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Role of Inter Atrial and Left Atrial Desynchrony Assessed by Tissue Doppler Imaging in Predicting Atrial Fibrillation in Patient with ST-Elevation Myocardial Infarction

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ORIGINAL ARTICLE

Role of Inter Atrial and Left Atrial Desynchrony Assessed by Tissue Doppler Imaging in Predicting Atrial Fibrillation in Patient with ST-Elevation Myocardial Infarction

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Abstract

Background: ***Atrial fibrillation (AF) frequently occurs among individuals having STEMI and is linked to a worse clinical prognosis. AF is characterized by irregular and often rapid contractions of the atrial cardiomyocytes, leading to a range of symptoms, including an unpredictable heart rhythm, palpitations, dizziness, shortness of breath, and fatigue.***

Objectives: ***This work aimed to study the role of interatrial desynchrony and LA desynchrony (determined utilizing tissue Doppler) in predicting AF among STEMI cases.***

Methods: ***Our prospective cohort study involved 100 patients. Patients were categorized into two groups based on AF development: Group 1 (n=11), who developed AF, and Group 2 (n=89), who did not develop AF. Electrocardiogram (ECG), transthoracic echocardiography, and tissue Doppler imaging (TDI) were evaluated for all cases.***

Results: ***A robust positive association exists between LA desynchrony and interatrial desynchrony among cases with anterior myocardial infarction (MI). At a cut-off point (24.5), the sensitivity and specificity of Interatrial desynchrony by echo in predicting the AF incidence among cases having anterior MI is 63.6 % and 78.7 %, respectively. At the cut-off point of 22.5, the sensitivity and specificity of LA desynchrony by echo in predicting the AF incidence among cases having anterior MI is 63.6 % and 79.8 %, respectively. The mean maximin p wave and p wave dispersion exhibited significantly greater values within the AF group. Hypertension and dyslipidemia were significantly higher in the AF group.***

Conclusion: ***Interatrial and LA desynchrony calculated by tissue Doppler have significant accuracy as predictors of AF for STEMI patients.***

Keywords: Inter Atrial; LA Dys-synchrony; Tissue Doppler imaging; Atrial fibrillation; ST-elevation Myocardial Infarction

1. Introduction

In Western countries, Atrial fibrillation (AF) represents the predominant cardiac arrhythmia. Once aberrant electrical signals are activated in the atria, thus overpowering the heart's natural pacemaker, the heart's rhythm becomes unregulated. AF causes irregular and often unusually fast atrial cardiomyocyte contractions, resulting in various symptoms such as an erratic heart rhythm, palpitations, dizziness, shortness of breath, and weariness. [1]

AF is a prevalent cardiac rhythm disorder observed in individuals with STEMI, and it is considered a significant prognostic factor for patient outcomes. It significantly affects the clinical progression as well as the illness' prognosis. Patients who develop AF after myocardial infarction (MI) show an increase in hospital complication and mortality rates during follow-up, so there has been advancement in the AF new-onset prediction after the acute episode, hoping to prevent it. [2]

AF often occurs as an adverse event following acute myocardial infarction (AMI). The documented AF occurrence varied significantly, falling between 2.3% and 21.0%, and its link to increased mortality was inconclusive. [3]

Our work aimed to examine the effects of interatrial desynchrony and left atrial (LA) dyssynchrony dyssynchrony, as evaluated by tissue Doppler, on predicting AF among cases with STEMI.

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2. Patients and methods

Our study involved a group of 100 patients who had anterior ST-elevation myocardial infarction as well as developing symptoms for a twelve-hour maximum duration. The STEMI diagnostic measures depend on chest pain lasting over 30 min, an ST-segment rise exceeding 2 mm in a minimum of 2 continuous precordial leads, and an elevated level of high-sensitive troponin T (HsTnT). The research was conducted between December 2022 and September 2023 after clearance from the Ethical Committee of Al-Azhar University and the National Heart Institute Hospitals in Cairo, Egypt. The patients provided their informed written permission.

The exclusion criteria included patients with types of myocardial infarction other than Anterior STEMI, patients with an ejection fraction less than 40%, Cases having documented paroxysmal atrial fibrillation at any time prior to the index event, patients in cardiogenic shock (since they were administered inotropes, thus triggering AF), patients with prior revascularization, patients with an unfavorable echocardiographic window, cases developing conduction abnormalities such as right bundle branch block, left bundle branch block, or intraventricular conduction delay, patients having significant valvular heart diseases, patients with left atrial volume index exceeding 34 ml/m2, and patients with a restrictive pattern of diastolic dysfunction.

