3D virtual histology of thrombi through non-contrast-enhanced X-ray propagation-based microCT

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Motivation & Background

- Annually, 15 million people worldwide suffer a stroke, of which 5 million are left permanently disabled.
- A treatment choice for acute ischemic stroke (AIS) is Mechanical Thrombectomy (MTB)
- Characterization of thrombi composition can explain mechanical properties of clot and improve the outcome of MTB.
- The standard method for composition analysis is optical microscopy BUT:
  - Only for 2D characterization
  - Limited to small field of view
  - Needs staining (invasive)

Methodology

- X-ray propagation-based phase contrast microtomography:
  - 3D characterization
  - Full field of view
  - No contrast agent (non-invasive)
  - High resolution & phase contrast
- Different dried blood clot samples were analyzed through micro/nanoCT
- Correlation of microCT data with:
  - Scanning electron microscopy (SEM)
  - X-ray diffraction (XRD)
  - Electron dispersive spectroscopy (EDS)

Results

MicroCT reconstructed slices of two patient clots:
- A red-looking clot
- A white-looking clot, inset: 3D rendering of red blood cells (RBCs)
- MicroCT 3D rendering of a segmented white blood clot volume. The volume fraction of each Structure can be Calculated.
- Co-registration of microCT structural information with SEM images.

Analysis

- Aggregates or individual RBCs are distinguished as hyper-intense signal.
- Fibrin-platelet masses are detected as low to intermediate signals, depending on the compactness.
- Calcifications appear as glassy opacity.
- XRD (phase) and EDS (elemental) analysis confirm the nano-polycrystalline calcifications in microCT, detected as ground-glass appearance.

Conclusion & Outlook

- It was demonstrated that X-ray phase-contrast microCT can provide fibrillary and cellular structures of the whole clot volume without any contrast agent.
- RBC shape and sizes are consistent with high resolution SEM images.
- MicroCT can provide volume fraction of porosity and clot structures, important in the mechanical properties of a clot.
- In a large-scale study combined with radiomics analysis, the microCT data can be correlated with clinical CT data to characterize thrombi and help to choose the best MTB strategy for thrombus management.

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References