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Localization of Accessory Pathway Using Tissue Doppler Echocardiography Prior Radiofrequency Ablation in Patients with Wolff-Parkinson-White Syndrome

Wolff-Parkinson-White Hastalarında Ablasyon İşlemi Öncesi Doku Doppler Ekokardiyografi ile Aksesuar Yolun Lokalizasyonunun Belirlenmesi

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ABSTRACT Objective: We sought to examine the diagnostic accuracy of tissue Doppler imaging (TDI) for the localization of the accessory pathways (APs) in Wolff-Parkinson-White (WPW) syndrome. **Material and Methods:** We prospectively studied 35 patients with evidence of pre-excitation on electrocardiography. Patients were categorized into three groups according to the site of the AP: left ventricular free wall; septal; and right ventricular free wall. The recordings obtained using TDI from the lateral mitral annulus, septal annulus, and lateral tricuspid annulus were respectively compared with the electrophysiological study (EPS) results for the location of the AP. Electromechanical interval (p-Sm) was defined as the time difference between the onset of the p wave and the onset of regional myocardial contraction (Sm) on echocardiography. **Results:** In patients with left free access in EPS, electromechanical interval (pre-p-Sm) in the lateral mitral annulus was significantly shorter in the other two regions (septal annulus, and lateral tricuspid annulus) in TDI before treatment (p=0.0001). In patients with septal AP and right free AP detected at EPS, the pre-p-Sm interval was shorter, respectively, at the septal annulus and lateral tricuspid annulus, but was not statistically significant, due to the small numbers of patients in both regions. **Conclusion:** The p-Sm interval in TDI before the ablation procedure, specifically in patients having a left free AP, was found to be short due to early stimulus. This was especially detected without using a free electrocardiogram (ECG) algorithm. The prediction of AP in TDI may play an important role in planning and performing the radiofrequency catheter ablation (RFCA).

Keywords: Wolff-Parkinson-White syndrome; echocardiography, Doppler

ÖZET Amaç: Wolff-Parkinson-White (WPW) sendromundaki aksesuar yolların (AP'ler) lokalizasyonu için doku Doppler görüntülemenin (TDI) tanısal doğruluğunu incelemeye çalıştık. **Gereç ve Yöntemler:** EKG'sinde preeksitasyonu olan 35 hastayı prospektif olarak inceledik. Hastalar aksesuar yolun sol ventrikül serbest, septal ve sağ ventrikül serbest duvar olmak üzere üç gruba ayrıldı. TDI'da hastaların lateral mitral annulus, septal mitral annulus ve lateral triküspit annulustan alınan kayıtlar, elektrofizyolojik çalışma (EPS) da aksesuar yolun olduğu bölgelerle karşılaştırıldı. Ekokardiyografik incelemedeki elektromekanik interval (p-Sm) p dalgasının başlangıcı ile bölgesel miyokard kasılması (Sm) arasında geçen zaman olarak tanımlandı. **Bulgular:** EPS'de sol serbest aksesuar yol izlenen hastalarda, işlem öncesi TDI'da lateral mitral annulusta elektromekanik interval (pre p-Sm) diğer iki bölgeden (septal annulus ve sağ lateral triküspit annulus) anlamlı şekilde daha kısa saptandı (p=0.0001). EPS'de septal aksesuar yol saptanan ve sağ aksesuar yol saptanan hastalarda, TDI de sırasıyla septal annulus ve sağ lateral triküspit annulusta p-Sm intervali daha kısa saptandı, ama istatistiksel olarak anlamlı düzeye ulaşmadı. **Sonuç:** Ablasyon işlemi öncesinde TDI'da p-Sm intervali erken iletiye bağlı olarak, özellikle sol serbest aksesuar yol saptanan hastalarda kısa bulundu. Bu, özellikle yüzey elektrokardiyo-grafi (EKG) algoritması kullanmadan saptanmıştır. TDI'da aksesuar yolun öngörülmesi, radyofrekans kateter ablasyonunun (RFCA) planlanması ve gerçekleştirilmesinde önemli bir rol oynayabilir.

