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Research Article

Prognostic Value of Left and Right Ventricle Myocardial Performance Indices and Introduction of a New Combined Myocardial Performance Index of Both Ventricles in Left Inferior ST Segment Elevated Myocardial Infarction

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Abstract

The study aimed to evaluate the prognostic role of combined myocardial performance index of both ventricles in comparison with the Left Index of Myocardial Performance (LIMP) and/or Right Index of Myocardial Performance (RIMP) for early and late cardiac events in Primary Left Ventricular (LV) inferior ST-Segment Elevated Myocardial Infarction (STEMI). The study sample was composed of 221 patients (age 58.4±5.5 years, 189 men) with primary LV inferior STEMI. All patients underwent Doppler echocardiography and ascertained one year follow-up. Cases of hospital cardiac deaths; Acute Cardiac Complications (ACCs) - Ventricular Extrasystoly ≥ Lown III^{O} (VE), sino-atrial or atrio-ventricular Heart Block of II-IIIO (HB), Supraventricular Tachyarrhythmia (SVT), and Cardiogenic Shock (CS); 1 year post-hospital cardiac deaths; and 1 year cardiac re-hospitalization were analyzed. LIMP was a significant explanatory factor for CS, 1-year cardiac death and 1-year re-hospitalization while RIMP predicted hospital cardiac death and all ACCs. Furthermore, [LIMP+ RIMP] ≥1.00 established its powerful predictive value in all study outcomes - hospital cardiac death, all ACCs (p<0.01 for all cases), 1-year cardiac death and re-hospitalization (p<0.001 for both cases). Combined LIMP and RIMP is shown to be a stronger prognostic factor than LIMP or RIMP alone for all the selected study outcomes. We suggest using this newly established index of [LIMP+ RIMP] ≥1.00 in identifying primary LV inferior STEMI high-risk patients for both early and late clinical outcomes.

Keywords: Myocardial performance index; Inferior STEMI; Prognosis

Abbreviations

ACCs - Acute Cardiac Complications; AMI - Acute Myocardial Infarction; CS - Cardiogenic Shock; DMI - Doppler Myocardial Imaging; FAC - Fractional Area Change; HB - sino-atrial or atrio-ventricular Heart Block of II-III^{O}; LIMP - Left Index of Myocardial Performance; LV - Left Ventricle; MPI - Myocardial Performance Index; OR_{adj} - Adjusted Odds Ratios; RIMP - Right Index of Myocardial Performance; RV - Right Ventricle; STEMI - ST-Segment Elevated Myocardial Infarction; SVT - Supraventricular Tachyarrhythmia; VE - Ventricular Extrasystoly ≥ Lown III^{O}

Introduction

The Doppler-derived myocardial performance index (MPI), also known as the Tei index, is a relatively new measure of combined systolic and diastolic functions [1]. It is based on the relationship between ejection and non-ejection work of the heart. MPI is simple, noninvasive, easy to estimate and reproducible.

Several studies have recently shown that Left Index of Myocardial Performance (LIMP) has a prognostic value for clinical outcomes in Acute Myocardial Infarction (AMI) and many authors underlined usefulness of this index for practical implementation, especially, for risk stratification purposes [2]. Particularly, LIMP has been shown to be a useful, sensitive, and reproducible indicator for myocardial dysfunction in many clinical settings in distinguishing patients with a poor in-hospital outcome, and its value as an independent predictor of cardiac events during hospitalization [3-5]. Also, it has been demonstrated that LIMP predicts LV remodeling [6] and improvement of LIMP closely reflects intrinsic improvement of cardiac function [7]. Further, in late phase of AMI the index has shown prognostic value regarding death, heart failure, and new cardiac events [8,9].

