

Increasing the accuracy of 3D heart models based on micro-computed tomography

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Aims: Micro-computed tomography (micro-CT) is an imaging technique that allows for achieving resolution significantly higher than clinical computed tomography (maximum resolution is 0.5 $\mu\text{m}/\text{pixel}$). This technique enables obtaining precise three-dimensional images of examined objects along with their internal structure, combining the micro and macro anatomy of the organ. The aim of the study was to establish an optimal ex-vivo tissue processing protocol for micro-CT imaging to enhance the accuracy of commonly available 3D anatomical models of the cardiovascular systems.

Methods: Twenty pig hearts obtained within 24 hours underwent isolation, perfusion, and flushing with isotonic solution to remove clots. Samples were treated with immersion reagents (KI2 3%, 10%, preceded by formalin) and injection reagents for coronary arteries (KI2 3%, 10%, liquid BaSO₄ solution, epoxy resins with BaSO₄, and toothpaste). Parameters such as storage temperature, immersion time, injection substance density, and application method were considered. Eight hearts were scanned using GE Nanotom S at AGH's Micro and Nano Tomography Laboratory (I=200A, U=80V, 60 μm) at AGH University in Krakow, Poland. Imaging parameters assessed contrasted structures, visualization accuracy, capillary passage, and attenuation level differentiation.

Results: Optimal results were achieved by injecting liquid BaSO₄ solution into coronary arteries, thickening under cold temperature. This solution prevented capillary blockage and leakage post-solidification. Immersion contrasts performed poorly, failing to visualize coronary vessel divisions. Despite high-resolution mCT data, cyclic gamma disturbances occurred, corrected in Adobe Photoshop without affecting pixel value differences. Liquid BaSO₄ injection into coronary arteries under cold temperature yielded optimal results. Figure 1 (view from Dicom Viewer, WL: 21981, WW:27639).

Conclusion: the developed and tested protocol allowed us to obtain satisfactory results, we obtained a view of the vessels at the level of detail 0, 11mm.

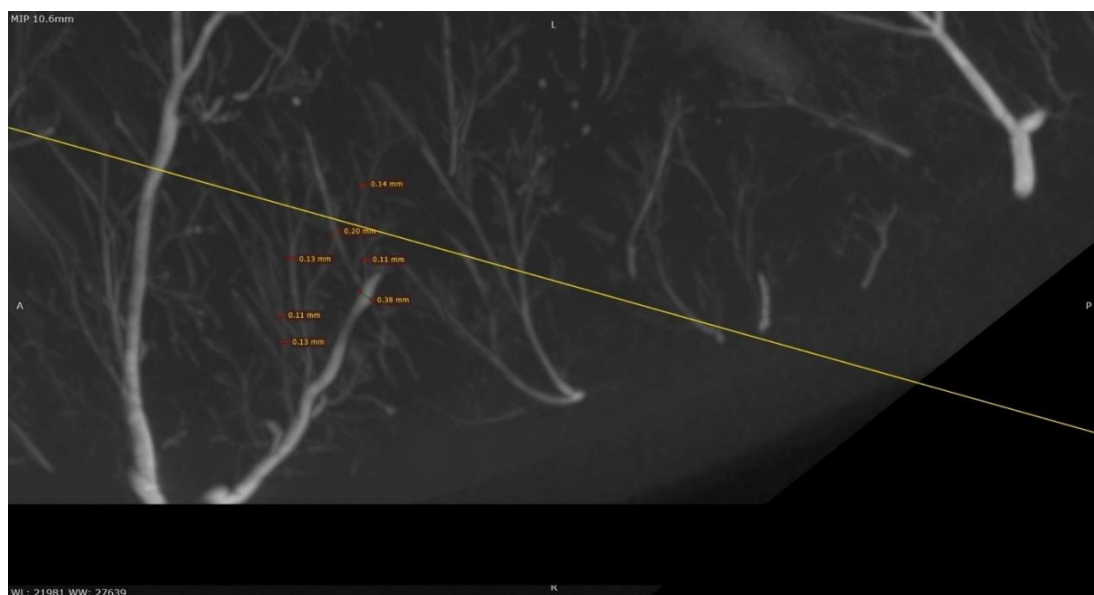


Figure 1. Viwe of obtained mCT data from Dicom Viewer, WL: 21981, WW:27639, measurements of the level of detail.