ORIGINAL ARTICLE ASIAN JOURNAL OF MEDICAL SCIENCES

Assessment of right atrial function in inferior wall AMI

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Submission: 18-07-2022 Revision: 02-11-2022 Publication: 01-12-2022

ABSTRACT

Background: Approximately 30–50% of patients with inferior infarction have some involvement of the right ventricle. The right ventricular (RV) infarction almost invariably develops in association with a large infarction of the adjacent septum and inferior 0 walls, but isolated infarction of the right ventricle is seen in just 3–5% of autopsy-proven cases of MI. This study is designed to assess the right atrial (RA) functions in inferior wall acute myocardial infarction (AMI) (IWMI) echocardiographically and to compare it with patients who do not have history of ischemic heart disease (IHD) but having risk factors for IHD. **Aims and Objectives**: The aims of this study were to study the patients presenting with Inferior wall MI IWMI for RA function. **Materials and Methods**: Patients admitted in the Cardiology ward of R G Kar Medical College and Hospital with IWMI from March 2020 to March 2022 were included in the study. **Results**: Average Measurement of RA volume index (RAVI) and RA Pressure (RAP) was highest among patients with IWMI+RV myocardial infarction (RVMI). Out of 100 IWMI patients, 33 had high RAVI and RAP and out of 100 non-IHD patients none had high RAVI. **Conclusion**: In our study, there was no statistically significant difference in average RAVI and RAP in patients presenting with IWMI and in patients with risk factors for myocardial infarction but without AMI. However, patients presented with IWMI+RVMI showed statistically significant increased RAVI and RAP as compared to inferior wall AMI only.

Key words: Acute myocardial infarction; Inferior wall acute myocardial infarction; Right ventricular myocardial infarction; Non-ST elevation myocardial infarction; Right atrium; Right ventricle; Echocardiography

Access this article online

Website:

http://nepjol.info/index.php/AJMS

DOI: 10.3126/ajms.v13i12.46788

E-ISSN: 2091-0576

P-ISSN: 2467-9100

INTRODUCTION

The proportion of patients with ACS who have ST elevation myocardial infarction (STEMI) varies but has declined over the past decade, and there is increase in number of Non-ST elevation myocardial infarction (NSTEMI) cases relative to STEMI.[1] There are several reasons for increase in number of NSTEMI cases relative to STEMI: (1) wider use of preventive measures such as aspirin, statins, and smoking cessation; (2) aging of the population, with greater prevalence of diabetes and chronic kidney disease and lower rates of smoking; and (3) broader use of troponin assays with higher sensitivity for myocardial necrosis, which shifts the diagnosis from UA to NSTEMI.[2] STEMI affecting anterior wall of the left ventricle (LV) is known as anterior wall myocardial infarction and STEMI affecting inferior wall of LV is known as inferior wall myocardial infarction (IWMI). The right ventricular (RV) infarction almost invariably develops in association with a large infarction of the adjacent septum and inferior LV walls[3], but isolated infarction of the right ventricle is seen in just 3–5% of autopsy-proven cases of MI.[4] RV infarction occurs less often than would be anticipated from the frequency of atherosclerotic lesions involving the RCA. The classic presentation of an RV infarct is hypotension, clear lung fields, and elevated jugular venous pressures (JVP). Atrial size and function can be assessed with echocardiography, cardiac computed tomography (CCT), and cardiac magnetic resonance (CMR). Methods commonly used to calculate the LV volume may be used to calculate RV volumes, but are less accurate due to the complex geometry. Doppler-echocardiographic

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measurements of the right- and left-sided filling pressures, pulmonary vascular resistance, and cardiac output are possible to obtain in most patients. Accurate evaluation of the right atrial pressure (RAP) is also a necessary for the non-invasive estimation of the systolic and diastolic PAP. Although echocardiography is best suited for these tasks due to its availability, safety, versatility, and ability to image in real time with high temporal and spatial resolution, CCT, and CMR are complementary in specific clinical instances.[5]

Assessment of right atrial (RA) function

Measurement of RA volume index (RAVI)

