SOBOLEWSKA, Adela, GIERULSKA, Natalia, STACHOWICZ, Hubert, IWANIUK, Kaja, BIAŁKOWSKA, Zuzanna, DANILUK, Aleksander, OSTAŃSKI, Jan, BUCZEK, Jakub, SAMCZUK, Maciej and GAWŁOWICZ, Łukasz. Variability of the origin and course of the uterine artery in clinical practice. Journal of Education, Health and Sport. 2024;69:49390. eISSN 2391-8306.
https://dx.doi.org/10.12775/JEHS.2024.69.49390
https://apcz.umk.pl/JEHS/article/view/49390

The journal has had 40 points in Minister of Science and Higher Education of Poland parametric evaluation. Annex to the announcement of the Minister of Education and Science of 05.01.2024 No. 32318. Has a Journal's Unique Identifier: 201159. Scientific disciplines assigned: Physical culture sciences (Field of medical and health sciences); Health Sciences (Field of medical and health sciences).
Punkty Ministerialne 40 punktów. Załącznik do komunikatu Ministra Nauki i Szkolnictwa Wyższego z dnia 05.01.2024 Lp. 32318. Posiada Unikatowy Identyfikator Czasopisma: 201159. Przypisane dyscypliny naukowe: Nauki o kulturze fizycznej (Dziedzina nauk medycznych i nauk o zdrowiu); Nauki o zdrowiu (Dziedzina nauk medycznych i nauk o zdrowiu).
The authors declare that there is no conflict of interests regarding the publication of this paper.
Received: 12.03.2024. Revised: 10.05.2024. Accepted: 14.05.2024. Published: 17.05.2024.

Variability of the origin and course of the uterine artery in clinical practice

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Abstract

In 2020, approximately 287,000 mothers died during pregnancy or childbirth, with one of the leading causes of maternal mortality being peripartum hemorrhage. It can be treated both pharmacologically and procedurally, for example, through uterine artery ligation, embolization, or hysterectomy. In case of procedural treatment, it is essential for the medical team to familiarize themselves with the anatomical structure of the patient's uterine arteries. Various variations in the course of this vessel are distinguished, such as the uterine artery branching as a bifurcation with the inferior gluteal artery, a common trunk of the uterine artery with another vessel, or even its duplication. Using radiological techniques such as angiography, it is possible to visualize vessels and their variations, which can allow for better patient care. Unfamiliarity with the departure and trajectory of the uterine artery may be associated with an increased risk of postoperative complications, especially after hysterectomy, where the uterine arteries close at the level of the uterus or at the beginning of their departure from the internal iliac artery. Ligating them in other place may result in ischemia of an area that should be continuously supplied with blood. Also, during surgery,

special attention should be paid to possible anatomical variations of the patient's uterine artery, which, although rare, can cause intraoperative complications. A thorough analysis of the departure and trajectory of the uterine artery by physicians can prevent postoperative complications and also allow for the safe conduct of embolization procedures. The following article presents a literature review on the departure and course of the uterine artery and its variations, as well as procedural interventions related to this vessel.

Keywords: Uterine artery, uterus, hemorrhage, anatomy

Introduction

Maternal mortality remains high, with approximately 287,000 mothers dying during pregnancy or childbirth in 2020, with nearly 95% of deaths occurring in developing countries [1].

The most common causes of maternal deaths include peripartum hemorrhage, infections, pregnancy-induced hypertension, birth complications, or lack of access to safe abortion. Globally, the leading causes of maternal mortality, after indirect causes such as infections and peripartum hemorrhage, are hypertension and subsequently sepsis [1].

Peripartum hemorrhage accounts for 8% of deaths in developed countries and approximately 20% in developing countries [1]. It can be defined as a cumulative blood loss exceeding 1000 ml or blood loss combined with signs of hypovolemia unrelated to the delivery route [2].

Tachycardia is often the first sign of hemorrhage, which, due to its nonspecific nature, can be easily overlooked. Other symptoms include hypotension, nausea, shallow breathing, or chest pain in cases of massive hemorrhage [3].

Primary peripartum hemorrhage occurs within the first day after delivery, while secondary hemorrhage occurs between the second day and 12 weeks after delivery. The most common causes of postpartum hemorrhage include uterine atony, coagulation factor deficiency, uterine rupture, or retained placental tissue in the uterus [2], placenta previa, retained conception products such as placental fragments, and cervical laceration [4]. Various forms of treatment are available depending on the extent of hemorrhage and the patient's condition. One pharmacological therapeutic option is the administration of fibrinogen to the patient (through concentrated plasma protein preparations - cryoprecipitate or fibrinogen concentrate, depending on availability). In cases of massive hemorrhage, mechanical and surgical treatment of peripartum hemorrhage should be considered. Some patients may require bilateral uterine artery ligation, hysterectomy, or uterine artery embolization, which is an option for over 50% of women, without subsequent indications for surgical intervention [5].

