RESEARCH ARTICLE

Uterine Artery Embolization End Points and Collateral Circulation: Value of Intra-Procedural Non-Contrast Cone Beam CT

Authors:
Jaron Tepper, MD
Division of Interventional Radiology
Department of Radiology
Montefiore Medical Center
Albert Einstein College of Medicine
Bronx, New York, United States
Email: jtepper@montefiore.org

Jacob Cynamon, MD, FACR, FSIR
Director, Division of Interventional Radiology
Department of Radiology
Montefiore Medical Center
Albert Einstein College of Medicine
Bronx, New York, United States
Email: jcynamon@montefiore.org

Abstract

Uterine artery embolization (UAE) is a well-accepted treatment for symptomatic uterine fibroids, but endpoints of UAE remain controversial. This is of significant concern as incomplete embolization can lead to treatment failure, necessitating repeat embolization or alternative treatments such as hysterectomy. Multiple potential causes of UAE failure have been described including failure to catheterize one or both of the uterine arteries, uterine artery spasm, clumping of embolic material and collateral blood supply vascularizing the fibroids. In this review, we discuss potential approaches to identifying collateral blood supply to the uterus and suggest that intra-procedural non-contrast cone beam CT provides unique advantages to addressing this issue.

Introduction

Uterine leiomyomas, also known as uterine fibroids, are common benign tumors that can cause symptoms including heavy uterine bleeding, fertility complications, pelvic pain and bulk-related symptoms. Treatment of symptomatic uterine fibroids has evolved to include uterine artery embolization (UAE) which has been shown to be a safe and effective alternative to hysterectomy.[1,2] However, in contrast to hysterectomy which has a clear procedural endpoint, the endpoint of UAE is variable. This has important implications as incomplete embolization of fibroids during UAE can lead to a higher rate of symptom recurrence and need for either repeat UAE or additional treatment with an alternate therapy.[3, 4] Multiple potential causes of UAE failure have been identified, and various approaches to avoid UAE failure and achieve satisfactory embolization have been described. These topics will be reviewed with a focus on the use of intra-procedural non-contrast cone beam CT (CBCT), which is a technique that can be used to confirm complete fibroid embolization during UAE.

Causes of UAE Failure

There have been four theoretical categories of incomplete fibroid infarction and UAE treatment failure described: failure to catheterize one or both of the uterine arteries, uterine artery spasm which may result in insufficient delivery of embolic material, clumping of embolic material giving a false appearance of occluded blood flow and collateral blood supply to the fibroids.[5]

Techniques to address many of these categories of potential incomplete UAE have been developed including newer embolic agents to address concerns of embolic material clumping and some authors suggesting the use of microcatheters to minimize vasospasm. Despite these improvements in UAE technique, endpoints of UAE remain controversial and identification of collateral supply to the fibroids still typically relies on aortography, which can be imprecise. The importance of identifying all vascular supply to the uterus is underscored by multiple studies which have shown that ovarian artery supply to uterine fibroids, whether direct or via collaterals, is an important cause of potential failure of UAE[6,7] and that identifying ovarian artery supply and embolization can improve clinical outcomes. Consequently, detection of all arterial supply to the uterus at the time of UAE is crucial to ensure clinical success of the procedure.

The common practice used to address this issue is intraprocedural aortography, however a study by White et al. demonstrated that routine aortography reveals ovarian arterial flow to the uterus in fewer than 1% of UAEs.[8] Additionally, in this same study selective ovarian catheterization performed to demonstrate the true incidence of significant ovarian arterial supply to the uterus showed significant ovarian supply to the uterus in approximately 6% of patients. Therefore, while performing aortography is routine in many practices, doing so may have minimal added benefit for the vast majority of patients, with an increase in radiation,

contrast dose and procedural time. Alternative means of screening for and identifying patients with significant collateral supply to the uterus is clearly needed.

Uterine Artery Variants and Embolization Endpoints

While blood supply to uterine fibroids typically arises from the uterine arteries, there are multiple well recognized variants that are important to identify. Broadly, two categories of variant anatomy exist – the first, anastomoses involving the uterine arteries most commonly from the ovarian artery, and the second, supply to a fibroid arising from a vessel other than the uterine artery.

