

**CARS2010****Section: CARS****ID:** 0299**Abstract Title:**

Thrombus Change Detection after Endovascular Abdominal Aortic Aneurysm Repair.

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**Purpose** A surgical technique currently used in the treatment of Abdominal Aortic Aneurysm (AAA) is the Endovascular Aneurysm Repair (EVAR). This minimally invasive procedure involves inserting prosthesis in the aortic vessel that excludes the aneurysm from the bloodstream. Nevertheless, in a long term perspective different complications such as prosthesis displacement or bloodstream leaks into or from the aneurysmatic bulge (endoleaks) could appear. At present Computed Tomographic Angiography (CTA) is the preferred method for stent graft monitoring. The purpose of this work is to study the application of image registration techniques to the detection of changes in the thrombus in order to assess the evolution of the aneurysm. Prior to registration, both the lumen and the thrombus are segmented.

**Methods**

We estimate the volumetric variations, as well as the deformations of the thrombus in a patient, (across different studies), registering the lumen of the aorta of the datasets to be compared, in order to place the respective thrombi in the same reference system, so that the comparison becomes meaningful. This registration is necessary because the relative position of the aorta varies from different studies of the same patient along time.

Fig.1: Pipeline of the thrombus change detection process

The pipeline of the process can be seen in Fig. 1. First, the lumen is segmented using a 3D region growing algorithm, followed by the calculation of the aorta centerline. The thrombus is segmented using a radial model approach. After that, the registration of the lumen extracted for two datasets of the same patient obtained at different moments in time is computed and then, the obtained transformation is applied to the thrombus. Next, we proceed to describe each component of the system.

*Region Growing based Lumen Segmentation*

Segmentation of the lumen is based on a 3D region-growing algorithm. At least a seed point placed in the lumen is required for the region growing algorithm to start. The algorithm, implemented in Insight Toolkit, includes voxels that lie in a confidence interval of the current segmented region in an iterative process

*Centerline Extraction*

The centerline approximates at each slice the centroid of the lumen region, and is a good approximation for the morphological skeleton of the aorta. It also serves as the starting point for the thrombus segmentation. A single point on the center-line is obtained for every slice, since the aorta is almost normal to axial slices. The center-line extraction is performed on a slice-by-slice basis using 2D image moments.

### *Thrombus Segmentation*

The internal and external radii of the thrombus of the aneurysm are modeled as radial functions in cylindrical coordinates.

At every value, the origin of these functions is chosen to be the centerline point at the corresponding slices. The external and internal radii of the thrombus and the aneurysm can be defined as two contours. The segmentation procedure consists of calculating the internal and external radii at every point, which enclose the segmented region corresponding to the thrombus.

### *Lumen Registration*

Binary images are obtained after segmentation process. Once the structures of interest are segmented, a 3D volume registration is performed. This corresponds to an intra-subject, mono-modal registration, as it examines the same patient on different dates. A sequence of rigid, affine and deformable (B-splines) registration procedures is performed. The earliest CT volume is considered the reference image and the others are registered relative to it. A linear interpolator, Mattes Mutual Information metric and Regular Step Gradient Descent Optimizer are used.

First, the two images corresponding to the patient lumen are roughly aligned by using a transform initialization and then the two images are registered using a rigid transformation. The rigid transformation is used to initialize a registration with an affine transform of the lumen. . The transform resulting from the affine registration is used as the bulk transform of a BSpline deformable transform.

### *Apply the Transformation to the Thrombus*

The registration process yields the transformation parameters that will be used to transform the thrombus of the moving images to the same reference system that we have the fixed image, to compare the volume changes and the deformation of the thrombus.

**Results** We have tested the approach with 3 patients –with 5 datasets each- which have been treated with stent-graft devices. The CT image stacks consists of dataset obtained from a LightSpeed16 CT scanner (GE Medical Systems, Fairfield, CT, USA) with 512x512x354 voxel resolution and 0.725x0.725x0.8 mm. spatial resolution. The time elapsed between different studies of the same subject varies between 6 and 12 months. The resulting application is currently being validated by the Vascular Surgery Unit and the Interventional Radiology Department of the Hospital X.

Fig. 2: Thrombus extracted for two points in time (semi-transparent blue for the first one, semi-transparent red the second one), both referenced to the lumen of the first point in time. It can be seen an increase in thrombus volume.

The segmented images are visualized in 3D together with a CT slice to have a referenced view. After the lumen is registered, volumetric changes and deformation of the thrombus from one point in time to the next can be visualized (Fig. 2).