The patients were categorized into two groups according to the occurrence of AF: Group 1 (n=11) consisted of patients who acquired AF, whereas Group 2 (n=89) included cases who did not exhibit AF.

All cases underwent a comprehensive assessment including medical history collection, physical examination, laboratory tests (including troponin level, hemoglobin (HB), HbA1C, lipid profile, and C-reactive protein (CRP)), electrocardiogram (ECG), 12-lead ECG procedure, transthoracic echocardiography, tissue Doppler imaging (TDI), and 24-hour Holter monitoring within one week after discharge.

Electrocardiography (ECG):

All patients were placed on continuous ECG monitoring for 48 hr. with daily 12-lead ECG until hospital discharge. A follow-up ECG was taken after one week. The follow-up ECG was analyzed for new-onset AF as well as P-wave duration and dispersion.

A few patients had leads placed to the right side of the heart (V3R, V4R, V5R, V6R) and to the back of the chest (V7 to V9) to identify infarctions in the right ventricle or posterior wall.

Transthoracic Echocardiography:

The procedure was conducted immediately after revascularization, either through thrombolytic treatment or primary percutaneous coronary intervention (PCI). The examination is conducted using conventional transducer placements to get standard images. The Vivid 9, a medical device manufactured by General Electric Healthcare GE Vingmed in Norway, was used. It was fitted possessing a harmonic M5S variable-frequency (1.7-4 MHz) phased-array transducer. The most recent ASE guideline for assessing cardiac chambers included gathering data on left ventricular (LV) dimensions, volumes, EF, and markers of LV diastolic function, such as E/A ratio, E\, E/ E\, ESPA pressure, and left atrial (LA) volume. The LA volume was evaluated through the biplane area length method.[4] An echocardiographic examination was used to exclude significant structural heart disease-causing arrhythmias involving valvular, myocardial, as well as pericardial CVDs.

Tissue Doppler imaging (TDI):

The pulsed-wave tissue Doppler sample volume was positioned at the lateral mitral annulus, septal mitral annulus, and tricuspid annulus regarding the apical four-chamber view. E′ represents the first negative waveform, indicating early myocardial relaxation during diastole. A′ represents the following negative waveform that indicates the atrial contraction. The electromechanical delay was assessed at many sites on the mitral annulus by determining the temporal discrepancy between the P-wave onset on the electrocardiogram and the A'-wave (P-A' interval) onset. Left atrial Desynchrony refers to the variations of P-A′ intervals between the lateral and septal mitral locations. Inter-atrial desynchronyis is the term used to describe the variation of P-A intervals seen in the lateral mitral and tricuspid locations. A mean value was computed based on three beats. In addition, the highest point of E′ was measured at each location. Additionally, the E/E′ ratio was measured. The mean of the averages from the three sites was then used for analysis.[5]

Holter monitoring was done for 24 hours within one week from discharge:

A 24-hour cardiac Holter monitor was used to identify Paroxysmal AF using a digital Holter device. The investigation of heart rate variability was conducted using a 24-hour digitally recorded ECG signal sampled at a rate of 100 Hz. The processed signal was obtained from surface electrodes placed on the chest. The program automatically detected and labeled the QRS complexes, which were then carefully checked to minimize any possible artifacts.

Statistical analysis

Data underwent a statistical analysis utilizing SPSS v26 (IBM Inc., Chicago, IL, USA). The mean, as well as SD, were utilized to describe the quantitative variables. Additionally, an unpaired Student's t-test was used to assess the groups' differences. The analysis provided the frequency

and percentage (%) of qualitative variables. The Chi-square or Fisher's exact test was utilized where it was suitable. The Pearson moment correlation equation measures the strength and direction of linear interactions among variables that are usually distributed. On the other hand, the Spearman rank correlation equation is used when dealing with variables that are not normally distributed and when the relationship between the variables is non-linear and monotonic. The overall performance of the test is evaluated through measuring the AUC. AUC values over 50% suggest satisfactory performance, and values approaching 100% imply excellent performance. A P value < 0.05 in both directions was deemed statistically significant [6]. The statistical analysis was performed utilizing the SPSS v26 program manufactured by IBM Inc. in Chicago, IL, USA. The two groups went through a comparison utilizing an unpaired Student's t-test, using the mean as well as SD of the quantitative data. The qualitative variables were displayed as frequencies and percentages (%) and then evaluated utilizing the Chi-square test or Fisher's exact test, depending on the specific situation. The Pearson moment correlation equation is used to determine the strength of linear interactions between normally distributed variables.

