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 μm/pixel for the objects 1-2mm). 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, basic 3 parameters: (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.

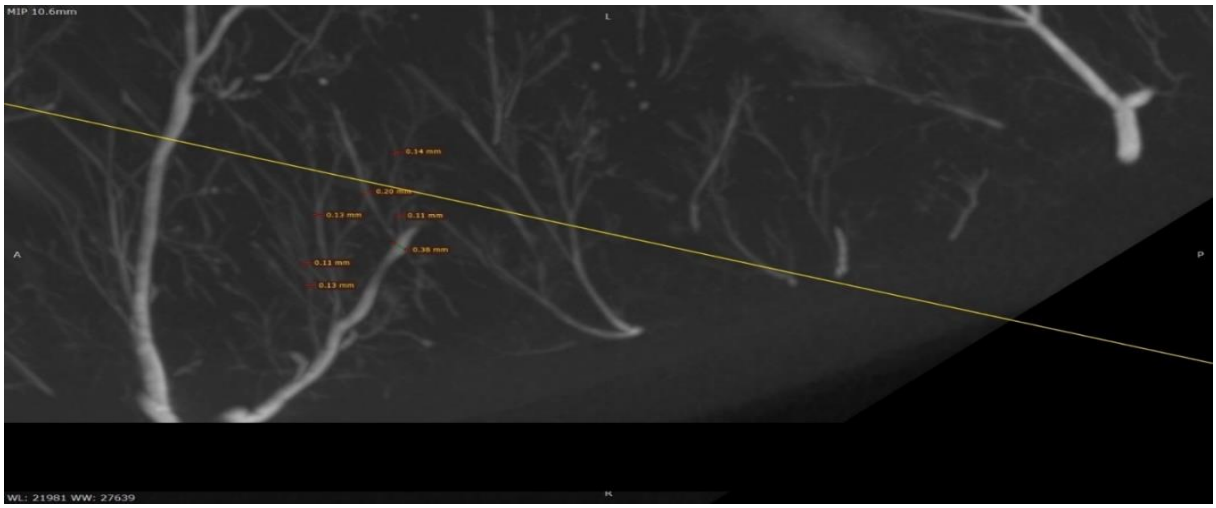

Figure 1. Viwe of obtained microCT data from Dicom Viewer, WL: 21981, WW:27639, measurements of the level of detail, e.g. one of the smallest vessel diameters: 0,11 mm.