Comparative Analysis of Cone-Beam CT Angiogram and Conventional CT Angiogram for Prostatic Artery Identification Prior to Embolization

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ABSTRACT

Pre-prostatic artery embolization (PAE) cone-beam computed tomography (CT) angiograms (n = 31; mean age: 62.4 ± 9.75 years) and conventional CT angiograms (n = 32; mean age: 62.5 ± 7.2 years) were retrospectively compared. Mean signal-to-noise ratio (SNR), contrast-to-noise ratio (CNR), radiation exposure, and prostatic artery (PA) identification scores (0–4) for cone-beam CT angiogram and conventional CT angiogram were 33.19 (± 14.31) and 18.13 (± 5.38) ($P < .01$); 27.42 (± 13.39) and 14.78 (± 4.92) ($P < .01$); 14.57 mSv (±2.5) and 19.25 mSv (±3.7) ($P < .01$); 3.36 (± 0.89) and 3.16 (± 0.95) ($P = .08$), respectively. Pre-PAE cone-beam CT angiogram allows for PA identification with improved SNR and CNR and less radiation dose compared to conventional CT angiogram.

ABBREVIATIONS

CNR = contrast-to-noise ratio, PAE = prostatic artery embolization, SNR = signal-to-noise ratio

INTRODUCTION

Identifying the prostatic arteries (PAs) during prostatic artery embolization (PAE) can be challenging due to the many adjacent arterial branches arising from the internal iliac artery and the variable origin of the PA (1,2). The consequence of incorrectly identifying the PAs can be nontarget embolization with potential injury to the penis, rectum. or bladder (3).

Conventional computed tomography (CT) angiograms of the pelvis have been shown to be useful for preprocedural PA identification (2). More recently, the utility of cone-beam CTangiograms for PA origin identification have also been described (4,5). However, there are known inferior imaging characteristics of cone-beam CT angiogram relative to conventional CT angiogram, including increased scatter resulting in artifact and decreased signal-to-noise ratio (SNR) (6). Given these shortcomings, the aim of this study was to retrospectively compare pre-PAE pelvic conventional CT angiogram to cone-beam CT angiogram, using both objective and subjective evaluation to determine if either is superior for PA identification. Additionally, radiation doses to the patient were compared.

METHODS

This single-center retrospective study was performed with institutional review board approval and with full Health Insurance Portability and Accountability Act compliance. Thirty-one consecutive pre-PAE pelvic cone-beam CT angiograms obtained between January 2016 and September 2016 were retrospectively compared to 32 consecutive pre-PAE conventional CT angiograms obtained between September 2014 and January 2016 (**Table 1**). Data from 5 of the patients within the conventional CT angiogram cohort were previously reported as part of a clinical trial publication (7). Subjective analysis was performed by 2 vascular radiologists (each with 4 years' experience interpreting conventional CT angiograms for PAE) using a 0–4 grading scale (**Table 2**) to evaluate the visibility of the PA. Scores for individual scans were obtained by averaging the

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Table 1. Mean Baseline Characteristics of Patients Undergoing PAE with Preprocedural Cone-Beam CT Angiogram Versus Conventional CT Angiogram

	Cone-Beam CT Angiogram	Conventional CT Angiogram	*P*
Age (years)	62.4 (range: 35–81)	62.5 (range: 52–83)	.97
Prostate volume	120.3 cm^3 (n = 16, range: 40–300)	101.2 cm^3 (n = 32, range: 26–197)	.34
IPSS	22 (n = 27, range: 13–34)	24 (n=25, range: 14–35)	.2

IPSS = international prostate symptom score; PAE = prostatic artery embolization.

Table 2. Grading Scale for PA Visualization on Cone-Beam CT Angiogram and Conventional CT Angiogram

0	Cannot see origin
1	Can only see origin
2	Can see origin, but course is incompletely visualized
3	Can see origin and complete course to prostate
4	Can see origin, complete course to prostate and intraprostatic branches.

