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Local anatomy around terminal ureter related to the anterior leaf of the vesicouterine ligament in radical hysterectomy

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ABSTRACT

Objectives: Radical hysterectomy is performed for invasive cervical cancer. In this surgery, separation of the anterior leaf and posterior leaves of the vesicouterine ligament (VUL) is important. We studied the local anatomy of the anterior leaf of the VUL, especially the branches of the umbilical artery from the view point of surgery and cadaver dissection.
Study Design: We observed the cervicovesical blood vessels and the connective tissue layer continued from umbilical artery and searched for the origin of the cervicovesical blood vessels in radical hysterectomy. We also dissected a formalin-fixed female cadaver, and observed the same points.
Results: After separation of the connective tissue of urinary bladder from the cervical fascia, we could discern the outline of the distal ureter near the ureterovesical junction. We separate the connective tissue of the so-called anterior leaf of the VUL enwrapping the ureter gently, and then the ureter with the connective tissue is completely rolled out laterally. We identified a cervicovesical vessel crossing over the ureter. We looked for the central side of the cervicovesical vessel and found that cervicovesical vessel was a branch of the superior vesical artery. And, during cadaver dissection, we found that the connective tissue and the branches of the superior vesical artery were similarly observed.
Conclusions: We found the precise anatomy of the connective tissue layer from umbilical artery to urinary bladder and the superior vesical artery. Our procedure based on the precise anatomy obtained in this study is reasonable anatomically as a method for separation of the vesicouterine ligament during radical hysterectomy.

Introduction

Radical hysterectomy is performed for invasive cervical cancer. Wertheim in Wiens first described radical hysterectomy in 1911, and this surgical procedure was modified by Okabayashi in Japan. The characteristics of Okabayashi's method are the wide extirpation of the parametrial tissue and separation of the posterior leaf of the vesicouterine ligament (VUL) [1]. Precise understanding of anatomy is required during radical hysterectomy, therefore many authors have mentioned the anatomy regarding radical hysterectomy [2–6]. In recent years, Fujii in Japan reported a nerve-sparing radical hysterectomy based on Okabayashi's method in detail, using illustrations and step-by-step instructions [7]. Fujii et al. pointed out that separation of the posterior leaf of the VUL is often difficult and not popular in western countries. The separation of the anterior and posterior leaves of the VUL is important because this procedure enables the gynecologic oncologist to separate the bladder with the ureter from the cervix completely. However, there are some technical problems with separation of the VUL, especially its anterior leaf. The first problem is bleeding. With the blind method in the conventional separation of the anterior leaf of the VUL, gynecologists encounter unexpected bleeding because of injury to fine blood vessels around the ureter. Another problem is injury to the ureter and the nerves around the ureter. It is reported that ureteral injuries occur frequently during gynecologic surgery [8]. Kraima et al. described that the vesical plexus was closely related to the distal ureter and located in the VUL [9]. Also, they pointed out that if gynecologists free the ureter up to the point of its insertion into the bladder, the vesical plexus will be sacrificed. Therefore, the anterior leaf of the VUL is the crucial area in radical hysterectomy.

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There have been some previous studies on safe techniques for the separation of the anterior leaf of the VUL. Fujii et al. observed the presence of small vessels in the anterior leaf of the VUL, naming them the cervicovesical blood vessels [1]. Then, they proposed the meticulous separation of the anterior leaf of the VUL by paying attention to the cevicovesical blood vessels. Also, Kobayashi et al. reported a novel technique for management of the VUL [10]. They injected diluted epinephrine near the VUL and easily discerned the cervicovesical blood vessels in VUL. The reports related to the cervicovesical blood vessels so far has contributed to performing radical hysterectomy accurately and safely. However, the origin of the cervicovesical blood vessels have not been described clearly.

The purpose of this study was to investigate the anatomy related to connective tissue and blood vessels including cervico-vesical vessels around terminal ureter in order to further improve radical hysterectomy.

Materials and methods

The study included 15 patients treated for early-stage cervical cancer at Keio University hospital between March 2015 and March 2016. All patients were operated on by the same surgeon. The surgical procedure was as follows.

