

Success Factors of Laparoscopic Nerve-sparing Radical Hysterectomy for Preserving Bladder Function in Patients with Cervical Cancer: A Protocol-Based Prospective Cohort Study

Hee Seung Kim, MD^{1,2}, Tae Hun Kim, MD³, Dong Hoon Suh, MD⁴, Sang Youn Kim, MD⁵, Min A. Kim, MD, PhD⁶, Chang Wook Jeong, MD, PhD⁷, Kyoung Sup Hong, MD⁸, and Yong Sang Song, MD, PhD^{1,2,9}

¹Department of Obstetrics and Gynecology, Seoul National University College of Medicine, Seoul, Republic of Korea; ²Cancer Research Institute, Seoul National University College of Medicine, Seoul, Republic of Korea; ³Department of Obstetrics and Gynecology, Korean Cancer Center Hospital, Korea Institute of Radiological and Medical Sciences, Seoul, Republic of Korea; ⁴Department of Obstetrics and Gynecology, Seoul National University Bundang Hospital, Seongnam, Republic of Korea; ⁵Department of Radiology, Seoul National University College of Medicine, Seoul, Republic of Korea; ⁶Department of Pathology, Seoul National University College of Medicine, Seoul, Republic of Korea; ⁷Department of Urology, Seoul National University College of Medicine, Seoul, Republic of Korea; ⁸Department of Internal Medicine, Seoul National University College of Medicine, Seoul, Republic of Korea; ⁹Major in Biomodulation, World Class University, Seoul National University, Seoul, Republic of Korea

ABSTRACT

Background. Success factors of laparoscopic nerve-sparing radical hysterectomy (LNRH) to preserve bladder function are little known despite its widespread use. Thus, we conducted a protocol-based prospective cohort study to evaluate clinicopathologic factors for preserving autonomic nerves and its impact on duration of postoperative catheterization (DPC).

Methods. From 2012 to 2014, 30 patients with stage IB1 to IIA2 cervical cancer were recruited prospectively to undergo LNRH. All procedures were performed on the left side of the patients by one gynecologic oncologist. Extent of resection and preservation of autonomic nerves were documented in the protocol during LNRH.

Results. All patients received laparoscopic type C1 radical hysterectomy, where extent of resection and preservation

of autonomic nerves were not different between the right and left sides. Stage IB1 disease was associated with the reduced risk of injury of the left junctions between the hypogastric and the splanchnic nerves; between the splanchnic nerve and the vesical branch of the pelvic plexus (S–V junction) (adjusted odds ratios, 0.06 and 0.06; 95 % confidence intervals, 0.01–0.92 and 0.01–0.48); the right S–V junction with marginal significance (adjusted odds ratio, 0.18; 95 % confidence interval, 0.03–1.06). Furthermore, bilateral preservation of autonomic nerves decreased DPC significantly when compared with failure or unilateral preservation (median, 6 days vs. 34 days or 57 days; $P < 0.05$).

Conclusions. LNRH has a higher likelihood of its success in stage IB1 than in stage IB2 to IIA disease. Moreover, preservation of bilateral autonomic nerves reduces DPC significantly in comparison with failure or unilateral preservation.

Behalf of the FUSION Study Group.

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Y. S. Song, MD, PhD
e-mail: yssong@snu.ac.kr

Conventional radical hysterectomy (CRH) is one of primary treatments for patients with early-stage cervical cancer. In the National Comprehensive Cancer Network (NCCN) guidelines for treating International Federation of Gynecology and Obstetrics (FIGO) stage IB1 to IIA2 cervical cancer, CRH is recommended mainly in stage IB1 or IIA1 disease with tumor size <4 cm, whereas radiotherapy is preferred in stage IB2 to IIA2 disease with bulky tumor

(≥ 4 cm).¹ However, CRH can be also considered as a primary treatment of stage IB2 to IIA2 disease because surgery without radiotherapy has a 5-year survival rate of 96 %, which is similar to the result in previous studies where adjuvant radiotherapy after surgery was used according to pathologic findings.^{2–6} Moreover, CRH is also meaningful in providing the possibility to avoid radiotherapy, thereby preventing radiotherapy-related complications.⁷

