



The Urodynamics and Survival Outcomes of Different Methods of Dissecting the Inferior Hypogastric Plexus in Laparoscopic Nerve-Sparing Radical Hysterectomy of Type C: A Randomized Controlled Study

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ABSTRACT

Background. Little data exist about the impact of dissection methods on bladder function during nerve-sparing radical hysterectomy (NSRH). This randomized controlled trial compared the urodynamic and survival outcomes of different methods dissecting the inferior hypogastric plexus (IHP) during laparoscopic NSRH.

Methods. Eligible patients presenting with stage IB cervical cancer from 9 May 2013 to 27 October 2015 were randomized at a ratio of 1:1 and subjected to waterjet (study group) or traditional blunt (control group) dissection of the IHP for laparoscopic type C radical hysterectomy. Participants were subjected to urodynamic evaluations before and after NSRH. The primary measurement was the proportion of patients with residual urine (RU) \leq 100 ml, while secondary measurements included urodynamic parameters, disease-free survival (DFS), and overall survival (OS).

Results. In total, 191 women met the inclusion criteria, and 160 patients were included in the final analysis, with 80 randomized to each group. At 14 days after NSRH, the study group had more patients with RU \leq 100 ml than the control group (82.5% vs. 62.5%, $p = 0.005$). The study group had similar urodynamic outcomes of preoperative

and postoperative tests. Comparison with the study group and preoperative tests revealed the control group had significant bladder function impairment at 4 months after NSRH. After a median follow-up of 33 months, the dissection methods had no significant impact on DFS or OS.

Conclusions. Waterjet dissection of the IHP in laparoscopic NSRH resulted in a more rapid return of normal urodynamics without compromising survival outcome.

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In patients treated with radical hysterectomy (RH), postoperative short- and long-term bladder dysfunction has been reported to occur in up to 85% and 80% of cases, respectively.¹ Nerve-sparing RH (NSRH) is proposed to reduce postoperative bladder function impairment by better identification of visceral nerve fibers and surgical landmarks, thereby improving preservation of the neural portion from the resected parametrium, i.e. patients' bladder function without compromising survival outcomes.^{2,3} Various types of NSRH have been tailored to patients with cervical carcinomas,⁴ but recognition and separation precision remain major concerns and controversies associated with NSRH procedures. Evidence supporting the protection of bladder function with different NSRH techniques is scarce because of the difficulties associated with identifying nerve tissues during the surgical procedures and the poorly controlled designs between different dissection methods and/or apparatuses despite several studies on the urodynamics of NSRH.^{5–9}

The nerve-sparing technique includes several principle steps, one of which is preservation of the inferior hypogastric plexus (IHP) during the section of the cardinal ligament as the plexus lies dorsal to the parametrial vessels

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at the level of the deep uterine vein.^{6,10} Because of the delicate anatomy of the IHP, any damage to the IHP and its bladder branches would cause a waste of effort in other steps. Traditionally, blunt dissection with irrigation has been used to identify the vesical veins and branches of the IHP. New apparatuses, such as the waterjet dissector, probably provide more opportunities to preserve the IHP and subsequent bladder function. In this study, we tried to compare the urodynamic parameters and survival outcomes between two groups subjected to waterjet or conventional dissection of bilateral IHP.

METHODS

Study Design

This was a randomized controlled trial (RCT) conducted at the Department of Obstetrics and Gynecology, Peking Union Medical College Hospital (PUMCH). Enrollment began on 9 May 2013 and ended on 27 October 2015; the follow-up period ended on 1 July 2017. Inclusion criteria consisted of the following: histopathologically proven primary cervical cancer of squamous carcinoma, adenocarcinoma or adenosquamous carcinoma; International Federation of Gynecology and Obstetrics (FIGO) stage IB diagnosed by imaging evaluations and pelvic examinations of two experienced gynecologic oncology physicians; and normal bladder filling and voiding function based on urodynamic tests and patient complaints before NSRH. Patients were excluded if they had distant metastasis in preoperative imaging, had any evidence of urinary infection before enrollment, or had administered any anticholinergic agents before NSRH. Written informed consent was obtained from every participant prior to surgery. The Institutional Review Board of PUMCH approved this study.

