Abdominal Nerve-Sparing Radical Hysterectomy

7

Tomoyasu Kato

Abstract

Damage to the autonomic nerves during radical hysterectomy is a major cause of postoperative bladder dysfunction. Japanese gynecologists established nerve-sparing radical hysterectomy in 1961. Although a reduction of voiding dysfunction was observed, it was a problem of compromising radicality. Based on our anatomical study, we showed that there was the possibility of improving its radicality by correcting the concept of nerve topography that leads to over-preservation of the cardinal ligament. We devised a new method of nerve-sparing radical hysterectomy with more extensive and deeper dissection of the cardinal ligament. Moreover, we focused on the ureterohypogastric fascia including the ureter and autonomic nerves. This fascia serves as an index during surgery of nerve-sparing technique. Our operative method of nerve-sparing radical hysterectomy consists of four points as follows:

1. The ureterohypogastric fascia including the ureter is separated from the posterior leaf of the broad ligament, and then the hypogastric nerves running along the rectum within the ureterohypogastric fascia are identified.
2. The cardinal ligaments above the middle rectal artery are dissected to raise radicality at pelvic sidewall.
3. For complete preservation of the pelvic plexus, the medial stump of the cardinal ligament is mobilized ventrally above the hypogastric nerve before the dissection of the uterosacral and rectovaginal ligaments.
4. To maximize preservation of bladder branches, rectovaginal ligaments are clamped with right angle forceps.

T. Kato (✉)
Department Gynecology, National Cancer Center Hospital, Chuo-ku, Tokyo, Japan
e-mail: tokato@ncc.go.jp

M. Mikami (ed.), *Surgery for Gynecologic Cancer*, Comprehensive Gynecology and Obstetrics, https://doi.org/10.1007/978-981-13-1519-0_7

Keywords
Nerve-sparing radical hysterectomy · Autonomic nerves · Hypogastric nerves Pelvic splanchnic nerves · Pelvic plexus · Bladder branches · Ureterohypogastric fascia

7.1 History

Abdominal radical hysterectomy was developed by Wertheim in 1912 [1]. But for its high mortality, radiation therapy became the favored approach in the early twentieth century. Meigs made the surgical approach focus again with modification of Wertheim operation with removal of all pelvic nodes [2]. In Japan, Radium was hard to obtain. So Okabayashi made a different improvement from Meigs with wider resection of surrounding tissues of primary lesion and completed Okabayashi radical hysterectomy [3].

Although the treatment outcome was improved, the pelvic nerve plexus was cut, so that postoperative urinary voiding dysfunction occurred frequently. Autonomic nerve damage during surgery was thought to play a crucial role in the etiology of bladder dysfunction, sexual dysfunction, and colorectal motility disorders that are seen in patients after radical hysterectomy [4]. Bladder dysfunction is present in 70–85% of patients for up to 12 months postoperatively, including urinary or anal incontinence or retention [4]. In order to prevent these complications, Japanese gynecologists introduced a surgical technique with preservation of the pelvic autonomic nerves in 1961 [5]. The most important concept of nerve-sparing radical hysterectomy is that the cardinal ligament is divided into two parts as shown in Fig. A. The superficial vascular part is dissected, while the deep neural part that contains the pelvic splanchnic nerves is preserved in non-touch status [6]. Thereafter Japanese doctors had learned and modified this procedure. In the twentieth century,

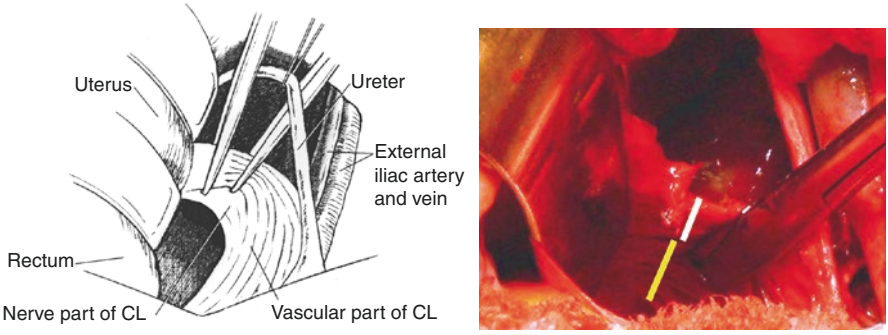


Fig. A Nerve-sparing radical hysterectomy. During nerve-sparing radical hysterectomy, the cardinal ligament is divided into two parts. The superficial vascular part is dissected, while the deep neural part that contains the pelvic splanchnic nerves is preserved **in non-touch status**

there were few articles reported in English [6, 7]. It is only recently that nerve-sparing radical hysterectomy has been introduced to Western [8] as well as to Asian countries [9]. As the postoperative QOL was noted, studies on precise neuroanatomical studies [4, 10] as well as the technique of nerve-sparing radical hysterectomy were reported [11]. Nowadays the concept of preservation of autonomic nerves during radical hysterectomy has become standard in many gynecological cancer centers in the world [12].

