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Original Research Article

PROGNOSTIC SIGNIFICANCE OF E/E′ RATIO IN RISK STRATIFICATION AND MORTALITY PREDICTION AMONG STEMI PATIENTS

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Abstract

Background: Despite its clinical utility, there is limited research comparing single-site and dual-annular approaches for refining risk stratification in STEMI. This study aimed to evaluate the association between E/e′ and in-hospital outcomes, focusing on its prognostic significance in acute STEMI management. **Materials and Methods:** This prospective observational study included 50 STEMI patients admitted to a coronary care unit. Clinical, laboratory, and echocardiographic data were collected within 24 h of admission. The E/e′ ratio was measured using tissue Doppler imaging, and the patients were categorized into groups based on E/e′ values (>14 and ≤14). Key clinical outcomes, including mortality and echocardiographic parameters, were analyzed. **Result:** Patients with E/e' >14 demonstrated significantly higher in-hospital mortality than those with E/e′ ≤14 (85.7% vs. 14.3%; p<0.001). Total leukocyte count (TLC) and peak E velocity (PEAKE) were significantly associated with mortality, with lower TLC (7008.43 ± 1135.38 cells/µL vs. 9063.63 ± 2623.76 cells/µL; p=0.048) and elevated PEAKE (68.73 ± 11.62 cm/s vs. 54.06 ± 18.49 cm/s; p=0.048) observed in the mortality group. While no significant differences were found in LV ejection fraction (LVEF) and LV dimensions, E/e′ >14 was identified as a superior predictor of mortality compared to conventional echocardiographic measures. **Conclusion:** This study highlights the prognostic significance of E/e′ in acute STEMI, with elevated values strongly associated with in-hospital mortality. Incorporating E/e′ into early risk stratification protocols can enhance decision-making and guide tailored therapies. Future research should focus on larger multicenter cohorts and serial echocardiographic assessments to validate these findings and explore the potential of dual-annular measurements in refining risk prediction.

INTRODUCTION

ST-segment elevation myocardial infarction (STEMI) continues to be a critical cardiovascular emergency, contributing significantly to global morbidity and mortality despite advancements in therapeutic strategies, such as primary percutaneous coronary intervention.[1] In India, cardiovascular diseases account for 27% of all deaths, with STEMI occurring a decade earlier in the Indian population than in its Western counterparts, further complicating its burden.[2,3] The acute phase of STEMI is often complicated by left ventricular dysfunction, leading to heart failure, cardiogenic shock, and arrhythmias, which are primary causes of in-hospital mortality.[4] Current estimates suggest a short-term mortality rate of 5-6% during hospitalization and up to 18% within the first year after STEMI.[5,6]

The left ventricular (LV) filling pressure is pivotal in predicting adverse outcomes following STEMI. Elevated LV filling pressures are associated with ventricular remodelling, progression to heart failure, and an increased mortality risk.[7-10] Although invasive hemodynamic monitoring remains the gold standard for measuring LV filling pressure, it poses procedural risks and is often less feasible in routine clinical settings. Echocardiographic assessment using the ratio of early mitral inflow velocity (E) to mitral annular early diastolic velocity (e′), known as E/e′, has emerged as a reliable non-invasive surrogate for estimating LV filling pressures and predicting prognosis in acute myocardial infarction.[11,12]

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Mitral annular e′ velocity, measured using tissue Doppler imaging (TDI), reflects myocardial relaxation and is less affected by preload variations than other parameters of diastolic function.[13] An elevated E/e′ ratio, particularly above 14, has been associated with poor outcomes, including increased mortality and heart failure following myocardial infarction.[14,15] Previous studies have predominantly focused on the lateral mitral annular e′-velocity for this ratio. However, incorporating the average septal and lateral annular e′ velocities may provide a more comprehensive assessment of diastolic function and improve prognostic accuracy. There is a limited body of research exploring advanced echocardiographic techniques for risk stratification in acute STEMI patients, particularly regarding the comparative effectiveness of single-site and dual-annular measurements. Therefore, this study aimed to evaluate the prognostic significance of E/e′ calculated using the average septal and lateral e′ velocities in predicting in-hospital mortality among patients with STEMI.

MATERIALS AND METHODS

Study Design Population and Duration: This prospective, observational, and cross-sectional study was conducted at the Coronary Care Unit of the Department of Cardiology, Government Medical College, Chennai, India. This study included consecutive patients diagnosed with ST-segment elevation myocardial infarction (STEMI) between January 2024 and March 2024. Fifty patients were enrolled based on the predefined inclusion and exclusion criteria.

Inclusion Criteria

- Adults aged ≥18 years.
- Diagnosis of STEMI based on electrocardiographic (ECG) criteria and clinical presentation.
- Admitted within 24 hours of symptom onset.

