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Nerve-Sparing Radical Hysterectomy Using Modern Bipolar Electrosurgical Instruments Based on the ForceTriad Energy Platform

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ABSTRACT Objective: To describe and evaluate a novel technique of nerve-sparing radical abdominal hysterectomy with pelvic lymphadenectomy (NSRH/PLND) using the bipolar Ligasure Atlas sealer/divider and Bissenger bipolar shears. Methods: Retrospective study of 4 consecutive patients who underwent NSRH/PLND for stage IB1-IIB cervical carcinoma was conducted. Resection of the cardinal and uterosacral ligaments was performed with the Ligasure Atlas. Pelvic autonomic nerve dissection and lymphadenectomy were completed with the bipolar shears. Outcomes were collectively analyzed. Results: Mean operative time was 251 minutes (range, 230–265). Blood loss averaged 625 mL (range, 400–900). Average LOS was 5 days (range, 4–5). Average duration until normal postvoid residual volume was 17 days (range, 10–24). No perioperative complications were encountered. Conclusion: Bipolar surgical instrumentation offers many advantages. The Ligasure Atlas provides efficient sealing and division of vascular pedicles, while the bipolar shears allow precise and fine dissection. Our results demonstrate the "bipolar sealer and shears technique" a preferable method of NSRH/PLND.

INTRODUCTION

The LigaSure vessel sealing system is a family of bipolar electrosurgical instruments with attendant generator designed to efficiently coagulate tissue. In 2008, an improved system, the LigaSure Tissue Fusion system (Valleylab, Boulder, CO) was introduced (Fig. 1). This system is composed of bipolar handpieces such as the LigaSure Atlas and the ForceTriad generator. The new electrosurgical generator (ForceTriad) utilizes TissueFect sensing technology that actively monitors changes in tissue impedance and provides real time adjustment control of the energy output. The new generator senses the tissue and makes 3,333 versus 200 decisions per second compared to the original system. This offers faster fusion cycles, more flexible fusion zones, and less desiccation than the original LigaSure generator. Radical hysterectomy and pelvic exenteration using the first generation LigaSure generator and LigaSure Atlas bipolar coagulator (handpiece) have been reported with favorable results.[1,2] However, due to its currency, studies utilizing the LigaSure Tissue Fusion system for radical hysterectomy have not been published to date.

Another bipolar instrument is the electrosurgical scissors. This technology has been existent since the late 1990s. Manufacturers have marketed three variations over the years, to include the PowerStar (Ethicon, Inc., Sommerville, NJ), Enable (Enable Medical Corp, Cincinnati, OH), and BiTech (Günter Bissinger Medizintechnik GmbH, Teningen, Germany) (Fig. 2). The bipolar scissors have been used predominantly in neurosurgery, otolaryngology, and vascular and colorectal surgery.[3,4] However, there is absence of literature on the use of the bipolar shears for nerve-sparing radical surgery and/or lymphadenectomy in gynecologic oncology. Theoretical benefits of the bipolar sealer/divider (LigaSure Atlas) and scissors (BiTech) include improved surgical precision, reduced instrument traffic, operative time, blood loss, and thermal spread. Hence, this study was conducted to evaluate our technique of nerve-sparing radical hysterectomy using the most current bipolar surgical technology, to ascertain its clinical performance, and to identify potential complications.

MATERIALS AND METHODS

Approval to conduct this study was obtained from the Institutional Review Board of Naval Medical Center San Diego, California. The protocol was approved as an analysis of data from a retrospective database. All subjects were accrued from Naval Medical Center San Diego. Between February and June 2008, four consecutive patients with invasive cervical cancer underwent nerve-sparing radical hysterectomy with lymphadenectomy. All operations were performed by the first author (J.SG.) with the assistance of an obstetrics gynecology resident. A review of the medical records was conducted. Patient demographics and clinical and surgical data were extracted. Potential complications related to bipolar surgical instruments, including equipment failure and immediate or delayed thermal injury (e.g., genitourinary

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FIGURE 1. LigaSure Tissue Fusion system (Valleylab, Boulder, CO). (A) ForceTriad electrosurgical generator utilizing TissueFect sensing technology. (B) LigaSure Atlas bipolar coagulator used to seal and divide right adnexa.

