, but there was no difference in MCC between SH and RH+RT group (Table 3). In addition, there was no significant difference in proportion of DODU among groups (SH:RH:RH+RT=18.1% vs. 12.3% vs. 16.3%, p=0.571).

To investigate the predictive factors for CIC in cervical cancer patients, univariate and multivariate logistic regression analysis was performed in 96 patients whose bladder function was evaluated at least one year after RH. The median gap between RH and urodynamic study was 66.3 months (range: 12.4–301.9). On multivariate analysis, successful self-voiding immediately after RH was protective factor for CIC (hazard ratio 0.411 [0.174–0.971], p=0.043) (Table 4). In 50 cervical cancer survivors whose bladder function was evaluated at least five years after RH (median 133.7 months; range 61.2–301.9), there was no identifiable predictive factor in both univariate and multivariate analysis.

**DISCUSSION**

The present study investigated the effects of different types of hysterectomies on voiding symptoms and bladder function. SUI was more common in SH patients, while UUI was more prevalent in patients with history of RH with or without RT. Higher proportion of RH patients complained of recurrent urinary tract infection and voiding symptoms (weak stream, residual urine sense and hesitancy) requiring CIC. Successful voiding immediately after RH was a protective factor for CIC in patients whose bladder function was evaluated at least one year after RH, but no predictive fac-

tor was identifiable in cervical cancer survivors.

Different types of hysterectomy are applied depending on the clinical setting; among them, RH for cervical cancer reportedly has a higher incidence of voiding dysfunction compared to SH [1]. The anatomical course of the inferior hypogastric plexus, which comprises parasympathetic nerves from S2–S4 and sympathetic nerves of the hypogastric plexus, passes through the uterosacral ligament posteriorly to the cervix and laterally to the cardinal ligament. The hypogastric nerves can be injured during the resection of uterosacral and rectovaginal ligaments, and nerve-sparing RH can preserve the lateral aspect of the uterosacral ligament depending on the disease stage [14,15]. Whether the nerves are spared or not, RH itself involves a wider dissection of the surrounding tissue compared to that for SH.

The common lower urinary tract symptoms after RH are urinary incontinence and urinary retention. Urinary incontinence is common in middle-aged and elderly women and can be roughly classified as stress, urge, and mixed incontinence. Anti-incontinence surgery, for example, mid-urethral sling or sub-urethral injection, can be considered for the treatment of stress urinary incontinence [16]. In our study, anti-incontinence surgery was performed less in RH patients (especially in cases of adjuvant RT) than in SH patients due to the higher risks of urinary retention and CIC after anti-incontinence surgery and higher risks of mesh complication in patients receiving radiation [17].

RH patients in this study had a higher prevalence of voiding symptoms (hesitancy, weak stream, and tenesmus) and inefficient bladder emptying on urodynamic study, which presented as lower maximal flow rate, higher post-void residual, and impaired detrusor contractility, than SH patients. Large volumes of residual urine sustained in the bladder could have resulted in more common recurrent urinary tract infections. About 20% of patients underwent

**Table 4.** Predictive factors of CIC in cervical cancer patients whose bladder function was evaluated at least 1-year after RH (n=96)

Variable	Univariate		Multivariate	
	OR (95% CI)	p-value	OR (95% CI)	p-value
Successful self-voiding immediately after RH	0.407 (0.172–0.962)	0.041	0.406 (0.169–0.972)	0.043
Operation method				
Open	Reference			
Laparoscopy	2.062 (0.876–4.858)	0.098		
Robotic	0.786 (0.075–8.222)	0.840		
Parametrium invasion	1.320 (0.527–3.309)	0.554		
Vagina invasion	1.273 (0.458–3.537)	0.644		
Adjuvant radiation therapy	0.855 (0.373–1.960)	0.711	0.624 (0.215–1.812)	0.386
Adjuvant chemotherapy	1.515 (0.630–3.643)	0.653	2.295 (0.743–7.087)	0.149

CIC, clean intermittent catheterization; RH, radical hysterectomy; OR, odds ratio; CI, confidence interval.

temporary CIC and 30% of patients continued CIC in RH patients. Except for one patient who could not continue the recommended catheterization before sleep (once per day) due to recurrent cystitis, all other patients showed decreased numbers of urinary tract infections. None of the cancer-free patients who were compliant to the recommended CIC showed upper tract damage during follow-up.

