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Original article

Non-conventional Echo-Cardio graphic Parameters in the Prediction of Occurrence of Atrial Fibrillation

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ABSTRACT

Background: Heart arrhythmias that are most common include atrial fibrillation (AF), which is linked to higher rates of death and morbidity as well as potentially fatal consequences such heart failure and stroke. Consequently, this study was conducted and aimed to test the hypothesis that measurement of the total atrial conduction time PA-TDI (Time-interval from initiation of the electrocardiographic P wave recorded by the echo machine (lead II) to the peak of the A wave of the atrial tissue Doppler tracing) and speckle tracking echo enable prediction of occurrence atrial fibrillation. **Methods:** We included 90 patients that were subdivided into two groups, first group with no history of AF and second group with history of Paroxysmal AF. Complete conventional echocardiography parameters were performed on admission including (2D, Doppler and Tissue Doppler Image modalities that were acquired in the standard parasternal and apical views, left atrial strain, LA reservoir strain, LA contractile and A conduit strain) to test the hypothesis of PA-TDI. **Results:** comparison between the two study groups revealed significant variations between two groups regarding the variables of transmitral Doppler inflow. The mean± SD of peak E velocity and peak A velocity of group A were 81.60±7.81 and 55.28±8.47, respectively, whereas that of group B were 9.56±8.79 and 65.89±17.03, respectively with p-value of 0.006 and 0.003, respectively. the mean± SD of PA-TDI duration of group A was 127.72±19.69 and it was 148.92±24.60 for group B with significant difference between the two groups. **Conclusion:** Speckle tracking echo and atrial tissue Doppler imaging parameters (PA-TDI) are promising tools to predict an occurrence of atrial fibrillation.

Keywords: Atrial fibrillation, PA-TDI, Echo-Cardiographic.

INTRODUCTION

The most prevalent prolonged cardiac arrhythmia, atrial fibrillation (AF), is linked to higher rates of death and morbidity, it may lead to potentially fatal consequences such heart failure and stroke. Unfortunately, treatment comes late when the stroke is the first manifestation of AF, treatment frequently occurs later [1,2].

Predicting and preventing AF and its complications is so crucial. In recent years, there has been a rise in the number of patient's hospitalization for AF. patients who admitted with cardio-embolic stroke are more likely to develop AF in order to facilitate primary prevention strategies [3].

The identification of clinical and echocardiographic factors linked to the onset of AF is the outcome of observational population studies. Nevertheless, the predictive utility of the risk stratification criteria that are now available is restricted for each individual patient. A depressed intra-atrial conduction or atrial dilatation may be caused by age or an underlying medical condition. This will enable to predict AF and result in an increase in the total atrial conduction time (TACT) [4]. This study aimed to determine prognostic value of speckle tracking echocardiography and tissue Doppler (PA-TDI) to predict occurrence of AF.

METHODS

This case-control study was conducted at cardiology department, Zagazig University Hospitals and national heart institute. We included 90 cardiac patients from January 2023 to February 2024. A written informed consent was taken from all patients and the study was accepted by the Research Ethical Committee of Faculty of Medicine, Zagazig University (ZU-IRB#10655-9-4-2023). The study was carried out according to the code of Ethics of the World Medical Association (Declaration of Helsinki) for Studies including humans.

All consecutive patients from cardiologists' outpatient clinic who were referred for a standard echocardiographic evaluation for a variety of cardiovascular disorders were included in the study, along with a control group that was matched for age and sex. Patients with history of paroxysmal atrial fibrillation (PAF) with current state in normal sinus rhythm. Exclusion criteria were age < 18 years, congenital heart disease, atrial tachycardia, current rhythm other than sinus rhythm, cardiomyopathy, ischemic heart disease, valvular dysfunction and implantable devices.

