O-11: Initial study on detection of blood clots in the leg using a portable device for telemedicine applications

Mariella Särestöniemi[1,2], Dr. (Tech), Carlos Pomalaza-Raez[2], Ph.D. (Tech), Teemu Myllylä[1], Dr. (Tech), Jarmo Reponen[1,4], MD.
[1]*Research unit of Medical Imaging, Physics and Technology (MIPT), University of Oulu, Finland*
[2]*Centre for Wireless Communications, University of Oulu, Finland*
[3]*Purdue University Fort Wayne, USA*
[4]*Medical Research Center Oulu (MRC Oulu), Oulu University Hospital and University of Oulu, Finland*

Introduction: Interest in wireless portable medical monitoring and diagnosis systems has increased significantly, motivated partially by their potential to address widely recognized challenges related to the aging population and equality in rural area health care. Detection of blood clots in their early phase is essential to avoid serious thrombosis. Current methods to detect blood clots are usually MRI, CT, or ultrasound which require visit in the hospitals. In rural areas, patients with suspected blood clot may need to travel hours to get verification for blood clot. Thus, diagnosis of blood clots with portable devices would be essential for modern healthcare. There are initial studies on detection of thrombosis with electrical impedance spectroscopy [1]. However, there is a lack of studies which present detection methods of miniature sized blood clots with realistic models. Our study presents an initial study on blood clot detection in the leg area using microwave radio channel analysis.

Material and Methods: The evaluations are conducted with electromagnetic simulations using anatomical voxel model and directive antennas operating at the frequency range 1-6 GHz. A small blood clot is modelled as sphere with radius 2.25 mm and with dielectric properties (DP) determined in [2]. The blood clot is inserted in the vein located in the muscle tissue of the lower leg at the same horizontal cross-section as the antennas. The radio channel parameter S21 is evaluated between two on-body antennas in the presence and absence of the blood clot. The physical phenomenon behind this idea is that DP of the blood clot differ from DP of blood, which causes changes in the radio channel between the antennas. Thus, blood clots can be detected with intelligent radio channel analysis.

Results: The S21 channel parameters in the presence and absence of blood is presented in Fig.1. It is found that even small blood clots may change the radio channel response and hence, blood clots could be detected with radio channel analysis. In this case, the maximum difference is 1.2 dB at 3.6 GHz. Obviously, the impact of the blood clot depends on the clot size and location as well as frequency range. The next step is to evaluate the blood clots having different sizes in different areas. Besides, optimal antenna types with most appropriate frequency range, number and locations of antennas are studied to maximize the detectability of blood clots.

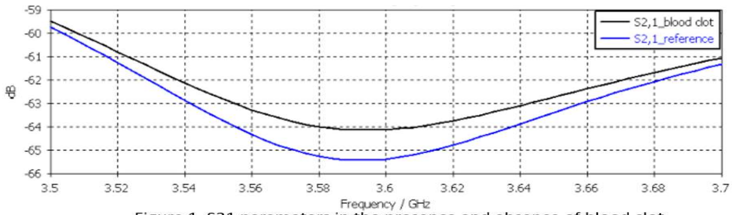

Figure 1. S21 parameters in the presence and absence of blood clot.

Discussion: This initial study presents the idea of detecting blood clots in the legs using a method based on microwave channel analysis. The first simulation results show that even small blood clot may cause detectable changes in the channel response. Further evaluations are needed to verify the detectability in different cases as well as study optimal types, number and location of the antennas. The proposed blood clot detection method could be realized with portable low-cost, low-power and safe devices which could be used as one of the telemedicine's advanced applications. The devices could be used in the ambulances or even at homes of the patients having clear risk for the blood clots, for instance after the surgery. In the case of blood clot suspicion, the patient could contact the hospital for further instructions, or even the device itself could inform the caregivers automatically. The proposed method would increase the equality in rural healthcare as well as enhance diagnosis in hospitals.

References:
[1] Jianping Li, et al, "Quantitative detection and evaluation of thrombus formation based on electrical impedance spectroscopy", Biosensors and Bioelectronics, Volume 141, 2019.
[2] Santorelli A, Fitzgerald S, Douglas A, Doyle K, O'Halloran M. Dielectric profile of blood clots to inform ischemic stroke treatments. Annu Int Conf IEEE Eng Med Biol Soc. 2020.