

ESTIMATING THE PERIODIC COMPRESSION OF THE CAROTID INTIMA-MEDIA USING ULTRASONOGRAPHY: A PROOF OF CONCEPT

S. Qorchi (1), M. Orkisz (1), D. Galbrun (1), A. Sérusclat (2), P. Moulin (3), G. Zahnd (4)

1. Univ. Lyon, Université Claude Bernard Lyon 1, CNRS, Inserm, CREATIS UMR 5220, U1206, F-69621, Lyon, France; 2. Department of Radiology, Hôpital Louis Pradel, Lyon, France; 3. INSERM UMR 1060 Department of Endocrinology, Hôpital Louis Pradel, Hospices Civils de Lyon, Université Lyon 1, Lyon, France; 4. Imaging-based Computational Biomedicine Lab, Nara Institute of Science and Technology, Japan

Introduction

Cardiovascular diseases are the leading cause of mortality in the world [1]. The carotid-artery intima-media thickness (IMT) is strongly correlated with cardiovascular diseases [2], but tends to overestimate the risk. Recently a promising predictor has been discovered: the IMT temporal variation during the cardiac cycle, which reflects the arterial stiffness and may be more sensitive than classical risk markers [3]. Few teams have worked on its estimation [3,4,5,6]; existing methods separately delineate the arterial wall in a series of B-Mode images to deduce a single IMT value at each time point. Their evaluation against contours manually traced in B-mode images is tedious and does not exploit the temporal consistency. In this paper, we investigate a less time-consuming process devised to create a temporally consistent manual reference.

Material and Methods

Study population: In this study, carotid-artery ultrasound (US) images of 34 healthy volunteers, 36 ± 15 years old, and 23 patients at high cardio-vascular risk, 56 ± 10 years old, were acquired. The volunteers were cardiovascular-risk-factor free, while the patients were suffering from diabetes mellitus or metabolic syndrome. Informed consent was obtained from all participants. The study fulfilled the requirements of our institutional review board and ethics committee. We randomly drew 15 subjects from each group to be our testing cohort; remaining data were used for training.

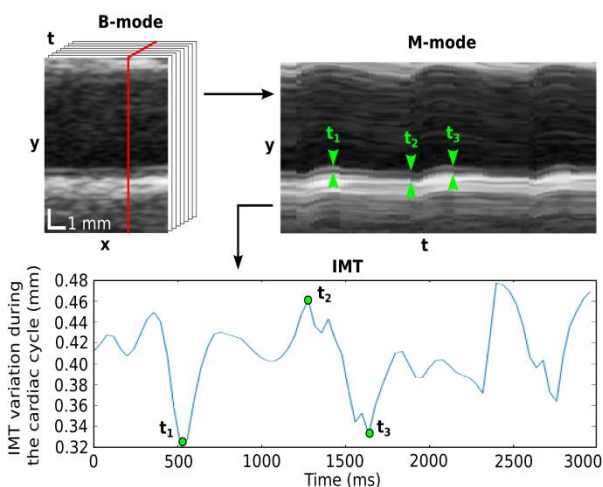


Figure 1: Pseudo M-mode image simulated from a B-mode sequence, and IMT variation obtained.

Simulated M-mode: Because it is difficult to trace contours in each frame of a B-mode US sequence consistently across time t , and because only one IMT value per frame is needed, we propose to trace reference curves in M-mode images. We mimicked the M-mode by taking a ty slice of the xyt volume representing a B-mode sequence. Actually, as such slices corresponding to a single x value show irregularities, spatial consistency was introduced by combining several slices.

Processing: For each subject, three observers, O1, O2, and O3, traced the lumen-intima and media-adventitia interfaces in the same M-mode image. Then O1 performed two additional tracings, in the same image and in an M-mode image from a different location, in order to assess intra-observer and spatial variability.

Results

Figure 1 shows an example of IMT temporal variation obtained in this study. Inter- and intra-observer variabilities among the curves were respectively of $68 \pm 59 \mu\text{m}$ and $71 \pm 89 \mu\text{m}$, and variability among curves obtained at different locations was of $106 \pm 56 \mu\text{m}$. The process took between 2 and 8 minutes per subject.

Discussion

This work confirmed the periodic compression of the carotid wall. Nevertheless, whereas the curves obtained in a subset of subjects are reproducible, the average variability of the measurements remains too high to create reliable reference in all cases. In the future work, we will investigate additional interactive tools devised to assist the user in the tracing process and take full advantage of the spatio-temporal consistency.

References

1. World Health Organization (WHO). Fact Sheet No. 317 at : <http://www.who.int/mediacentre/factsheets/fs317/en/>
2. Bots, ML. *et al.* Circulation 96(5):1432-1437, 1997.
3. Zahnd G. *et al.* Int J CARS, 9:645-658, 2014.
4. Ilea DE *et al.* IEEE UFCC, 60(1):158-177, 2013.
5. Cinthio M. *et al.* Proc IEEE US Symp 389-391, 2005.
6. Zahnd G. *et al.* Ultrasound Med Biol, 43:1,239-257, 2017.

Acknowledgements

This work was done within the framework of the LABEX ANR-11-LABX-0063 of Université de Lyon, within the program "Investissements d'Avenir" (ANR-11-IDEX-0007) operated by the French National Research Agency (ANR) and was partly supported by the JSPS #PE16208 funding.