Surg Radiol Anat (1991) 13 : 145-148

Surgical and Radiologic Anatomy
Journal of Clinical Anatomy

The anatomical basis and prevention of neurogenic voiding dysfunction following radical hysterectomy

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Summary. The disorder of neurogenic dysfunction is one of the most important complications of radical hysterectomy. In order to prevent this potential complication, the authors have studied the composition and layers of the pelvic paravisceral structures. The nerve branching and distribution of the pelvic plexus of 12 adult female cadavers were analyzed. From lateral to medial the pelvic paravisceral structure is made up of three layers. The lateral layer is the pelvic visceral fascia, the middle, a vascular layer, and the medial one, a nervous one which consists of the pelvic plexus and subsidiary plexuses. The pelvic plexus and subsidiary plexuses are laid closely to the lateral walls of pelvic organs. The ischial spine was taken as the central point and two perpendicular lines penetrating through the ischial spine were used as the longitudinal axis and transverse axis. According to these landmarks, the pelvic plexus could be divided into three parts : behind the longitudinal axis are the roots of the pelvic plexus, near the longitudinal axis is the uterovaginal plexus, and in front of the longitudinal axis are the branches distributed to bladder and urethra. The pelvic plexus and the uterosacral and cardinal ligaments are closely related. The pelvic and subsidiary plexuses can be damaged in radical hysterectomy and voiding dysfunction may then develop. Some anatomic bases are provided to explain and hopefully prevent this from happening.

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Bases anatomiques et prévention des dysfonctions neurogéniques induites après hystérectomies radicales

Résumé. L'atteinte neurologique de la miction est l'une des complications les plus importantes de l'hystérectomie radicale. Pour éviter les complications induites par l'hystérectomie radicale, les auteurs ont étudié l'anatomie, les branches et la distribution du plexus pelvien sur 12 cadavres féminins adultes. Les structures paraviscérales pelviennes sont formées de 3 couches. La couche externe correspond au fascia pelvien viscéral, la couche moyenne est une couche vasculaire et la couche interne nerveuse est composée du plexus pelvien et de plexi secondaires. Ceux-ci sont situés contre la paroi latérale des organes pelviens. Les repères ont été délimités de la façon suivante ; l'épine sciatique étant le point central, deux lignes croisent ce point comme axe transverse et longitudinal. Ainsi, le plexus pelvien peut être divisé en 3 parties : en arrière de l'axe longitudinal se trouvent les racines du plexus, à côté de l'axe longitudinal, le plexus utéro-vaginal et en avant de cet axe, les branches de distribution pour l'utètre et la vessie. Il existe des rapports étroits entre le plexus pelvien et les ligaments utéro-sacrés et cardinaux. Le plexus et les plexi secondaires peuvent être endommagés dans les hystérectomies radicales et une dysfonction induite se développer. Quelques bases anatomiques sont étudiées et la façon d'opérer pour protéger le plexus est discutée.

Key words: Radical hysterectomy - Pelvic paravisceral structure - Pelvic plexus - Neurogenic voiding dysfunction

The foundation of modern radical hysterectomy was laid in 1911 by Wertheim, who originally described a hysterectomy and salpingo-oophorectomy as well as excision of enlarged lymphatic nodes. Since then, although some improvements in Wertheim's hysterectomy have been made, neurogenic complications such as urinary retention, incontinence and vesical sensory deficiency have been reported following surgery [1, 2, 3, 4, 6, 7, 8, 10]. The majority of surgeons agree that these complications correspond to nerve damage to the pelvic plexus and pelvic organs. Various measures have been suggested in the hope of avoiding such complications [5, 6, 7, 9]. However, neuro-

genic dysfunction is still one of the most important complications of radical hysterectomy and this is ascribed to the complex relationships of pelvic paravisceral structures and the difficulty in recognizing the pelvic plexus. The present specimen dissection at operation of the pelvic paravisceral structures attempted to approach the anatomic factor, in order to prevent post operative neurogenic voiding dysfunction.

Materials and methods

The material constituted 12 female adult specimens, prepared for routine dissection by medical students. In 6, the pelvis was hemisected in the sagittal plane and the parietal peritoneum lifted in order to allow dissection from medial to lateral. In the remaining 6, after the landmarks were defined, the lateral walls of the pelvis were removed in order to allow dissection from lateral to medial (Fig. 1).

