

Assessment of right ventricular systolic function with dP/dt in healthy subjects: an observational study

*Sağlıklı bireylerde sağ ventrikül sistolik fonksiyonlarının dP/dt ile değerlendirilmesi:
Gözlemsel bir çalışma*

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ABSTRACT

Objective: The objective of our study is to determine the mean values of right ventricular (RV) dP/dt and to compare it with other right ventricular function parameters by echocardiography.

Methods: This observational study consisted of 112 healthy subjects who had trivial tricuspid regurgitation. Full echocardiographic examination was performed. RV systolic function was assessed by using myocardial performance index (RV MPI), tricuspid annular plane systolic excursion (TAPSE), myocardial acceleration during isovolumic contraction (RV IVA), RV fractional area change (RV FAC), tissue Doppler-derived tricuspid lateral annular systolic velocity (Tri S') and RV dP/dt (dP/dt). Pearson correlation test was used in examining the correlation between parameters. Differences between correlations were compared with Fisher's z transformation.

Results: The mean of RV dP/dt (0.5-2) was 1016±421 mmHg/s (95% CI=891-1142) and the mean of RV dP/dt (1-2) was 1524±573 mmHg/s (95% CI=1354-1694). RV pulse Doppler MPI and RV tissue Doppler imaging MPI were negatively correlated with RV dP/dt (0.5-2) (r=-0.482 and r=-0.504, p<0.01). Tri S' was positively correlated with RV dP/dt (0.5-2) (r=0.667, p<0.01) and with the RV dP/dt (1-2) (r=0.312, p<0.05). TAPSE was positively correlated with RV dP/dt (0.5-2) (r=0.585, p<0.01) and with the RV dP/dt (1-2) (r=0.323, p<0.05). RV IVA was positively correlated with RV dP/dt (0.5-2) (r=0.512, p<0.01). FAC (%) was not correlated with both RV dP/dt (0.5-2) and RV dP/dt (1-2).

Conclusion: The results of our study were as follows: 1) we described the mean of RV dP/dt (0.5-2) and RV dP/dt (1-2) in healthy population; 2) the correlation between dP/dt (0.5-2) and RV function parameters was better than between dP/dt (1-2) and RV function parameters.

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Key words: Right ventricular function, right ventricular dP/dt, Doppler echocardiography, healthy subjects

ÖZET

Amaç: Çalışmamızın amacı sağ ventrikül dP/dt'nin ortalama değerlerini tanımlamak ve diğer sağ ventrikül fonksiyon parametreleri ile karşılaştırmaktır.

Yöntemler: Bu gözlemsel çalışma eser triküspit yetmezliği olan 112 sağlıklı bireyden oluşmaktaydı. Tüm hastalarda ekokardiyografik inceleme uygulandı. Sağ ventrikül fonksiyonu miyokardiyal performans indeksi (RV MPI), triküspit anüler düzlem sistolik yerdeğişimi (TAPSE), izovolümik kontraksiyon esnasında miyokardiyal hızlanma (RV IVA), sağ ventrikül fraksiyonel alan değişimi (RV FAC), doku Doppler triküspit anüler lateral sistolik hız (Tri S') ve sağ ventrikül dP/dt (RV dP/dt) ile değerlendirildi. Parametreler arasındaki korelasyonun değerlendirilmesinde Pearson korelasyon testi kullanıldı. Korelasyonlar arasındaki farklar Fisher's z değişimi ile karşılaştırıldı.

Bulgular: RV dP/dt'nin (0.5-2) ortalama değerleri 1016±421 mmHg/s (%95 GA=891-1142) iken, RV dP/dt'nin (1-2) ortalama değerleri 1524±573 mmHg/s (%95 GA=1354-1694) idi. RV puls Doppler MPI ve RV doku Doppler MPI, RV dP/dt (0.5-2) ile negatif korelasyon gösteriyordu (r=-0.482 and r=-0.504, p<0.01). Tri S', RV dP/dt (0.5-2) (r=0.667, p<0.01) ve RV dP/dt (1-2) (r=0.312, p<0.05) ile pozitif korelasyon gösterdi. TAPSE, RV dP/dt (0.5-2) (r=0.585, p<0.01) ve RV dP/dt (1-2) (r=0.323, p<0.05) ile pozitif korelasyon gösterdi. RV IVA, RV dP/dt (0.5-2) (r=0.512, p<0.01) ile pozitif korele idi. FAC (%), RV dP/dt (0.5-2) ve RV dP/dt (1-2) ile korelasyon göstermedi.