The most common source of non-uterine artery blood supply to uterine fibroids is from the ovarian arteries. A classification system proposed by Razavi et al. describes three types of anastomoses between the ovarian and uterine arteries:[9] type I in which flow from the ovarian artery to the uterus occurs via anastomoses with the main uterine artery, type II in which the ovarian artery supplies the fibroids directly and type III in which the major blood supply to the ovary arises from the uterine artery. In addition to these three types, other arteries such as the round ligament artery, internal pudendal artery and inferior mesenteric artery can also occur as less common sources of blood to supply the uterus.[10]

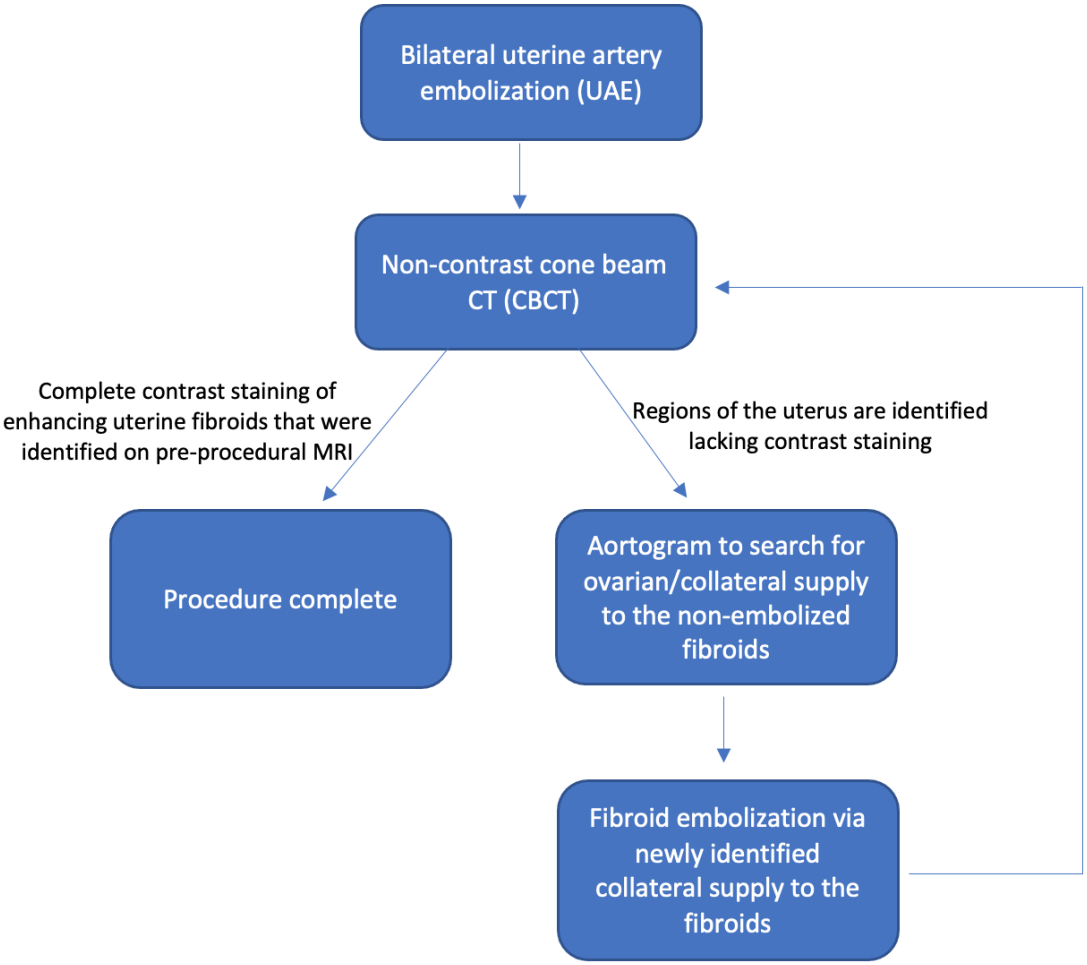
It is important to recognize that intra-uterine vascular communications may not be apparent on angiography.[11] To avoid this potential pitfall, many endpoints have been described in the literature including embolizing to the point of achieving a "pruned-tree appearance" of the uterine artery branches, achieving stasis in the uterine artery for a predetermined number of heartbeats or repeat aortography after embolization is complete. Our preferred endpoint is to embolize up to stasis or near-stasis. Given the potential of ovarian and uterine artery communication, the operator must be cautious to ensure that reflux into the ovarian arteries and reflux up the ovarian arteries into the aorta does not occur. It is important to recognize that proximal vasospasm of the uterine artery may decrease reflux flow up the ovarian artery by increasing prograde flow from the ovarian artery into the uterus.

