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Original Article *Özgün Araştırma*

A COMPARATIVE ASSESSMENT OF TRANSESOPHAGEAL AND TRANSTHORACIC ECHOCARDIOGRAPHY FOR ANALYSIS OF RIGHT VENTRICULAR DEFORMATION

Sağ Ventriküler Deformasyon Analizi İçin Transözofageal ve Transtorasik Ekokardiyografinin Karşılaştırmalı Değerlendirmesi

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ABSTRACT

Objective: The transthoracic echocardiography (TTE) is the primary method to evaluate the right ventricular (RV) functions, but the assessment of the RV by TTE can be difficult due to the complex structural and anatomical position of the RV. The transesophageal echocardiography (TEE) is a good alternative to TTE when faced with difficulties in obtaining images. In this study, we investigated the agreement between TTE and TEE for the evaluation of the RV functions.

Material and Methods: This study was carried out on 78 patients between January 2017 and May 2017. The TTE and TEE records of the patients were compared by using Bland Altman analysis, and the mean difference and confidence interval between them were analyzed.

Results: Seventy-eight patients were involved in this study. The mean age of patients was 42 years, and 34% of the participants were female. In Bland Altman analysis, there was a moderate agreement between TTE and TEE in terms of mean difference of the E velocity, the A velocity, E', A'. In contrast, there was a good agreement between TTE and TEE in terms of mean difference of RV strain, RV strain rate E, RV strain rate A, RV strain rate S which means that it could be appropriate to use them interchangeably.

Conclusion: The deformation parameters are essential for analyzing the RV functions, making a clinical decision, and estimating adverse events. The deformation parameters measured using TEE may yield information as accurate and useful as those measured using TTE, and they may be used interchangeably in making a clinical decision.

Keywords: Transthoracic echocardiography, transesophageal echocardiography, right ventricular, 2D echocardiography

ÖZ

Amaç: Transtorasik ekokardiyografi (TTE), sağ ventrikülün (SV) boyut ve fonksiyonunu değerlendirmek için birincil yöntemdir, ancak SV'nin karmaşık yapısal ve anatomik konumu nedeniyle TTE ile değerlendirilmesi güç olabilir. Transözofageal ekokardiyografi (TÖE), görüntü elde etmede zorluklarla karşılaşıldığında TTE'ye iyi bir alternatif olarak tercih edilmektedir. Bu çalışmada, RV işlevlerinin değerlendirilmesi için TTE ve TÖE arasındaki uyumu araştırdık.

Gereç ve Yöntemler: Bu çalışma Ocak 2017 ile Mayıs 2017 arasında 78 hasta üzerinde gerçekleştirildi. Hastaların TTE ve TEE kayıtları Bland Altman analizi ile karşılaştırılarak aralarındaki ortalama farkları ve güven aralığı analiz edildi.

Bulgular: Bu çalışmaya 78 hasta katıldı. Hastaların ortalama yaşı 42 idi ve katılımcıların% 34'ü kadındı. Bland Altman analizinde, E dalga velositesi, A dalga velositesi, E' ve A' değerleri ortalama farkları açısından, TTE ve TÖE arasında orta düzeyde bir uyum vardı. Bunun tersine, TTE ve TÖE arasında SV gerinim, SV gerinim hızı E, SV gerinim hızı A, SV gerinim hızı S değerlerinin ortalama farkları açısından iyi bir anlaşma vardı. Bu da her iki yöntemin birbirinin yerine kullanılmasının uygun olabileceği anlamına geliyordu.

Sonuç: Deformasyon parametreleri, SV işlevlerini analiz etmek, klinik bir karar vermek ve istenmeyen olayları tahmin etmek için gereklidir. TÖE kullanılarak ölçülen deformasyon parametreleri, TTE kullanılarak ölçülen bilgiler kadar doğru ve faydalı bilgi verebilir ve bu iki yöntem klinik bir karar vermede birbirinin yerine kullanılabilir.

Anahtar Kelimeler: Transtorasik ekokardiyografi, transözofageal ekokardiyografi, sağ ventrikül, 2D ekokardiyografi.

