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The Pulse Wave Velocity is Linearly Correlated with Resting Systolic and Diastolic Blood Pressure in Hypertensive Patients

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Introduction: Aortic stiffness is an independent predictor for cardiovascular event. If arteries lose their natural elasticity, systolic blood pressure become higher and diastolic blood pressure become lower. Method of evaluating arterial stiffness is aortic pulse wave velocity (PWV). Therefore, PWV has a potential application for screening vascular damage in large population.[2] Recent reports have shown that PWV obtained by noninvasive automatic devices (i.e. tonometry, cuff pressure) is not only a marker of vascular damages, but also a prognostic predictor in patients with hypertension.[3] The aim of this study is to investigate the correlation between PWV and systolic and diastolic blood pressure.

Methods : Male hypertensive patients, aged 40-60 years old who underwent Doppler Vascular were included in this study. The measurement of carotid-femoral PWV is made by dividing the distance (from the carotid point to the femoral point) by the so-called transit time (the time of travel of the foot of the wave over the distance). Hence, PWV = D (meters)/Dt (seconds). The correlation between PWV and systolic and diastolic blood pressure were analysed using linear regression test.

Results : A total 40 patients were included in this study. Those were significant correlation between PWV and systolic (R=0.473, p=0.002) and diastolic (R=0.454, p=0.003) blood pressure.

Conclusion : increasing PWV is linearly associated with systolic and diastolic blood pressure.

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Keywords : aortic stiffness, hypertension, pulse wave velocity

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Penelitian Klinis

Kecepatan Gelombang Pulsasi Berkorelasi secara Linear dengan Tekanan Darah Sistolik dan Diastolik pada Pasien Hipertensi

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Pendahuluan: Kekakuan aorta adalah prediktor independen untuk kejadian kardiovaskular. Jika elastisitas alami arteri hilang, tekanan darah sistolik menjadi lebih tinggi dan tekanan darah diastolik menjadi lebih rendah. Metode evaluasi kekakuan arteri adalah kecepatan gelombang pulsasi (*pulse wave velocity*/PWV). Oleh karena itu, PWV dapat diterapkan untuk skrining kerusakan vaskular pada populasi besar.[2] Laporan terbaru menunjukkan bahwa PWV yang diperoleh dengan perangkat otomatis non-invasif (yaitu tonometri, tekanan manset) tidak hanya merupakan penanda kerusakan vaskular, tetapi juga prediktor prognostik pada pasien dengan hipertensi.[3] Tujuan dari penelitian ini adalah untuk mengetahui hubungan antara PWV dan tekanan darah sistolik dan diastolik.
Metode: Pasien pria dengan hipertensi, berusia 40-60 tahun yang menjalani Doppler Vascular dimasukkan dalam penelitian ini. Pengukuran PWV karotid-femoralis dilakukan dengan membagi jarak (dari titik karotid ke titik femoral) dengan waktu transit. Oleh karena itu, PWV = D (meter) / Dt (detik). Korelasi antara tekanan darah PWV dan sistolik dan diastolik dianalisis dengan menggunakan uji regresi linier.
Hasil: Sebanyak 40 pasien dimasukkan dalam penelitian ini. Itu adalah korelasi yang signifikan antara tekanan darah PWV dan sistolik (R = 0,473, p = 0,002) dan diastolik (R = 0,454, p = 0,003).
Kesimpulan: Peningkatan PWV berhubungan linear dengan tekanan darah sistolik dan diastolik.