Every patient with history of AF had a complete history taken, which included questions about the patient's medical history, current medications, alcohol consumption, infections and was well as any prior pharmacologic or electrical interventions and their outcomes, as well as the existence of heart disease. Patients were subdivided into 2 groups, the first group (A): Patients with no history of AF and with normal echo findings. Group (B): Patients with history of paroxysmal AF and with normal echo findings. The TACT and PA-TDI interval was calculated in both groups of patients by using speckle tracking and left atrial strain method.

All subjects had a resting simultaneous 12-lead electrocardiogram (ECG) using electrocardiographic machine. At a calibration of 1 mm=0.1 mv and a paper speed of 25mm/s with the machine control set at standard response to diagnose patient in sinus rhythm. ECG findings were Lead V1's P-wave duration, QRS duration, PQ interval, adjusted QT interval (using Bazett's calculation) and P-wave terminal force [5].

Complete transthoracic echocardiography was performed on admission of the patient with patient in left lateral position and images were acquired at end of expiration. Echo cardiographic parameters were done as 2D, Doppler (CW, PW and color Doppler) and Tissue Doppler Image (TDI) In order to assess the morphology and function of the heart valves, following the American Society of Echocardiography's recommendations for data gathering, modalities were collected in both the standard parasternal and apical perspectives. Atrial left ventricle volume index. LV diastolic and systolic performance, LV resting wall motion, right side dimensions, functions and pericardium were all evaluated [6].

Using pulsed Doppler echocardiography, transmitral flow tracings were obtained in the apical 4 chamber view by putting the sample volume at the free ends of both mitral leaflets. E/A ratio, E-wave deceleration time (the slope from the E-wave peak to the baseline value), A-wave velocity, E-wave velocity, and isovolumetric relaxation time (the time interval between the aortic valve closure to the onset of ventricular filling) were measured at the end of expiration. Similarly, the left upper pulmonary vein's pulsed Doppler echocardiography recordings were made by inserting the sample volume roughly one centimeter into the vein. Retrograde atrial A-wave velocity, S/D ratio, D-wave velocity and S-wave velocity were the many measures made in the pulmonary vein. It was determined to find the mean of at least three successive beats [7].

The same echocardiographic device with STE turned on was used in both groups to provide speckle tracking images of the left atrium. Three consecutive cycles were averaged and observed. LA volume curve produced by computer during a single cardiac cycle. Using an apical four-chamber view and a point-and-click technique, the left atrium endocardial surface was manually traced, automatically creating an area of interest (ROI). When necessary, this was carefully modified to better fit the anatomy of the atrium. The beginning of the QRS signaled the start of the cardiac cycle. The ROI was then split into six pieces (two for two for the lateral wall, the interatrial septum and two for the left atrium roof). Alternatively, the following LA dynamic volumes might be computed using LA volume: LAV pre-a, LAV min, and LAV max are the LA volumes before the atrial contraction, the minimum LA volume and the maximum LA volume. Specifically, LAV pre-a is LAV at the beginning of atrial systole (P wave); LAV min was measured during mitral valve closure and LAV max was recorded shortly before mitral valve opening [8].

Additionally, tissue doppler imaging was used to determine the TACT. The pulsed-wave tissue doppler sample was placed precisely above the

mitral annulus on the left atrial lateral wall in the apical four-chamber view. The time interval between the start of the ECG P wave captured by the echo machine (lead II) and the peak of the A' wave of the atrial tissue doppler tracing over the course of three cardiac cycles was averaged to determine the PA-TDI interval [9].

Statistical analysis:

The recorded data was assessed using SPSS Inc.'s statistical program for social sciences, version 23.0 (Chicago, Illinois, USA). The quantitative data was presented using ranges and mean±standard deviation. The independent-samples t-test of significance was used to compare two means. For group comparisons using qualitative data, when the expected count in any particular cell was less than 5, Fisher's exact test was employed instead of the Chi-square test. The confidence interval was set at 95% and the acceptable margin of error at 5%. So, the p-value was considered P-value < 0.05 was considered significant. P-value <0.001 was considered as highly significant.

RESULTS

Table 1; showed that the comparison between the two groups regarding the demographic data displayed no significant differences.

