Patient Radiation Exposure during Uterine Fibroid Embolization and the Dose Attributable to Aortography

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The techniques used for uterine fibroid embolization (UFE) have rapidly evolved during the past decade. One source of uncertainty in the UFE technique has been the importance of the contribution of the ovarian artery to the blood supply of the uterus and fibroids. Although conventional aortography is often used after embolization to assess for collateral arterial supply, few patients are identified with sufficient collateral vessels to warrant supplemental embolization. One potential downside of routine aortography is the additional radiation dose. In this study, the radiation dose associated with UFE and the contribution of each component of the procedure to this dose were evaluated, with the specific goal of identifying the contribution from aortography. Although the overall radiation dose associated with UFE is moderate, aortography contributes a substantial amount of additional radiation, more than 20% of the total, which, coupled with its low clinical utility, suggests that the routine use of aortography at the conclusion of UFE should be reconsidered.


Abbreviations: BMI = body mass index, DAP = dose-area product, OAE = ovarian artery embolization, UFE = uterine fibroid embolization

UTERINE fibroid embolization (UFE) has gained increasing acceptance during the past several years in the treatment of symptomatic fibroids. As the number of procedures performed has increased, the technique for the procedure has matured. Relatively early in the development of the procedure it was recognized that the ovarian arteries occasionally provide supplemental ovarian supply to the uterus, with the frequency estimated to be 5%–10% in patients with primary UFE (1–4). A small number of these patients have enough ovarian arterial supply to indicate the need for supplemental ovarian artery embolization (OAE) to achieve successful clinical results (5,6). For this reason, flush abdominal aortography may be performed to enable assessment of the ovarian arterial supply to the uterus (1). Recent research, however, suggests that less than 1% of patients with primary UFE are identified at aortography as having a substantial collateral arterial supply (7). This low clinical yield brings into question the utility of abdominal aortography in routine UFE.

When considering the utility of aortography, the benefits of finding an additional ovarian supply must be weighed against any risks associated with the study. One potential issue to consider is the radiation dose associated with aortography. Although several investigators have evaluated the patient radiation exposure associated with UFE (8–11), none have determined the specific contribution of aortography to the overall radiation exposure.

The purpose of this study was to determine the total patient radiation dose associated with UFE and the contribution of each component of the procedure to this dose, with the specific goal of identifying the contribution from postembolization aortography. Our findings will provide a basis for determining the relative merits of aortography in routine UFE.

MATERIALS AND METHODS

Our study received institutional review board approval and was compliant with the Health Insurance Portability and Accountability Act. A waiver for specific patient informed consent was granted because data were collected during UFE by using a standard treatment protocol.

Prospective data were collected from 25 consecutive patients undergoing UFE. Each patient underwent bilateral uterine artery embolization performed by one experienced operator (J.B.S.), with one patient undergoing supplemental right OAE. The interventional radiologist is an expert in...
UFE, having performed more than 1,500 procedures. Bilateral femoral access was obtained and selective hypogastric catheterization completed with use of a 5-F hydrophilic catheter (Cobra 2 Glidecath; Terumo/Boston Scientific, Natick, Mass). A 3-F microcatheter (Renegade Hi-Flow; Target Therapeutics/Boston Scientific, Natick, Mass) was used. A digital roadmap was obtained to guide selective uterine artery catheterization. Subsequent uterine arteriography was used before and after embolization to confirm completion of uterine artery embolization. One image was obtained every other second. Embolization was performed by using either 355–500-μm polyvinyl alcohol particles (Contour; Boston Scientific) or 500–700- or 700–900-μm tri-acryl gelatin microspheres (Embosphere Microspheres; Biosphere Medical, Rockland, Md), as determined by the interventional radiologist. The rate of embolization was controlled to avoid reflux into the ovarian arteries, with the endpoint defined by the angiographic appearance of a patent main uterine artery with proximal or distal occlusion of its main branches as determined by the type of embolic material being used (12). Throughout the procedures, pulsed fluoroscopy at a rate of 15 pulses per second was used.

Abdominal aortography was performed in all patients at the conclusion of uterine artery embolization. To minimize the radiation dose to the patient during aortography, images were obtained at a rate of 1 frame every second from the pubic symphysis extending superiorly. Images were collimated side to side to include the common femoral arteries. A nonionic contrast medium (various manufacturers) was injected at a rate of 20 mL per second for 2 seconds.