Exclusion Criteria

- Patients with significant valvular heart disease.
- Known cardiomyopathy or previous myocardial infarction.
- Hemodynamically unstable patients or those requiring urgent surgical intervention.
- Poor echocardiographic windows precluding Doppler assessment.

Study Procedure

Data Collection: Detailed demographic and clinical data, including medical history, cardiovascular examination findings, and laboratory parameters, were collected using structured pro forma. Patients were followed up from admission until hospital discharge to record in-hospital mortality.

Electrocardiogram: A 12-lead ECG was performed on admission using a Philips TC20 machine. ST-segment elevation was measured 0.08 seconds after the J point, with the following criteria used for STEMI diagnosis:

- ST-segment elevation >0.1 mV in all leads except V2-V3.
- In leads V2-V3: >0.2 mV for men aged ≥40 years, >0.25 mV for men aged <40 years, or >0.15 mV for women.

Echocardiographic Assessment: Echocardiography was performed within 24 h of admission using a Philips IE33 machine equipped with a 3.5-MHz phased-array transducer. The following parameters were measured.

- Left Ventricular Ejection Fraction (LVEF) was calculated using the biplane method of disks (modified Simpson's rule).
- Left Ventricular Dimensions: End-diastolic and end-systolic dimensions measured from parasternal long-axis views.
- Mitral Valve Inflow: Pulsed-wave Doppler was used to measure the peak E- and A-wave velocities and deceleration time (DT) from the apical four-chamber view.
- Tissue Doppler Imaging (TDI): Mitral annular velocities (e′ and a′) were obtained from the lateral and septal annuli. The average of the two values was used in the analysis.
- E/e′ Ratio: Calculated as the ratio of mitral E-wave velocity to average e′ velocity.

Echocardiographic assessments were performed by a single experienced operator to minimize interobserver variability.

Endpoint: The primary endpoint was in-hospital mortality during the first week of admission, which was defined as death from any cause.

Statistical Analysis: Data were analyzed using STATA version 14. Continuous variables are expressed as mean ± standard deviation (SD) and were compared using an independent t-test. Categorical variables were expressed as proportions (%) and analyzed using the chi-square test. Mortality and echocardiographic parameters were analyzed using independent t-tests or Wilcoxon rank-sum test. Statistical significance was set at $p < 0.05$.

Ethical Considerations: This study was conducted in accordance with the principles of the Declaration of Helsinki. Ethical approval was obtained from the Institutional Ethics Committee. Written informed consent was obtained from all participants prior to enrollment.

RESULTS

The association between clinical characteristics and E/e′ ratio is shown in [Table 1]. Among the clinical characteristics, mechanical ventilation and mortality were significantly associated with an E/e′ >14. Mechanical ventilation was more prevalent in patients with E/e′ >14 (33.3%, p=0.030), and mortality was significantly higher in this group (85.7%, p<0.001). Other variables, including age, sex, smoking, alcohol use, and dyslipidemia, did not show statistically significant differences between the groups.

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The association between echocardiographic characteristics and the E/e′ ratio is shown in [Table 2]. Among the echocardiographic parameters, peak E velocity (PEAKE) was significantly higher in patients with E/e′ >14 compared to those with E/e′ ≤14 (71.69 ± 9.41 cm/s vs. 53.99 ± 18.28 cm/s; p=0.025). No significant differences were observed for other parameters, including haemoglobin levels, LV dimensions, or LVEF.

In the mortality analysis, total leukocyte count (TLC) and peak E velocity (PEAKE) were significantly associated with mortality group. TLC was lower in the mortality group than in the survivors (7008.43 ± 1135.38 cells/μL vs. 9063.63 ± 2623.76 cells/μL; p=0.048). Similarly, PEAKE was elevated in the mortality group (68.73 ± 11.62 cm/s vs. 54.06 ± 18.49 cm/s; p=0.048). Other variables, including haemoglobin, creatinine, and LVEF, showed no significant differences [Table 3].

Table 1: Association of Clinical Characteristics with E/e′ ratio (N=50).

