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Original Article

Radiation dose reduction utilizing noise reduction technology during uterine artery embolization: a pilot study☆,☆☆

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ABSTRACT

Objective: To assess the radiation dose reduction during uterine artery embolization utilizing dose reduction technology.
Methods: A total of 58 women underwent uterine artery embolization. A total of 26 procedures were performed in a standard fluoroscopy suite; 32 procedures were performed utilizing a novel imaging platform. Radiation dose data and acquisition parameters were compared.
Results: The new platform provided significant reduction in the median radiation dose ($P<.001$): from 389 Gy cm^2 to 145 Gy cm^2. There were no differences between the groups with regard to acquisition parameters.
Conclusion: The new imaging platform provided a 61% dose reduction during uterine artery embolization without a significant change in acquisition parameters.

1. Introduction

Women seeking uterine artery embolization (UAE) for the treatment of symptomatic uterine fibroids are relatively young and often desire future fertility. UAE has been shown to be at least equal to surgical myomectomy or hysterectomy in terms of clinical outcomes [1,2]. Clinical studies have also shown that UAE provides control of fibroid-related symptoms in a majority of patients with an acceptably low reintervention rate at 10 years [3]. Nonetheless, there remains some reluctance from referring physicians to recommend UAE for treatment of uterine fibroids due to concerns regarding exposure to ionizing radiation [4]. As such, methods to decrease radiation exposure to patients during this procedure are of paramount importance. Previous studies have addressed procedural techniques for reducing radiation exposure during UAE, including limiting use of oblique positioning and magnification [5]. This study focuses on the potential contribution of optimized imaging technology toward the goal of minimizing radiation dose during UAE. However, in accordance with the low as reasonably achievable principle, the goal of minimizing radiation dose should not supersede the necessity of obtaining acceptable clinical images and completing the procedures with satisfactory technical success rates.

A new imaging platform utilizing hardware adjustments and synergistic image processing was designed to allow for dose reduction during digital subtraction angiography (DSA) and fluoroscopy without impairing image quality. A previous study addressed the relative dose reduction in a cohort of patients undergoing diagnostic neuroangiography or interventional neuroradiology procedures utilizing the same new platform optimized for neurointerventional procedures [6]. The study demonstrated approximately 60% radiation dose reduction for the new platform group ($n=302$) in comparison to the standard group ($n=312$). The current study aims to quantify the relative dose reduction in patients undergoing UAE, testing the hypothesis that optimized settings would significantly reduce radiation exposure compared to the same procedure conducted with standard settings. The study also aims to determine if parameters related to procedure workflow, such as fluoroscopic time and number of acquired DSA images, were affected by fluoroscopic settings.

2. Materials and methods

Data acquired from a standard imaging platform (Allura Xper, FD20; Philips Healthcare, Andover, MA) was compared to data acquired from a novel imaging platform equipped with hardware and software adjustments to reduce procedural dose (AlluraClarity, FD20; Philips Healthcare).

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Procedure and dose data were collected from both the standard and optimized fluoroscopic systems from July 2013 through January 2015.

The hardware adjustments and image processing algorithms of the new imaging platform that allow for reduced radiation exposure to the patient during neuroangiography were previously described by Soderman et al. [6]. However, the specific parameters of the image processing chain were selected for optimization of vascular procedures, an option included in the commercially available product.

During the study period, patients were subjected to uterine artery angiography and embolization for treatment of symptomatic uterine fibroids. Beginning in July 2013, patients were consecutively subjected to "standard imaging platform" (Group 1). After installation of AlluraClarity in one of the four angiography suites in November 2013, patients were preferentially subjected to the "new imaging platform" (Group 2) unless the updated suite was unavailable. In these instances, patients were subjected to the standard platform and included in Group 1. Age of the patient at the time of the procedure was recorded. Body mass index (BMI) was calculated for patients in whom the necessary information was available in medical records ($n=34$ and $n=17$ for both Group 1 and Group 2).

The same five attending interventional radiologists performed the procedures, utilizing the same catheterization techniques with the assistance of interventional radiology fellows and diagnostic radiology residents at our institution. Arterial access was gained via a transradial approach in accordance to the protocol described by Resnick et al. [7]. After palpation of the left radial artery and completion of a Barbeau test to confirm ulnopalmar arch patency, the left wrist was prepped and draped in standard sterile technique. The left radial artery was punctured under direct ultrasound guidance with a 21-gauge, 2.5-cm echogenic needle (Cook, Bloomington, IN) and a 0.018-inch wire was advanced into the left radial artery. After the radial artery had been accessed, a 4-F hydrophilic Glidesheath (Terumo, Somerset, NJ) was placed. A solution of 3000 U heparin, 200 μg nitroglycerin, and 2.5 mg verapamil was slowly injected to mitigate radial artery spasm and thrombosis formation.

