Clinical Trials and Regulatory Science in Cardiology 9 (2015) 1–3

Contents lists available at ScienceDirect

Clinical Trials and Regulatory Science in Cardiology

journal homepage: http://www.elsevier.com/locate/ctrsc

Novel vascular indices evaluated non-invasively in end-stage renal disease patients on hemodialysis

Keywords:
Central blood pressure
Non-invasive measurement
Hemodialysis

Blood pressure (BP) is pulse wave caused by cardiac and vascular functions, and systolic BP (SBP) and diastolic BP (DBP) are just maximum and minimum values of this pulse wave, respectively. On the other hand, mean BP (MBP) reflects averaged squares which the pulse wave occupies, and pulse pressure (PP) is the amplitude of pulse wave and is known to be associated with compliances of elastic artery. Hence, to measure MBP and PP could be more valuable than to measure SBP and DBP for evaluating organ damages. Furthermore, increased central BP (CBP) causes vascular wall stresses in peripheral vessels and accelerates atherosclerosis in these arteries, leading various cardiovascular diseases (CVDs). CBP is also known to be a more precise predictor of CVD than brachial BP measured oscillometrically [1]. PP, defined as the amplitude of pulse wave, generally reflects increased large arterial stiffness [2], and might be a reliable predictor of cardiovascular mortality in both general and hypertensive populations [3]. Recently, we also reported that PP could be a more useful risk marker in coronary artery disease (CAD) patients than other BP parameters [4].

Patients with chronic kidney disease (CKD) explosively increased worldwide, and increasing end-stage renal disease (ESRD) patients on hemodialysis (HD) have been social problems in recent days [5,6]. Because the main causes of death in ESRD patients on HD are CVDs [7], risk stratification of CVD in these patients might be very important. However, hemodynamic status and vascular compliances of HD patients are entirely specific in CKD patients. Therefore, clinical significances of BP and vascular function measurements such as pulse wave velocity (PWV) or cardio-ankle vascular index (CAVI) in ESRD patients could be also different from those in non-HD patients.

We recently reported a novel mathematical transformation function (TF) for CBP values estimated by non-invasive oscillometric BP measurements [8], and the association of estimated CBP with PWV in CAD patients by using new vascular indices, such as arterial velocity pulse index (AVI) and arterial pressure-volume index (API) [9]. In the present study, hence, we sought to examine the association of estimated CBP and PP with AVI and API in ESRD patients.

We recruited 34 ESRD patients who were on regular HD three times a week. Oscillometrical brachial BP in patients was routinely measured just before HD. CBP, AVI and API values were measured non-invasively by a Pasesa AVE-1500 (Shisei Datum, Tokyo, Japan) in the opposite upper arm of arteriovenous shunt side, and were calculated using new TF in HD patients. In brief, we made a correlation matrix to investigate the correlation among several independent variables. The independent variables, which had significant correlations with aortic systolic BP (AoSBP) were age, SBP, DBP, AVI and API values obtained in this matrix. To examine multiple regression equation, we used AoSBP as a dependent variable and adopted the five above-mentioned variables as independent variables. We obtained intercepts and coefficients for each independent variable and constructed the formulas. CAVI values in HD patients were measured using a device for a VaSera VS-1500 (Fukuda Denshi Co., Tokyo, Japan), according to the method reported previously [10].

The baseline characteristics of HD patients were shown in Table 1 (male; n = 24 [71%] and female; n = 10 [29%], average: 67.3 ± 10.5 years old). The causative diseases of HD were diabetic nephropathy(52.9%), chronic glomerulonephritis(14.7%), nephrosclerosis(5.9%) and others(26.5%). The duration of HD was 9.3 ± 8.3 (years). The estimated CBP was significantly and strongly correlated both with AVI and API values ($r = 0.42$, $p = 0.013$ and $r = 0.66$, $p < 0.001$, Fig. 1A and B, respectively), and the brachial PP values were also significantly and strongly correlated with AVI and API values ($r = 0.43$, $p = 0.011$ and $r = 0.81$, $p < 0.001$ Fig. 1C and D, respectively). By contrast, the CAVI values were not significantly correlated with AVI and API values ($r = 0.04$, $p = 0.82$ and $r = 0.14$, $p = 0.43$ Fig. 2A and B, respectively).

