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ORIGINAL ARTICLE

Standardization of laparoscopic extrafascial hysterectomy: anatomic considerations to protect the ureter

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Abstract

Purpose To describe the procedure of laparoscopic extrafascial hysterectomy to avoid ureter injury.

Methods Data were obtained from: (1) anatomic study of ten fresh female cadavers to measure the distance between the point where the ureter and uterine artery cross and the level of section of the ascending branch of the uterine artery during extrafascial dissection of the uterine pedicle and uterosacral ligament (Paris School of Surgery). The Wilcoxon test was used to compare measurements within each subject. $P < 0.05$ was considered to denote significance; (2) prospectively collected clinical data from women undergoing laparoscopic extrafascial hysterectomy from July 2006 to March 2014 at Poissy University Hospital, to describe the laparoscopic extrafascial hysterectomy technique with analysis of surgical complications using the Clavien–Dindo classification.

Results Anatomic study: The mean (SD) distance between the point where the ureter and uterine artery cross and the level of the section of the ascending branch of the uterine artery were: 11.6 mm (5.2) in neutral position and 25 mm (7.5) after pulling the uterus laterally; and 25mm (8.9) after sectioning the ascending portion of the uterine pedicle and 38.6 mm (4.5) after complete uterine artery pedicle dissection through the uterosacral ligaments. After release of the ureter, the curve in front of the uterine artery disappeared.

Clinical laparoscopic study: Sixty-eight patients underwent laparoscopic extrafascial hysterectomy. No ureteral complications occurred.

Conclusion Laparoscopic extrafascial hysterectomy is a safe and feasible procedure. Combined lateralization and elevation of the uterus, section of the ascending branch of the uterine artery, and its extrafascial dissection along the uterosacral ligament contribute to protecting the ureter during the procedure.

Keywords Anatomy · Extrafascial hysterectomy · Laparoscopy · Ureter

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Introduction

Hysterectomy is a common gynaecologic surgery accounting for more than 600,000 operations a year in the United States. Ureteral injury constitutes a major complication of hysterectomy [5]. This contributes to postoperative morbidity with the possible loss of a kidney and additional surgery as most ureter injuries go undetected during the hysterectomy procedure [1].

Extrafascial hysterectomy is performed for pelvic cancers [3] and benign indications (endometriosis, cervical or broad ligament fibroids, and cervical dysplasia) because of the involvement of pericervical tissue and/or uterosacral ligaments (USL) and to protect the ureter. Contrary to intrafascial hysterectomy, the technique involves excising the uterus and removing the surrounding conjunctive

tissue. Laparoscopic hysterectomy has some advantages over abdominal hysterectomy as it is a shorter procedure, the patient can return to normal activities faster, and there is a lower risk of fever and wound or abdominal infections [1]. However, a recent Cochrane meta-analysis found a higher rate of ureteral injury with laparoscopic compared to abdominal hysterectomy [1]. Moreover, the additional dissection of the cervix and surrounding connective tissue during laparoscopic extrafascial hysterectomy (LEH) may increase the risk of ureteral injury. To date, the LEH procedure has not been described or standardized in the literature, especially with a view to reducing the risk of ureteral injury.

Consequently, there is a lack of educational material to teach gynaecologic residents how to avoid ureter injury during LEH.

The aim of this study was, therefore, (i) to investigate the relationship of the ureter in the operative field during the procedure so as to avoid ureteral injury and (ii) to describe a standardized LEH procedure.

Methods

Study design

The anatomic data were obtained from ten fresh female cadavers dissected at the Paris School of Surgery. We also prospectively collected clinical data from women undergoing LEH from July 2006 to March 2014 at the Poissy University Hospital.

The scientific committee of the Paris School of Surgery ensured that written consent for body donation had been obtained and filed prior to death for all the anatomic subjects.

Our work complied with French regulations which waver Ethics Committee approval for epidemiological surveys. The study was also exempt from French law pertaining to biomedical research (the Huriet–Serusclat Law, 20 December 1998) as no additional interventions were required.

Anatomic study

Twenty hemipelvis specimens from ten fresh female cadavers were dissected. All the subjects were Caucasians. All the cadavers were free of cervical or other diseases which may have altered the location of the ureter.