In spite of the clinical efficacy of CRH for patients with cervical cancer, it causes urinary dysfunctions, including bladder hypotonia, urinary incontinence, and abnormal sensation, in 12–85 % of patients.^{8–10} The reason for this is that the pelvic autonomic nerves are injured during CRH, which play a major role of the neurogenic control of urinary functions. Thus, nerve-sparing radical hysterectomy (NRH) has emerged in the last 30 years for decreasing postoperative urinary dysfunctions without compromising oncologic outcomes, and the feasibility and efficacy of NRH have been suggested in a growing number of studies.¹¹ Furthermore, Schneider and colleagues have reported identification and preservation of the pelvic splanchnic nerves in the cardinal ligament during laparoscopic radical hysterectomy, and some relevant studies have suggested the feasibility and efficacy of laparoscopic nerve-sparing radical hysterectomy (LNRH) since then.^{12–15}

However, there are some limitations to replacing CRH with NRH, as follows: no consensus on the nerve-sparing technique; and an unresolved concern about whether the efficacy of NRH on preservation of bladder function is different among failure, unilateral, and bilateral preservation of autonomic nerves. Thus, we made a protocol for LNRH according to relevant anatomic identification and performed a protocol-based prospective cohort study. In the current study, we evaluated the success rate and factors for preservation of autonomic nerves during LNRH and compared postoperative bladder function among failure, unilateral, and bilateral preservation of autonomic nerves in patients with cervical cancer.

STUDY DESIGN

Protocol

We reviewed anatomic identification of NRH as demonstrated in a previous study and then created a protocol for the current study (Supplementary Table 1).¹⁶ One experienced gynecologic oncologist performed LNRH on the left side of all patients according to Fujii's method.¹⁶ Briefly, we found the hypogastric nerve containing sympathetic nerves on the rectal side of the pararectal space; the branch of the splanchnic nerve containing parasympathetic nerves was

TABLE 1 Clinicopathologic characteristics of 30 patients treated with laparoscopic nerve-sparing radical hysterectomy

Characteristic	Value
Age, years	48 (29–79)
Menopause	14 (46.7)
Parity	2 (0–7)
Body mass index, kg/m ²	24.1 (19.2–33.4)
FIGO stage	
IB1	23 (76.6)
IB2	2 (6.7)
IIA1	3 (10)
IIA2	2 (6.7)
Histology	
Squamous cell carcinoma	27 (90.1)
Adenocarcinoma	1 (3.3)
Adenosquamous carcinoma	1 (3.3)
Small cell carcinoma	1 (3.3)
Tumor size, cm	2.8 (1.0–9.8)
LVSI	12 (40)
Stromal invasion	
<1/2	14 (46.7)
$\geq 1/2$	16 (53.3)
Lymph node metastasis	5 (16.7)
Positive resection margin	3 (10)
Parametrial invasion	6 (20)
Operative time, min	265 (185–545)
Estimated blood loss, ml	500 (80–1,000)
Transfusion	0 (0–3)
Adjuvant treatment	
None	16 (53.3)
CCRT	12 (40)
CCRT followed by chemotherapy	2 (6.7)
Disease recurrence	0 (0)
Complications	5 (16.7)

Data are presented as median (range) or *n* (%)

FIGO International Federation of Gynecology and Obstetrics, LVSI lymphovascular space invasion, CCRT concurrent chemoradiation

then identified after we cut the deep uterine vein in the deep portion of the parametrial connective tissue. Furthermore, we separated the anterior leaf of the vesicouterine ligament meticulously, and the posterior leaf of the vesicouterine ligament with the middle and inferior vesical veins was separated. We next identified the vesical branch of the pelvic plexus containing both sympathetic and parasympathetic nerves. In the protocol, LNRH-related structures for resection or preservation were demonstrated. Although the splanchnic nerve can be preserved easily if the deep uterine vein is identified and separated from the surrounding tissues, the junctions between the hypogastric and the splanchnic nerves (H–S junction) and between the splanchnic nerve and