The composition and dividing layers of the pelvic paravisceral structures were investigated along with the location, composition, branching pattern and distribution of the pelvic plexus. The relationships between the pelvic plexus and the uterosacral and cardinal ligaments were examined.

Results

The composition and layers of the pelvic paravisceral structures and the position of the pelvic plexus

The pelvic parietal peritoneum was reflected back and the underlying space was exposed. The space is limited laterally by the pelvic parietal fascia and medially by the pelvic visceral fascia. The pelvic parietal fascia and pelvic visceral fasciae were attached to each other at the tendinous arch of levator ani. Visceral branches of the internal iliac vessels and hypogastric nerve were found to run from the superolateral to the inferomedial aspect of the pelvic subperitoneal space, and to penetrate the pelvic visceral fascia, and remain medial to it.

Table 1. Covering area of pelvic paravisceral structure X + SD (cm)
Dimensions des structures pelviennes paraviscérales X + SD (cm)

Localizating points	P	A	B	I
Distance between superior border and PI line	2.2 + 0.8	1.9 + 1.1	2.1 + 0.1	2.6 + 1
Distance between inferior border and PI line	1.4 + 0.5	1.9 + 0.5	1.6 + 0.6	1.3 + 0.5

The vascular branches and nerves were pushed to the visceral side during further dissection in the space. From lateral to medial, pelvic paravisceral structures can be divided into three layers: lateral layer, the pelvic visceral fascia; middle layer, the vascular layers composed of venous plexus and arterial branches distributed to the pelvic organs; medial layer, the nervous layer including the pelvic plexus and subsidiary plexuses lying close to the lateral walls of the pelvic organs.

We chose the PI (pubic symphysis-ischial spine) line as the reference line which is located between the middle point of inferior fringe of the symphysis pubis (P) and the point of the ischial spine [I].

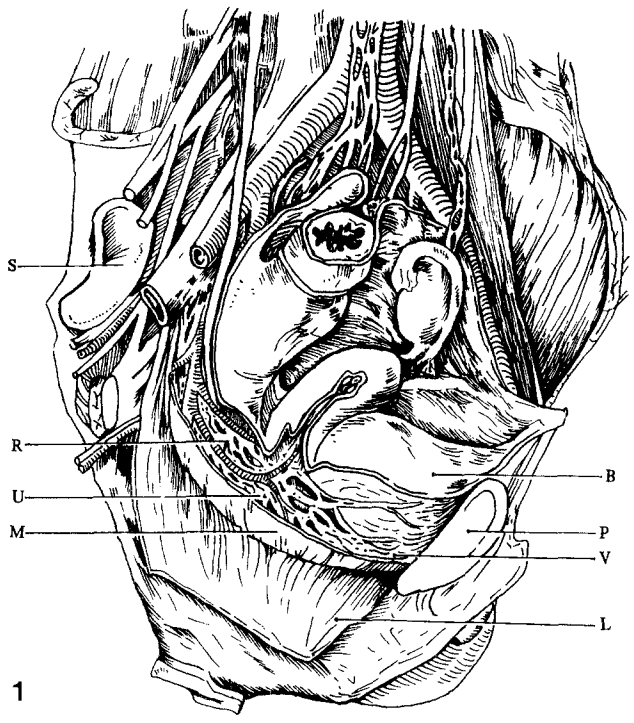
The edge of the vascular layer was taken as the border. We measured P point, A point, B point and I point, respectively (Fig. 2, Table 1), the vertical distances between the superior edge (SP, SA, SB, SI). Similarly we measured the distance between the basic line and the inferior edge (IP, IA, IB, II).