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Sonuç: Biz bu çalışmamızda 1) sağlıklı bireylerde RV dP/dt (0.5-2) ve RV dP/dt (1-2)'nin ortalama değerlerini ortaya koyduk; 2) dP/dt (0.5-2) ile sağ ventrikül fonksiyon parametreleri arasında korelasyon, dP/dt (1-2)'ye göre daha iyiydi. (*Anadolu Kardiyol Derg 2013; 13: 103-7*)

Anahtar kelimeler: Sağ ventrikül fonksiyonu, sağ ventriküler dP/dt, Doppler ekokardiyografi, sağlıklı bireyler

Introduction

Right ventricular (RV) systolic performance has paramount importance in various disease states and right ventricular dysfunction has prognostic value in heart failure, pulmonary hypertension, congenital heart disease and myocardial infarction (1). RV systolic performance is a reflection of contractility, preload and afterload (1). Complex interplay among these variables can be better understood by right ventricle pressure-volume relation. However, it is not suitable for daily practice because of its invasive nature. Magnetic resonance imaging is the gold standard for assessment of RV systolic function but is not as practical as echocardiography (2).

Therefore, echocardiography becomes prominent method for the evaluation of right ventricle.

Right ventricular systolic function can be assessed echocardiographically by using several parameters including RV index of myocardial performance (RV MPI), tricuspid annular plane systolic excursion (TAPSE), myocardial acceleration during isovolumic contraction (RV IVA), right ventricular fractional area change (RV FAC), three-dimensional RV ejection fraction (3D RVEF), tissue Doppler-derived tricuspid lateral annular systolic velocity (Tri S), and longitudinal strain and strain rate. TAPSE, pulsed or tissue Doppler derived RV MPI, peak systolic tricuspid annular velocity, fractional area change and RV dP/dt have been recently proposed as tools for assessment of RV systolic function (3).

dP/dt, the rate of pressure rise, was initially described by Gleason and Braunwald in 1962 as an invasive measurement index of ventricular contractility (4). A good correlation between the noninvasive Doppler-derived and catheter-derived left ventricular dP/dt was demonstrated (5). Left ventricular dP/dt was found to be a sensitive method in detecting early myocardial dysfunction in patients with chronic mitral regurgitation (6). RV dP/dt can be accurately estimated from the ascending limb of the tricuspid regurgitation continuous-wave Doppler signal (7, 8). Because of the lack of data in normal subjects, RV dP/dt has not been gained acceptance for routine use so far.

We aimed to measure the mean dP/dt of the right ventricle using tricuspid regurgitation in healthy individuals and to compare with other RV function parameters.

Methods

Study design and population

An observational study consisted of 112 healthy subjects with trivial tricuspid regurgitation (56 male and 56 female, age range 20 to 61 years, mean age 44±6 years), who were admitted to our outpatient clinic in Gülhane Military Medical Academy between February 2011 and November 2011. None of the

patients had diabetes mellitus, hypertension, valvular heart disease, coronary artery disease, and had normal physical examination and electrocardiogram. The institutional review board of the hospital approved the study and all subjects signed informed consent before participation.

Echocardiography

Transthoracic echocardiographic examination including tissue Doppler modality were performed with a commercially available ultrasound system (Philips IE 33 6.0, Philips Medical Systems, Andover, MA, USA) equipped with a 2.5-MHz transducer. Standard echocardiographic windows including parasternal long axis, apical four chamber and two chamber views in left lateral position at the end of the expiration were obtained in all participants (9). Special emphasis was given to apical 4-chamber view focusing on the right ventricle. All data were stored digitally and analyzed off-line.