Terminology

The revised *Terminologia Anatomica* described by Ercoli [8] in 2005 was used to avoid confusion in describing anatomic terms of the pelvic connective tissues. When a term was missing in the *Terminologia Anatomica,* we used unofficial, but frequently cited, terms [8, 9, 19].

Definition of terms used.

The medial pararectal space corresponds to the pararectal space located between the uterosacral ligament and the mesoureter. It communicates with the rectum and mesorectum, and reveals the hypogastric nerve at the bottom. It is opened by separating connective tissue from the posterior broad ligament. The deep uterine vein and the mesoureter constitute the external limit, and the uterosacral ligament constitutes the internal limit. It, thus, corresponds to "the medial–caudal pararectal space". It is also known as the Okabayashi space [8, 9, 19].

The lateral pararectal space corresponds to the pararectal space located between the mesoureter and the internal iliac vessel sheath from the main body. It, thus, corresponds to "the lateral–cranial pararectal space" [8, 9, 19].

Mesoureter corresponds to the connective tissue bundle that emerges from between the medial pararectal and the lateral pararectal spaces. Two visceral pelvic fasciae are fused within the mesoureter, between which the ureter, hypogastric nerve, and ureteral branch of the internal iliac artery are found [8, 19].

Deep uterine vein is the most cranial vein of the venous root and drains the paravisceral venous plexus into the internal iliac vein within the paracervix. It originates from the uterus fond and remains under the uterine artery and joins the internal iliac vein laterally and posteriorly [8, 9, 19].

Parametrium is the connective mesenteries formed mainly by areolar tissue enveloping the visceral branches of the hypogastric vessels during their course toward the uterine cervix [8, 19].

Paracervix is the connective mesenteries formed mainly by areolar tissue enveloping the visceral branches of the hypogastric vessels during their course toward the vagina [8, 19].

Retro-ligamentous part of the ureter is the portion of the pelvic ureter before its entry into the parametrium.

Pre-ligamentous part of the ureter is the portion of the pelvic ureter after its passage through parametrium and before its entry into the bladder.

Intra-ligamentous part of the ureter is the portion of the pelvic ureter during its passage through parametrium.

Superficial layer of vesicouterine ligament corresponds to a constant bilateral ventral expansion of the parametrium organized around the cervicovesical branches of the uterine artery. In the literature, the term "bladder pillar" is sometimes employed.

Deep layer of vesicouterine ligament corresponds to the connective mesenteries surrounding inferior vesical vessels in the paracervix. It is a neurovascular bundle that connects the bladder, uterus, and lateral ligament of the pelvis.

Procedure

In the dissection protocol, an arciform incision was made connecting the lower margin of the twelfth right rib, right anterior superior iliac spine, pubic symphysis, left anterior superior iliac spine, and lower margin of the twelfth left rib.

The preliminary steps of the anatomic study were to identify the pelvic ureter at three definite landmarks corresponding to classic ureteral injury locations: the retro-ligamentous, the pre-ligamentous, and the intra-ligamentous parts of the ureter [12]. At each step, the ureter was left in place and not further dissected to keep its exact initial position.

(i) Identification of the retro-ligamentous part of the ureter (Figs. 1, 2).