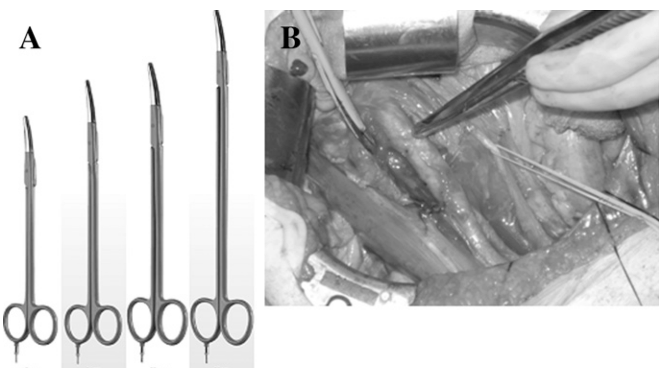

FIGURE 2. BiTech bipolar scissors (Günter Bissinger Medizintechnik GmbH, Teningen, Germany). (A) Bipolar scissors of varying lengths. (B) Bipolar scissors used for right common iliac lymphadenectomy.

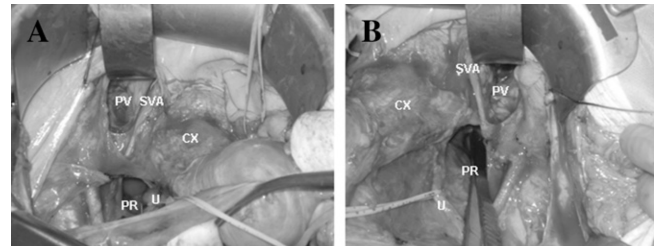

FIGURE 3. Development of lateral pelvic avascular spaces. (A) Left paravesical and pararectal spaces are opened. (B) Right ureter and superior vesical artery are identified and isolated. PV, paravesical space; PR, pararectal space; U, ureter; SVA, superior vesical artery; CX, cervix.

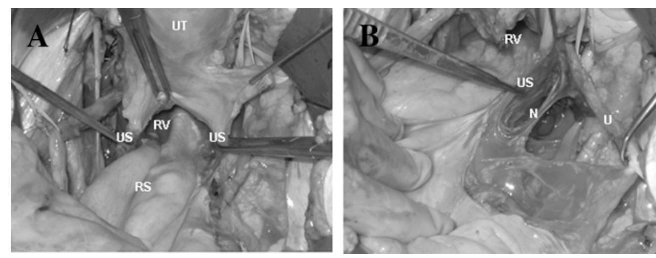

FIGURE 4. Development of posterior pelvic avascular space. (A) Rectovaginal space is opened and bilateral uterosacral ligaments are isolated. (B) Dissection and separation of the right hypogastric nerves (T11–L2) from the uterosacral ligment medially and ureter superior-laterally (patient 2). US, uterosacral ligament; UT, uterus; RS, rectosigmoid; RV, rectovaginal space; N, hypogastric nerves; U, ureter.

or gastrointestinal fistulas) were also gleaned. Collected data were summarized with descriptive statistics. Statistical analyses were performed using SPSS 11.0 for Windows (SPSS Inc., Chicago, Illinois).