As described above, MBP and PP could be more valuable than SBP and DBP, and CBP is well known to be better predictor of CVD than brachial BP measured oscillometrically. Also brachial PP might be

Table 1
Baseline characteristics of 34 ESRD patients on HD.

Clinical characteristics	Values
Age (years)	67.3 ± 10.5
Male (%)	67.6
Duration on HD (years)	9.3 ± 8.3
Body weight before HD (kg)	57.0 ± 10.2
BMI before HD (kg/m^2)	22.1 ± 2.9
Hypertension (%)	94.1
Diabetes mellitus (%)	52.9
Laboratory data before HD	Values
BUN (mg/dL)	51.9 ± 13.9
Creatinine (mg/dL)	10.3 ± 2.9
Sodium (mEq/L)	137 ± 2.8
Potassium (mEq/L)	4.4 ± 0.7
Calcium (mg/dL)	8.7 ± 0.6
Albumin (g/dL)	3.5 ± 0.5
CRP(mg/dL)	0.6 ± 0.9
Hemoglobin(g/dL)	10.3 ± 1.2
Uric acid (mg/dL)	6.6 ± 1.2
LDL-C (mg/dL)	70.7 ± 29.1
HDL-C(mg/dL)	42.6 ± 11.1

Data are expressed as means ± standard deviations.
Abbreviations used: ESRD, end-stage renal disease; HD, hemodialysis; BMI, body mass index; BUN, blood urea nitrogen; CRP, C-reactive protein; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol.

