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FREQUENCY AND SPECTRUM OF MECHANICAL COMPLICATIONS IN ACUTE STEMI

Original Research

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ABSTRACT

Background: Acute ST-elevation myocardial infarction (STEMI) remains a major global cause of morbidity and mortality. Despite advancements in reperfusion therapy, mechanical complications such as ventricular septal rupture, free wall rupture, and acute mitral regurgitation continue to contribute to adverse outcomes. Although rare, these complications are associated with high mortality rates, often due to hemodynamic instability and cardiogenic shock. Identifying patients at higher risk remains crucial for improving survival and optimizing treatment strategies.

Objective: To determine the incidence and spectrum of mechanical complications in patients with acute STEMI and evaluate their clinical predictors and outcomes in a tertiary care setting.

Method: This prospective, descriptive study was conducted from July to November 2024 at a tertiary care hospital in Islamabad. A total of 165 patients with confirmed acute STEMI were enrolled using a non-probability sequential sampling method. Clinical data, including demographics, comorbidities, Killip classification, and reperfusion status, were systematically documented. Transthoracic echocardiography was performed to identify mechanical complications. Laboratory parameters and procedural details were recorded. Statistical analyses were conducted using SPSS version 26, with categorical variables assessed using the Chi-square test and continuous variables analyzed using the Student's t-test. A p-value of <0.05 was considered statistically significant.

Results: The study cohort had a mean age of 62.4 ± 10.5 years, with 63.6% being male. Anterior STEMI was the most common presentation (51.5%), followed by inferior (36.4%) and posterior (12.1%) STEMI. Mechanical complications occurred in 5% of cases, with ventricular septal rupture, free wall rupture, and acute mitral regurgitation identified. Patients with complications exhibited significantly higher rates of renal impairment (66.7% vs. 12.8%, p=0.001), anemia (55.6% vs. 15.4%, p=0.007), and thrombocytopenia (33.3% vs. 2.6%, p=0.001). Advanced Killip class (Class IV) was strongly associated with mechanical complications (44.4% vs. 4.5%, p=0.001). The 30-day mortality rate among patients with complications was markedly higher (66.7%) compared to those without (6.4%), with cardiogenic shock being the leading cause of death (44.4%).

Conclusion: Although mechanical complications post-STEMI are uncommon, they significantly increase mortality. Risk factors such as renal impairment, anemia, and advanced Killip class strongly correlate with their occurrence. Early recognition, timely intervention, and optimized management strategies are imperative to reduce mortality and improve patient outcomes.

Keywords: Anemia, Cardiogenic shock, Echocardiography, Myocardial infarction, Renal impairment, STEMI, Ventricular septal rupture

INTRODUCTION

Acute myocardial infarction (AMI) remains a leading cause of global morbidity and mortality, with significant advancements in reperfusion therapy over the past three decades contributing to a substantial decline in fatality rates. However, despite these advancements, mechanical complications following ST-elevation myocardial infarction (STEMI) persist as critical determinants of adverse outcomes. Mechanical complications, including ventricular septal rupture, free wall rupture, and acute mitral regurgitation, though relatively rare, are associated with high mortality rates, necessitating prompt recognition and intervention (2). The reported global incidence of these complications stands at approximately 0.27%, while regional data from Pakistan indicate a prevalence of 1.32% based on a study conducted in Peshawar between 2012 and 2013 (3). Early reperfusion strategies have contributed to a notable reduction in incidence, with recent estimates suggesting a prevalence of less than 0.1% following AMI. However, this decline has not been accompanied by a proportional reduction in mortality, emphasizing the need for continued vigilance in identifying and managing these life-threatening events (4,5).

Several risk factors predispose individuals to post-STEMI mechanical complications, including advanced age, diabetes mellitus, hypertension, and female sex (5). Among these complications, ischemic mitral rupture leading to acute mitral regurgitation has been recognized for its severe clinical consequences, influencing both acute and chronic phases of the disease, with an occurrence rate as high as 64% in comprehensive investigations (4). Free wall rupture, observed in approximately 83% of cases, frequently presents with pericardial effusion, further complicating the clinical scenario (6). Left ventricular aneurysms develop in 30–35% of affected individuals, contributing to adverse remodeling and progressive cardiac dysfunction (7). Additionally, ventricular septal rupture, a devastating complication, has been documented in 54% of post-STEMI cases, further underscoring the urgency of timely intervention to mitigate morbidity and mortality (8).