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Kata kunci: kekakuan aorta, hipertensi, kecepatan gelombang pulsasi

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Background

The association between blood pressure components and major cardiovascular events is well documented in both normotensive and hypertensive individuals.[1] Numerous observational epidemiology studies and clinical trials have shown a strong positive, continuous, and graded association between systolic and diastolic blood pressure and/or pulse pressure and cardiovascular risk and adverse events.[2] Cardiovascular disease and outcome are also related to invasively measured central aortic pulse blood pressure, the pressure exerted on the heart, brain, and kidneys.[2] Since central systolic and pulse blood pressure are related to changes in arterial effects and can be measured easily, accurately, and noninvasively using a validated generalized transfer function and pulse wave analysis, attention has been directed toward arterial stiffness, pulse wave velocity (PWV), and wave reflections as indepedent cardiovascular risk factors that predict adverse events and relate to outcome.[2,3] Recent reports have shown that PWV obtained by noninvasive automatic devices (i.e. tonometry, cuff pressure) is not only a marker of vascular damages, but also a prognostic predictor in patients with hypertension or end-stage renal failure, independently of classical risk factors.[3]

Arterial stiffness is determined by functional and structural components related to the intrinsic elastic properties of the artery. Persistently elevated blood pressure (BP) accelerates arterial smooth muscle hyperplasia and hypertrophy, and collagen synthesis, thereby increasing arterial stiffness.[4] Aortic PWV is an index of arterial stiffness and recent studies shown that the carotid femoral PWV has become available as a means of measuring PWV. The aim of this study is to investigate the correlation between PWV and systolic and diastolic blood pressure.

Patients And Method

Study Population

This is a cross sectional observational study with minimum sample 40 patients. Male hypertensive patients, aged 40-60 years old were examined between September 2014 and December 2014 who underwent Doppler vascular at R.D. Kandou General Hospital, Manado, Indonesia were included in this study. We excluded subjects with history of myocardial infarction, history of percutaneous coronary intervention or prior coronary arterial bypass surgery. We also excluded patient with kidney disease and diabetic patient. Body Mass index, Waist circumference, systolic blood pressure, diastolic blood pressure, PWV, total cholesterol, low density lipoprotein (LDL), high density lipoprotein (HDL), triglyceride, and uric acid were measured in all subject. Written informed consent was obtained from all patients.

Hypertension was defined as systolic pressure ≥140mmHg and/or diastolic pressure ≥90mmHg; or if the individual was taking antihypertensive medications. Waist circumference was measured in centimeter (cm). Body mass index (BMI) was calculated as weight (kg) devided by the square of height (m^2).[5] The measurement of carotid-femoral PWV is made by dividing the distance (from the carotid point to the femoral point) by the so-called transit time (the time of travel of the foot of the wave over the distance). Hence, PWV = D (meters)/Dt (seconds) (**Figure 1**).[6]

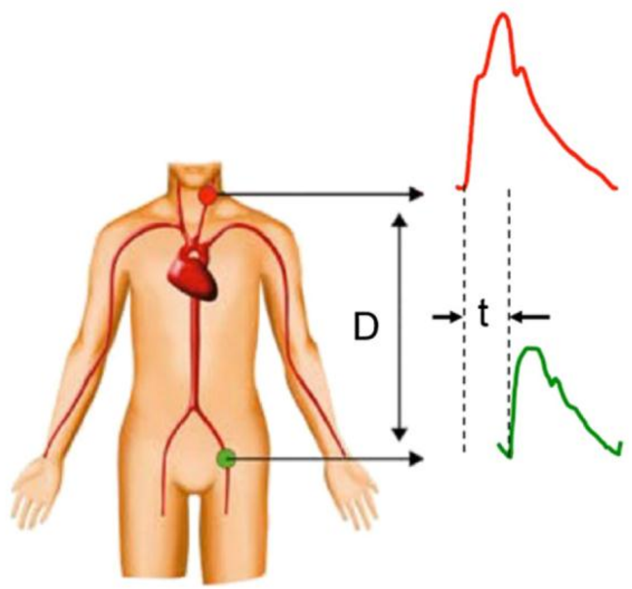

Figure 1. figure shows a schematic representation of pulse wave velocity. Pulse wave travel time: t; distance: D.[6]

The correlation between PWV and systolic and diastolic blood pressure were analysed using linear regression test. A P value <0.05 was considered to indicate statistical significance. All statistical analyses were performed using the SPSS ver. 17.0 software (SPSS, Chicago, IL).

