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The role of speckle tracking in precise localization of accessory pathway in Wolff-Parkinson-White syndrome

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***Abstract*---**Background: The non-Doppler echocardiographic technique known as two-dimensional speckle tracking echocardiography (2D-STE) has been demonstrated to help assess dyssynchrony and allow quantification of cardiac deformity and timing in 2D greyscale images. This study evaluated the 2D speckle tracking role in the accessory pathway (AP) localization compared to the electrophysiology study (EPS) as the gold standard technique. Methods: This study was performed on patients with evident Wolff-Parkinson-White (WPW) syndrome who were recommended to undergo EPS and ablation. Patients were recruited based on results from the resting ECG, clinical history of recurrent palpitations, or an ECG with confirmed bouts of atrioventricular reentrant tachycardia (AVRT). The patients were evaluated using electrocardiography, conventional 2D echocardiography, and 2D-STE and were assessed for the possibility of ablation. Results: Thirteen patients were included (seven males and six females) with a mean age of 29.23 ± 9.3 years. All patients had a negative family history of WPW syndrome. ECG revealed that AP localization was posteroseptal in 4 patients (30.8%), anteroseptal in 3 (23.1%), right lateral in 2 (15.4%), left lateral in 1 (7.7%), anterolateral in 1 (7.7%), right posterior in 1 (7.7%), and left posterior in 1 (7.7%). Compared to EPS as the gold standard for localizing APs, a perfect agreement was achieved in two patients (18.2%), an adjacent agreement was achieved in eight patients (72.7%) patients, and disagreement was observed in one patient (9.1%). Conclusions: AP localization in WPW syndrome was determined using non-invasive 2D-STE. It identified contractile anomalies associated with the AP without

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the need for invasive methods. ECG remains a precise and reliable tool for AP localization.

***Keywords*---**2D-speckle tracking, localization, accessory pathway, Wolff-Parkinson-White syndrome.

Introduction

Early depolarization and subsequent contraction of a portion of ventricles at the region of atrioventricular accessory pathways (AP) is the defining feature of Wolff-Parkinson-White (WPW) syndrome (Leonelli, De Ponti, & Bagliani, 2020). While many body surface electrocardiogram techniques have been developed, the invasive electrophysiological examination is the most effective way to locate the AP and enable catheter ablation (R. El-Bouhi, Sami Abd El-Samea, & M. Aaref, 2020). Patients with WPW syndrome have been found to have abnormal LV wall motion. Some research has suggested that abnormal interventricular septal wall motion may be one of the factors contributing to LV dyssynchrony and, ultimately, reversible LV dysfunction that is not caused by tachyarrhythmia (Khan, Klettas, Kapetanakis, & Monaghan, 2016; Panizo, Barra, Mellor, Heck, & Agarwal, 2018; Uhm et al., 2019).

For AP localization, radioactive ventriculography is utilized to analyze the time of cardiac contractions based on Fourier phase histograms. Alternate methods for locating the site of early contraction in these patients include tissue Doppler imaging (TDI) and echocardiography. (Nakajima et al., 2017). Two-dimensional (2D) speckle-tracking strain imaging is a non-Doppler approach that quantifies cardiac deformation and its timing on 2D grayscale pictures without the possible hazards of tissue Doppler (R. El-Bouhi et al., 2020). The STAR study demonstrated that speckle-tracking strain might be used to assess LV dyssynchrony with the added value of distinguishing active from passive motions regardless of the Doppler angle. In addition, a study indicated that longitudinal 2D-spectral monitoring could detect myocardial AP-related contraction anomalies (Delelis et al., 2012). Hence, this study intended to evaluate the role of 2D speckle tracking in the localization of accessory pathways compared to electrophysiology study (EPS) as the gold standard technique.