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INTRODUCTION

The right ventricular (RV) functions are affected by several diseases and evaluating the RV function plays a key role in patients with pulmonary hypertension, pulmonary embolism, RV infarction, pulmonary and tricuspid valvular heart disease and intracardiac shunts. In recent years, the RV size and function have received increasing attention even in left heart disease (1). Also, current studies have shown that RV dysfunction affects patients' effort capacity and survival. Therefore, the evaluation of RV function and size is becoming increasingly important. However, RV is a cardiac chamber, functions of which we know very little about because of its asymmetric and complex anatomical structure (2).

The gold standard in determining the size and function of the RV is magnetic resonance imaging, but it is expensive and difficult to achieve for each patient. The right heart catheterization is the gold standard method for the measurement of pulmonary pressures; however, it is not preferred because it is time-consuming and causes radiation exposure (3). Therefore, transthoracic echocardiography (TTE) stands out as the first method to be used in the evaluation of RV (4-6). Although TTE offers fast and reliable results, the diagnostic power of TTE reduces in some cases, when the image quality is not good, or it is necessary to evaluate the mass-thrombus distinction and valve structure and functions (7). Furthermore, there are some difficulties because of the eccentric crescent form wrapping the left ventricle, localization behind the sternum and complex contraction mechanism of the RV (3). So, in such cases, transesophageal echocardiography (TEE) may be an excellent alternative to TTE (8-10).

Even though both methods are frequently used in current practice, there is no study directly comparing their measurement accuracy in evaluating the RV function. The current guidelines state that there is inadequate data to make particular recommendations for RV size and function with TEE (3, 11). In the present study, we investigated the agreement between TTE and TEE in evaluating the RV functions by using Bland Altman analysis.

MATERIALS AND METHODS

This study was carried out on the patient population that applied to our clinic between January 2017 and December 2017 and underwent echocardiographic evaluation because of cardiac anomaly screening. The written informed consent of patients and the approval of the ethics committee were obtained (The Ethics Committee of Erzurum Regional Training and Research Hospital- 04.06.2018- 2018/11-107). Patients having bad echogenicity, those that were not able to tolerate the procedure, and those that were not voluntary in participation were excluded. Right ventricular echocardiographic parameters of the patients were measured and recorded simultaneously with TTE and TEE methods.

Transthoracic Echocardiography

All of the patients underwent echocardiographic examination in the left lateral decubitus position by using a Vivid 7 device. In accordance with the current American society of echocardiography recommendations, the images for the offline analyses were recorded from all the windows in apnea periods, in the length of a minimum three cardiac cycles, and at 50-70 fps.

Transesophageal Echocardiography

After at least 4 hours of fasting, TEE was performed to all the patients in the left lateral decubitus position by using Vivid 7 (GE Healthcare Horten, Norway) device and 5 MHz TEE probe. Xylocaine spray (5%), was used for pharyngeal anesthesia. The blood pressure values and heart rates of the patients were recorded during the procedure. TEE probe was pushed forward through the esophagus and the cardiac structures were analyzed. The records were taken for offline analysis in the apnea period and the length of a minimum of three cardiac cycles. All of the cardiac chambers and valves were

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analyzed, and the procedure was terminated when the records were taken. No complication developed after the procedure.

Offline Analysis

The records were assessed by two experienced cardiologists in accordance with current ASE recommendations and by using ECHOPAC (GE-Healthcare, Milwaukee, Wisconsin, USA) software. All of the patients underwent standard echocardiographic examination including 2D (two-dimensional), PW (pulsed-wave) Doppler, color Doppler and M-mode echocardiography by using both TTE and TEE. The deformation analyses were interpreted over the video records, which were recorded at the rate of 50-75 frames/sec and in which the endocardial borders are visible. The endocardial borders were manually drawn by using the pointer. Then, the device calculated the RV strain and RV strain rate parameters. The measurements were repeated after a week, and the intra-observer and inter-observer variability were calculated.