All patients accepted urodynamic evaluation before and after NSRH. Eligible patients accepted the same perioperative care and procedures of laparoscopic NSRH, except for the dissection methods of the IHP in the deep layer of vesicocervical ligaments. According to the different dissection methods on the IHP, patients were randomized to accept waterjet dissection (study group) and conventional dissection (control group) methods. Randomization was based on computer-generated numbers at a 1:1 ratio. Randomized patients were excluded for the final analysis of urodynamics if they failed to preserve bilateral IHP, had any injuries of the bladder and/or ureter that were discovered during or after NSRH, had no urodynamic tests after NSRH, or did not finish adjuvant radiotherapy at 4 months after NSRH. No anticholinergic agent was administered to patients within 4 weeks after NSRH.

The primary endpoint was the proportion of patients with residual urine (RU) ≤ 100 ml at 14 days after NSRH, while the secondary endpoints included a comparison of the urodynamic parameters and survival outcomes. Based on class I and II error probabilities (α and β) of 0.05 and 0.20, respectively, each group needed 82 or 97 participants (with the power of 0.8038 or 0.8003) to estimate whether 60% and 80% of patients, respectively, had RU ≤ 100 ml at 14 days after NSRH in each arm.

Surgical Treatment

Surgical treatment consisted of laparoscopic NSRH, bilateral salpingo-oophorectomy, and lymphadenectomy of the pelvic lymph nodes and para-aortic lymph nodes by total conventional laparoscopy. To preserve the ovaries for young patients, salpingectomy was undertaken along with suspension of the ovaries to the peritoneum at the level of the anterior superior spine. All NSRH procedures were performed according to type C1 RH of the Querleu and Morrow (Q–M) classification.^{11,12} After truncation of the uterine deep veins and the principle body of the cardinal ligaments, the pelvic splanchnic nerves beneath were sufficiently exposed. Up to this point, the study group and control group were subjected to the same surgical procedures. After clamping and pulling the peduncles of the uterine deep veins, a waterjet was used in the study group to clear up the adipose tissue and distinguish the vessels and nerves, while suction apparatus with blunt dissection was used in the control group. Once the alignment and terminal of the middle vesical veins (MVVs) and inferior vesical veins (IVVs) were determined, the MVVs and IVVs were cut-off close to the bladder. Waterjet or conventional methods were used to further expose the main body and branches of the IHP. After recognition and amputation of the uterine branches of the IHP, the main bodies of the IHP were separated from the parametrium and the vesical, and the vesical, rectal, and vaginal branches of the IHP were preserved.

Complications related to RH within 3 months were reviewed as adverse events according to the Common Terminology Criteria for Adverse Events v4.03.¹³ Neoadjuvant chemotherapy and postoperative adjuvant therapies had been described elsewhere.¹⁴ All specimens underwent thorough pathologic examinations. The surgical extension was determined by the resection length of the cardinal ligaments, uterosacral ligaments, and anterior and posterior vaginal wall.

Waterjet Dissector with Hybrid Technology

The waterjet dissector was a basic module (ERBEJET® 2) compatible with the ERBE Workstation (Erbe