Procedural Technique

All patients underwent routine preoperative bowel preparation with polyethylene glycol. Intravenous antibiotic prophylaxis, i.e., first- or second-generation cephalosporin, was administered preoperatively and repeated if the operation exceeded 3 hours. Sequential compression stockings were used for thrombosis prophylaxis. A standard midline vertical laparotomy incision was made in all patients. Incisions were extended above the umbilicus, as necessary, for exposure. Radical hysterectomy was performed in standard fashion after opening the bilateral pararectal and paravesical spaces and isolation of the ureters and superior vesical arteries (Fig. 3). The LigaSure Atlas sealer/divider was used to divide the infundibulopelvic or ovarian ligaments, uterosacral ligaments, cardinal ligaments, and parametria/paracolpos. The BiTech bipolar scissors were utilized for precise and meticulous dissection of the autonomic pelvic nerves (lateral to the uterosacral ligaments), the rectovaginal space, the vesicocervical/vesicovaginal ligaments, and the ureterolysis (Fig. 4). Transection and closure of the vaginal cuff was performed with conventional clamps, scissors, and suture ligation (Fig. 5). Upon completion of the radical hysterectomy, systematic pelvic and/or para-aortic lymphadenectomy were performed after isolation of the borders of planned dissection. Abiding by the Gynecologic Oncology Group (GOG) surgical manual, the borders of lymphadenectomy were as follows: superiorly midportion of common iliac artery, inferiorly deep circumflex iliac vein, laterally midportion of psoas muscle, posterior medially ureter, and anterior medially medial umbilical ligament (from the anterior obturator fossa to obturator nerve). Our 3-step bipolar scissors technique consisted of: (1) elevation of the lymphatic tissues overlying vascular structures with Russian forceps, (2) creation of avascular windows along the outer edge of lymphatic bundles by spreading the tip of the scissors, and (3) simultaneous coagulation and cutting of intervening lymphovascular channels with the shears (set at 35–40 watts, range 40–70) (Fig. 6).

Bilateral ovarian transposition was performed in standard fashion, if indicated, for ovarian preservation. For postoperative urinary drainage, a suprapubic foley catheter was placed via the antimesenteric dome of the bladder. At the completion of the operation, hyaluronate/carboxy-methylcellulose antiadhesive barriers (3 sheets) were placed in the pelvis over the sites of retroperitoneal dissection and beneath the laparotomy incision (3 sheets in tandem). Before abdominal fascial closure,

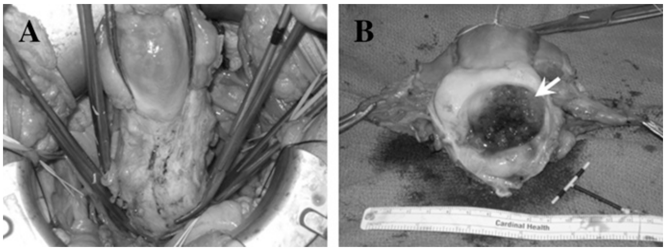

FIGURE 5. Completion of nerve-sparing radical hysterectomy. (A) Anterior view of clamping and transection of vaginal cuff with conventional techniques. (B) Radical hysterectomy specimen (patient 4) demonstrating adequate parametria/paracolpos and vaginal margins around a 4- to 5-cm cervical tumor (arrow).

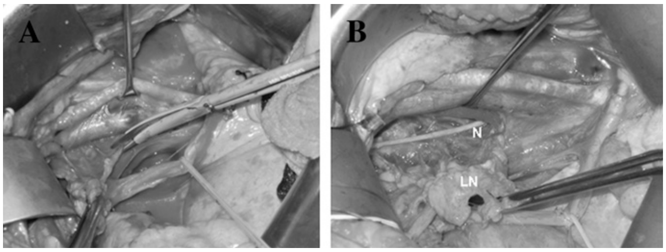

FIGURE 6. Pelvic lymphadenectomy. (A) One-instrument technique (spread-coagulate-cut) of lymphadenectomy using bipolar scissors. (B) Completed right pelvic lymphadenectomy (patient 4). N, obturator nerve; LN, obturator lymph nodes.

