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ORIGINAL ARTICLE

Lower uterine blood supply: extrauterine anastomotic system and its application in surgical devascularization techniques

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Abstract

Background. To establish the arterial components that determine lower uterine blood supply, varieties and anastomoses that result in complications during selective devascularization procedures. *Methods.* Thirty-nine female cadaveric pelvises with latex repletion in pelvic arteries were used. All the material was studied through direct dissection, and dissection enlarged with a 90-diopter magnifying glass, establishing origin, course, and anastomoses of the genital arteries. Axial calibers of the uterine and the main vaginal arteries were compared. An anatomical and a historical compilation of the uterine artery was made, with special reference to anastomotic areas in the lower sector. *Results.* Three main pedicles were determined in the lower uterine blood supply: a cephalic one constituted by the uterine artery, a medial one made up by the cervical artery, and a distal one formed by the vaginal arteries. Different types of anastomoses were distinguished among the upper, middle, and lower pedicles. All types of anastomoses displayed similar features and were interconnected along the isthmic-vaginal borders, or as an intramural anastomotic network. In many cases, a transmedial interuterine anastomosis of axial caliber equivalent to the uterine artery itself could be observed. The bibliography consulted provided neither detailed descriptions of the cervical-segmental arterial system nor of the vaginal system or its anastomoses. In two cases, images were found in books that show this anastomotic system without further explanation. *Conclusion.* A not very well known anastomotic system was described between uterine and vaginal arteries. This system explains some reported failures, complications, and hemodynamic changes after uterine devascularization procedures.

Key words: *Uterine blood supply, utero-vaginal anastomotic system, extrauterine anastomotic system, vaginal arteries, lower uterine blood supply*

The study of uterine arterial blood supply has remained static for years. During the nineteenth century, numerous anatomical descriptions referred to branching variations and to a hint of anastomoses among the uterine, ovarian, and vaginal systems (1). Its study seemed to be complete about the middle of the twentieth century, when Fenström (2) did a complete arteriographic study of the uterine artery relating arteriographic patterns to different gynecological and obstetric diseases. In addition, in 1934, Belou (3) published a complete collection of the arterial system. Although it is almost unknown these days, his work contains a full iconography of the genital system, and plenty of descriptions and anastomoses with the adjacent systems. Since then, the anatomical study of the uterine artery has apparently become less interesting, most probably for its lack of practical application. However, the use of selective devascularization procedures, such as embolization or surgical arterial ligation, has brought about a number of questions regarding the variations and anastomoses among the uterine, ovarian, and vaginal arterial pedicles. To date, the only known anastomosis of the uterine artery is the distal branch of the ovarian artery, also known as proximal anastomosis. Due to the appearance of

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hormonal alterations after the occlusion of the uterine–ovarian arterial axis, or after surgery, the study of proximal anastomoses (4) was unavoidable. Nevertheless, and even though complications in uterine devascularization procedures were noticed (5–8), studies, images, or descriptions of vessels below the uterine segment, also known as distal or lower arterial anastomoses, are scanty. This study tries to describe and illustrate the lower uterine arterial supply, its characteristics and anastomoses, with the aim of increasing the efficacy and safety of selective devascularization procedures.

Material and methods

Bilateral catheterizations of the internal pudendal artery and of the internal iliac artery's anterior branch were performed in 39 female cadaveric pelvises. The arterial system was washed by dripping a 10% peroxide solution until it was cleansed. After 6 h, the pieces were injected with water-based artificially colored latex (70% v/v), to be finally fixed in a 10% formaldehyde solution for one month. The latex injection by dripping was made 1 m above the corpse's heart to avoid the overdistension of vessels and to diminish measurement artifacts. Prior to dissecting the material, 2 paramedian cuts were made with a circular saw, which were 2 cm outside the insertion of the ischial spine. In 15 pelvises the pubis was dried up together with 2 cm of the ischiopubic ramus. All the material was studied through direct dissection, and dissection enlarged with a 90-diopter magnifying glass, establishing the origin, course, and anastomoses of the genital arteries. The measurements were performed on both sides of each subject; axial calibers of the uterine and the main vaginal artery (MaVA) were compared with a caliper gauge. The measurement site of the uterine artery was the junction of the horizontal segment with its ascending one, and measurement site of the MaVA arises. Data were tabulated according to side (right or left) in order to compare the sectional diameters of both homolateral uterine arteries (UA) and the same MaVA. With the aim of establishing statistical differences between these vessels, Student's *t*-test method, variance (S^2), and standard deviation (SD) were performed.

