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## **Anatomical variations of the pelvis during abdominal hysterectomy for benign conditions**

A. Matsas et al., Anatomical variations of the pelvis during abdominal hysterectomy

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### **Abstract**

**Background:** Anatomical variations are defined as atypical morphologic and positional presentations of anatomical entities. Pelvic anatomical variations encountered during abdominal hysterectomy can be of clinical interest, given that misidentification of certain structures can lead to iatrogenic injuries and postoperative sequelae. The aim of the present study was to detect and highlight the anatomical structures of interest and their variations to the surgeon performing abdominal hysterectomy for benign conditions.

**Materials and methods:** A narrative review of the literature was performed including reports of anatomical variations encountered in cadavers, by surgeons during abdominal hysterectomy and radiologists on computed tomography angiography, searching within a 10-year span on Pubmed

database. Studies regarding the treatment of malignant conditions requiring lymphadenectomy and different modes of surgical approach were reviewed with regards to the aspects relevant to benign conditions. The search was extended to the reference lists of all retrieved articles.

**Results:** Ureters and the uterine arteries, due to anatomical variations, are the anatomical structures most vulnerable during abdominal hysterectomy. Specifically, the ureters can present duplications, retroiliac positionings and ureteric diverticula, whereas, the uterine arteries can present notable variability in their origins. Such variations can be detected preoperatively or intraoperatively.

**Conclusions:** Although rare, the presence of anatomical variations of the uterine arteries and ureters can increase the possibility of complications should they escape detection. Intraoperative misidentification could lead to improper dissection or ligation of the affected structures. Knowledge of these variations, coupled with extensive preoperative investigation and intraoperative vigilance can minimize the risk of complications.

**Key words: anatomical variations, abdominal hysterectomy, benign gynecological conditions, ureters, uterine arteries**

## **INTRODUCTION**

Hysterectomy is considered to be the most frequent major gynecological operation, with the open abdominal approach performed in over 50% of the reported cases, despite more recent advances in minimally invasive procedures [57]. Abdominal hysterectomy is performed for the surgical treatment of both benign and malignant gynecological conditions. Amongst the common indications for abdominal hysterectomy are the benign conditions of large ovarian cysts and uterine fibroids, uterine bleeding, extensive adhesive conditions, myoma uteri, endometriosis, adenomyosis, benign adnexal masses, simple endometrial hyperplasia without atypia and pelvic pain, as well as the malignant conditions of endometrial, cervical and ovarian cancer [36, 48]. A differentiating feature of hysterectomy carried out for the treatment of a benign condition versus a malignant one is the extent to which the procedure is carried out: when treating a malignant

condition, radical hysterectomy is usually performed, during which, apart from the uterus, the upper vagina, cervix, fallopian tubes, ovaries, parametrium tissue and pelvic lymph nodes are also removed in most cases [58]. As all surgical procedures, abdominal hysterectomy carries a risk of complications which can occur both intraoperatively and postoperatively. Complications include infections, injuries to anatomical structures and other pathological entities, such as thromboembolisms [44]. Infectious complications are the most common ones, accounting for 10% of all complications in abdominal hysterectomy followed by thromboembolisms which, depending on the sensitivity of the method of diagnosis, range from 1% to 12% [12, 26, 32, 33]. Anatomical complications, especially the most common ones of bladder and ureteric injuries, occur in about 1% to 8% of the cases, with the ureter remaining undetectable at the time of the surgery at a rate of 66% [13, 18, 51, 53]. It is to be expected that the more extensive the operation, the higher the risk of complications arising: for example, abdominal radical hysterectomy which includes pelvic lymphadenectomy, involves anatomical structures of the lymphatic system which can present complications, such as lymphocysts and lymphoceles [7, 10]. The above holds true even for anatomical entities which are of concern in the treatment of both benign and malignant pathologies, as ureteric injuries appear in 5% to 8% of the cases undergoing surgery for malignancies versus a 1% to 3% appearance in surgery for benign conditions [53]. Given the above, when employing abdominal hysterectomy specifically for benign conditions, the possibility of complications is generally expected to be lower.