Despite significant advancements in interventional cardiology, mechanical complications of STEMI continue to pose formidable challenges in contemporary clinical practice. Given their profound impact on patient prognosis, there is an urgent need for heightened clinical awareness, early recognition, and timely surgical or percutaneous interventions to improve survival outcomes. This study aims to determine the frequency and spectrum of mechanical complications in acute STEMI, providing insights into their prevalence and clinical burden. By enhancing awareness, optimizing resource allocation, and informing preventive strategies, the findings may contribute to improved regional protocols and patient management approaches, ultimately reducing the burden of these life-threatening complications.

METHODS

This descriptive, prospective study was conducted to determine the frequency and types of mechanical complications following ST-elevation myocardial infarction (STEMI). The study was carried out at a tertiary care hospital in Islamabad between July 2024 and November 2024. Patients admitted with a diagnosis of acute STEMI were enrolled based on predefined inclusion and exclusion criteria. The inclusion criteria comprised individuals aged between 18 and 80 years, of either gender, who were diagnosed with STEMI and received either reperfusion therapy or standard medical treatment in accordance with established guidelines. Patients with preexisting cardiac abnormalities, including rheumatic heart disease, acute stent thrombosis, advanced malignancies, end-stage renal disease, decompensated chronic liver disease, mitral valve prolapse, ventricular septal defect (VSD), and left ventricular aneurysm, were excluded from the study to ensure that mechanical complications were solely attributable to the index myocardial infarction.

A total sample size of 165 patients was calculated using the WHO sample size calculator, based on a confidence level of 95%, an assumed population proportion of 30%, and a 7% margin of error (2). Non-probability sequential sampling was employed for patient recruitment. Upon admission, demographic details, medical history, time since symptom onset, comorbidities, and treatment modalities, including the success of reperfusion therapy, were systematically documented on a structured proforma. The diagnosis of STEMI was established based on clinical presentation, electrocardiographic changes, and cardiac biomarkers. Cases involving new-onset left bundle branch block or posterior wall myocardial infarction were also included.

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All patients were closely monitored throughout hospitalization for any signs of hemodynamic instability, including chest pain, dyspnea, cardiogenic shock, or pulmonary edema. Transthoracic echocardiography was performed upon admission and was repeated in cases where mechanical complications were suspected. Patients who underwent coronary angiography or percutaneous coronary intervention (PCI) had their coronary lesions and interventional details meticulously recorded. Any additional treatment administered following the onset of mechanical complications was documented. Mechanical complications were categorized based on standardized diagnostic criteria. Ventricular septal rupture (VSR) was identified using two-dimensional (2D) echocardiography, with color flow mapping demonstrating a shunt across the interventricular septum. Moderate to severe mitral regurgitation (MR) was defined by the presence of a regurgitant jet extending into the left atrium and occupying more than 20% of the left atrial area, with cases involving flail mitral valve leaflets also included (9,10). Free wall rupture was diagnosed through 2D echocardiography upon detection of a new pericardial effusion associated with an anatomical discontinuity in the free wall of the left ventricle (3,11). The study was conducted in compliance with ethical principles and was approved by the Institutional Review Board (IRB) of the Pakistan Institute of Medical Sciences (PIMS). Written informed consent was obtained from all participants prior to enrollment. Data analysis was performed using SPSS software, version 26.0. Categorical variables, including gender, type of myocardial infarction, history of hypertension, diabetes, smoking, menopausal status, hypothyroidism, coronary lesion type, success of reperfusion therapy, and nature of arrhythmias, were presented as frequencies and percentages. Quantitative variables such as age, time since symptom onset, serum creatinine levels, glycated hemoglobin (HbA1c), days since admission, number of coronary lesions, systolic blood pressure, and Killip class were expressed as means with standard deviations. All variables were stratified to control for potential confounders. Comparisons between categorical variables were performed using the Chi-square test, whereas continuous variables were analyzed using the Student's t-test. A p-value of less than 0.05 was considered statistically significant for all analyses.

RESULTS

The study included 165 patients, with a mean age of 62.4 ± 10.5 years. Males constituted the majority of the cohort (63.6%), and the mean BMI was recorded at 28.3 ± 4.6 kg/m². Smoking was prevalent among 51.5% of participants, while hypertension and diabetes mellitus were present in 67.9% and 47.3% of patients, respectively. A history of coronary artery disease was documented in 30.3% of cases, and 21.2% had a prior myocardial infarction. Upon admission, clinical classification using the Killip system revealed that 54.5% of patients were in Class I, 30.3% in Class II, 9.1% in Class III, and 6.1% in Class IV. Anterior STEMI was the most frequently observed infarction type, affecting 51.5% of patients, followed by inferior STEMI in 36.4% and posterior STEMI in 12.1%.