The course of the uterine artery significantly influences the control of peripartum hemorrhage. Studies have shown that the uterine artery mostly originates as a separate branch from the internal iliac artery as a bifurcation with the inferior gluteal artery or a bifurcation with the superior and inferior gluteal arteries [6].In fewer studies, the main source of the uterine artery was the inferior gluteal artery, while in others, it was the umbilical artery. A rare variant of the uterine artery is a common trunk with another artery branching from the internal iliac artery, such as the vaginal or internal pudendal artery [7]. During pregnancy, the uterine arteries undergo significant changes, increasing their surface area and becoming increasingly tortuous [6].

Additionally, aside from changes in arteries caused by pregnancy, the correct course of the uterine artery itself requires precision in all procedures performed on it. It is divided into three parts: descending, transverse, and ascending. The descending part lies retroperitoneally in the vascular-nerve plate, laterally and anteriorly to the ureter. It then runs along the base of the broad ligament, where it crosses the ureter and forms an arch approaching the uterine isthmus. There, it transitions into the ascending part and runs between the layers of the broad ligament [8].

Cases of absent internal iliac arteries also occur, which, however, do not pose a problem in later procedures involving the uterine artery, as access to it can be achieved from the uterine side [9].

Although rare cases of arteriovenous malformations (AVMs) occur, which can cause life-threatening uterine bleeding. They are divided into congenital and acquired. With the increasing development of radiological imaging techniques, the diagnosis of this condition is also increasing [9].

Arteriovenous malformations are fistulas connecting arterial branches with the uterine venous plexus [10].

Digital subtraction angiography is one of the best ways to visualize arteriovenous malformations (AVMs).

It can show bilateral hypertrophy of the uterine arteries, which become the origin of a tortuous, hypertrophic mass of arteries, as well as the same venous phenomenon, connected to the arteries. Through imaging, it is possible to discover which vessel is causing the bleeding and determine treatment based on the patient's age, condition, and her decisions regarding future pregnancies [11]. Embolization is a good intervention for AVMs, after which a visible reduction in the number of tortuous vessels can be achieved in angiography [12].

Arteriovenous malformations tend to proliferate during pregnancy, so it is important to consider that women with this condition are mostly of reproductive age. Research from New Delhi suggests that 1 in 10 women attempting pregnancy experienced peripartum hemorrhage after previous uterine artery embolization (UAE). Two patients had uncomplicated pregnancies, one had a cesarean section due to a failed induction, and another due to severe oligohydramnios [13].

Unfortunately, pathological changes in the uterus such as fibroids, endometriosis, adhesions from previous pelvic surgeries, or ovarian remnants can disrupt anatomical relationships, posing problems during surgery. One solution may be retroperitoneal dissection to ligate the uterine artery at its vascular source [6].

Knowledge of the course of the uterine artery and its variations is crucial in both surgical and interventional radiology. During surgeries such as hysterectomy, where the uterine artery is

usually ligated, familiarity with its course is necessary to avoid potential complications and consider the possibility of one of the anatomical variations of this vessel [14].

Materials and methods

Scientific works were searched on PubMed, in medical literature books, and scientific literature on October 17, 2023, and October 20, 2023. The sought data spanned from 2014 to 2023. Keywords such as "Uterine artery haemorrhage" were entered, yielding 1588 results, out of which 746 were rejected due to paid access. Additionally, some articles were excluded due to their lack of relevance to the research topic. Subsequently, after excluding works with paid access, keywords like "Uterine artery embolization" were searched, resulting in 489 hits, "Interventional radiology AND uterine artery" with 180 results, "Uterine artery course AND haemorrhage" with 32 hits, and "Postpartum haemorrhage AND uterine artery" with 168 hits. Furthermore, to explore the variability of the uterine artery, terms such as "Uterine artery AND variability" yielded 93 results, and "Uterine artery AND origin" returned 83 hits. All the aforementioned articles were freely accessible. Selected works were primarily written in Polish or English; however, a few articles in other languages such as German were also included in this review. Additionally, to accurately assess the anatomical course of the uterine artery, Volume III of "Human Anatomy" authored by Adam Bochenek and Michał Reicher was consulted. A total of 24 articles were utilized as the basis for this work.

Among these, 7 results pertained to the departure, course, and anatomical variants of the uterine artery, while another 7 focused on peripartum haemorrhage and its treatment.

Discussion

Understanding the origin, course, and branching pattern of the uterine artery is essential in treating patients with peripartum hemorrhage. Additionally, the variability of this vessel should be considered, as it may pose challenges in certain medical procedures associated with it. Peripartum hemorrhages are most commonly treated with surgical interventions such as hysterectomy or uterine artery embolization [5].