7.2 Principle and Indication

7.2.1 Neural Control of the Lower Urinary Tract

Pelvic organ function is organized by both central and peripheral nerve system. For instance, the lower urinary tract is innervated by three sets of peripheral nerves involving the parasympathetic, sympathetic, and somatic nervous systems: pelvic parasympathetic nerves arise at the sacral level of the spinal cord, excite the bladder, and relax the urethra. Lumbar sympathetic nerves inhibit the bladder body and excite the bladder base and urethra. Pudendal nerves excite the external urethral sphincter. These nerves contain afferent sensory as well as efferent motor axons.

7.2.2 Running of the Autonomic Nerves

These autonomic nerves are running and distributed by cadaver study as shown in Fig. 7.1**.** These autonomic nerves related to bladder function can be dissected during the different phases of radical hysterectomy (Fig. 7.2). The hypogastric nerves were cut when the sacral uterine ligaments were cut, the pelvic splanchnic nerves were cut when the cardinal ligaments were cut, the pelvic plexus and the bladder branches were damaged during dissection of the recto-vaginal ligaments, the bladder branches were injured by disseciton of vesicouterine ligaments.

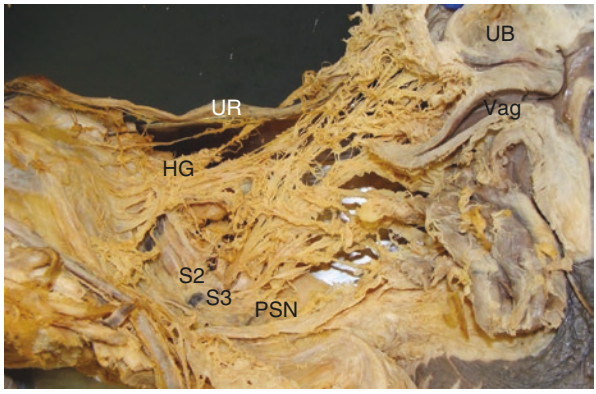


Fig. 7.1 Distribution of the left side of autonomic nerves from medial view by cadaver dissection. *UR* ureter, *Vag* vagina, *UB* urinary bladder, *HGN* hypogastric nerve, *PSN* pelvic splanchnic nerve

- Hypogastric nerves
  - sympathetic
- Pelvic splanchnic nerves
  - parasympathetic
- Pelvic plexus
- bladder branches

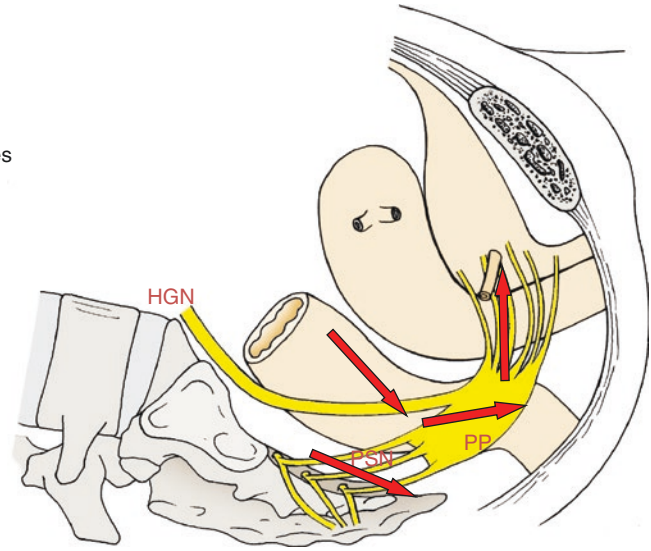


Fig. 7.2 Autonomic nerves related to voiding function. These autonomic nerves can be dissected during the different phases of radical hysterectomy

7.2.3 Principal of Autonomic Nerves During Radical Hysterectomy

A level of nerve preservation is classified into four levels: non-touch, exposure, partial preservation, and dissection. From a point of view on nerve preservation, non-touch preservation provides high quality of life. Simple and modified radical hysterectomy can archive non-touch preservation of autonomic nerves; however, they compromise radicality for invasive cervical cancer. To achieve a good balance between radicality and retaining pelvic function, we conducted to perform exposure or partial preservation of these autonomic nerves.