Procedure were performed in an angiographic suite containing equipment with an integrated dosimeter (Axiom Artis; Siemens Medical System, Malvern, Pa). The system is compliant with the dosimetry portion of the International Electrochemical Commission standard 60601-2-43 (13). Dosimetry data—including dose-area product (DAP), cumulative dose, and fluoroscopy time—were displayed directly on the console in the control room, allowing data collection at various stages of the procedure by a research associate without increasing procedure time or otherwise affecting procedure workflow. Baseline patient data collection included age, body mass index (BMI), uterine volume, and dominant fibroid volume. Procedure time and dosimetry data were collected at the following points during the procedure (in order): (a) after obtaining femoral access, (b) after bilateral uterine artery catheterization, (c) after initial uterine arteriography, (d) after bilateral uterine artery embolization, (e) after aortography, (f) after additional angiographic evaluation and/or OAE, when performed, and (g) at procedure completion. Additional data recorded included the number of angiographic frames required for each run, the number of frames obtained during aortography, and the volume of contrast medium used.

Descriptive and summary statistics were used to analyze dosimetry data with use of software (Excel 2003; Microsoft, Redmond, Wash). Normalized values were calculated by using the mean American female BMI of 26.5 given the well-established dependence of radiation dose on BMI. To analyze the correlation between radiation dose and patient variables, the log transformation was taken for each measure to bring it closer to a normal distribution and to equalize the variance across values of DAP. The correlations of all measures were calculated according to the Pearson correlation coefficient. Variables that were not correlated with each other were included in a generalized linear model in a regression-type analysis to examine their relationship with DAP. Any variables indicative of a nonlinear relationship were also included as a quadratic to fully describe the relationships. Backward selection was used to remove any insignificant interaction terms and quadratic terms.

RESULTS

Twenty-five patients who underwent UFE (mean patient age, 45.4 years; age range, 37–55 years; mean BMI, 25.8; BMI range, 19–53) underwent bilateral uterine artery embolization, with one patient undergoing supplemental right OAE. The mean uterine volume was 488.2 cm³ (range, 197–1,639 cm³), and the mean dominant fibroid volume was 131.2 cm³ (range, 16–437 cm³). The mean contrast medium volume used was 129 mL.

Table 1 presents data about the mean procedure time and the mean, minimum, and maximum values for fluoroscopy time, DAP, DAP normalized to a BMI of 26.5, cumulative dose, and number of images obtained. The main component of the overall DAP was the embolization procedure itself, contributing 49% of the dose. However, 21% of the total dose was related to the aortography portion of the examination.

The only measure that showed a statistically significant correlation with DAP was BMI. The correlation of the logs of these measures was 0.70 (P < .001). The correlation between DAP and dominant fibroid volume and DAP and uterine volume was 0.32 and 0.28, respectively (P = .12 and P = .28, respectively, not statistically significant).

Table 2 presents the estimated DAP for a BMI of 20 and 30 with dominant fibroid volumes of 50 cm³, 100 cm³, and 200 cm³. For example, women with a BMI of 20 and a dominant fibroid volume of 50 cm³ are likely to have a mean total DAP of 1,904.38 cGy · cm², with a mean confidence interval of approximately 1436.55, 2514.93. Without routine aortography, we can estimate the average dose reduction to be approximately 20%.

DISCUSSION

Abdominal aortography is often performed to screen for residual ovarian artery supply to the uterus after the completion of uterine artery embolization (1). Further assessment of arterial flow may be performed with selective ovarian artery catheterization and arteriography. If substantial ovarian artery collateral supply to the uterus is identified, these patients may benefit from supplemental OAE (5,6).