Complications attributable to sustained injury to anatomical structures can be rendered more frequent in the presence of anatomical variations. In the case of abdominal hysterectomy the variations of interest pertain to the pelvic region including variations of the ureters, blood vessels, lymph vessels and lymph nodes [28]. Due to the less extensive nature of hysterectomy carried out for benign conditions, the surgeon's interest for relevant pelvic anatomical variations is restricted to those which concern the ureters, specifically their most caudal segment, as well as those which concern the uterine arteries. Anatomical variations can be described as non-pathological variations of human anatomy, where the morphology of an anatomical structure differs from the common descriptions in the literature [59]. Variations may include differences in the positioning and branching of blood vessels, alternative innervation of organs, differences in the orientation and attachment of ligaments, as well as morphological deviations of muscles and bones [2]. While such variations usually do not have a negative impact on the function of the

organs, they can be clinically relevant, especially in surgery, where failure to acknowledge them could lead to injury to the unexpected surrounding structures and subsequent complications[8].

This narrative review focused on those pelvic anatomical variations that are of clinical significance when performing an abdominal hysterectomy for benign conditions only. A Pubmed search was performed within a 10 year span literature for reports of anatomical variations encountered in cadavers, by surgeons during abdominal hysterectomy and by radiologists on computed tomography angiography. Reports of malignant conditions requiring lymphadenectomy and different modes of surgical approach were reviewed with regards to the aspects relevant to benign conditions, given that such reports implicate additional anatomical structures and their respective variations. The keywords utilized for the search included “anatomical variations”, “abdominal hysterectomy”, “benign gynecological conditions”, “ureters”, “uterine arteries” and relevant combinations. The search was also extended to include relevant material in the reference lists of all the articles retrieved.

Solid knowledge of anatomical variants of the ureters as well as the uterine vessels can reduce intraoperative complications associated with injury, should they be identified during the operation. Furthermore, the suspicion of presence of variations in other organs of common embryonic origin can prompt towards performing an extensive and targeted pre-operative investigation[28].

## **ANATOMICAL VARIATIONS OF THE URETER AND THEIR CLINICAL SIGNIFICANCE**

Ureteric injuries of iatrogenic nature are a complication that might evade the surgeon’s attention during the operation and give postoperative symptoms [45]. Ureteric injuries mostly occur in two distinct anatomical locations. The first is on the plane defined by the presence of the infundibulopelvic ligament. The second lies deeper in the pelvic area at the point where the ureter traverses sideways to the uterosacral ligament’s peritoneum [28]. Early detection and subsequent treatment is considered of utmost importance if such intraoperative injuries are suspected, hence, knowing the symptoms is advised for any surgeon performing abdominal hysterectomies [39, 45]. Amongst the most common symptoms are pain, fever, abnormalities in

urination, such as anuria or oliguria and urinary leakage [16, 25, 39, 56]. Presentation of some of those symptoms, especially pain, can be confounded with expected post-operative discomfort or side-effects, which calls for increased vigilance on the surgeon's part during patient's postoperative assessment [45].

While in half of the cases of ureteric damage no risk factor can be acknowledged, the remaining cases can be attributed to factors contributing to anatomical alterations of the ureter that are conducive to injury. Such conditions include large ovarian masses, previous pelvic surgery that might have deformed the area, endometriosis and the presence of ureteric variations [53].

Three main categories of ureteric variations are of interest to the surgeon performing an abdominal hysterectomy. Those are ureteric diverticula, retroiliac presence of the ureter and multiplications of the ureter.

Ureteric diverticulum is characterized as a rare variation, reported so far in only 50 cases in the international literature [35]. It is defined as a sac-like enlargement of the ureteric wall of unknown etiopathology [35]. Its presence might remain undetected since it can often be asymptomatic, although it has been reported to correlate with urinary tract infections, transient hematuria and pyuria [34]. While it can be an incidental finding during various medical imaging procedures, it can also be diagnosed utilizing excretory urography [1, 15, 35, 55]. Ureteric diverticula are classified into three distinct categories according to their ontogenesis, which are true congenital diverticulum, abortive diverticulum and acquired diverticulum [22, 42]. Despite being a rare variation, surgical caution is advised since the presence of the diverticulum may be misidentified as vasculature or as a cyst-like formation and as such be ligated or incised by the surgeon [28].