7.2.4 Indication

7.2.4.1 Indication

The most common indication for radical hysterectomy is early-stage invasive cancer of the cervix, FIGO stage IB1–IIA2. The cancer of the endometrium FIGO stage II or that of upper vagina is also an indication for radical hysterectomy. In Japan, radical hysterectomy is performed according to Okabayashi's method which removes paracolpium widely than Meigs' method. Therefore, the cancer of cervix stage IIB has been included in an indication for Okabayashi's radical hysterectomy.

7.2.4.2 Differences Between the Two Techniques (Meigs vs. Okabayashi)

After dissecting of the anterior layer of the vesicouterine ligament, the paracolpium and the posterior layer of the vesicouterine ligament were clamped by long forceps together and cut and ligated by the procedure of Meigs' radical hysterectomy. In contrast, by the procedure of Okabayashi's radical hysterectomy, the paracolpium was separated from the posterior layer of the vesicouterine ligament [3, 13]. This separation can lead to dissect the bladder thoroughly and resect the paracolpium and vagina wider and longer. Due to the higher local control, Okabayashi radical hysterectomy have been performed even in stage IIB cervical cancer in Japan.

7.3 Preoperative Evaluation

7.3.1 Physical Examination

The physical examination should evaluate the primary lesion and potential sites of metastatic nodes, such as the left supraclavicular fossa and groin. Inspection by naked eye or colposcope of the distal vagina and ectocervix is warranted to determine stage II diseases. The presence of parametrial extension is particularly important for determining the clinical stage and treatment modality by rectal examination. The shortening of fornix of the vagina indicates the invasion into the muscle of the vagina nevertheless the intact mucosa of the vagina. With this finding, the pTNM classification is likely to be pT2BN0, 1 M0.

7.3.2 CT Scan

Computed tomography (CT) scanning has been widely used in the preoperative evaluation of significant lymphadenopathy.

CT findings may provide delineating anatomic variances that alter surgical management, such as ureteral duplication or the presence of a duplicate of infra vena cava. Three-dimensional CT angiography may be helpful in identifying these variances. CT scanning and MRI are equally accurate (~84%) in detecting para-aortic metastasis [14].

7.3.3 MR Imaging

MRI is essential for evaluating the tumor, because MRI can discriminate tumor-containing tissue from non-tumor-containing tissue. Preoperative evaluation includes the size and shape of the primary tumor, depth of stromal invasion, and vaginal or parametrial extension as well as nodal involvement [15, 16].

7.4 Technique

7.4.1 Extended Nerve-Sparing Radical Hysterectomy

Based on the previous anatomical study, we showed that there was the possibility of improving its radicality by correcting the concept of nerve anatomy that leads to over-preservation of the cardinal ligament [10, 17]. Therefore, we devised a new method of nerve-sparing radical hysterectomy more extensive and deeper dissection of the cardinal ligament to increase radicality [18].

7.4.2 Procedures

Each step of our procedures is noted as follows.

7.4.2.1 Opening of Retroperitoneal Spaces

The round ligament is divided, and the broad ligament is opened to expose the retroperitoneal structure including the ureter and ovarian vessels attached to the medial aspect.

7.4.2.2 Identification of the Hypogastric Nerves During the Development of the Pararectal Space

Developing the pararectal space between the ureter and the internal iliac vessels, the hypogastric nerves (HGN) running along the rectum are to be identified. The ureter is separated from the retroperitoneum, and this tissue plane is kept facing downward. The ureter should not be free from the posterior layer of the broad ligament. HGN are found to be running in parallel under 3–4 cm of the ureter. The ureter and the hypogastric nerve are covered with the same fascia. It is important to keep the peeling layer until the hypogastric nerve can be seen without scooping only the ureter. This tissue plane is corresponded to the ureterohypogastric fascia (UHF), which includes the HGN and the pelvic plexus (Fig. 7.3).

7.4.2.3 Developing the Vesicouterine Spaces

Sharp dissection of bladder peritoneum is employed to create vesicouterine spaces. The bladder is separated from the anterior cervix with dissecting correct tissue plane.