Recent studies showed that in patients with Left Ventricular (LV) inferior STEMI, involvement of Right Ventricle (RV) in AMI can significantly change the clinical course, which is associated with development of RV dysfunction and acute cardiac arrhythmias and blocks. Mehta showed in a meta-analysis that patients with RV involvement in inferior AMI were at increased risk of adverse events and demonstrated that RV involvement is not due to more

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extensive infarction of the LV [10]. In post-AMI patients with LV dysfunction, Zornoff and Anavekar confirmed that RV function is weakly correlated with LV function and demonstrated that RV function quantified with RV Fractional Area Change (FAC) was independently associated with an increased risk of mortality and heart failure [11].

Since LV inferior STEMI is a unique pathology with possible involvement of RV in AMI leading to RV dysfunction and worsen clinical outcomes, it would be reasonable to assess function of not only LV, but also RV in such patients.

The purpose of the current study was to test prognostic importance of a combination of LIMP (as a measurement of LV dysfunction) and RIMP (as a measurement of RV dysfunction) in comparison with LIMP or RIMP used individually in patients with primary LV inferior STEMI. As a specific objective, this study evaluates the ability of LIMP, RIMP and the sum of LIMP and RIMP to independently predict early (hospital) and late (1-year) cardiac morbidity and mortality in patients with LV inferior STEMI.

Materials and Methods

This study was approved by the local Ethics Committee of Yerevan State Medical University and all subjects were fully informed about the study and provided an informed consent to voluntary participate in the study.

Study Sample

236 patients with primary LV inferior STEMI who underwent Doppler Myocardial Imaging (DMI) at the Department of Urgent Cardiology of Erebouni Medical Centre, Yerevan in 1998-2011 were considered for study recruitment and 221 met eligibility criteria. The reasons for non-inclusion were the following diseases and conditions detected by history or typical symptoms that could bias the study findings - permanent or persistent atrial fibrillation; congenital heart diseases; significant rheumatic aortal and/or mitral stenoses; permanent pacemaker; strokes; diseases with severe pulmonary hypertension; chronic kidney diseases; blood diseases and anemia and other metabolic and oncological diseases.

Of the 221 study patients, 189 (85.5%) were male and 32 (14.5%) were female. Age range was 38 to 72 years (mean 58.2±4.5 years). A careful medical history for each of 221 enrolled patients was thoroughly assessed and a complete physical and standard instrumental and lab examination was performed on all the study subjects.

With regard to the diagnosis of LV inferior STEMI and treatment strategy, patients were treated according to the institutional AMI STEMI management algorithm based on the current evidence-based treatment guidelines [12,13]. 34 (15.4%) study subjects underwent primary Percutaneous Coronary Intervention (PCI) and the remaining 187 (84.6 %) received conservative treatment including 15 who received thrombolytic treatment.

Based on LIMP, RIMP and [LIMP+ RIMP] values, all 221 patients were categorized into the following groups:

- LIMP ≥ 0.55 (n= 18) vs. LIMP<0.55 (n=103);
- RIMP ≥ 0.45 (n =106) vs. RIMP<0.45 (n=115); and
- [LIMP+RIMP]≥1.00 (n = 106) vs. [LIMP+RIMP]<1.00 (n=115).

There were no statistically significant differences in the demographic characteristics and the preexisting morbidity among the study participants in the different study groups (assessed variables were age, Arterial Hypertension (AH), Diabetes Mellitus (DM), and Chronic Obstructive Pulmonary Disease (COPD)). Table 1 summarizes the baseline clinical characteristics of the study sample by defined groups.

Follow-up and Endpoints

For the inpatient period, the following research outcomes were thoroughly documented: cardiac death and any case of below listed Acute Cardiac Complications (ACCs): Ventricular Extrasystoly ≥ Lown III^{O} (VE); sino-atrial or atrio-ventricular Heart Block of II-III^{O} (HB); Supraventricular Tachyarrhythmia (SVT); and Cardiogenic Shock (CS). Patients were followed up for a median of 12 months for any occurrence of cardiac mortality and/or re-hospitalization due cardiac events. No patients were lost to 12-month follow-up.

Calculation of LIMP and RIMP by Pulsed Doppler Echocardiography

All DMI examinations and LIMP and RIMP calculations were performed with an ultrasound machine "Siemens G65" (Germany)

Table 1: Baseline Characteristics of the Study Population.