Table I: Demographic and clinical characteristics of the study sample

Variable	n (%) or Mean ± SD
Age (years)	62.4 ± 10.5
Gender	
Male	105 (63.6%)
Female	60 (36.4%)
BMI (kg/m²)	28.3 ± 4.6
Smoking Status	
Current Smoker	85 (51.5%)
Non-Smoker	80 (48.5%)
Hypertension	112 (67.9%)
Diabetes Mellitus	78 (47.3%)
Family History of CAD	50 (30.3%)

Variable	n (%) or Mean ± SD
Previous MI	35 (21.2%)
Killip Class on Admission	
Class I	90 (54.5%)
Class II	50 (30.3%)
Class III	15 (9.1%)
Class IV	10 (6.1%)
Type of STEMI	
Anterior	85 (51.5%)
Inferior	60 (36.4%)
Posterior	20 (12.1%)

Mechanical complications were identified in 5% of the study population, with the remaining 95% not experiencing any such complications. A significant association was observed between mechanical complications and several clinical characteristics. Renal impairment was significantly higher among patients with complications (66.7%) compared to those without (12.8%, p=0.001). Anemia was also notably more frequent in patients with complications (55.6%) than those without (15.4%, p=0.007). Thrombocytopenia was detected in 33.3% of patients with complications, contrasting with 2.6% in those without (p=0.001). Advanced heart failure severity was more prevalent among patients with mechanical complications, with 44.4% classified as Killip Class IV, whereas only 4.5% of those without complications were in this category (p=0.001).

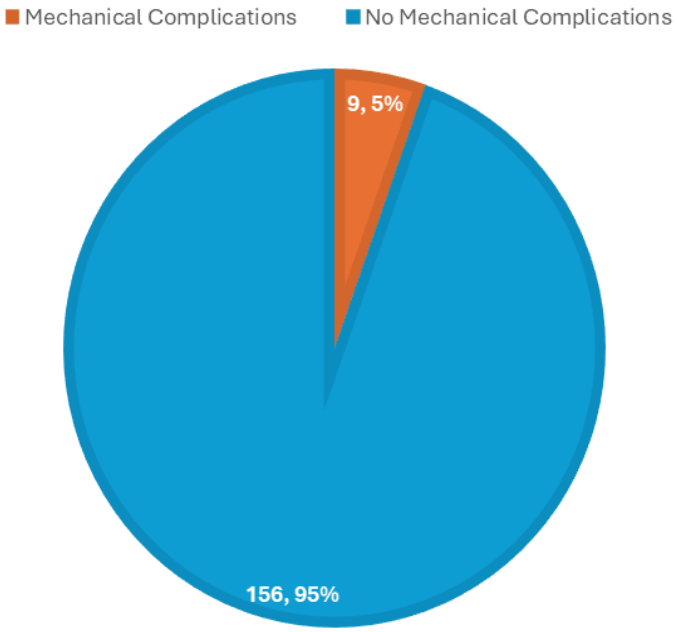

Figure-I: Incidence of Mechanical complications among the study sample

The 30-day mortality rate was significantly higher among patients with mechanical complications, reaching 66.7%, compared to 6.4% in those without complications. The leading cause of mortality in patients with mechanical complications was cardiogenic shock, accounting for 44.4% of deaths, followed by heart failure in 22.2%. Among patients without complications, mortality causes were distributed among cardiogenic shock (1.9%), heart failure (1.3%), arrhythmias (2.6%), and other causes (0.6%).

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Table II: Comparison of Clinical Characteristics Between Patients With and Without Mechanical Complications