Anahtar Kelimeler: Wolff-Parkinson-White sendromu; ekokardiyografi, Doppler

Wolff-Parkinson-White (WPW) syndrome is a conduction disturbance in which atrial impulses are transmitted to the ventricle by an accessory pathways (AP) besides normal atrioventricular conduction. WPW is one of the most common congenital cardiac abnormalities among the ventricular pre-excitation syndromes, with a prevalence of 0.9% to 3% in the general population.[1] The pre-excitation syndrome is diagnosed by a surface electrocardiography (ECG) in sinus rhythm, which shows a typical pattern of a short PR interval (<0.12 s in adults) and a widening of QRS complex, associated with a delta wave.[2] Patients with WPW syndrome may present with palpitations, presyncope, syncope, or sudden cardiac death (SCD). The most effective treatment in symptomatic patients is radiofrequency catheter ablation (RFCA); the success rate is reasonably high.[3]

Noninvasive techniques for the localization of accessory pathways (APs) might help guide mapping procedures and ablation techniques.[4,5] We sought to examine the diagnostic accuracy of tissue Doppler echocardiography (TDI) for the localization of the APs in Wolff-Parkinson-White (WPW) syndrome. In this study, independent from surface electrocardiogram (ECG), electromechanical interval measurement in TDI was obtained. Analysis was based on the assumption that conduction should occur within a shorter time in the region where the AP is located.

MATERIAL AND METHODS

STUDY POPULATION

The study population comprised 35 patients (23 males, 12 females; mean age, 33.3 ± 10.4 years) who had a manifest AP. The patients had undergone radiofrequency catheter ablation (RFCA) due to either drug refractoriness or clinically intolerable tachycardia. Patients with hypertension, coronary artery disease, severe valvular heart disease, left ventricular (LV) systolic dysfunction, bundle branch block, atrioventricular (AV) conduction abnormalities on ECG, or multiple APs as assessed during electrophysiological study (EPS) were excluded from the study. The institutional ethics committee approved the study protocol.

ELECTROPHYSIOLOGICAL STUDY AND ABLATION PROCEDURE

Antiarrhythmic agents were discontinued in all patients, for at least 5 half-lives before the invasive EPS and RFCA. EPS, immediately followed by RFCA were performed for each patient. EPS was performed using 3 diagnostic electrodes introduced under fluoroscopic guidance. Quadripolar electrodes were introduced via the femoral vein into the His-bundle area (His-bundle electrode [HBE]) and the right ventricle apex (RVA). A third decapolar diagnostic electrode, recording unipolar and bipolar signals from the coronary sinus, was also introduced via the right femoral vein. Catheter ablation was performed by the conventional method using a transaortic approach via the right femoral artery on the left side AP, and a right transatrial approach via the right femoral vein on the right-sided APs. Temperature-controlled radiofrequency energy (30–50 W) was delivered by the ablation system using a 7 French deflectable electrode catheter with a 4 mm tip and 2.5 mm interelectrode spacing (Medtronic RF Marinr). The RF current was supplied by a 484 kHz generator (Medtronic Atakr II, Medtronic Inc., MN, USA). Data were displayed and recorded using an electrophysiological monitoring system (Quinton Electrophysiology Corp., Seattle, WA, USA). The location of the AP was defined by standard techniques involving: (1) identification of the shortest atrioventricular time in sinus rhythm; (2) mapping of the shortest ventriculoatrial conduction time during ventricular pacing or orthodromic reciprocating tachycardia; and (3) identification of an AP potential. The location of the AP was confirmed as a successful ablation site.

ECHOCARDIOGRAPHIC EXAMINATION

Echocardiographic examinations were performed for all patients before and 1 day after RFCA. All transthoracic (TTE) examination was performed using a machine (GE vivid S6 Vingmed system 5, Horten, Norway) equipped with 2.5-7.5 MHz

transducers. All patients were examined in the left lateral position by 2-dimensional and Doppler echocardiography. A single lead electrocardiogram was recorded continuously. The average of at least 3 cardiac cycles was obtained for all measurements. Tissue Doppler imaging was performed using transducer frequencies between 3.5 and 4.0 MHz, by adjusting the spectral pulsed-Doppler signal filters until a Nyquist limit of 15–20 cm/s was reached, and using the minimal optimal gain. The monitor sweep speed was set to 50–100 mm/s to optimize the spectral display of myocardial velocities. In the apical 4-chamber view, the pulsed-Doppler sample volume was subsequently placed at the level of the left ventricular (LV) lateral mitral annulus, septal mitral annulus, and right ventricular (RV) lateral tricuspid annulus. Every effort was made to align the pulsed wave cursor so that the Doppler angle of incidence was as close to 0 as possible to the direction of these walls.