Retroiliac ureters are another rare congenital variation that, as the term suggests, pertains to the trajectory of the ureters when they are located in a posterior position relative to the iliac arteries [14]. This variation has been reported to be both unilateral and bilateral [50]. Retroiliac ureter symptomatology encompasses pain in the flank area of the body as well as symptoms arising from ureteric obstruction. The diagnosis usually takes place intraoperatively. It should be noted that suspicion concerning the presence of this type of ureteric variation can be raised in the case of diagnosis of other anomalies of the urogenital system. Coexistence of hypoplastic or malrotated kidneys, urometrocolpos, vaginal atresia, urosacral agenesis along with this variation

has been reported in the literature [19, 23, 27, 37, 46]. Given the ectopic nature of the retroiliac ureter, care should be taken not to be misidentified as a vascular structure during abdominal hysterectomy.

Finally, ureters may be duplicated or otherwise multiplied along their longitudinal axis, giving rise to two or more parallel anatomical entities. Duplicated ureters are by far the most commonly detected multiplication thought to occur in about 1% of the general population [4, 49]. Their high incidence combined with the fact that they are more common in females, renders the knowledge of their existence significant to the gynecological surgeon since failure to acknowledge them can lead to their erroneous incision or ligation [6]. Ureteric duplication may be either complete, where the resulting ureters enter the urinary bladder in two distinct openings, or incomplete (bifid) where the ureters fuse before their common orifice in the bladder [21]. Bifid duplications tend to be detected unilaterally and they display a preference towards the right side [17]. On the other hand, complete duplications display a tendency towards bilaterality [41]. Two kinds of ureteric injury can arise during hysterectomy. One of them pertains to direct injury sustained to the ureter itself, the ureter being mistaken for an artery. The other involves the interruption of the blood supply of the ureters by injury to the associated vessels, since duplicated ureters tend to be encapsulated in a common sheath [17]. Distinction of vasculature and ureters during surgery can take place by observing the structure in question: should ambiguity arise, the surgeon can differentiate between ureters and other structures by the tell-tale peristaltic movement of the former, given that the ureters vermiculate [28].

## **ANATOMICAL VARIATIONS OF THE UTERINE ARTERY AND THEIR CLINICAL SIGNIFICANCE**

The main blood supply of the uterus derives from the uterine arteries. Therefore, the knowledge and identification of the location, origin and course of the uterine arteries are very important during abdominal hysterectomy for benign pathologies, given that high vascular ligation of these arteries is an integral part of the aforementioned operation. Nowadays, arterial embolization, either as preoperative adjuvant treatment or as an alternative to surgery altogether, has also been increasingly used making the adequate knowledge of the uterine artery anatomy even more important.

The uterine artery is considered by tradition to arise from the anterior division of the internal iliac artery. It then continues medially along the inferior aspect of the broad ligament of the uterus and descends and bifurcates into ascending and descending branches at the level of the isthmus. The ascending branches follow a course along the uterus and anastomose with the ovarian artery, whereas the descending branches anastomose with the vaginal and inferior rectal arteries [5, 40]. The uterine artery follows a course anteriorly to the ureter in the pelvis crossing it laterally at the level of the uterine cervix below the isthmus [24].

However, several studies mainly in the last 10 years have demonstrated a significant spectrum of anatomical variations with regards to the origin of the uterine artery which differs from our traditional knowledge. In 2019, Lakshmi *et al.* published a study of a total of 31 Indian female cadavers that showed that the uterine artery originated from the anterior division of the internal iliac artery in all the cadavers without any variations whatsoever [11]. In 2020, Orhan *et al.* published a study where, after 756 retroperitoneal dissections in 378 female patients during laparoscopic hysterectomy for benign conditions, the uterine artery was the first branch of the anterior internal iliac artery in 80.9% of the cases, The uterine artery was also the second branch of the anterior trunk of the iliac artery in 4.9% of the cases, the first or second branch of the anterior trunk in 3.7% of the cases but in a trifurcation model with the posterior trunk and the other visceral branches, and lastly the first branch of the internal iliac artery but as a single trunk in 3.1% of the cases. However, in 7.4% of the cases the origin of the uterine artery could not be determined [38].