Patients and Methods

Between September 2019 and November 2020, this study was performed on 13 patients with WPW syndrome recruited from the Cardiology Clinic of Mansoura specialized Hospital based on resting ECG abnormalities, clinical history of frequent palpitations, or documented ECG with AVRT events. The study was done after being accepted by the medical research ethics committee, Faculty of Medicine, Mansoura University. Each participant in the study provided informed verbal consent. All patients were recommended to undergo invasive endocardial mapping and radiofrequency catheter ablation (RFCA). Inclusion criteria were patients with WPW syndrome recommended to undergo EPS and ablation. Patients with structural heart disease that may induce LV dyssynchrony, such as cardiomyopathy, valvular heart disease, Ebstein anomaly, pacing-dependent patients, and Bundle branch block, were excluded. Each patient was exposed to Full personal and medical history, including age, gender, occupation, degree of functional activity, previous palpitation, previous arrhythmogenic syncope, prior hospitalization or ICU admission due to hemodynamically unstable tachyarrhythmias, current anti-arrhythmic medications, and previous need for electrical cardioversion. Additionally, all patients underwent complete general and local examinations.

Electrocardiographic evaluation

The electrocardiographic evaluation was conducted during sinus rhythm, including assessment of PR interval, QRS complex width, delta wave, and localization of accessory pathways (AP) using algorithms such as Aruda, Chiang, d'Avila, St. George, Fitzpatrick, Milstein's, and Xie. Additionally, it was done during tachyarrhythmias to document the presence of atrial fibrillation (AF).

Conventional 2D Echocardiographic evaluation

Conventional 2D echocardiographic evaluation was conducted using a commercially available system (Philips Affinity 50 Ultrasound system) equipped with an S4-2 (2-4 MHz) cardiac sector transducer. The examination was performed with simultaneous ECG recording over three cardiac cycles while the patient was in the left lateral position. Data acquisition was collected in both apical and parasternal views. M-mode and 2D strain images were obtained and saved in cine-loop format for further analysis. The evaluation aimed to assess ejection fraction, structural abnormalities, and resting segmental wall motion abnormalities.

2D-STE

A 2D wall motion tracking software called Automated Cardiac Motion Quantification AI (aCMQAI) was utilized to examine the images. The software calculated the timing of left ventricular myocardial segmental deformation, which was then automatically displayed in a bull's-eye diagram comprising 17 segments, consistent with the American Society of Echocardiography (ASE) model (Cerqueira et al., 2002). This evaluation aimed to assess the area of maximum delay, the number of pre-excited areas, and the effect of heart rate on the segments.

Electrophysiology study and the possibility of ablation

Within 24 hours of the initial echocardiography, all patients diagnosed with WPW underwent an invasive electrophysiological study to confirm the location of the accessory pathway (AP) and to evaluate the feasibility of AP ablation using a radiofrequency catheter. The procedure was considered successful if the anterograde and retrograde conduction of the AP was eliminated, resulting in the inability to induce atrioventricular reentrant tachycardia (AVRT).

Statistical analysis

The Windows version of the Statistical Package for Social Science (SPSS) was employed to analyze the data (version 21). The Shapiro-Wilk test and direct data visualization were used to determine the data normality. Quantitative data were summarized as means and standard deviations. Numbers and percentages were employed to describe qualitative data.

Results

The study included 13 patients (7 males and 6 females), with a mean age of 29.23 ± 9.3 years. Regarding residence, nine patients were from urban areas, while four were from rural areas. All patients had a negative family history of WPW syndrome. Regarding echocardiographic findings, the mean EF was 66.19 ± 4.89. The mean LVEDD and LVESD were 4.76 ± 0.73 and 2.98 ± 0.44, respectively. The mean LA was 3.37 ± 0.530. The majority of patients (92.3%) had palpitation. Only one patient had syncope, and two had stable hemodynamics (Table 1). The median QRS width of participants was 120, ranging from 80 to 160. The median antegrade and retrograde Rf were 280 and 310, respectively. The median RF time was 120, ranging from 30 to 120. The mean LV global longitudinal strain was -21.8 ±4.21. The mean LV4ch, LV2ch, and LV3ch strains were -22.1 ± 3.4, -21.1 ± 6.3, and -22.1 ± 4.3, respectively.

Regarding ECG AP localization, it was posteroseptal in 4 patients (30.8%), anteroseptal in 3 (23.1%), right lateral in 2 (15.4%), left lateral in 1 (7.7%), anterolateral in 1 (7.7%), right posterior in 1 (7.7%), and left posterior in 1 (7.7%). Regarding EPS AP location, it was posteroseptal in 8 patients (61.5%), anteroseptal in 3 (23.1%), left lateral in 1 (7.7%), anterolateral in 1 (7.7%), right lateral in 1 (7.7%), and right posterior in 1 (7.7%). The region of maximum delay by speckle was inferior in 4 patients (30.8%), inferior-septal in 2 (15.4%), septal in 4 (30.8%), anterior in 2 (15.4%), and anterior-inferior in 1 (7.7%). Five patients (38.5%) had intermittent preexcitation. Only one patient (7.7%) had positive MR (Table 2).