An anatomical and historical literature compilation of the uterine artery was performed. In this search review, the mention or description of anastomotic areas related in their lower sector was investigated in Medline database 1966–2006 (key words: uterine artery, lower uterine blood supply, uterine anastomotic system, uterine pedicles, uterine artery embolization, uterine devascularization procedures). Additionally, independent bibliographic research was done in the Library of the School of Medicine, University of Buenos Aires, Argentina, with special attention to thesis material, monographs, and papers in Spanish not indexed in online databases. Furthermore, a research paper in the Spanish-language database *Scielo* (Scientific electronic library online), depending of the Pan American Health Organization (PAHO-WHO), with identical key words.

Ethical permission for this study was granted by the School of Medicine's Ethical Committee. All the corpses included in the study were of unidentified persons.

Results

The existence of three main arterial pedicles was found in the lower uterine vascular supply: an upper one constituted by the uterine artery, a middle one made up by the cervical artery, and a lower one formed by the vaginal arteries (Table I). Topography of the vaginal arteries varied according to their origin, but they were always dorsal in relation to the ureter. In all cases the cervical artery's caliber was approximately one-third compared to the homolateral uterine artery, and had constant anastomoses with the lower pedicle (vaginal arteries). The lower

Table I. Lower uterine vascular supply

Upper pedicle	Uterine artery	100% from IIA
Middle pedicle	Cervical artery	67% from UA 23% from Vas 10% from LVeA
Lower pedicle	UVA: 18% from UA MVA: 11% from IIA LVA: 71% from PIA	75% as descending branch 25% as ascending branch
Sectional diameters	UA: 1.81 mm	MaVA: 1.88 mm

IIA, iliac internal artery; UA, uterine artery; Vas, vaginal arteries; LVeA, lower vesical artery; UVA, upper vaginal artery; MVA, middle vaginal artery; LVA, lower vaginal artery; PIA, pudendal internal artery; MaVA, main vaginal artery.

vaginal pedicle was the origin of the lower vesical artery in 90% of the cases, and in the remaining 10% it stemmed as a direct branch of the internal iliac artery. Different types of anastomoses were distinguished among the upper, middle, and lower pedicles. All of them were interconnected along the isthmic-vaginal borders or in the thickness of the cervico-vaginal junction (intramural anastomotic network). This disposition could only be recognized in one group of previous published arteriographies (Figures 1–3).

In 15 of the 39 pelvises studied a transmedial interuterine anastomosis (TIA) of axial caliber equivalent to the uterine artery itself could be observed (Figures 4 and 5). The TIA was always located in the anterior cervical-isthmic union and it widely connected the upper, middle, and lower pedicles. The statistical analyses between the main pedicles are shown in Table II.

The duplicity of the uterine artery was only seen in one case (Figure 6). Direct visualization of the lower-lateral pelvic wall makes it possible to visualize the distal pedicle accurately (Figures 7–9).

The bibliography consulted did not provide neither written descriptions of the cervical-segmental arterial system or of the vaginal system or its anastomoses.