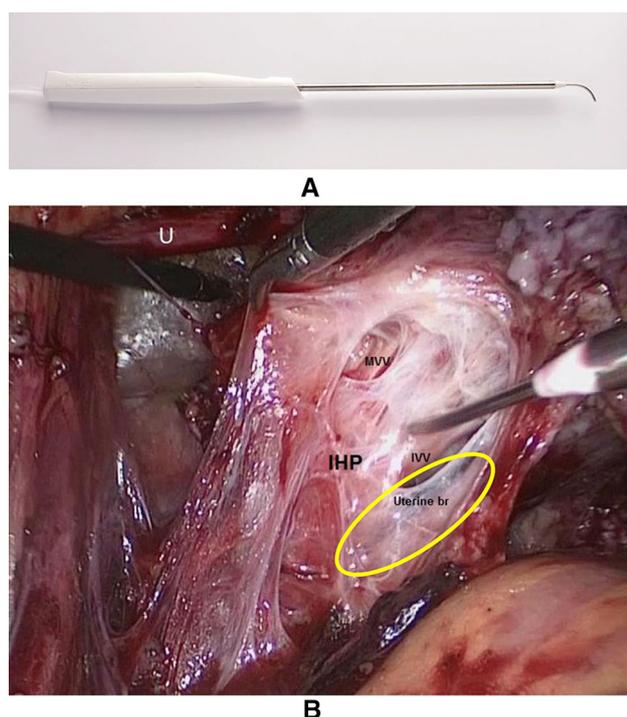


FIG. 1 a Curved tip of the waterjet surgery device. b Illustration of left IHP dissected by waterjet. *IHP* inferior hypogastric plexus, *IVV* inferior vesical vein, *MVV* middle vesical vein, *U* left ureter, *Uterine br* uterine branches of IHP

Elektromedizin GmbH, Waldhoernlestrasse 17, 72072 Tuebingen, Germany). An applicator with a curved tip (Fig. 1a) was adopted to dissect tissue structures selectively and gently, which allowed blood vessels and nerves to remain intact up to a pressure of 35–60 bars to dissect the MVVs, IVVs, and IHP (Fig. 1b).

Urodynamic Tests

Postoperative catheters were preserved until 14 days after NSRH. Bladder training was performed for all participants over 3–4 days by intermittently closing the catheters. On the morning of the 14th day, the urinary catheters were removed for all participants. After sufficient hydration by routine diet and drinking, the first spontaneous voiding was recorded and measured by trained nurses for voiding volume and voiding time, and an average urinary flow rate was calculated. Clean catheterization was used to obtain the precise RU. At $RU > 100$ ml, the catheter was kept in place until a second removal of the catheter was appropriate.

An MMS Solar Urodynamics measurement system (Medical Measurement Systems B.V., Colosseun 25, 7521 PV Enschede, The Netherlands) was employed to perform urodynamic tests within 2 weeks before NSRH and at 4 months (± 2 weeks) after NSRH. The urodynamic tests

included 10 parameters of bladder function, as listed in electronic supplementary Table 1, which were consistent with the recommendations of the International Urogynecological Association/International Continence Society.¹⁵

Statistical Analysis

SPSS version 23.0 (IBM Corporation, Armonk, NY, USA) was applied for the statistical analyses. Comparisons were performed via *t* tests or Mann–Whitney *U* tests for continuous variables, and the Chi square test or Fisher's test for categorical variables. The Kaplan–Meier method and Cox proportional hazards regression model were performed for the comparison of disease-free survival (DFS) and overall survival (OS) with hazard ratio (HR) and 95% confidence interval (95% CI).

RESULTS

Patient Characteristics

From 9 May 2013 to 27 October 2015, 228 women were admitted with FIGO stage IB cervical cancer; 191 patients met the inclusion criteria and were randomized. Six patients refused NSRH, 5 did not present preserved bilateral pelvic nerves because of distorted anatomy and/or massive bleeding, 15 missed urodynamic tests after NSRH, and 5 had not finished radiotherapy at 4 months after NSRH. In total, 160 cases were included in the final analysis, with 80 women in each arm (Fig. 2). The median age was 43 years (range 27–65), 92 cases (57.5%) were premenopausal women, and 66 cases (41.2%) had preserved their ovaries. For patients from the control and study groups, the epidemiologic and clinic characteristics before NSRH were well balanced (Table 1).

Surgical and Pathologic Characteristics

All patients accepted laparoscopic NSRH, and no conversion to laparotomy occurred. The surgical outcomes and extensions, pathologic outcomes, adjuvant therapy, and severe postoperative complications were all well-balanced between the two groups. For patients in the study group, the mean pressure of the right and left sides was 48.2 ± 6.0 bars and 47.6 ± 6.2 bars ($p = 0.068$), respectively. No significant differences between the study and control groups were observed for the dissection time on both the right and left IHP (Table 2).