Statistical Analyses

The normally distributed variables were expressed with mean and standard deviations, whereas the non-normally distributed variables were expressed in median and categorical variables in percent. Bland Altman analysis was performed to compare TTE and TEE measurements. The measurement results of both groups were compared using the Wilcoxon test. The analyses were performed using SPSS Version 22. The statistical significance was set at p <0.05.

RESULTS

Seventy-eight patients were enrolled in the present study. The mean age of the patients was 42 years, and 34% of them were female. When comparing the conventional and tissue Doppler parameters, no significant difference was found between TTE and TEE measurements (p>0.05, for all) (Table 1).

In Bland Altman analysis, there was a moderate agreement between TTE and TEE in terms of mean differences (Md) of the E velocity (Md=0.08), the A velocity (Md=-0.11), E’ (Md=0.03), A’ (Md=0.015) (Table 2), which means that they would not be appropriate to use them interchangeably.

When the RV deformation parameters were investigated, the values measured using TEE were higher than those measured TTE but there was no statistically significant difference (p>0.05 for RV strain and RV strain rate values). The deformation analyses of both groups are presented in Table 2. In Bland Altman analysis, there was a good agreement between TTE and TEE in terms of mean differences of RV strain (Md=0.79), RV strain rate E (Md=0.02), RV strain rate A (Md=-0.15), RV strain rate S (Md=0,12) which means that it could be appropriate to use them interchangeably (Figure 1).

Table 1: Comparison of transthoracic and transesophageal echocardiographic parameters

Variables	**TTE**	**TEE**	**P value**
LVDD (mm)	46.8±6.0	46.1±5	0.43
LVSD (mm)	26.2±5.2	25.4±5.2	0.67
RVD (mm)	37.5±6.2	37.1±6.2	0.21
TAPSE (mm)	19±5.2	20.2±5.2	0.45
sPAP (mmhg)	25.1±5.2	28.6±5.2	0.78
LV-EF (%)	62.4±6.0	62.9±6.0	0.32
E velocity (m/s)	1.2±0.14	1.1±0.10	0.36
A velocity (m/s)	0.59±0.10	0.70±0.10	0.56
E’(m/s)	0.14±0.02	0.11±0.03	0.23
A’(m/s)	0.16±0.01	0.15±0.01	0.19
IVRT (ms)	86.2±13.6	89.9±11.1	0.49
IVCT (ms)	42.2±8.1	44.4±9.3	0.67
RVS (%)	24.4±5.2	25.2±5.2	0.52
RVSR E (s^{-1})	1.1±0.2	1.3±0.2	0.43
RVSR A (s^{-1})	1.25±0.2	1.4±0.2	0.45
RVSR S (s^{-1})	1.02 ±0.2	1.14±0.2	0.71

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Table 2: The mean differences and limits of agreement of transthoracic and transesophageal echocardiographic parameters

Variables	Mean differences	95% Limits of agreement
LVDD (mm)	0.72	(-0.3) - (1.8)
LVSD (mm)	0.81	(-0.46) - (2.2)
RVD (mm)	0.39	(-0.23) - (1.1)
TAPSE (mm)	-1.2	(-21) - (19)
sPAP (mmhg)	-3.5	(-23) - (21)
LV-EF (%)	-1.5	(-11) - (18)
E velocity (m/s)	0.08	(0.16) - (0.28)
A velocity (m/s)	-0.11	(-0.32) - (0.25)
E'(m/s)	0.03	(-0.04) - (0.07)
A'(m/s)	0.015	(-0.24) - (0.45)
IVRT (ms)	-2.7	(-31) - (21)
IVCT (ms)	-2.2	(-19) - (23)
RVS (%)	0.79	(-0.43) - (2)
RVSR E (s^{-1})	0.02	(-0.13) - (0.17)
RVSR A (s^{-1})	-0.15	(-0.29) - (0.16)
RVSR S (s^{-1})	0.12	(0.07) - (0.23)

Abbreviations: LVDD; left ventricular end-diastolic diameter, LVSD; left ventricular end-systolic diameter, RVDD; right ventricular end-diastolic diameter, RVSD right ventricular end-systolic diameter, TAPSE; tricuspid annular plane systolic excursion, sPAP; systolic pulmonary artery pressure, LV-EF; left ventricular ejection fraction, IVRT; isovolumetric relaxation time, IVCT; isovolumetric contraction time, RVS; right ventricular strain, RVSR; right ventricular strain rate

