PAKISTAN JOURNAL OF Cardiovascular Intervention

OPEN ACCESS

ORIGINAL ARTICLE

Post–myocardial infarction ventricular septal rupture at a Pakistani tertiary cardiac center: documented short-term outcomes, management patterns, and unadjusted bivariable correlates in a retrospective observational cohort.

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Citation:
Khan MI, Waheed N, Zeb S, Ullah A, Raza A, Khan FR. Post–myocardial infarction ventricular septal rupture at a Pakistani tertiary cardiac center: documented short-term outcomes, management patterns, and unadjusted bivariable correlates in a retrospective observational cohort. PJCVI. 2026; 6(1): 03-14

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DOI: 10.58889/PJCVI.6.1.03.14

Funding:
This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Conflicts of Interests:
The authors declare no conflict of interest related to this publication.

Received 17/01/2026
Accepted 22/05/2026
First Published 01/06/2026

Abstract

Background: Post–myocardial infarction (MI) ventricular septal rupture (VSR) remains a devastating mechanical complication of acute MI, with persistently high mortality despite advances in reperfusion and structural cardiac intervention. In low- and middle-income settings, delayed presentation, referral barriers, and limited access to definitive repair may further affect outcomes. This study aimed to describe short-term outcomes, management patterns, and unadjusted bivariable correlates of confirmed outcome among patients with post-MI VSR at a tertiary cardiac center in Pakistan.

Methodology: This retrospective observational cohort study included consecutive patients with echocardiography-confirmed post-MI VSR presenting to the Peshawar Institute of Cardiology between January 1, 2023, and December 31, 2024. Data were abstracted from hospital records, discharge summaries, echocardiography reports, procedural documentation, and available follow-up records. Outcome status was classified as documented death, documented discharge/survival, or uncertain outcome.

Results: Among 51 patients, 20 (39.2%) had documented death, 15 (29.4%) had documented discharge alive or survival, and 16 (31.4%) had uncertain outcomes. Median age was 65.0 years [IQR, 59.5–71.0], and 22 (43.1%) were female. Hypertension, diabetes, and anterior MI were common. Most patients had no definitive repair documented (44/51, 86.3%). Among 35 patients with confirmed outcomes, no variable showed a statistically robust unadjusted association with short-term outcome.

Conclusion: Post-MI VSR was associated with substantial early mortality in this Pakistani cohort. However, incomplete follow-up and limited physiologic data restricted interpretation. Findings are exploratory and support the need for prospective multicenter studies with standardized follow-up.

Keywords

Ventricular Septal Rupture, Myocardial Infarction, Mortality, Retrospective Observational Cohort, Mechanical Complications, Pakistan.

Introduction

Post–myocardial infarction (MI) ventricular septal rupture (VSR) is an uncommon but catastrophic mechanical complication of acute MI that continues to carry exceptionally high mortality despite major advances in reperfusion therapy, interventional cardiology, and cardiac surgery. Although the incidence of post-MI VSR has substantially decreased in the primary percutaneous coronary intervention (PCI) era, the condition remains clinically important because of its abrupt hemodynamic consequences and persistently poor outcomes. Patients frequently develop acute left-to-right shunting, cardiogenic shock, pulmonary edema, multiorgan hypoperfusion, and rapid clinical deterioration, often within a narrow therapeutic window during which diagnosis, stabilization, and definitive intervention become critically important. Contemporary scientific statements and systematic reviews consistently identify post-MI VSR as one of the most lethal complications of acute coronary syndromes, with mortality remaining high even in specialized tertiary-care systems[1,2].

The pathophysiology of post-MI VSR is closely linked to transmural myocardial necrosis and structural weakening of the interventricular septum following delayed or failed reperfusion. Earlier reperfusion strategies have reduced the incidence of extensive infarction and therefore decreased the frequency of VSR; however, patients who continue to develop this complication often present with large infarcts, delayed hospital presentation, incomplete coronary reperfusion, or advanced hemodynamic compromise. Registry-based studies and multicenter observational analyses continue to demonstrate substantial mortality despite contemporary surgical and transcatheter approaches, with outcomes influenced by shock severity, timing of intervention, infarct location, right ventricular involvement, and access to advanced mechanical circulatory support[3,4].