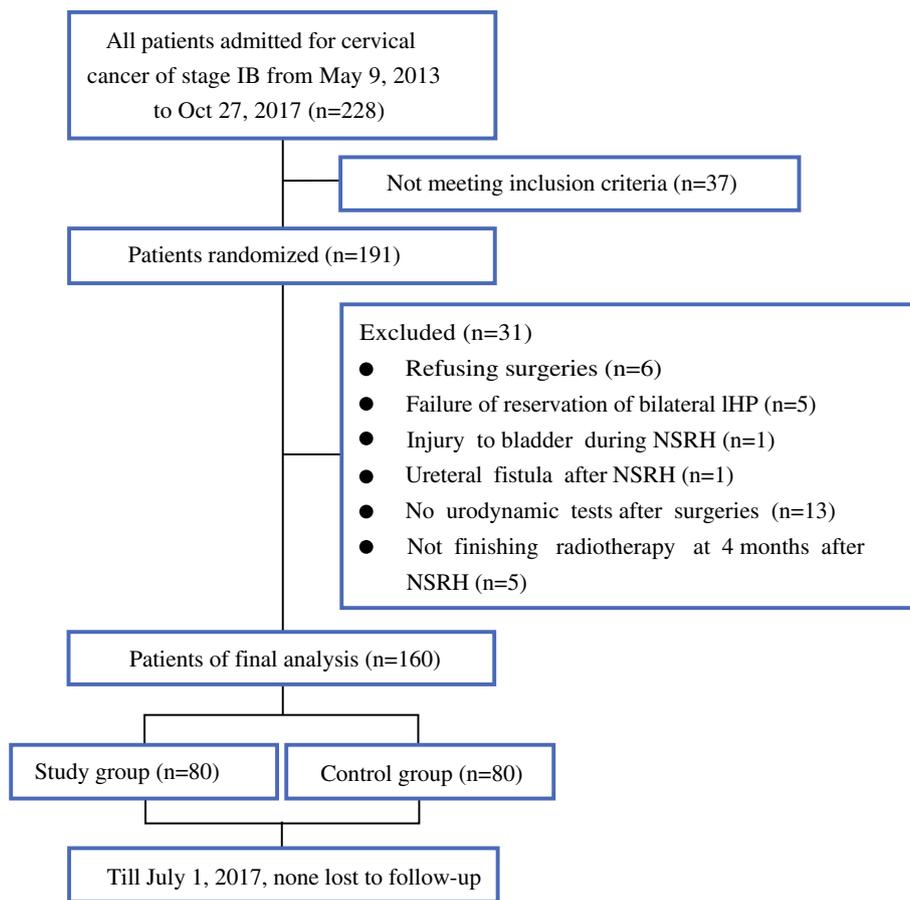


FIG. 2 Study selection process. *IHP* inferior hypogastric plexus, *NSRH* nerve-sparing radical hysterectomy

Urodynamic Measures and Bladder Dysfunction

The urodynamic parameters before NSRH are listed in Table 3. For the first catheter removal at 14 days after NSRH, the study and control groups had similar median voiding volume, voiding time, average flow rate (Q_{ave}) and RU. According to the primary endpoint, compared with the control group, the study group had more patients with $RU \leq 100$ ml (66/80 [82.5%; 95% CI 74.0–91.0%] vs. 50/80 [62.5%; 95% CI 51.7–73.3%], $p = 0.005$). The study group also had more patients with $RU \leq 150$ ml (69/80 [86.2%] vs. 55/80 [68.8%], $p = 0.008$).

