

Impact of Rigid Versus Dynamic Boundaries on Computational Fluid Dynamics Predictor of Left Atrial Appendage Thrombus Formation

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Aims: Reduced movement of the left atrium (LA) during atrial fibrillation (AF) is often used to justify rigid walls in computational fluid dynamics (CFD) simulations, although this assumption is only valid in persistent AF. This study aimed to investigate the effects of rigid vs. dynamic wall movement on commonly computed predictors of thrombus formation in the LA appendage (LAA) and risk of stroke, including low LAA ostium velocities and relative residence time (RRT).

Methods: We analyzed 4D-CT acquisitions of the LA in an AF patient using a verified and validated CFD solver. For the dynamic model, we applied patient-specific boundary movement registered from the CT as the wall condition, in contrast to a no-slip condition for the rigid model. At the pulmonary veins, we applied velocity profiles based on LA and left ventricular volume change. The computational model consisted of 3.6M cells, and included boundary layers to properly capture hemodynamic forces related to flow stagnation such as RRT.

Results: Low LAA ostium velocities averaging at $5.0 \cdot 10^{-3}$ m/s during atrial diastole and $6.0 \cdot 10^{-2}$ m/s during atrial systole were observed in the rigid model, which was 84% and 7.7% lower than the dynamic model, respectively. Mean LAA RRT values reached close to $1.7 \cdot 10^7$ 1/Pa in the rigid model, compared to $1.3 \cdot 10^2$ 1/Pa measured in the dynamic model, as shown in Figure 1. For the remaining LA lumen, there was only a $\pm 5\%$ change in RRT.

Conclusion: The preliminary results suggest that dynamic walls have a considerable impact on the hemodynamics and predictors of thrombus formation in the LAA, but have no noticeable impact in the LA lumen. Although we have demonstrated these effects in only one AF patient, the results indicate that risk stratification based on computational models should be performed with caution.

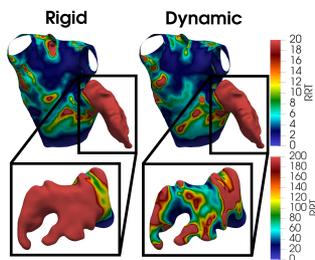


Figure 1: Qualitative results show visible differences, particularly in the LAA.