Measurements of longitudinal movement of the arterial wall during breathing

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Background, Motivation and Objective

Longitudinal movement of the arterial wall (LMov) is an intriguing novel property (Am J Physiol 291:H394-H402, 2006). To avoid disturbing global motion due to breathing when recording LMov of the carotid artery, we normally ask the research persons to gently stop breathing. However, to be able to perform ultrasound investigations during interventions it is not always desirable to stop breathing. The aim of this study was to evaluate the performance of a novel phase averaging method that can remove global motion caused by breathing.

Statement of Contribution/Methods

4-6 cardiac cycles of the diameter change and the LMov of the right common carotid artery were recorded using an EPIQ 7 in 20 research subjects both during normal breathing, and when the subjects have gently stopped breathing.

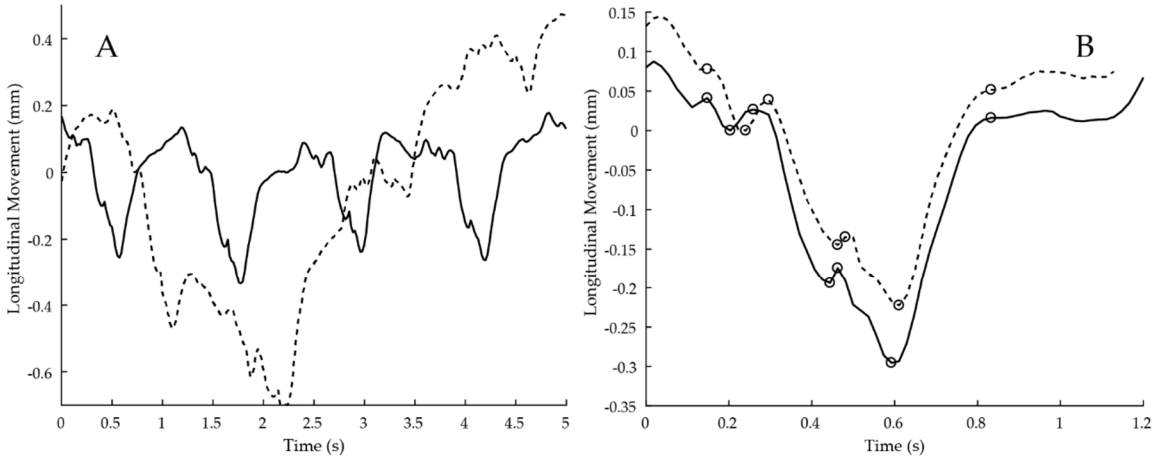
To estimate the averaged longitudinal movement during a cardiac cycle the movement curve was differentiated and Hilbert transformed into a complex signal. Based on the timing of end-diastole the complex signal was divided into equally long cardiac cycles. Then, each cardiac cycle was phase shifted to match the average phase of all cardiac cycles. Finally, all cardiac cycles were averaged in the corrected complex signal before taking the cumulative sum of the real part.

The agreement was evaluated using intraclass correlation coefficient (ICC) and Bland-Altman.

Results/Discussion

Figure A and B show an LMov curve both during normal breathing and when the subject has stopped breathing and the corresponding averaged movement curves. The maximal LMov was mean 434 µm and the five phases during a cardiac cycle (UMB 44:2283-2295, 2018) were mean 106, 328, 265, 101 and 22 µm, respectively. The ICC showed excellent agreement between measurement obtained during normal breathing, and when the subjects have gently stopped breathing, and ranged between 0.92–0.97 ($p < 10^{-7}$). The mean differences were 0.4 ± 94, -0.6 ±40, -14 ± 54 -9 ± 81, 13 ± 44, and 4 ± 18 µm, respectively.

The measurements of LMov during breathing is difficult as LMov take place perpendicular to the transducer, its displacement is only a few beam widths long and the global motion during breathing is often several times larger. The novel phase averaging method show, however, promise and this study show that it is possible to remove global motion even though the global motion has a bi-directional motion pattern.



A) The multiphasic longitudinal movement curves of the common carotid artery wall in a 63 year-old male during normal breathing (dashed) and when the research person has gentle stopped breathing. B) The corresponding averaged movement curves. The demarcation of the five phases of the longitidnal movement is shown by the rings.