THROMBUS MECHANICS: FROM MICROSTRUCTURE TO IMAGING AND DEVICE DESIGN

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Background

Thrombi play a crucial role in two vascular diseases. If a gets lodged in an intracranial artery, this may lead to local reduction of blood flow to the brain, inducing an acute ischemic stroke (AIS). A thrombus can also form in the venous system, and if this happens in the legs, this leads to deep vein thrombosis (DVT). Although these diseases differ in aetiology, they also have something in common; patients benefit hugely from fast and efficient thrombus removal from the arteries in the brain or the veins in the leg.

Clinical studies show that mechanical removal of thrombi -also called thrombectomy- greatly benefits the patients. The two main approaches to thrombectomy are (i) thrombus removal by aspiration, and (ii) thrombus removal using a stent retriever. It is still unclear what the optimal treatment strategy during an interventional procedure is and what the best device design is for thrombus removal.

Multiscale thrombus models

The mechanical properties of the thrombus play a crucial role in thrombectomy; the interaction with the vessel wall, the large deformation imposed on the thrombus by the device, and the thrombus fracture properties determine the success of the procedure. Recently developed mechanical models of the thrombus to describe these properties in a quantitative manner, and how they are related to the microstructure, are key elements in supporting the impact of thrombus biomechanics on clinical applications. The relationship between the 3D structure of the thrombus, the interaction between the (active) components in the thrombus, and how this is reflected in imaging characteristics and macroscopic properties (figure 1) are the key elements of this perspective talk[1,2, 3].

Dr. Frank Gijsen is currently associate professor at the department of Biomechanical Engineering at the TUDelft and the department of Cardiology at the ErasmusMC, and he is Editor in Chief of the Journal of Biomechanics. His present research focuses on image-based cardiovascular biomechanics, with an emphasis on application of multiscale models on the prediction of the growth, remodeling and failure of cardiovascular tissues.

Current and future applications

Once these models are validated, they can be applied in optimizing the design of new devices and treatment strategies through *in silico* approaches. To improve the treatment of AIS and DVT patients, these thrombus models can be used to develop *in silico* tools for virtual intervention planning and simulated clinical trials, and develop *in vitro* and *in silico* methods for the design and optimization of new devices. These topics will also be addressed in this talk[3,4].

References

1. Boodt et al. Stroke52, 2021
2. Fereidoonnezhad et al., Acta Biomateralia, 2021
3. Cahalane et al., JBM, 2021
4. Luraghi et al, JBM, 2021
5. Bridio at al., FMT, 2021

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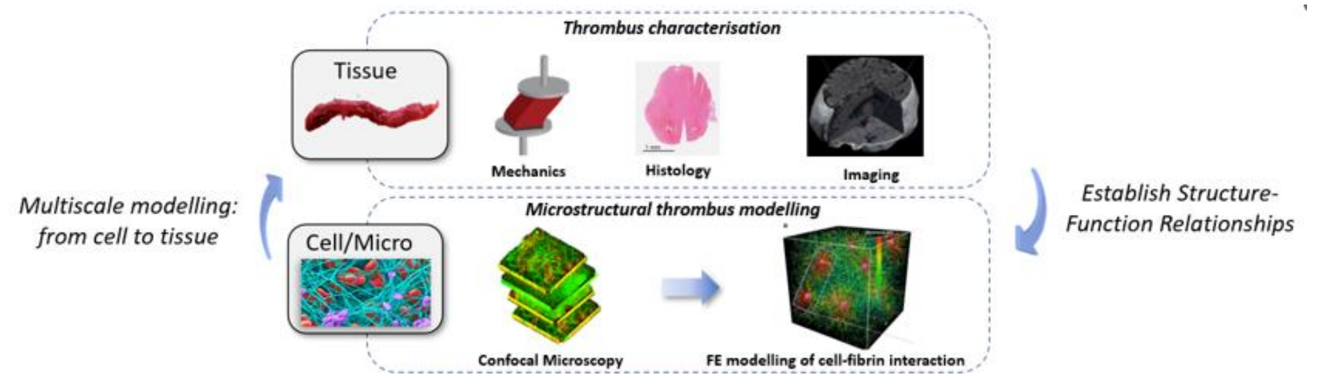

Figure 1: the relationship between microstructure and macroscopic behavior of thrombi