The electromechanical interval (p-Sm) was defined as the time difference between the onset of the p wave and the onset of the regional myocardial contraction wave (Sm) from the LV lateral mitral annulus, septal mitral annulus, and right ventricular (RV) lateral tricuspid annulus, and these were named left p-Sm, septal p-Sm, and right p-Sm, respectively. Other TDI parameters that were also evaluated included isovolumetric contraction time (IVCT), isovolumic relaxation time (IVRT), the peak myocardial velocity which is formed during isovolumic contraction (IVV), peak myocardial systolic velocity (Sm), early diastolic myocardial velocity (Em), late diastolic myocardial velocity (Am), and ejection time (ET). These parameters and examples of the electromechanical interval (the distance between the start of the p wave and the start of myocardial contraction (Sm)) are shown in (Figure 1).

STATISTICAL ANALYSIS

Statistical analyses were performed using the Number Cruncher Statistical System (NCSS) 2007 Statistical Software (Utah, USA) package program. In addition to descriptive statistics (mean, standard deviation), one-way analysis of variance with Tukey multiple comparisons test was used for comparisons between groups, and the paired t-test was used for pre- versus post- comparison. A p value <0.05 was considered statistically significant.

RESULTS

The demographic and baseline echocardiographic characteristics of patients are shown in (Table 1).

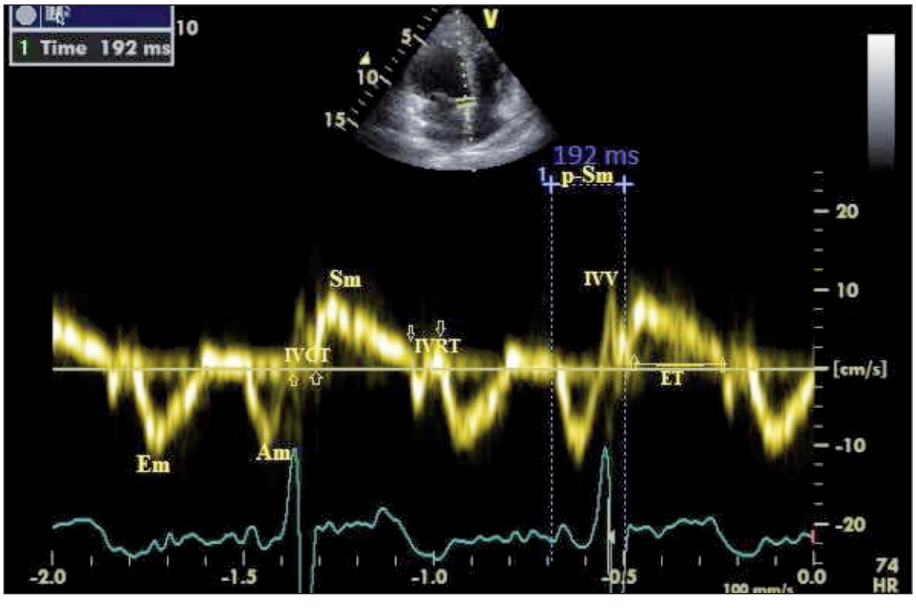

FIGURE 1: The parameters which we evaluate in tissue Doppler images (TDI) are shown.

TABLE 1: Demographic, echocardiographic and electrophysiological parameters of the patients at baseline (n=35).