The procedures performed in these areas are technically challenging, requiring precision, and the additional anatomical variability of this vessel may increase the risk of complications [5].

One of the surgical methods for treating peripartum hemorrhages is laparoscopic hysterectomy, which involves ligating the uterine arteries. This method is relatively restrictive and is currently only used as a last resort. The two main options for hysterectomy involve ligating the uterine arteries either at their origin from the internal iliac artery or at the level of the uterus. The latter option is more commonly used during procedures because it is considered easier, allowing avoidance of opening the retroperitoneal space. In the case of total hysterectomy, only open, transvaginal, or total laparoscopic approaches are used. The choice of method is based on the surgeon's opinion, experience, and preference. However, studies have shown that ligating the uterine artery at its origin is associated with less intraoperative blood loss and, consequently, a higher operation success rate than ligation at the level of the uterus [15].

Hysterectomy is more frequently used in patients who gave birth before 38 weeks of gestation after initial therapeutic measures compared to women who gave birth after 38 weeks. Regardless of the method used, additional effectiveness of the procedure will be increased by also ligating the internal iliac artery, reducing the risk of further bleeding [16].

Hysterectomy was performed, for example, in a 27-year-old patient described in one of the scientific papers. Initially, the woman presented to the hospital at 22 weeks and 4 days of pregnancy due to pain in the lower right quadrant of the abdomen and hematuria. Ten days earlier, the patient underwent diagnostic laparoscopy and the removal of the right fallopian tube and ovary due to a retroperitoneal hematoma. Numerous ruptures of the serous membrane and clots were present on the left lateral, posterior wall of the uterus. During intra-arterial embolization, complications occurred, resulting in complete stasis in the uterine artery. Unfortunately, postoperative complications occurred, and the patient was diagnosed with pulmonary embolism. At 34 weeks and 4 days of pregnancy, a cesarean section and hysterectomy were performed due to the detection of extensive necrosis in the posterior part of the uterus with active bleeding. Ultimately, both the woman and the child are healthy, and this procedure saved both their lives. This case demonstrates how complex peripartum hemorrhages can be, especially, and how the use of a single method may not always be

sufficient. In such situations, various treatment options, including hysterectomy, should be considered when other methods fail [17].

Another hysterectomy was described in a 39-year-old woman. During a sudden delivery, the patient experienced a rupture of the uterine artery and intraperitoneal hemorrhage. Immediately after delivery, she lost 1000 ml of blood, and strong bleeding from the genital tract occurred in the operating room. Additionally, the patient experienced tachycardia and hypotension. After stabilizing her condition, a rupture of the uterine artery and the uterus itself was diagnosed. It was decided to perform a hysterectomy of the upper part of the uterus and to remove the left ovary [18].

However, currently, the first-choice therapy for controlling peripartum hemorrhage is uterine artery embolization. This is due to the speed of the procedure, broad indications for its performance, low invasiveness, and preservation of the uterus [6].

Embolization is most commonly performed under conscious sedation with continuous angiographic monitoring. The procedure itself is not very complicated and can be performed in less than an hour by experienced physicians. Access to the uterine arteries is obtained through the femoral artery using superselective technique and coaxial catheterization, which is sequentially placed in the artery. During the procedure, special care must be taken to ensure a good and stable position to avoid targeting branches other than the uterine arteries of the internal iliac artery. During embolization, a French 2-3 coaxial catheter is recommended to avoid spasm, which can significantly complicate the entire procedure. The aim of the entire procedure is to transfer embolic particles to the selected artery, thereby occluding its lumen. Particles are injected into each uterine artery until complete or nearly complete arterial stasis is achieved. This is necessary because cross-flow protection prevents infarction. The puncture site is usually controlled by simple manual pressure. Throughout the procedure, patients are monitored using angiography. To minimize radiation exposure to women, modern imaging devices should be used, allowing the overlay of vessel anatomy on live fluoroscopic images [19].

The use of angiography depends on several factors, including the patient's clinical condition, vital signs, and the continuous need for resuscitation. The primary indication for angiography

is suspicion of pelvic artery injury. However, complex clinical situations such as anterior-posterior pelvic fractures may lead to a dilemma regarding which exact artery is bleeding [20].

There are several embolic agents that can be used in this procedure, but there is no consensus on which one is the best. The specific nature of the chosen embolic material likely does not have a significant impact on the course or outcomes of the procedure [19]. Polyvinyl alcohol particles are often used, although some physicians prefer newer agents such as Embosphere, Embozene, and Gelfoam. The latter is mainly used in postpartum hemorrhage control and is attributed with a role as a temporary embolic agent [19].