At 4 months after NSRH, compared with the study group, patients in the control group had lower bladder capacity at the first void sense (median 150.5 [range 74–274] vs. 180 [range 81–349], $p = 0.008$) and at normal desire to void (median 264.5 [range 122–454] vs. 300.5 [range 171–445], $p = 0.016$), lower maximum flow rate (Q_{max} ; median 24 [range 9–60] vs. 26 [range 10–50], $p = 0.045$) and lower detrusor compliance (C_{det}) at strong desire to void (SDV) (median 29 [range 12–70] vs. 35.5 [range 18–69], $p = 0.021$).

The self-contrast comparison of the preoperative and postoperative urodynamic parameters are listed in electronic supplementary Table 1. For all patients, the postoperative bladder pressure (P_{ves}) at Q_{max} , and detrusor pressure (P_{det}) at Q_{max} , decreased significantly ($p = 0.018$ and 0.010, respectively). For patients in the control group, the Q_{max} , P_{ves} at Q_{max} , P_{det} at Q_{max} , bladder compliance (C_{ves}) at SDV, and C_{det} at SDV all decreased significantly (all p values < 0.05). For patients in the study group, differences in the parameters were not observed.

At 4 months after NSRH, bladder dysfunction was diagnosed in the control group and study group in seven (8.8%) and four (3.8%) cases, respectively ($p = 0.349$). In the control group, detrusor dysfunction, low compliance, and mixed urinary incontinence were diagnosed in 3 (3.8%), 3 (3.8%), and 2 (2.5%) cases, respectively; in the study group, detrusor dysfunction, low compliance, and stress urinary incontinence were diagnosed in 1 (1.2%), 2 (2.5%), and 1 (1.2%) cases, respectively. At 12 months after NSRH, all these symptoms disappeared except in one patient in the control group, who presented with mixed urinary incontinence.

TABLE 1 Epidemiological and clinical characteristics of the participants

	Control group [N = 80]	Waterjet group [N = 80]	p value
Age, years [median (range)]	41.5 (27–65)	44 (28–57)	0.094
Menopause [n (%)]	11 (13.8)	18 (22.5)	0.151
Gravidity [median (range)]	2 (0–6)	3 (0–7)	0.471
Parity [median (range)]	1 (0–3)	1 (0–4)	0.480
Weight, kg [mean ± SD]	61.2 ± 9.1	60.6 ± 8.4	0.887
Height, cm [mean ± SD]	162 ± 4	162 ± 5	0.617
BMI, kg/m ² [mean ± SD]	23.2 ± 3.4	23.1 ± 2.9	0.493
History of pelvic surgeries [n (%)]	16 (20.0)	20 (25.0)	0.449
CA125, U/ml [median (range)]	13.3 (5.3–60.9) [n = 33]	16.8 (5.1–1259.8) [n = 30]	0.912
SCC-Ag, µg/L [median (range)]	1.2 (0.3–14.8) [n = 60]	1.3 (0.3–18.2) [n = 65]	0.107
Preoperative chemotherapy [n (%)]	23 (28.8)	31 (38.8)	0.181
Cycles [median (range)]	2 (1–3)	1 (1–3)	0.417
Preoperative imaging [n (%)]			
Involvement of the parametrium	1 (1.3)	5 (6.3)	0.210
Positive LNs	23 (28.8)	21 (26.3)	0.723
Conization before RH [n (%)]	25 (31.3)	30 (37.5)	0.405
Clinical stage [n (%)]			0.182
IB1	56 (70.0)	48 (60.0)	
IB2	24 (30.0)	32 (40.0)	

BMI body mass index, CA125 cancer antigen 125, LNs lymph nodes, RH radical hysterectomy, SCC-Ag squamous cell carcinoma antigen, SD standard deviation

Follow-Up and Survival Outcomes

After a median 33 months (range 8–49) of follow-up, the control and study groups had similar survival outcomes (electronic supplementary Table 2). Univariate analysis indicated that the different dissection methods on the IHP did not have an impact on recurrence ($p = 0.897$) [electronic supplementary Fig. 3a] or mortality ($p = 0.295$) [electronic supplementary Fig. 3b].