Right ventricular function parameters

Right ventricular MPI, also known Tei index, was calculated by two methods: the pulsed Doppler method and the tissue Doppler method. The MPI is defined as the ratio of isovolumic time divided by ejection time (ET) (10). Tissue Doppler-derived tricuspid lateral annular systolic velocity (Tri S) was measured by placing the cursor into the basal RV free wall on apical 4-chamber view (11). TAPSE is the distance of systolic excursion of the basal RV free wall along its longitudinal plane on apical 4-chamber view. M-mode derived TAPSE (cm) was measured according to the method proposed by Kaul et al. (12). Myocardial acceleration during isovolumic contraction (RV IVA) is defined as the peak isovolumic myocardial velocity divided by time to peak velocity and is measured by using Doppler tissue imaging at the lateral tricuspid annulus (13). RV FAC is obtained by tracing the RV endocardium both in systole and diastole from 4 chamber view and is defined as (end-diastolic area -end-systolic area)/end-diastolic area x 100 (14).

Right ventricular dP/dt measurement

The instantaneous pressure drop between the right ventricle and the right atrium was calculated from the modified Bernoulli equation (15, 16). $\Delta P=4v^2$, where ΔP is the pressure drop (mmHg) and v is the instantaneous regurgitant jet velocity (m/sec). Continuous wave Doppler tracing of tricuspid regurgitation velocity curves were recorded at a sweep speed of 100 mm/sec. Three points were selected on the steepest ascending segment of the continuous tricuspid regurgitation velocity curves (point A, 0.5 m/sec=1 mmHg; point B, 1m/sec=4 mmHg; point C, 2m/sec=16 mmHg) and the time interval between them was measured. Pressure rise between A and C is 15 mmHg; dP/dt (0.5-2)

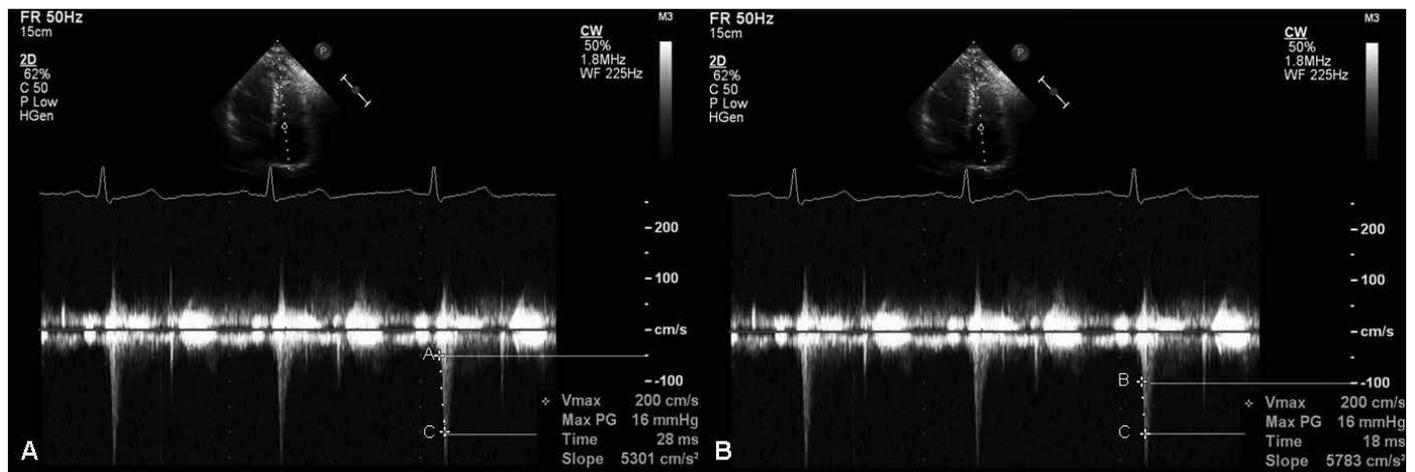


Figure 1. Continuous wave Doppler echocardiographic measurement of dP/dt (0.5-2) and dP/dt (1-2). The time interval between 0.5 m/s (A) and 2 m/s (C) is 28 ms (0.028 sec) and pressure rise between A and C is 15 mmHg; dP/dt (0.5-2) is 15 mmHg/0.028 sec (1A). The time interval between 1 m/s and 2 m/s is 18 ms (0.018 sec) and pressure rise between B and C is 12 mmHg; dP/dt (1-2) is 12 mmHg/0.018 sec (1B)

is 15 mmHg/t. Pressure rise between B and C is 12 mmHg; dP/dt (1-2) is 12 mmHg/t (Fig. 1).