ON-Q pain pump (I-Flow, Lake Forest, California) catheters were threaded intrafascially for delivery of bupivacaine (0.5%) as a means of postoperative analgesia.[5] All wounds were then closed using a mass closure technique employing the looped O-PDS suture. Jackson-Pratt drains (10 mm) were placed in pelvis and subcutaneous space for closed-suction drainage.

After hospital discharge, the patient's postoperative bladder function was assessed weekly in the clinic setting. To determine the post void residual (PVR) volume, sterile water (~300 mL) was instilled into the bladder through the suprapubic catheter. After patient voiding, the residual volume was drained from the suprapubic catheter for measurement. Postoperative bladder function was considered normal when spontaneous voiding and PVR <100 mL were present, whereas retention was defined as PVR >100 mL and self-catheterization was necessary. Antibiotic prophylaxis for urinary tract infections were prescribed during suprapubic catheterization.

RESULTS

Four patients underwent nerve-sparing radical surgery and lymphadenectomy during the study period. Patient characteristics are summarized in Table I. The median age of our study population was 34.5 years (range, 31–40). The physical characteristics, to include median height, weight, and body mass index, were 64.5 inches (range, 60–72), 139 lbs (range, 128–185), and 24 kg/m^2 (range, 24–25), respectively. The Federation of Gynecology and Obstetrics (FIGO) stage was IB1 in three (75%) patients and IIB in one (25%) patient. Of note, patient 4 initially underwent hand-assisted laparoscopic (HAL) bilateral ovarian transposition before chemoradiation for stage IIB mucinous adenocarcinoma. After 5 weeks of whole pelvic irradiation with concurrent cisplatin chemotherapy, the tumor exhibited minimal shrinkage and was deemed radioresistant. Radical hysterectomy was necessitated for tumor extirpation. Tumor size and histology type are also presented in Table I.

Surgical procedures and parameters of surgical outcome are listed in Table II. The mean estimated blood loss was 625 mL (range, 400–900). Our first patient developed symptomatic anemia on postoperative day 2 with a drop in hematocrit from a preoperative value of 41% to 18%. She was transfused 2 units of packed red blood cells with ensuing appropriate rise in hematocrit (25%) and resolution of symptoms. The mean operative time was 251 min (range, 230–265). Mean length of hospital stay was 5 days (range, 4–5). Suprapubic catheterization was maintained for a mean of 17 days (range, 10–24). As for wound complications, no surgical site infections were encountered during the initial 30-day postoperative study period. No intraoperative technical complications, in particular on the use of electrosurgical instruments, were encountered. Furthermore, no perioperative electrothermal injuries or complications have developed in any subjects since their operation with an observation period of 9–13 months. In terms of sexual function, none of the four patients has thus far reported difficulty with arousal or orgasm.

DISCUSSION

The pioneer and major proponents of nerve-sparing radical hysterectomy (NSRH) originated in Japan.[6–8] Kobayashi first published the concept of nerve-sparing radical hysterectomy in 1961; this was revised and popularized by Sakamoto in the early 1970s.[6,9] Subsequently, surgeons from Germany, The Netherlands, and Italy have further conducted meticulous anatomical studies and developed operative techniques for autonomic nerve preservation during radical hysterectomy.[9–11] The interest in nerve-sparing surgical procedures reaches far beyond the field of gynecologic oncology. In fact, pelvic autonomic nerve preservation techniques in retropubic prostatectomy (RP) and total mesorectal excision (TME) for prostate and rectal cancer, respectively, are established procedures with continuing refinement and expanding interest.[3,12–15] Traditionally, in surgical oncology, radicality is the key to cure. Now, tailoring and refining our radical operations in select patients offer preservation of genitourinary function and improvement in quality of life without compromising local tumor recurrence.[16] Specifically, preservation of the hypogastric nerves (T11–L2) carrying sympathetic innervation to the pelvis maintains bladder compliance and smooth muscle contractions of orgasm, while the parasympathetic fibers of the inferior hypogastric plexus (S2–4) maintains detrusor contractility, colorectal motility, and normal sexual arousal and response.[17] In this study, we used the two most advanced electrosurgical instruments to perform nerve-sparing