DISCUSSION

The hypogastric nerves are regarded by some authors as the anatomical landmark used to accomplish total laparoscopic NSRH.^{16,17} Preservation of the splanchnic nerves¹⁶ and the most distal part of the IHP,¹⁷ rather than the hypogastric nerves, was suggested as critical for quickly regaining bladder function. For these reasons, IHP and its dissection became the focus of this study. We did not include patients with unilateral nerve-sparing approaches because bladder function in the immediate postoperative period was reported as more severely impaired in patients who had undergone unilateral nerve sparing than in those who had undergone the bilateral procedure.¹⁸

We reported postoperative RU ≤ 100 ml as the primary measurement of the impact of laparoscopic NSRH on the IHP because these data could indicate short-term

urodynamic changes. As expected, the explicit recognition and preservation of the bladder branches of the IHP would result in significantly more patients with RU ≤ 100 ml 2 weeks after NSRH, which suggested the most significant advantage of the study using the water jet technique. Other studies revealed that laparoscopic NSRH resulted in a shorter duration of RU ≤ 50 ml^{9,19} or postoperative catheterization²⁰ than traditional laparoscopic RH. The interpretations of these findings may vary. The comparative urodynamic study showed a mild functional impairment in the early postoperative period, and the most frequent finding was the reduced detrusor activity observed during the voiding phase, which is consistent with the straining required to void.⁷ In a small prospective study, NSRH did not cause voiding dysfunction but could induce detrusor overactivity and de novo urge incontinence, even in the short term (1 week) after NSRH.⁸ Based on the surgical characteristics and the urodynamic findings after NSRH in our study, we are prone to support the former opinion.

At 4 months after NSRH, the urodynamic parameters of the study group had returned to preoperative levels, whereas some impairment of bladder function, especial voiding function impairment, was observed in the control group when all urodynamic parameters were considered together, which is consistent with the short-term results presented in other reports.^{6–9} However, the Q_{\max} exceeding 12 ml/s in both the study and control groups did not

TABLE 2 Surgical and pathologic characteristics and postoperative adjuvant treatment of participants

	Control group [<i>N</i> = 80]	Waterjet group [<i>N</i> = 80]	<i>p</i> value
Operation duration, min [median (range)]	190 (130–400)	190 (120–280)	0.533
Dissection time of IHP (s)			
Right IHP	366 (186–585)	384 (182–598)	0.761
Left IHP	345.5 (182–533)	388 (178–723)	0.711
EBL, ml [median (range)]	200 (20–3800)	200 (20–1000)	0.160
Transfusion, ml [median (range)]	1700 (400–3000) [<i>n</i> = 2]	400 (200–400) [<i>n</i> = 4]	0.422
Preservation of ovaries [<i>n</i> (%)]	32 (40.0)	36 (45.0)	0.522
Resection extension [mean ± SD]			
Cardinal ligament, cm	3.6 ± 0.7	3.5 ± 0.7	0.695
Uterosacral ligament, cm	3.6 ± 0.6	3.7 ± 0.6	0.251
Anterior vaginal wall, cm	3.9 ± 0.3	3.8 ± 0.4	0.179
Posterior vaginal wall, cm	3.8 ± 0.4	3.8 ± 0.4	0.233
Hospital stay [median (range)]			
Postoperative stay, days	8 (5–32)	8 (5–20)	0.058
Total stay, days	11 (6–61)	11.5 (6–28)	0.213
Diameter of tumor, mm [median (range)]	25 (10–60)	30 (10–70)	0.184
Pathologic subtype [<i>n</i> (%)]			0.483
Squamous carcinoma	64 (80.0)	68 (85.0)	
Adenocarcinoma	13 (16.3)	8 (10.0)	
Adenosquamous carcinoma	3 (3.8)	4 (5.0)	
Residual lesions in RH specimens [<i>n</i> (%)]	59 (73.8)	66 (82.5)	0.181
Pathological differentiation [<i>n</i> (%)]			0.189
Grade 1	16 (20.0)	10 (12.5)	
Grade 2	36 (45.0)	47 (58.8)	
Grade 3	28 (35.0)	23 (28.8)	
Invasion depth of stroma [<i>n</i> (%)]			0.141
≤ 1/3	31 (38.8)	41 (51.3)	
1/3–2/3	27 (33.8)	19 (23.8)	
> 2/3	22 (27.5)	20 (25)	
LVSI in RH specimens [<i>n</i> (%)]	13 (16.3)	6 (7.5)	0.087
Involvement of uterine body [<i>n</i> (%)]	7 (8.8)	10 (12.5)	0.442
Involvement of parametrium [<i>n</i> (%)]	1 (1.3)	4 (5.0)	0.367
Positive vaginal margin [<i>n</i> (%)]	3 (3.8)	4 (5.0)	1.000
LN metastasis			
PLN no. [median (range)]	29 (9–55)	26 (10–50)	0.068
Positive no. [<i>n</i> (%)]	11 (13.8)	12 (15.0)	0.822
Common iliac LN no. [median (range)]	3 (1–7)	3 (1–7)	0.917
Positive no. [<i>n</i> (%)]	4 (5.0)	3 (3.8)	1.000
PALN no. [median (range)]	12.5 (5–25)	12.5 (6–25)	0.398
Positive no. [<i>n</i> (%)]	3 (3.8)	2 (2.5)	1.000
Postoperative radiotherapy [<i>n</i> (%)]			0.850
None	29 (36.3)	28 (35.0)	
CCRT	40 (50.0)	43 (53.8)	
Radiotherapy only	11 (13.8)	9 (11.3)	
Chemotherapy in CCRT [median (range)]	4 (1–6) [<i>n</i> = 51]	4 (1–6) [<i>n</i> = 43]	0.188
Postoperative chemotherapy [<i>n</i> (%)]	5 (6.3)	4 (5.0)	1.000

