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Original Article

The long-term prognostic value of E/e' in patients with ST segment elevation myocardial infarction

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ABSTRACT

Objectives: This study aimed to evaluate the long-term prognostic value of E/e' ratio in patients with ST-segment elevation myocardial infarction (STEMI).
Methods: We retrospectively assessed 314 patients who underwent primary coronary interventions between January 2010 and December 2015. The included patients were classified into two groups according to the E/e' ratios: E/e'<15 (n = 245) and E/e'≥15 (n = 69). We investigated the incidence of major adverse cardiac events (MACEs) from the event to the final follow-up period of at least three years.
Results: A total of 55 cases of MACEs occurred during the follow-up. The E/e'≥15 group showed a significantly higher rate of MACEs than the E/e'<15 group (34.8% vs. 12.7%, p < 0.001). Among the MACE, the percentage of cardiac deaths (17.4% vs. 0.4%, p < 0.001) was higher in the E/e'≥15 group than in the E/e'<15 group. In the multivariable model, E/e'≥15 was demonstrated as the strongest prognostic factor for MACEs (hazard ratio [HR], 2.597; 95% confidence interval [CI], 1.294–5.211; p = 0.007) and cardiac death (HR, 27.537; 95% CI, 3.287–230.689; p = 0.002), while left ventricular ejection fraction (LVEF) was not. Neither the discrepancy of systolic nor diastolic function between initial and follow-up echocardiography affected the overall prevalence of MACEs. A disparity was observed between the two groups, with a significant increase in the rate of MACEs in the E/e'≥15 group (log-rank test, p < 0.001).
Conclusion: The baseline E/e'≥15 in patients with STEMI after successful reperfusion is the strongest predictor of poor long-term clinical outcomes among those analyzed.
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1. Introduction

Despite technical advances in the field of coronary intervention, the development of major adverse cardiac events (MACEs) after acute myocardial infarction (MI) remains a major cause of mortality and morbidity worldwide.[1,2] Effective risk stratification is crucial for high-risk patients to decide on early aggressive management, which may improve the overall clinical outcomes.[3] Prior studies have suggested various predictors of MACEs in patients with MI, including high-scoring systems (SYNTAX, TIMI, and GRACE), infarct size, and certain echocardiographic parameters.[1,4] MI induces direct damage and necrosis of the myocytes, leading to the impairment of cardiac function.[5] However, several data on patients with ST segment elevation MI (STEMI) alone exist, resulting from a high percentage of critical initial conditions.[2,6,7] Because of its heterogeneous pathophysiology, STEMI is considered as a differentiated disease entity compared with non-ST segment elevation MI (NSTEMI).[8,9] Furthermore, predicting clinical outcomes in STEMI applying left ventricular ejection fraction (LVEF) and left ventricular (LV) diastolic function still remains controversial.[1] The role of LV diastolic function, evaluated by the E/e' ratio, has emerged as an important predictor of outcome in patients with STEMI since LV diastolic dysfunction precedesLV systolic dysfunction after myocardial ischemia occurs.[10,11] Nevertheless, some problems with the E/e' ratio in the STEMI field remain. For example, there remains

Abbreviations: STEMI, ST-segment elevation myocardial infarction; MACEs, Major adverse cardiac events; LVEF, Left ventricular ejection fraction; NSTEMI, Non-ST segment elevation MI; PCI, Percutaneous coronary intervention; CVA, Cerebrovascular accident; BNP, Pro brain natriuretic peptide; LDL, Low-density lipoprotein; DES, Drug-eluting stent; LAD, Left anterior descending artery.

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a need for data with a longer follow-up period regarding the association with cardiac deaths and the clinical implications of follow-up echocardiographic parameters.[1,6,12] Hence, we aimed to investigate the clinical implications of the E/e' ratio with long-term MACEs in patients with ST-elevation myocardial infarction (STEMI).

2. Methods

2.1. Study population

A total of 314 consecutive patients presenting with STEMI who visited the emergent department at Haeundae Paik Hospital between January 2010 and December 2015 were analyzed in the study. The inclusion criteria were STEMI episode in which emergent percutaneous coronary intervention (PCI) was performed within 12 h from the symptom onset, and age ≥18 years. A total of 334 patients with STEMI were initially included in the study; however, twenty patients were excluded due to omission of initial echocardiographic data, intervention after 12 h of symptom onset, or uncertain diagnosis. STEMI was defined according to the guidelines of the American College of Cardiology and European Society of Cardiology guidelines.[13,14] The ethical review board of our institution approved this retrospective study and waived the requirement for informed consent requirement (IRB no. HPIRB 2020-07-014). This study was conducted in accordance with the principles of the Declaration of Helsinki.

