

POPULAR SCIENTIFIC SUMMARY

The main cause of death in many countries, including Poland, are heart and circulatory system diseases. Among them, the highest risk of death is coronary heart disease and its complications. The diagnosis of the disease is based on the detection of atherosclerotic changes in the coronary arteries, causing the narrowing of the vessel lumen or changes causing blood clots. Coronary artery constriction reduces blood supply to the heart muscle. The essence of this disease is most often a periodic imbalance between the heart muscle's demand for oxygen, especially during exercise, and the possibilities of oxygen supply, which may consequently lead to a heart attack.

The standard treatment of coronary artery stenosis is a coronary angioplasty procedure, which consists in restoring a narrowed or closed arteries. The procedure is performed under local anesthesia at the puncture site of the femoral, radial or brachial arteries. A surgical guide is inserted through the puncture to the coronary arteries under the control of x-rays. Then, a balloon catheter is inserted over the guide, which is expanded in the lumen of the artery, causing the destruction of the atherosclerotic plaque and restoration of the coronary artery. In the case of large narrowing of the vessel's lumen, a metal mesh (so-called stent) is also inserted to ensure better maintenance of vessel expansion.

Coronary angioplasty carries a certain risk of complications during and after surgery. The risk depends on the structure and complexity of the patient's coronary vascular system, the location of the stenosis, and the severity of the vascular disease. The serious intraoperative complications include sudden closure of the coronary vessel, perforation of the coronary artery, secondary myocardial infarction due to the closure of the lateral branches of the coronary arteries and the formation of blood clots, cardiac arrest and sudden cardiac death.

In order to minimize the risk of complications, a great facilitation in angioplasty procedures will be the ability to accurately reproduce the three-dimensional anatomy of the coronary arterial system before the planned intervention and the possibility to perform a virtual surgery in the patient, reflecting the individual anatomy of the coronary vessels. The aim of the project is to create automatic methods to create real models of coronary vessels and appropriate simulations of treatments in conditions similar to real ones using the virtual reality technique, reflecting the real anatomy of the coronary artery system, so that the doctor performing the procedure could perform it in simulated conditions, before the actual surgery.

To achieve these goals, appropriate algorithmic solutions in the field of image processing, machine learning, artificial intelligence and computer modeling will be developed to automate the diagnostic and therapeutic process. The innovative nature of the research includes the creation of methods allowing for automatic segmentation of coronary vessels from computed tomography, detection of their narrowing and simulation of the procedure in virtual reality conditions. The target result of the Project implementation will be the first research work of this type, with a potentially groundbreaking importance for diagnostics and cardiological therapy. As at the date of submitting the application, there are no competitive solutions based on a similar research methodology available worldwide.