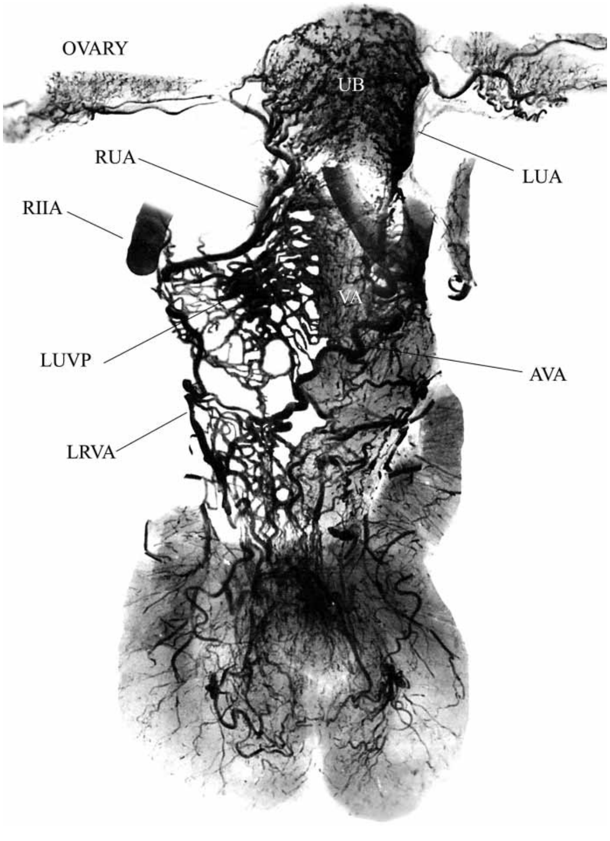

Figure 1. Complete arteriography of female genital organs, including vagina and vulva (female newborn). With permission from Ref. (3), p. 114. AVA, Azygos vaginal artery; LRVA, lower right vaginal artery; LUA, left uterine artery; LUVP, lateral uterine-vaginal plexus; RIIA, right internal iliac artery; RUA, right uterine artery; UB, uterine body; VA, vagina.

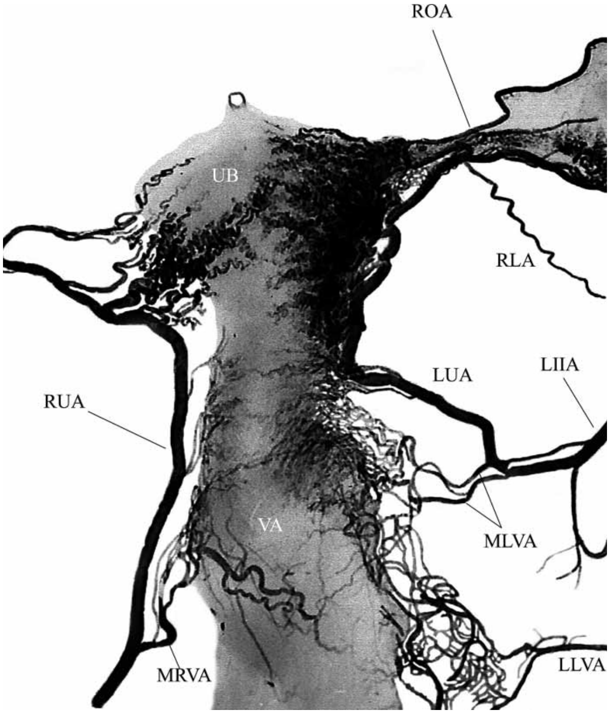

Figure 2. Arteriography of uterus, ovaries, fallopian tubes, and upper vaginal segment. With permission from Ref. (3), p. 114. LIIA, left internal iliac artery; LLVA, lower left vaginal artery; LUA, left uterine artery; MLVA, middle left vaginal artery; MRVA, middle right vaginal artery; RLA, round ligament artery; ROA, right ovarian artery; RUA, right uterine artery; UB, uterine body; VA, vagina.

Discussion

One of the least studied and least known areas of the uterine vascular supply is the distal one. This statement is especially true when one tries to outline the connection and anastomoses among the uterine vessels and the vaginal, rectal, and vesical systems. However, as has occurred with other organs in the body, a detailed study is essential when precise knowledge for safe practice is needed.

Even though the vaginal arteries have different trunk origins (uterine artery, iliac artery, internal pudendal artery), there is no doubt about the role of the vaginal pedicles in uterine arterial blood supply, as shown in the fetal arteriographic and anatomical studies (3). The analysis of the vascular diameter establishes that the MaVA is the dominant extra-uterine anastomotic pedicle.