Agreement between AP localization by ECG and EPS

Using EPS as the gold standard for localizing APs, a perfect agreement was achieved in 8/13 patients (61.5%), an adjacent agreement was achieved in 4/13 (30.8%) patients, and disagreement was observed in 1/13 (7.7%) (Table 3).

Agreement between AP localization by 2D-speckle and EPS

Using EPS as the gold standard for localizing Aps, a perfect agreement was achieved in 2/11 patients (18.2%), an adjacent agreement was achieved in 8/11 (72.7%) patients, and disagreement was observed in 1/11 (9.1%) (Table 4).

Discussion

Several echocardiographic procedures have been investigated as non-invasive alternatives for AP localization. Because systolic dyssynchrony in WPW is brought on by electrical pre-excitation, strain via speckle tracking can be utilized to pinpoint the location of the first mechanical activation. In this study, we evaluated the 2D speckle tracking role in the localization of AP in comparison to EPS as the gold standard technique. In line with the current study, Tanabe et al. reported a 65-year-old male with paroxysmal atrial fibrillation and WPW syndrome. They reported that loss of systolic shortening in the early activated region is evident using longitudinal 2D-STE (Tanabe, Watanabe, Yamaguchi, & Tanabe, 2021).

El-Bouhi et al. demonstrated that ECG has a distinct advantage over 2D-STE for estimating the location of APs. They examined 15 patients with left-sided APs. The 2D-STE could reliably locate the AP site in 10 patients (66.6%). In contrast, ECG could do so in 12 patients (80%). Nevertheless, some investigations concluded that the accuracy of ECG algorithms is lower than the level their designers initially claimed (Maden et al., 2015). Additionally, Wren et al. investigated seven ECG techniques for locating APs and stated that none of the algorithms accurately predicted the APs location (Wren et al., 2012). On the other hand, 3D-STE is superior to ECG in localizing APs (Ishizu et al., 2016). Esmaeilzadeh et al. indicated that strain imaging parameters are superior to ECG prediction (Esmaeilzadeh et al., 2013). ECG is superior to other conventional echocardiographic modalities, including M-Mode and trans-Esophageal Echocardiography (TEE) (Badran, Ahmed, Beshay, & Zein, 2019).

In the current study, the ability of the 2D-STE to localize APs was proven. Parallel with our findings, Delelis et al. concluded that 2D-STE can assess myocardial dyssynchrony and AP location (Delelis et al., 2012). In addition, Ishizu et al. verified the use of 2D-STE in the localization of APs (Ishizu et al., 2016). Regarding identifying left-sided auxiliary routes, tissue Doppler cardiac imaging is more accurate (80–90%) than traditional M-mode and 2D imaging (Cai, Shuraih, & Nagueh, 2012). Myocardial translational motion artifacts, the need for ideal Doppler alignment, the lack of consistency, time-consuming off-line analysis, and angle dependence have all hampered the therapeutic value of TDI-derived strain. In contrast, 2D-STE is a non-Doppler technique that enables assessment of the timing of cardiac deformation on 2D greyscale pictures without the hazards of tissue Doppler.

This study was subjected to some limitations. The first is the small sample size. Secondly, the 2D-STE only addresses mechanical activation rather than electric activation. Thirdly, 3D-STE is the best modality because it does not lose track of the target ultrasonic speckle within the 3D region of interest. However, we employed 2D-STE. Therefore, the cardiac memory phenomenon, defined as the persistence of repolarization anomalies following successful ablation, was not our main focus (Ghosh, Rhee, Avari, Woodard, & Rudy, 2008).

Conclusion

Various echocardiographic techniques have been explored as non-invasive options for AP localization. 2D-STE has been found to accurately identify contractile anomalies associated with AP and correlate with endocardial mapping results for AP localization. This enables non-invasive AP localization in patients with WPW syndrome. ECG remains a precise and reliable tool for AP localization, and 2D-STE can offer an additional imaging modality to help with diagnosis and treatment planning.

