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ARTreat: A multiscale model for prediction of atherosclerosis

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On August 31st, 2013 the ARTreat project successfully ended after 60 months of intense activities. It created a 3D image reconstruction of the arteries and modelling of blood flow and plaque. An interview with the coordinator, Prof. Parodi, sheds more light on this interesting project.



[1]

The ARTreat project (ICT-2007, FP7-224297), entitled “Multi-level patient-specific artery and atherogenesis model for outcome prediction, decision support treatment, and virtual hand-on training” just came to an end. The project was coordinated by the National Council of Research (CNR) of Italy, managing a total of 20 EU partners who provided a multidisciplinary approach (IT, biological, medical, bioengineering) to the project objectives.

An interview with the coordinator, Prof. Oberdan Parodi, will talk us through the project.

Prof. Parodi, could you please describe in a few words what atherosclerosis is?

Atherosclerosis is a disease of the arterial blood vessels (arteries), in which the walls of the blood vessels become thickened and hardened by "plaques." The plaques are composed of cholesterol and other lipids, inflammatory cells, and calcium deposits. The plaques can slow the flow of blood through the arteries, and if the plaques rupture, the blood flow can become completely obstructed.

Atherosclerosis can be easily confused with arteriosclerosis. Arteriosclerosis is a general term describing any hardening (and loss of elasticity) of medium or large arteries, while atherosclerosis is a

hardening of an artery specifically due to an atheromatous plaque.

What are the main goals ARTreat focused on?

ARTreat aimed to develop a multiscale and predictive model, which integrates:

1. 3D image reconstruction,
2. blood flow modelling,
3. modelling of the initiation and progression of the plaque and plaque characterization.

Around this three-level multiscale model, a treatment decision support system and training services have also been developed.

What are the key factors for success of the approach proposed by the project?

The early detection and prediction of the progression of atherosclerosis are crucial requirements towards improved treatment, and reduction in mortality and morbidity. Despite the many advances in imaging and functional measurements, determining optimal treatment strategies for patient with cardiovascular disease remained problematic.

In ARTreat, the integration of multiple types of anatomical and functional patient data produced from different technologies into a consistent framework helps in managing the complex care process of cardiovascular diseases (CVD), and provides support in prescribing the optimal patient treatment. ARTreat produced tools to assist doctors in making decisions and developing solutions act to minimize future therapy costs, by providing personalized treatment support.

What are the technological achievements reached over the course of the project?

From a technical point of view, compared to previous products for ATS diagnosis and prediction of progression, ARTreat has been able to provide an integrated platform offering several functionalities in terms of:

1. 3D artery reconstruction and plaque characterization from several different Imaging modalities (Intravascular Ultrasound and Biplane coronary angiography, coronary and carotid Computer Tomography, carotid Magnetic Resonance Imaging)
2. Blood flow modelling, in the above 3D models, taking into account of different properties for meshing, rigid walls, fluid structure interaction, and boundary conditions
3. Plaque progression modelling using several different user patient specific parameters as presented above.
4. Treatment decision support system that takes into account the knowledge provided by ARTreat combined with the existing clinical workflow.
5. Training services in terms of stent placement with a haptic device, border detection in all the above mentioned imaging modalities, plaque recognition and characterization from all the above mentioned imaging modalities.

From a medical point of view, how can ARTreat improve the current clinical practice?

The most innovative output of ARTreat platform lies in the development and validation of a patient-specific predictive tool of atherosclerotic plaque formation and progression, based on integration of systemic features with local features, namely artery anatomy, blood flow and particle dynamics. Local parameters were assessed by advanced imaging modalities (CT angiography, MRI), Computational Flow Dynamics and newly developed mass transfer computations.

Compared to previous studies, new features were included in the specific risk prediction model, including markers of systemic inflammation (monocyte activation, circulating levels of adhesion molecules) and HDL circulating levels.

Another relevant achievement beyond the state of the art was to develop a tool for clinical decision support. In the diagnostic workflow, no previous platforms integrated clinical information (risk scores, results of functional tests) with tools capable of predicting plaque progression from three level models. The development of such tools presents the ability to capture the complex and multi-factorial relationships that link underlying pathophysiologic mechanisms.

The major achievement of dissemination on how ARTreat can improve the current clinical practice has been represented by the organization of the International Workshop on the ARTreat results (Cape Sounio, Greece, May 2013), whereas all Consortium participated to the dissemination event by providing results on the project clinical and scientific outputs. The project results were presented to an audience of cardiologists, neurologists, biologists and bio-engineers involved in atherosclerosis research.

Has the ARTreat system been tested in a real clinical setting?

Although in a limited population, this predictive tool was tested against the most reliable end-point, namely a prolonged clinical and imaging follow-up of the atherosclerotic process.

By this approach, ARTreat platform not only is focusing on features correlated with plaque progression (systemic and local), but also infers on formation of de-novo plaques in apparently normal vascular territories at baseline evaluation.

The role of adhesion molecules, diabetes, low HDL and local wall shear stress in formation and progression of atherosclerotic plaques has been assessed in two groups of patients with coronary or carotid atherosclerotic disease, and used for modeling plaque growth in human beings, creating a tool for treatment decision support.

Do you already have plans for the future exploitation of these tools?

The application in patient-specific context makes ARTreat a promising system for application of the developed models to the clinical arena. Key steps needed to transform ARTreat prototypes into industrial products to be leaded in the Healthcare IT market of standalone medical devices software include two different phases after the project conclusion:

Phase 1 R&D and Validation: aiming at the finalization of product development activities (Artool Treatment and Interventional Decision Support System - TDSS and IDSS) design verification and technological improvement (including the migration to Web technology, fundamental step for the next Cloud based business model) as well as initiate the further developments of the additional and futuristic features of the technology (e.g. inclusion of genetic information in the patient specific model and/or environmental factors affecting the disease progression etc.).

Phase 1 is composed by two main development blocks: ARTreat 1 (2013-2018), which includes the steps, timing and resources needed to develop a solution to be validated and patented in preparation to the industrialization of the ARTreat project results, and ARTreat 2 (2013-2017), which includes the steps, timing and resources needed to develop the additional and futuristic features of the technology (e.g. inclusion of genetic information, other innovative features associated to disease progression, etc).

Phase 2 Market penetration composed of several steps that will start in 2015 with the market launch

of the training service application, followed by marketing and packaging of the ARTool, TDSS and IDSS (from 2018), and market penetration scenario for the 3 tools (from 2018).

Thank you professor.

The ARTreat project ran from 1/9/2008 until 31/8/2013.

Total cost of the project: 9.512.460 €

Contribution EU: 7.108.834 €

For more information, please visit the ARTreat website www.artreat.org [2]

This interview appeared on the website of the [VPH Institute](http://www.vph-institute.org) [3].

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