ORIGINAL RESEARCH

Changes and Significance of 2D-STI and Right Ventricular Function Parameters in Evaluating Cardiac Function in Patients with Coronary Heart Disease and Atrial Fibrillation

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ABSTRACT

Objective • To investigate the changes and clinical significance of two-dimensional speckle tracking imaging (2D-STI) and echocardiography in patients with coronary heart disease (CHD) and atrial fibrillation (AF).

Methods • In this study, 102 patients with CHD accompanied by AF were selected as the case group, and 100 patients with CHD but without AF were selected as the control group. All patients received conventional echocardiography and 2D-STI, and the right heart function parameters and right heart strain parameters were compared. The relationship between the above indicators and the occurrence of adverse endpoint events in patients from the case group was analyzed by a logistic regression model.

Results • The values of right ventricular ejection fraction (RVEF), right ventricular systolic volume (RVSV), and tricuspid valve systolic displacement (TAPSE) in the case group were lower than those in the control group, and the differences were statistically significant ($P < .05$). The values of right ventricular end-diastolic volume (RVEDV) and right ventricular end-systolic volume (RVESV) in the case group were higher than those in the control group, and the differences were statistically significant ($P < .05$). The values of right ventricular longitudinal strain in the basal segment (RVLSbas), right ventricular longitudinal strain in the middle segment (RVLSmid), right ventricular longitudinal strain in the apical segment (RVLSapi), and right ventricular longitudinal strain in the free wall (RVLSfw) in the case group were higher than those in the control group, and the differences were statistically significant ($P < .05$). The number of coronary lesions ≥2 branches, cardiac function class ≥III, coronary stenosis ≥70%, reduced RVEF, increased RVLSbas, RVLSmid, RVLSapi, and RVLSfw were found to be independent risk factors for adverse endpoint events in patients with CHD and AF ($P < 0.05$).

Conclusion • In patients with CHD accompanied by AF, the right ventricular systolic function and myocardial longitudinal strain capacity decreases, and the decreased right ventricular function was closely related to the occurrence of adverse endpoint events. (*Altern Ther Health Med.* 2023;29(5):40-44).

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INTRODUCTION

Atrial fibrillation (AF) is one of the common arrhythmias, and coronary heart disease (CHD) together with AF not only causes damage to the left heart function of patients, but also affects the right ventricular function.[1,2] The importance of right heart function has received increasing attention for the treatment and prognostic evaluation of such patients. Accurate evaluation of right heart function in patients with AF in coronary heart disease has important clinical value.[3-5] The left and right ventricles share a common septum, and when the function of the left heart is diminished, it may also affect the function of the right heart. Therefore, assessment of the right heart function in patients with CHD and AF may have some significance for disease regression and prognosis.[6,7] In the past, conventional ultrasonography was often used to assess right ventricular systolic function, but the test is angle-dependent and has poor sensitivity.[8-10] Two-dimensional speckle tracking image (2D-

STI) provides a detailed description of myocardial deformation in three directions: longitudinal, radial, and circumferential, and its longitudinal systolic strain has been shown to be highly sensitive in the diagnosis of patients with pulmonary hypertension, arrhythmogenic right ventricular cardiomyopathy, and congenital heart disease.[11-13] Studies have claimed that myocardial diastolic deformation-related strain parameters measured by 2D-STI are more sensitive to subtle changes in myocardial functional contractility compared to conventional contraction parameters.[14,15] The right ventricle has a special structure with longitudinal shortening that allows assessment of its systolic function.[16,17] Given that 2D-STE examination can acquire relevant strain and strain rate parameters, the 2D-STI technique is used to detect right ventricular strain parameters and right heart function parameters in patients with AF in CHD, with the aim of improving the sensitivity of right ventricular function detection.

METHODS

General information

In this study, 102 patients who were diagnosed with CHD accompanied by AF from July 2018 to July 2021 at Shanghai Oriental Hospital, Tongji University were selected as the case group, and another 100 patients with CHD without AF were selected as the control group. The baseline data of the two groups were statistically analyzed, and there was no significant difference between the two groups ($P > .05$); see Table 1.