**Conclusion** We have developed a method that places the thrombi of different datasets of the same patient referenced to the lumen of the first dataset. The method allows detecting small changes in volume or deformation of the thrombus that may go unnoticed for radiologists while comparing individual slices of the same patient along time.

With our method, any change in volume can be detected easily.

In the future, we expect to obtain quantitative values of the changes in the thrombus after register images from different studies of the same patient. This could lead to a model that could predict the evolution of other patients and provide

quantitative measurements for decision support. Support Vector Machines (SVM) will be used to determine if the evolution of the EVAR is positive or not. These data will be integrated into a more complex database, where information about patients and monitored aneurysms will be available for comparative studies..

fig.1

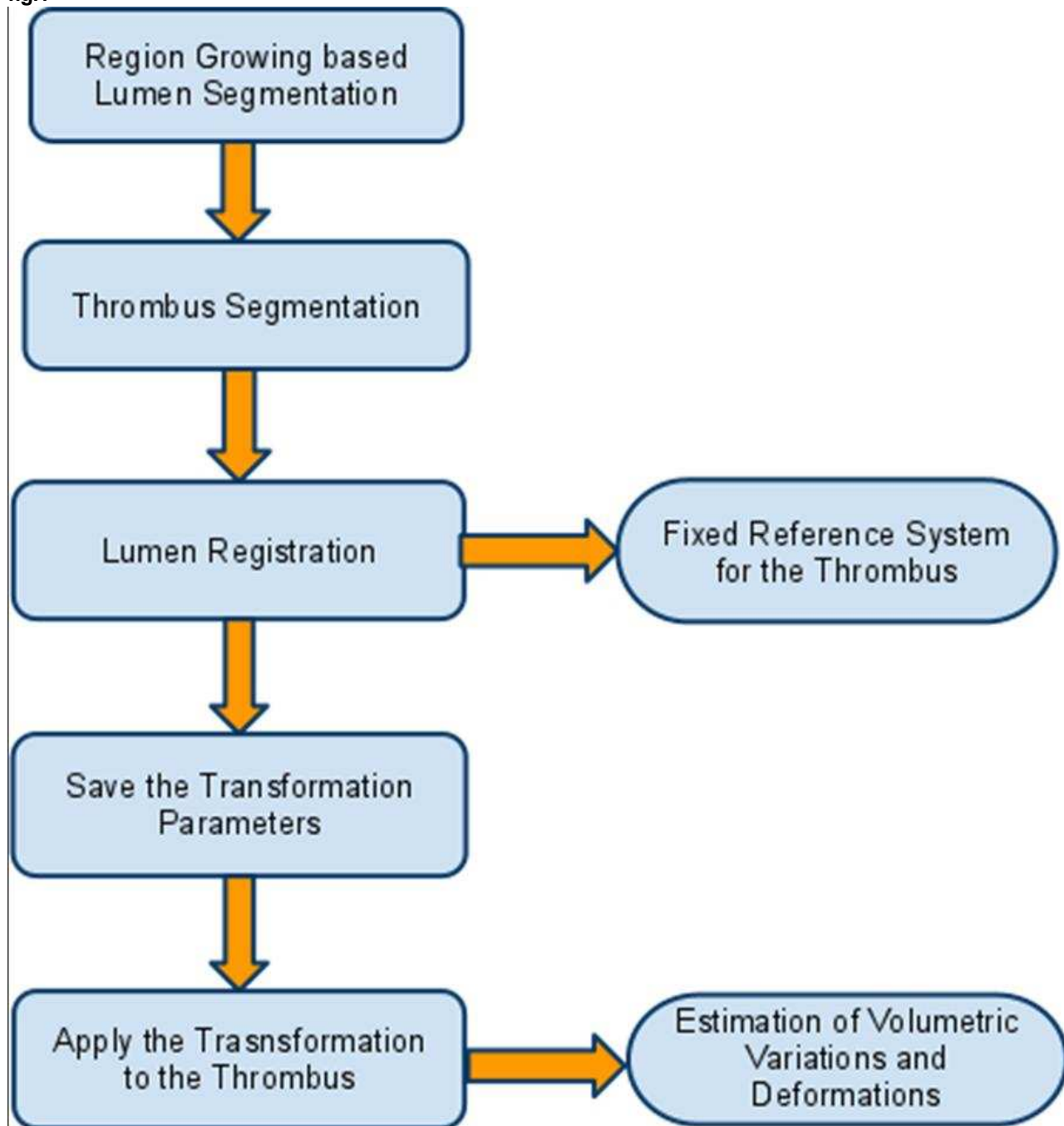


fig.2