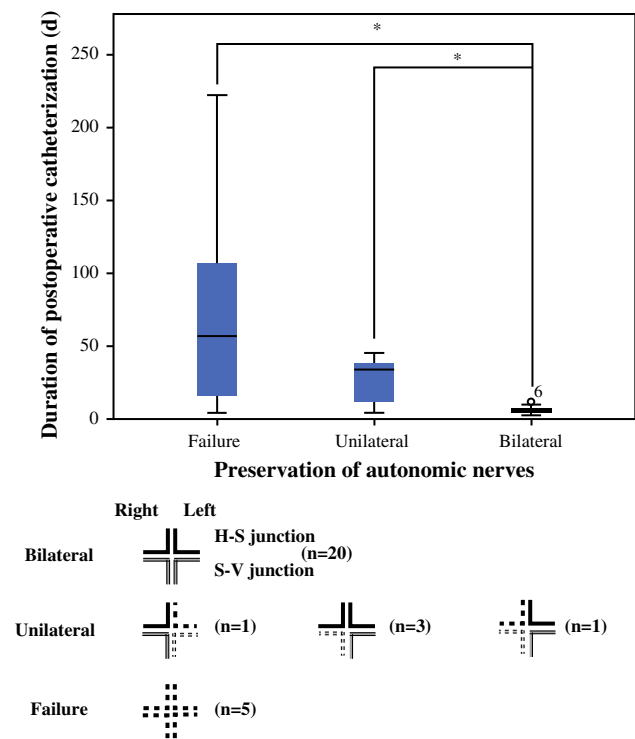


FIG. 1 Comparison of duration of postoperative catheterization after laparoscopic nerve-sparing (type C1) radical hysterectomy among failure, unilateral, and bilateral preservation of junctions between hypogastric and splanchnic nerves (H–S junction) and between splanchnic nerve and vesical branch of pelvic plexus (S–V junction); * $P < 0.05$

the vesical branch of the pelvic plexus (S–V junction) are easily injured by transection or thermal damage during dissection of the vesicouterine and uterosacral ligaments located in the proximal side of the uterus.¹⁷ Thus, we considered H–S and S–V junctions as the two points that should be preserved during LNRH in our protocol (Supplementary Fig. 1).

Patients

We recruited patients with cervical cancer consecutively between September 2012 and April 2014. Eligibility criteria were as follows: FIGO stage IB1 to IIA2 disease; no previous abdominal surgery; no neoadjuvant chemotherapy; laparoscopic type C1 radical hysterectomy based on the Querleu-Morrow system; no abdominal disease hindering LNRH; documentation of the protocol during LNRH; and patients’ written informed consent.¹⁸ Among 40 patients who fulfilled the eligibility criteria during this period, 10 were excluded because of a finding of noncervical cancer at final pathology ($n = 2$), conversion to laparotomy ($n = 2$), loss of follow-up after surgery ($n = 3$), and incomplete documentation of the protocol ($n = 3$). Adjuvant concurrent chemoradiotherapy (CCRT)

or CCRT followed by chemotherapy using cisplatin was administered to 14 patients (46.7 %) according to the following criteria: ≥ 2 intermediate-risk factors including tumor size ≥ 4 cm, stromal invasion $\geq 1/2$, and lymphovascular space invasion (LVSI); or ≥ 1 high-risk factors including lymph node metastasis, parametrial invasion, and positive resection margin.

A Foley catheter was inserted until 2 days after surgery; all patients were then encouraged to void. We checked postvoid residual urine volume (PVR) after urination, and the patients were instructed to perform clean intermittent self-catheterization if PVR was less than 100 ml until 5 days after surgery. Thus, duration of postoperative catheterization (DPC) was defined as the time to achieve three consecutive PVRs of <100 ml after surgery.