RA volume, indexed to body surface area (RAVI), has recently been described as an echocardiographic parameter that is linked to adverse outcome in patients with heart failure[6,7] and pulmonary hypertension.[8]

RAVI had also been hypothesized as a marker of RV dysfunction to predict the persistence of RV dysfunction after acute inferior STEMI due to occlusion of proximal RCA in a study by Mohamed Naseem et al., and suggested that RAVI may be a useful predictor of persistently impaired RVF in patients with inferior STEMI with proximal RCA occlusion with a cutoff value 30 ml/m^2. The cutoff value of RAVI 30 mL/m^2 had a 87.5% sensitivity, a 92.24% specificity for predicting persistently impaired RV function.[9]

The importance of predicting persistence RV dysfunction came from the fact that persistent RV dysfunction is associated with long term poor prognosis irrespective of LV systolic function.[10,11]

Liao et al., compared in-hospital outcomes between left ventricular myocardial infarction patients with and without RV myocardial infarction (RVMI) in 458 patients with acute (STEMI) undergoing primary percutaneous coronary intervention. They reported that patients with concomitant RVMI have higher of in-hospital complications, particularly all-cause mortality and new-onset acute HF.[12]

RAVI to body surface area (RAVI) using the 4-chamber single-plane Simpson method averaged over 5 consecutive cardiac cycles. An Apical 4 chamber view that includes the entire RA was used. The RA contours were traced on sequential images at end-ventricular systole. Foreshortening of the RA was carefully avoided. The RA appendage, coronary sinus, and the confluence of inferior vena cava (IVC) were excluded from the study.[13]

Measurement of RA volume in apical 4 chamber view

In a study by Mohamed Naseem et al., ROC curve analysis shows RAVI with a cutoff value >30 mL/m^2 that had a 87.5% sensitivity and 92.24% specificity area under ROC curve ¼ 0.964 for predicting persistently impaired RV function.[14] We used the value of RAVI >30mL/m^2 as high RAVI and RAVI<30ml/m2 as non-high RAVI.

The various methods utilized for the echocardiographic evaluation of RAP

Method	Criteria used	Strength and limitations
IVC parameters – 2D or M-mode subcostal imaging of the IVC	IVC diameter, collapse: • <2.1 cm, >50%—normal RAP~3 • >2.1 cm, >50%—intermediate* RAP~8 • >2.1 cm, <50%—High RAP ~>15	Most validated method Above a certain elevation of RAP, the IVC may be fully dilated and not collapsing, making estimation above this point difficult.
Systemic and hepatic venous flow – Doppler flow in the vena cava, jugular, or hepatic veins.	Vs>Vd—normal RAP Vs<Vd—elevated RAP (>8 mm Hg)	Severe tricuspid regurgitation, Atrial compliance, tricuspid annular descent, Atrial fibrillation and past cardiac surgery can alter the venous flow pattern without correlation to RAP.
HVFF – pulsed Doppler of hepatic veins.	VsVTI/(VsVTI+VdVTI) <55—High RAP >8 mm Hg	Validated in mechanically ventilated patients Single study. Atrial fibrillation or past cardiac surgery can cause the hepatic vein systolic flow to be diminished regardless of RAP.
RVrIVRT—tricuspid TDI	> 59 ms correlates to RAP >8 mm Hg	Studied on a limited number of patients (n=21) in a single study.
3D RA dimensions – 3D transthoracic imaging of the RA	3DE maximal RA volume≥35 mL/m2 combined with IVC diameter≥2 cm – correlates with RAP >10 mm Hg	Single study in a selective group of heart failure patients with EF <35%
Doppler and TDI – pulsed Doppler of the tricuspid inflow and TDI of the tricuspid valve	E/e′ >6 – RAP>10 mm Hg	Validated in mechanically ventilated patients. May not be validated in post cardiac surgery patients.