7.4.2.4 Pelvic Lymphadenectomy

The systemic pelvic lymphadenectomy is started from the center height of the common iliac vessels. The dissection of the external and internal iliac vessel continues caudally until the deep circumflex vein. Great care need to preserve the obturator nerve and vessels.

7.4.2.5 Preserving the Pelvic Splanchnic Nerves During Dividing of the Cardinal Ligament

The uterine artery is ligated close to its origin at the internal iliac artery. The cardinal ligament (CL) is identified with developing both of the paravesical and

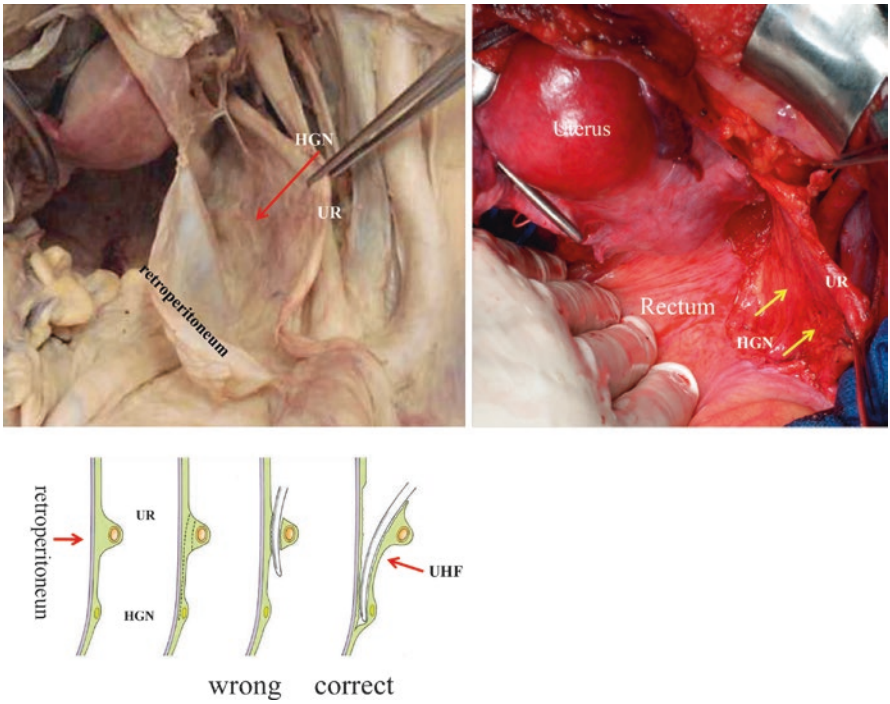


Fig. 7.3 Separation of the ureter hypogastric fascia. This fascia on the dorsal side of the ureter is thin and easy to break. It is gentle with formalin fixation, but it is difficult with actual surgery. This tissue plane is corresponded to the ureter hypogastric fascia, which includes the *hypogastric nerve* (HGN) and the pelvic plexus (PP)

pararectal spaces. According to the original procedure of nerve-sparing radical hysterectomy [5, 6], the CL is divided into two parts. The superficial vascular part is dissected, while the deep neural part that contains the PSN is preserved. Because the surgical margin of the CL might compromise radicality, the indication of this method is limited to cervical cancer with early stage. In order to raise radicality of nerve-sparing radical hysterectomy, we demonstrated that the pelvic splanchnic nerves (PSN) arise from the dorsomedial portion of the neural part of the CL, based on operative findings as well as fresh cadaver studies [10].

In order to increase the margin, the CL is dissected immediately above the middle rectal artery as close as possible to the pelvic sidewall. The PSN originating from S3 run to the pelvic plexus dorsal to the middle rectal artery. Deeply putting retractors in the paravesical space and pararectal space, the cardinial ligament is strained. As the connective tissue on the dorsal side of the deep uterine vein is incised, middle rectal artery is identified. The landmark of middle rectal artery are vessels that run under 1–2 cm of the deep uterine vein and pierce the pelvic plexus.

7.4.2.6 Developing the Rectovaginal Space

The ureter is further separated from the posterior layer of the broad ligament to clarify the entrance of ureteric tunnel, and the broad ligament is incised. Connecting both ends, the peritoneum of cul-de-sac is incised. As the rectum is being pulled cranially with gauze, the rectovaginal space is developed.