Management of post-MI VSR remains particularly challenging because treatment decisions are highly individualized and frequently constrained by clinical instability, tissue friability, timing of rupture, and institutional expertise. Surgical repair has traditionally represented the standard definitive treatment, but operative mortality remains considerable, especially among unstable patients requiring emergent intervention. More recently, transcatheter device closure techniques have emerged as alternative or bridging approaches in selected patients; nevertheless, both surgical and percutaneous strategies remain vulnerable to treatment-selection bias because patients who survive long enough to undergo intervention are often fundamentally different from those who deteriorate before definitive repair becomes feasible[4,5]. Moreover, contemporary international surveys continue to show substantial variability in timing of intervention, bridging strategies, use of mechanical circulatory support, and preference for surgical versus transcatheter repair across centers and healthcare systems[6].

These challenges may be amplified in low- and middle-income countries such as Pakistan, where delayed healthcare access, limited availability of advanced structural interventions, referral barriers, financial constraints, and fragmented follow-up systems may all influence both management pathways and outcome ascertainment. In many resource-constrained settings, treatment decisions are shaped not only by anatomical suitability and hemodynamic status but also by institutional capacity, transfer logistics, affordability, and procedural accessibility. Consequently, real-world management patterns in such environments may differ substantially from those reported in highly specialized international registries. Despite these realities, locally relevant observational data describing the clinical profile, management approaches, and short-term outcomes of post-MI VSR in Pakistan remain sparse[7-10].

Another important methodological challenge in retrospective post-MI VSR research relates to incomplete outcome ascertainment. Patients with severe disease frequently undergo transfer between facilities, experience early mortality, or are lost to follow-up after discharge, thereby increasing the risk of survival misclassification in retrospective cohorts. Similarly, several clinically important prognostic variables including cardiogenic shock severity, vasopressor requirement, renal dysfunction, lactate levels, timing from MI to rupture, and timing to

intervention may be incompletely documented in routine hospital records, limiting the strength of causal inference in observational analyses[8-12].

Against this background, the present study was conducted to describe documented short-term outcomes, management patterns, and unadjusted bivariable correlates among patients presenting with post-MI VSR at a tertiary cardiac center in Pakistan. By focusing on routinely documented demographic, clinical, echocardiographic, and procedural variables, this retrospective observational cohort aims to provide locally relevant descriptive data reflecting real-world tertiary-care experience in a resource-constrained setting. Given the retrospective design, incomplete follow-up ascertainment, and limited availability of key physiologic and timing-related variables, all observed associations were considered exploratory and hypothesis-generating rather than predictive or causal.

Methodology

Study Design

This retrospective observational cohort study was conducted to evaluate documented short-term outcomes and unadjusted bivariable correlates among patients diagnosed with post–myocardial infarction (MI) ventricular septal rupture (VSR) at a tertiary cardiac care center in Pakistan. Data were collected retrospectively through structured chart abstraction from existing hospital records rather than through prospective enrollment or follow-up. Given the rarity of post-MI VSR and the relatively small cohort size, the study was designed primarily as a descriptive exploratory investigation focusing on consecutive case inclusion, transparent outcome ascertainment, and real-world management patterns instead of causal modeling or predictive risk estimation. The study therefore emphasizes hypothesis-generating associations rather than definitive prognostic conclusions. Contemporary literature continues to identify post-MI VSR as a highly lethal complication with substantial early mortality despite advances in reperfusion and structural intervention techniques.

Ethics

Ethical approval for the study was obtained from the Institutional Review Board under reference number IRC/24/70. All patient-related information was handled in accordance with institutional ethical standards and confidentiality principles. Data were anonymized and de-identified before analysis to protect patient privacy and prevent re-identification. Since the study relied exclusively on retrospective review of routinely documented clinical records, no direct patient contact or intervention was performed during the study period.