TABLE 2 continued

	Control group [N = 80]	Waterjet group [N = 80]	p value
Cycles [median (range)]	4 (1–6) [n = 5]	6 (5–6) [n = 4]	0.067
Severe complications [n (%)]			
Perioperative	6 (7.5)	3 (3.8)	0.495
Within 3 months	10 (12.5)	6 (7.5)	0.292

CCRT concurrent chemoradiotherapy, EBL estimated blood loss, IHP inferior hypogastric plexus, LN lymph node, LVSI lymphovascular space invasion, PALN para-aortic lymph nodes, PLN pelvic lymph nodes, RH radical hysterectomy

TABLE 3 Comparison of urodynamic parameters between the control and waterjet groups

Parameters	Control group [N = 80]	Waterjet group [N = 80]	p value
First removal of catheter at 14 days after RH			
Residual urine volume, ml	50 (0–500)	50 (0–400)	0.065
Residual urine volume ≤ 100 ml [n (%)]	50 (62.5%)	66 (82.5%)	0.005
Residual urine volume ≤ 50 ml [n (%)]	34 (42.5%)	49 (61.3%)	0.018
Voiding volume, ml	200 (30–400)	200 (10–350)	0.331
Voiding time, s	57 (10–300)	50 (3–300)	0.567
Average urinary flow rates, ml/s	2.9 (0.5–18.0)	3.0 (1.0–10.0)	0.889
Second removal of catheter after RH, days	21 (13–42) [n = 32]	21 (13–28) [n = 14]	0.971
Preoperative urodynamic parameters			
Bladder capacity at the first void sense, ml	169 (82–263)	181 (90–346)	0.293
Bladder capacity at normal desire to void, ml	275 (190–445)	313 (157–464)	0.068
Bladder capacity at SDV, ml	441 (302–755)	434.5 (296–571)	0.118
Q_{max} , ml/s	27 (11–79)	29 (11–60)	0.536
Q_{ave} , ml/s	14 (6–29)	13 (4–27)	0.730
P_{ves} at Q_{max} , cmH ₂ O	42 (22–101)	41 (21–81)	0.551
P_{det} at Q_{max} , cmH ₂ O	34 (16–52)	30 (14–64)	0.053
C_{ves} at SDV, ml/cmH ₂ O	50 (24–90)	54 (23–96)	0.125
C_{det} at SDV, ml/cmH ₂ O	27.5 (20–74)	32.5 (21–72)	0.056
Residual urine volume, ml	0 (0–20)	0 (0–30)	0.785
Postoperative urodynamic parameters			
Bladder capacity at the first void sense, ml	150.5 (74–274)	180 (81–349)	0.008
Bladder capacity at normal desire to void, ml	264.5 (122–454)	300.5 (171–445)	0.016
Bladder capacity at SDV, ml	440 (191–647)	411 (300–580)	0.228
Q_{max} , ml/s	24 (9–60)	26 (10–50)	0.045
Q_{ave} , ml/s	12 (5–28)	12 (3–27)	0.463
P_{ves} at Q_{max} , cmH ₂ O	43 (19–106)	41 (23–80)	0.836
P_{det} at Q_{max} , cmH ₂ O	30 (13–54)	29 (14–67)	0.666
C_{ves} at SDV, ml/cmH ₂ O	45 (20–92)	53.5 (24–96)	0.067
C_{det} at SDV, ml/cmH ₂ O	29 (12–70)	35.5 (18–69)	0.021
Residual urine volume, ml	0 (0–50)	0 (0–50)	0.305

