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# Growth prediction of abdominal aortic aneurysms and its association of intraluminal thrombus

**Seungik Baek[1], Byron A. Zambrano[1], Jongeun Choi[1,2] and Chae-Young Lim[3]**

[1] Department of Mechanical Engineering (sbaek@egr.msu.edu, zambran2@msu.edu)
[2] Department of Electrical and Computer Engineering (jchoi@egr.msu.edu)
[3] Department of Statistics and Probability, Michigan State University, Lansing, USA (lim@stt.msu.edu)

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A body of literature garners the importance of the intraluminal thrombus layer (ILT) as a key factor for the abdominal aortic aneurysm associated with its growth and rupture. There are, however, multiple, often opposite views, on the role of ILT regarding to the pathological, biosolid, and biofluid aspects. Hence, there is a significant need to understand how the ILT is associated with the growth and the rupture and how an aneurysm, with a given patient, predicts its aneurysmal growth. In this work, we use existing patients' CT data and investigate the association of the ILT in the aneurysm growth rate, with general and localized trends, and its role of biomechanics. We discuss a statistical framework using a computational model of aneurysm growth, which will empower the prediction capability for the clinical management.

## Method

The first set of 39 CT images from 9 patients is used to generate multiple hypotheses for AAA expansion and biomechanics associated with ILT. For this purpose, the current data set is classified according to the ILT content in patients with low and high ILT. This classification enables us to identify the effect of ILT on the AAA expansion process. For both group of patients, lumen and AAA outer surfaces from each CT data were segmented and registered according to the junction of the centerline iliac branches as a reference point and the renal level as direction for alignment. Surface expansion measurements and ILT thickness were used to analyze AAA expansion and ILT content along the centerline. Surface expansion and ILT thickness were obtained by circumferentially averaged local values of surface displacement and ILT thickness respectively. Surface displacement is defined locally as the normal distance between two consecutive AAA outer surfaces while ILT thickness is defined as the normal distance between AAA outer and lumen surface of a given scan.

## Results

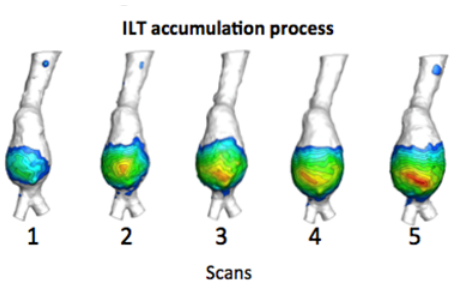
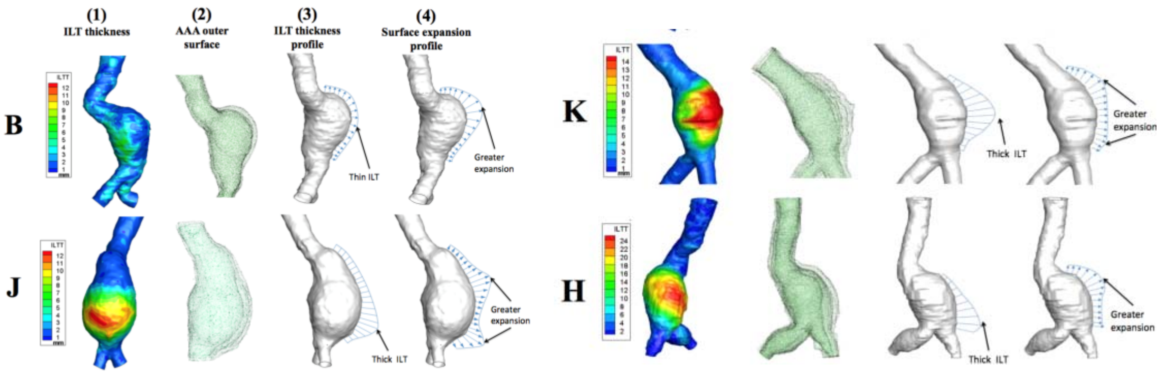



**Figure1. ILT accumulation process explained using patient J. From this patient it can be seen at the first scan with a small accumulation that at later scan spread to the surrounding regions associated with an increase of ILT thickness**.

The onset of ILT accumulation seems to begin by a small-localized accumulation at further regions from the centerline, as observed in patients that showed high ILT, classified as "the high ILT group" (figure 1). This localized accumulation spread to the surrounding regions as the aneurysm enlarges. At the same time that ILT spreads, an increase of ILT thickness was observed at the areas previously covered by ILT. Over the same regions, a slowdown of the expansion was seen as the ILT thickness increases. This effect is not seen in the patients with the low ILT group that showed an increase of the surface expansion with an increase of the diameter. These results are explained in figure 2 that sketched ILT thickness and surface expansion profiles for patients with low (patient B) and high ILT (patients J, K, H). In patients with low ILT, an increases of the surface expansion is seen as the diameter increases while for patients with high ILT (patients J, K, H), a slowdown of the expansion is observed as the ILT thickness increases.

**Figure 2. Columns: (1) shows the ILT thickness. While patient B shows a very low or no thrombus accumulation, patients J, K, and H are classified as the high ILT group. (2) shows the expansion of the aneurysm surfaces overlapped using longitudinal images. (3 and 4) show sketches of ILT thickness and expansion profiles for patients according to what was consistently seen in the patients at all scans.**




## Conclusion

We found that the relationship between AAA's expansion rate and maximum diameter can be modulated by the inhomogeneous distribution of ILT thickness. In general, the presence of ILT is associated with the aneurysm expansion rate. Nevertheless, a slowdown of the expansion was found in the areas of thick ILT. This could be an evidence to support both competing hypotheses but ILT plays their role at different times, initial stage with thin ILT and later stage with both low ILT and high ILT regions. In addition, there is an evidence to support a hypothesis that ILT would form in order to maintain the lumen area cross section. Finally, in patients with high ILT, the maximum expansion rate did not always occur at the location of the maximum diameter, which in turn is the location of thicker thrombus. Although it is a matter of debate, recent studies reported that an exponential and logistic function can capture the growth of a localized abdominal aortic aneurysm (AAA) [1]. For patient-specific clinical management, it is important to calibrate computational growth and remodeling model taking into account given subject's longitudinal CT images. A statistical framework for calibrating the computational model in a patient-specific manner shall be developed to fuse growth and remodeling computation, prior distributions of internal parameters, uncertainty models, and patient-specific data. This will improve quality of prediction of AAAs and its uncertainty for personalized diagnosis, management, and surgical planning tool.

## REFERENCES

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