Variables	With Mechanical Complications (n=9)	Without Mechanical Complications (n=156)	p-value
Atrial Fibrillation/Flutter	2 (22.2%)	8 (5.1%)	0.062
BMI (kg/m²)	26.8 ± 3.9	27.2 ± 4.3	0.575
History of Stroke	1 (11.1%)	6 (3.8%)	0.312
Chronic Obstructive Pulmonary Disease (COPD)	1 (11.1%)	5 (3.2%)	0.267
Smoking Status	4 (44.4%)	55 (35.3%)	0.628
Diabetes Mellitus	4 (44.4%)	38 (24.4%)	0.185
Hyperlipidemia	5 (55.6%)	68 (43.6%)	0.482
Hypertension	6 (66.7%)	85 (54.5%)	0.531
Peripheral Artery Disease	1 (11.1%)	5 (3.2%)	0.294
Previous Myocardial Infarction	2 (22.2%)	10 (6.4%)	0.095
Prior PCI	1 (11.1%)	15 (9.6%)	0.841
Previous CABG	1 (11.1%)	3 (1.9%)	0.180
Renal Impairment	6 (66.7%)	20 (12.8%)	0.001**
Left Ventricular Ejection Fraction (LVEF, %)	44.2 ± 12.5	46.3 ± 11.2	0.482
Anemia	5 (55.6%)	24 (15.4%)	0.007**
Thrombocytopenia	3 (33.3%)	4 (2.6%)	0.001**
Congestive Heart Failure			0.001**
Killip Class I	1 (11.1%)	105 (67.3%)	0.001**
Killip Class II	3 (33.3%)	40 (25.6%)	0.725
Killip Class III	1 (11.1%)	4 (2.6%)	0.178
Killip Class IV	4 (44.4%)	7 (4.5%)	0.001**

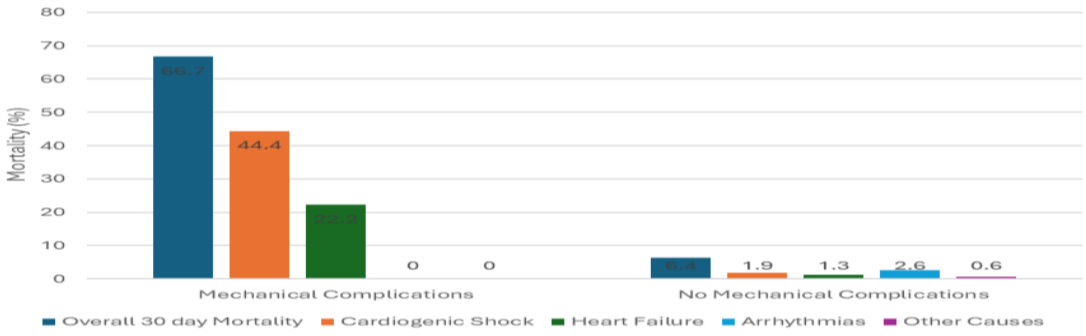

Figure-II: Comparison of 30-day Mortality among study sample

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DISCUSSION

The findings of this study indicate that mechanical complications following ST-elevation myocardial infarction (STEMI) occurred in 5% of cases, which aligns with the lower spectrum of previously reported rates, typically ranging between 1% and 10% (12,13,14). The relatively low incidence observed may be attributed to advancements in reperfusion strategies and contemporary medical management. However, mechanical complications remain a significant contributor to morbidity and mortality, particularly among patients who do not receive timely reperfusion therapy. Unlike prior studies focusing on patients presenting within 24 hours of symptom onset, this study encompassed a diverse cohort with varying time intervals to medical intervention, providing a broader perspective on risk factors and outcomes. The demographic characteristics of the study population were consistent with previous research, with a mean age of 62.4 years and a male predominance (63.6%). The elevated mean BMI (28.3 kg/m²) and high prevalence of smoking (51.5%), hypertension (67.9%), and diabetes mellitus (47.3%) highlight the well-established association between metabolic and cardiovascular risk factors and the development of acute myocardial infarction (15,16,17,18). These findings reaffirm that hypertension, diabetes, and smoking contribute significantly to endothelial dysfunction, atherosclerosis, and plaque rupture, ultimately increasing the risk of adverse cardiac events. Previous research has also suggested that female patients and those of advanced age are more vulnerable to mechanical complications post-STEMI, potentially due to smaller coronary artery dimensions and delays in seeking medical care (13,19). The observed sex-related differences in cardiovascular risk profiles, with males being more prone to obesity-related complications and females exhibiting higher multimorbidity rates associated with diabetes and hypertension, further support existing evidence on gender disparities in cardiac outcomes (15).