http://dx.doi.org/10.1016/j.ctrsc.2015.09.001

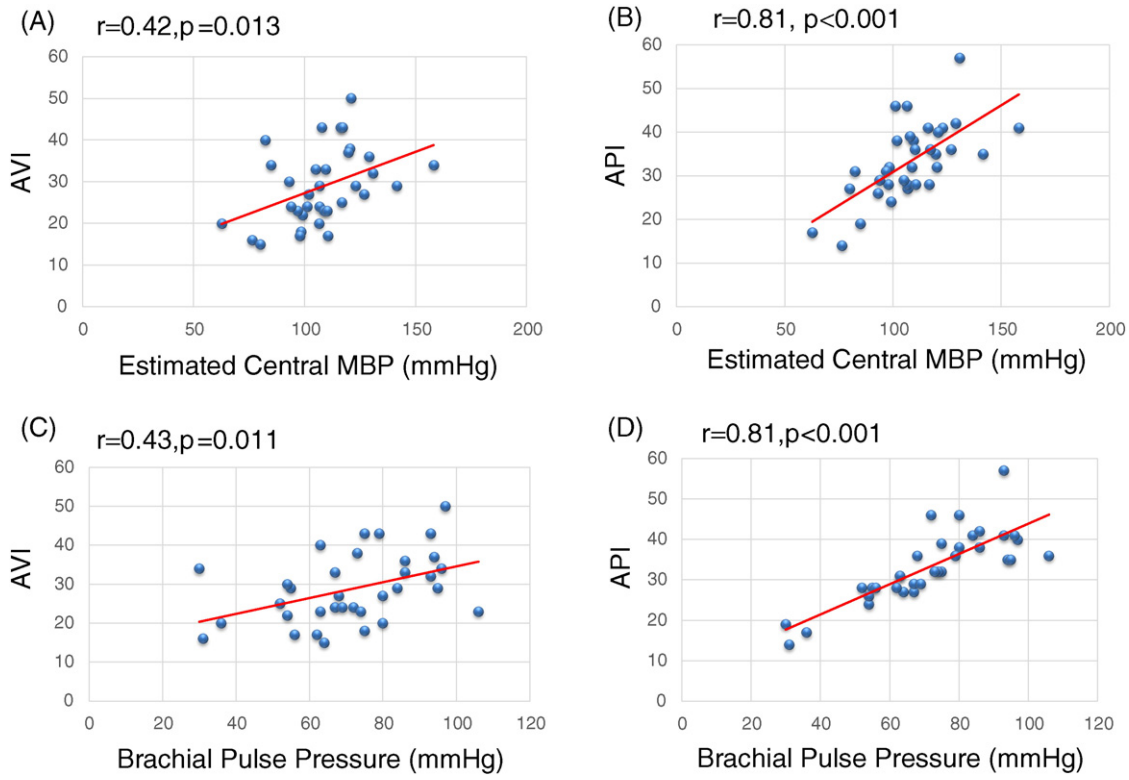

Fig. 1. A and B, the correlations of estimated central SBP with AVI and API valves. C and D, the correlations of PP with AVI and API values. MBP, mean blood pressure; AVI, arterial velocity pulse index; API, arterial pressure-volume index; SBP;, systolic blood pressure; PP, pulse pressure.

predictive factor of CVD in various patients, however the significance of PP in ESRD patients remains still unclear. In this study, hence, we investigated the association of central MBP and brachial PP with vascular indices in ESRD, using new modality of BP measurement. As a result, there were significant correlations of CBP and PP values with AVI and API values in these patients.

Because PWV was reported to be associated with the prognosis of HD patients [11], the assessment of vascular function might be useful also in HD patients. This study demonstrated that both AVI and API values, new vascular indices, were strongly associated with MBP and PP, which are established as prognostic factors of CVD, in HD patients. These indicated that the AVI and API have possibility to be useful predictors of CVD occurrence in ESRD patients. Although the AVI and API are very new vascular indices [8,9,12] and there are no reports demonstrating prognostic significance of these indices in CVD. We firstly clarified the significant association of AVI and API with other BP parameters in HD patients, and the usefulness of new TF for risk stratification of ESRD patients. On the other hand, the CAVI values were not significantly correlated with AVI and API values in this study. Although CAVI is established as useful modality estimating vascular function, the prognostic value of CAVI in HD patients remains totally unclear. Hence, further clinical study is essential to elucidate the clinical significance of CAVI in HD patient.

The present study has several limitations. First, this study was performed in a single-center and the number of patients is relatively small. Second, the present study was aimed at patients with ESRD, all of whom take a variety of cardiovascular agents. Various values estimated in this study could be have been influenced by these medications. Despite these limitations, we clearly and firstly demonstrated the close association between new vascular indices and conventional BP parameters, indicating clinical usefulness of AVI and API measurements for risk stratification of ESRD patients on HD.

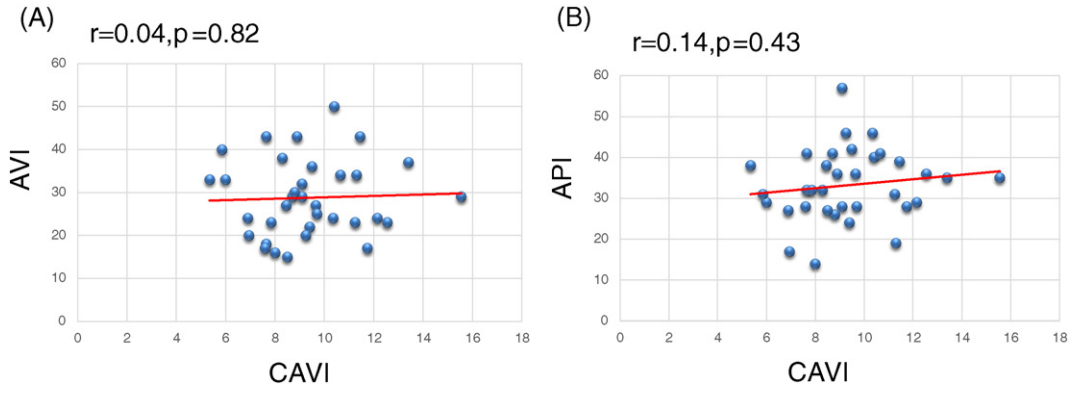

Fig. 2. A and B; the correlations of CAVI, with AVI and API values. CAVI; cardio-ankle vascular index. Abbreviations used are the same as in Fig. 1.