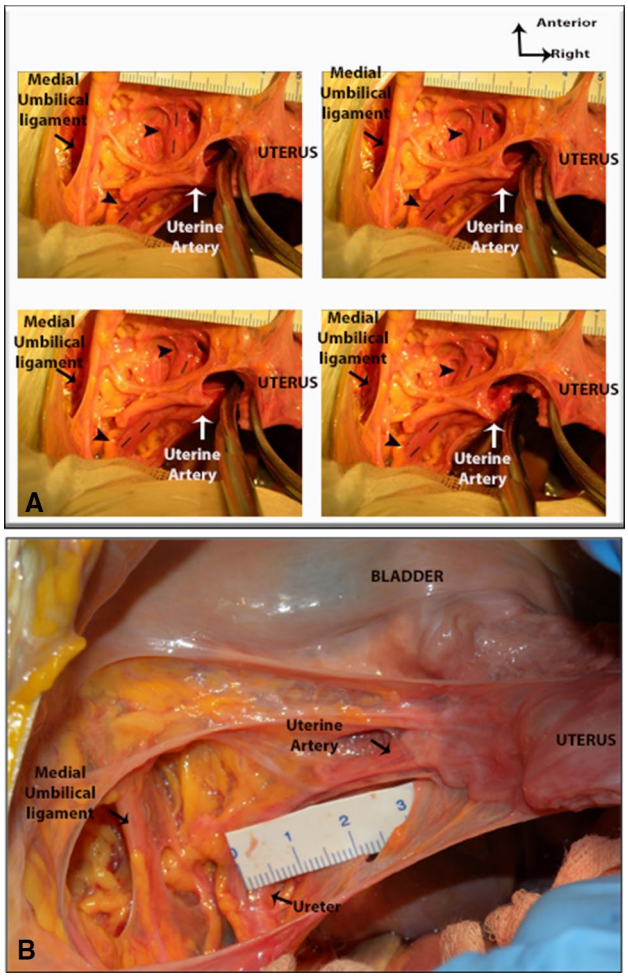

Fig. 1 Anatomic view of the bony pelvis of a fresh female cadaver. **a** First captions show the disappearance of the knee of the ureter. **b** How to measure the distance between the knee of the ureter and the section of the ascending uterine artery before section of the uterosacral ligament and uterine artery

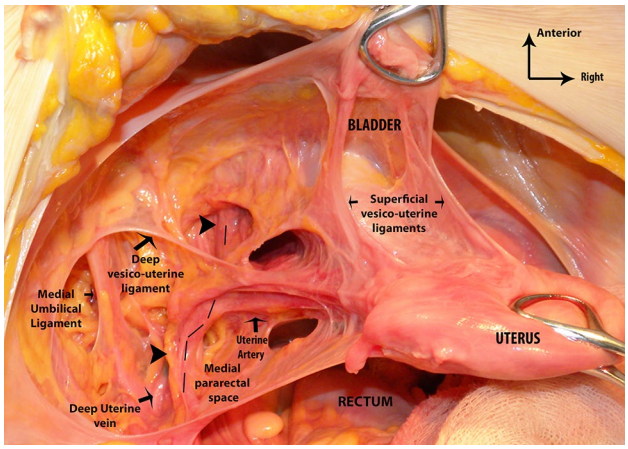

Fig. 2 Anatomic view of the bony pelvis of a fresh female cadaver. The position of the ureter can be seen before section of the uterosacral ligament and uterine artery with its curve or the knee of the ureter. The medial pararectal and paravesical spaces are opened

The medial pararectal space was opened backwards and laterally to the USL and medially to the deep uterine vein to identify the retro-ligamentous part of the ureter (Fig. 1).

(ii) Identification of the pre-ligamentous part of the ureter.

The anterior side of the uterine pedicle was dissected forwards, outside the superficial vesicouterine ligament to identify the pre-ligamentous part of the ureter before its entry into the bladder (Fig. 2).

(iii) Identification of the intra-ligamentous part of the ureter (where the ureter crosses the uterine artery).

The intra-ligamentous part of the ureter course was easily visualized after the previous dissection of the retro-ligamentous and pre-ligamentous parts. This point was identified and used for the measurements.

At this moment, we were, thus, able to see the exact path of the entire pelvic ureter.

We then performed an extrafascial hysterectomy following exactly the same operative steps as described above. During the dissection of the uterine pedicle, the uterus was pulled upwards and ventrally to protect the ureter as in the LEH procedure (Fig. 2).

The uterine artery was sectioned at the level of the ascending portion beside the uterine isthmus.

We measured the shortest distance in centimeters using a graduated ruler between the intra-ligamentous part of the ureter at the point it crossed the uterine artery and the level of the section of the ascending branch of the uterine artery beside the uterine isthmus (Fig. 1):

- before section of the ascending branch of the uterine artery: (i) uterus in neutral position; (ii) after pulling the uterus upwards and laterally,
- after section of the ascending branch of the uterine pedicle: (iii) before complete extrafascial dissection of the uterine pedicle through the USL; (iv) after complete extrafascial dissection of the uterine pedicle through the USL.