Statistical Analysis

The main study outcomes were clinicopathologic factors for preserving autonomic nerves and DPC based on the degree of their preservation. We considered “not identified” or “thermal damage” as failure of preservation because it may increase the possibility of autonomic nerve injury. For identifying clinicopathologic factors to preserve autonomic nerves, we performed χ^2 or Fisher’s exact tests. After we selected potential factors on χ^2 or Fisher’s exact tests ($P < 0.2$), univariate and multivariate logistic regression analyses with odds ratio (OR) and 95 % confidence interval (CI) were performed by using the potential factors. Moreover, power analysis was performed to demonstrate the effects of other covariates.

Next, we performed Mann–Whitney U or Kruskal–Wallis tests for comparing DPC among failure, unilateral, and bilateral preservation of autonomic nerves. For statistical analyses, we used SPSS software version 19.0 (IBM, Armonk, NY, USA), and a P value of <0.05 was considered to be statistically significant.

RESULTS

Preservation of Autonomic Nerves

Table 1 summarizes clinicopathologic characteristics of a total of 30 patients enrolled onto the current study. The median follow-up was 7.4 months (range, 3–20.6 months). No patient showed disease recurrence, and 5 patients (16.7 %) had surgery-related complications such as ureteral stricture, vesicovaginal fistula, urinoma, infected lymphocele, and lymphedema.

During LNRH, most of structures were resected according to the criteria of type C1 radical hysterectomy except the uterosacral ligament and length of the resected

TABLE 2 Extent of resection and preservation of autonomic nerves during laparoscopic nerve-sparing radical hysterectomy

Characteristic	Right	Left	<i>P</i>
<i>Extent of resection</i>			
Uterine artery			NA
Transected near the internal iliac artery	30 (100)	30 (100)	
Anterior leaf of the vesicouterine ligament			NA
Complete separated	30 (100)	30 (100)	
Posterior leaf of the vesicouterine ligament			NA
Transected near the bladder	30 (100)	30 (100)	
Deep uterine vein			NA
Transected near the internal iliac vein	30 (100)	30 (100)	
Uterosacral ligament			1.00
Transected in the middle	12 (40)	12 (40)	
Transected near the rectum	18 (60)	18 (60)	
Paracolpium			1.00
Transected near S–V junction	5 (16.7)	5 (16.7)	
Transected near the lower margin of the resected vagina	25 (83.3)	25 (83.3)	
Length of resected vagina, cm	2 (1–3)	2 (1–3)	0.84
Lymphadenectomy			
Pelvic only	16 (53.3)		
Pelvic and para-aortic	14 (46.7)		
<i>Preservation of autonomic nerves</i>			
H–S junction			0.79
Not identified	1 (3.3)	2 (6.7)	
Identified and preserved with thermal damage	4 (13.2)	3 (10)	
Identified and preserved without thermal damage	25 (83.5)	25 (83.3)	
S–V junction			0.66
Not identified	4 (13.4)	3 (10)	
Identified and preserved with thermal damage	5 (16.7)	3 (10)	
Identified and preserved without thermal damage	21 (69.9)	24 (80)	

Data are presented as median (range) or *n* (%)

NA not available, H–S junction junction between the hypogastric and the splanchnic nerves, S–V junction junction between the splanchnic nerve and the vesical branch of the pelvic plexus

vagina and paracolpium due to intraoperative adhesion or bleeding.¹⁷ The uterosacral ligament was resected near the rectum in 18 patients (60%), and length of the resected vagina of <1.5 cm and the paracolpium transected near S–V junction were observed in 4 (13.3%) and 5 (16.7%), respectively. However, there were no differences in extent

of resection and preservation of autonomic nerves between the right and left sides (Table 2).

When we evaluated the success rate of preservation of H–S and S–V junctions according to clinicopathologic characteristics, the left H–S junction was preserved more commonly in stage IB1 disease (91.3%) and no parametrial invasion (91.7%) than in stage IB2 to IIA2 disease (57.1%) and parametrial invasion (50%), respectively. Moreover, we preserved the left S–V junction more frequently in stage IB1 than in IB2 to IIA2 disease (91.3 vs. 42.9%), and it was preserved more commonly when the paracolpium was transected near the lower margin of the resected vagina (88 vs. 40%; Table 3).