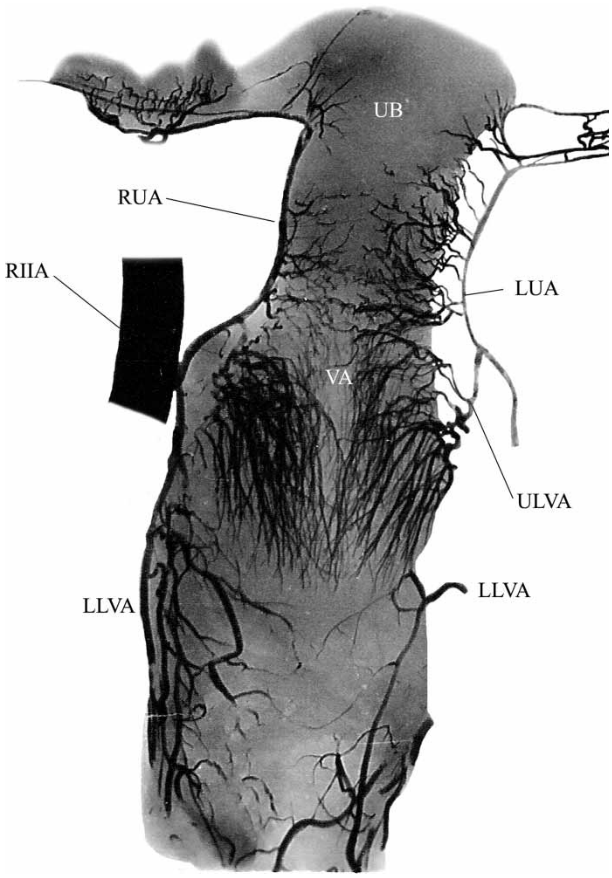

Figure 3. Arteriography of ovaries, fallopian tubes, uterus, and upper vaginal segment (female newborn). With permission from Ref. (3), p. 115. ULVA, upper left vaginal artery; LLVA, lower left vaginal artery; LUA, left uterine artery; RIIA, right internal iliac artery; RUA, right uterine artery; UB, uterine body; VA, vagina.

Knowledge of these anastomoses between the uterine and vaginal arterial systems is important in order to understand certain complications reported in the literature after uterine embolization. Indeed, bladder and vulvar ischemic complications were reported after uterine arterial embolization with small-sized embolic material (particles $<300\,\mu$ or gelfoam powder) (9–13). Although it has been speculated in those reports that arterial reflux of the embolic agents might have caused the complications, none of the articles actually described arterial reflux during embolization. A better possible explanation could be the undesired passage of the embolic material from the uterine artery towards the vaginal artery through the anastomotic plexus described in our case material, due to the small particle size or overembolization.

It is conventionally asserted that uterine circulation is provided mainly (3) by the uterine arteries and secondarily by anastomotic flow of the ovarian arteries. However, and following this theory, it would be difficult to explain how the uterus' nurturing flow can be maintained after complete occlusion of its main branches (uterine arteries), and sometimes even after occluding the tubal-ovarian branches. Analyses of both dissection results and of the available iconography make it possible to establish that, in the circumstances described, uterine circulation is supplied by the flow coming from the vaginal pedicles. The duplicity of the uterine artery is very rare and it should not be considered a suppletory variant secondary to occlusion of the main trunk. Updated information of the uterine artery and of its therapeutics mentions that the uterus' suppletory potential is established by collaterals originating in the cervical artery, in the round ligament artery, and in other unidentified pelvic vessels (14). Nevertheless, due to its short diameter, flow, and constancy of the referred vessels, it is unlikely that this should happen.

Recently, Cicinelli et al. (15) have shown, through physiological experiments, the existence of flow from the vaginal arteries towards the uterus. Besides, it has been proved that bilateral and simultaneous occlusion of the ovarian and uterine arteries causes insignificant changes in the PO_2 (partial oxygen pressure in arterial blood) obtained from the middle sector of the uterine artery compared with that simultaneously obtained in the radial artery (personal unpublished data). The phenomenon could only be explained by the existence of an important suppletory flow to the uterus from the vaginal arteries, which have both enough size and connections to justify oximetry values.