A notable finding of this study was the significantly higher 30-day mortality rate among patients with mechanical complications, reaching 66.7% compared to 6.4% in those without. Cardiogenic shock was the leading cause of death in the former group, accounting for 44.4% of cases. These findings are consistent with previous literature, which has demonstrated that mechanical complications, such as ventricular septal rupture and free wall rupture, dramatically increase mortality due to progressive hemodynamic deterioration (20). The strong correlation between higher Killip classes and adverse outcomes further reinforces the prognostic value of this classification system, as severe heart failure (Killip Class IV) has been consistently linked to an increased risk of death in STEMI patients (21,22,23). Despite advances in primary percutaneous coronary intervention (PCI) and pharmacological therapies, mechanical complications remain a challenge in STEMI management. The findings of this study underscore the necessity of prompt STEMI recognition and early intervention to minimize the likelihood of these complications. Public health initiatives aimed at increasing awareness of myocardial infarction symptoms and reducing pre-hospital delays may play a crucial role in improving outcomes (24). Furthermore, routine echocardiographic assessment in high-risk patients and early consideration of mechanical circulatory support in cases of hemodynamic instability could enhance survival rates. Recent investigations have emphasized the importance of optimizing STEMI care pathways to facilitate timely diagnosis and intervention, which remains a crucial aspect of improving long-term prognosis (25).

This study has several strengths, including its prospective design and comprehensive assessment of clinical and demographic factors influencing mechanical complications. However, certain limitations must be acknowledged. The single-center nature of the study may limit generalizability, and the relatively small sample size, particularly for the subgroup of patients with mechanical complications, may affect the statistical power of some associations. Additionally, the study did not incorporate long-term follow-up beyond 30 days, preventing an evaluation of late mortality and functional outcomes. Future research should focus on multicenter studies with larger cohorts to provide a more robust understanding of mechanical complications, their predictors, and the impact of emerging therapeutic strategies.

CONCLUSION

The findings of this study underscore the critical impact of mechanical complications in patients with ST-elevation myocardial infarction, emphasizing the urgent need for early identification and timely intervention to improve patient outcomes. The strong association of renal impairment, anemia, thrombocytopenia, and advanced heart failure severity with these complications highlights the importance of comprehensive risk assessment and close monitoring of high-risk individuals. Cardiogenic shock emerged as a predominant cause of mortality, reinforcing the necessity for proactive management strategies and optimized critical care pathways. Enhancing public awareness, ensuring prompt medical attention, and integrating advanced therapeutic approaches may play a pivotal role in reducing the burden of these life-threatening complications and improving survival rates in affected patients.

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Author Contribution

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Rao Tayaaba Noor	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Muhammad Shafique Arshad	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Muhammad Asif Nawaz	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Muhammad Tariq	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Mehboob Ur Rehman	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Sidra Zahoor	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Muhammad Farrukh Habib*	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

REFERENCES

1. El Ouaddi N, de Diego O, Labata C, Rueda F, Martínez MJ, Cámara ML, et al. Mechanical complications in STEMI: prevalence and mortality trends in the primary PCI era. The Ruti-STEMI Registry. Rev Esp Cardiol (Engl Ed). 2023 Jun 1;76(6):427-33.

2. El Ouaddi N, de Diego O, Labata C, Rueda F, Martínez MJ, Cámara ML, Berastegui E, et al. Mechanical complications in STEMI: prevalence and mortality trends in the primary PCI era. The Ruti-STEMI Registry. Rev Esp Cardiol (Engl Ed). 2023 Jun 1;76(6):427-33.

3. Shams O, Rathi N, Kumar J, Sahito AA, Rathi KK. Prevalence of mechanical vs. non-mechanical complications in patients with acute STEMI. J Peoples Univ Med Health Sci Nawabshah. 2020 Mar 31;10(1).

4. Khan N, Arshad MS, Khan A, Hashmi MO, Rathore TA, Younas N. Frequency of ischemic mitral regurgitation in ST-elevation myocardial infarction and its impact on hospital course. Pak J Med Health Sci. 2023 Mar 9;17(01):562.

5. Goraya MHN, Kalsoom S, Almas T, Amin MK, Hussain N, Awan J, et al. Simultaneous left ventricular aneurysm and ventricular septal rupture complicating delayed STEMI presentation: a case-based review of post-MI mechanical complications amid the COVID-19 pandemic. J Investig Med High Impact Case Rep. 2021;9.

6. Panesar G, Bhende VV, Sharma TS, Karna SK, Tiwari M, Sonia KA, et al. Perioperative management of a patient with left ventricular free wall rupture after myocardial infarction: a rare case scenario. Cureus. 2022 Sep 20;14(9).

7. Kotecha T, Martinez-Naharro A, Boldrini M, et al. Advanced myocardial characterization and function with cardiac CT. Int J Cardiovasc Imaging. 2024;40(1):1-12.