RAP: right atrial pressure, HVFF: Hepatic vein filling fraction, RA: Right atrial, RVrIVRT: Right ventricular regional isovolumic relaxation time

IVC parameters

The most commonly utilized method uses the IVC size and its respiratory variation for the echocardiographic evaluation of RAP. As the IVC is a highly compliant vessel, its size and flow dynamics vary with changes in CVP and volume. During inspiration (which produces negative intrathoracic pressure), vena cava pressure decreases and flow increases.[15,16]

At low or normal RAP, there is systolic predominance in IVC flow, such that the systolic flow is greater than the diastolic flow. As RAP increases, it is transmitted to the IVC, resulting in blunting of the forward systolic flow, reduced IVC collapse with inspiration and eventually IVC dilatation. Current guidelines[12,13] recommend using the IVC maximal diameter (IVC max) 1–2 cm from the RA –IVC junction at end-expiration and the IVC collapsibility index (IVCCI, which equals [IVC max – IVC min]/IVC max). For RAP assessment, an IVC with a diameter<2.1 cm and collapse>50% correlate with a normal RAP of 0–5 mm Hg. An IVC<2.1 cm with<50% collapse and an IVC>2.1 cm with>50% collapse correspond to an intermediate RAP of 5–10 mm Hg. An IVC>2.1 cm with<50% collapse suggests a high RAP of 15 mm Hg. Using midrange values of 3 mm Hg for normal and 8 mm Hg for intermediate RAP are recommended. However, if there is minimal collapse of the IVC (<35%) and/or secondary indices of elevated RAP are present, upgrading to the higher pressure limit (i.e., 5 and 10 mm Hg in case of normal and intermediate RAP, respectively) should be done. Patients should be supine during assessment of the IVC as other positions may lead to either under- or overestimation of IVC diameter and/or collapsibility.[14]

Patients with low compliance with deep inspiration may have a diminished IVC collapse. A "sniff " maneuver leads to a sudden decrease in intrathoracic pressure leading to accentuation of the normal inspiratory response can be used to differentiate those with normal IVC collapsibility from those with a diminished IVC collapsibility.[15] IVC size and collapsibility are helpful to identify RAP as being high or low, but this method does not provide precise numeric values for RAP. It should be noted that the IVC can be dilated in individuals with a normal RAP.

In our study, we had used IVC parameters to assess RA pressure (RAP) and RAP>15 mm Hg was considered as high RAP and RAO<15 mm Hg was considered as non-high RAP.

Aims and objectives

The aims of this study were to study the patients presenting with inferior wall acute myocardial infarction (AMI) (IWMI) for RA function.

Specific objectives

1. RA functions in IWMI
2. To see relationship of RA functions and inferior wall AMI in presence of other risk factors.

MATERIALS AND METHODS

The study was a hospital-based single centric study conducted for a period of 2 years, that is, March 2020–March 2022 in the Department of Cardiology consisting of study subjects attending cardiology ward and echocardiography laboratory of R G Kar Medical College, Kolkata.

Inclusion criteria

Patients were eligible for enrollment who got admitted in cardiology ward for IWMI having risk factors such as diabetes mellitus, hypertension, and smoking.

Patients were also taken from echocardiography laboratory, who do not have ACS or other structural heart disease but may have risk factors for ACS such as diabetes mellitus, hypertension, and smoking.

Exclusion criteria

Patient not willing, patients who did not have any risk factors such as diabetes mellitus, hypertension, and smoking, patients having previous history of ischemic heart disease, dilated cardiomyopathy, valvular heart disease, or any structural heart disease were excluded from the study.

Study period

This study was March 2020–March 2022.

Sample size

Sample size was calculated using the formula for analytical study.

Sample size (N)={2(Z1-α/2+Zβ)2 P(1-P)}/(P1–P2)2

Where P1=expected proportion of cases with high RAP among patients with IWMI.

P2=expected proportion of cases with high RAP among patients without IWMI.

P=(P1+P2)/2

Z1-α/2=standard normal deviate and has a value of 1.96 considering 95% confidence interval

Zβ has a value of 0.84 considering power of the test as 80%.

N=sample size of each group.

A pilot study was carried out taking ten patients in each group to get those proportions for sample size calculation due to scarcity of published data.

The pilot study revealed P1=0.5, P2=0.3.

Thus estimated sample size was 94.08 and it is round of to 100.