Casuistic analysis has shown that the object of previous published reports has in most cases been the uterus in isolation; occasionally, the tubes together with the ovaries, but hardly ever the vagina (1). Inherent technical difficulty and lack of a well defined practical application are possible reasons why vaginal irrigation has not been much studied. The technical limitation imposed by the lower-lateral pelvic wall makes it impossible to visualize the distal pedicle correctly. To change this limitation, we adapted the usual preparations to the anatomical study of them. The paracolpium provides connective

Table II. Statistical analysis of the main anastomotic pedicles

LUA	SD: 0.1889416	S^2: 0.0356989
RUA	SD: 0.1584157	S^2: 0.0250955
LLVA	SD: 0.1884685	S^2: 0.0355204
RLVA	SD: 0.210915	S^2: 0.0444852
LUA versus LLVA	t-test: $p > 0.3338$ NS	
RUA versus RLVA	t-test: $p > 0.2239$ NS	

LUA, left uterine artery; RUA, right uterine artery; LLVA, left lower vaginal artery; RLVA, right lower vaginal artery; SD, standard deviation; S^2, variance; t-test, Student's t-test.

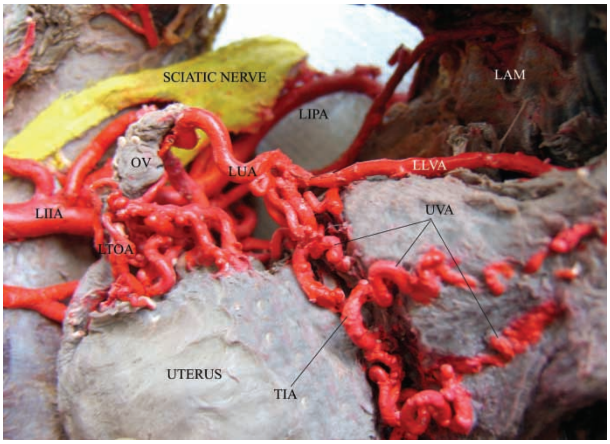

Figure 4. Cadaveric specimen. Upper and left view of the genital-urinary organs. In the middle sector of the illustration a thick intrauterine anastomosis can be identified. Below, thick vaginal branches anastomosing with the uterine artery can be observed. LAM, levator ani muscle; LIIA, left internal iliac artery; LIPA, left internal pudendal artery; LLVA, lower left vaginal artery; LTOA, left tubo-ovarian artery; LUA, left uterine artery; OV, ovary; TIA, transmedial interuterine anastomosis; UVA, utero-vaginal anastomosis.

tissue to the arterial tree-like branching, and as it reaches the organ's lateral border, an amalgam is built between the connective tissue and the vagina's external wall, which is hard to distinguish. Once inside the organ, the vessels spread in the muscle thickness like an intramural net, a fact that particularly conditions the study of the vaginal anastomotic component through direct dissection.

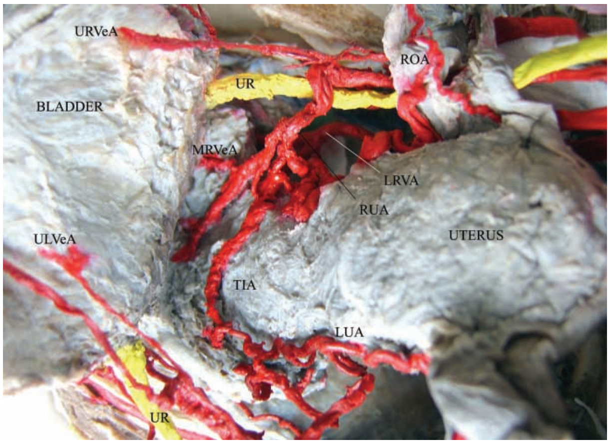

Figure 5. Cadaveric specimen. Upper view of the genital-urinary organs. On the left, the bladder and on the right, the uterus. On the anterior sector of the uterine cervix a transversal anastomosis can be seen between the right and left uterine arteries. LRVA, lower right vaginal artery; LUA, left uterine artery; MRVeA, middle right vesical artery; ROA, right ovarian artery; RUA, right uterine artery; TIA, transmedial interuterine anastomosis; ULVeA, upper left vesical artery; UR, ureter; URVA, upper right vaginal artery; URVeA, upper right vesical artery.