We also made a note of any dynamic qualitative change in the ureter path after pulling the uterus upwards and laterally and after section of the uterine artery.

All measurements were taken twice and the mean of these two measurements used for analyses. The Wilcoxon test was used to compare the measurements within each subject.

$P < 0.05$ was considered to denote significance.

Clinical laparoscopic pelvic study

Consecutive women over 18 years old consulting at the University Department of Obstetrics and Gynaecology (Poissy/Saint-Germain Hospital) between July 2006 and March 2014 and who underwent LEH were included. Indications for LEH constituted: pelvic cancer; benign pathologies with involvement of pericervical tissue and/or USL (endometriosis or dense adhesion with obliteration of the cul-de-sac); cervical or broad ligament fibroids requiring protection of the ureter.

All the surgical procedures were performed by one gynaecologic surgeon experienced in minimally invasive surgery (AF). The procedures were conducted as follows:

(i) Cannulation of the uterus.

First, the uterus was cannulated by the Clermont-Ferrand uterine manipulator (Storz 26168 D).

(ii) Bilateral opening of the medial pararectal space (Fig. 3).

The medial pararectal space was dissected by pushing the uterus upwards and forwards while opening the peritoneum laterally to the USL. This allowed identification of the deep uterine vein which was pulled aside to protect the retro-ligamentous part of the ureter (Fig. 3) [13]. However, the plexus was not systematically identified unless the LEH was performed for extensive endometriosis in which case it was pushed aside in the interest of nerve-sparing surgery.

(iii) Opening of the rectovaginal space.

The superficial portion of USL was then cut and the rectovaginal space opened. The length of the USL section was tailored according to the pathology.

(iv) Identification of superficial and deep vesicouterine ligament (Fig. 4).

The superficial vesicouterine ligament is easily identified after opening the vesicouterine and vesicovaginal space by a smooth dissection of the loose connective tissue covering the ventral side of the ascending portion of the uterine pedicle with the uterus pushed upwards and laterally to the contralateral side. This opens a triangular space limited medially by the superficial vesicouterine ligament, dorsally by the ascending portion of the uterine pedicle, and laterally–caudally by the deep lateral aspect of the vesicouterine

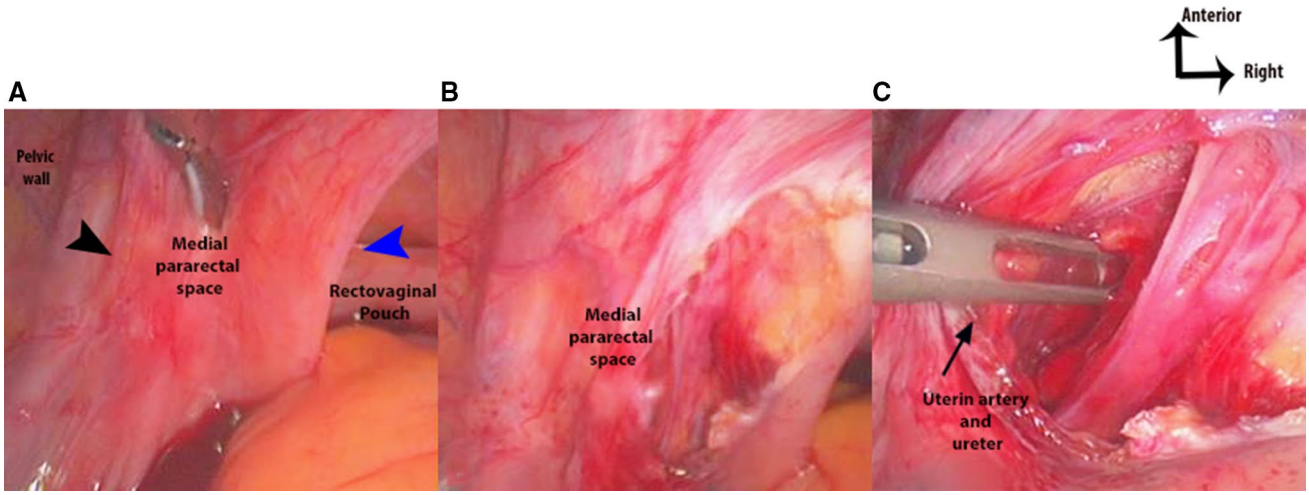

Fig. 3 Laparoscopic opening of the medial pararectal space: **a** The medial pararectal space is limited by the mesoureter laterally (black arrow) and the uterosacral ligament (blue arrow) medially. **b** Incision of the peritoneal tissue to open the medial pararectal space. **c** After opening the medial pararectal space