Nonetheless, several other studies, including Liapis *et al.*, have reported that the uterine artery can also originate from the umbilical artery or from the internal iliac artery as a common trunk along with the umbilical artery, the superior gluteal artery, the inferior gluteal artery, the superior vesical artery, the inferior vesical artery, the middle rectal artery, the internal pudental artery and the obturator artery [30]. In 2014, Chantalat *et al.* published a study of 218 uterine artery origins in 114 Caucasian females (60 cadaveric, 100 intraoperative and 58 post CT angiography) that showed that in 80.7% of the cases the uterine artery originated from a common trunk with the umbilical artery, separately from the internal iliac artery in 13.16% of the cases, directly from the superior gluteal artery in 3.51% of the cases, from a common trunk with the internal pudental artery in 1.75% of the cases and separately from the obturator artery in 0.88% of the cases [9]. In



2018, Arfi *et al.* published a radiological study where 86 origins of the uterine artery were visualised and in 62.4% of the cases the uterine artery was branch of a common trunk with the umbilical artery, in 9.3% of the cases it originated from the superior gluteal artery, in 2.3% it originated from the internal pudendal artery and only in 25.6% of the cases did the uterine artery originate from the internal iliac artery [3]. All the above findings are of great significance given that the risk of intraoperative iatrogenic injury to the uterine artery is increased when the artery arises from the umbilical artery due to the fact that the uterine artery crosses the operative field in this case [28].

Equally interestingly, in 2019, Yun Xiu Hao *et al.* published a radiological study of 224 origins of the uterine artery which showed that in 64.3% of the cases the uterine artery originated from the inferior gluteal artery, in 22.8% of the cases from the internal iliac artery and in 12.9% of the cases as a trifurcation along with the inferior gluteal and the superior gluteal artery. In the same study, only in 60.7% of the cases the origin of the uterine artery was consistent between the right and left side [20]. Finally, the uterine artery has rarely been found to originate from the inferior vesical artery, the middle rectal, or the inferior epigastric artery, whereas, even the complete absence of it has been reported as well [29, 31, 47, 52, 54].

## **CONCLUSIONS AND COMMENTARY**

Anatomical variations are akin to a change in a landmark during a hiker's expedition on a well-trodden path: it can be the root of confusion and unexpected sequelae. While the anatomical variations presented here tend to be rare, a surgeon should be aware of their existence, so as to modify the course of action should they present themselves during the operation. Preoperative preparedness in the form of extensive investigation, if suspicion of variations is present, as well as intraoperative vigilance can minimize complications attributed to iatrogenic damage to the unexpected anatomical findings.

The knowledge and identification of the location, origin and course of the ureters and the uterine arteries are very important during abdominal hysterectomy for benign pathologies. Ureters can show variations in morphology, such as ureteric diverticula or multiplications, as well as changes in positioning, such as following a retroiliac course. Those variations can be detected

preoperatively with extensive investigation employing imaging techniques [15, 22, 55]. Such an approach is recommended in the presence of other variations detected in the urogenital system. Furthermore, the surgeon should employ both morphological and functional criteria to identify the ureters intraoperatively, in order to detect deviations from their typical presentation. High vascular ligation of the uterine arteries is an integral part of abdominal hysterectomy. Careful retroperitoneal dissection beginning at the iliac bifurcation down to the crossing of the uterine artery with the ureter, in order to ligate the uterine artery at its origin, can overcome obstacles due to anatomical variations and result in a safer operation [38, 43]. Additionally, computed tomography angiography, as an easily performed, non-invasive and financially efficient technique, can display the anatomical variations of the origin of the uterine artery and facilitate the performance of safer operations[20].

**Conflict of interest:** None declared

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