Table 1. Baseline Data of the Patients in Both Groups

Index	Case group (n = 102)	Control group (n = 100)	t/χ^2	*P* value
Age (year)	63.19 ± 10.03	61.70 ± 9.58	1.079	.282
BMI (kg/m^2)	23.96 ± 1.92	23.81 ± 2.20	0.517	.606
Gender (%)			2.955	.086
Man	64 (62.75)	74 (74.00)		
Woman	38 (37.25)	26 (26.00)		
Smoke (%)			0.497	.481
Yes	53 (51.96)	47 (47.00)		
No	49 (48.04)	53 (53.00)		
Drink (%)			0.792	.374
Yes	44 (43.14)	37 (37.00)		
No	58 (56.86)	63 (63.00)		
Comorbidity (%)				
Hypertension	51 (50.00)	44 (44.00)	0.730	.393
Diabetes mellitus	33 (32.35)	28 (28.00)	0.454	.500
Dyslipidemia	68 (66.67)	60 (60.00)	0.967	.325

Inclusion criteria: (1) the diagnostic criteria for patients with CHD referred to the guidelines for the diagnosis of CHD established by the American Heart Association (AHA), and at least one coronary artery had stenosis ≥50% by coronary angiography;[18] (2) the patients' age range was 19-79 years; (3) the patients had received at least 1 year of follow-up observation of their disease; (4) the diagnostic criteria for patients with AF referred to the 2020 ACC Expert Consensus Decision Pathway for Anticoagulant and Antiplatelet Therapy in Patients With Atrial Fibrillation or Venous Thromboembolism Undergoing Percutaneous Coronary Intervention or With Atherosclerotic Cardiovascular Disease[19], and all AF were persistent; (5) the 2D-STI and echocardiographic measurements were complete.

Exclusion criteria: (1) patients with cancer; (2) with severe underlying diseases (liver and kidney failure, cerebrovascular diseases); (3) history of major trauma; (4) patients with underlying hematologic diseases (coagulation factor deficiency, hematopoietic system diseases, etc.).

Inspection method and observation indicators

Echocardiography was used to detect right ventricular ejection fraction (RVEF), right ventricular end-diastolic volume (RVEDV), right ventricular end-systolic volume (RVESV), right ventricular systolic volume (RVSV), and tricuspid valve systolic displacement (TAPSE) in both study groups; 2D-STI was used to determine the peak systolic strain, i.e., right ventricular longitudinal strain (RVLS) in each segment of both study groups: right ventricular longitudinal strain in the basal segment (RVLSbas), right ventricular longitudinal strain in the middle segment (RVLSmid), right ventricular longitudinal strain in the apical segment (RVLSapi), and overall right ventricular longitudinal strain in the free wall (RVLSfw) of the right ventricle.

Philips EPIQ 7C ultrasound diagnostic instrument with probe S5-1 was used. Ultrasound two-dimensional images were acquired, and the electrocardiogram (ECG) was connected simultaneously. The probe was placed in the apical four-chamber heart more eccentric to the right shoulder, and the four-chamber heart section centered on the right ventricle was acquired for 3 consecutive cardiac cycles, and the information was saved and analyzed by Q-LAB software. The region of interest was manually adjusted to just cover the right ventricular myocardium, and strain curves for a total of 3 segments including the basal, intermediate and apical segments of the right ventricular free wall were acquired, and the peak systolic strain (RVLS) was recorded. RVLSbas, RVLSmid, RVLSapi, and RVLSfw were measured and recorded.

The right ventricular endocardial inferior boundary was focused on to obtain RVEF, RVEDV, RVESV, and RVSV, respectively.

Acquisition of TAPSE value: M-mode ultrasound was used, and the examination was performed in the apical four-chamber cardiac section. The sample line was taken through the lateral tricuspid annulus, parallel to the long axis of the right ventricle as far as possible, and the displacement distance of the tricuspid annulus from end-diastole to end-systole was measured, which is the TAPSE value.

Statistical analysis

The data were processed with Statistical Product and Service Solutions (SPSS) 21.0 (IBM, Armonk, NY, USA). All the count data including RVEF, RVSV, TAPSE, RVEDV, RVESV, RVLSbas, RVLSmid, RVLSapi, and RVLSfw measurements were normally distributed, and was described by ($\bar{x} \pm s$), and *t* test was used to test the hypothesis of the comparison between the two groups for the above measurement data. The count data (gender, comorbidity, number of lesion branches, etc.) were described by the

number of cases (percentage), and the χ^2 test was used for the comparative analysis between the two groups. Logistic regression analysis was used for the multifactorial analysis and $P < .05$ indicated that the statistical differences were significant.

RESULTS

Comparison of the right heart function parameters between the two groups

The values of RVEF, RVSV and TAPSE in the study group were lower than those in the control group, and the differences were statistically significant ($P < .05$); the values of RVEDV and RVESV in the study group were higher than those in the control group, and the differences were statistically significant ($P < .05$); see Table 2.