Baseline characteristics	The whole study population	LIMP				RIMP (or [LIMP+ RIMP])			
		≥0.55	<0.55	x^2	*p*-value	≥0.45	<0.45	x^2	*p*-value
Subjects, n (%)	221 (100)	118 (53.4)	103 (46.6)	-	-	106 (48.0)	115 (52.0)	-	-
Males, n (%)	189 (85.5)	100 (84.7)	89 (86.4)	0.12	0.73 (NS)	94 (88.7)	95 (82.6)	1.64	0.20 (NS)
Age, mean±SD	58.4±5.5	58.1±4.7	57.8±4.9	0.88	0.93 (NS)	58.7±4.7	58.9±5.6	0.88	0.93 (NS)
AH, n (%)	93 (42.1)	49 (41.5)	44 (42.7)	0.09	0.76 (NS)	45 (42.4)	48 (41.7)	0.02	0.89 (NS)
DM, n (%)	47 (21.3)	26 (22.0)	21 (20.4)	0.03	0.86 (NS)	22 (20.7)	25 (21.7)	0.01	0.91(NS)
COPD, n (%)	86 (38.9)	46 (39.0)	40 (38.8)	0.00	0.98 (NS)	41 (38.7)	45 (39.1)	0.00	0.94 (NS)
Primary PCI, n (%)	34 (15.4)	19 (16.1)	15 (14.5)	0.10	0.75 (NS)	16 (15.1)	18 (15.6)	0.01	0.91 (NS)
TT, n (%)	15 (6.8)	9 (7.6)	6 (5.8)	0.28	0.59 (NS)	7 (6.6)	8 (6.9)	0.29	0.59 (NS)

Abbreviations: LIMP – Left Index of Myocardial Performance; RIMP – Right Index of Myocardial Performance; x^2 – chi-square statistics; SD – Standard Deviation; NS – Non Sense (not significant difference); AH – Arterial Hypertension; DM – Diabetes Mellitus; COPD -Chronic Obstructive Pulmonary; PCI – Percutaneous Coronary Intervention; TT – Thrombolytic Treatment

Table 2: Comparative Analysis of LIMP Means or Medians.

Cardiac events	Event existence (+) LIMP mean±SD or median	Event absence (-) LIMP mean±SD or median	Difference	*p*-value
Hospital death (n_+=23, n_-=198)*	0.58**	0.51**	0.07	NS
VE (n_+=51, n_-=170)	0.55±0.16	0.50±0.18	0.05	NS
HB (n_+=53, n_-=168)	0.59±0.17	0.55±0.16	0.04	NS
SVT (n_+=25, n_-=196)	0.59**	0.56**	0.03	NS
CS (n_+=17, n_-=204)	0.64**	0.41**	0.23	p<0.05
1-year death (n_+=44, n_-=154)	0.68±0.15	0.41±0.13	0.27	p<0.05
1-year re-hospitalization (n_+=57, n_-=141)	0.69±0.14	0.40±0.12	0.29	p<0.05

Notes: *n_+ is the number of cases with and n_- – without a given parameter; **medians rather than means are presented (n_+<30)

Abbreviations: LIMP – Left Index of Myocardial Performance; SD – Standard Deviation; NS – Non Sense (not significant difference); VE – Ventricular Extrasystoly Lown III^O and more; HB – sino-atrial or atrio-ventricular Heart Blocks II-III^O; SVT – Supraventricular Tachyarrhythmia; CS – Cardiogenic Shock

Table 3: Comparative Analysis of RIMP Means or Medians.