PA = prostatic artery.

visibility score of the right PA by radiologist 1, visibility score of the right PA by radiologist 2, visibility score of the left PA by radiologist 1, and visibility score of the left PA by radiologist 2. Specific examples of scans associated with each score are provided as **Videos 1–4** (available online at *www.jvir.org*). In the event the complete course of the PA was not visualized on the images under evaluation, the corresponding digital subtraction angiography was reviewed to confirm correct identification of the PA origin. Objective evaluation included SNR, contrast-to-noise ratio (CNR), and radiation dose exposure measurements. SNR and CNR were calculated using Hounsfield units (HU) measured at the iliacus muscle, origin of the internal iliac arteries, and abdominal subcutaneous fat (**Fig 1**). Specifically, SNR was calculated with [HU at internal iliac artery ÷ standard deviation in subcutaneous fat], and CNR was calculated with [(HU at internal iliac artery - HU at iliacus) ÷ standard deviation in subcutaneous fat] (8). Effective doses to the patient were calculated using the dose area products (DAPs) for the cone-beam CT angiograms and dose length products (DLPs) for the conventional CT angiograms. DAPs and DLPs were converted to mSv using .26 mSv/Gycmˆ2 and .015 mSv/mGycm as conversion factors, respectively (9,10).

Conventional CT Angiogram Protocol

Imaging was performed on a 64-slice scanner (Somatom Sensation 64, Siemens Medical Solutions, Munich, Germany). Prior to scanning, 2 sprays of sublingual nitroglycerin (800 mcg, Wilshire Pharmaceuticals, Atlanta, Georgia) were administered to potentially dilate the PAs for improved visualization, unless the patient had taken a

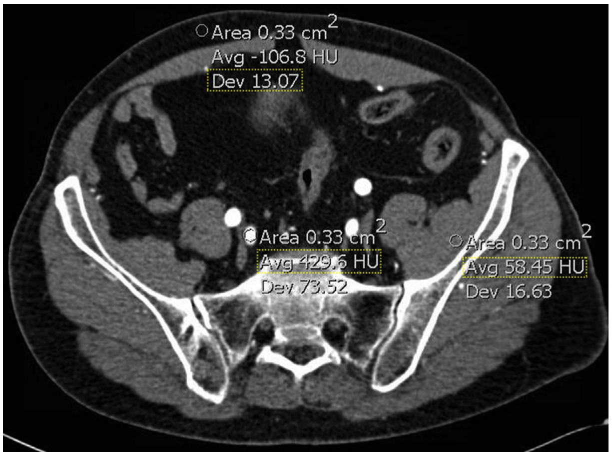

Figure 1. Axial image from conventional pelvic CT angiogram demonstrating regions of interest within the subcutaneous fat, iliacus muscle, and the internal iliac artery used for SNR and CNR calculations.

phosphodiesterase inhibitor in the previous 48 hours. A contrast bolus of 150 ml of iohexol (Omnipaque 350, GE Healthcare, Waukesha, Wisconsin) was injected at a rate of 4–6 ml per second, depending on the caliber of the intravenous catheter. Cranial-to-caudal imaging was triggered when a region of interest in the inferior abdominal aorta reached a threshold of 300 HU followed by a 4-second delay. Additional imaging parameters included: .6 mm collimator, pitch .9, .33 second gantry rotation period, 120 Kv, and 180 reference mAs with automated modulation along the z-axis based on body mass (CARE Dose 4D, Siemens Medical Solutions). Axial images were reconstructed in 2-mm slices. Side-by-side intraprocedural fluoroscopic image and fluoroscopic image with 3-dimensional (3D) rendered conventional CT angiogram fusion was used for guidance.

Cone-Beam CT Angiogram Protocol

Through either common femoral or radial artery access, a 5F multihole catheter was placed in the inferior abdominal aorta. Using a floor-mounted fluoroscopy unit (Zeego, Siemens Medical Solutions), a 6-second cone-beam CT angiogram (DynaCT, Siemens Medical Solution; frame rate: 66.67 fps, kVp: 90-125, FOV: 18.5-cm height x 24-cm diameter, matrix size: 512 x 512) was performed while iohexol diluted to 50% concentration with saline was power injected through the catheter. The injection was performed at a rate of 4 ml per second for a total of 11 seconds (5 seconds before image acquisition and 6 seconds during image acquisition), at a pressure of 800 psi. Axial images were reconstructed with a thickness of 2 mm. Side-by-side intraprocedural fluoroscopic image and fluoroscopic image with 3D-rendered cone-beam CT angiogram overlay was used for guidance (**Figure 2**).

Statistical Analysis

Linearly weighted Cohen's kappa was calculated to measure interobserver agreement. Statistical significance for ordinal