Comparison of the 2D-STI parameters between the two groups

The values of RVLSbas, RVLSmid, RVLSapi, and RVLSfw in the study group were higher than those in the control group, and the differences were statistically significant ($P < .05$); see Table 3.

The value of right heart function parameters and 2D-STI parameters in the diagnosis of CHD with AF

Receiver operating characteristic curve (ROC) analysis showed that the ROC curve was drawn based on the measured values of RVEF, RVSV, TAPS, RVEDV, RVESV, RVLSbas, RVLSmid, RVLSapi, and RVLSfw. The results showed that the value of RVLSbas and RVLSmid were high in the diagnosis of CHD with AF. The diagnostic values of other indicators are shown in Table 4.

Univariate analysis of patients with CHD with AF with adverse endpoint events

Among 102 patients in the study group, 18 patients were hospitalized for myocardial infarction, 12 patients were admitted for heart failure episode and 2 patients died. These 32 patients were divided into the group with adverse endpoint events (occurrence group) and 70 patients without adverse events (non-occurrence group). Upon univariate analysis, the coronary lesion branch, cardiac function grade, and the degree of coronary stenosis were found to be statistically significant ($P < .05$); see Table 5.

Comparison of right ventricular function parameters and 2D-STI parameters between patients with and without adverse endpoint events

The measured values of RVEF and TAPSE in the occurrence group were lower than those in the non-occurrence group, and the measured values of RVLSbas, RVLSmid, and RVLSfw in the occurrence group were significantly higher than those in the non-occurrence group ($P < .05$); See Table 6.

Table 2. Comparison of Right Heart Function Parameters Between the Two Groups ($\bar{x} \pm s$)

Group	n	RVEF (%)	RVEDV (ml)	RVESV (ml)	RVSV (ml)	TAPSE (mm)
Case group	102	49.63 ± 5.19	120.71 ± 9.40	65.29 ± 10.02	54.20 ± 6.73	18.77 ± 2.64
Control group	100	55.08 ± 5.84	114.36 ± 7.57	50.96 ± 8.97	63.98 ± 7.14	24.78 ± 3.10
t		-7.014	5.282	10.702	-10.020	-14.845
P value		<.001	<.001	<.001	<.001	<.001

Table 3. Comparison of 2D-STI Parameters Between the Two Groups ($\bar{x} \pm s$)

Group	n	RVLSbas	RVLSmid	RVLSapi	RVLSfw
Case group	102	-22.76 ± 5.11	-17.42 ± 5.59	-12.74 ± 3.78	-17.88 ± 4.73
Control group	100	-37.61 ± 8.94	-25.66 ± 5.80	-15.83 ± 4.40	-26.61 ± 6.43
t		-14.529	-10.282	-5.357	-11.007
P value		<.001	<.001	<.001	<.001

Table 4. Value of Right Heart Function Parameters and 2D-STI Parameters in the Diagnosis of Coronary Heart Disease with Atrial Fibrillation

Parameter	Sensitivity (%)	Specificity (%)	Missed diagnosis rate (%)	Misdiagnosis rete (%)	AUC value
RVEF	66.71	73.02	33.29	26.98	0.701
RVEDV	63.30	64.58	36.70	35.42	0.659
RVESV	78.54	74.11	21.46	25.89	0.755
RVSV	75.90	69.43	24.10	30.57	0.724
TAPSE	83.41	75.30	16.59	24.70	0.747
RVLSbas	84.20	83.41	15.80	16.59	0.842
RVLSmid	81.56	85.29	18.44	14.71	0.861
RVLSapi	67.40	76.40	32.60	23.60	0.747
RVLSfw	75.10	79.40	24.90	20.60	0.806

Table 5. Univariate Analysis of Patients with Coronary Heart Disease with Atrial Fibrillation with Adverse Endpoint Events