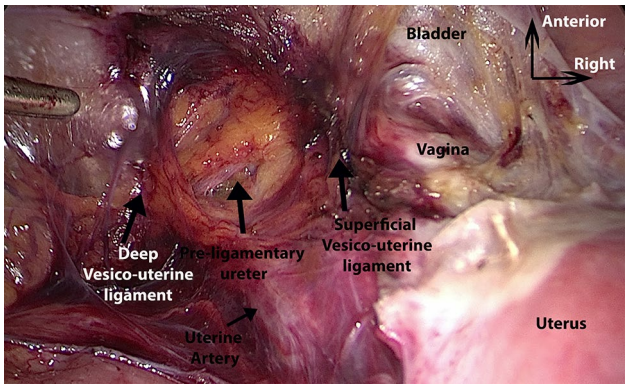

Fig. 4 Laparoscopic view of the vesicouterine ligament. A triangular space where the pre-ligamentous part of the ureter may be found is defined medially by the superficial vesico-uterine ligament, dorsally by the ascending portion of the uterine pedicle and laterally–caudally by the deep lateral aspect of the vesicouterine ligament

ligament (Fig. 4). In this space, the pre-ligamentous part of the ureter may be found. It has already crossed the uterine artery forming a curve in a medial direction to join the bladder with a caudal and external convexity, known as "the knee of the ureter". Nonetheless, at this point, the ureter was not systematically identified.

(v) Section of the uterine and cervicovaginal arteries.

The uterine and cervicovaginal arteries were sectioned and the surrounding tissue dissected along the lateral border of the USL (Fig. 5). The uterine artery was sectioned at the level of the ascending portion beside the uterine isthmus. To avoid thermal ureteral injury, the uterus was firmly pushed upwards and laterally to the contralateral side. Then, the uterine artery was dissected along the USL using coagulating and cutting dissection. Finally, the superficial part of vesicouterine ligament was sectioned.

(vi) Anterior and posterior colpotomy.

Colpotomy was the last step of the LEH at the level of the USL section. The deep portion of the USL (including the distal portion of the uterine vein) was sectioned up to the posterior vaginal wall. At the same time, the ureter was protected by pushing away the uterine artery, deep uterine vein, and surrounding tissue laterally. In the case of complete cul-de-sac obliteration or rectal involvement (i.e., by endometriosis), a posterior colpotomy was performed inside the vagina. This allows safe reverse dissection of the mesorectum and is an additional step to treat rectal involvement.

Postoperative complications were classified according to the Clavien–Dindo classification system as minor (grades I–II) or major (grades IIIA and IIIB-IV) [6]. We considered ureteral complications to be all ureter injuries diagnosed during the procedure or in the postoperative period including urine leakage or fistula with or without urinoma and ureteral stenosis.

All the women had at least 3 months of postsurgical follow-up.

