CLINICAL STUDY

Radiation Dose Reduction during Uterine Fibroid Embolization Using an Optimized Imaging Platform

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ABSTRACT

Purpose: To assess radiation dose reduction during uterine fibroid embolization (UFE) using an optimized angiographic processing and acquisition platform.

Materials and Methods: Radiation dose data for 70 women (mean age, 46 y; range, 34–67 y) who underwent UFE were retrospectively analyzed. Twenty-one patients underwent UFE using the baseline fluoroscopic and angiographic image acquisition platform, and 49 underwent UFE after implementing an optimized imaging platform in otherwise identical angiography suites. Cumulative kerma-area product (CKAP), cumulative air kerma (CAK), total fluoroscopy time, and image exposure number were collected for each procedure. Image quality was assessed by 3 interventional radiologists blinded to the platform used for image acquisition and processing.

Results: Patients undergoing UFE using the new x-ray fluoroscopy platform had significantly lower CKAP and CAK indicators than patients for whom baseline settings were used. Mean CKAP decreased by 60% from 438.5 Gy · cm^2 (range, 180.3–1,081.1 Gy · cm^2) to 175.2 Gy · cm^2 (range, 47.1–757.0 Gy · cm^2; $P < .0001$). Mean CAK decreased by 45% from 2,034.2 mGy (range, 699.3–5,056.0 mGy) to 1,109.8 mGy (range, 256.6–4,513.6 mGy; $P = .001$). No degradation of image quality was identified through qualitative evaluation.

Conclusions: Significant reduction in patient radiation dose indicators can be achieved with use of an optimized image acquisition and processing platform.

ABBREVIATIONS

CAK = cumulative air kerma, CKAP = cumulative kerma-area product, DSA = digital subtraction angiography, LFOV = large field of view, PACS = picture archival communication system, RG = reference group, SFOV = small field of view, SG = study group, UFE = uterine fibroid embolization

Uterine fibroid embolization (UFE) is recognized by the American College of Obstetricians and Gynecologists as a safe and effective therapy for symptomatic fibroids in women who elect not to pursue hysterectomy or myomectomy (1). In contrast to surgical treatments for uterine fibroids, however, UFE employs ionizing radiation during the procedure. Moreover, according to some risk models, young to middle-aged female patients are at higher theoretical risk for stochastic radiation effects than their male counterparts (2). This underscores the importance of following the ALARA (as low as reasonably achievable) principle during UFE treatment.

Several studies to date have shown that a commercially available image acquisition and processing platform (ClarityIQ; Philips Healthcare, Best, The Netherlands) reduces radiation dose to patients during various

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angiographic procedures (3–9). This dose reduction is achieved through both software and hardware optimization. With regard to software improvements, multiple algorithms for noise reduction, edge sharpening, and contrast optimization are used by the system to obtain angiographic and fluoroscopic images, preserving image quality while reducing the radiation dose. In addition, the effects of patient motion are minimized by motion compensation techniques. Hardware parameters are adjusted depending on the patient's body habitus and the clinical task, with the x-ray tube output and beam filtration (including copper and aluminum filters) modified dynamically. Despite using less radiation to form each image, several studies have shown that image quality is not degraded (4–7,9). It was hypothesized that patient radiation dose reduction could be achieved during UFE using this x-ray fluoroscopy imaging technology. The purpose was this study was to retrospectively quantify the radiation dose reduction for UFE when this advanced platform is employed.

MATERIALS AND METHODS

The institutional review board of the investigating institution approved this retrospective study.

Imaging Equipment

All UFE procedures were performed on Philips Allura FD20 angiography systems (Philips Healthcare), each using a single flat panel detector. Between January 1, 2013, and February 12, 2015, 21 patients underwent UFE on 1 of 2 identical systems employing the manufacturer's Eco (low-dose) settings. Between January 16, 2014, and July 8, 2016, 49 patients underwent UFE on 1 of 3 identical systems using the optimized imaging platform. As this platform was not installed in all angiography suites simultaneously, overlap of these dates exists. In addition, the third optimized unit was constructed in early 2015 and first used clinically in October 2015. UFE procedures performed using the baseline angiography platform were included in the reference group (RG). These baseline settings included a 0.7-mm focal spot and nominal tube voltage of 80 kV with only inherent filtration. Real-time fluoroscopy was performed at 15 frames/s with a detector dose of 1.9 μGy per frame. UFE procedures performed on the upgraded acquisition platform were included in the study group (SG). The dose settings used for SG procedures were characterized by the same 80-kV nominal tube voltage and 0.7-mm focal spot but with increased beam filtration (0.1-mm copper and 1.0-mm aluminum). Conventional fluoroscopy was performed at 15 frames/s, with 1.0 μGy per frame requested at the detector. For this vendor, 15 frames/s is standard during most fluoroscopic applications; dose reduction during fluoroscopy is achieved by decreasing tube current and pulse duration rather than frame rate.

Procedure Description

UFE was performed using unilateral common femoral artery access in all cases. An abdominal aortogram was performed at the level of the ovarian arteries to exclude accessory arterial supply to the uterus, either before or after treatment of the uterine arteries. The internal iliac arteries were each catheterized in succession with a 5-F diagnostic catheter, through which a microcatheter was placed. After achieving microcatheter access to each uterine artery, embolization was performed with embolic microspheres measuring 500–700 μm and/or 700–900 μm in diameter (Embosphere microspheres; Merit Medical Systems, Inc, South Jordan, Utah). Depending on the operator, the desired endpoint was either stasis or near-stasis in each uterine artery.

Inclusion and Exclusion Criteria

All patients who underwent UFE at the investigating institution during the study period were included in the analysis. Patients with coexisting adenomyosis were not excluded from the study, but no patient was treated for adenomyosis alone. All patients undergoing uterine artery embolization for other indications, such as postpartum hemorrhage, were excluded.

Data Acquisition

Radiation dose and utilization data were acquired by querying databases directly linked to the 3 x-ray angiography suites in which UFE procedures were performed. Cumulative kerma-area product (CKAP) and cumulative air kerma (CAK) for each procedure represented a summed exposure from conventional fluoroscopy, digital subtraction angiography (DSA), and (in a single case) cone-beam computed tomography (CT). The number of exposures for each procedure represented a sum of the DSA frames, cone-beam CT projections, and single exposures acquired. For 2 of the 3 suites, radiation dose data were gathered from the DoseWatch radiation dose monitoring software (GE Medical, Little Chalfont, United Kingdom). Data from the third angiography suite were gathered from the Radimetrics dose surveillance system (Bayer HealthCare, Whippany, New Jersey).

Patient size was assessed using anteroposterior pelvic thickness from each patient's most recent cross-sectional imaging study on a picture archival communication system (PACS) station. The measurement was obtained in the axial plane at the superior-most aspect of the femoral heads. Accurate patient weight and body mass index data at the time of each procedure were not consistently available.

Image Quality Assessment

To assess image quality, 10 UFE cases from the RG and 10 UFE cases from the SG were selected at random. Cases with severe motion degradation were excluded. Cases were assessed by 3 interventional radiologists (K.P.K., A.G.T., M.C.), each with between 5 and 9 years of experience. None