CLINICAL STUDY

Radiation Exposure of Patients and Interventional Radiologists during Prostatic Artery Embolization: A Prospective Single-Operator Study

Gustavo Andrade, MD, Helen J. Khoury, PhD, William J. Garzón, PhD, Felipe Dubourcq, MD, MsC, Michel F. Bredow, MD, Lucas M. Monsignore, MD, PhD, and Daniel G. Abud, MD, PhD

ABSTRACT

Purpose: To prospectively analyze the radiation exposure of patients and interventional radiologists during prostatic artery embolization (PAE).

Materials and Methods: Twenty-five consecutive PAE procedures performed with an Artis zee system in a single center by an interventional radiologist were prospectively monitored. The mean age, weight, and prostate volume of the patients were 65.7 year (range, 43–85 y), 71.4 kg (range, 54–88 kg), and 79 cm^3 (range, 36–157 cm^3), respectively. In addition to Digital Imaging and Communications in Medicine radiation data, direct measures were also obtained. Radiochromic film was used to evaluate peak skin dose (PSD). The radiologist wore a protective apron and a thyroid collar, and a ceiling-suspended screen and a table curtain were used. To estimate the absorbed doses, nine pairs of dosimeters were attached to the operator's body.

Results: The average fluoroscopy time was 30.9 minutes (range, 15.5–48.3 min). The mean total dose–area product (DAP) was 450.7 $Gy \cdot cm^2$ (range, 248.3–791.73 $Gy \cdot cm^2$) per procedure. Digital subtraction angiography was responsible for 71.5% of the total DAP, followed by fluoroscopy and cone-beam computed tomography. The mean PSD was 2,420.3 mGy (range, 1,390–3,616 mGy). The average effective dose for the interventional radiologist was 17 μSv (range, 4–47 μSv); values for the eyes, hands, and feet were obtained, and were all greater on the left side.

Conclusions: PAE may lead to high x-ray exposures to patients and interventional radiologists.

ABBREVIATIONS

DAP = dose–area product, DSA = digital subtraction angiography, PAE = prostatic artery embolization, PSD = peak skin dose

Prostatic artery embolization (PAE) has been increasingly accepted as a therapeutic approach for the treatment of lower urinary tract symptoms caused by benign prostatic hyperplasia. It is a technically challenging procedure because of complex anatomic variations and thin prostatic arteries. It is also a time-consuming procedure, with a long fluoroscopy time, multiple oblique and magnification views, and use of cone-beam computed tomography (CT), which can lead to high radiation doses (1–5).

Although pelvic embolization procedures have been found to be associated with high radiation exposure values for physicians, only two studies of which we are aware have investigated radiation doses during PAE. One is a case report and the other is a small series of five patients (4–6). In the present study, 25 PAE procedures were prospectively analyzed to obtain direct and indirect measures of radiation exposure.

From AngioRad–Interventional Radiology (G.A.), Recife-PE, Brazil; Nuclear Energy Department (H.J.K., W.J.G.), Universidade Federal de Pernambuco, Recife-PE, Brazil; Urology Department (F.D., M.F.B.), Hospital Getulio Vargas, Recife, Brazil; and Faculty of Medicine (G.A., L.M.M., D.G.A.), Universidade de São Paulo, Ribeirão Preto, Brazil. Received October 30, 2016; final revision received January 6, 2017; accepted January 7, 2017. **Address correspondence to** G.A., AngioRad–Interventional Radiology, Av. Agamenon Magalhaes, 2291/302 Boa Vista, Recife, PE 50100-010 Brazil; E-mail: guga.andrade@gmail.com

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MATERIALS AND METHODS

In August 2015, a prospective study was initiated to evaluate PAE procedures. After the five first cases, we started evaluating radiation exposure after approval of the national research ethics system was granted (CAAE: 53083016.2.0000.5198). Written informed consent was obtained from all patients.

PAE was performed by one interventional radiologist with more than 10 years of experience, who completed a PAE technique course, assisted five procedures overseas, and performed five PAE procedures alone. From November 2015 through September 2016, 25 men with lower urinary tract symptoms underwent PAE at our hospital and were enrolled in this single-center prospective study. Patient demographic data were as follows: mean age, 65.7 years ± 11.5 (standard deviation; range, 43–85 y); weight, 71.4 kg ± 9.5 (range, 54–88 kg); height, 167.3 cm ± 6.4 (range, 155–180 cm); prostate volume, 79 cm^3 ± 36.3 (range, 36–157 cm^3); and prostate-specific antigen level, 5.9 ng/mL ± 3.5 (range, 1.8–15.2 ng/mL). The patients did not undergo CT angiography or magnetic resonance imaging.