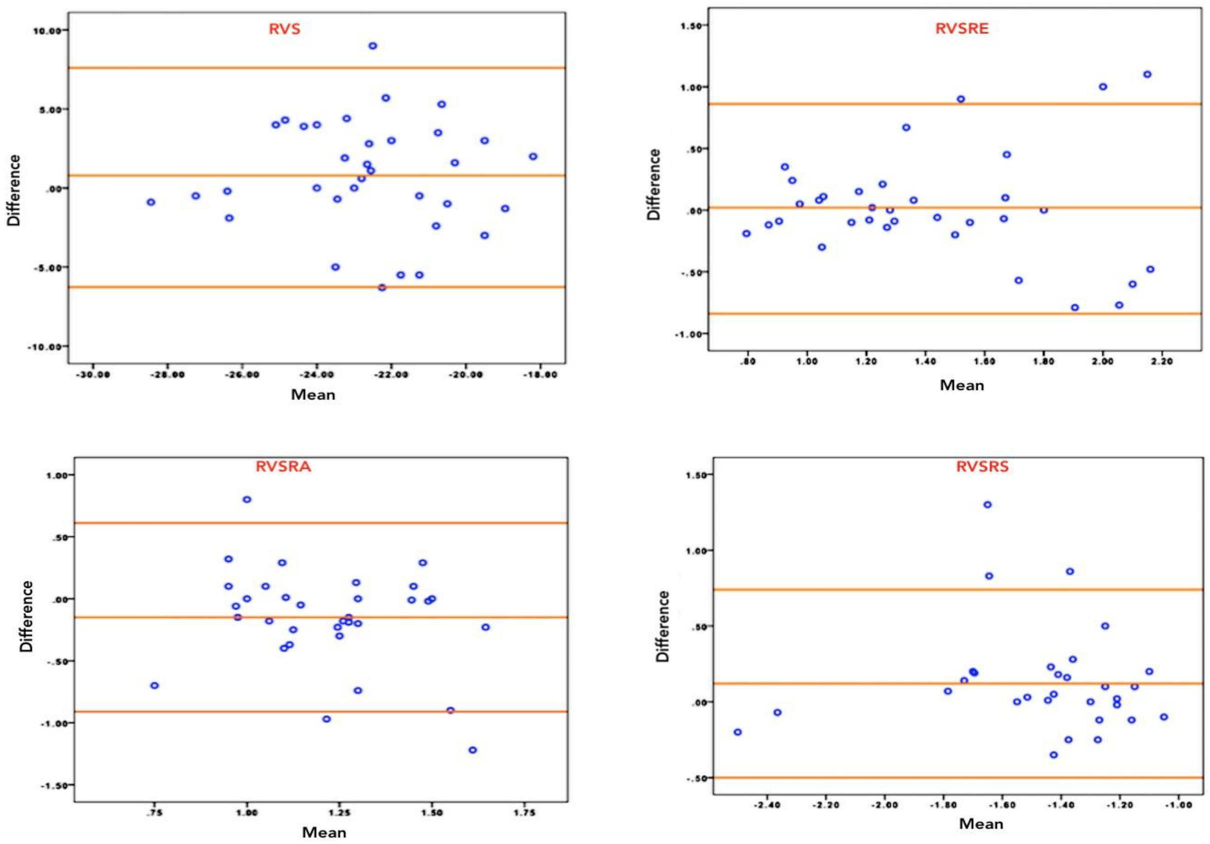

Figure 1: Bland Altman Analysis for Right Ventricular Deformation Parameters

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DISCUSSION

In the present study, we investigated the agreement between TTE and TEE in evaluating the RV function and size, and we showed that there were a good agreement between deformation parameters assessed by TTE and TEE when compared to conventional Doppler echocardiography methods. To our knowledge, this is the first study to show the agreement between TTE and TEE in evaluating the RV function.