TABLE I. Patient Characteristics

Patient	Age	Ht (in)	Wt (lbs)	BMI (kg/m^2)	FIGO Stage	Tumor Size (width × depth) (cm)	Pathology
1	40	60	128	24	IB1	0.5 × 0.5[a]	Adenocarcinoma
2	35	66	146	24	IB1	1.2 × 1.7[b]	Adenosquamous carcinoma
3	34	63	133	24	IB1	0.5 × 1.2[a]	Adenocarcinoma + Squamous CIS
4	31	72	185	25	IIB	4.5 × 4.5[c]	Mucinous Adenocarcinoma

BMI (kg/m^2) = weight (lb) × 703/height^2 (in^2). FIGO, International Federation of Gynecology and Obstetrics; CIS, carcinoma in situ.
[a]Dimensions obtained from cone specimen prior to radical hysterectomy. [b]Dimensions obtained from radical hysterectomy specimen. [c]Dimension obtained at examination under anesthesia.

TABLE II. Surgical Data

Patient	Surgical Procedures	OP Time (min)	EBL (mL)	LOS (days)	SP CATH (days)	Complications	
						Intraoperative	Postoperative
1	NSRH + PLND Ovarian transposition Appendectomy SP catheter ON-Q pump	265	900	5	18	None	Anemia[a]
2	NSRH + PLND Ovarian transposition Appendectomy SP catheter ON-Q pump	230	500	4	24	None	None
3	NSRH + PLND Ovarian transposition Appendectomy SP catheter ON-Q pump	250	400	5	10	None	None
4	NSRH + PLND SP catheter ON-Q pump	260	700	5	16	None	None
Mean (range)		251 (230–265)	625 (400–900)	5 (4–5)	17 (10–24)		

OP, operative; EBL, estimated blood loss; LOS, length of hospital stay; SP CATH, suprapubic catheterization; B/L, bilateral; LND, lymph node dissection; NSRH, nerve-sparing radical hysterectomy; PLND, pelvic lymph node dissection; SP catheter, suprapubic catheterization; ON-Q pump, ON-Q anesthetic system.
[a]Patient required red cell transfusion for symptomatic anemia on postoperative day 2 (2 units).

radical hysterectomy and lymphadenectomy. Although the ultimate goal of autonomic nerve preservation is functional outcome, the focus of our study was on the performance of bipolar surgical instrumentation and its utility in nerve-sparing cancer surgery.

The LigaSure Atlas sealer/divider is a bipolar surgical instrument designed for coagulating and cutting tissue with the benefit of minimal collateral thermal spread. The mechanism of coagulation by the bipolar instrument is through denaturing and reforming of collagen and elastin in vessel walls and surrounding connective tissues. This is achieved by applying low voltage, high current energy between the compressed jaws of the instrument. The new electrosurgical generator (ForceTriad) uses radiofrequency bipolar current for vessel sealing. To minimize excessive thermal spread, the TissueFect sensing technology employs an integrated feedback control that optimizes energy output while providing heat-sinking capability to expel excess heat from the target area. The new generator senses the tissue and makes 3,333 decisions per second, which allows faster fusion cycles, more flexible fusion zones, and less desiccation. Campbell et al. studied the thermal effects of the LigaSure Atlas (LS1100) using the original generator in a porcine model.[18] They demonstrated the average thermal spread was only 1.8 mm lateral to the device head and the maximum temperature on the exposed surface of the jaws during activation was only 35° C. Moreover, the maximum temperature in the collateral tissues reached just above 80° C after 1.2 seconds of activation that lasted approximately 500 milliseconds. Although thermographic studies using the new TissueFect generator have not been published up to now, the manufacturer declares the new energy platform decreases tissue fusion time compared to the original generator and reduces tissue desiccation and charring. The handle of the LigaSure Atlas is composed of an activation hand-switch and a "trigger style" cutting mechanism. A major advantage of this dual mechanism is that tissue coagulation and cutting may be performed with a single surgical instrument rather than the conventional multistep "clamp-cut-suture" technique. This means fewer surgical instruments on the field and reduction in instrument exchanges during the course of a procedure. As a result, the LigaSure Atlas allows the surgeon to efficiently clamp, coagulate, and cut all with one instrument.