For evaluating independent factors for preservation of autonomic nerves, we selected stage IB1 disease, pelvic lymphadenectomy only, enough paracolpium, no LVSI, no lymph node metastasis, no parametrial invasion, negative resection margin, operative time <270 min and no transfusion as potential factors ($P < 0.2$), and then performed univariate and multivariate logistic regression analyses. We found that stage IB1 disease was related to a reduced risk of injury of left H–S (power 72.3%; OR 0.06; 95% CI 0.01–0.92) and left S–V junctions (power, 71.1%; OR 0.06; 95% CI 0.01–0.48). Moreover, it was also associated with a decreased risk of injury of the right S–V junction with marginal significance (power 73.7%; OR 0.18; 95% CI 0.03–1.06) (Table 4).

Duration of Postoperative Catheterization

When we compared DPC according to whether the H–S or S–V junction was injured, DPC was 82 days (range, 16–222 days), 38 days (range, 5–45 days), and 6 days (range, 3–34 days) in failure, unilateral, and bilateral preservation of H–S junction ($P < 0.01$), respectively. Among the 3 groups, we found a significant difference in DPC between failure and bilateral preservation. In terms of S–V junction, DPC was 57 days (range, 5–222 days), 34 days (range, 5–34 days), and 6 days (range, 3–12 days) in failure, unilateral, and bilateral preservation ($P = 0.01$), respectively, and it was different significantly between failure and bilateral preservation or between unilateral and bilateral preservation. For a comprehensive understanding of autonomic nerve function, we combined the data for both the H–S and S–V junctions and evaluated the impact of preservation of both junctions on recovery of postoperative bladder function. As a result, DPC was 57 days (range, 5–222 days), 34 days (range, 5–45 days) and 6 days (range, 3–12 days) in failure, unilateral, and bilateral preservation ($P < 0.01$), respectively. Among the 3 groups, DPC was significantly different between failure and bilateral preservation and between unilateral and bilateral preservation (Fig. 1).

TABLE 3 Clinicopathologic factors affecting preservation of autonomic nerves during laparoscopic nerve-sparing radical hysterectomy