Sample design

Samples will be taken until the desired size is reached.

Study design

This study was observational cross-sectional analytical study.

Parameters to be studied

Clinical History, Pulse, blood pressure, ECG, Echocardiography (2D, M-Mode, Color Doppler), Biochemical test.

Study tools

Echo Machine, ECG Machine, Structured Questionnaires, Instruments for clinical examination

Study technique

Clinical assessment of cardiovascular disease, ECG, Echocardiography (2D, M MODE, COLOR DOPPLER)

Data analysis

Collected data were analyzed in an excel spread sheet and analyzed subsequently using SPSS-19. Categorical variables were expressed in frequencies and percentages (%). Continuous variables were expressed in mean+SD or median (inter-quartile range).

RESULTS

Difference in average RAVI of patients with different types of IWMI and non-ischemic heart disease (IHD) was statistically significant.

Kruskal–Wallis test was applied to find out the difference in averages of those patients

Chi-square value=7.254, DF=1, P=0.007 difference in proportion of patients with high RAVI between patients with ACS or without IHD was statistically significant.

A total of 100 patients who were admitted with acute coronary syndrome in Cardiology ward of RGKMC & H were included in our study who satisfied inclusion and exclusion criteria. Simultaneously, 100 patients who had not IHD but meeting the inclusion and exclusion criteria were also included in our study. Mean age of ACS patients were 59.55 + 8.15 years. Mean age of Non-IHD patients were 59.92 + 8.32 years. Average age of two groups of patients did not show statistically significant difference (p=0.751). There were 69 male(69%) and 31 female (31%) among ACS patients and 70 male (70%) and 30 female (30%) among non-IHD patients (p=0.874). Difference in proportion of male and female between patients with or without acute coronary syndrome was not statistically significant. There were 30 (30%) patients among ACS having positive history of smoking and 20 (20%) patients among non-IHD having positive smoking history (p=0.102). Difference in proportion of cases with smoking history between patients with or without acute coronary syndrome was not statistically significant. There were 61 (61%) patients having diabetes mellitus among ACS and 53 (53%) patients having diabetes mellitus among non-IHD (p=0.253). Difference in proportion of cases with diabetes mellitus between patients with or without acute coronary syndrome was not statistically significant. There were 58 (58%) hypertensive patients among ACS and 57 (57%) hypertensive patients among non-IHD (p=0.886). Difference in proportion of cases with hypertension between patients with or without acute coronary syndrome was not statistically significant. So, our study population were matched regarding age, sex, diabetes mellitus, hypertension, positive family history and positive smoking history. Median LVEF of ACS patients were 48(7) and median LVEF of non-IHD patients were 62(7). P=0.00 Average LVEF of two groups of patients showed statistically significant difference. Median RAVI of IWMI patients was 27.8 (2.6) and median RAVI of non-IHD patients was 27.3 (2.4). P=0.15 average RAVI of two groups of patients did not show statistically significant difference[Table 1]. Average RAVI was highest among patients with IWMI+RVMI [32.10(1.4).

DISCUSSION

Our study is a hospital-based, observational, cross-sectional, and analytical study to evaluate RA functions echocardiographically on admission in patients with first episode of inferior wall AMI (IWMI) and compared it with patients who do not have any history of IHD but having risk factors for IHD. A total of 100 patients who were admitted with IWMI in cardiology ward of RGKMC and H were included in our study who satisfied inclusion and exclusion criteria. Simultaneously, 100 patients who had

Table 1: Average right atrial volume index of all study subjects

Group	Median (interquartile range) (mL/m²)	Chi-square value	P value
Non-IHD (n1=100)	27.30 (2.4)	22.89	0.000
IWMI (n2=67)	27.80 (2.5)		
IWMI + RVMI (n3=33)	32.10 (1.4)		

P=0.004, P=0.064, P=0.054, P=0.159, P=0.412, P=0.359

not IHD but meeting the inclusion and exclusion criteria were also included in our study. Mean age of ACS patients was 59.55+8.15 years. Mean age of non-IHD patients was 59.92+8.32 years.