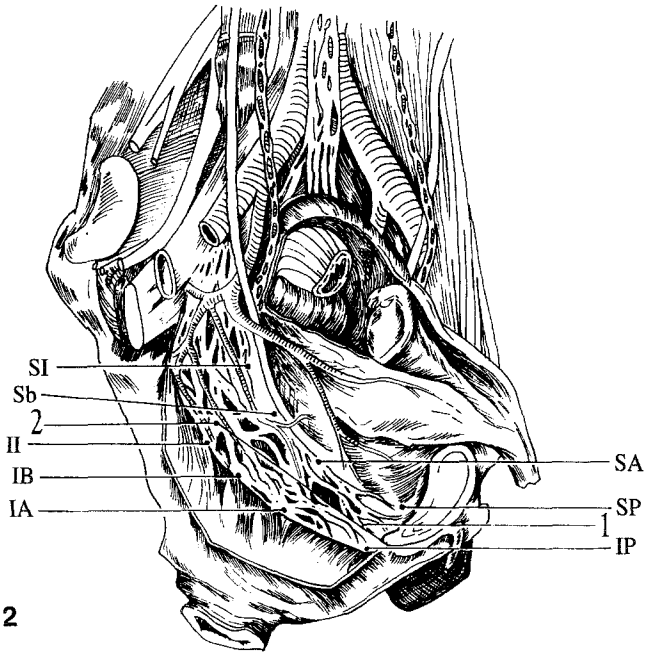
As SP, SA, SB and SI points represent the superior border of vascular layer and IP, IA, IB and II points represent the inferior border of the vascular layer, the covering area of pelvic paravisceral structure was displayed

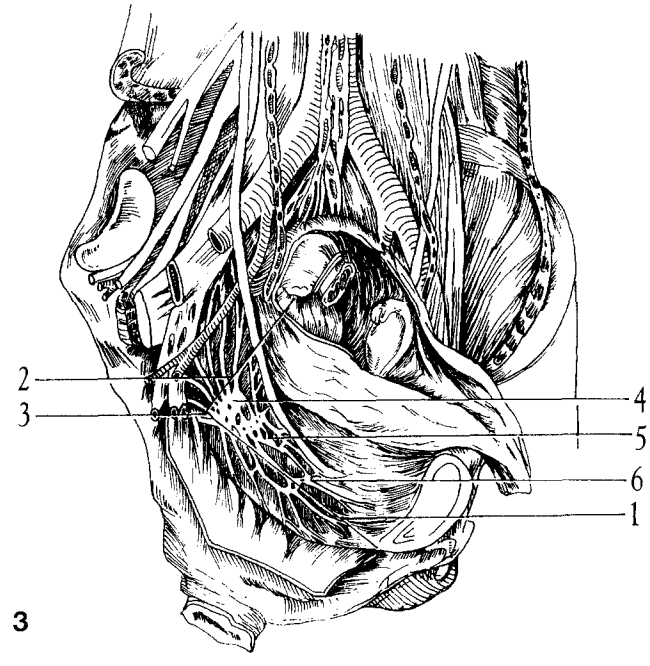
Location of pelvic plexus

After the pelvic visceral fascia and vascular layer of pelvic paravisceral structures were removed, the pelvic plexus and subsidiary plexuses could be demonstrated. The pelvic plexus, the direct continuations and expansions of the hypogastric nerves, the slender branches from the sacral sympathetic trunk, and the sacral parasympathetic fibers were arranged lateral or lateroventral to the rectal ampulla. Twigs arose off from the posteromedial, medial and anteroinferior aspect of the pelvic plexus and distributed themselves to the rectum, uterus, vagina, bladder and urethra. The dividing area of the pelvic plexus was referenced to the following landmarks : the ischial spine as the central point, PI line as the transverse axis, and a line penetrating through the ischial spine and vertical to the PI line as the longitudinal axis.

Being on different planes the locating landmarks and the pelvic plexus were projected onto the midsagittal plane. On the projecting plane, the pelvic plexus could be approximately divided into three parts according to the landmarks. Behind the longitudinal axis were the roots of the pelvic plexus (hypogastric nerves and pelvic parasympathetic nerves) and the branches distributed to the rectum (rectal plexus). Near the longitudinal axis, twigs were given off by the pelvic plexus to the uterus and vaginal wall (uterovaginal plexus). In front







Figs. 1-3

1 The lateral wall of the pelvis was removed. *L* Pelvic parietal fascia *M* Pelvic visceral fascia *P* Pubic symphysis *B* Bladder *S* Sacral auricular articulation *R* Rectal venous plexus *U* Uterovaginal venous plexus *V* Vesical venous plexus **2** *1* PI line *2* Ischial spine **3** Location of pelvic plexus. *1* PI line *2* Longitudinal axis *3* Ischial spine *4* Pelvic plexus *5* Uterovaginal plexus *6* Vesical plexus