On the other hand, the Spearman rank correlation equation is utilized to determine the correlations' strength among variables that are not normally distributed and do not follow a linear pattern but rather a monotonic one. The AUC is a measure used to evaluate the overall efficacy of a test. Achieving an area under the curve (AUC) greater than 50% indicates good performance. However, an AUC value approaching 100% suggests the highest possible performance of the test. A consensus was reached that a two-tailed P value below 0.05 was deemed to show statistical significance.

3. Results

The mean age was 57.2 ± 12.1 years. They included 71(71%) males and 29(29 %) females. They included 43(43%) diabetics, 57(57%) hypertensive patients, 63(63%) smokers, 60(60%) patients with dyslipidemia, and 45 (45%) patients with positive family history of CAD. The mean Hb was 11.7 ± 1.3 g/mL, while the mean HbA1c was 6.3 ± 2.1%. The HS Troponin was 1689.7 ± 1137.9 ng/mL. while the mean CRP was 2.7 ± 1.6. Fifty % of the studied patients were revascularized using PCI, while the other 50% used SK. Table 1

Table 1. Demographic, laboratory data as well as type of revascularization used among cases

		N=100
AGE (YEAR)		57.2 ± 12.1
SEX	Male	71 (71 %)
	Female	29 (29 %)
HEIGHT (M)		171.2 ± 6.3
WEIGHT (KG)		82.0 ± 8.3
BSA (M^2)		1.9 ± 0.1
MEDICAL HISTORY	DM	43(43%)
	HTN	57 (57%)
	Smoking	63 (63%)
	Dyslipidemia	60(60%)
FAMILY HISTORY OF CAD		45(45%)
LABORATORY DATA	Hb (g/dL)	11.7 ± 1.3
	HbA1c	6.3 ± 2.1
	HS troponin	1689.7 ± 1137.9
	CRP (mg/L)	2.7 ± 1.6
REVASCULARIZATION TYPE	PCI	50 (50 %)
	SK	50 (50 %)

The mean LVEF of the studied patients was 52.2 ± 4.8 %, while the mean interatrial desynchrony

was 20.6 ± 7.3 ms, and the mean LA desynchrony was 19.0 ± 6.9 ms. Seventy–five % of the patients had normal diastolic function, while the other 25% had DD grade 1. 10 (10 %) had AF during hospital stay and 1 AF after one week. (1%) had AF by Holter within 1 week after discharge. Table 2

Table 2. Echocardiographic data after revascularization, ECG data and AF rate by Holter within 1 week after discharge among the studied population

		N=100
ECHOCARDIOGRAPHIC DATA		
LVEF (%)		52.2 ± 4.8
PA ‘(SEPTAL)		85.0 ± 12.4
PA ‘(LATERAL)		104.0 ± 13.4
PA ‘(TRICUSPID)		83.5 ± 11.3
INTERATRIAL DESYNCHRONY		20.6 ± 7.3
LA DESYNCHRONY		19.0 ± 6.9
LVEDD		50.1 ± 4.5
LVESD		32.8 ± 3.7
LAV		46.4 ± 7.2
DIASTOLIC FUNCTION BY E/A RATIO	Normal	75 (75 %)
	DD grade 1	25 (25 %)
VALVULAR HEART DISEASE	Normal	67 (67 %)
	Mild MR	17 (17%)
	Mild TR	13 (13 %)
	Mild MR + mild TR	3 (3 %)
DURING HOSPITAL STAY	Maximum P wave	106.9 ± 7.4
	Minimum P wave	68.1 ± 7.0
	P wave dispersion	38.8 ± 9.3
	AF Rate	10(10.0%)
AFTER 1 WEEK	Maximum P wave	105.8 ± 6.9
	Minimum P wave	68.7 ± 6.4
	P wave dispersion	37.1 ± 8.7
	AF Rate	1((1.0%)
AF RATE		1 (1 %)

No statistically significant correlation was documented among AF as well as all sociodemographic factors or comorbidities, as well as any of the laboratory data (p>0.05), except for hypertension and dyslipidemia, which were shown to be considerably more prevalent within AF group (p=0.016 and 0.027, respectively). The AF occurrence exhibited considerably greater values within the SK group (p=0.042). Table 3