RV has an active role in the fetal period, and this role continues throughout the later stages of life (12). However, even though it plays such an important role, the RV is a cardiac chamber, which is not sufficiently studied because of its complex geometrical structure (4,5,13,14). The strain of the RV wall suggests the moderate risk of emboli in the acute period of the patients with pulmonary emboli and also it is a significant predictor of mortality and adverse event in long-term follow-up. Similarly, the increased RV diastolic diameters of chronic obstructive pulmonary disease patients are related to mortality and adverse event. Finally, decreased RV functions are associated with mortality and adverse event in chronic thromboembolic pulmonary hypertension patients (6,13,15-17). In conclusion, RV size and functions are affected by many diseases. In clinical practice, the algorithms of diagnosis, treatment, and follow-up are determined in parallel with these parameters. As in assessing the left cardiac chambers, the TTE is the first option in evaluating the RV structure and functions (18-20).

In the previous studies, TEE was shown to be superior to TTE in assessing the diameter and functions of the RV (21). Furthermore, TEE is also superior to TTE in assessing the appendix functions and morphology, as well as detecting the cardiac mass or anomaly. 3D image support may also increase the success of the procedure by providing the operator with better visibility (8-10,22). Finally, TEE is the only option when no measurement or assessment can be done by using standard TTE in cases such as obesity or cardiac anatomic variation. Besides the advantages emphasized above, its main disadvantage is being a relatively invasive procedure that needs an anesthetic protocol and its costs are higher (23).

Studies comparing TEE and TTE have been conducted to evaluate RV diameter and functions, and the similarity between the data has been reported to be good. However, when these two techniques are compared, there is poor compliance with Doppler parameters (8-10,22,24-25). Likewise, the similarity between the Doppler parameters was found to be at a moderate level in the present study. This may be caused by the fact that the Doppler parameters are more affected by volume and hemodynamic status and changes in angular image quality (26). Also, it was shown in previous studies that the Doppler parameters might be affected by preoperative status, heart rate, and blood pressure change or intra-observer variations (27). However, when we examined the deformation analysis, the compliance between the two technics was interestingly better than the Doppler parameters. The reason for this result may be that the deformation analysis is less affected by the operator and the clinical situation. From this aspect, it can be said that the deformation analyses can be used interchangeably and, in suitable cases, the RV strain measurement made with TEE can be sufficient in making a clinical decision without any correction.

In the present article, RV Strain, RV strain rate A, RV strain rate E, and RV strain rate S are used as RV deformation parameters. Strain is measured from a change in length between two points before and after movement. Strain rate is expressed as systole (S), isovolumic relaxation, early diastole (E), and late diastole (A) during isovolumic contraction (28). Tissue Doppler is an echocardiographic technique that uses Doppler principles to measure the velocity of myocardial motion. Tissue Doppler wall velocities during systole, early relaxation (E), and atrial systole (A) are processed from RV-free wall and interventricular septum at three sites (basal, mid cavity, and apical). E' and A' are their Tissue Doppler velocities (29). RV isovolumic relaxation time (IVRT) time is described as the period from pulmonary valve closure to tricuspid valve opening. RV isovolumic conratcion time (IVCT) is defined as the interval between coaptation of the tricuspid valve leaflets and the pulmonic valve opening (30).

The major limitations of the current study are that it included a small number of patients and had a retrospective design. These may affect the statistical analysis. Also, 3D deformation analysis or cardiac magnetic resonance imaging analysis that is giving more accurate data about RV could not be applied due to the lack of the required equipment.

The deformation parameters are important in assessing the RV functions, making clinical decisions, and estimating the adverse events. The deformation parameters measured with TEE are as accurate and useful as those measured with TTE, and they can be used interchangeably in making a clinical decision. However, it has been demonstrated that TEE is superior to TTE in the evaluation of Doppler parameters and cannot be used interchangeably in clinical practice. In addition, it is predicted that RV strain measurement with TEE may be sufficient for clinical decision making without any correction. It is important to conduct future studies with larger samples and in subgroups of patients with special clinical significance, such as pulmonary embolism, right ventricular cardiogenic shock, and subgroup evaluations of pulmonary hypertension.

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