Table 2; showed that the comparison between the two study groups revealed significant variations between the two groups regarding the variables of transmitral doppler inflow. Also, there was a significant difference between the two groups regarding E/A ration. Also, the comparison between the two groups regarding the data of TDI-derived mitral annular velocities displayed significant variations. The mean±SD of Lat S for group A displayed a significant difference. There was a significant difference between the two groups regarding Lat E. The mean±SD of Lat A revealed a significant difference between the two groups. Also, the mean±SD of Lat E/E significantly varied between the two groups.

Table 3; showed that the mean±SD of PA-TDI duration showed a significant difference between the two groups.

Table 4; showed that that the mean±SD of LA reservoir strain displaying a significant variation. Also, significant variations were found between the two groups regarding the mean±SD of group A and group B regarding four-chamber and the two chambers. The mean±SD of LA conduit strain revealing a significant variance. The mean±SD of four chambers (%) for group A and B were significantly varied between the two groups). Also, the two groups were significantly varied regarding the two chambers (%) mean values. There was no significant difference between the two groups regarding LA contractile strain (%), the four chambers (%) and the two chambers (%). There was a significant variation regarding the mean of LA conduit/contractile strain ratio between the mean±SD of group A and group B. The global LV longitudinal strain (%) was varied significantly between group A. The mean±SD of early diastolic strain rate of group A was significantly higher compared to that of group B. The mean±SD of late diastolic strain rate of group A was similar to that of group B with no significant difference

Table 5; showed that our study revealed that there were significant correlations between LA reservoir strain (%) and seven factors; the significant positive correlations were between LA reservoir strain (%) and HR, QRs complex and PA-TDI duration. The negative correlations were found between LA reservoir strain (%) and BMI, SBP and peak A velocity. There were six significant correlations found between LA conduit strain (%) and other variables; the positive correlations were found with HR, QRs complex and PA-TDI duration. The negative correlations were found between LA conduit strain (%) and SBP and peak A velocity. LA contractile strain (%) showed no significant correlations with the evaluated factors.

Table (1): Comparison between the two groups according to demographic data

Demographic	Group A: with no history of AF *(n=45)*	Group B: with history of Paroxysmal AF *(n=45)*	Test value	P-value
Age "years"	41.09±7.24	43.92±5.10	0.748	0.182
Male/ Female	25"55.6%"/ 20"44.4%"	27"60%"/ 18 "40%"	0.685	0.215

Demographic	Group A: with no history of AF *(n=45)*	Group B: with history of Paroxysmal AF *(n=45)*	Test value	P-value
Wt. "kg"	79.47±13.06	83.09±11.02	0.417	0.555
Ht. "cm"	178.30±9.79	174.36±8.47	0.134	0.780
BMI [wt/(ht)^2]	26.50±2.75	27.60±1.63	0.437	0.494
BSA	1.94±0.26	2.00±0.17	0.659	0.235
SBP (mmHg)	117.88±10.81	119.92±17.85	0.595	0.293
DBP (mmHg)	80.80±9.79	81.89±8.16	0.703	0.212
Mean BP (mmHg)	90.51±6.12	93.81±9.79	0.127	0.825
HR (beat/min)	80.90±8.36	79.47±9.08	0.182	0.763
Pulse pressure	45.46±10.51	47.79±14.99	0.240	0.731

Table (2): Comparison between the two groups according to transmitral doppler velocity and TDI data between 2 study groups

