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Original Article

Electrophysiological validation of total atrial conduction time measurement by tissue doppler echocardiography according to age and sex in healthy adults

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ABSTRACT

Background: We sought to validate total atrial conduction time (TACT) measurement via tissue Doppler imaging (TDI) by comparing the electrophysiological study (EPS) measurements of healthy subjects, according to age and sex.

Methods: Eighty patients with normal EPS results were included. TACT was measured by EPS and TDI. For validation, the results of TDI were compared with those of EPS. TACT was assessed by measuring the time interval between the beginning of the P-wave on the surface ECG, and the peak A-wave on TDI from the left atrial lateral wall, just over the mitral annulus. Electrophysiological TACT was defined as the time from the high right atrial electrogram to the distal coronary sinus atrial electrogram around the left lateral portion of the mitral ring.

Results: EPS and TDI measurements of the TACT were significantly and positively correlated among men and women in 20–30 years ($p=0.008$, $r=0.412$; $p>0.001$, $r=0.706$, respectively), and those in the 30–40 years group ($p=0.001$, $r=0.649$; $p=0.001$, $r=0.696$). In contrast, EPS and TDI measurements of TACT were not significantly different among men and women in the 20–30 years and those in the 30–40 years group ($p>0.05$, for both). On univariate regression analyses, TACT was independently associated with age ($\beta=0.342$, $=0.001$).

Conclusions: When assessed according to the age and sex of healthy participants, TDI and EPS measurements during TACT assessments were similar and correlated with each other. The measurement of TACT via TDI may be used accurately and confidently than the measurement via EPS in healthy individuals.

1. Introduction

Prolongation of total atrial conduction time (TACT) has been shown to increase the risk of atrial fibrillation in many studies [1–3]. Many different methods can be used to evaluate the TACT. Although 12-lead, signal-averaged, M-mode, and tissue Doppler echocardiography are usually used, intracardiac measurements using the electrophysiological study (EPS) remain the gold standard method. In recent years, 2-dimensional echocardiographic tissue Doppler has been used for measuring the ACT (atrial conduction time) in many clinical studies. Although it is not the gold standard, this non-invasive method is usually preferred for ACT measurements [1,2,4]. However, to the best of our knowledge, no study has directly compared the TDI TACT measurements with the currently accepted gold standard electrophysiological TACT measurements for validation, except one where conventional Doppler echocardiography was used instead of TDI in healthy subject [5]. Moreover, no validation study has been performed among different age and sex groups in subjects with normal EPS results. In this study, we aimed to compare the TACT measured by TDI and EPS according to age and sex among healthy individuals without cardiovascular and systemic diseases for the purpose of validation of TDI use in the evaluation of TACT.

2. Methods

2.1. Study population

Eighty healthy subjects with normal EPS results (40 women and 40 men; 2 different age groups [20–30 and 30–40 years]), who were referred to our EPS laboratory for various reasons, such as

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unexplained palpitation or syncope, were included in this study. Four groups, consisting of 20 subjects in each group, were organized according to age and gender (Group A: women, aged 20–30; Group B: women, aged 30–40; Group C: men, aged 20–30; Group D: men, aged 30–40). Only individuals with normal EPS results were included. Subjects with any kind of known systemic disease and history of drug use that may affect the conduction system were excluded. All subjects had normal cardiac anatomy, cardiac systolic and diastolic functions on echocardiography, and normal sinus rhythm on electrocardiography (ECG). The entire study population's demographic characteristics, biochemical parameters, lipid values, and ECGs were obtained. Patients with at least one of the following conditions were excluded from the study: hyperthyroidism, hypothyroidism, acute coronary syndrome, prior myocardial infarction and coronary artery disease, congestive heart failure, left ventricular (LV) hypertrophy, left and right atrial enlargement, prolonged QRS duration ($\geq$ 120 msn), reduced LV ejection fraction ($<$ 55%), atrial flutter or fibrillation, significant valvular heart disease, pacemaker implantation, frequent ventricular pre-excitation and atrio-ventricular conduction abnormalities, diabetes mellitus, arterial hypertension (resting blood pressure $\geq$ 140/90 or antihypertensive drug use), medications known to alter cardiac conduction, peripheral vascular diseases, congenital heart disease, pulmonary or neurological disease, pericarditis, peripheral neuropathy, alcohol abuse, renal or hepatic disease and poor echocardiographic imaging. Echocardiographic measurements were obtained after the completion of electrophysiological studies in the same day. The local ethics committee approved this study and all subjects gave their informed consent prior to participation.