2.2. Echocardiographic analysis

Initial echocardiography was performed within one week of the event using a Siemens ACUSON SC 2000 machine (Siemens Healthineers, Germany). We assessed the necessary echocardiographic parameters in accordance with the American Society of Echocardiography.[15,16] LV systolic dysfunction was defined as LVEF <40%. Mitral inflow velocity and deceleration time were acquired using a spectrum pulsed-wave Doppler with an apical 4-chamber view. Additionally, tissue Doppler was performed in an apical 4-chamber view to assess the mitral annulus motion by placing the sample volume on the anterior, posterior, septal, and lateral mitral annulus. E/e' was automatically calculated from the computer by dividing the early trans-mitral inflow velocity (E) by the septal mitral annular early diastolic velocity (e'). Color Doppler was obtained from the apical four, three, and two chambers for grading mitral valve regurgitation. We determined an E/e' ≥15 as abnormal according to the current guidelines.[15]

2.3. Clinical outcome and definitions

The primary endpoint was long-term MACE with a minimum follow-up of 3 years (mean, 64 months; median, 58 months). MACE was defined as a composite of cardiac death, non-fatal myocardial infarction (MI), repeat revascularization, and/or cerebrovascular accident (CVA). The secondary endpoint was incidence of cardiac death. Cardiac death was defined as death of cardiac origin unless apparent non-cardiac death was established.

2.4. Statistical analysis

Continuous variables are reported as mean ± standard deviation, and categorical variables are expressed as numbers and percentages. Differences between the two groups were analyzed using the χ^2 test or Student's *t*-test, as appropriate. A paired *t*-test was performed to compare the initial to the follow-up echocardiographic data. We used the Cox proportional hazards model with multivariate analysis to assess the clinical association between E/e' and MACE. A receiver operating characteristic (ROC) curve and the area under the curve were analyzed to verify the predictive ability of the variables for poor prognosis. The cumulative event-free survival curves were described using the Kaplan–Meier method, and the discrepancy between the curves was analyzed using the log-rank test. *p*-value was set at $p < 0.05$. The overall analysis was performed using Predictive Analytics Software (PASW) Statistics 22.0 for Windows (Statistical Package for the Social Sciences, SPSS Inc., Chicago, IL, USA).

3. Results

3.1. Baseline and procedural characteristics

A total of 314 STEMI patients who underwent primary PCI were included in the current study. The baseline characteristics and laboratory findings of the patients are summarized in Table 1. The overall mean age of the total population was 64.8 ± 11.9 years and majority of the patients were men (77.7%). Significant differences in age, sex, hypertension, and diabetes were observed, whereas no differences were found in the percentages of previous vascular events, smoking status, initial blood pressure, and use of antiplatelet agents. Interestingly, the E/e'≥15 group showed a significantly higher initial heart rate, higher percentages of Killip class ≥2, and LVEF <40%. Laboratory variables revealed significantly higher initial troponin I, serum creatinine levels, pro brain natriuretic peptide (BNP), and highly sensitive C-reactive protein levels, while hemoglobin, triglycerides, and low-density lipoprotein (LDL) levels were significantly lower. This cholesterol paradox might have resulted from the higher percentage of hypertensive patients who received serial medical examinations and monitoring.

The percentage of drug-eluting stent (DES) implantation in the culprit lesion was approximately 93.9%. The radial approach was significantly more common in the E/e'<15 group (93.5%) than in the E/e'≥15 group (82.6%). The left anterior descending artery was the most common culprit vessel in the abnormal E/e' group (59.4% vs. 39.5%), while the right coronary artery was the most common in the normal E/e' group. Among the total population, 63.4% had multivessel coronary diseases. The percentage of 3-vessel coronary disease, chronic total occlusion, thrombus aspiration, and the use of an intra-aortic balloon pump were significantly higher in the abnormal E/e' group than in the normal group.