Surgical procedure

We performed the following surgical procedures to free the urinary bladder and the ureter from the cervical fascia in radical hysterectomy.

Step 1: We dissect the peritoneum of the vesicouterine pouch. The space beneath the peritoneum is composed of avascular loose connective tissue and fat. We dissect this avascular loose connective tissue sharply with a monopolar electric device. Also, the urinary bladder is mobilized caudally away from the cervical fascia. Mobilization of the urinary bladder is mainly performed on the central wall of the cervix down to about 2 cm below to the anterior vaginal fornix. During this step, we consider whether this loose connective tissue and the blood vessels in the connective tissue are derived from either the cervical fascia or vesical fascia. We try to leave fat tissue on the vesical fascia as much as possible.

Step 2: Continuously, we mobilize the urinary bladder on the lateral side wall of cervix carefully until we discern the yellowish fascia (Fig. 1).

Step 3: We think this yellowish fascia is connective tissue ventral to the ureter, the so called anterior leaf of the VUL. Superficial vessels of the cervical fascia and vaginal wall are running from the cranial side to the caudal side. On the other hand, we can discern the vessels running parallel to the ureter in the yellowish fascia. After separation of the yellowish connective tissue from the cervical fascia, we can discern the outline of the distal ureter enwrapped by the connective tissue near the ureterovesical junction (Fig. 2).

Step 4: We separate the connective tissue at the border of the connective tissue and the cervical fascia without creating a ureteral tunnel. We dissect the superficial small vessels on the cervical fascia mainly with a vessel sealing device.

Step 5: We separate the connective tissue of the so-called anterior leaf of the VUL enwrapping the ureter gently, and then the ureter with the connective tissue is completely rolled out laterally.

Cadaver dissection

We dissected three formalin-fixed female cadavers. This dissections was performed in a clinical anatomy laboratory based on the guidelines for cadaver dissection in education and research of clinical medicine at the Keio University School of Medicine. This study was approved by the institutional ethics committee (Registration number 20070026).

We separated the urinary bladder from the cervical fascia. We observed the connective tissue layer stretching from the umbilical artery to the urinary bladder, superior vesical artery and uterine artery.

Results

Clinical results

The median operative time was 195 min. The median estimated blood loss was 430 ml. There were no intra or postoperative complications including injury to the ureter.

Surgical procedure

We dissected the avascular loose connective tissue beneath the peritoneum of the vesico-uterine pouch sharply with a monopolar electric device. As a result, we exposed the cervical fascia without cutting and ligating blood vessels, especially on the central wall of the cervix. We could separate the urinary bladder on the lateral side wall of the cervix, and we could discern the yellowish fascia next to the central wall from the cervix to the vagina (Fig. 1). After separation of the yellowish connective tissue from the cervical fascia, we could discern the outline of the distal ureter near the ureterovesical junction (Fig. 2). We identified a cervicovesical vessel crossing over the ureter (Fig. 3). We looked for the central side of the cervicovesical vessel and found that cervicovesical vessel was a branch of the superior vesical artery (Figs. 4 and 5). And, the superior vesical artery had several branches on urinary bladder.

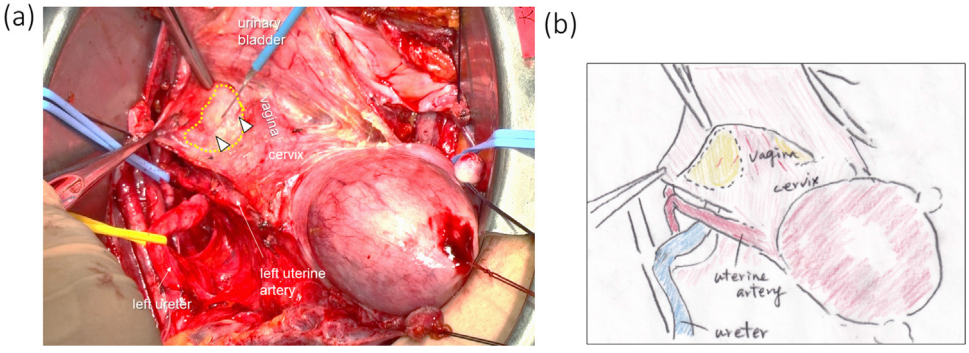

Fig. 1. a and b The yellowish fascia next to central wall from cervix to vagina was appreciated. Dotted line shows the yellowish fascia. The vessels in the yellowish fascia which were different direction from other superficial vessels of cervical fascia were appreciated. Arrowhead shows the vessels.

