Radiation exposure in prostatic embolization

By Dr G. Andrade & Dr D. G. Abud

Prostatic artery embolization (PAE) is a minimally invasive procedure that is being increasingly accepted as an alternative treatment of the lower urinary tract symptoms caused by benign prostatic hyperplasia (BPH). PAE is a time-consuming and technically challenging procedure due to the thinness of prostatic arteries and complex anatomic variations. The technique is characterized by long fluoroscopy times, the optional use of cone-beam computed tomography (CBCT) acquisitions, multiple oblique projections and magnification views, all of which can lead to high radiation doses to both patients and staff [1, 2, 3]. Very few studies have however actually quantitated radiation exposure in PAE. This article summarizes the results of our recent prospective single-operator study of radiation exposure in PAE.

STUDY DESIGN

We prospectively analyzed 25 PAE procedures carried out using a Artis Zee ceiling-mounted system (Siemens, Germany) from November 2015 through September 2016 in the largest public hospital of Recife-PE, Brazil. The mean age of the patients was 65.7 years (43-85y), mean weight 71.4 kg (54-88 kg), mean height 167.3 cm (155-180 cm) and mean prostate volume 79 cm^3 (36-157 cm^3). Fluoroscopy was performed at 15 images per second and digital subtraction angiographies (DSA) at 2 images per second, using a standard abdomen protocol (85 kV, 100 ms, 0.9-mm Cu -filter and a dose of 3,600 µGray per frame).

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All procedures were performed under local anesthesia using a single common femoral artery approach with a 5F 11 cm sheath. Bilateral internal iliac artery catheterization was carried out using 5 F Mikaelson catheter; DSA was performed in ipsilateral oblique (40°) view using a power injector and 32cm field of view (FOV). After identification of the prostatic artery, a microcatheter and a 0.014" guidewire were introduced coaxially. Once the catheter entered into the prostatic artery the same ipsilateral oblique and frontal DSA were performed by hand injection in a 22-cm FOV. CBCT was performed only if the interventional radiologist (IR) judged it to be necessary.

PAE was performed using particles until the end-point of complete occlusion and reflux toward the origin of the artery was reached. Hand-injection DSA through the microcatheter was used to confirm complete occlusion. After bilateral embolization, the sheath was withdrawn and compression hemostasis performed for ten minutes. All patients were discharged in less than 24 hours. After each procedure several parameters were extracted from the DICOM headers, namely the fluoroscopy time, dose-area product (DAP; or kerma-area product), the number of images taken and irradiation parameters (voltage, current and pulse width) for DSA, fluoroscopy and CBCT techniques.

To evaluate the peak skin dose (PSD) to the patient, a Gaf-Chromic XR-RV3 film (Wayne, New Jersey) was placed under the patient. In all procedures, the radiologist wore a protective apron and thyroid collar; a ceiling-suspended

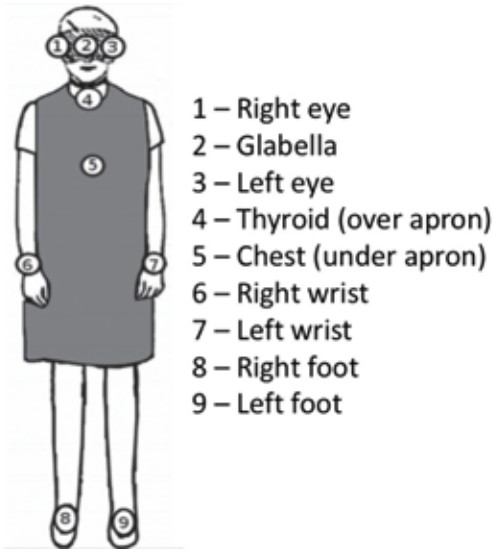

Figure 1. To estimate absorbed doses, nine pairs of thermoluminescent dosimeters were used