7.4.2.7 Dissection of the Anterior Layer of Vesicouterine Ligaments (VUL) with Keeping the Ureterohypogastric Fascia (UHF)

The ureteral tunnel is deroofed, allowing exposure of the uterus. The uterine artery is ligated close to its origin at the internal iliac artery. Keeping the ureterohypogastric fascia (UHF) is important to avoid bleeding during dissection of the anterior layer of vesicouterine ligament. Division of the cervicovesical vessels leads to roll the ureter downward and laterally. The bladder is further dissected caudally to expose the paracolpium.

7.4.2.8 Incision of the UHF

The UHF is incised at midline between the ureter and HGN. Then the medial stump of the cardinal ligaments is re-clamped from the inside of the UHF. So far, the UHF is maintained as an index where autonomic nerves are located.

7.4.2.9 Preserving the Pelvic Plexus During Dissection of the Uterosacral Ligaments

The UHF is incised at midline between the HGN and the ureter. The HGN entered the pelvic plexus at the anterosuperior corner. Deep uterine vein is located below the HGN. The HGN and the pelvic plexus were frequently damaged during dissection of the uterosacral ligaments (USL). To diminish these nerve injuries, the medial stump of the CL should be fully mobilized above the HGN before dissecting the USL (Fig. 7.4). In the case of the tumor with deep myometrial or parametrial

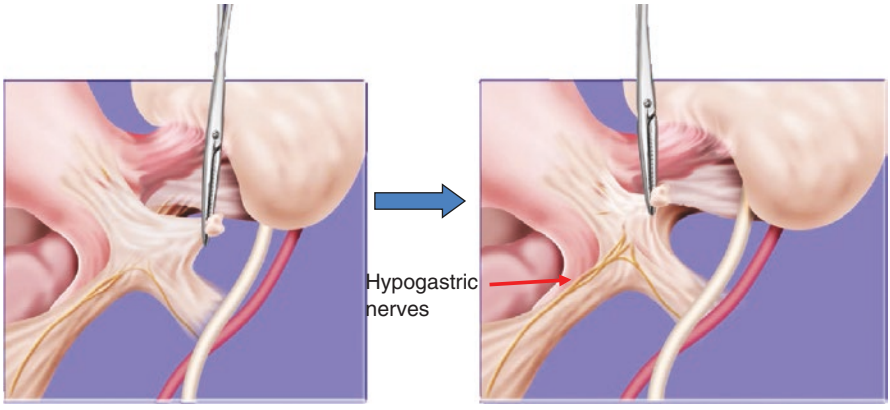


Fig. 7.4 Mobilization of the visceral stump of the cardinal ligament. For total preservation of the pelvic plexus, this stump should be mobilized ventrally above the hypogastric nerves before dissection of the uterosacral and rectovaginal ligaments

invasion, we dissect the USL just below the medial stump of the CL. Then dorsal area of the pelvic plexus is preserved.

7.4.2.10 Preserving the Bladder Branches During the Dissection of the Rectovaginal Ligaments

The ventral half of bladder branches to the ureter are more likely to be injured in dissection of the posterior leaf of the vesicouterine ligaments for wide resection of the paracolpium and the vagina. In order to maximize preservation of the dorsal half of bladder branches, the rectovaginal ligaments should be clamped using right angle forceps so as not to involve them.

7.4.2.11 Dissection of the Posterior Layer of Vesicouterine Ligaments

Further rolling the ureter allows the clearance of the boundary between the posterior layer of the vesicouterine ligaments and the paracolpium. Forceps are inserted into this boundary.

7.4.2.12 Dividing the Paracolpium and the Vagina

Separating the paracolpium from the posterior layer of the vesicouterine ligament to extend the resection field of the paracolpium is an original point of Okabayashi's hysterectomy [3, 13]. This procedure allows us wider and longer resection of the paracolpium and vagina. Then the paracolpium is divided by two steps. The specimen is removed by dividing the vagina. The vagina vault is closed with a Z-figure suture Fig. 7.5 and 7.6.