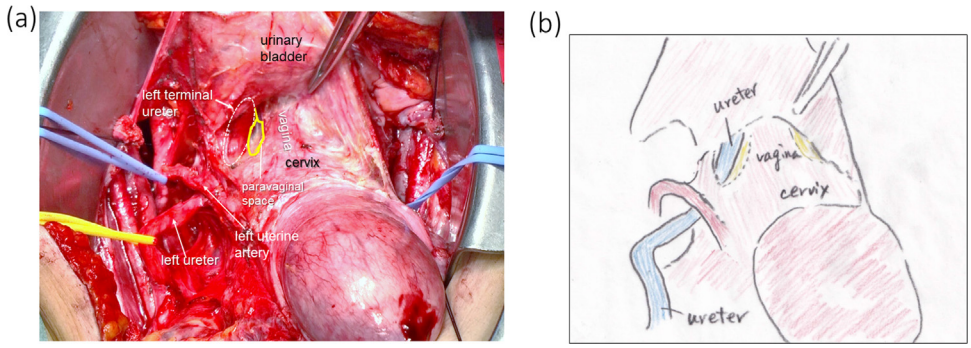

Fig. 2. a and b After separation of the yellowish connective tissue from the cervical fascia, the outline of the distal ureter near the ureterovesical junction is identified (dotted line circle).

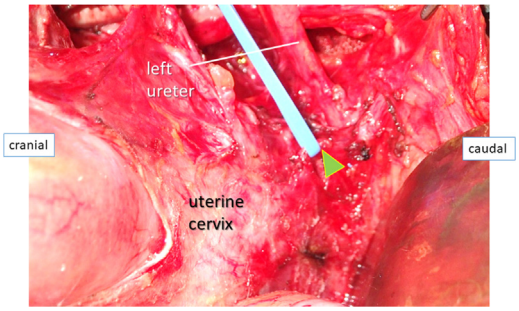

Fig. 3. This photograph shows operative view. We identified a cervicovesical vessel crossing over the ureter.

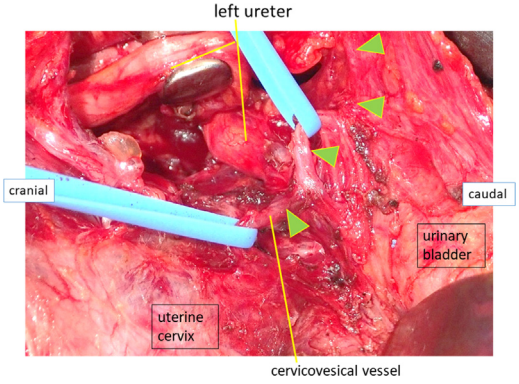

Fig. 4. I looked for the central side of the cervicovesical vessel. These arrowhead indicates a blood vessel.

Cadaver dissection

The connective tissue layer continued from umbilical artery to urinary bladder (Fig. 6). This layer could be separated from cervical fascia. We found that this layer covered the distal part of the ureter, and that this layer was very close to the ureterohypogastric nerve fascia (Fig. 7). Branches of the superior vesical artery were similarly observed in cadavers (Fig. 8). Orange dye in these photographs is the color of lead oxide in blood vessels. These blood vessels ran on the ventral side of the ureter and were distributed in the cervical fascia and the bladder.