Monitor Location	Glabella	Left eyebrow	Right eyebrow	Left wrist	Right wrist	Left foot	Right foot	Chest (under apron)	Neck (over apron)
Mean (μSv)	353	378	135	781	332	1369	770	8	213
SD	±211	±241	±96	±452	±152	±1425	±841	±5	±187
Minimum	104	94	27	203	84	94	60	1	19
Maximum	876	955	367	2003	626	4797	2664	18	711

Table 1. The average equivalent dose in each location received by the Interventional radiologist during PAE procedures. Values in μSv

screen and table curtain (all 0.5 mm of lead equivalent) were always used. To estimate the absorbed doses, nine pairs of thermoluminescent dosimeters (TLD-100; Waltham, Massachusetts) were strategically attached to the interventional radiologist (IR) [Figure 1]. To estimate the effective dose von Boetticher's double dosimetry algorithm were used.

RESULTS

Bilateral PAE was successful in all patients and no skin lesions were seen. The average fluoroscopy time was 30.9 min (15.5-48.3 min). The mean total DAP per procedure was 450.7 Gy.cm^2 (248.3-791.73 Gy.cm^2). DSA was found to be responsible for 71.5% of the total DAP, followed by fluoroscopy (19.9%) and CBCT (8.6%). The mean number of DSA series and images were 20.8 (9-36) and 463.5 (275-710), respectively. CBCT was performed in seven of 25 patients (28%), with the mean image acquisition number being 400 images (396-404). The mean patient PSD was 2,420.3 mGy (1,390 – 3,616) and the average effective dose for the IR was 17 μSv (4 – 47 μSv). The average equivalent dose in each location received by the IR during each PAE are shown in Table 1.

SIGNIFICANCE AND FUTURE DIRECTION

One case of radiation-induced dermatitis was reported after a PAE procedure, which had a fluoroscopy time of 72 minutes and a total DAP of 8 023.1 Gy.cm^2 [3]. Of other published reports the study with the largest number of patients involved 630 PAE patients who underwent CT angiography before PAE, with a low fluoroscopy time (19.5 min) but the highest total DAP (2,415 Gy.cm^2) [4]. The PSDs in our study are above the 2 Gy threshold for transient erythema, but no erythema were observed in our pateients within 3 months. The radiation exposure of patients who underwent PAE is similar to that reported for other complex interventional procedures.

During PAE using the femoral approach, the interventionalist has to stay close to the patient's irradiated area. In our study, the average effective dose per procedure was comparable to those in studies with highest exposure (17μSv).

The occurrence of cataracts and brain tumors in the left hemisphere of interventionists has already been described. After several such studies reporting a significant increase in radiation-associated eye lens opacities and cataracts among interventional physicians, the International Commission on Radiological Protection (ICRP) reduced the annual limit for equivalent dose for lens of eyes to 20mSv [5]. The results of our study show that any physician carrying out PAE procedures — even with a ceiling-suspended shield — would reach the annual limit for the left eye with just one procedure per week.

The collective dose of radiation used in medicine has increased more than seven-fold between 1980 and 2006; this increase has continued over the last decade [6]. Consequently the use of ionizing radiation in medicine has become an important, yet potentially avoidable, public health threat that deserves considerable attention. In the light of these data, we entered into a cooperative project with the Brazilian Department of Nuclear Energy (DEN-UFPE) and Siemens to develop a low dose protocol with the goal of reducing radiation exposure while maintaining diagnostic image quality in PAE. Based on the CARE algorithm (**C**ombined **A**pplications to **R**educe **E**xposure) from Siemens and deliberately pushing the As Low As Reasonably Achievable (ALARA) principle to the limit, we finally arrived at the development of a protocol known as RECiFE (**R**adiation **E**xposure **C**urtailment **f**or **E**mbolization). The RECiFE protocol is applicable to fluoroscopy, DSA and CBCT. Fifteen consecutive PAE procedures have been performed under the new protocol and preliminary results show an overall dose reduction of about 70%. These results and experimental details will be published soon.

CONCLUSIONS

PAE is a complex procedure and has now been shown to involve high radiation exposure for patient and staff. A change in the radiological protection culture among interventional radiologists should be encouraged, not to get the best image but to fully respect the ALARA principle.

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