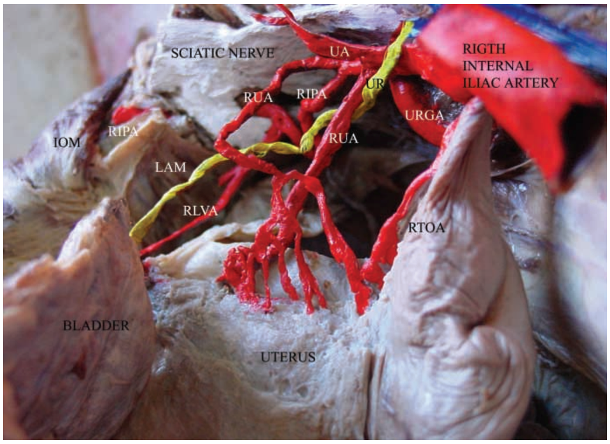

Figure 6. Cadaveric specimen. View of the genital-urinary organs, from top to right. Variety that includes a right double uterine artery. Note the dorsal distribution of the lower vaginal artery regarding the pelvic ureter. IOM, internal obturator muscle; LAM, levator ani muscle; LRVA, lower right vaginal artery; RIPA, right internal pudendal artery; RTOA, right tubo-ovarian artery; RUA (1) and (2), right uterine artery; UA, umbilical artery; URGA, upper right gluteal artery.

Available iconography of the vaginal system is very limited, which is why cadaveric anatomical study with injection of radio-opaque substances has become invaluable. The cadaveric anatomical arteriographies (3–16) have shown constant and thick anastomoses between the vaginal and uterine groups, and also a thick transverse anastomosis

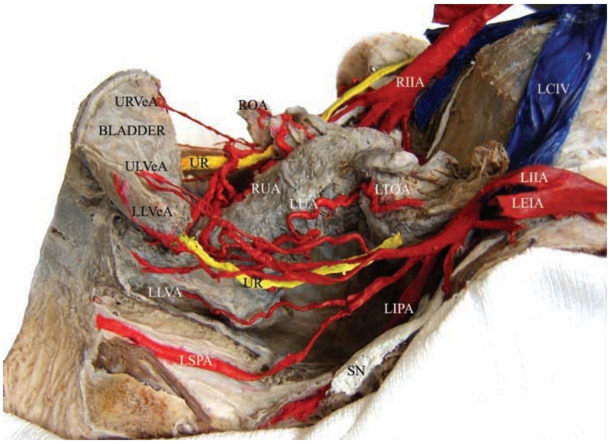

Figure 7. Cadaveric specimen. Typical anatomical specimen (panoramic image). The pelvis' lateral cut allows dissection of the lateral vascular components without difficulty. Besides, anterior-lateral bone removal makes it possible to work on the narrow angle between the organs' lateral wall and the levator ani muscle. LCIA, left common iliac artery; LEIA, left external iliac artery; LIIA, left internal iliac artery; LIPA, left internal pudendal artery; LLVA, lower left vaginal artery; LLVeA, lower left vesical artery; LSPA, left superficial perineal artery; LTOA, left tubo-ovarian artery; LUA, left uterine artery; RIIA, right internal iliac artery; ROA, right ovarian artery; RUA, right uterine artery; SN, schiatic nerve; ULVeA, upper left vesical artery; UR, ureter; URVeA, upper right vesical artery.