3.2. Initial and follow-up echocardiographic parameters

Echocardiographic parameters of the study cohort are presented in Table 2(mean: 3 days; median: 3.56 days). The overall average E/e' ratio was 12.7 ± 7.0. Approximately 22% of the total population showed abnormal E/e' values. These patients had a significantly lower LVEF, more dilated left ventricular end dimensions, more elevated left ventricular mass, higher maximal tricuspid regurgitation velocity (TR Vmax), and shorter deceleration time. Furthermore, they were more likely to have mitral regurgitation that was over grade II. Among the total population, 34 patients (10.8%) had diastolic dysfunction higher than grade II.

We also collected follow-up echocardiographic data, which were recorded in approximately 75.5% of the included study cohort (mean: 24.85 months; median: 15.63 months). Among these patients, 32 (13.8%) showed deterioration of diastolic dysfunction grade, while 34 patients (14.7%) showed recovery. The overall LVEF deteriorations was observed in 28 patients (11.8%), and recovery was documented in 68 patients (28.7%). The average follow-up LVEF was 51.7 ± 9.8%, which showed a significant increase ($p < 0.001$) between the initial LVEF, whereas the E/e' ratio was 11.8 ± 5.4 without a significant decrease ($p = 0.134$).

Table 1
Baseline characteristics of the study population.

	Total (n = 314)	E/e'<15 (n = 245)	E/e'≥15 (n = 69)	*p* value
Age (years)	64.8 ± 11.9	62.6 ± 11.4	72.5 ± 10.6	<0.001
Men (n,%)	244 (77.7%)	204 (83.3%)	40 (58.0%)	<0.001
BMI (kg/m^2)	23.7 ± 3.4	23.8 ± 3.5	23.3 ± 2.9	0.295
Coronary disease risk factors (n, %)				
Hypertension	146 (46.5%)	105 (42.9%)	41 (59.4%)	0.02
Diabetes	76 (24.2%)	51 (20.8%)	25 (36.2%)	0.01
Current smoker	166 (52.9%)	133 (54.3%)	33 (47.8%)	0.41
Dyslipidemia	22 (7.0%)	18 (7.3%)	4 (5.8%)	0.79
Previous angina	19 (6.1%)	14 (5.7%)	5 (7.2%)	0.58
Previous MI	8 (2.5%)	7 (2.9%)	1 (1.4%)	1.0
Previous PTCA	14 (4.5%)	12 (4.9%)	2 (2.9%)	0.74
Previous CABG	0 (0%)	–	–	NS
Previous CVA	8 (2.5%)	6 (2.4%)	2 (2.9%)	0.69
Killip Class ≥ II (n, %)	138 (44.0%)	83 (33.9%)	55 (79.7%)	<0.001
SBP (mm Hg)	123.8 ± 34.8	124.7 ± 34.4	120.8 ± 36.1	0.41
DBP (mm Hg)	73.6 ± 18.9	74.1 ± 18.9	71.7 ± 18.9	0.35
HR (per min)	72 ± 20	70 ± 19	81 ± 24	<0.001
Medication on discharge (n,%)				
Aspirin	301 (95.9%)	240 (98.8%)	61 (100%)	1.00
Clopidogrel	264 (84.1%)	212 (87.2%)	52 (85.2%)	0.67
Ticagrelor	37 (11.8%)	29 (11.9%)	8 (13.1%)	0.83
ACEI/ARB	263 (83.8%)	217 (89.3%)	46 (75.4%)	0.01
Beta blocker	285 (90.8%)	231 (95.1%)	54 (88.5%)	0.08
Statins	298 (94.9%)	239 (98.4%)	59 (96.7%)	0.35
Laboratory findings				
Initial WBC (x10^6/L)	11411.9 ± 3795.2	11288.4 ± 3795.8	11850.6 ± 3788.2	0.28
Hemoglobin (g/dL)	14.2 ± 1.9	14.5 ± 1.7	13.0 ± 2.0	<0.001
Initial CK-MB (ng/ml)	20.4 ± 3.13	17.40 ± 3.39	31.3 ± 7.57	0.98
Initial Troponin I (ng/ml)	3.8 ± 0.92	2.5 ± 0.85	7.8 ± 2.90	0.04
Pro BNP (pg/ml)	2355.9 ± 1184.1	1867.5 ± 1495.9	4061.9 ± 992.0	<0.001
Hs-CRP (mg/dL)	0.74 ± 1.93	0.43 ± 1.01	1.89 ± 3.49	<0.001
Creatinine (mg/dl)	1.15 ± 0.54	1.10 ± 0.28	1.35 ± 1.02	0.04
Total cholesterol (mg/dL)	176.8 ± 40.6	181.0 ± 40.6	161.4 ± 37.2	<0.001
Triglyceride (mg/dL)	104.3 ± 85.5	110.9 ± 91.3	80.9 ± 55.1	0.001
LDL cholesterol (mg/dL)	111.7 ± 40.9	114.8 ± 41.7	100.8 ± 36.3	0.01
HDL cholesterol (mg/dL)	41.6 ± 10.9	41.8 ± 10.7	40.7 ± 11.6	0.44