Blood pressure measurement

Conventional office blood pressure was measured at the hospital by sphyghmomanometri (korotkoff phases I and V). After 5 minutes of rest, 3 consecutive measurements were taken at the nondominant arm, with the participant seated, and always by the same trained investigator.

Pulse Wave Velocity (PWV) Measurement

All measurements were performed in a quiet room with controlled ambient temperature. The PWV was

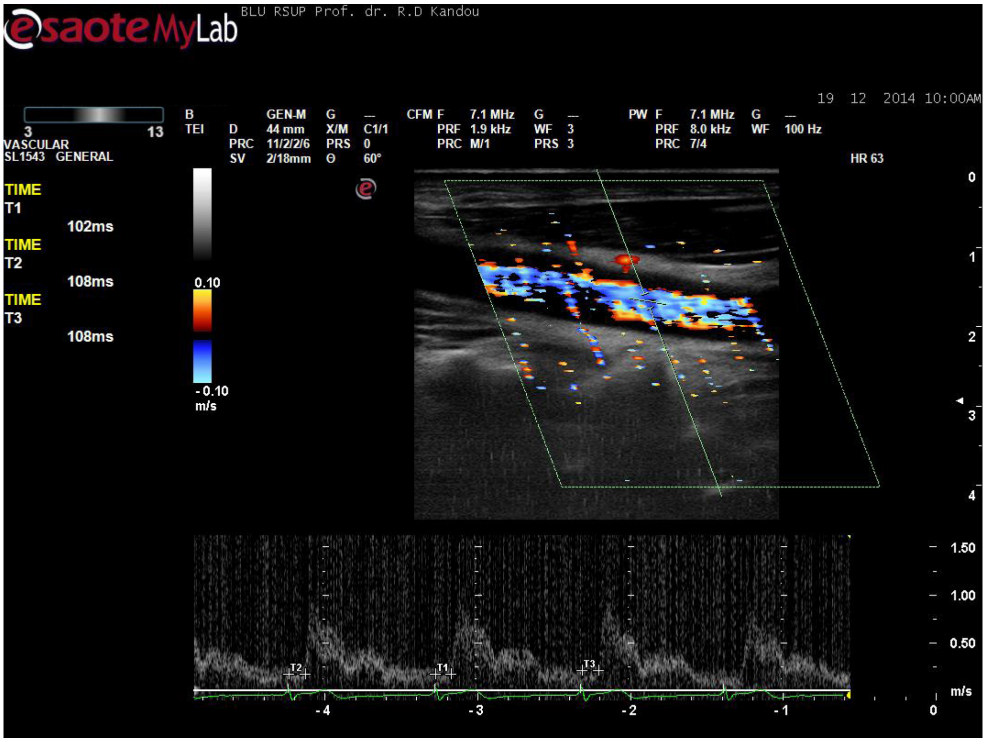

Figure 2. Time measurement in femoral artery gatting with ECG

performed in the supine position after 5 min of bed rest, using eSaote MyLab 40 cardiac ultrasound unit (eSaote Group, Genoa, Italy). The pulse wave of the carotid and femoral arteries was analyzed, estimating the delay with respect to the ECG wave and calculating the PWV.

PWV was calculated as the carotid-femoral path length divided by the carotid-femoral transit time and expressed as m/sec (figure 1).[6,7,8] Carotid-femoral path length was measured as the difference between the surface distances joining the suprasternal notch, the umbilicus and the femoral pulse. Carotid-femoral transit time was estimated in 8–10 sequential electrocardiogram femoral and carotid waveforms as the average time difference between the onset of the femoral and carotid waveforms. Transit time is commonly estimated by the foot-to foot method (Figure 1). The foot of the wave is defined at the end of diastole, when the steep rise of the wave front begins. The transit time is the time of travel of the foot of the wave over a known distance.