Cardiac events	Event existence (+) RIMP mean±SD or median	Event absence (-) RIMP mean±SD or median	Difference	p-value
Hospital death (n_+=23, n_-=198)*	0.53**	0.41**	0.12	p<0.05
VE (n_+=51, n_-=170)	0.54±0.16	0.41±0.18	0.13	p<0.05
HB (n_+=53, n_-=168)	0.57±0.17	0.42±0.15	0.15	p<0.05
SVT (n_+=25, n_-=196)	0.55**	0.40**	0.15	p<0.05
CS (n_+=17, n_-=204)	0.54**	0.42**	0.22	p<0.05
1-year death (n_+=44, n_-=154)	0.49±0.23	0.42±0.19	0.07	NS
1-year re-hospitalization (n_+=57, n_-=141)	0.60±0.13	0.36±0.11	0.24	p<0.05

Notes: *n_+ is the number of cases with and n_- – without a given parameter; **medians rather than means are presented (n_+<30)

Abbreviations: RIMP – Right Index of Myocardial Performance; SD – Standard Deviation; NS – Non Sense (not significant difference); VE – Ventricular Extrasystoly Lown III^O and more; HB – sino-atrial or atrio-ventricular Heart Blocks II-III^O; SVT – Supraventricular Tachyarrhythmia; CS – Cardiogenic Shock

within 24 hours of LV inferior STEMI onset. DMI methodology of was based on the American Society of Echocardiography's Guidelines [14,15].

LIMP was measured based on Doppler time intervals. It was calculated as the sum of the isovolumic contraction time and isovolumic relaxation time divided by the ejection time of LV. The sum of isovolumic construction and relaxation times was determined by measuring the time from the end of atrial filling (end of A-wave) to the onset of atrial filling (onset of E-wave) minus ejection time. Ejection time was determined by measuring the LV-outflow velocity with the Pulsed Doppler in the 5-chamber apical view just below the aortic valve [16].

As for the RIMP, ejection time was measured with pulsed Doppler of RV outflow (time from the onset to the cessation of flow), and the tricuspid (valve) closure-opening time was measured with the pulsed Doppler of the tricuspid inflow (time from the end of the transtricuspid A wave to the beginning of the transtricuspid E wave). These measurements were taken from different images by using beats with similar R-R intervals to obtain a more accurate RIMP value. RIMP was calculated as the difference of tricuspid closure-opening and ejection times divided by ejection time [15]. The combined MPI of both ventricles (noted as [LIMP + RIMP]) was calculated as a simple sum of LIMP and RIMP.

An experienced physician did both the DMI examinations and the reading of the images, unaware of the clinical data of the subjects.

Statistical Methods

Statistical analyses were performed with a statistical software program SPSS 17.0 (SPSS, Inc., Chicago, IL, USA). Descriptive data summaries are presented with means and Standard Deviations (SD) or numbers (percentages). Bivariate analyses for the categorical outcome variables were conducted between groups using the x^2 (chi-square) test. Logistic regression was used to determine whether a combination of LIMP and RIMP might be a better discriminator than each of those parameters alone in stratifying high-risk patients for hospital cardiac mortality, ACCs, 1-year cardiac mortality and 1-year re-hospitalization. Covariate information (age, gender and clinical data regarding AH, DM, and COPD) was collected at the time of the echocardiographic examination in all enrolled patients.

We conducted comparisons of means or medians (if n<30) to test between-group differences of study parameters. Adjusted to all above covariates Odds Ratios (OR_{adj}) were calculated by applying binominal logistic regression model to evaluate the individual predictive importance of research parameters – LIMP, RIMP and [LIMP + RIMP]. All statistical tests were two-sided, and tests with P-values of less than 0.05 were considered statistically significant. In the multivariate models, an independent variable was considered a significant predictor of the outcome variable (s) if the *p*-value was less than 0.05.

Results

The study results are presented separately for LIMP, RIMP and [LIMP + RIMP].

Left Index of Myocardial Performance

When comparing LIMP means between groups of those with and without clinical endpoints in hospital period, we found statistically significant difference only for CS (Table 2). The LIMP of 17 patients who had CS within the hospital treatment period was significantly greater than that of remaining 204 subjects who did not experience CS (median = 0.64 vs. median = 0.41, p<0.05).