7.4.2.13 The Level of Preservation of Autonomic Nerves After Nerve-Sparing Radical Hysterectomy

Dissection line of autonomic nerves by our procedures is indicated by a red line in Fig. 7.7. According to our method, the HGN are found to be preserved in exposure,

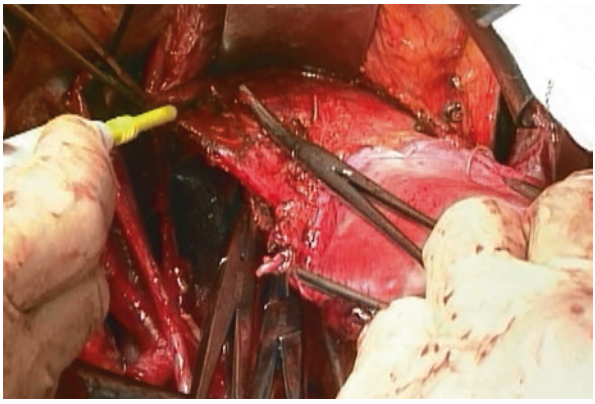


Fig. 7.5 Rolling the ureter. The top of electric cautery indicates the boundary between the paracolpium and the posterior layer of the vesicouterine ligaments

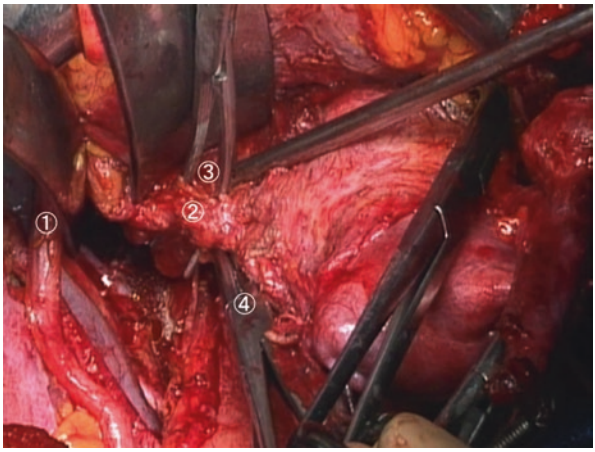


Fig. 7.6 Division of the posterior layer of the vesicouterine ligaments. The forceps are inserted into this boundary and the posterior layer of the vesicouterine ligaments is divided. *1* Ureter, *2* posterior layer of the vesicouterine ligaments, *3* paracolpium, *4* medial stump of the cardinal ligaments

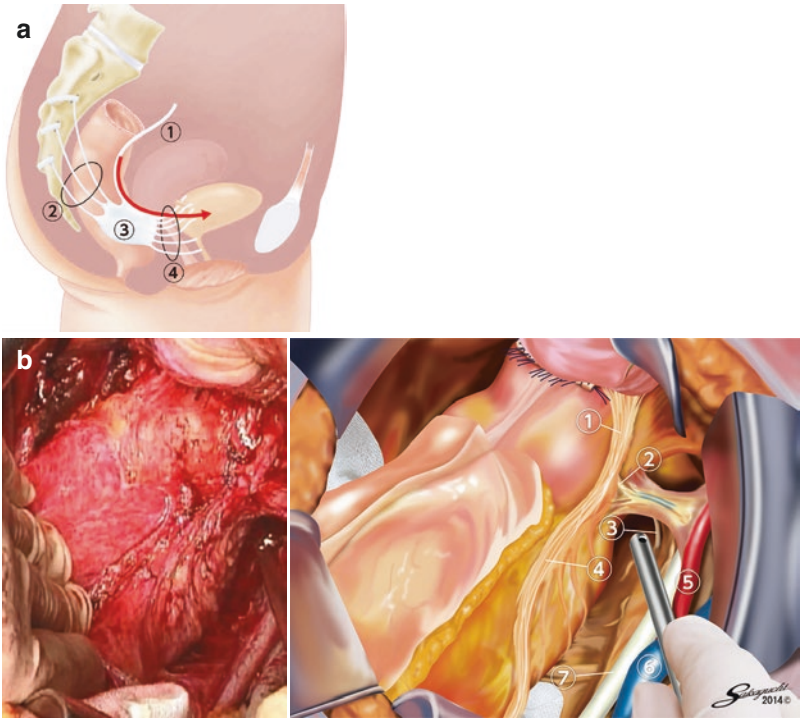


Fig. 7.7 (**a**) Red line indicates the cutting line of total preservation of pelvic plexus and hypogastric nerves and dorsal half preservation of vesical branches. *1* Hypogastric nerves, *2* pelvic splanchnic nerves (S2–4), *3* pelvic plexus, *4* vesical branches. (**b**) Completion of nerve-sparing RH. Hypogastric nerve and bladder branches are found to be preserved. *1* Bladder branches, *2* pelvic plexus, *3* pelvic splanchnic nerves, *4* hypogastric nerves, *5* internal iliac artery, *6* external iliac artery, *7* ureter

the PSN in non-touch or exposure, pelvic plexus in exposure or partial, and bladder branches in partial preservation. The difference of dissection line between radical hysterectomy and nerve-sparing radical hysterectomy is also shown in Fig. 7.7.