1 La paroi latérale du pelvis est enlevée. *L* fascia pelvien pariétal *M* fascia pelvien viscéral *P* symphyse pubienne *S* articulation sacro-iliaque *R* plexus veineux rectal *U* plexus veineux utérovaginal *V* plexus veineux vésical **2** *1* ligne PI *2* épine sciatique **3** Situation du plexus pelvien. *1* ligne PI 22 axe longitudinal *3* épine sciatique *4* plexus pelvien *5* plexus utérovaginal *6* plexus vésical

of the longitudinal axis were the branches of the pelvic plexus. These branches were distributed to the bladder and urethra. The branches located in front of the longitudinal axis were divided into two parts by PI line. The branches superior to the PI line continued forward along the inferolateral margin of the ureter and were distributed to the bladder wall at the level where the ureter penetrated the bladder. The branches inferior to the PI line were a bundle arising from the anteroinferior angle of the pelvic plexus. The bundle ran forward and downward to the bladder neck and urethra (Fig. 3).

The relationship between the uterosacral and cardinal ligaments and the pelvic plexus

The uterosacral ligaments attached to the posterior aspect of the cervix pass around the lateral margins of the rectum to insert on the anterior surface of the sacrum. In addition to the fascial and connective tissue components, the uterosacral ligaments contain important pelvic parasympathetic and hypogastric nerves rami. Cardinal ligaments are located at the base of broad ligaments and belong to the pubovesicocervical fascia, surrounding the cervix and extending laterally to attach to pelvic walls.

At the lateral margin of the cervix the fibers inferior to the PI line run forward and downward to form an acute angle with the cardinal ligaments ; they were distributed to the bladder and urethra.

Discussion

The pelvic paravisceral layer neighbouring bilaterally the pelvic viscera is in nature neuro-vascular. As the pelvic parietal peritoneum is opened in the course of radical hysterectomy, the pelvic paravisceral layer is actually pushed to the visceral side if slight detachment is done in the pelvic subperitoneal space. Nevertheless, the pelvic plexus is not liable to be damaged during the removal of lymph nodes at the pelvic walls and the pelvic base. The vascular layer is a larger layer within the pelvic paravisceral structure and covers the nervous layer. Since the position of blood vessels to be ligated is more superficial, "don't worry about damage to the nerve plexus".

Only nerve branches near the organ to be resected can be damaged in a radical operation. The innervation of normal viscera should be preserved to ensure their normal functional recovery following surgery. However, it is difficult to prevent pelvic plexus damage in such a large operation. According to the landmark line defined in this article, the pelvic plexus can be divided into three parts. If excessive resection is made in the field behind the longitudinal axis, the roots of the pelvic plexus will be liable to damage. The branches running through the superior and inferior portions of PI line in front of longitudinal axis should also be protected.

The uterosacral and cardinal ligaments are resected in radical hysterectomy. Since the two ligaments are closely related to the pelvic plexus, how much of them can be removed, so that the pelvic plexus can be preserved? In addition the close relationships between the uterosacral ligament and the roots of the pelvic plexus give rise to new questions: how much of the uterosacral ligament is resected? How far from the sacral concavity is the resected part? How deep is the resected part ?

The uterosacral ligaments must not be removed excessively, the resected part should be far from the sacral concavity and the partial removal of ligament should not be too deep; thus the pelvic parasympathetic nerve fibers will be retained and voiding function following radical hysterectomy can be recovered rapidly.

The inferior part of cardinal ligament being associated with the nerve bundle, its removal is a key step of the operation. For a wider view of the operative field, after the stump of the infundibulo-pelvic ligament is pulled up by the bladder retractor, the paravesical space and the pararectal space are opened by blunt finger dissection so that the cardinal ligaments can be better exposed. The lower part of the cardinal ligament has an autonomic nerve bundle which is easily recognised by palpation. Thereafter the cardinal ligaments away from the lateral margin of cervix are clamped and preserved; the ligaments are separated medially (to the nerve bundle) and the connective tissue around the nerve bundle is finally cleared away. Surgeons should try their best to protect the nerve bundle bilaterally. If damage is unavoidable, the lateral nerve bundle should at least be preserved to ensure that the innervation of the bladder and urethra is maintained.

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Received June 27, 1990/Accepted in final form February 7, 1991