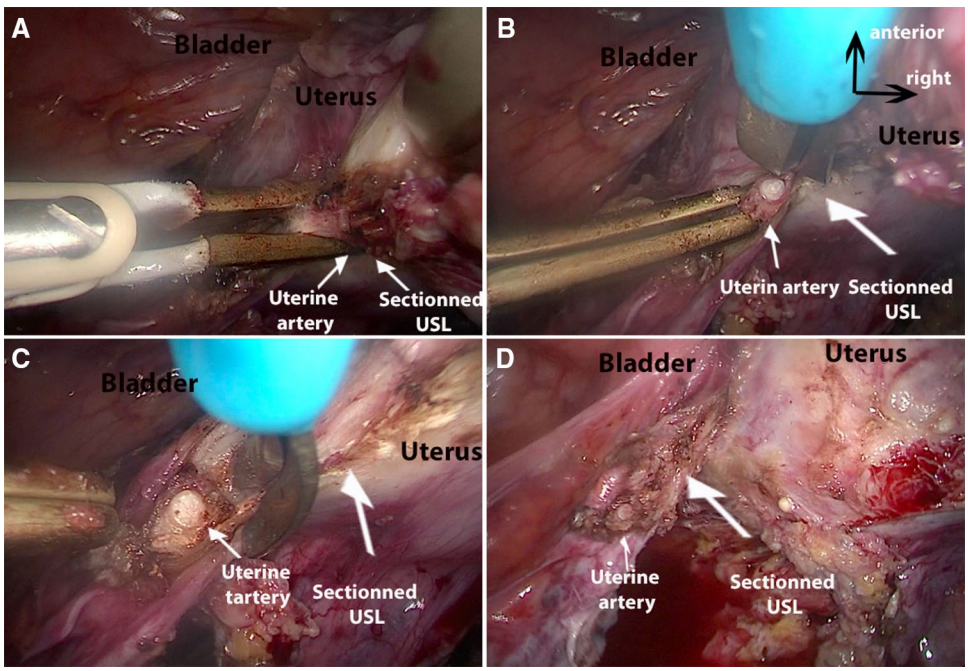

Fig. 5 Laparoscopic view of ascending uterine artery branch during section and dissection along the uterosacral ligament. **a** Horizontal plane of section of the ascending branch of uterine artery. **b** Section of the ascending branch of uterine artery. **c** Dissection of the uterine artery along the uterosacral ligament. **d** After section and dissection of the uterine artery along the uterosacral ligament. *USL* Utero-Sacral Ligament

Results

Anatomic study

Before sectioning the ascending portion of the uterine artery

The mean (SD) distance between the intra-ligamentous parts of the ureter from the crossing of the uterine artery up to the level of the future section of the ascending branch of the uterine artery were 11.6 mm (5.2) in neutral position and 25 mm (7.5) after pulling the uterus laterally ($P = 0.004$).

At the point where the ureter crosses the uterine artery, the ureter turns medially to join the bladder describing a curve with a lateral and caudal convexity. This curve is known as the "knee of the ureter" (Fig. 2).

After sectioning the ascending portion of the uterine artery

The mean (SD) distance between the intra-ligamentous parts of the ureter from the crossing of the uterine artery up to the level of the section of the ascending branch of the uterine artery were 25 mm (8.9) before and 38.6 mm (4.5) after complete dissection of the uterine artery pedicle through the USL ($P = 0.004$) (Fig. 1).

The ureter was then released and pulled laterally and its curve describing the knee of the ureter in front of the uterine cross reversed towards the pelvic sidewall (Fig. 6). The curve was then completely straightened out, away from the cervix and vagina (Fig. 6).

Figure 6 shows the key anatomic points of the LEH technique.

Clinical laparoscopic study: standardization of the procedure

Epidemiologic characteristics of the population

Between 2006 and 2014, a total of 68 patients underwent LEH. The median follow-up was 42 months (3–115).

No Clavien–Dindo grade IV or V complications occurred (Table 1). No ureteral injuries were observed.

Discussion

The present study provides a precise description of the LEH procedure and highlights crucial steps to protect the ureter. Our study highlights that combined lateralization and elevation of the uterus, sectioning the ascending branch of the uterine artery and dissecting it along the USL help to protect the ureter. The LEH technique which we describe here is safe and feasible.

