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Variability of atrial blood stasis estimates from patient-specific CFD simulations

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The global incidence of ischemic stroke is 18 million per year. Approximately 30% of these strokes are caused by emboli originating at the left atrium (LA) of atrial fibrillation (AF) patients. Up to 30% more are highly suspected of being atrioembolic in patients with subclinical fibrillation or in sinus rhythm. Current tools to estimate ischemic stroke risk focus on patients in AF only and are based on population demographics and comorbidities. These tools do not consider patient-specific information about intracardiac flow, a crucial mechanistic factor in thrombogenesis, and have modest predictive accuracy.

Computational fluid dynamics (CFD) analysis based on patient-specific medical image data is a powerful tool to investigate the mechanistic underpinnings of atrial thrombogenesis. However, CFD-based predictions need to consider physiological sources of uncertainty coming from e.g., variations in inflow conditions caused by body posture changes, cycle-to-cycle variability, etc. To address this issue, we compiled a database of patient specific CFD simulations of LA flow. We performed simulations using an in-house solver fed with patient-specific anatomies obtained from 4D CT scans [1]. The database has N=20 patients covering a wide range of atrial function and including cases in sinus rhythm and AF. For each anatomy, we varied the flow split between the pulmonary veins (PV) that drain into the LA within physiological values, resulting in a database with 60 simulations.

We found that the LA ejection fraction is a major determinant of flow kinetic energy and blood stasis in the left atrial appendage (LAA), i.e., the most common site of LA thrombosis. However, while the PV split influences the flow patterns in the LA body, it does not seem to drastically affect LAA kinetic energy or blood stasis. Our results suggest that atrial function (measured in terms of LA or LAA ejection fractions) has potential to improve current tools to estimate risk of ischemic stroke.

REFERENCES

[1] Garcia-Villalba et al., Demonstration of patient-specific simulations to assess left atrial appendage thrombogenesis risk. *Frontiers in Physiology*. 2021.