Table 3. Comparison of sociodemographic characteristics, common risk factors, laboratory data, and kind of revascularization used in both study groups

		AF (N=11)	NO AF (N=89)	P
AGE (YEAR)		56.5 ± 6.2	57.3 ± 12.6	0.854
SEX	Male	9 (81.8 %)	62 (69.7 %)	0.402

	Female	2 (18.2 %)	27 (30.3 %)	
HEIGHT		172.9 ± 3.9	171.0 ± 6.5	0.349
WEIGHT		84.4 ± 4.5	81.7 ± 8.6	0.308
BSA		2.0 ± 0.1	2.0 ± 0.2	0.274
DM		4 (36.4 %)	39 (43.8 %)	0.637
HYPERTENSION		10 (90.9 %)	47 (52.8 %)	0.016*
SMOKING		8 (72.7 %)	55 (61.8 %)	0.479
DYSLIPIDEMIA		10 (90.9 %)	50 (56.2 %)	0.027*
FAMILY HISTORY OF CAD		3 (27.3 %)	42 (47.2 %)	0.210
LABORATORY DATA	Hb(g/dL)	11.8 ± 1.6	11.7 ± 1.3	0.805
	HbA1c	6.0 ± 1.9	6.3 ± 2.1	0.648
	HS troponin	1905.6 ± 911.5	1663.0 ± 1164.3	0.507
	CRP (mg/L)	3.0 ± 1.5	2.7 ± 1.6	0.579
REVASCULARIZATION TYPE	PCI	2 (18.2 %)	48 (53.9 %)	0.025
	SK	9 (81.8 %)	41 (46.1 %)	

The average LVEF was considerably lower in the group with AF, addressing a p-value of 0.020. In contrast, the average PA mitral, interatrial desynchrony, LA desynchrony, LAV, rate of DD, and rate of valvular heart disease were significantly greater in the AF group, addressing a p-value below 0.001.Table 4

Table 4. Comparison among the two groups according to the echocardiographic data after revascularization among both studied groups.

		AF (N=11)	NO AF (N=89)	P
LVEF (%)		49.0 ± 4.3	52.6 ± 4.8	0.020*
PA ‘(SEPTAL)		88.1 ± 16.1	84.7 ± 11.9	0.388
PA ‘(LATERAL)		115.2 ± 9.7	102.6 ± 13.2	0.003*
PA ‘(TRICUSPID)		85.7 ± 13.4	83.2 ± 11.1	0.489
INTERATRIAL DESYNCHRONY		29.5 ± 11.2	19.5 ± 6.0	<0.001*
LA DESYNCHRONY		27.1 ± 12.2	17.9 ± 5.2	<0.001*
LVEDD		51.0 ± 4.9	50.0 ± 4.4	0.455
LVESD		33.0 ± 3.5	32.8 ± 3.7	0.857
LAV		61.2 ± 2.8	44.5 ± 5.1	<0.001*
DIASTOLIC FUNCTION BY E/A RATIO	Normal	3 (27.3 %)	72 (80.9%)	<0.001#
	DD grade 1	8 (72.7 %)	17 (19.1%)	
VALVULAR HEART DISEASE	Normal	2 (18.2 %)	65 (73 %)	<0.001#
	Mild MR	5 (45.4%)	12 (13.5%)	
	Mild TR	1 (9.1 %)	12 (13.5 %)	
	Mild MR + mild TR	3 (27.3 %)	0(0.0%)	

The average maximum p wave and p wave dispersion exhibited substantial greater values within the AF group (p < 0.001). Table 5

Table 5. Correlation between the AF occurrence as well as the ECG data in the group under investigation

	AF (N=11)	NO AF (N=89)	P
MAXIMUM P WAVE	117.3 ± 6.2	105.6 ± 6.5	<0.001*
MINIMUM P WAVE	62.6 ± 2.3	68.7 ± 7.1	0.006*
P WAVE DISPERSION (MS)	54.6 ± 7.8	36.9 ± 7.4	<0.001*