Finally, the distension waves obtained at a short time interval at two arterial sites (common carotid and femoral artery, for instance) by high-resolution echo-tracking devices can be also used to calculate PWV, using the R-wave of the ECG for calculating the time delay (**Figure 2**).[6]

Results

The study included 40 male hypertensive patients. Table 1 presents the baseline clinical characteristics. The mean age was 53,60 $\pm$ 5,203 . The mean systolic blood pressure was 133,25 ± 18,864; and diastolic blood pressure was 87,75 ±8,317. Those were significant correlation between PWV and systolic (R=0.473, p=0.002) and diastolic (R=0.454, p=0.003) blood pressure. The results of correlation between PWV and systolic and diastolic blood pressure are shown in figure 3. We also find significant correlation between PWV and pulse pressure (R=0.388, p=0.013) are shown in figure 4.

Discussion

Aging, hypertension and other risk factors can alter the structural and functional properties of the arterial wall, leading to a decrease in arterial distensibility,

Table 1. Baseline Characteristic of the subject

Descriptive Statistics				
Variables	N	Minimum	Maximum	Mean ±SD
Age	40	42	60	53.60±5.203
BMI	40	20.00	35.00	27.0395±3.32408
Waist circumference	40	73	120	92.62±9.023
Systolic blood pressure	40	100	170	133.25±18.864
Diastolic blood pressure	40	80	110	87.75±8.317
Fasting blood glucose	40	69	126	99.10±11.933
Ureum	40	14	40	24.68±8.154
Creatinine	40	.9	2.1	1.320±2933
Total cholesterol	40	155	286	209.83±34.698
LDL	40	89	191	135.13±28.488
HDL	40	30	80	40.35±11.304
Triglyceride	40	62	396	174.18±85.000
Uric acid	40	3.8	10.2	7.520±1.4703
PWV	40	0.73	2.73	1.211±.4026

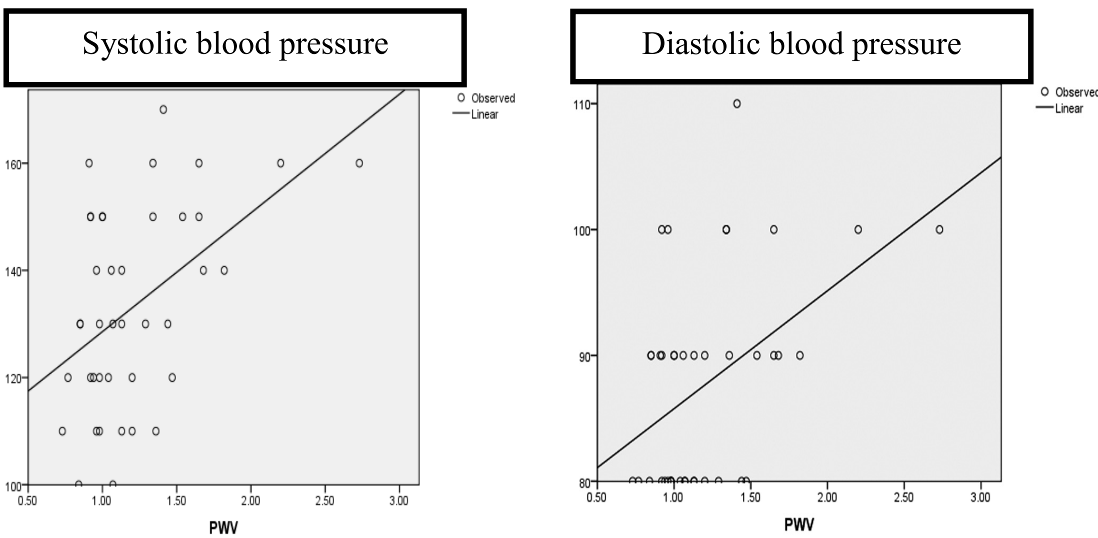

Figure 3. The results of correlation between PWV and systolic and diastolic blood pressure