2.2. Conventional echocardiography

All subjects were evaluated by transthoracic M mode, two dimensional (2D), pulsed-wave (PW), continuous wave (CW), color flow, and tissue Doppler imaging (TDI). Echocardiographic examinations were performed using the GE- Vivid-3 system (GE Vingmed, Horten, Norway) with a 2–4 MHz transducer at a depth of 16 cm. During echocardiography, continuous single-lead ECG recording was obtained. Images were obtained in the left lateral decubitus position. The 2D and conventional Doppler examinations were obtained in the parasternal and apical views, according to the guidelines of the American Society of Echocardiography [6]. LV diameters and wall thickness were measured by M-mode echocardiography. LV ejection fraction was calculated using the apical two-and four-chamber views by Simpson's method, according to American Society of Echocardiography guidelines [6]. The mitral valve inflow patterns [E-wave, A-wave, E-wave deceleration time (Dt), E/A ratios, and isovolumic relaxation times (IVRT)] were measured using PW Doppler.

2.3. Tissue Doppler echocardiography

TDI was performed using transducer frequencies of 3.5–4.0 MHz, adjusting the spectral pulsed Doppler signal filters until the Nyquist limit of 15–20 cm/s was reached, and using the minimal optimal gain. Myocardial TDI velocities (Peak systolic [Sm], early diastolic [Em] and late diastolic velocities [Am]) were measured via spectral pulsed Doppler of the LV-free wall from the apical four-chamber view [6]. The ultrasound beam was positioned, as parallel as possible, to the myocardial segment in order to acquire the optimal imaging angle. A novel echocardiographic consideration based on TDI was introduced in order to assess the total atrial conduction time [4]. The total atrial conduction time was assessed by measuring the time interval between the beginning of the P wave on the surface ECG and the point of the peak A wave on TDI from the LA lateral wall just over the mitral annulus [2,4]. All measurements were repeated three times and average values were received for each of the parameters. The measurements were also corrected for the heart rate using the following formula: Corrected ACT = ACT $\times$ 800/R-R [5,7]. Two experienced investigators, who were unaware of the subject's clinical status, performed all measurements. If a difference of $>$ 5% in any of the variables measured by both investigators was found, the patient was not included, whereas if the difference was $<$ 5%, the measurements were averaged.

2.4. Electrophysiology study

All patients underwent an EPS after at least 6–8 h fasting. The measurements related to the ACT were performed on subjects with normal EPS results using four multi-electrode mapping catheters (Medtronic, Inc., USA). Intracardiac recordings were received via a computer with EP Tracer (CardioTek, Maastricht, the Netherlands) software. Surface ECG and intracardiac electrograms (EGMs) were recorded simultaneously, and the conduction times were measured at a rate of 300 mm/s. The first quadripolar catheter was placed on the high right atrial (HRA) region. A second decapolar catheter was positioned into the coronary sinus (CS) around the left lateral portion of the mitral ring. Additionally, another catheter was placed on the His bundle (HB) region. Electrophysiological total atrial conduction time was defined as the time from the atrial HRA electrogram to the distal CS atrial electrogram around the left lateral portion of the mitral ring. The measurements were also corrected for the heart rate as the TDI measurements using the mentioned formula [5,7].

3. Statistical analysis

All analyses were performed using the SPSS (SPSS Inc., Chicago, IL, USA) software package. All data were presented as the mean $\pm$ standard deviation. Total atrial conduction time measurements by the two methods were compared using the paired *t* tests. The comparison of echocardiographic data between the two groups were performed using one-way analysis of variance (ANOVA) with post hoc analysis by Tukey's Honestly Significant Difference (HSD) or independent sample *t*-tests, and Kruskal–Wallis tests or Mann–Whitney *U* test for normally and abnormally distributed data, respectively. Correlations between variables were tested by means of Pearson's bivariate correlation testing. We used a univariate logistic regression analysis to quantify the association of variables with TACT. Variables that were found to be statistically significant in the univariate analysis and other potential confounders were used in a multiple logistic regression model using the forward stepwise method, in order to determine the independent prognostic factors. Analyses of the differences in the TDI and EPS measurements were performed according to the Bland–Altman technique. A value of $p < 0.05$ was considered statistically significant.

4. Results

4.1. Clinical and echocardiographic assessment

The clinical cardiovascular examination, chest radiography, cardiac systolic and diastolic functions, cardiac volumes, and ejection fractions were normal in all subjects. Baseline demographic and laboratory characteristics of all subjects are shown in Table 1. Additionally, the echocardiographic characteristics of all subjects are shown in Table 2. There were no complications related to the EPS procedures.