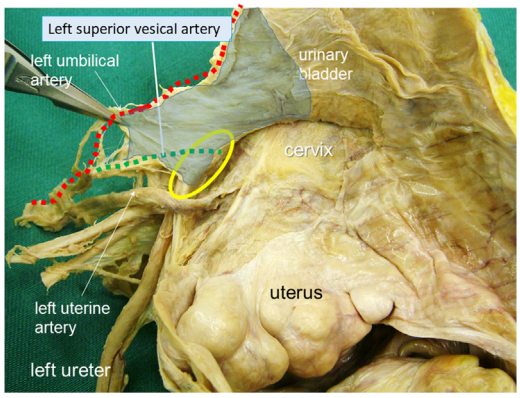

Fig. 6. The connective tissue layer (blue shaded part) continued from umbilical artery to urinary bladder. The ureter is covered with this connective tissue which is called the vesicouterine ligament (yellow circle). The superior vesical artery runs in the green dot line (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

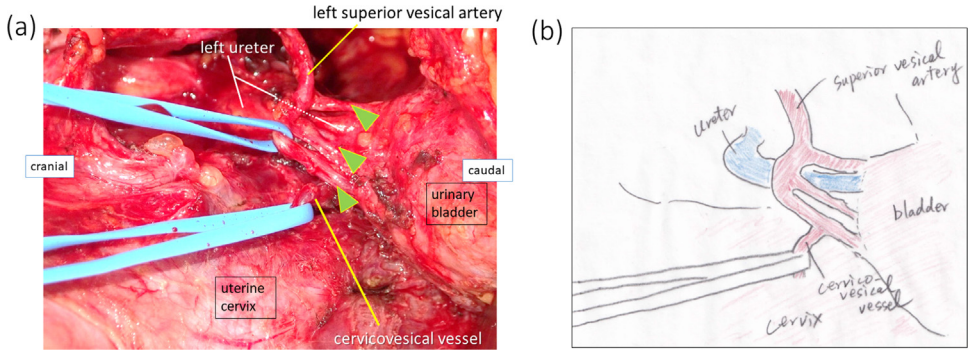

Fig. 5. a and b The central side of the cervicovesical vessel was a superior vesical artery. And, the superior vesical artery had a several branches on urinary bladder (arrow heads).

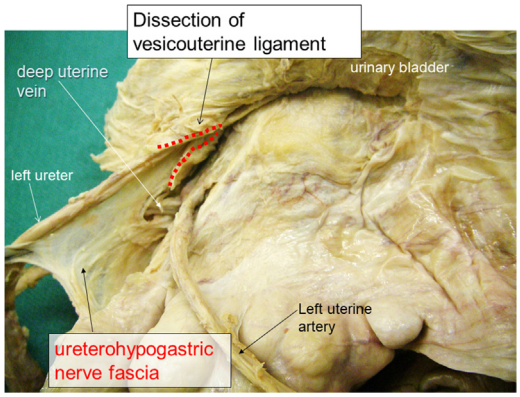

Fig. 7. The connective tissue layer continuing from umbilical artery was very close to the ureterohypogastric nerve fascia.

Comment

Radical hysterectomy is performed for invasive cervical cancer. The separation of the anterior leaf and the posterior leaf of the VUL is important because this procedure enables the gynecologic oncologist to separate the bladder with the ureter from the cervix completely. The procedure for the anterior leaf of the VUL is as follows: after a ureteric tunnel is created using scissors, the VUL is opened by simultaneous clamping and incision. However, there are some technical problems with the separation of the VUL, especially the anterior leaf of the VUL. Problems are bleeding, and injury to the ureter and the nerves around the ureter. There have been some previous studies on safe techniques for the separation of the anterior leaf of the VUL [1,10]. We paid attention to the border in connective tissue between the cervical and vesical fasciae, and tried to separate connective tissue of the urinary bladder and the ureterovesical junction from the cervical fascia meticulously as one of the safe procedures for the anterior leaf of the VUL in radical hysterectomy.