Age (years)	33.3±10.4
Gender (female)	12 (34)
Body mass index (kg/m2)	24.1±3.3
Right ventricular dimension (mm)	33±3
Left ventricular diastolic diameter (mm)	46±3
Left ventricular systolic diameter (mm)	29±3
Interventricular septum (mm)	9.1±1.1
Posterior wall (mm)	8.9±0.8
Left atrial dimension (mm)	33±4
Left ventricular ejection fraction (%)	65.4±3.2
Mitral E wave (cm/s)	0.75±0.14
Mitral A wave (cm/s)	0.57±0.13
Mitral DT (ms)	183.6±44.4
Pre-excited R-R interval in atrial fibrillation (ms)	247.5±29.6
BCL (ms)	795±132
AH interval (ms)	83.2±19.5
HV interval (ms)	5.6±9.2
AP localization	
Left free wall	17 (48.6)
Septal pathways	11 (31.4)
Right free pathways	7 (20)

Data are given as mean±SD or as n (%), BCL:Baseline cycle time, AP: accessory pathway, DT:deceleration time, ms:milliseconds, s:second.

Other parameters we observed and evaluated using TDI are shown in Figure 1. Figure 2 shows the lateral mitral annulus, septal mitral annulus, and lateral tricuspid annulus images from TDI taken preoperatively in a patient in whom a ventricular free wall AP was detected in EPS; the shortest p-Sm was measured from the lateral mitral annulus (Figure 2).

Electrophysiological findings: According to the EPS data, an LV free wall AP was detected in 17 patients; a septal AP was detected in 11 patients (obtained from right posteroseptal, left posteroseptal, mid, and anteroseptal paths), and an RV free wall AP was detected in 7 patients. The detailed localizations of the APs were 8 right posterior septum, 1 mid septum, 1 anterior septum, 1 left posterior septum, 3 right lateral, 4 right posterior, 8 left lateral, 3 left anterior lateral, 1 left anterior, 4 left posterior, and 1 left posterior lateral. After successful RFCA, no ventricular pre-excitation or inducible supraventricular tachyarrhythmia could be recorded, and no complications were present.

The TDI findings: Table 2 shows the pre- and post-TDI recordings obtained from the lateral mitral annulus, septal mitral annulus, and lateral tricuspid annulus of patients in whom the right free AP was detected in EPS. Though the shortest pre-p-Sm interval measured in our study was in the lateral tricuspid annulus, this was not statistically significant. Along with the loss of right APs after RFCA, the post-p-Sm value at the lateral tricuspid annulus on TDI was significantly prolonged, compared to the pre-s-Sm. No difference was observed in any of the other time intervals (IVRT, IVCT, and ET). Despite the fact that there were differences between regions of waves demonstrating myocardial function, no significant change was observed before or after the operation (Table 2).

Table 3 shows the TDI recordings taken from the lateral mitral annulus, septal mitral annulus, and lateral tricuspid annulus of patients in whom a septal AP was detected in EPS. Though the pre-p-Sm distance was detected at the shortest septal region in our study, this was not statistically significant. The loss of pre-excitation after ablation increased the post-p-Sm value in the septal region. Differences between regions at IVRT, IVCT, and ET were not observed. As expected, a difference between regions in terms of the IVV, S wave, and E and A waves was observed (Table 3).

Table 4 shows the TDI recordings taken from the lateral mitral annulus, septal mitral annulus, and lateral tricuspid annulus of patients in whom a LV free wall AP was detected in EPS. The pre-p-Sm distance (the p-Sm in TDI before ablation) was detected as shortest at the lateral mitral annulus; this difference was statistically significant ($p= 0.0001$). The loss of the left AP after ablation and the post-p-Sm value of the lateral mitral annulus in TDI increased significantly when compared with the pre-p-Sm value ($p = 0.002$). The other comparative TDI parameters are shown in (Table 4).