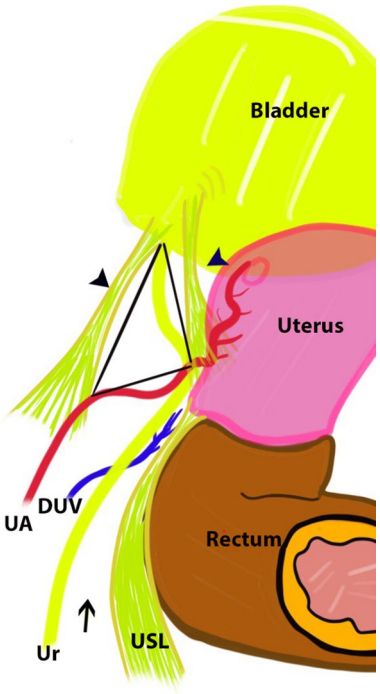

Fig. 6 Diagram of pelvic anatomy. This shows a triangular space limited medially by the superficial vesicouterine ligament (blue arrowhead), dorsally by the ascending portion of the uterine pedicle, and laterally–caudally by the deep lateral aspect of the vesicouterine ligament (black arrowhead). The pre-ligamentous part of the ureter is found. It has already crossed the uterine artery forming a curve in a medial direction to join the bladder with a caudal and external convexity (the knee of the ureter). It also shows (arrow) the medial pararectal space with the deep uterine vein within *USL* uterosacral ligaments, *DUV* deep uterine vein, *Ur* ureter, *UA* uterine artery

Extrafascial hysterectomy is a common surgical technique employed in many indications in gynaecology and the laparoscopic approach has been shown to have many benefits compared to the abdominal approach. Nevertheless, the only descriptions of the laparotomy approach are found in classical textbooks [11, 18]. The anatomic study which we present provides relevant anatomic observations derived from fresh female cadavers.

From an anatomic point of view, contrary to classic radical hysterectomy [17] with complete dissection of pelvic ureter, the challenge for physicians performing LEH is to protect the ureter without visualization or palpation. Ureterolysis of the intra-ligamentous part of the ureter is not performed systematically. Moreover, adapting the extrafascial technique to laparoscopy exposes the ureter to the risk of thermal damage due to the use of bipolar diathermy as heat can damage collateral tissue including the ureter [16]. An in vivo thermometry study of women undergoing

Table 1 Epidemiologic characteristics of the population

Characteristics ($n=68$)	Patients
Peri-operative characteristics of patients	
Median age (years) (range)	46 (36–84)
Median body mass index (kg/m^2) (range)	24.7 (19–27)
Median parity (*n*) (range)	2 (0–5)
Previous gynaecologic surgery (*n*) (%)	24 (35%)
Cesarean section	8 (11.7%)
Myomectomy	6 (8.8%)
Endometriosis surgery	4 (5.8%)
Gynaecologic symptoms	
Vaginal bleeding	47 (69%)
Non-menstrual pain	40 (59%)
Dyspareunia	14 (20.5%)
Indications	
Endometriosis	37 (54.5%)
Myomas	20 (29.4%)
Adenomyosis	18 (26.5%)
Uterine cancer	8 (11.7%)
Cervical cancer	6 (8.8%)
Surgical data	
Median duration of surgery (min) (range)	204 (90–420)
Conversion to open from laparoscopy, *n* (%)	1 (1.5%)
Associated acts	
Adhesiolysis	15 (22%)
Bilateral salpingo-oophorectomy	32 (36.8%)
Uni- or bilateral ureterolysis	16 (23.5%)
Uterosacral ligament removal	51 (83.8%)
Colpectomy	4 (5%)
Parametrectomy	8 (11.7%)
Pelvic lymphadenectomy	15 (22%)
Ureter discrossing	5 (7.4%)
Rectal shaving	2 (2.9%)
Removal of the rectovaginal pouch	1 (1.5%)
Rectal resection	1 (1.1%)
Median uterus weight (g) (range)	144 (53–685)
Median blood loss (ml) (range)	126 (0–500)
Per-operative complications *n* (%)	0 (0%)
Post-operative data	
Median duration of bladder catheterization	1 (1–7)
Post-operative Clavien–Dindo complications *n* (%)	24 (35%)
Grade 1 *n* (%)	9 (13.2%)
Grade 2 *n* (%)	11 (16%)
Grade 3 *n* (%)	4 (5.9%)
Grade 4 *n* (%)	0 (0%)
Grade 5 *n* (%)	0 (0%)

hysterectomy with bipolar forceps demonstrated that the risk of thermal injury may be avoided by keeping the ureter at 2 cm or more from the instrument [7]. In the present study, we observed that the distance between the nearest part of the ureter lies at more than 2 cm from the coagulating point of the uterine pedicle and that it moved away during the extrafascial dissection of the uterine pedicle.