7.5 Morbidity

7.5.1 Five-Year Overall Survival

FIGO annual reported showed that 5-year overall survival of 3010 patients with cervical cancer stage IB1 was 89.1% [19]. In contrast, Japanese study demonstrated that a 5-year OS was 93.3% [20]. The difference could be explained by the wider resection of the paracolpium according to Okabayashi's procedure.

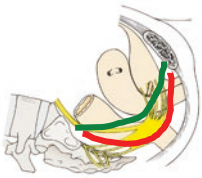
7.5.2 Postoperative Complication

The major postoperative complication of radical hysterectomy is the bladder dysfunction due to damage of autonomic nerves in the pelvis. Bladder function recovery by procedure of hysterectomy is shown in Table 7.1 [18]. The degree of nerve

Table 7.1 Bladder function recovery

Method	HGN	PSN	P Plexus	bladder braches	PVR<50ml
Simple Hx	◎	◎	◎	◎	<5POD
class II RH	◎	◎	◎	○	7-16POD
class III RH	×	◎(S2,3,4)	△	△	CIC: 10%
Nerve-sparing ARH (Tokyo)	○	◎(S2,3,4)	○	△	18POD
Extended NS ARH (total)	○	×(S2)○(S3,4)	○	△	18POD
NS ARH (partial)	×	×(S2)○(S3,4)	△	△	24POD

◎ non-touch preservation
○ exposure preservation
△ partial preservation
× dissection



This table summarizes a degree of preservation of each autonomic nerves according to procedure of hysterectomy
Needles to say, preservation of bladder branches is important
This concept is also shown in this figure

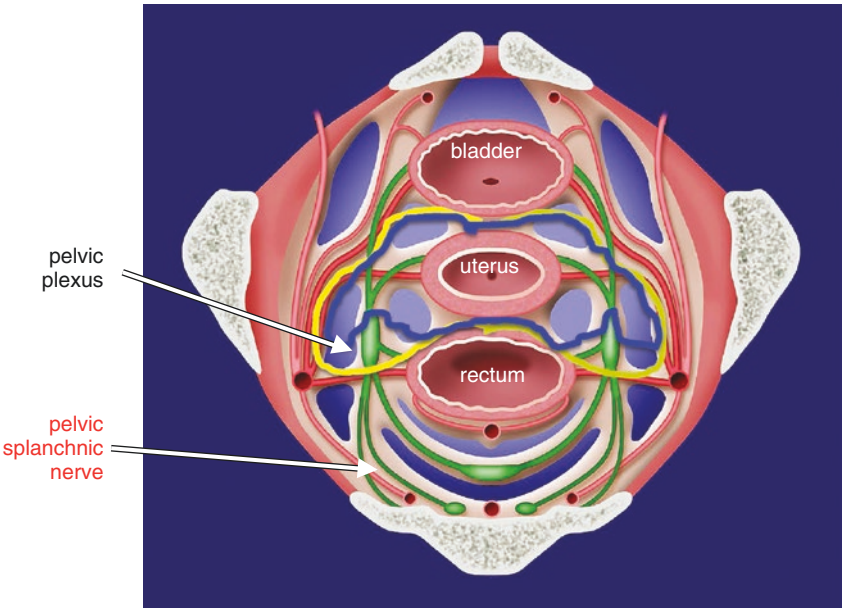


Fig. 7.8 Dissection line by class III and nerve-sparing radical hysterectomy. Scheme of the axial section of the female pelvis is shown. Green line, a nerve system; yellow line, the cut line of the radical hysterectomy (RH); blue line, the cut line of nerve-sparing RH

preservation is divided into four levels such as non-touch, exposure, partial, and non-preserved.

7.6 Future Prospect

A growing literature supports (robot-assisted) laparoscopic radical hysterectomy in early-stage cervical cancer. One review shows that robot-assisted radical hysterectomy is associated with minimal blood loss, a shortened hospital stay, and few operative complications [21].

Even when these minimally invasive surgeries are widespread, locally advanced tumors such as stages IB2, IIA2, and IIB, especially adenocarcinoma, will continue to be indicated for abdominal radical hysterectomy. The abdominal approach is the basis of radical hysterectomy, and we need to master it (Fig. 7.8).