Further, LIMP was significantly greater in 44 patients who died within 1 year post-infarction period or 57 patients who were re-hospitalized due cardiac events than that of 154 subjects who remained alive or 141 subjects who were not re-hospitalized for the same period of time (0.68 vs. 0.41, p<0.05 and 0.69 vs. 0.40, p<0.05, respectively).

In order to test predictive importance of LIMP≥0.55, we compared rates of clinical endpoints as well as calculated and compared ORs for that group with those with LIMP<0.55.

Table 4: Comparative Analysis of [LIMP+RIMP] Means or Medians.

Cardiac events	Event existence (+) [LIMP+RIMP] mean±SD or median	Event absence (-) [LIMP+RIMP] mean±SD or median	Difference	*p*-value
Hospital death (n_+=23, n_-=198)*	1.22**	0.88**	0.34	p<0.05
- VE (n_+=51, n_-=170)	1.14±0.16	0.89±0.18	0.25	p<0.05
- HB (n_+=53, n_-=168)	1.13±0.17	0.91±0.15	0.22	p<0.05
- SVT (n_+=25, n_-=196)	1.15**	0.85**	0.30	p<0.05
- CS (n_+=17, n_-=204)	1.14**	0.82**	0.32	p<0.05
1-year death (n_+=44, n_-=154)	1.21±0.22	0.82±0.19	0.39	p<0.05
1-year re-hospitalization (n_+=57, n_-=141)	1.18±0.24	0.81±0.20	0.37	p<0.05

Notes: *n_+ is the number of cases with and n_- – without a given parameter; **medians rather than means are presented (n_+ < 30)
Abbreviations: LIMP – Left Index of Myocardial Performance; NS – Non Sense (not significant difference); RIMP – Right Index of Myocardial Performance; SD – Standard Deviation; VE – Ventricular Extrasystoly Lown III^O and more; HB – sino-atrial or atrio-ventricular Heart Blocks II-III^O; SVT – Supraventricular Tachyarrhythmia; CS – Cardiogenic Shock

Table 5: Frequency Distributions and Chi-square Analyses of the Study Outcomes.

Cardiac events	The whole study population n (%)	LIMP			RIMP			[LIMP + RIMP]		
		≥0.55	<0.55	X^2	≥0.45	<0.45	X^2	≥1.00	<1.00	X^2
		n (%)	n (%)		n (%)	n (%)		n (%)	n (%)	
Hospital cardiac death	23 (10.4)	14 (11.9)	9 (8.7)	0.58	19 (17.9)	4 (3.5)	12.35***	19 (17.9)	4 (3.5)	12.35***
VE	51 (23.0)	27 (22.9)	24 (23.9)	0.01	32 (30.2)	19 (16.5)	5.80*	33 (31.1)	18 (15.6)	7.45**
HB	53 (24.0)	27 (22.9)	26 (25.2)	0.17	34 (32.1)	19 (16.5)	7.32**	35 (33.0)	18 (15.6)	9.13***
SVT	25 (11.3)	14 (11.9)	11 (10.7)	0.33	17 (16.0)	8 (7.0)	4.53*	19 (17.9)	6 (5.2)	8.88**
CS	17 (7.7)	13 (11.0)	4 (3.9)	3.94*	14 (13.2)	3 (2.6)	8.72**	15 (14.1)	2 (1.7)	11.97***
1-year death	44 (19.9)	32 (30.8)	12 (12.8)	9.26***	23 (26.4)	21 (18.9)	1.59	33 (37.9)	11 (9.9)	22.16***
1-year re-hospitalization	57 (25.8)	41 (39.4)	16 (17.0)	12.09***	33 (37.9)	24 (21.6)	6.33*	38 (43.7)	19 (17.9)	16.78***

Abbreviations: LIMP – Left Index of Myocardial Performance; RIMP – Right Index of Myocardial Performance; X^2 – chi-square statistics; VE – Ventricular Extrasystoly Lown III^O and more; HB – sino-atrial or atrio-ventricular Heart Blocks II-III^O; SVT – Supraventricular Tachyarrhythmia; CS – Cardiogenic Shock
Note: Bolded figures indicate significant differences, * p<0.05, ** p<0.01, *** p<0.001