ACEI: angiotensin converting enzyme inhibitor, ARB: angiotensin II receptor blocker, BNP: brain natriuretic peptide, CABG: coronary artery bypass graft, CK-MB: creatine kinase-muscle/brain, CVA; cerebrovascular accident, DBP: diastolic blood pressure, DM: diabetes mellitus, ESRD: end-stage renal disease, HDL: high density lipoprotein, HR: heart rate, hs-CRP: highly sensitive C-reactive protein, LDL: low density lipoprotein, MI; myocardial infarction, PTCA: percutaneous tranluminal coronary angioplasty, SBP: systolic blood pressure, WBC: white blood cell.

Table 2
Echocardiographic parameters of the population.

	Total (n = 314)	E/e'<15 (n = 245)	E/e'≥15 (n = 69)	*p* value
IVST (mm)	10.23 ± 1.83	10.29 ± 1.83	10.03 ± 1.82	0.302
PWT (mm)	9.72 ± 4.90	9.73 ± 5.49	9.67 ± 1.46	0.924
LVEDD (mm)	51.00 ± 5.40	49.98 ± 4.53	54.71 ± 6.57	<0.001
LVESD (mm)	37.31 ± 6.30	35.84 ± 4.97	42.59 ± 7.64	<0.001
LV mass (g)	194.28 ± 54.94	189.47 ± 48.43	211.6 ± 71.58	0.018
LVEF (%)	50.05 ± 9.25	52.07 ± 8.00	42.87 ± 9.84	<0.001
LVEF <40% (n, %)	32 (10.2%)	9 (3.7%)	23 (33.3%)	<0.001
LA size (mm)	38.13 ± 4.45	37.36 ± 3.95	40.90 ± 5.07	<0.001
E/e' ratio	12.70 ± 6.96	9.98 ± 2.16	22.37 ± 9.18	<0.001
Trans-mitral E velocity (m/s)	68.02 ± 21.52	62.65 ± 16.57	87.37 ± 25.88	<0.001
Trans-mitral A velocity (m/s)	77.76 ± 19.71	76.84 ± 16.73	81.66 ± 28.95	0.227
Deceleration Time (ms)	229.62 ± 50.15	236.16 ± 45.91	202.90 ± 57.79	<0.001
Septal e' velocity (m/s)	5.95 ± 1.94	6.43 ± 0.12	4.21 ± 0.17	<0.001
TR Vmax (m/s)	2.33 ± 0.35	2.26 ± 0.30	2.56 ± 0.43	<0.001
RWMA (n, %)	271 (86.3%)	207 (84.5%)	64 (92.8%)	0.111
MR grade ≥ II (n,%)	25 (8.0%)	7 (2.9%)	18 (26.5%)	<0.001

IVST: Inter-ventricular septal thickness, LA: left atrium, LV: left ventricle, LVEDD: left ventricular end-diastolic dimension, LVEF: left ventricular ejection fraction, LVESD: left ventricular end-systolic dimension, MR; mitral regurgitation, PWT: posterior wall thickness, RWMA: regional wall motion abnormality, TR Vmax: the maximal tricuspid regurgitation velocity.

3.3. Clinical outcomes according to E/e' (Table 3)

During the follow-up period, 55 MACEs (17.5%) occurred. The overall percentage of MACE was significantly higher in those with an abnormal E/e' ratio than in those with a normal E/e' ratio (34.8% vs. 12.7%, p < 0.001). Cardiac death was the only component of MACEs and was significantly higher in those with abnormal E/e' ratios than in those with normal E/e' ratios (17.4% vs. 0.4%, P < 0.001). Meanwhile, the other components of MACE (non-fatal MI, repeat revascularization, and CVA) were not significantly

Table 3
Clinical outcome stratified according to E/e'.