Variable	Group A: with no history of AF *(n=45)*	Group B: with history of Paroxysmal AF *(n=45)*	t-test	p-value
Transmitral Doppler inflow cm/s				
Peak E velocity	81.60±7.81	89.56±8.79	2.837	0.006*
Peak A velocity	55.28±8.47	65.89±17.03	2.794	0.003*
E/A ratio	1.48±0.21	1.36±0.20	2.157	0.035*
TDI- derived mitral annular velocities				
Med S	8.27±1.33	9.87±1.63	5.044	<0.001**
Med E'	12.82±2.14	11.12±2.14	3.640	0.007*
Med A'	9.97±1.53	8.17±1.22	4.424	<0.001**
Med E/E'	7.15±1.63	8.96±2.04	3.843	0.003*
Lat S	9.19±1.73	10.69±1.73	3.374	0.015*
Lat E'	14.67±2.26	12.15±2.26	4.557	<0.001**
Lat A'	8.17±2.86	10.38±2.35	2.665	0.016*
Lat E/E'	6.22±1.53	8.75±2.75	4.438	<0.001**

Data are presented as mean ± standard deviation (SD) Using: t-Independent Sample t-test for Mean±SD; p-value >0.05 is insignificant; *p-value <0.05 is significant; **p-value <0.001 is highly significant

Table (3): Comparison between the two groups according to PA-TDI duration (ms)

PA-TDI duration (ms)	Group A: with no history of AF (n=45)	Group B: with history of Paroxysmal AF (n=45)	t-test	p-value
Mean±SD	127.72±19.69	148.92±24.60	6.281	<0.001**

***p-value <0.001 is highly significant*

Table (4): Comparison between the two groups according to LA strain parameters values

Variables	Group A: with no history of AF *(n=45)*	Group B: with history of Paroxysmal AF *(n=45)*	t-test	p-value
LA reservoir strain (%)	38.05±11.22	34.99±10.20	3.511	0.012*
Four-chamber (%)	37.74±12.14	34.37±10.51	3.274	0.016*
Two-chamber (%)	38.45±11.02	35.60±11.02	3.576	0.010*
LA conduit strain (%)	23.97±10.00	20.71±8.67	4.594	<0.001**
Four-chamber (%)	24.48±10.61	20.91±9.08	3.370	0.016*
Two-chamber (%)	23.36±10.00	20.40±9.18	4.710	<0.001**
LA contractile strain (%)	14.08±3.67	14.28±3.77	1.577	0.104
Four-chamber (%)	13.16±4.18	13.46±4.08	1.781	0.101
Two-chamber (%)	15.10±4.49	15.20±4.69	1.218	0.113
LA conduit/contractile strain ratio	1.84±0.82	1.53±0.71	4.078	<0.001**

Table (5): Correlation between LA strain of patients with different parameters

	LA reservoir strain (%)		LA conduit strain (%)		LA contractile strain (%)	
	R	P	r	p	R	p
Demographic data						
Age "years"	0.198	0.410	0.029	0.828	0.145	0.544
Wt. "kg"	0.118	0.609	0.094	0.743	0.060	0.784
Ht. "cm"	0.166	0.428	0.099	0.742	0.292	0.209
BMI [wt/(ht)^2]	-0.445	0.017*	0.171	0.423	0.271	0.243
BSA	0.265	0.257	0.234	0.396	0.123	0.588
SBP (mmHg)	-0.335	0.030*	-0.365	0.025*	0.257	0.295
DBP (mmHg)	0.113	0.628	0.128	0.565	0.176	0.419
Mean BP (mmHg)	0.117	0.613	0.161	0.485	0.254	0.345

	LA reservoir strain (%)		LA conduit strain (%)		LA contractile strain (%)	
	R	**P**	**R**	**P**	**R**	**P**
HR (beat/min)	0.380	0.019*	0.538	0.015*	0.133	0.548
Pulse pressure	0.015	0.873	0.119	0.605	0.247	0.384
ECG						
P wave duration	0.340	0.028*	0.366	0.020*	0.128	0.571
QRs complex	0.340	0.029*	0.328	0.039*	0.106	0.707
Corrected QT using Bazzet's formula	0.208	0.403	0.110	0.647	0.059	0.807
P terminal force V1	0.025	0.853	0.139	0.546	0.158	0.504
PA-TDI duration (ms)	0.398	0.026*	0.384	0.035*	0.124	0.636
Transmitral Doppler inflow cm/s						
Peak E velocity	0.122	0.588	0.158	0.528	0.030	0.810
Peak A velocity	-0.458	0.016*	-0.441	0.018*	0.064	0.764
E/A ratio	0.291	0.242	0.164	0.458	0.102	0.722