According to chi-square analysis, LIMP≥0.55 reflecting LV dysfunction was a significant predictor for CS occurred during the inpatient period (11.0% vs. 3.9%, p<0.05); cardiac mortality (30.8% vs. 12.8%, p<0.001); and re-hospitalization (39.4% vs. 17.0%, p<0.05) within 1 year after LV inferior STEMI (Table 5). However, LIMP≥0.55 did not predict hospital cardiac morbidity (11.9% vs. 8.7%, p<0.45) or other ACCs.

Multivariate risk analyses (Table 6) even after adjusting for traditional risk factors (age, gender, AH, DM, COPD) further indicated that patients with LIMP≥0.55 were at greater risk for CS (OR_{adj}=2.83, p<0.05). 1 year after LV inferior STEMI, LIMP≥0.55 predicted cardiac death (OR_{adj}=2.41, p<0.01) and re-hospitalization (OR_{adj}=2.32, p<0.01) as well.

Right Index of Myocardial Performance

Contrary to LIMP, means or medians of RIMP between groups of those with and without clinical endpoints were statistically different for all clinical end-points except for 1-year cardiac deaths (Table 3).

The RIMP of those 23 patients who died in hospital was significantly greater than that of 198 subjects who were discharged from the hospital (median = 0.53 vs. median = 0.41, p<0.05). As for ACCs during the inpatient stay, RIMP of those 51 patients who had VE was significantly greater than that of 170 study participants who did not experience VE (0.54 vs. 0.41, p<0.05). Similar results were obtained for other ACCs – HB (0.57 among 53 with HB vs. 0.42 among 168 without HB, p<0.05), SVT (median = 0.55 among 25 with SVT vs. median = 0.40 among 196 without SVT, p<0.05), and CS (median = 0.54 among 17 with CS vs. median = 0.42 among 204 without CS, p<0.05). For 1 year post-infarction period, RIMP was significantly greater for 57 subjects who were re-hospitalized due cardiac events than that of 141 subjects who were not re-hospitalized for the same period of time (0.60 vs. 0.36, p<0.05).

Again, in order to test predictive importance of RIMP, we compared rates of clinical endpoints and calculated and compared ORs for the groups of patients with RIMP≥0.45 with those with RIMP<0.45.

Chi-square analysis indicated that RIMP≥0.45 reflecting RV dysfunction was a significant predictor for hospital cardiac mortality (17.9% vs. 3.5%, p<0.001), all ACCs during hospital treatment (for VE – 30.2% vs. 16.5%, p<0.05, for HB – 32.1% vs. 16.5%, p<0.01, for SVT – 16.0% vs. 7.0%, p<0.05, and, for CS – 13.2% vs. 2.6%, p<0.01) and 1-year cardiac re-hospitalization (37.9% vs. 21.6%, p<0.05) (Table 5). However, RIMP≥0.45 did not predict 1-year cardiac morbidity (26.4% vs. 18.9%, p>0.21).

Table 6: Summary of Multivariate Risk Analyses.

Cardiac events	LIMP≥0.55		RIMP≥0.45		[LIMP+RIMP]≥1.00	
	OR_{adj} *(CI)*	*p*-value	OR_{adj} *(CI)*	*p*-value	OR_{adj} *(CI)*	*p*-value
Hospital cardiac death	1.36	NS	5.15 *99% (1.30-20.36)*	0.01	5.15 *99% (1.30-20.36)*	0.01
VE	0.61	NS	1.83 *95% (1.10-3.02)*	0.05	1.99 *95% (1.02-3.89)*	0.05
HB	0.57	NS	1.94 *95% (1.18-3.19)*	0.05	2.10 *99% (1.09-4.09)*	0.01
SVT	0.53	NS	2.30 *95% (1.04-5.12)*	0.05	3.43 *99% (1.08-10.9)*	0.01
CS	2.83 *95% (1.01-8.40)*	0.05	5.06 *99% (1.02-25.12)*	0.01	8.14 *99% (1.21-54.82)*	0.01
1-year cardiac death	2.41 *99% (1.09-5.32)*	0.01	1.40	NS	3.83 *99% (1.35-10.87)*	0.001
1-year cardiac re-hospitalization	2.32 *99% (1.19-4.50)*	0.01	1.75 *95% (1.12-2.74)*	0.05	2.55 *99.9% (1.15-5.65)*	0.001