	E/e'<15 (n = 245)	E/e'≥15 (n = 69)	*p*-value
Total MACEs (n,%)	31 (12.7%)	24 (34.8%)	<0.001
Cardiac death	1 (0.4%)	12 (17.4%)	<0.001
Non-fatal MI	6 (2.4%)	4 (6.1%)	0.228
Repeat Revascularization	27 (11.0%)	10 (15.2%)	0.392
CVA	4 (1.6%)	2 (3.0%)	0.611
In-hospital death	1 (0.4%)	7 (10.1%)	<0.001
Non-cardiac death (n,%)	5 (2.0%)	3 (4.5%)	0.373

CVA: cerebrovascular accident, MACE: major adverse cardiac events, MI: myocardial infarction.
* MACE was defined as the composite of cardiac death, non-fatal MI, repeat revascularization, and/or CVA.

different between the two groups. Among the 13 events of cardiac death, eight cases occurred during the index hospitalization, of which seven cases involved patients with abnormal E/e' ratios.

3.4. Predictors of MACEs and cardiac death

On univariate analysis, age, diabetes, initial heart rate, Killip class ≥II, trans-mitral E velocity, septal e' velocity, serum creatinine, pro BNP, initial diastolic grade ≥II, TR Vmax, intervention approach site, E/e'≥15, and LVEF <40% were identified as independent risk factors for MACE. On multivariate Cox analysis, wherein the well-known risk factors and all the independent factors of the univariate model were adjusted, an E/e' ratio ≥15 was shown as a powerful predictive factor (hazard ratio [HR], 2.597; 95% confidence interval [CI], 1.297–5.211; p = 0.007). The other relevant prognostic factors were diabetes (HR, 2.271; 95% CI, 1.153–4.471; p = 0.018) and initial heart rate (HR, 1.018; 95% CI, 1.002–1.033; p = 0.028). Fig. 1 shows the survival curve for MACE constructed according to E/e' ratio and LVEF. Although LVEF and E/e' provide a distinct separation of the curve (log-rank chi-square = 9.283; p = 0.002), stratification by E/e' ratio revealed a more distinct separation (log-rank chi-square = 22.575, p < 0.001), suggesting a higher capability to predict MACE.

In addition, we evaluated individual predictors of cardiac death (Table 4). For cardiac death, an E/e' ratio≥15 (HR: 27.537; 95% CI: 3.287–230.689; p = 0.002) and initial heart rate (HR: 1.037; 95% CI: 1.009–1.066; p = 0.010) were the only significant predictors after adjusting for univariate predictors of outcome. An E/e' ratio ≥15 was identified as the strongest predictor of cardiac death, which was more predominant in cardiac death than in MACE.

3.5. Discriminative competence of E/e' ratio and LVEF for MACEs

The area under the curve (AUC) of E/e' ratio for long-term MACE (0.631, p = 0.002) was greater than that of other variables, including LVEF (0.559, p = 0.167) and diastolic dysfunction grade (0.610, p = 0.013). Especially for cardiac death, the AUC for E/e'ratio (0.862, p < 0.001) took a distinct priority over LVEF (0.647, p = 0.073) and Killip class (0.683, p = 0.026).

4. Discussion

The principal point of the current study was that an E/e' ratio ≥15 was the strongest variable predicting the long-term adverse cardiac outcomes in patients with STEMI after successful coronary intervention and showed superiority over LVEF and other confounding factors. Furthermore, the study revealed that the initial E/e' ratio was the only echocardiographic parameter that predicted poor prognosis after adjustment, whereas the disparities of the E/e' ratio or LVEF between the initial and follow-up echocardiography were not associated with long-term MACEs.