With our procedure, we could discern the yellowish fascia next to the central wall from cervical fascia after separating the urinary bladder from the cervical fascia meticulously. This yellowish part is considered to be near ureterovesical junction and the connective tissue over the ureter. We could roll out the ureter enwrapped by the connective tissue laterally without dissection of the connective tissue. The anatomical findings support our surgical method. During cadaver dissection, the connective tissue covering the ureter and the urinary bladder were separated from the cervical fascia. We think that the yellowish tissue discerned with our method corresponds to the connective tissue around the uretetrovesical junction. This yellowish and somewhat shiny tissue exists on the bladder side. In other words, the yellowish tissue layer corresponds to the so-called anterior leaf of the VUL containing the cervicovesical blood vessels. The gap between the vaginal wall and the yellowish tissue seems to correspond to the ventral side of the so-called vaginal space (Fig. 2). We can understand that this layer is distributed among the umbilical artery, uterine artery and urinary bladder from anatomical findings. Furthermore, this layer structure can be conscious by pulling the umbilical artery also during radical hysterectomy (Fig. 9). This layer is also distinguished in laparoscopic view (Fig. 10).

We considered whether the connective tissue and the blood vessels in the connective tissue are derived from either the cervical fascia or vesical fascia. As a result, it is only necessary for us to dissect some small blood vessels from the cervical fascia. These vessels were considered as “cervicovesical vessels” named by Fujii [1].

In this study, we focused on the connective tissue around the ureterovesical junction. Regarding this area, the anatomy of the ureterovesical junction and distal ureter has been discussed from a long time ago in the field of urology [11,12]. Also, from the gynecologic standpoint, there have been several reports regarding the neuroanatomy around the distal ureter [13,14]. Kraima et al. described that the vesical plexus derived from the inferior hypogastric plexus is closely related to the distal part of the

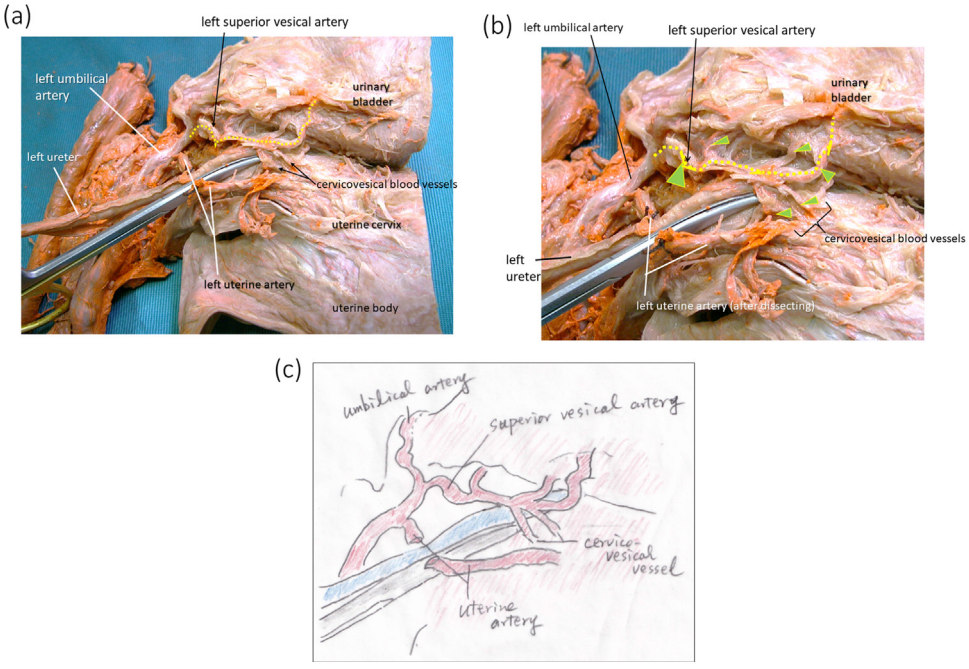

Fig. 8. a–c Superior vesical artery in cadaver dissection. Many of the branches of the superior vesical artery were distributed in the bladder, but one distributed to the uterine cervix. This vessel was thought to be cervico-vesico vessel. Orange dye is the color of lead oxide in blood vessels. There were several branches of superior vesical artery around the ureterovesical junction (distal ureter).

