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Letter to the Editor

Arterial pulse pressure waveform monitoring by novel optical probe☆,☆☆

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Blood pressure indices can be considered as main risk factors of cardiovascular disease (CVD). This fact highlights the growing awareness that there are more vascular health parameters to assess rather than the maximum and minimum pressures, measured as brachial blood pressure with a sphygmomanometer in the traditional clinical assessment [1].

Information about the interaction between the left ventricle ejection and the physical properties of the arterial circulation can be determined by the descriptive and quantitative analysis of the arterial pulse waveform (APW), providing indirect but global markers of arterial stiffness. It is that morphologic features of individual arterial pressure waveforms provide diagnostic clues to various pathologic conditions [2]. Emerging innovations in cardiovascular monitoring are moving away from more invasive technologies to portable and non-invasive solutions [3], particularly those able to perform multi-parameter assessment from the APW analysis. However, all of them establish direct contact with the patient's tissues at the artery site. The clinical application of a non-contact method can overcome practical and technical limitations inherent to the currently used methods, such as arterial applanation tonometry, ultrasound and plethysmography, that require physical contact of the probe with the patient, compress the artery and distort the shape of the pulse curve [4,5]. The non-contact nature of optical technology allows a measurement without distortions in the shape of the arterial pulse.

The optical probe used in this work is enclosed in a plastic box that ensures a non-contact signal acquisition, by keeping a small distance between the sensors and skin, 3 mm. This optical system proved to be reliable in detecting the arterial distension waveform. A comparative test between the distension waveform measuring with optical probe at the carotid artery and the invasive profile of the pulse pressure acquired by an intra-arterial catheter showed a strong correlation between the waves, and validates the capability to estimate the APW with a non-invasive way by the contactless optical probe [6]. For these reasons the concept of pulse pressure waveform and distension waveform is used based on their correspondence.

In this work, the study protocol was approved by the ethical committee of the Centro Hospitalar e Universitário de Coimbra, Portugal. The patient volunteered and gave a written informed consent. The tests were performed in a patient who had undergone a carotid angiography, and the assessment trials were made before and after the endovascular angioplasty proceeding. The subject under study is a 76-year-old woman with a diagnosis of 90% left internal carotid artery stenosis.

Measurements were performed after a rest period (15 min) in a temperature-controlled environment (21 °C). Each exam procedure consisted in the acquisition of a set of cardiac cycles at the carotid artery with the optical probe and the patient laid in supine position for 2 min. The carotid artery is the natural probing site for APW measurement due to the heart proximity and because it is easily accessible (i.e. it is close to the skin surface). The operator positioned the probe in the proximal common carotid artery, about 1 cm from the bifurcation site (estimated by the trained operator) and the same procedure was followed pre- and post-surgery.

The detected waveform before the surgery revealed a modified profile when compared to the normal range, with a large increase of pressure at the end of the diastole period (Fig. 1a). In Fig. 1a, the APWs show the presence of a reflected wave, marked in blue for the reflection point (RP), prior to the systolic point (SP), which is caused by the reflection of the APW in the atherosclerotic plaque of the internal carotid artery wall. At the end of the diastole period an increase of pressure is noticed, marked with red circle, that is not common in normal pulse waveforms that will be analyzed below.

☆ This author takes responsibility for all aspects of the reliability and freedom from bias of the data presented and their discussed interpretation.

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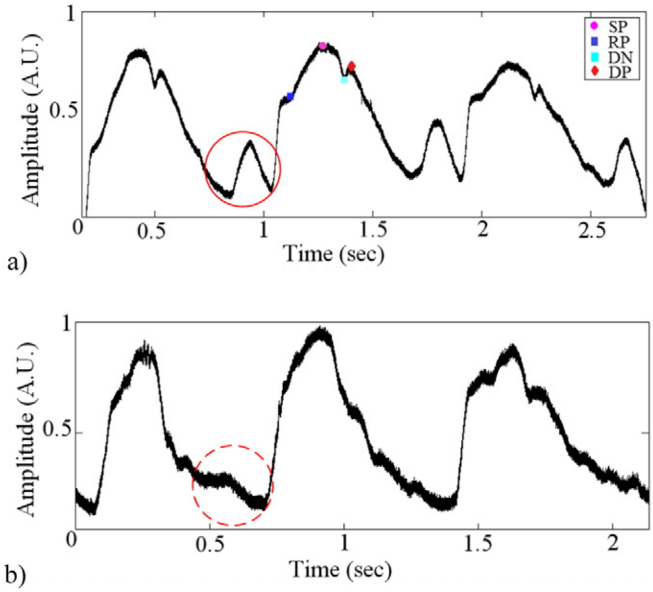

Fig. 1. Set of a few APWs detected with the optical probe at the carotid site. (a) Before the surgical procedure. Main features marked in the waveform: SP, RP, dicrotic notch (DN), dicrotic peak (DP) and abnormal effect marked with a circle. (b) Signal after the surgical procedure.

After the procedure, few pulse waveform signals were acquired once again, with the optical probe at the carotid site, for comparison with the pre-surgery signals. The waveform acquired after the surgery presents the characteristics of a normal APW, which seems to indicate that the anomalous inflections disappeared with the correction of the diameter of the vessel (area represented with dotted red circle in Fig. 1b).

As already stated, in the pulse waveform acquired before the surgical procedure, it is notable that an early wave reflection occurs due to the severe obstruction in the internal carotid artery. In fact, due to the proximity of the atherosclerotic plaque to the assessment local, this reflection was expected and is actually easily observed immediately before the systolic peak. However, in the later diastole a phenomenon of augmented pressure is evident (red circle in Fig. 1a). The fact that the pressure increases at the end of the diastole period is likely corroborative with a distal event.

The hypothetical justification that can be given to explain this occurrence is based on collateral circulation confirmed by the angiography data. It is known and described that in cases of severe internal carotid artery stenosis, cerebral collateral circulation can occur [7–9]. This phenomenon compensates the lack of perfusion, through existing anastomoses, namely the circle of Willis [7,10].

Once the distal region of the stenotic artery has a lower pressure than the proximal segment of the artery, the blood tends to flow downstream from the anastomosis towards the distal end of the plaque. Hence, a hypothesis could be made and the increase of pressure in diastole may be explained by a latter backward blood flow in the stenotic internal carotid artery, due to the collateral circulation.

This case illustrates the variation of the APW in a stenosis intervention case, and suggests that the analysis of the APW could help in the early diagnosis of CVD, in particular, of stenotic events.

Conflict of interest

There is no conflict of interest in this paper.

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