Data are expressed as median (range) unless otherwise specified

C_{det} detrusor compliance, C_{ves} bladder compliance, P_{det} detrusor pressure, P_{ves} bladder pressure, Q_{ave} average flow rate, Q_{max} maximum flow rate, RH radical hysterectomy, SDV strong desire to void

support significant bladder dysfunction. Despite a lack of adequate power to ascertain the significance, the differences in the self-contrast comparison of the preoperative

and postoperative urodynamic parameters illustrated the superiority of waterjet dissection on voiding function. The pathophysiological mechanisms of bladder dysfunction

after NSRH are multifactorial and are not fully understood. Adjuvant radiotherapy after surgery was a risk factor for persistent low C_{ves} .^{21,22} In a prospective cohort study, laparoscopic NSRH had a higher likelihood of success in stage IB1 than in stages IB2 to IIA disease.²³

The development of innovative surgical devices, including the cavitron ultrasonic surgical aspirator,²⁴ intraoperative electrical stimulation,²⁵ and electromyography,²⁶ may help improve bladder function during the NSRH procedure. Nevertheless, these studies did not present a rigorously controlled design. We first introduced the waterjet for the dissection of pelvic nerves in NSRH and accomplished a preset primary endpoint. Indeed, the waterjet dissector has been applied as a surface treatment in animal models,^{27–29} for studies in urology,^{30,31} and general surgery.^{32,33} Initial promising clinical results on this novel minimally invasive treatment option for lower urinary tract symptoms in male patients indicated an efficacy comparable to that of standard techniques, and this technique was often associated with a more favorable safety profile, particularly regarding the preservation of sexual function³⁴ and improvement of patients' postoperative quality of life.³⁰ However, the surgeon must be aware of the limitations and risks of spray dispersion of surgical debridement devices such as the waterjet.³⁵

Our study presented several limitations. The major limitation is the lack of surveys on quality of life, including anorectal and sex functioning. A long-term follow-up urodynamics evaluation is also needed to clarify the complex pathophysiology of bladder dysfunction after NSRH. Because a consensus has not been reached regarding whether adjuvant therapy would affect the urinary function²¹ or not,³⁶ the impact on bladder functions from potential confounding factors, such as radiotherapy, should be determined in an analysis of a larger sample. Preoperative parameters of P_{det} at Q_{max} and C_{det} at SDV were not well-balanced between the two groups (with p values of 0.053 and 0.056, respectively), which would probably interfere with the explanation of results.

CONCLUSION

Waterjet dissection of the IHP is an innovative and safe treatment for laparoscopic NSRH procedures, resulting in a more rapid return of normal urodynamics without compromising survival outcomes.

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DISCLOSURE All authors declare that they have no conflict of interest.

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