Table 1
General and clinical characteristics of the studied patients

Parameter		WPW syndrome (N=13)	
Age*	Mean ± SD	29.23 ± 9.3	
Sex	Male	7	53.8%
	Female	6	46.2%
Residence	Urban	9	69.2%
	Rural	4	30.8%
Family Hx of WPW syndrome	Negative	13	100.0%
	Positive	0	0.0%
EF (%)	Mean ± SD	66.19 ± 4.89	
LVEDD (units)	Mean ± SD	4.76 ± 0.73	
LVESD	Mean ± SD	2.98 ± 0.44	
LA	Mean ± SD	3.37 ± 0.530	
EF	Mean ± SD	66.19 ± 4.89(repeat)	
LVEDD	Mean ± SD	4.76 ± 0.73	
LVESD	Mean ± SD	2.98 ± 0.44	
LA	Mean ± SD	3.37 ± 0.530	
Palpitation	Negative	1	7.7%
	Positive	12	92.3%
Syncope	Negative	12	92.3%
	Positive	1	7.7%
Hemodynamics stability	Negative	11	84.6%
	Positive	2	15.4%

EF: ejection fraction, LVEDD: Left ventricular end-diastolic diameter, LVESD: Left Ventricular End-Systolic Diameter, LA: Left Atrium.

Table 2
QRS width, radiofrequency, LV strain, and accessory pathway localization of the studied patients

Parameter		
QRS width, median (range)		120.0 (80-160)
Ante grade Rf, median (range)		280.0 (220-400)
Retro grade Rf, median (range)		310.0 (240-540)
RF time median (range)		120.0 (30-120)
Mean LV global longitudinal strain		-21.8 ±4.21
Mean LV4ch strain		-22.1 ± 3.4
Mean LV2ch strain		-21.1 ± 6.3
Mean LV3ch strain		-22.1 ± 4.3
ECG AP localization	Posteroseptal	4 (30.8%)
	Anteroseptal	3 (23.1%)

	Rt lateral	2 (15.4%)
	Lt lateral	1 (7.7%)
	Anterolateral	1 (7.7%)
	Rt posterior	1 (7.7%)
	Lt posterior	1 (7.7%)
EPS AP location	Posteroseptal	8 (61.5%)
	Anteroseptal	1 (7.7%)
	Lt lateral	1 (7.7%)
	Anterolateral	1 (7.7%)
	Rt lateral	1 (7.7%)
	Rt posterior	1 (7.7%)
EPS	Septal	9 (69.2%)
	Lateral	2 (15.4%)
	RT	2 (15.4%)
Region of maximum delay by speckle	Inferior	4 (30.8%)
	Inferior-septal	2 (15.4%)
	Septal	4 (30.8%)
	Anterior	2 (15.4%)
	Anterior-inferior	1 (7.7%)
Intermittent preexcitation	Negative	8 (61.5%)
	Positive	5 (38.5%)
MR	Negative	12 (92.3%)
	Positive	1 (7.7%)

Table 3
Agreement between AP localization by ECG and EPS

	ECG AP localization					
EPS AP localization		LL/LAL	LP	RL/RP	PS	AS
	LL/LAL	1	1			
	RL/RP			2		
	PS	1		1	4	2
	AS					1

Green cell indicate perfect match, pale green indicate non-perfect but adjacent localization. Red cell indicate disagreement. Numbers indicate number of patients. LL/LAL: left lateral/left anterolateral, LP: left posterior, RL/RP: right lateral/right posterior, PS: posteroseptal, AS: anteroseptal.

Table 4
Agreement between AP localization by 2D speckle and EPS

	2D speckle tracking AP localization						
EPS AP localization		A	AL	IL	I	IS	AS
	A						
	LL/AL	1			1		
	LPL						
	LP						

	PS				2	2	4
	AS					1	

Green cell indicate perfect match, pale green indicate non-perfect but adjacent localization. Red cell indicate disagreement. Numbers indicate the number of patients. A: anterior, LL/AL: left lateral/anterolateral, LP: left posterior, LPL: left posterior lateral, PS: posteroseptal, AS: anteroseptal. IL: inferolateral, I: inferior, IS: inferoseptum, AS: anteroseptum.

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Conflict of interest

No potential conflict of interest relevant to this article was reported.

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