References

1. Wertheim E. The extended abdominal operation for carcinoma of the cervix. Am J Obstet Gynecol. 1912;66:169–232.
2. Meigs JV. Radical hysterectomy with bilateral pelvic lymph node dissections; a report of 100 patients operated on five or more years ago. Am J Obstet Gynecol. 1951;62:854–70.

3. Okabayashi H. Radical hysterectomy for cancer of the cervix uteri. Surg Gynecol Obstet. 1921;33:335–43.
4. Zullo MA, Manci N, Angioli R, et al. Vesical dysfunctions after radical hysterectomy for cervical cancer: a critical review. Crit Rev Oncol Hematol. 2003;48:287–93.
5. Kobayashi T. Radical hysterectomy. Tokyo: Nanzando; 1961. (in Japanese)
6. Sakamoto S, Takizawa K. An improved radical hysterectomy with fewer urological complications and with no loss of therapeutic results for invasive cervical cancer. Ballieres Clin Obstet Gynecol. 1988;2:953–62.
7. Yabuki Y, Asamoto A, Hoshiba T, et al. Radical hysterectomy: an anatomic evaluation of parametrial dissection. Gynecol Oncol. 2000;77:155–63.
8. Trimbos JB, Maas CP, Deruiter MC, Peters AA, Kenter GG. A nerve-sparing radical hysterectomy: guidelines and feasibility in Western patients. Int J Gynecol Cancer. 2001;11:180–6.
9. Lee YN, Wang KL, Lin MH, Liu CH, Wang KG, Lan CC, et al. Radical hysterectomy with pelvic lymph node dissection for treatment of cervical cancer: a clinical review of 954 cases. Gynecol Oncol. 1989;32:135–42.
10. Kato T, Murakami G, Yabuki Y. A new perspective on nerve-sparing radical hysterectomy: nerve topography and over-preservation of the cardinal ligament. Jpn J Clin Oncol. 2003;33:589–91.
11. Sakuragi N, Todo Y, Kudo M, Yamamoto R, Sato T. A systematic nerve-sparing radical hysterectomy technique in invasive cervical cancer for preserving postsurgical bladder function. Int J Gynecol Cancer. 2005;15:389–97.
12. Querleu D, Morrow CP. Classification of radical hysterectomy. Lancet Oncol. 2008;9:297–303.
13. Fujii S. Anatomic identification and functional outcomes of the nerve sparing Okabayashi radical hysterectomy. Gynecol Oncol. 2007;107:4–13.
14. Scheidler J, Hricak H, Yu KK, et al. Radiological evaluation of lymph node metastases in patients with cervical cancer. A meta-analysis. JAMA. 1997;278:1096–101.
15. Mitchell DG, Snyder B, Coakley F, Reinhold C, Thomas G, Amendola M. Early invasive cervical cancer: tumor delineation by magnetic resonance imaging, computed tomography, and clinical examination, verified by pathologic results, in the ACRIN 6651/GOG 183 Intergroup Study. J Clin Oncol. 2006;24:5687–94.
16. Sahdev A, Sohaib SA, Wenaden AE, Shepherd JH, Reznek RH. The performance of magnetic resonance imaging in early cervical carcinoma: a long-term experience. Int J Gynecol Cancer. 2007;17:629–36.
17. Kato T, Murakami G, Yabuki Y. Does the cardinal ligament of the uterus contain a nerve that should be preserved in radical hysterectomy? Anat Sci Int. 2002;77:16–8.
18. Kato T. Extended nerve-sparing radical hysterectomy. Acta Obstet Gynaecol Jpn. 2004;56:1369–76. in Japanese
19. Quinn MA, Benedet JL, Odicino F, Maisonneuve P, Beller U, Creasman WT, et al. Carcinoma of the cervix uteri. FIGO 6th Annual Report on the Results of Treatment in Gynecological Cancer. Int J Gynaecol Obstet. 2006;95:Sd43–103.
20. Kato T, Takashima A, Kasamatsu T, et al. Clinical tumor diameter and prognosis of patients with FIGO stage IB1 cervical cancer (JCOG0806-A). Gynecol Oncol. 2015;137:34–9.
21. Lowe MP, Chamberlain DH, Kamelle SA, Johnson PR, Tillmanns TD. A multi-institutional experience with robotic-assisted radical hysterectomy for early stage cervical cancer. Gynecol Oncol. 2009;113(2):191–4.