At this time, there is not yet a consensus among the interventional radiology community as to the role of aortography in routine UFE. Although aortography depicts at least one visible ovarian artery in almost 20% of patients with primary UFE (7,14,15), recent studies indicate that the extent of arterial flow to the uterus is often not accurately evaluated at aortography when compared with selective ovarian arteriography (7). Although just less than 6% of primary UFE pa-
patients may benefit from supplemental OAE, aortography has been reported as depicting only 1% of women as having substantial collateral uterine perfusion to benefit from this supplemental embolization (7). Thus, both the small number of patients with substantial ovarian artery collateral supply and the low sensitivity of aortography in the identification of this collateral supply bring into question the utility of aortography in routine UFE. We recognize that by not using routine aortography, ovarian vessels providing supply to the uterus will not be detected in a small number of patients. However, it is not clear in every case that the ovarian flow that is detected is supplying fibroids or is important as a potential cause of failure. In addition, many patients are not counseled about the potential risks or benefits of OAE. OAE has not been fully characterized and, therefore, the risks of ovarian injury are not yet fully known. For this reason, we have typically not proceeded with OAE at the time of the initial UFE unless there is very substantial flow to the uterus and fibroids from one or both of the ovarian arteries. This circumstance is very unusual.

Although numerous studies have documented the DAP, cumulative dose, and fluoroscopy time associated with UFE, none have reported the contribution to the total dose attributable to aortography (8–11). Our mean DAP is within the range reported in other studies, although it is well below the reported mean (8). When compared specifically with one of the largest multicenter studies—the Radiation Dose in Interventional Radiology (RAD-IR) study by Miller et al (8)—the reported mean DAP for UFE is 29,822 cGy · cm², with a range of 416–81,575 cGy · cm². There are two reasons that may help explain our lower patient radiation exposure during the same procedure. The first is that all procedures in this study were performed by an expert in UFE. This substantial experience with UFE may have decreased the total procedure time and decreased the fluoroscopy time needed for uterine artery catheterization. Second, our protocol for UFE at this institution is to limit, as much as possible, the number of angiographic images. This includes filming rates of 1 frame every 2 seconds for uterine arteriography and 1 frame per second for aortography. In addition, preliminary iliac arteriography is not performed. This suggests that operators should consider reviewing their protocols to reduce patient radiation dose by limiting the angiographic filming routinely done.

We acknowledge limitations of our study. First, all procedures were performed by one experienced operator (J.B.S., who has performed more than 1,500 UFE procedures). On the basis of this experience and our techniques, the proportion of radiation dose reduction may be more or less among other practices. Specifically, one technique that we use is bilateral femoral access. We recognize that there are different approaches that many find provide better access, with recent advances including the Roberts catheter (Cook, Bloomington, Ind) and the Binkert catheter (Cook). There is currently no demonstrated advantage to any specific approach, however,
and we have chosen a bilateral approach on the basis of our own experience, in which we find decreased uterine artery spasm and decreased fluoroscopy time with use of bilateral femoral puncture (16,17). This concept, however, has not been confirmed with a randomized clinical study and, therefore, may be subject to selection bias.

A second limitation to this study is the relatively small number of patients included. A larger study, with a wider variety of settings, may present different values for both the proportion and total radiation dose reduction. Similarly, in our study, one of the 25 patients underwent supplemental OAE, although our previous study (7), in which we used aortography to assess ovarian artery collateral supply in more than 1,100 patients, depicted less than 1% of patients as having such substantial collateral flow. We believe that the larger of these studies more accurately reflects the true incidence. Third, we have specifically evaluated aortograms after embolization, which may alter pelvic arterial flow patterns to an uncertain extent and, therefore, reduce the angiographic identification of ovarian arteries. Having said that, we believe that the detection of clinically important ovarian flow to fibroids is best identified after the primary supply from the uterine arteries is occluded.

Although the overall radiation dose associated with UFE is moderate, the results of this study indicate that aortography contributes a substantial portion, with more than 20% of the total dose attributable to aortography alone. We believe that the radiation exposure attributable to aortography in UFE, coupled with the low yield in identifying substantial collateral uterine perfusion, supports the conclusion that the routine use of aortography after UFE should be reconsidered. We believe that a subset of patients with a higher likelihood of collateral ovarian artery supply may benefit from postembolization aortography. If this subset can be identified, aortography can be targeted among these patients. Further research is required to identify clinical factors (eg, previous pelvic surgery) and angiographic findings (eg, a disproportionately small uterine artery) that may be associated with substantial residual ovarian arterial supply. The identification of these factors will enable us to use aortography to screen only those patients most likely to have additional uterine supply from ovarian arteries and, therefore, minimize unnecessary patient radiation exposure.

References