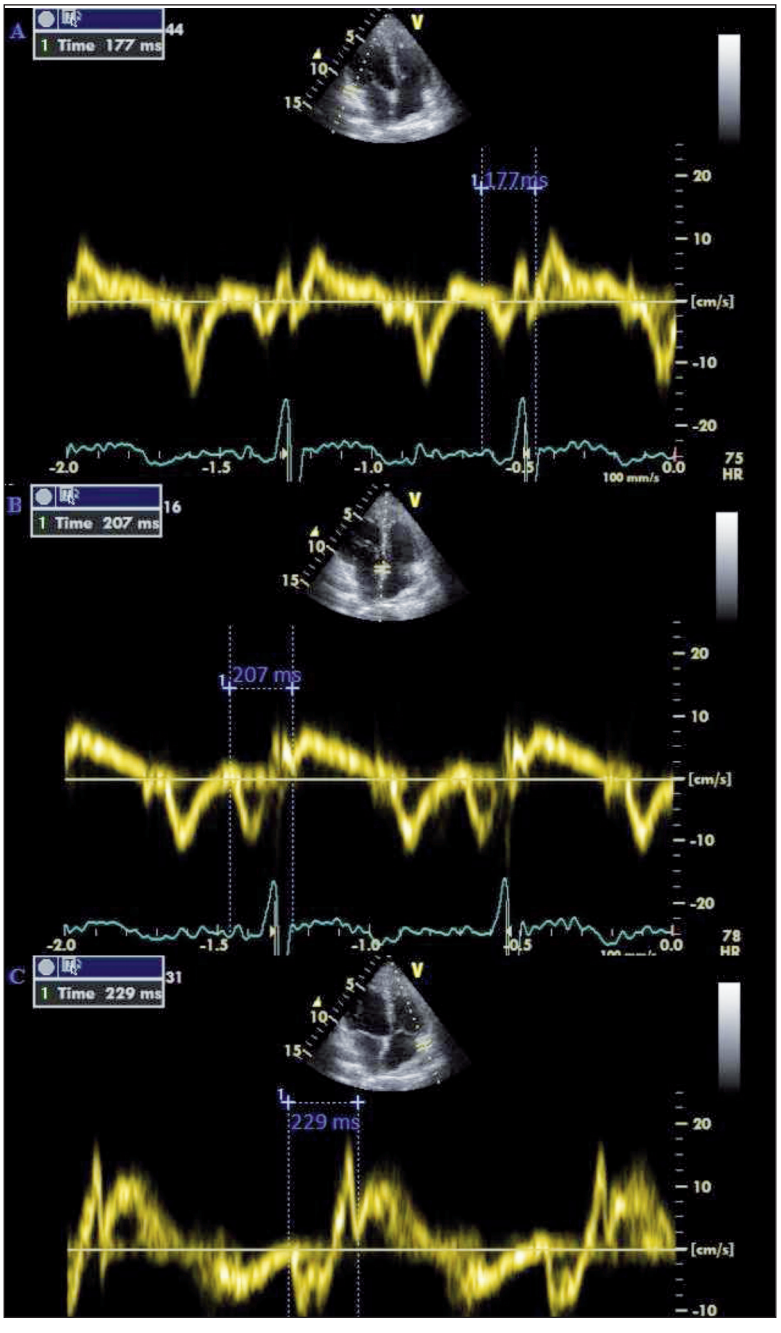

FIGURE 2: Images taken from the lateral mitral annulus, septal mitral annulus, and lateral tricuspid annulus on preoperative TDI in a patient in whom the left free AP was detected in EPS. The shortest p-Sm was measured from the lateral mitral annulus.

DISCUSSION

In this study, the p-Sm in TDI before the ablation procedure, specifically in patients having a left free AP, was found to be short due to early stimulus. This was especially detected without using a free ECG algorithm. When these three regions were compared, only patients with LV free wall APs showed a statistically significant difference, with the shortest p-Sm times in the lateral mitral annulus. Further, left post-p-Sm for the patients in whom a left free AP was detected in EPS and right post-p-Sm duration for those in whom a right free AP was detected were significantly longer than the

TABLE 2: The TDI findings of patients (n:7) with right accessory pathway in EPS.