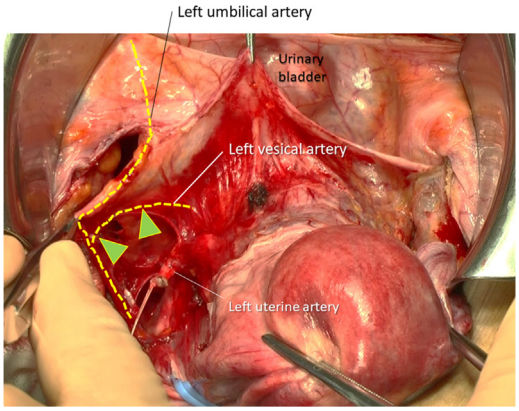

Fig. 9. The connective tissue layer can be conscious by pulling the umbilical artery also during radical hysterectomy.

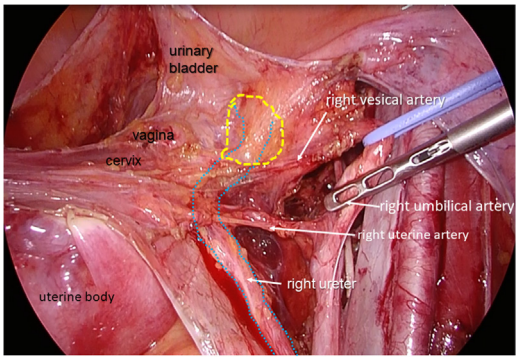

Fig. 10. The connective tissue layer can be also distinguished in laparoscopic radical hysterectomy.

ureter [9]. They also stated that "If gynecologists free up the ureter until its insertion in the bladder, the vesical plexus will be consequently sacrificed." Our cadaveric findings showed that the ureterohypogastric nerve fascia lies on the lateral side of the distal part of the ureter. Consistent with other reports, our results suggest that nerve fibers running from the inferior hypogastric plexus are closely located. With our method, we do not have to free the ureter.

We focused on the connective tissue around the ureterovesical junction. Close attention to the color of the tissue enabled us to perform this procedure by direct visualization, not under magnification. It is quite possible that the conventional procedure for the anterior leaf of the VUL is easier than ours. However, the conventional procedure is thought to be a blind technique, as Fujii et al. pointed out [1]. Blind placement may cause injury to the blood vessels running near the ureter. We think that our procedure is not necessarily superior to the conventional procedure, however, our procedure can be a candidate stable technique based on anatomy. I think that there are opinions that our method finding the distal ureter is dangerous, however there is an advantage that you can grasp the whole ureteral travel as soon as possible, and the surgery will be done smoothly as a result.

Today, a surgical device such as a vessel sealing device enables us to deal with fine vessels meticulously. As a result, surgical layers are maintained based on anatomy although surgical layers are destroyed with the conventional procedure involving the clamping of connective tissue and vessels collectively. Our method might be useful in laparoscopic radical hysterectomy, in which it is difficult to retract the ureter, because this procedure does not require retraction of the ureter. And the surgical method based on systematic anatomy like our result can be thought to be methods consistent with laparoscopic and robotic surgery which is good at observing detailed anatomical structures.

Furthermore, in this study we described the origin of the cervicovesical blood vessels clearly during both surgery and cadaver dissection. Although it is common sense for gynecologists that the uterine artery runs on the ventral side of the ureter, the superior vesical artery also runs over the ureter as well as the uterine artery. It was found that a branch called cervicovesical vessel were distributed in the cervical fascia. Cervicovesical blood vessels can be quickly found by conscious of the superior vesical artery. This knowledge makes it possible to reliable ligation of the blood vessels in the anterior leaf of the VUL.

Although it is difficult to conclude because there are restrictions on the number of individuals, it is considered important for safe gynecological surgery to pay attention not only to the uterine artery but also to the superior vesical artery.

In conclusion, we found the precise anatomy of the connective tissue layer from umbilical artery to urinary bladder and the superior vesical artery. Our procedure based on the precise anatomy obtained in this study is reasonable anatomically as a method for separation of the vesicouterine ligament during radical hysterectomy.

Conflict of interest statement

We declare there is no conflict of interest.

Acknowledgment

We are grateful to those who donated their bodies to science.

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