All PAE procedures were performed with an Artis zee ceiling-mounted system (Siemens, Erlangen, Germany) equipped with a 30-cm × 40-cm rectangular flat-panel detector. Fluoroscopy was performed at 15 images per second. Digital subtraction angiography (DSA) was performed at two images per second with the standard aortic protocol (85 kV, 100 ms, 0.9-mm Cu filter, and dose of 3,600 μGy per frame), and available cone-beam CT was used. The equipment test showed it to to be functioning in compliance with the manufacturer's specifications and national regulations.

All procedures were performed under local anesthesia with the use of a single common femoral approach with a 5-F, 11-cm sheath and an indwelling bladder catheter filled with 10% iodinated contrast solution. Bilateral internal iliac artery catheterizations were performed with a Mikaelson catheter and a 0.035-inch hydrophilic guide wire (Cook, Bloomington, Indiana). In each artery, DSA was performed in ipsilateral oblique view (40°) and with cranial tilt (10°) with the use of a power injector and 32-cm field of view. For selective catheterization of the prostatic arteries, an Excelsior 1018 microcatheter and 0.014-inch Transend guide wire (Stryker Neurovascular, Fremont, California) were introduced coaxially. After catheterization of the prostatic artery, DSA was performed in the same ipsilateral oblique and posteroanterior views by hand injection with a 22-cm field of view. If a dangerous anastomosis was identified, coil embolization was performed before particle injection. If the interventional radiologist decided to perform cone-beam CT to check potential nontarget embolization or confirm the amount of prostatic parenchyma perfusion, it was done by injection through the microcatheter with a power injector (0.3 mL/s for 16 s) with the standard protocol of a 6-second rotational scan of 200° at 33° rotation per second, with image acquisition starting 10 seconds after the beginning of the injection every 0.5° (90 kV, 5.0 ms, and 0.36 μGy per frame; Fig 1). Only during rotational acquisition was the interventional radiologist outside of the suite.

PAE was then performed with the use of 100–200-μm nonspherical polyvinyl alcohol particles (Cook) or 400-μm Polyzene-coated hydrogel microspheres (Embozene; CeloNova BioSciences, San Antonio, Texas). The endpoint was complete occlusion and reflux toward the origin of the artery. DSA by hand injection through the microcatheter confirmed complete occlusion of the vessel. All patients were discharged from the hospital on the day of treatment or the next day. After each procedure, the fluoroscopy time, dose–area product (DAP; or kerma–area product), number of images, and irradiation parameters (voltage, current, and pulse width) for DSA, fluoroscopy, and cone-beam CT were extracted from the Digital Imaging and Communications in Medicine headers.

To evaluate the peak skin dose (PSD) to the patient, a GafChromic XR-RV3 radiochromic film (International Specialty Products, Wayne, New Jersey) measuring 35.6 cm × 43.2 cm was placed under the patient, around the hip region. The films were calibrated before and, after at least 24 hours of the procedure; when film-darkening stabilization was achieved, reflective densities were measured in the Metrology Laboratory of Ionizing Radiation of the Nuclear Energy Department of the Federal University (Brazil). Technical details of XR-RV3 GafChromic films have been published elsewhere (4,7). All patients were evaluated clinically at 15 days, 1 month, and 3 months after treatment. This

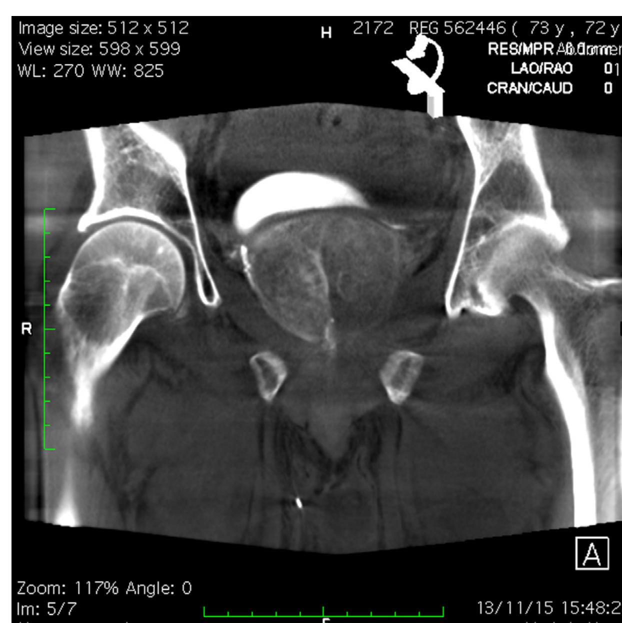

Figure 1. Coronal cone-beam CT imaging with microcatheter injection shows only prostate parenchymal perfusion.