Abbreviations: LIMP – Left Index of Myocardial Performance; OR_{adj} – Adjusted Odds Ratio; CI – Confidence Interval, VE – Ventricular Extrasystoly Lown III^{O} and more; HB – sino-atrial or atrio-ventricular Heart Blocks II-III^{O}; SVT – Supraventricular Tachyarrhythmia; CS –Cardiogenic Shock

Adjusted multivariate risk analyses (Table 6) further indicated that patients in the group of RIMP≥0.45 were at greater risk for hospital cardiac death (OR_{adj}=5.15, p<0.01) and all ACCs - VE (OR_{adj}=1.83, p<0.05), HB (OR_{adj}=1.94, p<0.05), STA (OR_{adj}=2.30, p<0.05), and CS (OR_{adj}=5.06, p<0.01). After 1 year of LV inferior STEMI, RIMP≥0.45 predicted re-hospitalization (OR_{adj}=1.75, p<0.05) as well.

Combined Left and Right Indices of Myocardial Performance

Means of [LIMP+RIMP] between groups of those with and without study endpoints were statistically different for all clinical end-points (Table 4).

The [LIMP+ RIMP] of those 23 patients who died during the hospital treatment course was significantly greater than that of 198 subjects who were discharged from the hospital (median = 1.22 vs. median = 0.88, p<0.05). When analyzing associations between [LIMP+RIMP] and ACCs, [LIMP+ RIMP] of those 51 patients who had VE was significantly greater than that of 170 subjects who did not experience VE (1.14 vs. 0.89, p<0.05). Significant between-group differences were observed for the remaining ACCs – HB (1.13 among 53 with HB vs. 0.91 among 168 without HB, p<0.05), SVT (median = 1.15 among 25 with SVT vs. median = 0.85 among 196 without SVT, p<0.05), and CS (median = 1.14 among 17 with CS vs. median = 0.82 among 204 without CS, p<0.05). For the 1-year post-AMI period [LIMP+RIMP] was significantly greater for those 44 subjects who died due to cardiac events than that of 154 subjects who did not for the same period of time (1.21 vs. 0.82, p<0.05) and those of 57 subjects who were re-hospitalized due to cardiac events than that of 141 subjects who did not for the same period of time (1.18 vs. 0.81, p<0.05).

Analogously with the two previous cases of MPIs, in order to test predictive importance of [LIMP+ RIMP]≥1.0, we compared rates of study endpoints and calculated and compared ORs for that group with those of [LIMP+ RIMP]<1.0.

Similar to results with RMPI≥0.45, chi-square analysis indicated that [LIMP+RIMP] reflecting dysfunction of both ventricles was a significant predictor for cardiac mortality (17.9% vs. 3.5%, p<0.001), all ACCs during hospital treatment (for VE – 31.1% vs. 15.6%, p<0.01, for HB – 33.0% vs. 15.6%, p<0.001, for SVT – 17.9% vs. 5.2%, p<0.01, and for CS – 14.1% vs. 1.7%, p<0.001). However, in contrast to RIMP, this new indicator showed significant association with both 1-year cardiac mortality (37.9% vs. 9.9%, p<0.001) and re-hospitalization (43.7% vs. 17.9%, p<0.001) (Table 5).