8. Figueras J, Cortadellas J, Soler-Soler J. Comparison of ventricular septal and left ventricular free wall rupture in acute myocardial infarction. Am J Cardiol. 1998 Feb 15;81(4):495-7.

9. Hartikainen TS, Sörensen NA, Haller PM, Goßling A, Lehmacher J, Zeller T, et al. Clinical application of the 4th Universal Definition of Myocardial Infarction. Eur Heart J. 2020 Jun 14;41(23):2209-16.

10. Shahsawar MU, Sharif MH, Afzal Z. Frequency of ventricular septal rupture as a complication of acute ST-elevation myocardial infarction in patients presenting to a tertiary care hospital. J Ayub Med Coll Abbottabad. 2022;34(4 Suppl 1):983-6.

11. Elbadawi A, Elgendy IY, Mahmoud K, et al. Temporal trends and outcomes of mechanical complications in patients with acute myocardial infarction. JACC Cardiovasc Interv. 2019;12(18):1825-36.

12. Goyal A, Menon VK, Sharma A, et al. Mechanical complications of acute myocardial infarction: a review. JAMA Cardiol. 2020;5(3):324-36.

13. Lanz J, Wyss D, Räber L, Stortecky S, Hunziker L, Blöchlinger S, et al. Mechanical complications in patients with ST-segment elevation myocardial infarction: a single-center experience. PLoS One. 2019 Feb 22;14(2):e0209502.

14. Tripathi B, Aggarwal V, Abbott JD, Kumbhani DJ, Giri J, Kalra A, et al. Mechanical complications in ST-elevation myocardial infarction (STEMI) based on different reperfusion strategies. Am J Cardiol. 2021 Oct 1;156:79-84.

15. El-Metwally A, Fatani F, Binhowaimel N, Al Khateeb BF, Al Kadri HM, Alshahrani A, et al. Effect modification by age and gender in the correlation between diabetes mellitus, hypertension, and obesity. J Prim Care Community Health. 2023 Dec;14:21501319231220234.

16. Sia CH, Ko J, Zheng H, Ho AF, Foo D, Foo LL, et al. Association of body mass index, metabolic health status and clinical outcomes in acute myocardial infarction patients: a national registry-based study. Front Cardiovasc Med. 2023 Jun 26;10:1142078.

17. Chen L, Zhang J, Zhou N, Weng JY, Bao ZY, Wu LD. Association of different obesity patterns with hypertension in US male adults: a cross-sectional study. Sci Rep. 2023 Jun 29;13(1):10551.

18. El-Metwally A, Fatani F, Binhowaimel N, Al Khateeb BF, Al Kadri HM, Alshahrani A, et al. Effect modification by age and gender in the correlation between diabetes mellitus, hypertension, and obesity. J Prim Care Community Health. 2023 Dec;14:21501319231220234.

19. Xu J, Han L, Sun W, et al. Risk factors for cardiac rupture after acute ST-segment elevation myocardial infarction during the percutaneous coronary intervention era: a retrospective case-control study. J Thorac Dis. 2022;14(7):2458-66.

20. Elbadawi A, Elgendy IY, Mahmoud K, et al. Temporal trends and outcomes of mechanical complications in patients with acute myocardial infarction. JACC Cardiovasc Interv. 2019;12(18):1825-36.

21. Zhang Z, Liu Y, Cheng Q, Zhang J, Gao C. Development of a nomogram to predict 30-day mortality in patients with post-infarction ventricular septal rupture. Sci Rep. 2024 Jul 31;14(1):17690.

22. Kosaraju A, Pendela VS, Hai O. Cardiogenic shock. In: StatPearls [Internet]. StatPearls Publishing; 2023 Apr 7.

23. Kit WC. Predictors of outcomes in acute myocardial infarction complicated by cardiogenic shock in a regional hospital. J Hong Kong Coll Cardiol. 2024;31(3):2.

24. Anggraini NA, Said F, Umar NS, Ambarika R. Importance of acute coronary syndrome knowledge to improve early detection and reduce prehospital delay in patients with acute coronary syndrome: a systematic review. Open Access Maced J Med Sci. 2023 Jan 2;11(G):33-42.

25. Al Shammeri O, El-Saka H, Al-Hutahly BE, Abd Elmoniem AE. Call for awareness: ST-segment elevation myocardial infarction presentation is delayed more than what we expect. Dr. Sulaiman Al Habib Med J. 2021 Mar 1;3(1):36-9.