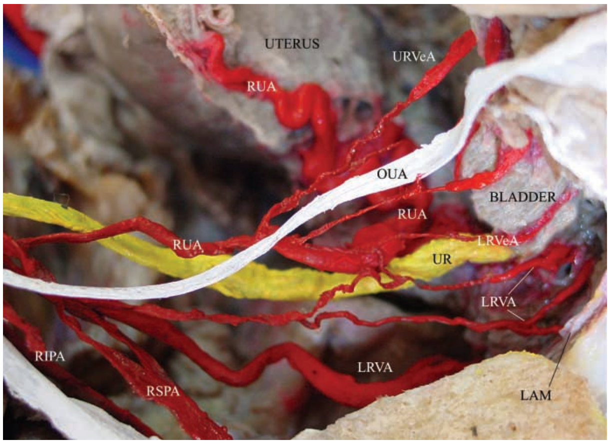

Figure 8. Cadaveric specimen. Lower and right lateral view of the genital-urinary organs. The distribution of the lower vaginal vessels in relation to the pelvic ureter can be seen in detail. In this particular case, the uterine artery is the origin of the upper vesical pedicle, while the internal pudendal artery is that of the lower pedicle. LAM, levator ani muscle; LRVA, lower right vaginal artery; LRVeA, lower right vesical artery; OUA, obliterate umbilical artery; RIPA, right internal pudendal artery; RSPA, right superficial perineal artery; RUA, right uterine artery; SN, schiatic nerve; UR, ureter; URVeA, upper right vesical artery.

described in the literature as vaginal azygos (Figure 10). All cadaveric arteriographies show a wide anastomotic net between the uterine and vaginal systems, and also trunk arteries of equivalent diameter (uterine and vaginal arteries). These findings are the same as the results obtained in the cadaveric dissection, which was the reason for the study. This particular type of anastomotic system can be seen at angiography after wedge injection of contrast media

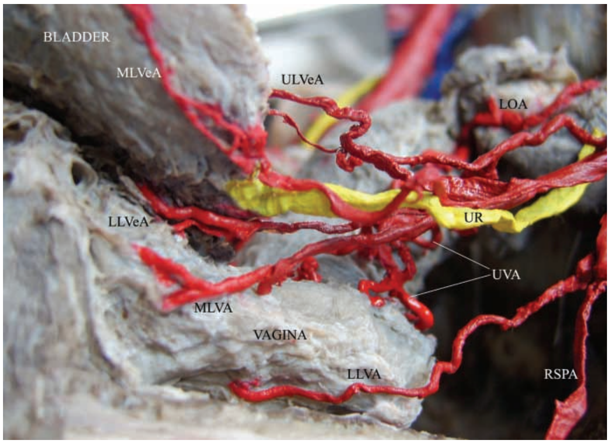

Figure 9. Cadaveric specimen. Left lateral view of the genital-urinary organs. Detail of anastomoses among the vaginal, vesical and uterine systems. Note the distribution of the vascular elements in relation to the pelvic ureter. LLVA, lower left vaginal artery; LLVeA, lower left vesical artery; LOA, left ovary artery; MLVA, middle left vaginal artery; MLVeA, middle left vesical artery; RSPA, right superficial perineal artery; ULVeA, upper left vesical artery; UR, ureter; UVA, uterine-vaginal anastomosis.