To ensure embolization of all fibroids, we perform a post-embolization non-contrast cone beam CT. This enables the identification of embolized and non-embolized portions of the uterus and may prompt a search for additional vascular supply. In addition to routine use of aortography, screening for collateral vascular supply to the uterus has taken several approaches.

Intraprocedural Cone Beam CT

Korff et al. described the use of post embolization intraprocedural non-contrast cone beam CT to enable the direct visualization of contrast retention in the fibroids that have been embolized, and lack of contrast retention in areas that have not been embolized. Non-contrast cone beam CT may have several advantages over intra-procedural angiography. If an area of the uterus fails to demonstrate contrast retention on cone beam CT after embolization, direct comparison to pre-procedural MRI can

quickly be performed, and if there is no staining of a portion of the uterus or fibroids that enhanced on pre-procedure MRI, arteriography can be performed to search for additional arterial supply to that region (Flowchart 1). Cone beam CT can be repeated after additional embolization to confirm satisfactory completion (Figure 1).



Flowchart 1

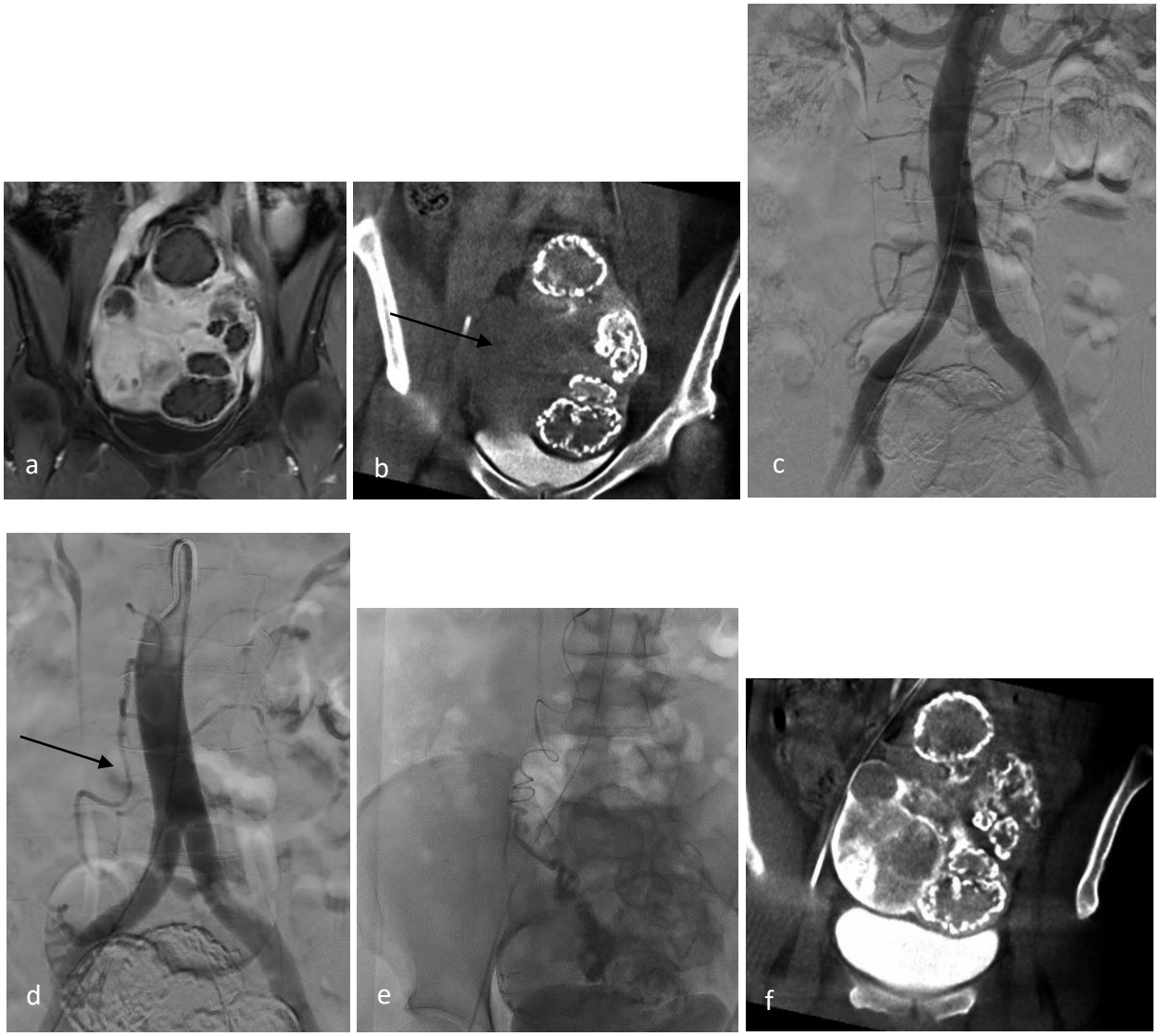


Figure 1: (a) Pre-procedural MRI demonstrates an enlarged myomatous uterus containing enhancing and atrophic fibroids. (b) Cone beam CT performed after the embolization of the right and left uterine arteries demonstrates a lack of contrast staining in a large right sided fibroid (arrow). Additional atrophic calcified fibroids and regions of contrast staining are also visualized. (c) Initial aortogram did not reveal a significant right ovarian artery. (d) Additional aortography was performed to search for the right ovarian artery supplying the right uterine fibroid, which was identified (arrow). (e) The right ovarian was then embolized. (f) Repeat cone beam CT reveals contrast retention within the right uterine fibroid, demonstrating embolization of this region. The portions of the uterus with contrast staining on this cone beam CT correspond to the portion of the uterus that enhanced on pre-procedural pelvic MRI, which enables the operator to confirm complete embolization.

Korff et al. performed a study of 430 UAE procedures in 427 patients using this technique, which assisted the operator in identifying significant ovarian artery supply to the uterus in 4.7% of patients, suggesting a significantly higher sensitivity for detecting collateral supply than aortography.[12] In doing so, the interventionalist can then decide to