One interesting finding is, although patients who underwent RH were more likely to present UUI, urgency was less common than SH group. This might be due to the decreased bladder sensation and decreased compliance on urodynamic study. Lower urinary tract symptoms were assessed with patients' subjective symptom that urgency was defined sudden desire to urinate which is hard to defer and UUI was defined complaint of involuntary urine loss associated with urgency. Patients who underwent RH were less likely to report urgency at daily voiding due to decreased bladder sensation and their bladder might have been distended fully enough when they felt urge to urinate. However, they could not hold urine until they arrived at toilet due to bladder capacity. RH patients' UUI might hold some component of overflow incontinence. In addition, decreased bladder compliance and higher prevalence of detrusor leak point pressure could have attributed to UUI—patients are more likely to suffer from involuntary urine leak without circumstances which increase abdominal pressure.

On the contrary, patients who underwent SH were more likely to present SUI only than RH groups. This might be due to the differences in chief complaints in each group. On initial interview, RH patients focused more on voiding difficulty—weak stream, hesitancy and residual urine sense that patients could have neglected or denied simple SUI. Meanwhile, initial chief complaints of SH patients were urinary incontinence that they were more likely to describe their incontinence in detail. Moreover, RH patients had more complex changes in urinary bladder that their lower urinary tract symptoms could have resulted in intermingled symptoms. Finally, RH groups are cancer patients that some of the patient population could have relatively impaired performance status than those of SH group that they were less exposed to physical activities which trigger SUI.

Diagnosis of detrusor underactivity in women is still challenging due to lack of standardized criteria [18]. We have used BCI which is most commonly used to define DU, but there are other competing criteria as well; 1)  $P_{det}Q_{max} \leq 10$  cm H<sub>2</sub>O and  $Q_{max} \leq 12$  mL/s [19]; 2)  $P_{det}Q_{max} < 30$  cm H<sub>2</sub>O and pressure-flow study (PFS)  $Q_{max} < 10$  mL/s [20]; 3)  $P_{det} @ Q_{max} + PFS Q_{max} < 30$  [21]. The prevalence of DU varied depending on the criteria used but DU was predominant in

RH groups in all cases. In addition, there was no difference in prevalence of DODU among groups except when Jeong's criteria was applied; DODU was more prevalent in RH+RT group than SH and RH only group.

Plasticity refers to the inherent capacity to undergo structural and functional modification. Bladder function is considered to be restored to acceptable levels at least 6 to 12 months after radical pelvic surgery. We evaluated the risk factors for CIC in cervical cancer patients whose bladder function was evaluated at least one year after RH and long-term cervical cancer survivors without evidence of tumor recurrence. Cancer-free patients were selected because the presence of local recurrence might have a direct invasion or mass effect on the bladder, while systemic recurrence requires systematic chemotherapy which might influence the general condition of patients. One and five-year period were selected because the typical observational period of bladder function recovery after pelvic surgery is over 12 months, and 5 years is commonly used as a cut-off for cancer survival rates. Successful self-voiding immediately after RH might affect bladder function at median of 66.3 months, but its effect did not last for more than 10 years.

This study is limited by its retrospective design and our result need to be interpreted with caution as we only included patients who underwent urodynamic study after hysterectomy. To overcome these issues, we adjusted multiple variables which could be responsible for various lower urinary tract symptoms. In addition, this study presents the longest follow-up data in cervical cancer survivors up to date although no definite predictive factors were identified. As most of the hysterectomies are performed by gynecologist, it is very difficult to prospectively assess the role of different hysterectomies on lower urinary tract symptoms. However, further prospective and nationwide study is warranted to investigate the effect of different types of hysterectomies on voiding.

## CONCLUSIONS

The predominant lower urinary tract symptoms differed between patients who underwent SH or RH. RH resulted in inefficient bladder emptying, which led to recurrent urinary tract infection and voiding symptoms requiring CIC. Adjuvant RT after RH exacerbated bladder compliance, leading to increased bladder sensation and decreased maximal capacity.

## CONFLICTS OF INTEREST

The authors have nothing to disclose.

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## AUTHORS' CONTRIBUTIONS

Research Conception and design: Jung Hyun Shin. Data acquisition: Jung Hyun Shin, Chan Hoon Gwak, and Min Uk Park. Statistical analysis: Jung Hyun Shin, Chan Hoon Gwak, and Min Uk Park. Data analysis and interpretation: Jung Hyun Shin, and Myung-Soo Choo. Drafting the manuscript: Jung Hyun Shin. Critical revision of the manuscript: Jung Hyun Shin. Supervision: Myung-Soo Choo. Approval of the final manuscript: Myung-Soo Choo.

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