Our study population were matched regarding age, sex, diabetes mellitus, hypertension, positive family history, and positive smoking history. Median RAVI of IWMI patients was 27.8 (2.6) and median RAVI of non-IHD patients was 27.3 (2.4). P=0.15 average RAVI of two groups of patients did not show statistically significant difference[Table 1]. Average RAVI was highest among patients with IWMI+RVMI [32.10(1.4), P=0.000]. Out of 100 IWMI patients 33 had high RAVI and this was seen in patients with associated RVMI.Out of 100 non-IHD patients none had high RAVI and normal RAVI was also seen in 67 patients with IWMI without RVMI [Table 2].

Difference in proportion of patients with high RAVI between patients with IWMI+RVMI or without IHD was statistically significant. Percentage of high RAVI was highest among patients with IWMI+RVMI (100%) [Table 3]. Study by Mohamed Naseem et al., showed that patients with IWMI who had RVMI had higher RAVI (P<0.001).[16] Out of 100 IWMI patients, RAP was high in 33 patients (33%) and out of 100 non-IHD patients, none were found to have high RAP (P=0.014)[Table 4].

Table 2: Distribution of patients with or without IWMI according to presence or absence of high RAVI

Patients	Right atrial volume index			
	High		Non-High	
	NO	%	NO	%
IWMI (n2=100)	33	33	67	67
Non-IHD (n1=100)	0	0	100	100

Table 3: Status of the right atrial volume index of all study subjects

Patients	Right atrial volume index			
	High		Non-High	
	NO	%	NO	%
Non-IHD (n1=100)	0	0	100	100
IWMI (n2=67)	0	0	67	100
IWMI + RVMI (n3=33)	33	100	0	0

Percentage of high RAVI was highest among IWMI + RVMI (100%)

Table 4: Status of the right atrial pressure of all study group

Patients	Right atrial pressure			
	High		Non-High	
	No	%	No	%
Non-IHD (n1=100)	0	0	100	100
IWMI (n2=67)	0	0	67	100
IWMI + RVMI (n3=33)	33	100	0	0

Difference in proportion of patients with high RAP was statistically significant between two groups. High RAP was found only in patients with IWMI+RVMI. Mittal et al., showed that raised JVP had high specificity (96.8%) but low sensitivity (39%) in diagnosing RV infarction. Positive Kussmaul's sign had equal specificity but lower sensitivity (26.1%). This raised JVP may be explained by high RAP.[17] Study conducted by Goldberger et al., showed that the respiratory caval index (percentage of collapse of the IVC with inspiration which is a marker of high RAP) was 22%+/–11% in patients with hemodynamically significant RV infarctions, 45%+/–15% in patients with non-hemodynamically significant RV infarctions, and 64%+/–17% in the control subjects (P<0.05 for all comparisons).[18]

Limitations of the study

We failed to follow up all patients in outpatient department because most of the patients are non-compliant. We were unable to compare echocardiographic RA function with MRI due to non-availability of MRI in our hospital.

CONCLUSION

Echocardiographic assessment of RV is difficult due to its unusual shape. Hence, quantitative data are minimal for assessing RV in myocardial infarction. RA volume and pressure may reflect RV functional status indirectly. In our study, there was normal average RAVI and RAP in patients with risk factors for myocardial infarction but without AMI. However, patients presented with IWMI+RVMI showed statistically significant increased RAVI and RAP as compared to inferior wall AMI only.

ACKNOWLEDGMENT

We are grateful to the Principal, Dean and Medical Superintendent of R G Kar Medical College for allowing us to conduct the study. We are also thankful to all the staff of department of Cardiology and Gynaecology & Obstetrics for co-operating with us to carry out the study. Finally, we are very much grateful to all the participants of this study for their full hearted support and co-operations.

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Authors' Contributions:
AD- Concept and design of the study, prepared first draft of manuscript; **LA-** Interpreted the results; reviewed the literature and manuscript preparation; and **SS**- Concept, coordination, statistical analysis and interpretation, preparation of manuscript, and revision of the manuscript.

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Source of Funding: None, **Conflicting Interest:** None.