The BiTech bipolar scissors is a mergence of the Metzenbaum scissors and bipolar electricity. When activated while set on low wattage, bipolar coagulation takes place between the tips of the scissors. This instrument is particularly effective for precise dissection with the added benefit of pinpoint coagulation.

Our clinical experience with the bipolar sealer/divider showed that the instrument was easy to use and reliable in sealing vascular pedicles quickly. Negligible sticking, charring, or collateral thermal spread was noted, and no equipment failures or technical difficulties were encountered. More importantly, the narrow device head allowed negotiation of the instrument into deep and narrow pelvic spaces for relatively "cool" coagulation of vascular pedicles near heat-vulnerable organs, (intestines, ureters, and nerves). As for the bipolar scissors, the refined, slender tips permitted precise and fine dissection along the pelvic autonomic nerves and over delicate pelvic vasculature. The instrument provided superb hemostasis through controlled coagulation of diminutive vasculature as those perforating vessels over the aorta and vena cava. Set on 35–40 watts, the scissors transected lymph node bundles quickly and efficiently and permitted blunt sweeping of lymphatic tissue off vessels between the scissor tips with concomitant hemostasis. During the procedures, no complications or limitations were experienced with either the bipolar coagulator or scissors. Of note, the hematocrit of patient 1 dropped significantly by postoperative day 2. Gradual vaginal cuff bleeding suspected from suture-line loosening was thought to have contributed to her complication. Acute large vessel bleeding after bipolar coagulation was considered but doubtful because of the delayed timing and gradual decline of hematocrit. Furthermore, in vivo studies have shown the durability and high supra-physiologic burst strengths of vessels sealed by bipolar coagulation (738 ± 237 mmHg for arteries and 378 ± 211 mmHg for veins).[19]

Overall, the results of our study compare favorably to conventional, stapled, and antedated bipolar coagulation techniques for radical hysterectomy. Table III provides a summary of surgical outcomes from nine studies spanning 36 years (1969–2005) on conventional abdominal radical hysterectomy.[20,21] With a total of 1,551 patients, the mean operative time and EBL were 208 min (range, 99–340) and 965 mL (range, 300–1800), respectively. The median transfusion rate and LOS were 32% (range, 2–92%) and 10 days (range, 3–18), respectively. Unfortunately, post void residual volumes could not be amassed from these studies due to inconsistent or lack of reporting on urinary dysfunction. Table IV provides a comparison of our surgical data to conventional abdominal and other nerve-sparing radical hysterectomy techniques.[8,11,22,23] Our surgical outcome compared to conventional

TABLE III. Conventional Abdominal Radical Hysterectomy

Author[a] (enrollment period)	ARHPLND	Patients (*n*)	OP time (min)	EBL (mL)	Transfusion (%)	LOS (d)
Mann et al. (1969–1979)	Type 3	207	210	1,800		10
Artman et al. (1971–1982)	Type 3	137	340	1,800	92	
Powell et al. (1974–1982)	Type 3	255	255	943	65	13
Landoni et al. (1987–1993)	Type 3	119	180	580	43	10
Pastner et al. (1990–2000)	Type 3	175	130	600	3	3
Abu-Rustum et al. (1990–2000)	Type 3	195	295	693	21	10
Yang et al. (1993–1995)	Type 3	102	217	1,474	62	18
Steed et al. (1996–2003)	Type 3	205	150	500	8	5
Pikaart et al. (1997–2005)	Type 3	156	99	300	2	3
		1,551	208[b] (99–340)	965[b] (300–800)	32[c] (2–92)	10[c] (3–18)

ARHPLND, abdominal radical hysterectomy with pelvic lymph node dissection; OP, operative; EBL, estimated blood loss; LOS, length of hospital stay.
[a]This table is adapted and modified from Pikaart et al.[15] [b]Mean (range). [c]Median (range).

