RESEARCH ARTICLE

Investigating the correlation of the second derivative of digital pulse wave (DPW) with QT variability index in women

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Abstract

Objective: To determine the correlation between the second derivative of digital pulse wave and the QT variability index.

Method: The cross-sectional study was conducted from October 2021 to May 2022 at the Department of Physiology, College of Medicine, University of Mustansiriyah, Baghdad, Iraq, and comprised healthy women. Samples were raised by simple random technique. Digital pulse waves were captured using a fingertip pulse wave transducer. Lab Chart Pro version 7.2 was used to automatically detect and quantify the amplitude of A, B, C, D and E waves expressed by the second derivative. QT interval of each beat was recorded by electrocardiogram, and was calculated automatically via Lab chart Pro version 7.2 without averaging. Data was spread out on Microsoft Office Excel 2013 and analysed using SPSS version 26.

Results: There were 55 women with mean age 37.4±9.9 years and mean body mass index 31.2±7.2kg/m^2. Age was positively associated with QT variability index and normalised wave amplitude values of B/A and (B-C-D-E)/A ($p<0.05$).QT variability index was positively associated with the normalised values of the second derivative of digital pulse wave B/A and (B-C-D-E)/A ($p<0.05$).

Conclusion: QT variability index I was significantly correlated with second derivative of photoplethysmogram, and both were affected by age and arterial stiffness.

Key Words: Photoplethysmography, Vascular Stiffness, Electrocardiography, Transducers

(JPMA 74: S26 (Supple-8); 2024) **DOI: https://doi.org/10.47391/JPMA-BAGH-16-07**

Introduction

Temporal ventricular repolarisation dispersion can be assessed by QT variability index (QTVI), which is a non-invasive measurement that has been used on a wide range of patients with cardiovascular illness.[1,2] It can be used to predict supraventricular and ventricular arrhythmias as well as death.[3] The QT interval varies from beat to beat, showing minor temporal variations in ventricular repolarisation.[4] QT variability (QTV) is affected by RR interval variability (RRV).[2] QTV is a cardiac autonomic function parameter that, when aberrant, is associated with ventricular arrhythmias and a poor clinical outcome.[5] Increased QTV can be produced by sympathetic overactivity,[6] which might occur as a result of congestive heart failure's diminished cardiac output.[7] Healthy persons have a negative QTVI measurement.[8]

Two mathematical differentiations of the original photoplethysmogram (PTG) lead to the production of second derivative of PTG (SDPTG).[9] It has been used as a non-invasive test for arterial stiffness (AS) since it detects the blood's acceleration in the finger.[9] AS is a powerful and independent predictor of cardiovascular events, such as heart attack, stroke and aortic syndromes.[10] In SDPTG, 4 distinct systolic waves (waves A, B, C and D) and a diastolic wave (wave E) were found.[11] The SDPTG's A and B waves are included in the PTG's early systolic phase, whereas the C and D waves are included in the PTG's late systolic phase.

The current study was planned to determine the correlation between SDDPW and QTVI.

Subjects and Methods

The cross-sectional study was conducted from October 2021 to May 2022 at the Department of Physiology, College of Medicine, University of Mustansiriyah, Baghdad, Iraq, and comprised healthy women. After approval from the institutional ethics review committee, the sample was raised from among non-pregnant females with normal menstrual cycle who had no serious illness, were not taking any medicine, and were not consumers of either tobacco or alcohol. After taking informed consent, data was collected using a questionnaire. The current sample was raised using a simple random sampling technique.

On the day of the test, the participants had been fasting

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for >12 hours. Anthropometry data was noted, and eachwoman's right brachial artery systolic blood pressure (SBP) and diastolic blood pressure (DBP) was taken while lying on the sofa with the head moderately bent and entirely supported by the couch surface after 5 minutes of uninterrupted rest. Blood pressure (BP) and heart rate (HR) were taken repeatedly using an automated sphygmomanometer (BLS-2009C, Germany) until stable values for both variables were obtained.

Using a piezoelectric finger pulse transducer (RoHS, China), 5-minute digital pulse wave (DPW) signals and Lead II electrocardiograms (ECG) were simultaneously recorded. The transducer can capture the pulsatile variations in blood volume generated by arterial blood flow at the measuring point (fingertip). Three surface leads were used to record Lead II ECG. The data was recorded on the computer using the Power Lab Data Acquisition Unit (AD Instruments Pty Ltd, New South Wales, Australia). For offline signal analysis, computer Lab Chart Pro version 7.2 software was employed.

