IMAGING AND MECHANICAL CHARACTERISATION OF HUMAN BLOOD CLOT ANALOGUES WITH DIFFERENT COMPOSITIONS AND DEGREES OF CONTRACTION

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Introduction

Stroke is the 2nd leading cause of death worldwide. Endovascular thrombectomy is the current standard of care for patients with large vessel occlusions. However, these procedures are not effective in up to 40% of the cases [1]. Thrombi causing stroke are diverse in their composition and mechanical behaviour. In addition, clot composition and contraction are known to affect thrombus behaviour [2]. Computed tomography (CT) could be a suitable modality to assess thrombus properties prior to the thrombectomy [3]. The purpose of this study is to examine the imaging and mechanical properties of clot analogues with different RBC compositions and degrees of contraction.

Methods

Clot analogues were made from citrated whole blood of six healthy human donors. Clots were made with five different red blood cell (RBC) contents: 0, 25, 77, 94 and 99%, which span the range of compositions from ex vivo thrombi. Also, clots were made with three different platelet concentrations: $30*10^3$, $90*10^3$, and $270*10^3$ platelets/µL, which result in a low, medium, and high level of contraction, respectively. Clinical CT imaging was performed to measure the density. Perviousness, which reflects the clot's permeability, was quantified by measuring the density after the administration of a contrast agent. Unconfined compression tests were performed and the high strain stiffness was obtained from the slope of the stress-strain curves at 75-80% strain.

Results

The compressive stiffness was significantly higher for the highly contracted clots compared to the low contracted clots (Fig. 1A). Within the high and medium contracted clot groups the stiffness tended to decrease with increasing RBC volume (Fig. 1B). Higher levels of contraction increased the CT density values (Fig. 2A). Also, the density values were higher for increasing RBC volume (Fig. 2B). Highly contracted clots tended to have higher perviousness values compared with medium and low contracted clots (Fig. 2C). There was only a significant difference in perviousness between the RBC volume groups within the highly contracted clot group (Fig. 2D).

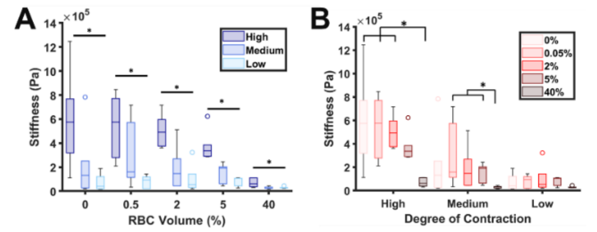

Figure 1: Clot mechanics. Compressive stiffness per (A) RBC volume group and (B) per contraction group.

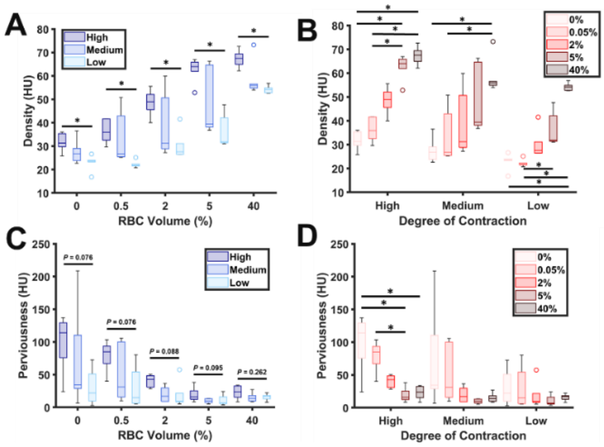

Figure 2: Clot imaging characteristics. NCCT density per (A) RBC group and (B) contraction group. Perviousness per (C) RBC group and (D) contraction group.

Discussion

We demonstrated that clot compressive stiffness is dependent on both the degree of contraction and RBC content. As expected, the clot CT density increased with increasing RBC content. For the first time we showed that the density also increased with increasing degree of contraction. The perviousness appeared to increase with increasing level of contraction, but is only affected by RBC content in highly contracted clots. The implication is that the assessed CT imaging characteristics alone cannot directly characterize a clot's RBC content and degree of contraction, and may therefore not be predictive of the mechanical behaviour.

References

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