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Determination of accurate stent graft configuration in abdominal aortic aneurysm using computed tomography: a preliminary study☆

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Abstract

An aortic stent graft is frequently used to cure an abdominal aortic aneurysm (AAA). It is critical to accurately fit the size and shape of the stent graft to the target region on the aorta. Proper sizing and shaping require the measurement of the orthogonal diameter of the target region from medical images. The present study aimed to acquire an accurate three-dimensional (3D) reconstruction of the aorta to determine the shape of the cross-sectional area where the stent graft would be implanted. A conventional geometric-active contour model was enhanced to prevent blurring and to improve edge detection with high noise resistivity. After the segmentation of two-dimensional (2D) images using the model, a 3D-reconstructed configuration of the aorta was achieved using a surface-rendering technique. The model could segment several selected synthetic images more accurately than conventional methods. Also, a 3D-reconstructed configuration of the abdominal aorta could be achieved using boundary coordinates extracted from 2D image segmentation. This preliminary study indicates the utility of the approach in optimizing stent graft configuration for AAA patients, thus enhancing stent graft healing.

Keywords: Abdominal aortic aneurysm; Stent graft; Image segmentation; 3D modeling; Morphological gradient edge function

1. Introduction

Abdominal aortic aneurysm (AAA) is a vascular disease involving an enlargement of the abdominal aorta due to a weakened aortic wall, which can be fatal [1–3]. If left untreated, the progressively expanding AAA increases the risk of aortic wall rupture. In treating AAA, the stent graft procedure has been increasingly accepted and used over the past decade. However, despite the satisfactory results of aortic stent graft implantation, some procedure-related complications have been noted on long-term follow-up [4].

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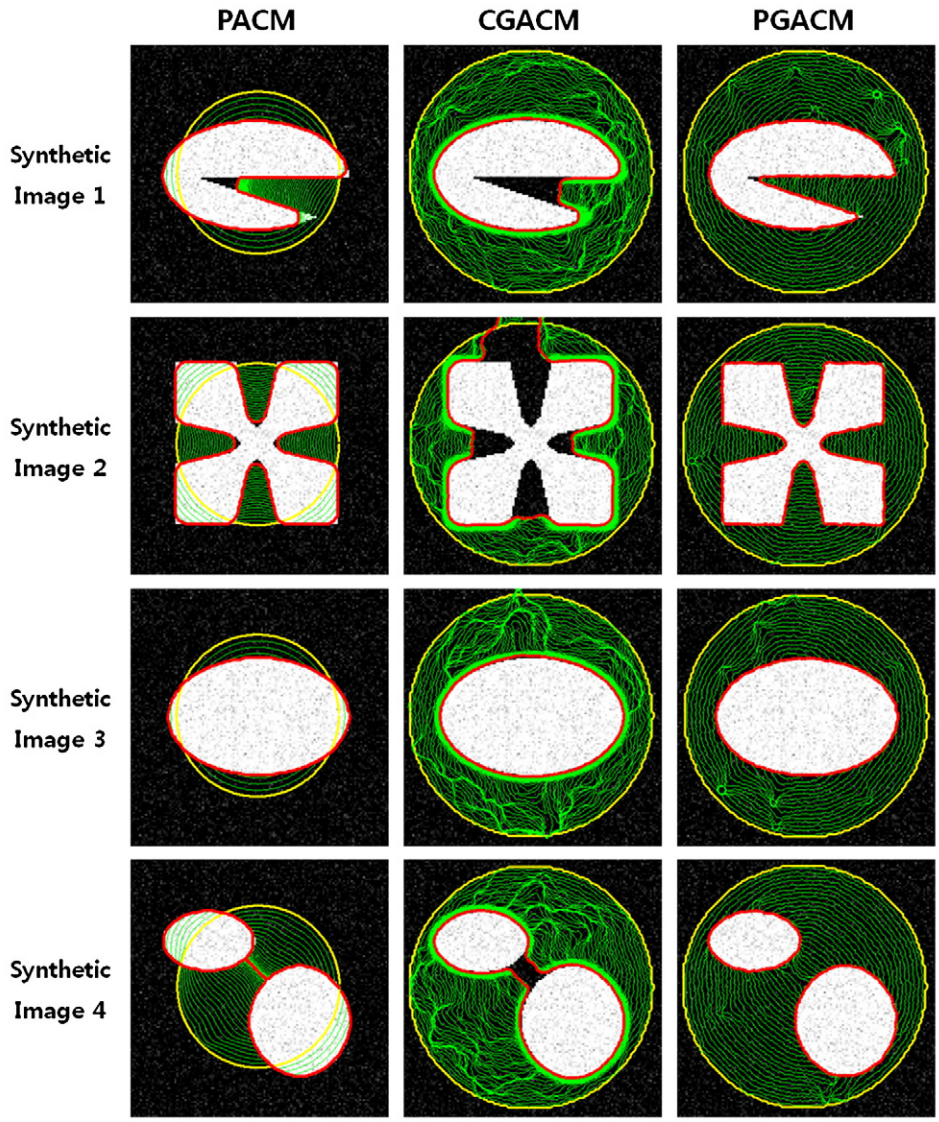

Fig. 1. Results of an edge detection performance experiment using Gaussian noise with synthetic images containing 0 mean and 0.01 variance. PACM: scale parameter=2, iteration=70; CGACM: scale parameter=2, iteration=700; PGACM: structuring element=3, iteration=700.

One of the most common and frequent of these complications is perigraft endoleak, which is induced by a mismatch between stent configuration and aneurysm morphology in the proximal neck of the aneurysm, distal common iliac arteries, or attachment zone of the graft limb [5]. For the prevention of perigraft endoleak, it is important to fit exactly the size and shape of the stent graft to the implanted region on the aorta. For the manufacture of the stent graft configuration in accordance with the implanted region, accurate information on the size and shape of the implanted region must be extracted from various medical images of the AAA patient.

Recently developed computed tomography (CT) approaches such as axial CT supply a volume-rendering function that automatically constructs a three-dimensional (3D) configuration of the aorta [6]. However, volume-rendered 3D imaging has poor resolution and, as a result, accurate extraction of the orthogonal shape of the cross-sectional area is difficult. In addition, the orthogonal diameter of the target area must be measured manually from the image, making inaccuracy and poor precision inevitable. Several studies have reported that axial CT frequently overestimates the diameter of the target area where the vessel is bent [5,7–9]. In addition, other studies have reported that the aneurysmal aorta interobserver variability in axial CT is 2.8–4.3 mm for the anteroposterior (AP) diameter [10–12] and 7.0 mm for the transverse (TR) diameter [11]. Another study reported that an ultrasound image can approximate an accurate perpendicular diameter of the aorta better than an axial CT image [7]. The latter researchers reported that when the bent angle of the aorta exceeded 25°, axial CT could not reliably extract the diameter, while the capability of ultrasound was not affected. However, even ultrasound can be subjected to interobserver