Following placement of the radial vascular sheath, a 4-F angled tip hydrophilic Glidecath (Terumo), either 120 cm or 150 cm in length, was advanced down the aorta in standard fashion. The catheter tip was positioned within the horizontal segment of the uterine artery. In cases with difficult anatomy, a Renegade (Boston Scientific, Natick, MA) or Progreat (Terumo) microcatheter was deployed. Ovarian artery coils were deployed prior to embolization if prominent uterine–ovarian anastamoses were demonstrated during uterine artery angiography. Embolization was performed with Embosphere particles (Merit Medical, South Jordan, UT) ranging in size from 500 to 900 microns. After embolization of the right uterine artery was completed, the catheter was retracted and then repositioned into the left uterine artery, which was then embolized in a similar fashion.

Patient radiation dose indicators, represented by cumulative dose area product (DAP), were collected. Acquisition parameters, such as fluoroscopy time and number of DSA images, were also recorded. DSA frame per second (fps) settings were documented retrospectively.

The primary outcome of the study was radiation dose quantified by total DAP. Secondary outcomes were fluoroscopy time and number of DSA images acquired during procedure.

This clinical retrospective study was approved by the local institutional review board at our hospital. The conduction of the study was in accordance with the declaration of Helsinki.

2.1. Statistical analysis

Patient characteristics were delineated with descriptive statistics and compared with the Student's *t* test. Differences between Group 1 and Group 2 were evaluated at a significance level of $\alpha=0.01$. DSA settings were also compared with the Student's *t* test. Acquisition parameters such as fluoroscopy time and number of DSA images acquired were compared with AVOVA, using an *F* test at a significance level of $\alpha=0.01$. Given that total radiation exposure in both groups demonstrated a nonparametric distribution, DAP was compared with Wilcoxon rank-sum analysis, using a *W* test at a significance level of $\alpha=0.01$. The effects of DSA setting upon DAP and fluoroscopy time were determined with ANCOVA, using an *F* test at significance level of $\alpha=0.01$.

3. Results

3.1. Subjects

From July 2013 through January 2015, 71 women underwent UAE for symptomatic uterine fibroids. Five procedures were performed in a fluoroscopic suite that was neither the standard nor the new platform, resulting in the exclusion of these patients from the study. An additional 8 procedures were performed via femoral access and were subsequently excluded from our analysis. Among the 58 remaining procedures, 26 procedures were performed in the standard platform (Group 1) and 32 procedures were performed in the new platform (Group 2). Bilateral uterine artery catheterization was completed in all cases. Two cases in Group 2 and one case in Group 1 required right uterine artery microcatheterization. One case in Group 1 required bilateral uterine artery microcatheterization. One case in Group 1 required coiling of an ovarian artery. Patient demographics are summarized in Table 1. No significant differences were demonstrated between the groups with regard to age ($P=.50$) or BMI ($P=.62$).

3.2. Cumulative DAP

Cumulative DAP values showed a high variety within both groups (Fig. 1). Median total DAP in Group 2 was decreased from 389 Gy cm^2 to 145 Gy cm^2 (Table 2). Overall, there was a 61% reduction in total DAP from Group 2 compared to Group 1.

3.3. Acquisition parameters

The number of DSA images acquired was highly variable within both groups. However, the difference in number of DSA images acquired was not significant (Table 3). Similarly, there was no significant difference in fluoroscopy time. An analysis of covariance was conducted to determine the impact of DSA setting upon cumulative DAP values and fluoroscopy time because there was a significant difference between the mean DSA fps settings between the groups ($P<.001$): 2.50 fps in Group 1 versus 2.97 fps in Group 2. There was no effect of DSA fps setting on cumulative DAP ($P=.02$) or fluoroscopy time ($P=.17$). An analysis of covariance between DSA images acquired and DSA fps was not necessary as the number of acquired frames is a direct function of DSA setting.

Table 1
Patient demographics

Characteristic	Group 1, standard platform	Group 2, new platform	Total	*P* value
Age				.50
n	26	32	58	
Mean±S.D.	44±6.1	43.0±5.0	43.5±5.5	
95% CI	41.5–46.5	41.2–44.8	42.0–44.9	
Median	44.5	44	44	
Minimun–Maximum	23–56	32–51	23–56	
BMI				.62
n	17	17	34	
Mean±S.D.	30.9±7.5	32.3±8.3	31.6±7.8	
95% CI	27.1–34.8	28.0–36.6	28.9–34.4	
Median	30.9	29.9	30.1	
Minimum–Maximum	19.8–48.4	24–58.3	19.8–58.3	

CI, confidence interval; S.D., standard deviation; *P* value (two-tailed) calculated from Student's *t* test; BMI data compiled from available data within medical records.