Statistical analysis

SPSS package program for Windows, Version 15.0 (SPSS Inc., Chicago, IL, USA) was used to assess the data. Continuous data are expressed as mean±standard deviation. Pearson correlation test was used in examining the correlation between parameters. $P < 0.05$ was considered statistically significant. Differences between correlations were compared with Fisher's z transformation.

Results

Clinical characteristics and RV echocardiographic parameters are shown in Table 1. The mean of RV dP/dt (0.5-2) was 1016 ± 421 mmHg/s (95% CI=891-1142, interquartile range=357, minimum=600, maximum=1955) and the mean of RV dP/dt (1-2) was 1524 ± 573 mmHg/s (95% CI=1354-1694, interquartile range=623, minimum=857, maximum=2358).

The correlation between RV dP/dt and other RV function parameters are shown in Table 2. RV pulse Doppler MPI was negatively correlated with RV dP/dt (0.5-2) ($r = -0.482$, $p < 0.01$) but not with the RV dP/dt (1-2) ($r = -0.143$, $p > 0.05$). Similarly, RV TDI MPI was negatively correlated with RV dP/dt (0.5-2) ($r = -0.504$, $p < 0.01$) but not with the RV dP/dt (1-2) ($r = -0.153$). Tri S' was positively correlated with RV dP/dt (0.5-2) ($r = 0.667$, $p < 0.01$) and with the RV dP/dt (1-2) ($r = 0.312$, $p < 0.05$). TAPSE was positively correlated with RV dP/dt (0.5-2) ($r = 0.585$, $p < 0.01$) and with the RV dP/dt (1-2) ($r = 0.323$, $p < 0.05$). RV IVA was positively correlated with RV dP/dt (0.5-2) ($r = 0.512$, $p < 0.01$), whereas there was no correlation with RV dP/dt (1-2) ($r = 0.148$). FAC (%) was not correlated with both RV dP/dt (0.5-2) and RV dP/dt (1-2). According to Fisher z transformation, correlation between RV dP/dt (0.5-2) and RV function parameters except for FAC (%) was better than between RV dP/dt (1-2) and RV function parameters.

Table 1. Baseline demographic, clinical and right ventricular function parameters of the study group

Study group	(n=112)
Age, years	44±6
Gender, F/M	56/56
BMI, kg/m ²	24.54±1.94
BSA, m ²	1.78±0.17
Systolic BP, mmHg	128.5±5.1
Diastolic BP, mmHg	83.4±5.6
Pulse Pressure, mmHg	50.4±5.8
RV PD MPI	0.26±0.7
RV TDI MPI	0.39±0.17
Tri S', cm/s	13.98±2.43
TAPSE, cm	2.59±0.33
RV IVA, m/s ²	2.66±0.68
RV FAC, %	47±4.6
RV dP/dt (0.5-2), mmHg/s	1016±421
RV dP/dt (1-2), mmHg/s	1524±573

Values are presented as number and mean±SD
 BMI - body mass index, BP - blood pressure, BSA - body surface area, FAC - fractional area change, IVA - isovolumic acceleration, PD MPI - pulsed-wave Doppler myocardial perfusion index, RV - right ventricle, TDI MPI - tissue Doppler imaging myocardial perfusion index

Discussion

Right ventricular dP/dt is a tool for measuring right ventricular function but there is a few data hindering its widespread use in decision making process. We tried to help solve the problem by determining the mean of RV dP/dt (0.5-2) and RV dP/dt (1-2) in healthy population. We found that the mean of RV dP/dt (0.5-2) and RV dP/dt (1-2) was 1016 ± 421 mmHg/s (95% CI, 891-1142) and 1524 ± 573 mmHg/s (95% CI, 1354-1694), respectively. These values were lower than that reported by Anconina et al. (7) but their

Table 2. The correlation between RV dP/dt and the right ventricular function parameters in normal subjects