From each record, 30-40 consecutive clear cycles were chosen and examined. The A, B, C, D and E waves of the SDDPW were automatically detected and measured using the peak analysis feature built into Lab Chart Pro Software. Low pass filter with 50Hz cut-off frequency was used. The trigger's highest or lowest setting was changed for the detection of A, C and E, or B and D, respectively. For amplitude measurement, the pertinent recognised waves for each cardiac cycle were selected, and the irrelevant identified waves were eliminated. The value of the QT interval of each beat was measured automatically via Lab chart without averaging. QTVI was calculated using Piccirillo et al.'s formula[12]:

QTVI = log10 {[(QTv)/(QTm)2]. / [(RRv)/(RRm)2]}

QT interval cut-off values <300 msec were excluded from the calculation.

Data was spread out on Microsoft Office Excel 2013 and analysed using SPSS version 26. Data was expressed as mean ± standard deviation (SD). Correlation between the variables was explored using Excel. Rosner's Extreme Studentised Deviate test for multiple outliers was used to identify and eliminate the outlier data, including abnormal beats and artifacts, with a probability of <0.05. The mean QT (QTm) and mean RR (RRm) intervals and QT variance (QTv) and RR variance (RRv) were computed using Excel. P<0.05 was considered significant.

Results

There were 55 women with mean age 37.4±9.9 years (range: 20-58 years) and mean body mass index (BMI) was 31.2±7.2kg/m^2 (range: 18.8-56.5kg/m^2). Mean SBP was 117.6±11.0mmHg (range: 90-145mmHg), and 1(1.8%) subject had a SBP slightly >140mmHg. The mean DBP was 76.5±7.4mmHg (range: 61-93mmHg), and 3(5.5%) subjects had a DBP marginally >90mmHg) (Table 1).

Age was positively associated with QTVI (Figure 1) and normalised wave amplitude values of B/A and (B-C-D-E)/A (Figure 2). QTVI was positively associated with the

Table-1: Demographic data.

The measured variables	Mean ± SD
Age (year)	37.4 ± 9.9
BMI (kg/m2)	31.2 ± 7.2
SBP (mm Hg)	117.6 ± 11.0
DBP (mm Hg)	76.5 ± 7.4
QTVI	-0.42 ± 0.49
B/A (N=49) *	-0.65 ± 0.13
D/A (N=52) *	-0.24 ± 0.30
E/A (N =54) *	0.40 ± 0.23
(B-C-D-E)/A (N=51) *	-1.47 ± 0.35

* After exclusion of the outlier values.

BMI: Body mass index, SBP: Systolic blood pressure, DBP: Diastolic blood pressure. QTVI: QT variability index, N: Number of participants.

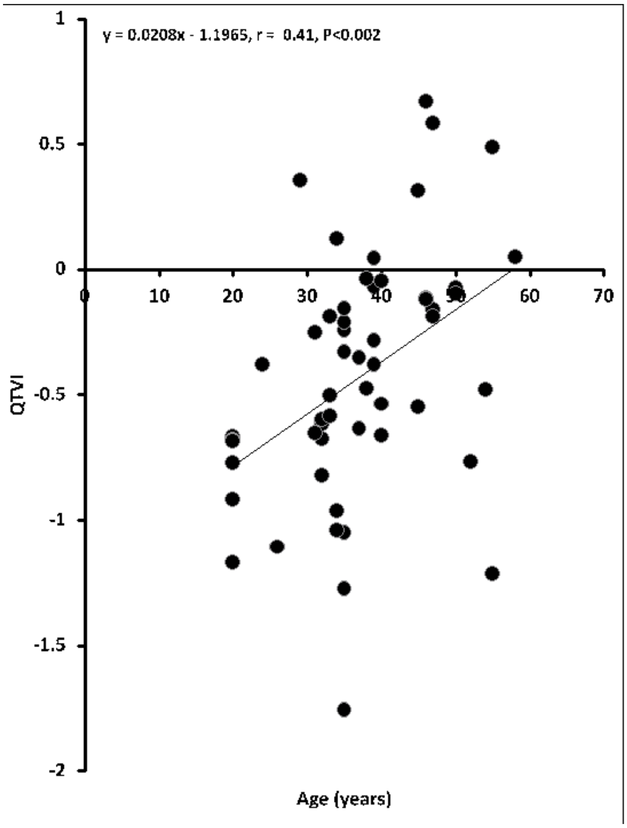

Figure-1: The relationship between age and QT variability index (QTVI). N = 54.