Index	Occurrence Group (n = 32)	Non-occurrence group (n = 70)	t/χ^2	*P* value
Age (year)	64.88 ± 9.51	62.80 ± 8.74	1.085	.281
BMI (kg/m^2)	24.11 ± 1.56	23.81 ± 1.80	0.813	.418
Gender (%)			0.842	.359
Man	18 (56.25)	46 (65.71)		
Woman	14 (43.75)	24 (34.29)		
Smoke (%)			0.483	.487
Yes	15 (46.88)	38 (54.29)		
No	17 (53.13)	32 (45.71)		
Drink (%)			0.895	.344
Yes	16 (50.00)	28 (40.00)		
No	16 (50.00)	42 (60.00)		
Comorbidity (%)				
Hypertension	19 (59.38)	32 (45.71)	1.639	.302
Diabetes mellitus	14 (43.75)	19 (27.14)	2.767	.096
Dyslipidemia	25 (78.13)	43 (61.43)	2.755	.097
coronary lesion branch (%)			3.906	.048
Single branch	12 (37.50)	41 (58.57)		
Be equal or greater than 2 branches	20 (62.50)	29 (41.43)		
Cardiac functional grading (%)			5.968	.015
<III	20 (62.50)	59 (84.29)		
≥III	12 (37.50)	11 (15.71)		
Degree of coronary stenosis (%)			11.306	.001
≥70%	26 (81.25)	32 (45.71)		
<70%	6 (18.75)	38 (54.29)		

Table 6. Univariate Analysis of Right Heart Function Parameters, 2D-STI Parameters and Adverse Endpoints of Patients

Group	n	RVEF (%)	RVEDV (mL)	RVESV (mL)	RVSV (mL)	TAPSE (mm)	RVLSbas	RVLSmid	RVLSapi	RVLSfw
Occurrence group	32	48.40 ± 5.11	122.01 ± 9.12	66.43 ± 8.46	54.85 ± 6.30	17.90 ± 2.46	-20.40 ± 4.78	-15.30 ± 5.14	-12.53 ± 3.26	-15.48 ± 4.14
Non-occurrence group	70	50.78 ± 4.76	118.63 ± 8.94	64.11 ± 9.44	53.46 ± 6.12	19.01 ± 2.54	-25.48 ± 4.92	-19.46 ± 4.80	-12.98 ± 3.55	-19.63 ± 4.61
t		-2.290	1.761	1.189	1.055	-2.068	-4.881	-3.972	-0.609	-4.351
P value		0.024	0.081	0.237	0.294	0.041	0.000	0.000	0.544	0.000

Table 7. Multivariate Analysis of the Occurrence of Adverse Endpoint Events

Index	β	SE	Walds	*P* value	OR	95% CI	
Number of coronary lesions	0.492	0.177	7.727	<.001	1.636	1.156	2.314
Cardiac functional grading	0.501	0.204	6.031	.004	1.650	1.106	2.462
The greatest degree of coronary artery stenosis	0.704	0.268	6.900	<.001	2.022	1.196	3.419
RVEF	-0.677	0.251	7.275	<.001	0.508	0.311	0.831
RVEDV	0.511	0.409	1.561	.298	1.667	0.748	3.716
RVESV	0.548	0.511	1.150	.417	1.730	0.635	4.709
RVSV	0.504	0.396	1.620	.285	1.655	0.762	3.597
TAPSE	0.481	0.304	2.503	.143	1.618	0.892	2.935
RVLSbas	0.664	0.261	6.472	.001	1.943	1.165	3.240
RVLSmid	0.592	0.284	4.345	.045	1.808	1.036	3.154
RVLSapi	0.704	0.289	5.934	.007	2.022	1.147	3.562
RVLSfw	0.618	0.286	4.669	.046	1.855	1.059	3.250
Constant term	1.409	0.927	2.310	.178	4.092	0.665	25.177

Multivariate analysis of the occurrence of adverse endpoint events

With the adverse endpoint event group whether occurring within 12 months of patient follow-up as the independent variable, the number of coronary lesion branches, cardiac function grade, degree of coronary stenosis, RVEF, RVSV, TAPSE, RVEDV, RVESV, RVLSbas, RVLSmid, RVLSapi, and RVLSfw, which were statistically significant by univariate analysis, were used as dependent variables to establish the logistic regression model. Results suggested that the number of coronary lesions ≥2 branches, cardiac function grade ≥III, the degree of coronary stenosis ≥70%, decreased RVEF, increased RVLSbas, RVLSmid, RVLSapi, and RVLSfw were independent risk factors for adverse endpoint events in patients with CHD and AF ($P < .05$); see Table 7.