		Lateral tricuspid annulus (right)	Lateral mitral annulus (left)	Septal annulus (septal)	p
IVRT (ms)	Pre	57,29±35,2	53,57±8,32	63±15,75	0,741
	Post	57,43±36,69	59±12,26	64,71±11,88	0,830
	p	0,986	0,271	0,776	
IVCT (ms)	Pre	60±11,9	47,71±7,54	55±10,69	0,105
	Post	55,86±11,34	51,43±11,55	50,14±12,05	0,636
	p	0,264	0,436	0,347	
ET (ms)	Pre	272,14±29,24	292,14±23,06	269,29±23,51	0,214
	Post	278,57±20,94	289,43±24,55	281,71±25,26	0,682
	p	0,484	0,846	0,197	
IVV (cm/s)	Pre	13,71±3,2	10,57±3,31	9,14±1,68	**0,022**
	Post	12,43±2,07	9,29±1,89	9,29±1,98	**0,011**
	p	0,281	0,426	0,869	
Sm (cm/s)	Pre	15,57±3,91	12,83±2,93	9±2	**0,006**
	Post	15,29±2,29	11,17±3,31	10,33±4,08	**0,03**
	p	0,793	0,224	0,249	
Em (cm/s)	Pre	12,43±3,31	16,29±3,25	10,86±2,48	**0,011**
	Post	13,43±2,82	15,29±3,64	10,86±3,58	0,072
	p	0,520	0,177	0,999	
Am (cm/s)	Pre	14±3,92	13,43±2,76	8,57±1,4	**0,004**
	Post	14±4,55	11±4,24	8,86±1,95	0,06
	p	0,999	0,124	0,654	
p-Sm distance (ms)	Pre	189,57±13,27	209,29±19,92	202,57±19,77	0,141
	Post	223,43±29,78	214,57±20,71	219,86±19,54	0,785
	p	**0,005**	0,331	**0,001**	

Data are given as mean±SD

ms:milliseconds s:second, IVCT:isovolumic contraction time, IVRT:isovolumic relaxation time, IVV:the peak myocardial velocity which is formed during isovolumic contraction, Em:early diastolic myocardial velocity, Am: late diastolic myocardial velocity, ET:ejection time, p-Sm:the electromechanical interval from the start of the p wave on ECG to the start of the regional myocardial contraction wave (Sm).

pre-p-Sm values due to the loss of AP following RFCA.

Since there were some studies in the literature on surface ECG algorithm, we did not use these data in our study. Moreover, there is little information about TDI in the literature. Estimating the location of the AP before the procedure is helpful for catheter mapping to determine a precise ablation site and to shorten the time required for ablation. Quantum resonance spectrometry (QRS) polarity and delta wave polarity on a 12-lead ECG have been widely used to determine AP location.[6,7] Recently, new algorithms for APs in different localizations from 12-derivation surface ECG have been generated.[8,9] Several noninvasive echocardiographic methods of estimating the location of the AP have been proposed. Other methods that have been employed to detect the AP include M-mode echocardiography, phase analysis of 2-dimensional echocardiographic images, Doppler myocardial imaging, and TDI.[10-17] These methods have focused mainly on abnormal ventricular motion. Previous authors have, for example, analyzed the time-sequential changes in ventricular wall motion in WPW syndrome using TDI in their studies.[11-13] The early contraction was represented by a red or blue spot appearing on the subendocardial side at the time of the delta wave on ECG. In our study, the conduction intervals from regions of lateral mitral annulus, septal mitral annulus, and lateral tricus-

TABLE 3: The TDI findings of patients (n:11) with septal accessory pathway in EPS.