Using: Pearson's correlation coefficient (r)
*p-value >0.05 NS; *p-value <0.05 S; **p-value <0.001 HS.*

DISCUSSION

This study revealed that the mean P wave duration for group A was significantly higher compared to that of group B. The mean ± SD of QRs complex and corrected QT were significantly higher compared to the mean ± SD of QRs and corrected QT of group B. The mean±SD of P-terminal force V1 was with a significant difference.

In addition, Hensen et al. [10] and Tjahjadi et al. [11], have shown the predictive impact of PA-TDI duration on the incidence of AF recurrence after cardioversion or ablation, postoperative AF, and new-onset AF, hence indirectly strengthening its validity. Schumacher et al. [12] revealed that the 12-lead ECG has a significant utility in the prediction of inapparent AF. Additionally, AF and cardiac structural remodeling are linked to PR-interval. P-wave dispersion (PWD) and P-terminal force in the precordial lead VI (PTFV1) are linked to AF in patients with cryptogenic stroke [13, 14].

Consistent with our findings, it has been confirmed that the entire atrial conduction time may be estimated using PA-TDI duration by Merckx et al. [15] utilizing the "gold standard" of P-wave duration (PWD) on the signal-averaged ECG (R = 0.911, p < 0.001).In addition, Hensen et al. [10] and Tjahjadi et al. [11], have indirectly strengthened its validity by demonstrating the predictive influence of the impact of PA-TDI duration on the incidence of recurrent AF after cardioversion or ablation, postoperative AF and new-onset AF.

Schumacher et al. [12] revealed that the 12-lead ECG has a significant utility in predicting the absence of apparent AF. Additionally, AF and cardiac structural remodeling are linked to PR-interval.

Platonov et al. [14] revealed that the occurrence of AF is caused by distinctions in conduction, including variations in channelopathies, electrolyte changes, vagal tone modulation, or pulmonary vein ectopy caused by lifestyle factors, as well as underlying pathologic structural modifications of the LA and various prediction models [16]. None of the patients in the EAHsy-AF cohort analysis had channelopathies, alcoholism, hyperthyroidism, or a history of extreme endurance sports. To avoid AF recurrence, these factors need to be considered in addition to the echocardiographic characteristics mentioned.

This study revealed that the comparison between the two groups regarding the demographic data displayed no significant differences. The

male/female ratio for the first group also displayed no significant difference. Groups A and B did not exhibit any statistically significant differences in terms of weight, height, BMI or BSA levels. Moreover, there was no appreciable variation in DBP across the two cohorts. There was no significant difference seen in the mean±SD of blood pressure, heart rate and pulse pressure between the two groups. These findings concur with the research conducted by Weijs et al. [17]. Additionally, Weijs et al. showed that valvular illness, hypertension, a history of AF and a greater body mass index all increase the length of the PA-TDI [17].

This study revealed that the comparison between the two study groups revealed significant variations between the two groups regarding the variables of transmitral doppler inflow. Regarding the E/A ratio, there was also a notable distinction between the two groups. Also, the two groups' comparison with regard to the data of TDI-derived mitral annular velocities displayed significant variations. The mean±SD of Lat S for group A displayed a significant difference. Regarding Lat E, there was a notable distinction between the two groups. There was a substantial difference between the two groups as indicated by the mean±SD of Lat A. Also, the mean±SD of Lat E/E significantly varied between the two groups.

According to reports, atrial remodeling comprises electrical remodeling that shortens the refractory time and the action potential length by Qiu et al. [18] as well as structural modification, which results in a heterogeneous substrate with a decreased impulse propagation conduction velocity, according to Nattel et al. [19] aiding in the start or continuation of AF. Persistent AF is characterized as AF that lasts more than seven days but less than a year, or less than a week but needs a successful CV to bring SR back.