Adjusted multivariate risk analysis (Table 6) further indicated advantages of [LIMP+RIMP]≥1.00 as inheriting much greater risk. Patients with [LIMP+RIMP]≥1.00 were at greater risk for hospital cardiac death (OR_{adj}=5.15, P < 0.01) and most of ACCs - VE (OR_{adj}=1.99, p<0.05), HB (OR_{adj}=2.10, p<0.01), STA (OR_{adj}=3.43, p<0.01), and CS (OR_{adj}= 8.14, p<0.01). Moreover, [LIMP+RIMP] ≥1.00 predicted both cardiac mortality (OR_{adj}=3.83, p<0.001) and re-hospitalization (OR_{adj}=2.55, p<0.001) after 1 year of LV inferior STEMI.

Discussion

Based on the published literature, the established prognostic usefulness of MPI remains somewhat controversial. While there are some studies underlining the role of LIMP in identifying patients with higher cardiac mortality risk [17], other researchers suggest that in the acute phase of myocardial infarction, LIMP measured at admission cannot reliably predict which patients are at high risk for in-hospital cardiac events [18].

To date, some research was done to define reference ranges of LIMP for use in clinical practice. Ascione established that LIMP≥0.47 is useful in predicting which patients with first AMI are at high risk for hospital cardiac events (death, heart failure, arrhythmias, or post-AMI angina) [3]. Poulsen showed that the LIMP>0.45 in AMI patients is the strongest independent predictor of the development of congestive heart failure [19]. Further, Moller demonstrated that 1-year survival in first AMI patients with LIMP<0.63 was 89%, whereas in patients with LIMP≥0.63 it was 37% [20]. Finally, we showed that LIMP≥0.55 was associated with 1-year cardiac death and re-hospitalization in primary LV inferior STEMI as well [21].

Published research studies have demonstrated the clinical utility and value of RIMP along with Tricuspid Annular Plane Systolic Excursion (TAPSE) and RV FAC. As an estimator of the global RV function, RIMP was extensively researched for diseases and conditions accompanied with the pulmonary hypertension. To date however, a little is known on the usefulness of RIMP in patients with AMI [22, 23]. A review of over 23 studies with a total of > 1000 healthy individuals and control subjects demonstrated that RIMP>0.40 by pulsed Doppler indicates RV dysfunction [15].

In this prospective case-control study, we demonstrated that

Doppler measurements of both LV and RV functions are risk factors for mortality and morbidity. MPIs provided prognostic information beyond that of currently established or existing measurements of cardiac function and conventional risk factors. Above all, we demonstrated that RIMP determined within the first 24 hours of the inferior STEMI onset enables noninvasive prediction of subsequent complications and early cardiac mortality.

In addition, the study results indicate that predictive capacity of MPIs could be explained by the fact that LIMP reflects global LV function, RIMP - global RV function, and the sum of LIMP and RIMP - combined global functions of both ventricles.

Furthermore, the study outlines the usefulness of RIMP as a parameter for prediction of early hospital mortality and ACCs and the combined sum of LIMP and RIMP as a "universal risk factor" for both early and late cardiac morbidity and mortality.

We explored the relevant literature and found some evidence concerning prognostic importance of LIMP and little data on RIMP for patients with AMI. Few of our findings were related to LV inferior STEMI. However, we found no data that would compare predictive patterns of LIMP and RIMP, especially in patients with LV inferior STEMI. Moreover, there was no published evidence that could examine the MPI indicator that combines both LIMP and RIMP.

Study Limitations

The main limitation of the present study relates to the relatively small sample size of the patient population. This study also lacked measurements of other echocardiographic parameters of LV and RV function, which also may be useful predictors of adverse outcomes in LV inferior STEMI patients. Therefore, with the above-mentioned limitations, long-term follow-up and large-scale prospective studies are needed to further confirm the predictive value of the suggested combined parameter and support our findings.

Conclusion

The sum of LIMP and RIMP appears to be a clinically relevant measurement of both ventricles' global function and may prove to be a valuable tool in assessing the risk of both early and late cardiac morbidity and mortality. Thus, we suggest using the combined MPI of both ventricles of ≥ 1.0 for identifying high risk patients in hospital and 1-year post-infarction periods in patients with primary inferior STEMI.

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