search for collateral supply to the uterus. Of the 411 patients who were thought to have complete embolization prior to cone beam CT, 38 (9.2%) were actually found to be lacking contrast retention in a portion of the uterus. Arteriography was then performed in these 38 cases which revealed ovarian artery supply to the uterus in 24 (63.2%) of these cases, supply from a branched/duplicated uterine artery in 2 (5.3%) of these cases and no collateral supply in 12 (31.6%) of these cases. Overall, ovarian artery supply to the uterus was found in 26 (6.0%) of the 427 patients included in this study. This study also suggested that the dose area product (DAP) of an intraprocedural pelvic cone beam CT is lower than that of aortography.

Preprocedural MRA

Another method to identify the anatomic vascular supply to the fibroids is pre-procedural magnetic resonance angiography (MRA). As magnetic resonance (MR) imaging is being used commonly in the evaluation of fibroids pre-UAE, MRA can be performed concurrently. One prospective study of 90 patients in which MRA was performed prior to UAE demonstrated that contrast enhanced MRA was able to depict ovarian arteries and help distinguish between ovarian arteries that have a negligible versus high probability of supplying uterine fibroids.[13] A larger retrospective study of 349 patients who underwent contrast enhanced MRA and UAE demonstrated that contrast enhanced MRA was helpful for the prediction of ovarian artery embolization during UAE.[14] However, the use of MRA fails to predict the alteration in flow that occurs during and after UAE and may not be able to differentiate between the various types of ovarian artery to uterine artery anastomoses.

Other Endpoints

Other authors have identified criteria centered on patient characteristics to identify these patients including history of prior pelvic surgery, tubo-oviarian pathology and the presence of large fundal fibroids.[15] While this may help predict patients with ovarian artery supply to fibroids, like MRA, this method cannot predict the alteration in flow that occurs during and after UAE, nor can it differentiate between the various types of ovarian artery to uterine artery anastomoses.

Conclusion

Identifying collateral vascular supply to the uterus is critical to ensuring a positive clinical outcome of UAE. While multiple methods to predict collateral arterial supply to the uterus have been reported in the literature, non-contrast cone beam CT performed post-embolization is unique in providing real-time visualization of embolization extent and can allow the operator to identify the small subset of patients for whom arteriography would be beneficial.

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