TABLE IV. Abdominal Radical Hysterectomy Techniques

Author (enrollment period)	ARHPLND Technique	Patients (*n*)	OP time (min)	EBL (mL)	Transfusion (%)	LOS (d)	CATH[b] (d)
9 Studies (1969–2005)[a]	ARHPLND Conventional	1,551	208 (99–340)	965 (300–1,800)	32 (2–90)	10 (3–18)	—
Fanning et al.[17] (1991–1997)	ARHPLND Stapler	100	192 (138–420)	500 (200–5500)	—	6 (3–49)	17[c] (7–102)
Tamussino et al.[1] (2001–2004)	ARHPLND Ligasure VSS	31	199	—	26	11.4	—
Charoenkwan et al.[18] (2005)	NS ARHPLND Conventional	21	220 (180–270)	510 (200–1,300)	23	—	10.5 (5–26)
Fujii et al.[8] (2004–2006)	NS ARHPLND Conventional	24	340	—	—	—	14.6 (11–19)
Raspagliesi et al.[11] (2000–2002)	NS ARHPLND CUSA	23	219 (150–270)	489 (200–800)	—	10 (5–16)	6 (4–28)
Shen-Gunther et al. (2009)	NS ARHPLND Bipolar S&S	4	251 (230–265)	625 (400–900)	20	5 (4–5)	17 (10–24)

Dashed line (—) denotes nonreported information. ARHPLND, abdominal radical hysterectomy with pelvic lymph node dissection; OP, operative; EBL, estimated blood loss; LOS, length of hospital stay; CATH, catheterization; NS ARHPLND, nerve-sparing abdominal radical hysterectomy with pelvic lymph node dissection; VSS, vessel sealing system; CUSA, Cavitron Ultrasonic Surgical Aspirator; Bipolar S&S, bipolar sealer & scissors.
[a]Composite of summarized data from Table III. [b]Catheterization methods (suprapubic, transurethral, intermittent self). [c]One patient had prolonged bladder atony over 1 year.

radical hysterectomy revealed a slightly longer operative time of 40–50 minutes, but significantly lower EBL, transfusion rate, and LOS. The prolonged operative time is attributed to: (1) meticulous dissection required for nerve-sparing techniques, (2) secondary procedures to include ovarian transposition, appendectomy, antiadhesive barrier application, and ON-Q pain pump installation. In comparison to corresponding contemporary nerve-sparing radical hysterectomy series, other outcome parameters (operative time, EBL, transfusion rate, and length of catheterization) were comparable. Most importantly, the return of bladder function fell within the first 2–2.5 weeks postoperatively, and none exceeded 1 month. The early return of detrusor function in NSRH was demonstrated by Sakamoto et al. in 1988.[6] This large series revealed a low incidence of urinary retention (>50 mL) at 1 month postoperatively, that is, 10% (36/368 patients) versus 37% (17/46 patients) for NSRH and non-NSRH, respectively.

In summary, we evaluated the performance, safety, complications, and limitations of the bipolar sealer/divider and scissors in NSRH with lymphadenectomy. Although our experience was preliminary, the safety, simplicity, and excellent surgical results of the modern bipolar electrosurgical instruments prove these multifunctional instruments offer many advantages over standard technique. The reduction in instrument traffic and procedural steps allowing efficiency of movement, along with superb hemostasis, make the two bipolar devices particularly attractive. We have adopted the "bipolar sealer and shears technique" as a preferable method of nerve-sparing radical hysterectomy.

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