		Lateral tricuspid annulus (right)	Lateral mitral annulus (left)	Septal annulus (septal)	p
IVRT (ms)	Pre	54,64±15,13	54,64±20,6	68,09±23,19	0,205
	Post	52,88±15,96	49±14	65,75±16,49	0,102
	p	0,829	0,133	0,606	
IVCT (ms)	Pre	62,27±16,35	51,91±11,34	58,82±15,97	0,259
	Post	63,38±14,31	61,25±17,75	64,88±16,28	0,904
	p	0,845	**0,036**	0,334	
ET (ms)	Pre	277,18±28,27	287,45±36,59	282,4±28,93	0,750
	Post	274,13±34,56	286±36,08	264,88±27,7	0,452
	p	0,228	0,977	0,168	
IVV (cm/s)	Pre	11,64±3,36	10,55±1,86	8,09±1,92	**0,007**
	Post	12,63±4,47	10,75±2,38	8,25±2,25	**0,04**
	p	0,161	0,723	0,567	
Sm (cm/s)	Pre	13,91±2,55	11,91±1,97	8,6±1,71	**0,0001**
	Post	14,13±1,96	11,75±2,82	8,13±2,03	**0,0001**
	p	0,285	0,685	0,623	
Em (cm/s)	Pre	12,45±4,28	15,45±3,42	11,55±2,42	**0,032**
	Post	13,5±2,45	14,5±4,07	10,5±2,83	0,053
	p	0,361	0,999	**0,02**	
Am (cm/s)	Pre	12,82±4,71	10,64±2,73	8,36±1,43	**0,012**
	Post	14,38±6,02	9,13±2,53	9,5±2,2	**0,027**
	p	0,077	0,064	0,213	
p-Sm start distance (ms)	Pre	219,27±23,71	223,82±35,62	197,45±22,4	0,076
	Post	230,38±32,15	235,75±39,71	217,13±30,77	0,548
	p	0,389	0,381	0,08	

Data are given as mean±SD

ms:milliseconds s:second, IVCT:isovolumic contraction time, IVRT:isovolumic relaxation time, IVV:the peak myocardial velocity which is formed during isovolumic contraction, Em:early diastolic myocardial velocity, Am: late diastolic myocardial velocity, ET:ejection time, p-Sm:the electromechanical interval from the start of the p wave on ECG to the start of the regional myocardial contraction wave (Sm).

pid annulus were measured with electrocardiographic recordings; results were compared with those of TDI. Moreover, similar to our study, Esmaeilzadeh et al. sought to examine the diagnostic accuracy of strain imaging for the localization of APs in WPW syndrome.[5] There was a significant difference between the time to onset of the delta wave to the onset of peak systolic motion in the location of the AP and normal segments, compared with that in normal volunteers. They demonstrated that TDI-derived parameters such as onset of systolic velocity (δ-So) and strain (δ-Strain) have better diagnostic yields than the ECG for the noninvasive localization of the AP in patients with WPW syndrome. Comparisons of the ECG algorithm were made in their study. In our study, regions were compared with each other, and since the delta wave was not always observed, the p wave was accepted as the start. Parameters between regions and postoperative parameters were compared in our study, as opposed to using a control group. Also, Cakmak et al. compared the conventional Doppler echocardiographic parameters before and after AP ablation in 30 patients with WPW syndrome.[4] They found that the pulmonary valve opened earlier than the aortic valve when the AP was located on the RV side. However, if the AP was located on the LV side, the aortic valve opened earlier. Intervals between the onsets of aortic and pulmonary flows were shortened after RFCA.

TABLE 4: The TDI findings of patients (n:17) with left accessory pathway in EPS.

		Lateral tricuspid annulus (right)	Lateral mitral annulus (left)	Septal annulus (septal)	p
IVRT (ms)	Pre	44,59±13,74	58,18±15,5	53,65±13,48	0,055
	Post	47,5±18,99	52,81±12,81	57,75±12,94	0,173
	p	0,502	0,093	0,08	
IVCT (ms)	Pre	55,47±13,13	57,24±11,31	50,71±9,49	0.057
	Post	56,06±13,35	57,81±9,81	52,69±9,88	0,424
	p	0,814	0,967	0,064	
ET (ms)	Pre	280,76±34,31	281,88±30,36	294,12±23,42	0,355
	Post	258,27±20,31	274,94±24,32	271,06±19,71	0,093
	p	**0,008**	0,175	**0,001**	
IVV (cm/s)	Pre	12,76±3,46	7,94±2,3	7,59±1,97	**0,0001**
	Post	14,31±3,54	7,69±1,62	8±2,28	**0,0001**
	p	0,014	0,999	0,383	
Sm (cm/s)	Pre	15,47±4,19	11,29±3,06	9,92±1,89	**0,0001**
	Post	15,19±3,06	11,06±2,11	10,62±1,66	**0,0001**
	p	0,446	0,921	0,082	
Em (cm/s)	Pre	13,24±2,99	13,29±3,35	11,88±2,42	0,296
	Post	12,06±3,62	12,56±3,95	10,56±1,71	0,205
	p	0,117	0,333	**0,037**	
Am (cm/s)	Pre	13,65±3,89	10,35±3,04	9,59±2,09	**0,001**
	Post	13,63±4,3	10,13±2,36	10,69±2,3	**0,006**
	p	0,999	0,840	**0,024**	
p-Sm start distance (ms)	Pre	224,5±21,89	189,06±20,45	205,41±17,77	**0,0001**
	Post	220,69±23,64	212,88±26,62	211,31±26,01	0,541
	p	0,431	**0,002**	0,332	