From a clinical point of view, LEH seems to be safe and reproducible, and is routinely performed for oncologic indications as well as for benign pathologies such as myomas and endometriosis. A description of extrafascial hysterectomy via laparoscopy is, thus, crucial for educational purposes. In the 68 patients who underwent LEH in our center during the study period, no intraoperative complications were observed, and no patients experienced Clavien–Dindo grade IV or V complications. Importantly, no patient experienced urinary tract injury or, more specifically, ureteral injury. Other studies have reported ureteral injury rates from 0.2% to 8.3% for laparoscopic hysterectomy [14, 15]. In a systematic review, Adelman estimated a rate of ureteral injury of 0.4% during total laparoscopic hysterectomy. However, the review only included studies focusing on intrafascial hysterectomy and excluded those with hysterectomy for endometriosis or myomas indications [2]. The recent Cochrane study noted that ureteral injury is more frequent with the laparoscopic than the abdominal approach (OR 3.46, 95%IC {0.94–12.71}) [1]. Ureteral lesions are responsible for high morbidity, resulting in additional surgery, loss of a kidney, ureterovaginal fistula, or stent placement [2]. Furthermore, only 40% of ureteral injuries were detected intraoperatively. Unrecognized ureteral injury leads to higher morbimortality [4].

We found two crucial steps during LEH that progressively increase the distance between the ureter and the uterine artery. The first step is the combined lateralization and elevation of the uterus. This maneuver increases the distance between the intra-ligamentous part of the ureter and the level of section of the ascending branch of uterine artery. During LEH, the mobility of the uterus is conditioned by the use of manipulators and by sectioning the USL. The second step is the section of the ascending branch of the uterine artery and its dissection along the USL. This step involves first identifying the ascending branch of the uterine artery through the superficial vesicouterine ligament. At the point where the ureter crosses uterine artery, there can, sometimes, be a ureteral branch of the uterine artery [10]. This element may explain the lateral "*en bloc* movement" of the ureter and uterine artery when sectioning the ascending branch of the uterine artery and freeing its ascending portion from the cervix. In the present study, we observed the disappearance of the curve of the ureter after section of uterine artery and its dissection along the USL.

Lateralization and elevation of the uterus are routinely performed in both open and minimally invasive surgery. This study provides anatomical evidence of the importance of this maneuver to prevent ureter injury. Along with

photos, video, and diagrams, our study could be used as educational material for residents in gynaecologic surgery.

Some limitations of the present study deserve to be underlined. First, the indications for the extrafascial hysterectomies were heterogeneous. A common indication was endometriosis where mobilization of the uterus to protect the ureter may be challenging. Furthermore, the surgical risk for the ureter in patients with endometriosis is different than in patients with myomas. On the other hand, the various indications emphasize the validity of the LEH procedure. Second, all the procedures were performed by one surgeon in one center. The LEH technique which we describe should, therefore, undergo external validation with other surgeons as we know that complications during laparoscopic hysterectomy are surgeon-related [13]. However, the relevance of ureter safety during the standardized LEH procedure is supported by the anatomic study. Third, the true rate of ureteral injury may be underestimated due to the small patient sample, though here again findings from the anatomic study were consistent with the clinical results. Moreover, the patients did not undergo a specific examination to detect ureteral injury. However, post-operative urinary tract injuries would have been identified as they are painful and the mean follow-up in our study was 42 months. Fourth, in the anatomic study, we did not explore the possibility of lesion induced by bipolar forceps (thermal damage). However, the measurements show a distance of more than 2 cm between the ureter and uterine artery and, according to the literature, the use of thermometry at this distance protects the ureter [16]. Finally, while the anatomic study was performed with open dissection, the objective anatomic data were coherent with the clinical study data.

Conclusion

Here, we describe the surgical steps of a standardized LEH procedure with a particular focus on protecting the ureter. Our findings suggest that the procedure is valid and safe. Pending external validation, we recommend that surgeons conducting LEH be made aware of this technique to avoid ureteral injury.

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Author contributions The last author, AF, designed the study. The first author, KNT, collected the data and analyzed all the data and participated in drafting the article. CP collected and analyzed all the data. VL, CT, and AF participated in drafting and approving the article.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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