Pulsatility Imaging of Saccular Aneurysm Model by 64-Slice CT with Dynamic Multiscan Technique

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The feasibility of imaging pulsatility in an aneurysm model with the high-resolution dynamic multiscan technique of 64-slice computed tomography (CT) was studied. A pulsatile aneurysm phantom was constructed and imaged with dynamic multiscan technique. The aneurysm model was filled with iodinated contrast material (250 Hounsfield Units) and was scanned with use of a gantry rotation time of 0.33 seconds, slice thickness of 1.2 mm, effective coverage of 24 mm, and total imaging time of 4 seconds. Images were reconstructed at 50-msec intervals. The visualization of wall motion was qualitatively evaluated by direct comparison of four-dimensional images versus phantom motion. Pulsatility imaging without perceptible artifact or need for cardiac gating was achieved with the use of this technique.

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Abbreviations: ECG = electrocardiographic, 4D = four-dimensional, 3D = three-dimensional

INTRODUCTION

IN the evaluation of aneurysms, factors other than size, such as wall thickness, hemodynamic factors, and focal shear stresses on the aneurysm wall, may influence the risk of rupture (1). Multislice computed tomographic (CT) angiography with two- and three-dimensional (3D) reformation is a robust technique for the evaluation of aneurysms (2); however, images obtained with this technique only provide static information about size and morphology. Identifying wall motion abnormalities such as asynchronous pulsation or focal ballooning of an aneurysm dome can potentially help to risk-stratify aneurysms based on their pulsatility (3,4). Recent work with electrocardiographic (ECG)–gated multislice CT angiography has shown that aneurysm wall motion can be imaged in four dimensions by adding the dimension of time to 3D images (3,5); however, artifacts associated with this technique occur and can potentially limit the usefulness of this technique (3,6).

We report four-dimensional (4D) imaging of aneurysm phantom pulsatility with the dynamic multiscan method and show improvement in image quality compared with ECG-gated imaging.

MATERIALS AND METHODS

Aneurysm Model

A pulsating aneurysm phantom was constructed in our laboratory. A polyvinyl tube with an inner diameter of 9.5 mm and wall thickness of 1.58 mm was used as the model for the parent artery. A 4-mm hole representing the neck of aneurysm was drilled in one side of the tube. Dome-shaped sidewall aneurysm with nonuniform wall stiffness was constructed with latex and attached to the polyvinyl tube over the 4-mm neck with a commercial sealant. The maximal diameter of the aneurysm at full expansion was 10 mm. The tube and aneurysm model were secured in a water-filled container to simulate a soft tissue environment and to decrease motion of the model secondary to table translation. The tubing was filled with diluted nonionic contrast medium (Omnipaque-350; GE Healthcare, Waukesha, Wis) to obtain a density of 250 Hounsfield Units. The tubing was connected to a blower pump (SP60-30; Iwaki America, Holliston, Mass), which circulated the contrast material with a pulsation frequency of 69 beats per minute (**Fig 1**; Movie 1). The aneurysm model had visible asymmetric wall motion as a result of the nonuniform wall stiffness.

Imaging Technique

The model was scanned with use of a 64-slice CT scanner (Sensation Cardiac 64; Siemens Medical Solutions, Malvern, Pa). The pulsating aneurysm

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Three video segments pertaining to this case are available online at *www.jvir.org*.

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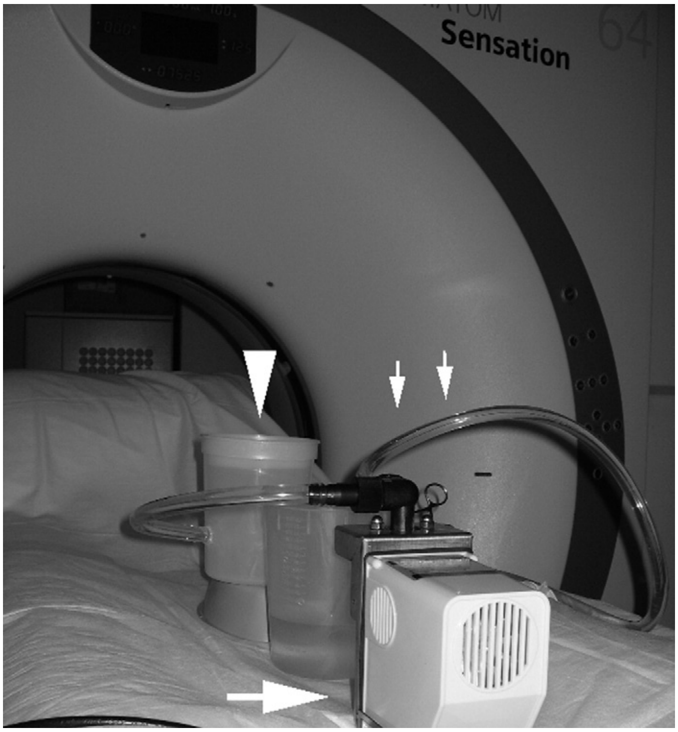