Data are given as mean±SD

IVCT:isovolumic contraction time, IVRT:isovolumic relaxation time, IVV:the peak myocardial velocity which is formed during isovolumic contraction, Em: early diastolic myocardial velocity, Am: late diastolic myocardial velocity, ET: ejection time, p-Sm: the electromechanical interval from the start of the p wave on ECG to the start of the regional myocardial contraction wave (Sm).

WPW syndrome causes asynchronous ventricular contractions along with pre-excitation in the ECG. Ventricles lead to initiation of mechanical systole by early stimulation on one side due to the localization of the AP and its conduction velocity; on the other hand, they cause contraction over the physiological conduction system by being stimulated. Thus, intraventricular asynchrony occurs and the duration of ventricle depolarization is prolonged. While Çakmak et al. separated APs into two regions according to the early openings of the aortic and pulmonary valves, we proposed three regions (septal, right, and left annulus) according to the earliest conduction. We consider that the septal paths were evaluated more precisely using this method. As a result, the distance (p-Sm) from the start of the p wave in TDI to the start of myocardial contraction (Sm) will be shortest in the region where an AP exists due to the early ventricular contraction. In our study, the lateral mitral annulus in patients with a left AP, namely left p-Sm, was statistically the shortest. Though the pre-p-Sm durations were measured as the shortest in the lateral tricuspid annulus and septal mitral annulus, in patients with right and septal APs, respectively, these differences were not statistically significant due, in part, to the small number of patients with pathways in these two regions. Other studies with larger study populations are required to obtain more information about this issue. Significant differences were not observed between regions in terms of IVCT, IVRT, ET, and the other time intervals assessed in our study.

STUDY LIMITATIONS

Limitations of this study include the single center design and the small number of patients included. In particular, the number of patients with RV free wall and septal APs was insufficient to allow for statistical data. The p-Sm could be better evaluated with the start of the delta wave; however, in our study the p wave was selected as it was clearer. The study focused on TDI and did not use strain and strain rate, the other electrocardiographic parameters. In our study, surface ECG algorithm was not used, and there was no control group.[18] Hence, comparison between surface ECG and TDI was not done. Intra-observer variability was not given; no power analysis was done for the study.

CONCLUSION

TDI is a readily available, noninvasive echocardiographic procedure. The measurement of the p-Sm in TDI enabled us to predict the LV free wall APs before RFCA in WPW patients. We detected the pre-p-Sm as short in patients without statistical significance whose septal and right APs were detected at the septal mitral annulus and lateral tricuspid annulus, respectively. More studies with larger patient populations are needed to show the clinical significance of this theory. The predicting of AP in TDI may be useful for planning and performing the RFCA.

Conflict of Interest

Authors declared no conflict of interest or financial support.

Authorship Contributions

Idea/Concept: *Mehmet Gül, Abdurrahman Eksik;* ***Design:*** *Mehmet Gül, Mehmet Rıfat Yıldırım;* ***Control/Supervision:*** *Hüseyin Altuğ Çakmak, Ali Birant;* ***Data Collection and/or Processing:*** *Hamdi Püşüroğlu, Muhammet Hulusi Satılmışoğlu, Özgür Sürgit, Ali Birant;* ***Literature Review:*** *Serkan Aslan, Hamdi Püşüroğlu, Derya Öztürk, Hüseyin Altuğ Çakmak, Sinem Özyılmaz;* ***Writing the Article:*** *Mehmet Rıfat Yıldırım, Mehmet Gül;* ***Critical Review:*** *Özgür Sürgit, Sinem Özyılmaz.*

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