Characteristic	Preservation of H-S junction				Preservation of S-V junction			
	Right	<i>P</i>	Left	<i>P</i>	Right	<i>P</i>	Left	<i>P</i>
Age		0.64		1.00		0.69		0.66
>48 years	11/14 (78.6 %)		12/14 (85.7 %)		9/14 (64.3 %)		12/14 (85.7 %)	
≤48 years	14/16 (87.5 %)		13/16 (81.3 %)		12/16 (75 %)		12/16 (75 %)	
Menopause		0.64		1.00		0.69		0.66
Yes	11/14 (78.6 %)		12/14 (85.7 %)		9/14 (64.3 %)		12/14 (85.7 %)	
No	14/16 (87.5 %)		13/16 (81.3 %)		12/16 (75 %)		12/16 (75 %)	
Parity ≥ 3		1.00		1.00		0.39		1.00
≥3	6/7 (85.7 %)		6/7 (85.7 %)		6/7 (85.7 %)		6/7 (85.7 %)	
<3	19/23 (82.6 %)		19/23 (82.6 %)		15/23 (85.2 %)		18/23 (78.3 %)	
Body mass index		1.00		0.62		0.70		1.00
≥25 kg/m ²	10/12 (83.3 %)		11/12 (91.7 %)		9/12 (75 %)		10/12 (83.3 %)	
<25 kg/m ²	15/18 (83.3 %)		14/18 (77.8 %)		12/18 (66.7 %)		14/18 (77.9 %)	
FIGO stage IB2 to IIA2		0.57		0.06		0.15		0.02
IB2 to IIA	5/7 (71.4 %)		4/7 (57.1 %)		3/7 (42.9 %)		3/7 (42.9 %)	
IB1	20/23 (87 %)		21/23 (91.3 %)		18/23 (78.3 %)		21/23 (91.3 %)	
Histology		1.00		1.00		0.53		1.00
Nonsquamous	3/3 (100 %)		3/3 (100 %)		3/3 (100 %)		3/3 (100 %)	
Squamous	22/27 (81.5 %)		22/27 (81.5 %)		18/27 (66.7 %)		21/27 (77.8 %)	
Uterosacral ligament		0.62		0.36		1.00		1.00
Transected in the middle	14/18 (77.8 %)		13/18 (72.2 %)		8/12 (66.7 %)		8/12 (66.7 %)	
Transected near the rectum	11/12 (91.7 %)		11/12 (91.7 %)		13/18 (72.2 %)		13/18 (72.2 %)	
Paracolpium		1.00		0.18		0.62		0.04
Transected near the lower margin of the resected vagina	21/25 (84 %)		22/25 (88 %)		18/25 (72 %)		22/25 (88 %)	
Transected near S-V junction	4/5 (80 %)		3/5 (60 %)		3/5 (60 %)		2/5 (40 %)	
Length of resected vagina		1.00		0.55		0.33		0.30
≥2 cm	5/6 (83.3 %)		6/6 (100 %)		3/6 (50 %)		6/6 (100 %)	
<2 cm	20/24 (83.3 %)		19/24 (79.2 %)		18/24 (75 %)		18/24 (75 %)	
Lymphadenectomy		0.16		0.64		0.69		1.00
Pelvic and para-aortic	10/14 (71.4 %)		11/14 (78.6 %)		9/14 (64.3 %)		11/14 (78.6 %)	
Pelvic only	15/16 (93.8 %)		14/16 (87.5 %)		12/16 (75 %)		13/16 (81.3 %)	
Tumor size		1.00		1.00		1.00		1.00
≥2 cm	16/19 (84.2 %)		16/19 (84.2 %)		13/19 (68.4 %)		15/19 (78.9 %)	
< 2 cm	9/11 (81.8 %)		9/11 (81.8 %)		8/11 (72.7 %)		9/11 (81.8 %)	
LVSI		1.00		0.36		1.00		0.18
Yes	10/12 (83.3 %)		9/12 (75 %)		8/12 (66.7 %)		8/12 (66.7 %)	
No	15/18 (83.3 %)		16/18 (88.9 %)		13/18 (72.2 %)		16/18 (88.9 %)	
Stromal invasion		1.00		1.00		0.69		1.00
≥1/2	13/16 (81.3 %)		13/16 (81.3 %)		9/14 (64.3 %)		11/14 (78.6 %)	
<1/2	12/14 (85.7 %)		12/14 (85.7 %)		12/16 (85.7 %)		13/16 (81.3 %)	
Lymph node metastasis		1.00		0.18		1.00		0.25
Yes	4/5 (80 %)		3/5 (60 %)		4/5 (80 %)		3/5 (60 %)	
No	21/25 (84 %)		22/25 (88 %)		17/25 (68 %)		21/25 (84 %)	
Parametrial invasion		0.25		0.04		0.33		0.07
Yes	4/6 (66.7 %)		3/6 (50 %)		3/6 (50 %)		3/6 (50 %)	
No	21/24 (87.5 %)		22/24 (91.7 %)		18/24 (75 %)		21/24 (87.5 %)	