Variable	N	E/e′ >14 (n=6) n (%)	E/e′ ≤14 (n=44) n (%)	p-value
Age				
<50	14 (100.0%)	0 (0.0%)	14 (100.0%)	0.103
>50	36 (100.0%)	6 (16.7%)	30 (83.3%)	
Sex				
Female	15 (100.0%)	2 (13.3%)	13 (86.7%)	0.849
Male	35 (100.0%)	4 (11.4%)	31 (88.6%)	
Smoking	20 (100.0%)	2 (10.0%)	18 (90.0%)	0.722
Alcohol use	21 (100.0%)	4 (19.1%)	17 (80.9%)	0.192
Dyslipidemia	17 (100.0%)	3 (17.7%)	14 (82.4%)	0.378
Diabetes	9 (100.0%)	1 (11.1%)	8 (88.9%)	0.878
Hypertension	16 (100.0%)	3 (18.8%)	13 (81.3%)	
Previous MI	1 (100.0%)	0 (0.0%)	1 (100.0%)	0.709
Thrombolysis	48 (100.0%)	6 (12.5%)	42 (87.5%)	0.594
PCI	5 (100.0%)	0 (0.0%)	5 (100.0%)	0.384
Mechanical Ventilation	9 (100.0%)	3 (33.3%)	6 (66.7%)	0.030
Death	7 (100.0%)	6 (85.7%)	1 (14.3%)	<0.001

Table 2: Association of lab and echocardiographic characteristics with E/e′ (N=50)

Variable	E/e′ >14 (Mean ± SD)	E/e′ ≤14 (Mean ± SD)	Mean Difference	t-value	p-value
HB (g/dL)	11.6 ± 1.82	12.62 ± 2.54	-1.02	-0.95	0.348
TLC (cells/μL)	6990.83 ± 1242.7	9019.32 ± 2609.68	-2028.49	-1.86	0.069
PLT (x10^9/L)	228 ± 50.79	254.02 ± 89.82	-26.02	-0.69	0.493
UREA (mg/dL)	30.33 ± 8.04	29.89 ± 11.30	0.45	0.09	0.926
CREAT (mg/dL)	1 ± 0.13	1.33 ± 0.55	-0.33	-1.45	0.153
TCHO (mg/dL)	204.5 ± 22.47	198.32 ± 38.94	6.18	0.38	0.707
HDL (mg/dL)	35.33 ± 7.84	42.48 ± 12.87	-7.14	-1.32	0.193
TGL (mg/dL)	170.83 ± 32.93	167.82 ± 49.72	3.02	0.14	0.886
KC (mEq/L)	1.83 ± 0.98	1.45 ± 0.76	0.38	1.11	0.274
WP (mmHg)	5 ± 2.0	5.18 ± 2.11	-0.18	-0.20	0.843
LVEDD (mm)	49.49 ± 2.32	48.78 ± 9.09	0.70	0.19	0.852
LVESD (mm)	37.7 ± 4.09	37.87 ± 8.84	-0.17	-0.05	0.963
LVEF (%)	39.5 ± 6.12	39.66 ± 10.30	-0.16	-0.04	0.971
LVFS (%)	18.5 ± 4.44	21.81 ± 7.61	-3.31	-1.03	0.306
PEAKE (cm/s)	71.69 ± 9.41	53.99 ± 18.28	17.70	2.32	0.025
PEAKA (cm/s)	44.93 ± 17.27	58.52 ± 18.13	-13.59	-1.73	0.090

Table 3: Association of lab and echocardiographic findings in mortality and survivor groups (N=50)

Variable	Mortality (Mean ± SD)	Survivors (Mean ± SD)	Mean Difference	p-value
HB (g/dL)	11.94 ± 1.89	12.59 ± 2.56	-0.65	0.526
TLC (cells/μL)	7008.43 ± 1135.38	9063.63 ± 2623.76	-2055.20	0.048
PLT (x10^9/L)	234 ± 49.00	253.65 ± 90.84	-19.65	0.581
UREA (mg/dL)	28.29 ± 9.12	30.21 ± 11.22	-1.92	0.669
CREAT (mg/dL)	0.99 ± 0.12	1.34 ± 0.55	-0.35	0.100
TCHO (mg/dL)	205 ± 20.56	198.09 ± 39.37	6.91	0.654
HDL (mg/dL)	35.29 ± 7.16	42.65 ± 12.96	-7.37	0.151
TGL (mg/dL)	169.71 ± 30.20	167.93 ± 50.30	1.78	0.928
KC (mEq/L)	1.86 ± 0.90	1.44 ± 0.77	0.42	0.200
WP (mmHg)	5.14 ± 1.86	5.16 ± 2.13	-0.02	0.982
LVEDD (mm)	51.30 ± 5.25	48.47 ± 8.95	2.83	0.422
LVESD (mm)	39.36 ± 5.76	37.61 ± 8.76	1.75	0.613
LVEF (%)	39.57 ± 5.59	39.65 ± 10.42	-0.08	0.984
LVFS (%)	18.53 ± 4.05	21.88 ± 7.69	-3.35	0.268
PEAKE (cm/s)	68.73 ± 11.62	54.06 ± 18.49	14.68	0.048
PEAKA (cm/s)	47.94 ± 17.67	58.34 ± 18.30	-10.41	0.168