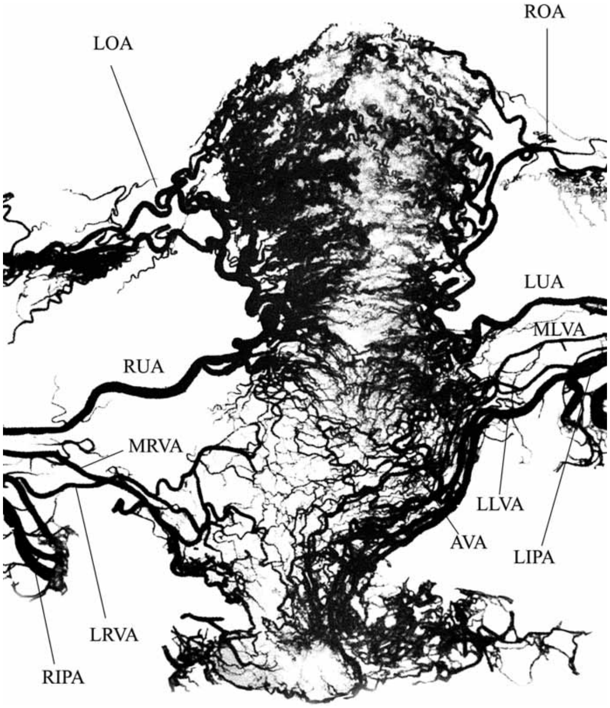

Figure 10. Arteriography of female genital system. With permission from Ref. (16), p. 348. AVA, azygos vaginal artery; LIPA, left internal pudendal artery; LLVA, lower left vaginal artery; LOA, left ovary artery; LRVA, lower right vaginal artery; LUA, left uterine artery; MLVA, middle left vaginal artery; MRVA, medial right vaginal artery; RIPA, right internal pudendal artery; ROA, right ovarian artery; RUA, right uterine artery.

in the MaVA (Figure 11). In this picture, the uterine circulation fills without direct opacity of the uterine artery. To our knowledge, this is the first published angiography that shows this anastomotic system in a patient.

Surgical or endovascular occlusion of the uterine arteries has proved to be inefficient in certain types of obstetric bleeding (17). These failures, inexplicable sometimes, have led different authors (18–20) to suspect and acknowledge the participation of extrauterine branches, such as the internal pudendal artery or some of its branches. Certain pathological entities, such as placenta percreta, are usually accompanied by an uncommon anastomotic profusion, which often produces failures in its specific hemostasis. In these pathological entities, uterine anastomotic interaction may alter the arterial flow from the uterine artery towards the vaginal artery or vice versa, which can result in recurrent bleeding, after a successful initial hemostasis.

The anastomotic channels are hard to observe in usual clinical practice situations. Nevertheless, they become evident in some physiological situations (e.g. pregnancy), in pathological cases, such as placental infiltration, or traumatic lesions in the birth canal, in

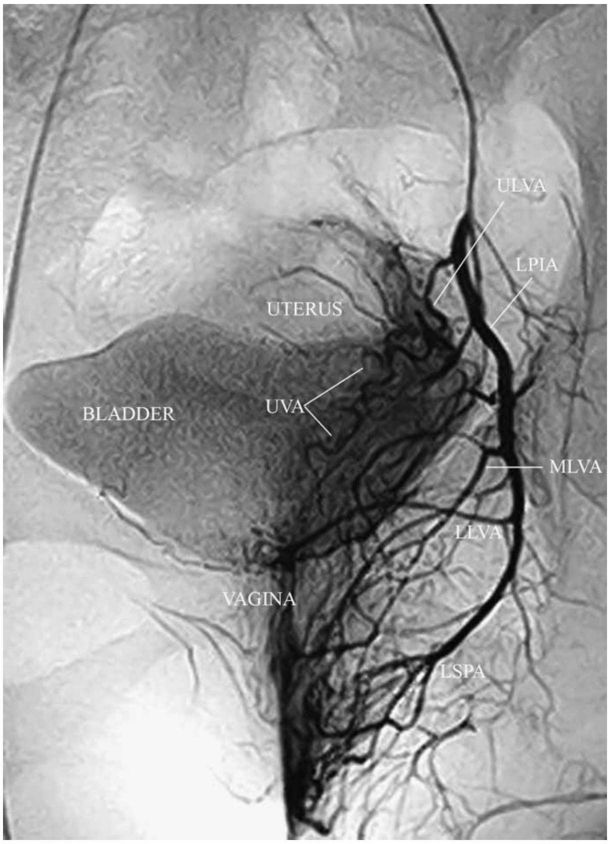

Figure 11. Arteriography in a patient with uterine blood supply opacity from vaginal vessels. LIPA, left internal pudendal artery; LLVA, lower left vaginal artery; MLVA, middle left vaginal artery; ULVA, upper left vaginal artery; LSPA, left superficial perineal artery; UVA, uterine-vaginal anastomosis.

which the origin of recurrent bleeding after uterine artery devascularization cannot sometimes be reliably explained. We believe that knowledge of the uterine-vaginal anastomotic system, together with an improved devascularization technique, will be of invaluable help to enhance selective devascularization treatments, increasing their efficacy and minimizing unwanted ischemic complications.

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