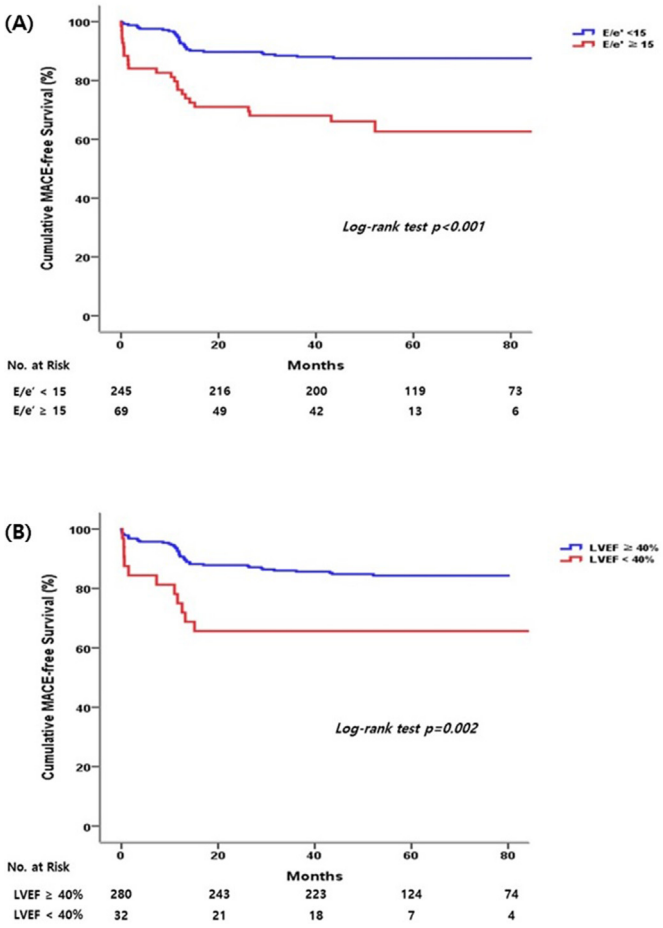

Fig. 1. Long term cumulative MACE-free survival curvesin patients with STEMI stratified according to E/e' (A) and LVEF (B)
All methods of stratification provide a distinct separation of the curve (log-rank chi-square = 9.283), classification by E/e' revealed more clear separation of curves (log-rank chi-square = 22.575) suggesting higher capability to predict MACEs.

Previous studies have emphasized the importance of diastolic function and compared it to the systolic function in acute MI patients, since diastolic parameters reflect multifactorial mechanisms that include both intrinsic and extrinsic factors which influence the overall heart function.[17,18] Diastolic dysfunction mainly occurs due to the impairment of myocardial relaxation and increased LV stiffness.[7] Several diastolic function parameters that were introduced and used for predicting the clinical outcome in acute MI include the LV filling pattern, deceleration time, LA volume index, Tei index, and E/e' ratio.[12,19,20] According to the latest recommendations, the E/e' ratio and mitral annular early diastolic velocity (e') using pulse-wave Doppler are strongly recommended for the assessment of LV diastolic dysfunction.[21] The early mitral inflow velocity increases while e' decreases under elevated LV filling pressure.[22] Therefore, the E/e' ratio is useful for diagnosing heart failure with preserved LVEF and objectively reflects pulmonary capillary wedge pressure.[23,24] Among the established prognostic factors, several studies have demonstrated the ascendancy of the E/e' ratio over other variables.[6,20,25] However, these studies were conducted in patients with acute MI, in which reperfusion therapy timing was different. To reduce such bias, we only included patients with STEMI who

Table 4
Prognostic predictors for long-term cardiac death.

	Hazard Ratio (95% confidence interval)			
	Univariate HR (95% CI)	*p*-value	Multivariate HR (95% CI)	*p*-value
Age	1.135 (1.065–1.211)	<0.001		
Sex (male)	3.197 (1.038–9.851)	0.043		
Hypertension	4.135 (1.116–15.330)	0.034		
Initial heart rate	1.053 (1.028–1.078)	<0.001	1.037 (1.009–1.066)	0.010
Killip Class ≥ II (%)	7.612 (1.658–34.947)	0.009		
E/e' ratio ≥ 15	54.222 (6.902–425.928)	<0.001	27.537 (3.287–230.689)	0.002
LA size	1.256 (1.099–1.435)	0.001		
LVEF < 40%	6.250 (1.910–20.448)	0.002		
LVEDD	1.131 (1.035–1.235)	0.006		
Pro BNP	1.632 (1.270–2.096)	<0.001		
LVESD	1.101 (1.021–1.188)	0.013		
Trans-mitral E velocity	1.055 (1.031–1.080)	<0.001		
Septal e' velocity	0.599 (0.405–0.884)	0.010		
MR grade ≥ II	4.182 (1.055–16.571)	0.042		
TR Vmax	16.422 (4.341–62.124)	<0.001		
Initial diastolic grade ≥ II (%)	5.889 (1.573–22.051)	0.008		
IABP	4.409 (1.369–14.194)	0.013		