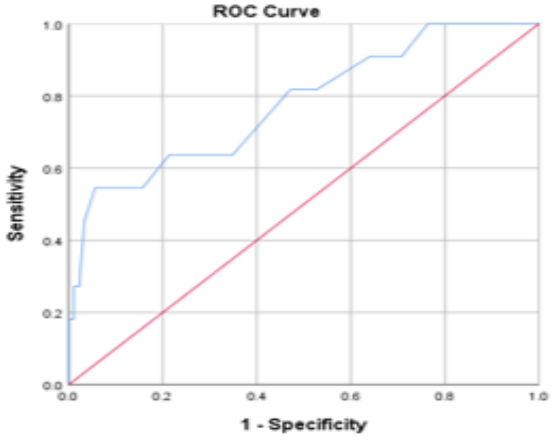
A strong association was observed between LA desynchrony and interatrial desynchrony in individuals who had an anterior myocardial infarction (MI) (p<0.001). (Table 6)

Table 6. Association between interatrial desynchrony as well as LA desynchrony in patients with anterior MI

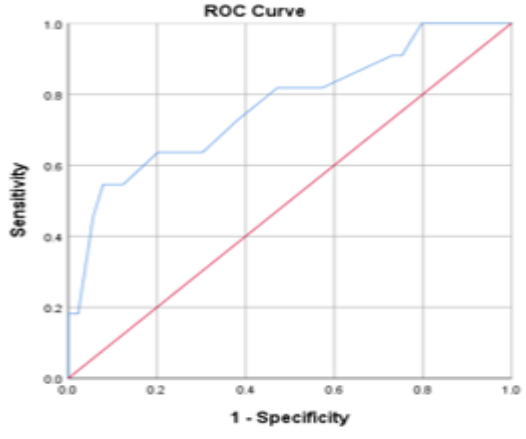
	LA DESYNCHRONY	
	R	P
INTERATRIAL DESYNCHRONY	0.839	<0.001*

The echo-based assessment detected a cut-off point 24.5 ms for interatrial desynchrony which predict the AF occurrence among cases having anterior MI. with sensitivity (63.6%) and specificity (78.7%).

The echo-based assessment detected a cut-off point (22.5) ms for left atrial desynchrony, which predict the AF occurrence among cases having anterior MI. with sensitivity 63.6% and specificity 79.8% (Figure 1)



A



B

Figure 1. ROC curve of (A) Interatrial desynchrony, (B) LA desynchrony, for prediction of

AF in patients with anterior MI

4. Discussion

With PCI's popularity rising, there has been a notable change in the treatment approach for STEMI, replacing the use of thrombolysis. Nevertheless, the death rates associated with STEMI remain high, with 30-day mortality rates falling between 7.4% and 11.4% and 1-year mortality rates falling between 13.7% and 14%.[6]

The study evaluated the AF predictive influence following STEMI managed by primary angioplasty. The documented AF prevalence reached 6.4%.[7]

Related to hypertension, our research revealed a statistically significant disparity between the AF group (with a notably higher prevalence of 90.9%) and the non-AF group (with a prevalence of 52.8%). The correlation between elevated BP levels and the likelihood of AF is a causative relationship.[8] The reason for this can be attributed to the elevated levels of angiotensin II found in all hypertensive patients. This occurs through the Renin Angiotensin Aldosterone System, stimulating AF by directly causing arrhythmogenic effects. Additionally, angiotensin II affects the structure and distribution of ion channels, particularly potassium channels. [9] These findings supported Podolecki et al.[11] a study demonstrated statistically significant increased hypertension in no AF group than the AF group (P=0.001). However, Yesin et al.[12] saw disparate outcomes. The study conducted did not observe any statistically significant disparity as regards hypertension among the AF group as well as the non-AF one. Also, Rhyou et al.[10] No statistically significant disparity was documented in the hypertension occurrence between the group with atrial fibrillation (AF) and the group without AF (P=0.33). Nevertheless, it is crucial to acknowledge that this study differs from our analysis in two key aspects. Firstly, it only focused on patients developing PCI. Secondly, the follow-up timeframe was limited to one year. Within the study's subjects, the prevalence of dyslipidemia was notably higher within the AF group in comparison with the non-AF one. Agreeing with our research, Nagai et al.[11] detected a significantly higher frequency of dyslipidemia among STEMI AF cases as opposed to those without AF. However, this study reported insignificant differences regarding hypertension and hypercholesterolemia. No significant relationship was documented between AF and any mean hemoglobin level, HbA1c, HS troponin, or CRP, p>0.05. Supporting the present work, Vukmirović et al.[13] reported that among AMI patients, there was a statistically insignificant difference between AF cases as opposed to those without AF as regards anemia. Also, in agreement with this study, Svartstein et al.[14] addressed statistically insignificant variation among STEMI patients with AF or without it regarding the mean CRP level.