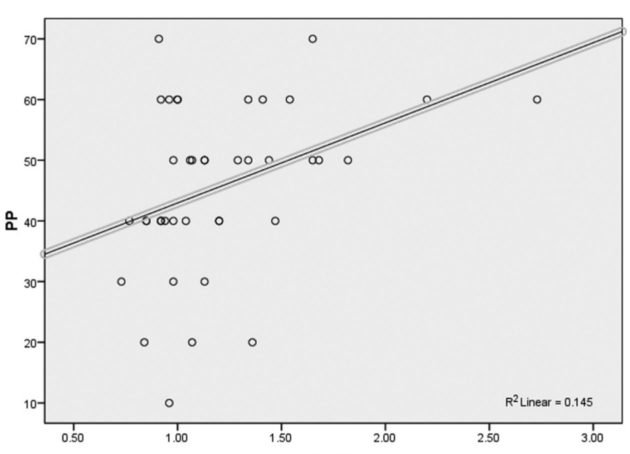

Figure 4. The result of correlation between PWV and pulse pressure

reflected wave amplitude increases and augments pressure in late systole, producing an increase in left ventricular afterload and myocardial oxygen demand which seems to be a common pathologic mechanism among CV diseases.[9] Arterial distensibility is a measure of the artery's ability to expand and contract with cardiac pulsation and relaxation. This enables the large arteries to regulate blood pressure by smoothing out the pulsations that occur with each ventricular ejection by instantaneously accommodating the volume of blood ejected from the heart, thereby storing part of the stroke volume during systolic ejection and preventing a precipitous increase in pressure.[10,11] The intrinsic elastic recoil of the aorta during diastole preserves a steady flow of blood to the peripheral circulation, maintaining the level of diastolic blood pressure and allowing continuous perfusion of organs and tissues. With increasing in arterial stiffness the cushioning effect is lost and this leads to an increase in systolic pressure. In addition, the normal elastic recoil during diastole does not occur and the diastolic pressure tends to fall. Blood pressure, is the main determinant of stiffness in both carotid and aortic stiffness.[12,13]

The assessment of PWV is considered to be the "gold standard" measurement of aortic stiffness, as it is a simple, non-invasive and reproducible method and has the largest amount of clinical evidence, providing the predictive value of aortic stiffness for CV events.[14] PWV can be measured from various arterial sites such as heart-carotid, carotid-brachial and femoral-ankle segments. Brachial-ankle PWV is more easily obtained and has been shown to be highly correlated ($r = 0.76$, $p < 0.0001$) with carotid-femoral PWV values,[15] Since the measurement of brachial ankle PWV includes both central and peripheral arterial,[16] confirmatory studies with carotid- femoral PWV are warranted. So we select carotid-femoral PWV to evaluating the arterial stiffness.

Conclusion

The strength of our study is that we were able to demonstrate increasing PWV is linearly associated with systolic and diastolic blood pressure in male hypertensive patients. There are several limitations to our study that should be acknowledged. First, this is a single center study with a small sample size. A multicenter studies with larger study population is still needed to confirm our findings. Second, the identification of hypertension was performed once (at the beginning of the study), and we were unable to examine detailed information on blood pressure, such as variations in blood pressure, during the follow-up period. Third, PWV measurement could bring a bias as inter-observer assessment may be different significantly.

Abbreviations

CV= cardiovascular
PWV= Pulse Wave Velocity
BP= blood pressure
LDL= low density lipoprotein
HDL= high density lipoprotein
BMI= Body mass index

Ethical Clearance

Ethical clearance number for this research is: TPEPK 071402

Conflict of Interest

None

Publication Agreement

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