Kawamura et al. [20] based on this classification, it was discovered that persistent AF represented a highly heterogeneous group with differing levels of atrial remodeling and differing reactions successively to electrical CV or AAD therapy.

Patients who are at a high risk of recurrence may benefit from noninvasive methods for assessing atrial remodeling and identifying the arrhythmic substrate. An accepted noninvasive technique for estimating TACT is the P-wave duration of the signal-averaged electrocardiogram (SA-ECG). In addition to the groundbreaking study by Glibbery et al. [21], which used cardiac MRI with late-gadolinium enhancement (LG-MRI) to show the left atrial arrhythmia's substrate, we have demonstrated the noninvasively detected TACT (PA-TDI interval) by echocardiography is linked with the degree of structural atrial remodeling.

Nevertheless, clinical routines do not employ either SA-ECG P-wave duration or LG-MRI due to practical constraints. According to Merckx et al., measuring the SA-ECG P-wave duration is anticipated to take 20 ± 5 minutes, while measuring the PA-TDI interval added 1 ± 0.5 minutes [15]. Thus, following a 6-month follow-up, den Uijl et al. [22] shown that the operative result of electrical CV15 or catheter ablation 21 may be predicted by the PA-TDI interval.

This study found that the mean±SD of PA-TDI duration differed significantly between the two groups. This conclusion was consistent with the findings of den Uijl et al. [22], who demonstrated that tissue doppler imaging measurement of total atrial conduction time can be utilized to predict recurrence of atrial fibrillation.

Similar to our findings, Allessie et al. [23] showed a much greater degree of functional reentry during long-term AF as opposed to acute AF, highlighting the significance of electrical remodeling in the formation of substrate for AF. Moreover, Choi et al. [24] showed that in certain individuals with persistent AF, burst-induction of AF might be avoided by reducing the overall atrial conduction time with linear triple-site pacing.

This unique echocardiographic measure has been evaluated against P-wave duration using signal-averaged electrocardiography, according to Merckx et al. [15]. Additionally, Linz et al. [25] and Müller et al. [26] observed a mean delta of 6.4 ± 5.7 ms in the PA-TDI length following efficient continuous positive airway pressure therapy, one of the main therapies for individuals with obstructive sleep apnea. This finding highlights both the dynamic nature of atrial remodeling and the possible advantages of prophylactic interventions. It also emphasizes how important PA-TDI length is in capturing these shifts.

A comprehensive study by Leung et al. [27] revealed that a longer PA-TDI duration was linked to a larger LA volume index (higher degree of left atrial dilatation) and a decreased LA reservoir strain (lower LA compliance or increased stiffness). The study comprised 602 AF patients and 342 controls.

The strength points of this study : This study's case-control study design and the fact that no patients were lost during the study period are its strongest aspects. It was the first investigation at

Zagazig University Hospitals to evaluate the theory that measurement of speckle tracking echo and PA-TDI allows for the prediction of AF occurrence. Every attempt was made to ensure that all follow-up data were recorded and that the data analysis contained only complete information. The same team conducted all clinical assessments and evaluated trial results.

The limitations of the study: It is important to note the study's limitations. Because it was conducted in a hospital, there were fewer cases and a smaller sample size compared to the study's outcomes. Because it was not a multicentric study, there was a significant risk of publication bias, and the study did not represent a particular community.

CONCLUSIONS

In conclusion, speckle tracking echo and atrial tissue doppler imaging parameters (PA-TDI) are promising tools to predict an occurrence of atrial fibrillation. Measurement of PA-TDI (the time from the initiation of the P wave on the ECG (lead11) to the A'wave on the lateral left atria tissue doppler tracing) and speckle tracking echo enable prediction of occurrence AF. this study presented the value of LA strain with reservoir, conduit, contractile components. Furthermore, the beginning of new-onset AF may be predicted by a prolonged PA-TDI delay.

Declaration of interest

The authors report no conflicts of interest. The authors along are responsible for the content and writing of the paper.

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