Among STEMI patients included in our research, the AF rate exhibited significantly greater values among patients treated with streptokinase (53.9%) than those treated with PCI (18.2%). This agrees with the Tariq & Kaleem[15] study, where arrhythmia was significantly more often among STEMI cases managed by streptokinase compared to those who underwent PCI.

The mean LVEF% among this study participants was 52.2 ± 4.8 %. On comparing the two groups in this study according to the echocardiographic data after revascularization, the mean LVEF exhibited significantly lower values within the AF group. Decreased LVEF triggers AF by causing increased left ventricular diastolic pressure and LA pressure [16]. Yildiz et al.[17] detected that among STEMI patients, LVEF% was 47.28±8.76%. Supporting our research, Rhyou et al.[10] addressed that STEMI patients with AF had significantly lower LVEF% (46.0 ± 8.6) than those without AF (48.4 ± 8.8).

Echocardiography after revascularization among the studied population showed the mean interatrial desynchrony was 20.6 ± 7.3, and the mean LA desynchrony was 19.0 ± 6.9. Interatrial desynchrony and LA desynchrony are significantly higher among STEMI patients with AF than those without AF. A strong positive association was documented between LA desynchrony and interatrial desynchrony in patients with anterior MI.

Atrial desynchrony is well recognized as being associated with contractile dysfunction. Inter-atrial desynchrony occurs when there is a lack of uniformity in the way the atria of the heart are electrically and mechanically coupled. Hence, it exhibits irregular areas of reduced blood supply, inflammation, and scarring in the atrial wall, creating an optimal condition for initiating AF after a STEMI.[18,19]. Agreeing with this, Mohamed et al.[18] stated that Interatrial desynchrony and LA desynchrony exhibited significantly greater values among STEMI cases having AF than those without AF.

In this study, the mean PA (mitral), LA Volume, and rate of DD by E/A ratio exhibited significantly greater values within the AF group, <0.001.

AF may be predicted by volume enlargement due to the protracted ectopic signals that facilitate the maintenance of AF.[20] The same was found in Mohamed et al.[18] study, where a statistically significant variation was documented among STEMI cases with and without AF, considering PA (mitral).

Among this study participants, a significantly greater valvular heart disease rate was documented in the AF group as opposed to the non-AF group. Congo et al.[21] s support this, where valvular heart disease was detected in 3.4% of patients with AF versus 0.7% without AF, with a statistically insignificant difference.

The average maximal p wave and p wave dispersion exhibited significantly greater values within the AF group, as indicated by ECG. Electromechanical delay may occur due to variations in conduction between the ischemia and neighboring non-ischemic myocardium. Consequently, this can lead to an increase in P wave dispersion and the occurrence of AF. [22] Agreeing with the present study, Yesin and colleagues[23] reported significantly greater p-max and P-dispersion in STEMI cases having AF than those without AF. This supported Samadikhah et al. [22] P wave dispersion differed significantly between patients within the AF group and controls. As regards predicting the AF incidence among cases having anterior MI, at a cut-off point of 24.5, the sensitivity and specificity of Interatrial dyssynchrony by echo in predicting the AF incidence among cases having anterior MI is 63.6 % and 78.7 %, respectively, with a statistical significant diagnostic accuracy.

At a cut-off point of 22.5, the sensitivity and specificity of LA dyssynchrony by echo in predicting the AF occurrence among cases having anterior MI is 63.6 % and 79.8 %, respectively, with statistically significant diagnostic accuracy. Xu et al.[24] It was determined that intra-atrial conduction delays of 4.450 msec and 20.650 msec could assist in AF prediction among cases undergoing treatment for PSVT. For these delays, sensitivity and specificity were 42%, 80%, 91%, and 81%, respectively. Kumar et al.[25] identified the optimal that combines sensitivity and specificity (74% and 63%, respectively) for an LA dyssynchrony time of 25 ms, with a negative predictive value of 85.5% and a positive predictive value exhibiting (53%).

Limitations: A relatively modest-sized investigation was carried out at a solitary facility. Furthermore, the actual number of AFs may have been underestimated due to the retrospective chart review with ECG used to diagnose new-onset AF.

4. Conclusion

Interatrial and LA desynchrony (determined utilizing tissue Doppler) calculated by tissue Doppler has significant accuracy as predictors of AF for STEMI patients.

Disclosure

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Authorship

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Conflicts of interest

There are no conflicts of interest.

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