TABLE 3 continued

Characteristic	Preservation of H–S junction				Preservation of S–V junction			
	Right	<i>P</i>	Left	<i>P</i>	Right	<i>P</i>	Left	<i>P</i>
Resection margin		0.43		0.06		1.00		0.09
Positive	2/3 (66.7 %)		1/3 (33.3 %)		2/3 (33.3 %)		1/3 (33.3 %)	
Negative	23/27 (85.2 %)		24/27 (88.9 %)		19/27 (70.4 %)		23/27 (85.2 %)	
Operation time		1.00		0.33		0.11		0.17
≥ 270 min	12/15 (80 %)		11/15 (73.3 %)		8/15 (53.3 %)		10/15 (66.7 %)	
< 270 min	13/15 (86.7 %)		14/15 (93.3 %)		13/15 (86.7 %)		14/15 (93.3 %)	
Estimated blood loss		1.00		1.00		1.00		1.00
> 500 ml	18/22 (81.8 %)		18/22 (81.8 %)		15/17 (68.2 %)		17/22 (77.3 %)	
≤ 500 ml	7/8 (87.5 %)		7/8 (87.5 %)		6/8 (75 %)		7/8 (87.5 %)	
Transfusion		0.57		0.57		0.15		0.60
≥ 1	5/7 (71.4 %)		5/7 (71.4 %)		3/7 (42.9 %)		5/7 (71.4 %)	
0	20/23 (87 %)		20/23 (87 %)		18/23 (78.3 %)		19/23 (82.6 %)	

H–S junction junction between hypogastric and splanchnic nerves, *S–V junction* junction between splanchnic nerve and vesical branch of pelvic plexus, FIGO International Federation of Gynecology and Obstetrics, *LVSI* lymphovascular space invasion

DISCUSSION

Generally, sympathetic nerves in the hypogastric nerve and the vesical branch of the pelvic plexus stimulate the urethral sphincter and inhibit the detrusor muscle of the bladder, whereas parasympathetic nerves in the splanchnic nerve and the vesical branch of the pelvic plexus relax the urethral sphincter and stimulate the detrusor muscle of the bladder.^{19,20} Because CRH causes pelvic autonomic dysregulation after surgical interruption, NRH has been the subject of interest because of its feasibility and safety.²¹ Depending on the development of the relevant anatomy, the hypogastric nerve can be separated from the uterosacral ligament, and the splanchnic nerve can be preserved during resection of the deep uterine vein and removal of the surrounding tissues called as the parametrium. Moreover, the vesical branch of the pelvic plexus can be separated from the paracolpium to remove a sufficient length of the vagina.^{16,22} Regarding its safety, NRH is expected to reduce postoperative bladder dysfunction without any decrease in radicality necessary to treat cervical cancer and to show a similar prognosis to CRH.^{23,24} However, no consensus of the nerve-sparing technique and an unresolved problem regarding the impact of the degree of preservation of autonomic nerves on postoperative bladder function are major limitations to change CRH into NRH as the primary treatment of cervical cancer.

In the current study, we found that FIGO stage IB1 disease was the only factor for enhancing the likelihood of the success of LNRH. Because there are few relevant studies, this finding is, to our knowledge, a new result for preserving autonomic nerves. It can be supported by a previous intention-to-treat study that showed a tendency

for NRH to be performed more commonly in stage IB1 than in stage IB2 to IIA disease compared with CRH (77.7 vs. 67.7 %).²⁵ This means that tumor extension to adjacent areas—stage IB2 to IIA2 disease—makes preservation of autonomic nerves by LNRH more difficult.

In particular, stage IB1 disease was an independent favorable factor for reducing the risk of injury of the left autonomic nerves, whereas it was related to the decreased risk of injury of the right S–V junction with marginal significance. The reason for this is that LNRH was performed in the left side of all patients. Actually, the surgeon experienced difficulty in preserving the right autonomic nerves because of the narrow range of motion with rigid instruments during laparoscopy. Preservation of autonomic nerves may thus be influenced by the surgeon's position during LNRH. This hypothesis may be supported by the finding that the success rates of preservation of H–S and S–V junctions were lower in the right side than in the left side in stage IB1 disease (87 vs. 91.3 %; 78.3 vs. 91.3 %). Thus, we thought that stage IB1 disease could not be a favorable factor for preservation of the right side because of the relatively low rate of success. To overcome this limitation, it is important to perform LNRH on the side of the distribution of autonomic nerves or to replace it with robot-assisted NRH because of the wide range of motion required for wristed instruments.