DISCUSSION

The left and right ventricles interact and influence each other. Clinically, attention is mainly paid to left heart systolic and diastolic function in patients with AF in CHD, and the right ventricle is often neglected because of the difficulty in evaluating its function due to the thin ventricular wall and poor contractility. A number of studies have shown the role of right heart function in the assessment of the diagnosis, prognosis, and regression of cardiopulmonary disease.[20-22]

The study intends to use 2D-STI to detect parameters related to right heart function. The results of the study showed that the RVEF, RVSV, and TAPSE measurement values of the study group were lower than that of the control group, and the values of RVEDV and RVESV were higher than that of the control group. Myocardial hypertrophy and fibrosis are involved in the onset and development of right ventricular systolic dysfunction. 2D-STI technique can track and analyze the peak motor torsion in each myocardial segment and provide real-time tracking of myocardial motor asynchrony, which can assess and predict myocardial function.[23,24] The 2D-STI technique can circumvent the influence of overall cardiac function parameters measured by conventional ultrasound techniques that are affected by the cardiac preload and afterload and heart rate, and it can measure local myocardial strain values with more accuracy.[25,26] 2D-STI technique uses TAPSE to reflect the motion of the right ventricular myocardium in the long-axis direction, and the motion is divided into longitudinal and radial motion, which is mostly accomplished by longitudinal movements.[27] TAPSE has become an index used to assess right ventricular systolic function because of its simplicity and ease of measurement.

It has been claimed that the right ventricular compliance is good and when it occurs in patients with CHD and AF, the right ventricle may change earlier, suggesting an increase in right ventricular pressure and volume load with disease progression.[28,29] In this study, the RVLSbas, RVLSmid, RVLSapi, and RVLSfw measurements were higher in the study group than in the control group, and the differences were statistically significant. Strain is a novel index for evaluating myocardial function, and the above-mentioned strain values measured by the 2D-STI technique provide a more objective and accurate evaluation of myocardial tissue spatial motility.[30] The present results suggest the importance of these strain values in the assessment of right ventricular function. The strain values are not only related to the reflection of the right ventricular systolic function, but also laterally to the left ventricular function. It is worth mentioning that since the longitudinal lateral wall of the right ventricle generates 80% of the right ventricular output per beat, strain values such as RVLSfw measured by 2D-STI can quantitatively reflect the overall right ventricular systolic function, which is more sensitive to subtle changes in myocardial contractility. The results of this study show that RVLSbas and RVLSmid have high value in the diagnosis of CHD with AF. It is suggested that the above changes of strain value can be used as the basis for diagnosis of CHD with AF.

In this study, reduced RVEF, along with increased RVLSbas, RVLSmid, RVLSapi, and RVLSfw were found to be independent risk factors for the occurrence of adverse endpoint events in patients with CHD and AF after controlling for left ventricular strain. It is suggested that reduced right heart function is closely related to the occurrence of adverse endpoint events in patients. Although left ventricular ejection fraction is normal in patients

with CHD and AF, right ventricular longitudinal systolic function may be significantly impaired.[31] However, the criteria for the optimal right ventricular longitudinal strain index are still unclear and therefore need to be further explored, but it is certain that the right ventricular longitudinal strain parameter has a certain status in the prediction of adverse endpoint events in patients.[32] The results of this study showed that the number of coronary lesions ≥2 branches, cardiac function grade ≥III, and the degree of coronary stenosis ≥70% were independent risk factors for adverse endpoint events in patients with CHD and AF. Previous studies have confirmed that myocardial systolic function is already impaired before the left ventricular ejection fraction (LVEF) abnormalities are observed in patients with CHD.[33-35] Those with a higher number of coronary lesion branches, higher cardiac function class, and more severe coronary stenosis have a greater degree of myocardial ischemia and hypoxia present, with significant changes in the local pattern of movement on torsional relaxation of myocardial fibers.

CONCLUSION

In this study, the 2D-STI technique was applied to assess right heart function in patients with CHD and AF, and the following conclusions were drawn: the 2D-STI technique can better assess right heart function; it can quantitatively assess overall and segmental functional changes in the right ventricle, and its parameter values can assess impaired right heart longitudinal systolic function in patients with coronary atrial fibrillation. The results of this study could provide valuable reference for the application of 2D-STI in the diagnosis and assessment of CHD and AF. Although some crucial results were obtained in this study, it has some limitations. This study did not consider the effect of conditions such as tricuspid regurgitation on the right heart load of patients, thus warranting further studies in the future.

In conclusion, right ventricular systolic function and myocardial longitudinal strain capacity was found to decrease in patients with CHD and AF, and the decreased right ventricular function was closely related to the occurrence of adverse endpoints in these patients.

AUTHOR DISCLOSURE STATEMENT

The authors have no potential conflict of interest to report relevant to this article.

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AUTHORS' CONTRIBUTIONS

YZ and BZ designed the study and performed the experiments, LX and YM collected the data, JX JH, and GL analyzed the data, YZ and BZ prepared the manuscript. All authors read and approved the final manuscript.

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