Table-2: The correlation between QT variable index (QTVI) and normalised second derivative of digital pulse wave (SDDPW).

	r =	P<
B/A (N=49) *	0.43	0.003
(B-C-D-E)/A (N=51) *	0.33	0.017

* After exclusion of the outlier values. N: Number of participants.

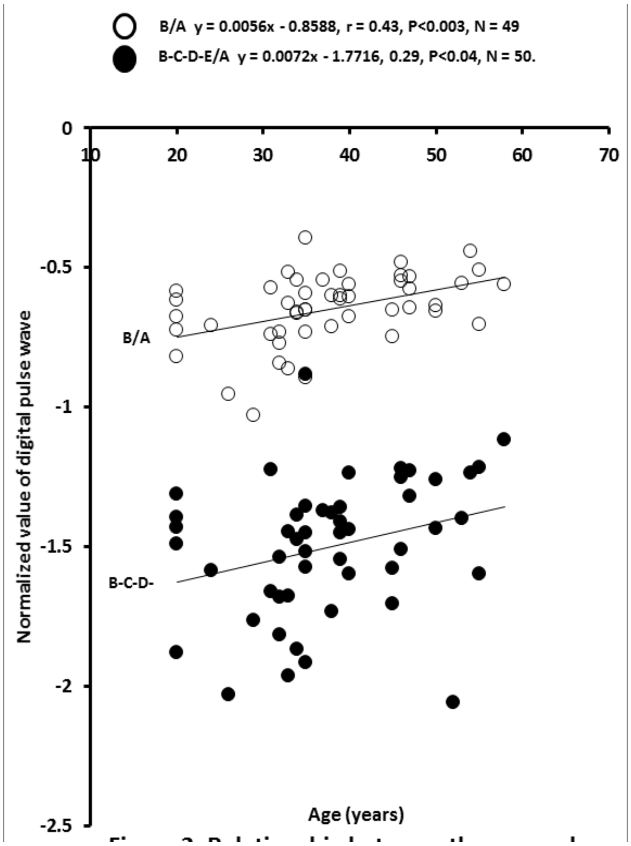

Figure-2: Relationship between the age and various normalized second derivative of digital pulse wave.

normalised values of the SDDPW (Table 2).

Discussion

Pulse wave analysis is utilised to determine the degree of AS linked to atherosclerosis, the aging of the vascular system, and hypertension.[13] As a result, it is only natural to assume that SDPTG represents vascular functional, and/or structural features. The correlations between the QTVI and SDPTG indices, on the other hand, have not been studied. The B/A ratio (-0.63±0.12) and D/A ratio (-0.26 ± 0.12) recorded by a study[14] were similar to those reported in the current study (-0.65±0.13 and -0.24±0.30 respectively). In addition, the aging index (AI) value (B-C-D-E)/A recorded in the current study is comparable to an earlier report.[15]

The current results showed a clear and highly significant correlation between age and QTVI. This supports earlier findings.[12] According to a study,[16] the SDDPW B/A wave ratio suggests either the power of ejection of the left ventricular, or the compliance of the central artery. A high B/A ratio rises with age and is linked to poor central artery compliance, higher cardiovascular risk, and atherosclerosis. A low B/A ratio diminishes with age and is related with good central artery compliance, and an athletic constitution.[17] The current results agree with these findings.

AI is used as a measure of overall vascular stiffness, or vascular age. A study[16] suggested that a high AI value is linked to atherosclerosis and rises with age, while a low AI value is associated with youth and an athletic constitution. These findings are consistent with the current findings. It is possible that aging increases in AS and peripheral vascular resistance. These changes are reflected in the present research by a positive correlation of age with B/A and AI. A study[18] demonstrated that AS increases with age and affects the central arteries more than the peripheral arteries. The fact that all parameters are influenced by the same causes (age and vascular stiffness) may explain the initial observation of a positive relationship between B/A and AI and QTVI.[19]

Limitation: The current study has limitations as the sample size was not calculated which could have affected the power and generalisability of the study.

Conclusion

There was a significant correlation between QTVI and SDDPW, and they were both affected by age and arterial stiffness.

Disclaimer: None.

Conflict of Interest: None.

Source of Funding: None.

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