The primary success rate after the first embolization in articles published after 2010 was significantly higher (81.5%) than in articles before 2010 (69.6%) - however, no differences were observed in the frequency of secondary success after multiple embolizations [21].

Embolization enables the avoidance of hysterectomy, theoretically preserving the possibility of subsequent pregnancies [6].

In interventional radiology, it is considered one of the superior forms of treatment for perioperative hemorrhages, with studies indicating a low incidence of subsequent complications in the majority of patients. Among 53 patients examined at a hospital in New Delhi, 49 (92%) did not require further interventions after embolization, which may signify the advantages of this method [12].

Embolization was utilized in a 45-year-old patient in one study with a fibroid on the posterior uterine wall [14]. Angiography of the left internal iliac artery was ordered to visualize the vessel and its branches. The examination revealed a bifurcation of the left uterine artery before its junction with the descending and transverse segments. Due to the medical team's awareness of this rare anatomical variant, the risk of treatment failure or complications during the procedure was minimized [14].

Therefore, it can be inferred that during the management of perioperative hemorrhage using embolization, familiarity with the anatomy of the uterine artery through angiography is necessary.

Similarly, in the case of treating uterine fibroids using this method, attention should be paid to the possibility of the uterine artery branching off in a slightly different location, which may affect the placement of the vascular catheter [22].

However, due to the circumstances, embolization may not always be worth the risk. If bleeding is not very severe, attempts can be made at aspiration under ultrasound guidance or attempted curettage. In both methods, intra-abdominal vessels should be monitored [23].

In the context of interventional radiology related to uterine arteries, attention should be paid to the possibility of tissue necrosis due to ischemia, as was the case with a 37-year-old patient who presented for treatment due to a uterine fibroid. Twelve days after the mentioned procedure, necrosis of the right buttock occurred, which is a relatively rare complication of embolization. Therefore, potential complications should be remembered, although the procedure itself is considered minimally invasive [24]. Interventional radiology plays an important role in treating pharmacologically uncontrollable bleeding. Currently, it is most commonly used as a complement to surgical procedures in cases where severe bleeding is suspected. Additionally, it allows for the preservation of fertility and the possibility of subsequent pregnancies [12].

Performing an ultrasound examination may indicate fluid in the abdominal cavity or retained placental products or clots. Doppler ultrasound, on the other hand, has little significant impact on the diagnosis of acute bleeding except in cases of uterine vascular malformations. Computed tomography angiography helps detect active extravasation or pseudoaneurysms. Magnetic resonance imaging is useful only in diagnosing abnormal placentation during pregnancy [26].

Conclusions

Postpartum hemorrhage remains a prevalent cause of maternal mortality. Its occurrence requires prompt intervention and urgent treatment as it constitutes a life-threatening condition. The uterine artery is the vessel supplying blood to the entire uterus, thus special attention should be paid to the possibility of its injury during surgical procedures. Conducting additional examinations by radiologists and surgeons before the procedure or surgery to

exclude any variations in the course and branching of the uterine artery could lead to a decrease in the number of deaths caused by postpartum hemorrhage.

The course and branching pattern of the uterine artery are extremely important both during surgical interventions and in interventional radiology. Cases of patients with such variability are not very common, but in the absence of prior preparation, it can significantly complicate the course of the procedure and prolong its duration. In order to safely and without complications perform interventions such as uterine artery embolization in cases of postpartum hemorrhage, it is necessary to familiarize oneself with the anatomy of the uterine artery in the specific patient by performing prior imaging studies such as ultrasound or scintigraphy. This allows avoiding embolization in the incorrect location of the vessel or, in the case of surgery, cutting or injuring the uterine artery. It also helps reduce the occurrence of side effects and complications during the procedure.

Disclosures:

All authors have read and agreed with the published version of the manuscript.
Conflict of interest: The authors declare no conflict of interest.
Funding statement: No external funding was received to perform this review.
Statement of data availability: not applicable
Statement of institutional review committee: not applicable
Statement of informed consent: not applicable

Author's contribution: conceptualisation: Hubert Stachowicz, Maciej Samczuk; methodology: Adela Sobolewska, Jan Ostański; software: Jakub Buczek, Zuzanna Białkowska; check: Natalia Gierulska, Aleksander Daniluk; formal analysis: Kaja Iwaniuk, Łukasz Gawłowicz; investigation: Adela Sobolewska, Natalia Gierulska; resources: Hubert Stachowicz, Jakub Buczek; data curation: Zuzanna Białkowska, Maciej Samczuk; writing-rough preparation: Jan Ostański, Kaja Iwaniuk; writing-review and editing: Aleksander Daniluk, Natalia Gierulska; visualisation: Łukasz Gawłowicz; supervision: Hubert Stachowicz; project administration: Adela Sobolewska; receiving funding: Hubert Stachowicz

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