Furthermore, bilateral preservation of autonomic nerves showed shorter DPC than failure or unilateral preservation. This finding is similar to previous studies in which unilateral preservation resulted in more damage to bladder function immediately after surgery than bilateral preservation.^{26,27} This means that failure or unilateral preservation may not play a role in preserving bladder

TABLE 4 Risk of injury of autonomic nerves during laparoscopic nerve-sparing radical hysterectomy

Characteristic	H-S junction			S-V junction		
	Right		Left	Right		Left
	OR (95 % CI)	Adjusted OR (95 % CI)	OR (95 % CI)	OR (95 % CI)	Adjusted OR (95 % CI)	Adjusted OR (95 % CI)
FIGO stage IB1	0.38 (0.05–2.88)	–	0.13 (0.02–1.02)	0.21 (0.04–1.25)	0.18 (0.03–1.06)	0.06 (0.01–0.48)
Paracolpium transected near lower margin of resected vagina	0.76 (0.07–8.73)	–	0.21 (0.02–1.77)	0.58 (0.08–4.27)	–	–
Pelvic lymphadenectomy only	0.17 (0.02–1.72)	–	0.52 (0.07–3.70)	0.60 (0.12–2.89)	–	–
No Lysi	1.00 (0.14–7.10)	–	0.38 (0.05–2.68)	0.77 (0.16–3.74)	–	–
No lymph node metastasis	0.76 (0.07–8.72)	–	0.21 (0.02–1.77)	0.53 (0.05–5.55)	–	–
No parametrial invasion	0.29 (0.04–2.30)	–	0.09 (0.01–0.79)	0.33 (0.05–2.12)	–	–
Negative resection margin	0.35 (0.03–4.80)	–	0.06 (0.01–0.92)	0.84 (0.07–10.66)	–	–
Operation time < 270 min	0.62 (0.09–4.34)	–	0.20 (0.02–2.02)	0.18 (0.03–1.07)	–	–
No transfusion	0.38 (0.05–2.88)	–	0.38 (0.05–2.88)	0.21 (0.04–1.25)	–	–

H-S junction junction between the hypogastric and the splanchnic nerves, *S-V junction* junction between the splanchnic nerve and the vesical branch of the pelvic plexus, *OR* odds ratio, *CI* confidence interval, *FIGO* International Federation of Gynecology and Obstetrics, *Lysi* lymphovascular space invasion

function, as bilateral preservation does. However, further investigation is necessary to compare bladder function among failure, unilateral and bilateral preservation after surgery because previous studies have reported no difference between unilateral and bilateral preservation in long-term follow-up.^{28–30}

The current study had the following advantages. First, some relevant studies have reported only the feasibility of NRH by many surgeons, without also reporting its success rate.^{14,15,25,29} We, however, conducted a protocol-based prospective cohort study where patients were recruited consecutively, and one gynecologic oncologist performed laparoscopic type C1 radical hysterectomy. Second, we reported the success rate of LNRH and found clinicopathologic factors affecting preservation of autonomic nerves. Third, we investigated postoperative bladder function according to the degree of preservation of autonomic nerves.

However, the current study has some limitations. The feasibility of laparoscopic radical surgery has not been established in clinical trials. However, we selected LNRH because it has been reported to be feasible in previous studies, and it has some advantages in terms of early recovery after surgery, short hospitalization, and a low rate of complications compared with laparotomic NRH. Moreover, the feasibility of LNRH is expected to be evaluated by an ongoing clinical trial in the near future.³¹ Second, a growing body of literature supports the use of type B surgery in patients with stage IB1 disease.³² However, we prefer type C1 LRH because of a lack of well-designed randomized controlled trials to provide the safety and efficacy of type B surgery in the patients. Third, the small number of patients (thus contributing to the study's relative low power, at <80%), the incomplete resection of the uterosacral ligament and the paracolpium, as well as the length of the resected vagina bias the interpretation of the current study's results.

However, the current study is meaningful in that LNRH may have a higher likelihood of its success in FIGO stage IB1 than in stage IB2 to IIA disease, and bilateral preservation of autonomic nerves may be more important to preserve bladder function immediately after surgery than failure or unilateral preservation. Further large protocol-based prospective study for LNRH are needed to approve these results.

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