Variables	RV dP/dt (0.5-2) r	*p (0.5-2)	RV dP/dt (1-2) r	*p (1-2)
RV PD MPI	-0.482	<0.01	-0.143	NS
RV TDI MPI	-0.504	<0.01	-0.153	NS
Tri S', cm/sn	0.667	<0.01	0.312	<0.05
TAPSE, cm	0.585	<0.01	0.323	<0.05
RV IVA, m/sn ²	0.512	<0.01	0.148	NS
FAC, %	0.026	NS	0.096	NS

*Pearson's correlation test

FAC - fractional area change, IVA - tissue Doppler imaging isovolumic acceleration, PD MPI - pulsed-wave Doppler myocardial perfusion index, RV - right ventricle, TAPSE - tricuspid annular plane systolic excursion, TDI MPI - tissue Doppler imaging myocardial perfusion index

study included patients with concomitant diseases which may affect right ventricle unfavorably.

We determined that only RV dP/dt (0.5-2) showed consistent but moderate correlation with echocardiographic RV systolic performance parameters in negative or positive directions except FAC. We can explain this result by Anconina et al. (8) study in which RV dP/dt showed high degree of correlation with catheter derived dP/dt at the velocity range of 0 to 2 m/sec ($r=0.93$) and 0.5 to 2 m/s ($r=0.90$) but not for the velocity range of 0 to 1 m/sec and 0.5 to 1.5 m/sec. We thought that RV dP/dt (1-2) includes relatively late beginning of right ventricular pressure rise which attenuate its correlation with right ventricular systolic performance parameters.

Although there was no previous study directly comparing TAPSE, Tri S' velocity, RV MPI and FAC in healthy volunteers, Saxena et al. (17) reported very high correlation coefficients among these parameters in patients with pulmonary hypertension. The absence of correlation between FAC and RV dP/dt can be considered as a normal finding because our study group consists of healthy volunteers.

We could not find any previous report correlating Doppler derived RV dP/dt with other echocardiographic right ventricular systolic function parameters in healthy volunteers but Dağdeviren et al. (18) showed very high correlation between RV dP/dt and tricuspid annular S wave velocity in patients with various cardiac diseases. Likewise, RV dP/dt (0.5-2) had highest correlation coefficient with Tri S' wave followed by TAPSE in our study.

Although all measured right ventricular systolic performance parameters including RV dP/dt in our study have been used for right ventricular evaluation, each is affected by various confounders, which may explain why we determined moderate correlation coefficients among these parameters. Left ventricular function has influence on TAPSE (19) and myocardial performance index includes both systolic and diastolic functions. RV IVA is somewhat different from other parameters and resembles RV dP/dt in such a way that both parameters reflect right ven-

tricular contractility (20, 21). However, RV IVA measures earlier isovolumic event than RV dP/dt (22) which may explain our finding of the absence of high correlation coefficient with RV dP/dt.

According to our opinion, the evaluation of RV systolic functions requires using different echocardiographic parameters as in valve regurgitation (23). Therefore, many RV systolic function parameters should be measured in an individual patient. In this respect, RV dP/dt may provide complementary data in such a patient and may help to the busy clinician for reaching a conclusion.

Study limitations

Doppler derived RV dP/dt measurement has some limitations. It is affected by preload and the angle of incidence (24). Adding catheter based dP/dt measurement to our study might have strengthened our study results. The need for assessing clinical utility of RV dP/dt in various disease states and providing cut-off values having prognostic significance may clarify by further studies.

Conclusion

There have been several parameters including RV MPI, Tri S' TAPSE, RV IVA and RV FAC used in evaluating right ventricular function so far. Despite being a simple technique with a strong physiological basis, RV dP/dt has not been recommended for routine uses because of the lack of data in normal subjects. In this study, we have described the mean of RV dP/dt (0.5-2) and RV dP/dt (1-2) in healthy population and have found that the correlation between RV dP/dt (0.5-2) and RV function parameters except for FAC % was better than between RV dP/dt (1-2) and RV function parameters. RV dP/dt (0.5-2) can be used in assessing the right ventricular function.

Conflict of interest: None declared.

Peer-review: Externally peer-reviewed.

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