Funding sources

None.

Potential conflict of interest

None.

Acknowledgments

None.

References

[1] Roman MJ, Devereux RB, Kizer JR, Okin PM, Lee ET, Wang W, et al. High central pulse pressure is independently associated with adverse cardiovascular outcome the strong heart study. J Am Coll Cardiol 2009;54:1730–4.
[2] Darne B, Girerd X, Safar M, Cambien F, Guize L. Pulsatile versus steady component of blood pressure: a cross-sectional analysis and a prospective analysis on cardiovascular mortality. Hypertension 1989;13:392–400.
[3] Benetos A, Rudnichi A, Safar M, Guize L. Pulse pressure and cardiovascular mortality in normotensive and hypertensive subjects. Hypertension 1998;32:560–4.
[4] Tokitsu T, Yamamoto E, Hirata Y, Fujisue K, Sueta D, Sugamura K, et al. Clinical significance of pulse pressure in patients with coronary artery disease. Int J Cardiol 2015;190:299–301.
[5] Ninomiya T, Kiyohara Y, Kubo M, Tanizaki Y, Doi Y, Okubo K, et al. Chronic kidney disease and cardiovascular disease in a general Japanese population: the Hisayama Study. Kidney Int 2005;68:228–36.
[6] Nagata M, Ninomiya T, Doi Y, Yonemoto K, Kubo M, Hata J, et al. Trends in the prevalence of chronic kidney disease and its risk factors in a general Japanese population: the Hisayama Study. Nephrol Dial Transplant 2010;25:2557–64.
[7] Hokimoto S, Sakamoto K, Akasaka T, Kaikita K, Honda O, Naruse M, et al. High mortality rate in hemodialysis patients who undergo invasive cardiovascular procedures related to peripheral artery disease - community-based observational study in Kumamoto Prefecture. Circ J 2015;79:1269–76.
[8] Sueta D, Yamamoto E, Tanaka T, Hirata Y, Sakamoto K, Tsujita K, et al. The accuracy of central blood pressure waveform by novel mathematical transformation of non-invasive measurement. Int J Cardiol 2015;189:244–6.
[9] Sueta D, Yamamoto E, Tanaka T, Hirata Y, Sakamoto K, Tsujita K, et al. Association of estimated central blood pressure measured non-invasively with pulse wave velocity in patients with coronary artery disease. Int J Cardiol Heart Vasculature 2015;8:52–4.
[10] Namikoshi T, Fujimoto S, Yorimitsu D, Ihoriya C, Fujimoto Y, Komai N, et al. Relationship between vascular function indexes, renal arteriolosclerosis, and renal clinical outcomes in chronic kidney disease. Nephrology 2015;20:585–90.
[11] Kitahara T, Ono K, Tsuchida A, Kawai H, Shinohara M, Ishii Y, et al. Impact of brachial-ankle pulse wave velocity and ankle-brachial blood pressure index on mortality in hemodialysis patients. Am J Kidney Dis 2005;46:688–96.
[12] Komine H, Asai Y, Yokoi T, Yoshizawa M. Non-invasive assessment of arterial stiffness using oscillometric blood pressure measurement. Biomed Eng Online 2012;11:6.

Daisuke Sueta
Eiichiro Yamamoto*
Yoshihiro Hirata
Takanori Tokitsu
Kenji Sakamoto
Kenichi Tsujita
Koichi Kaikita
Seiji Hokimoto
Department of Cardiovascular Medicine, Kumamoto University Graduate School of Medical Sciences, Kumamoto, Japan
*Corresponding author at: Department of Cardiovascular Medicine, Kumamoto University Graduate School of Medical Sciences, 1-1-1 Honjo, Kumamoto 860–8556, Japan.
E-mail address: eyamamo@kumamoto-u.ac.jp (E. Yamamoto).

Toshihiko Sakanashi
Sakanashi Heart Clinic, Aso, Kumamoto, Japan

Hisao Ogawa
Department of Cardiovascular Medicine, Kumamoto University Graduate School of Medical Sciences, Kumamoto, Japan

26 August 2015