Figure 1. Phantom pulsation was achieved by creating a closed-circuit loop that circulated diluted contrast material via a polyvinyl tube (small arrows) from a blower pump (large arrow) to the aneurysm phantom suspended in a water-filled container (arrowhead). There was continuous pulsation of the aneurysm model during image acquisition.

phantom was first scanned with the dynamic multiscan technique. Immediately afterward, the same phantom was imaged with use of ECG-gated technique.

Dynamic Multiscan Technique.—Dynamic multiscan technique uses rapid and continuous helical image acquisition without table movement. This technique has been used in CT perfusion imaging (7). Imaging was performed with a gantry rotation time of 0.33 seconds and a slice thickness of 1.2 mm with an effective scan width of 24 mm (20 × 1.2 mm). This is the widest possible area of coverage with the thinnest slice available for multiscan acquisition on this scanner. The tube current and voltage were set to 150 mA and 100 kV, respectively. These settings were selected so a similar radiation dose as the ECG-gated method was delivered to the phantom. The model was continuously imaged for 4 seconds so at least two pulsations were imaged. Source data image reconstructions were performed with 1.2-mm slice thickness with a temporal resolution of 50 msec.

ECG-gated Technique.—Detailed description of this technique is beyond the scope of this article and has been previously reported (8). Briefly, simultaneous acquisition of 64 slices is performed as the ECG signal is recorded to match the helical acquisition to specific phases of the cardiac cycle. With retrospective ECG gating, data acquired within several cardiac cycles can be combined to create 4D images by mapping the 3D spatial information to the sequential time relationship of the cardiac cycle. ECG-gated images were obtained with retrospective gating technique with tube current of 900 effective mA, voltage of 120 kV, gantry rotation time of 0.33 sec, pitch of 0.2, and slice thickness of 0.6 mm. A time-optimized partial scan–based helical algorithm was used. The scan time with the retrospective ECG-gating technique was 4 seconds so at least two pulsations were completely imaged. The scanner generated an artificial ECG tracing. To maintain uniform image quality, ECG-controlled tube current modulation, an option for reducing radiation on this scanner, was not used. ECG-gated source data image reconstruction included 0.6-mm slice thickness with 0.4-mm overlap.

Image Display

Four-dimensional images were generated and evaluated on a Leonardo workstation (Siemens Medical Solutions). Mapping the 3D spatial information to the specific time points during image acquisition created 4D images. Images obtained by the dynamic multiscan method do not require cardiac gating and were separated based on their acquisition time (ie, time resolved). The images obtained with the ECG-gated method were reconstructed at 10% intervals during the R-R interval (a total of 10 phases) to create the 4D data set. Two attending radiologists blinded to the imaging method (A.S., M.T.W.) evaluated the phantom and 4D images from each technique for differences in overall image quality and degree of artifact. The evaluation of image quality was performed on a five-point scale (1, poor; 2, acceptable; 3, good; 4, very good; 5, excellent). The evaluation of artifact was also performed on a five-point scale ranging from 1 (indicating no artifact) to 5 (indicating significant artifact). The mean score for each method was calculated.

RESULTS

Aneurysm wall motion was imaged by dynamic multiscan and ECG-gated methods. Four-dimensional images obtained by the dynamic multiscan method showed no artifactual motion when visually compared with the motion of the phantom. In addition, asymmetric wall motion in the aneurysm was visible and corresponded to the motion of the phantom (**Fig 2a–c**; Movie 2). This was in contrast to the ECG-gated technique image acquisition, which generated artifacts that degraded image quality. With the ECG-gated method, an artifact simulating a wavelike motion in the aneurysm parent artery and background structures was seen (**Fig 2d–f**; Movie 3). This was not seen with the dynamic multiscan method and on direct visualization of the phantom. There was also apparent distortion of the aneurysm surface with the ECG-gated method that was not present on direct visualization of