BNP: brain natriuretic peptide, IABP: intra-aortic balloon pump, HR: hazard ratio, LA: left atrium, LVEDD: left ventricular end-diastolic dimension, LVEF: left ventricular ejection fraction, LVESD: left ventricular end-systolic dimension, MR: mitral regurgitation, TR Vmax: the maximal tricuspid regurgitation velocity.
* *Adjusted for sex, age, hypertension, diabetes mellitus, initial heart rate, LA size, LVEDD, LVESD, Killip Class ≥ II, E/e' ratio ≥ 15, pro BNP, TR Vmax, initial diastolic grade ≥ II, trans-mitral E velocity, septal e' velocity, LVEF< 40%, IABP, MR grade ≥* II.

underwent coronary intervention within 12 hours of hospital arrival.

According to Ommen et al, E/e' ratios <8 and ≥ 15 are definite cut-off values for normal and elevated LV diastolic filling pressure, respectively.[26] The present study followed the criteria described in previous literature and derived the results. Our study demonstrated significantly lower MACE-free survival rates in both E/e' ratio ≥15 and LVEF <40% during the follow-up period, whereas an E/e' ratio ≥15 was the only significant predictive factor for MACE on multivariate analysis. Moreover, we independently assessed the risk factors for cardiac death as one of the components of MACEs, while several studies have focused on all-cause mortality.[1,6,27] An abnormal E/e' ratio has been shown to be a powerful risk factor for all-cause death across studies. According to Iwahashi et al, an E/e' ratio ≥15 observed two weeks after a STEMI event was shown as the strongest predictive factor of cardiac death and a strong prognostic implication of an abnormal E/e' ratio compared to the LVEF, which is consistent with our study, emphasizing the role of E/e' ratio as a powerful prognostic factor for adverse outcomes.[19] Moreover, Moller et al reported that abnormal LV filling patterns are associated with LV dilatation and may predict the risk of cardiac death after the first episode of MI.[3] The difference between prior studies and the current study is that we identified that an E/e'ratio ≥15 was the more powerful factor in predicting cardiac death than total MACE.

Certain factors have previously been reported as predictors of adverse clinical outcomes after STEMI, which have been related to decreased LVEF, deterioration of LVEF, and left anterior descending artery (LAD) as the culprit vessel.[28,29] Hospitalization due to adverse cardiac events may be associated with such issues. However, although higher percentages of decreased LVEF and LAD involvement were observed in the abnormal E/e' ratio group, this result did not influence the overall MACEs. Furthermore, hospitalization due to cardiac problems was not included in the present study after adjusting for the previously mentioned variables. In the present study, the E/e' ratio did not significantly decrease on the follow-up echocardiography. In addition, Subramaniyan et al. showed no significant improvement in the E/e' ratio after PCI in patients with STEMI, which supported that PCI is not the only factor affecting the E/e' ratio.[28]

The current study has the strength of long follow-up. Compared to prior studies in which the follow-up period ranged from six months to two years, we only included patients with at least a three-year follow-up, which was the longest duration among previous studies.[1,6,25,28] Therefore, the results of our study may provide a powerful consensus that the role of the initial E/e' ratio as a predictor for MACE or cardiac death does not end in the short term but is maintained for a long time.

Our study had several limitations. First, because this was a single-center study, with a small number of participants. However, we included patients with a relatively strict criteria and an extended follow-up duration, which may have strengthened the reliability of the results. Second, this is a retrospective study. Third, the patients who were unable to undergo echocardiography due to extremely unstable conditions or sudden cardiac death were excluded and a quarter of total study patients lack the follow-up echocardiographic data. Since the study focused on echocardiographic parameters, initial echocardiographic data were mandatory for all included patients to avoid study bias. Finally, the LA volume index was not measured and was not included as an obligatory parameter at our center. To overcome this shortcoming, we supplemented the variables including TR Vmax, diastolic grade, and other factors. Further larger studies are necessary to support the long-term prognostic implications of the E/e'ratio for predicting adverse clinical outcomes, including cardiac death, in patients with STEMI.

5. Conclusion

An initial E/e' ratio ≥15 in patients with STEMI after successful reperfusion was the strongest predictor of adverse clinical outcomes, including cardiac death among the analyzed variables. The current data suggest that the diastolic dysfunction may play a crucial role in the risk stratification of patients with STEMI.

Declaration of competing interest

The author(s) declared no potential conflicts of interest.

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