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DISCUSSION

This study evaluated the clinical and echocardiographic characteristics associated with the E/e′ ratio and its prognostic utility in patients with STEMI, focusing on in-hospital mortality and left ventricular diastolic function. Mechanical ventilation and mortality were significantly associated with E/e′ >14. Patients with E/e′ >14 had higher rates of mechanical ventilation use (33.3%, p=0.030) and significantly higher mortality (85.7%, p<0.001). These findings align with those of previous studies that highlighted elevated E/e′ as a marker of adverse outcomes, including mortality and heart failure.[10,12] Echocardiographically, peak E velocity was significantly higher in patients with E/e′ >14 (71.69 ± 9.41 cm/s vs. 53.99 ± 18.28 cm/s; p=0.025), consistent with prior evidence suggesting its role in reflecting elevated left ventricular filling pressures.[7,8] However, other echocardiographic parameters, including LVEF and LV dimensions, were not significantly different, emphasizing the specificity of E/e′ in the diastolic function assessment.

Mortality analysis in this study revealed that total leukocyte count (TLC) and peak E velocity (PEAKE) were significantly associated with higher in-hospital mortality among patients with STEMI. Patients in the mortality group demonstrated a lower mean TLC (7008.43 ± 1135.38 cells/μL) compared to survivors (9063.63 ± 2623.76 cells/μL; p=0.048). This reduced leukocyte count could reflect a systemic response to inflammation or stress, which are factors often implicated in adverse cardiac outcomes. Elevated PEAKE values were also observed in the mortality group (68.73 ± 11.62 cm/s vs. 54.06 ± 18.49 cm/s; p=0.048), indicating increased left ventricular filling pressures. The heightened peak E velocity may signify diastolic dysfunction and impaired relaxation of the left ventricle, which are known contributors to a poor prognosis in myocardial infarction. These findings align with earlier studies that have consistently identified an elevated E/e′ ratio, driven by changes in parameters such as PEAKE, as a reliable marker of adverse outcomes and mortality in acute myocardial infarction.[10,12,13]

Importantly, while no significant differences in left ventricular ejection fraction (LVEF) or left ventricular (LV) dimensions were noted between survivors and non-survivors, the higher E/e′ ratio in the mortality group underscores its value as a specific indicator of elevated filling pressure and diastolic dysfunction. This specificity makes E/e′ a superior prognostic tool compared to conventional measures, such as LVEF, which primarily reflects systolic function. The significance of PEAKE in predicting mortality is supported by its established role in evaluating left ventricular diastolic function. Increased peak E velocity has been shown to correlate with elevated left atrial pressure, a hallmark of advanced diastolic dysfunction, and heart failure. This relationship suggests that patients with elevated PEAKE and E/e′ >14 may experience greater hemodynamic instability and worse clinical outcomes during hospitalization. Thus, these parameters can guide the early identification of high-risk patients, prompting more aggressive monitoring and tailored therapeutic interventions.

Our study reinforces existing evidence that an elevated E/e′ ratio serves as an important indicator of elevated left ventricular filling pressures and is associated with adverse cardiac outcomes.[10,14,15] In particular, our findings highlight that an E/e′ >14 surpasses conventional echocardiographic measures in its ability to predict mortality, emphasizing its potential utility in risk stratification for patients with STEMI. This underscores the role of E/e′ as a reliable marker for identifying high-risk patients who may benefit from targeted therapeutic interventions. However, the E/e′ ratio is not without limitations; its poor sensitivity for intermediate values,[8–14] necessitates careful interpretation in conjunction with clinical findings and other echocardiographic parameters to ensure accurate risk assessment.[16] Incorporating E/e′ into early management protocols for STEMI patients could enhance risk prediction models, enabling clinicians to implement tailored therapies aimed at reducing cardiac filling pressures and improving patient outcomes.

The strengths of this study include its focus on E/e′ as a prognostic marker in STEMI and the detailed analysis of clinical and echocardiographic parameters. However, the small sample size and single-centre design limited the generalizability of the results. Additionally, only a single echocardiographic evaluation within 24 h of admission was performed, which may not capture dynamic changes in E/e′ during hospitalization. Future studies with larger cohorts and serial echocardiographic assessments are required to validate these findings.

CONCLUSION

This study highlights the prognostic value of the E/e′ ratio in predicting in-hospital mortality among patients with STEMI. E/e′ >14 was associated with higher mortality, emphasizing its utility in risk stratification and potential integration in clinical decision-making. Early identification and intervention targeting elevated E/e′ may improve the outcomes in this high-risk population. Further research is warranted to explore E/e′-guided therapeutic strategies for STEMI.

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