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Research Article

Comparison of ankle-brachial index and upstroke time in association with target organ damage: the Northern Shanghai Study

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Abstract

A recent study indicated that upstroke time per cardiac cycle (UTCC) in lower extremities is equivalent to ankle-brachial index (ABI) in diagnosing peripheral arterial disease and in predicting cardiovascular mortality. In this study, we aimed to compare ABI and UTCC in relation to target organ damage. A cohort of 1841 elderly participants from the Northern Shanghai Study was studied. ABI and UTCC were measured using VP-1000 device. Target organ damage including left ventricular hypertrophy and diastolic dysfunction, carotid intima-media thickness and plaque, carotid-femoral pulse wave velocity (CF-PWV), and renal damage, were evaluated by standardized methods. In correlation analysis, ABI and UTCC both significantly correlated with CF-PWV, carotid plaque, and estimated glomerular filtration rate, but not with cardiac damage. Compared with ABI, UTCC showed stronger correlation with CF-PWV. When ABI and UTCC separately put into fully adjusted multivariate logistic regression models, both ABI (OR: 2.27; 95% CI: 1.63–3.17) and UTCC (OR: 1.63; 95% CI: 1.18–2.24) significantly associated with carotid plaque, but only UTCC significantly associated with increased CF-PWV (OR: 1.66; 95% CI: 1.15–2.42) and renal damage (OR: 1.63; 95% CI: 1.07–2.47). When ABI and UTCC both put into multivariate stepwise logistic regression models together with covariates, consistent results were observed. In ROC curve analysis, after adjusted for cofounding factors, UTCC showed slightly greater area under curve than ABI in detecting increased CF-PWV (area under curve: 0.79 vs. 0.78; $P = .008$); however, no difference was observed between UTCC and ABI in discriminating renal damage and carotid plaque. In conclusion, compared with ABI, UTCC showed significantly stronger association with vascular and renal damage in this elderly Chinese cohort. J Am Soc Hypertens 2018;■(■):1–11. © 2018 American Heart Association. All rights reserved.

Keywords: Ankle-brachial index; target organ damage; upstroke time.

Introduction

Peripheral arterial disease (PAD) is a manifestation of general atherosclerosis and leads to a series of clinical conditions from asymptomatic disease to critical ischemia.[1] Ankle-brachial index (ABI), the ratio of the ankle and brachial systolic pressure, is a simple, quick, and noninvasive tool for diagnosing PAD and a useful predictor for cardiovascular morbidity and mortality, and thus is recommended by clinical guidelines.[2,3] Despite this, ABI has its limitations in clinical practice. For example, the sensitivity of ABI is relatively poor. Reported in recent guideline, the sensitivity of ABI $\leq$0.9 in diagnosing PAD is only 75%.[2] In addition, the diagnostic accuracy of ABI has a tendency to decrease with mild stenosis.[4] Thus, additional tools are needed to improve the accuracy of ABI in

Conflict of interest: None.

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diagnosing PAD. Upstroke time (UT), measured from the beginning of the systolic rise to the peak of the pulse wave in lower extremity (Figure 1), was reported to possess important value in diagnosing PAD.[5–7] In a recent study including 4055 subjects, Sheng et al. indicated that upstroke time per cardiac cycle (UTCC) was equivalent to ABI in diagnosing PAD and in predicting cardiovascular mortality, and they concluded that UTCC could be a complementary tool for diagnosing PAD.[8] However, the association of UTCC with subclinical organ damage is unclear so far, letting alone the comparison between ABI and UTCC in relation to target organ damage (TOD). In the present study, we aimed to investigate and compare the associations of ABI and UTCC with cardiac, vascular, and renal damage, in an elderly Chinese population.

Methods

Study Design and Population

The present study is a cross-sectional analysis based on the population of the Northern Shanghai Study (ClinicalTrials.gov Identifier: NCT02368938), an ongoing community-dwelling prospective study that aims to establish a cardiovascular risk evaluation system for the elderly Chinese. The detailed rationale and design of the Northern Shanghai Study has been described elsewhere.[9] In brief, this study included participants who met the following criteria: (1) age 65 years or more; (2) local resident from the urban communities in the northern Shanghai; and (3) willing to participate in the study and possible for long-term follow-up. The following participants were excluded: patients with (1) severe cardiac diseases (NYHA IV) or end-stage renal disease; (2) malignant tumor; and (3) stroke history within 3 months. The study protocol conforms to the ethical guidelines of the 1975 Declaration of Helsinki as reflected in a priori approval by the institution's human research committee. Written informed content was gained from each participant.

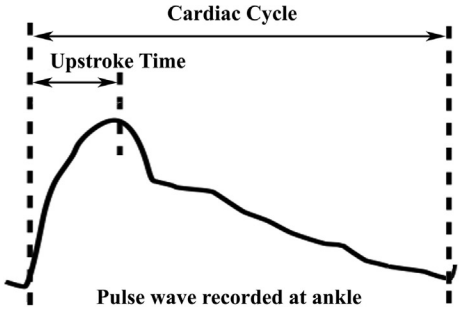
Since August 2014, 2098 participants (participation rate 92.9%) were enrolled in the Northern Shanghai Study. For the present analysis, 257 participants were further excluded due to pulse wave not recorded (188 participants) or lack of other information (69 participants). Finally, 1841 participants were included for the present analysis.

Social, Clinical, and Biological Data Collection

Medical history was obtained from all participants by a structured questionnaire, including information about age, gender, smoking status, exercise habits, history of diabetes mellitus, hypertension, cardiocerebrovascular disease, and usage of medications. After a rest for 5 minutes in a quiet room, participants' blood pressure was measured in a sitting position by a mercury sphygmomanometer, according to the recommendation of the European Society of Hypertension and European Society of Cardiology.[10] Blood pressure was measured three times spaced 2 minutes apart, and the average of the second and third values was used for further analysis. Hypertension was defined by brachial SBP/DBP $\geq$140/90 mm Hg or self-reported antihypertensive medication. Body weight and height of each participant were measured by a trained technician. Body mass index (BMI) was calculated as the body weight in kilograms divided by the body height in meters squared. Venous blood samples of each participant were obtained after an overnight fast. Biochemical parameters, including fasting plasma glucose, serum creatinine, and lipid profiles, were assayed by standard methods in the Department of Laboratory Medicine of Shanghai Tenth People's Hospital. Fasting plasma glucose was measured using the glucose oxidase method. Diabetes mellitus was defined as fasting serum glucose $\geq$7.0 mmol/L or self-reported antidiabetic medication. Estimated glomerular filtration rate (eGFR) was calculated by Asian-modified CKD-EPI method.[11] Renal damage was defined as eGFR$<$60 mL/min/1.73 m^2.

ABI and Pulse Wave Measurement

ABI and pulse wave measurement was performed by a trained staff who is blind to other results, with the VP-1000 device (Omron, Kyoto, Japan), which has been well validated.[12–15] With respect to the reproducibility of this device in measuring UTCC, it has been reported in a previous study that the coefficient of variation as the ratio of the mean difference between the two repeated measurements to



$$\text{UTCC} = \frac{\text{Upstroke Time}}{\text{Cardiac Cycle}} \times 100\%$$

Figure 1. Schematic diagram of measurement and calculation of UTCC. UTCC, upstroke time per cardiac cycle.

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