Setting

The study was conducted at the Peshawar Institute of Cardiology, a tertiary-care cardiac referral center managing acute coronary syndromes and complex cardiovascular emergencies. Patients presenting through emergency services, cardiology units, coronary care units, and inpatient cardiac pathways between January 1, 2023, and December 31, 2024, were eligible for review. Available documentation included emergency records, inpatient progress notes, discharge summaries, echocardiography reports, catheterization laboratory records, surgical documentation, and available follow-up records up to 3 months after index presentation. The 3-month follow-up period was selected because mortality associated with post-MI VSR is known to occur predominantly during the early post-infarction period.

Participants

The study included all consecutive patients diagnosed with post-MI VSR during the study period using consecutive non-probability sampling. Diagnosis was established through transthoracic echocardiography (TTE) demonstrating ventricular septal disruption with left-to-right shunting in the clinical context of acute MI, typically accompanied by a new harsh systolic murmur and hemodynamic compromise. Patients with other post-MI mechanical complications without confirmed VSR were excluded from the study. Inclusion of all consecutive eligible patients was intended to reduce selection bias within the limitations of a retrospective tertiary referral cohort.

Variables

Variables included in the analysis were selected based on clinical relevance and availability within routine documentation. Demographic and clinical variables included age, sex, hypertension, diabetes mellitus, infarct territory, thrombolytic exposure, VSR location, VSR size, and left ventricular ejection fraction (LVEF). VSR size was recorded as the maximum documented defect diameter in millimeters, while LVEF values were extracted directly from echocardiographic reports. Management-related variables included documentation of percutaneous coronary intervention (PCI), transcatheter device closure, surgical repair with or without coronary artery bypass grafting (CABG), and cases with no definitive repair documented. Because the study relied on retrospective records, several clinically important prognostic variables such as cardiogenic shock status, Killip class, serum lactate, renal function, vasopressor requirement, timing from MI to rupture, timing to intervention, and mechanical circulatory support use were inconsistently documented and therefore could not be reliably incorporated into the analytic dataset.

Data Sources / Measurement

Data were abstracted retrospectively from hospital charts, echocardiography records, discharge summaries, procedural reports, catheterization laboratory documentation, and available follow-up records. Outcome ascertainment followed a predefined hierarchical framework to improve transparency and reduce inappropriate survival assumptions. Patients were categorized as having documented death if mortality was explicitly recorded during hospitalization or follow-up, documented survival if discharge alive or survival status was explicitly mentioned, and uncertain outcome if no documented outcome was available in the accessible records. Management categories were similarly derived from available procedural documentation. The category "no definitive repair documented" was intentionally used because absence of recorded PCI, device closure, or surgery could not conclusively confirm medical-only management. Missing data were handled using an available-case approach, and variable-specific denominators were reported where applicable. No imputation methods were used.

Bias

Several potential sources of bias were recognized in this study. The retrospective single-center design introduced risks of selection bias, referral bias, survivor bias, and documentation bias. Incomplete follow-up records created the possibility of outcome misclassification, particularly among patients discharged alive without reliable subsequent documentation. Restricting comparative analyses to patients with confirmed documented outcomes was intended to reduce this misclassification risk. Additionally, the absence of several key hemodynamic, biochemical, and timing-related variables likely resulted in residual confounding, thereby limiting causal interpretation. Management comparisons were also vulnerable to treatment-selection bias because patients undergoing surgery or transcatheter intervention may have differed substantially in stability, timing, anatomical suitability, and institutional accessibility from those without documented definitive repair[8-12].

Study Size

Because post-MI VSR is an uncommon clinical complication, all eligible consecutive patients presenting during the predefined study period were included in the final cohort. The sample therefore represented the complete accessible institutional dataset rather than a predefined recruitment target. No formal a priori sample size calculation was performed for hypothesis testing or subgroup comparison because the study was exploratory in nature and focused on descriptive observational analysis of a rare condition[7].

Quantitative Variables

Continuous quantitative variables including age, left ventricular ejection fraction, and VSR size were summarized using median and interquartile range [IQR] because distributional assumptions could not be reliably established in the small cohort. Categorical variables including sex, hypertension, diabetes mellitus, infarct territory, thrombolytic exposure, VSR location, and management categories were summarized using frequencies and

percentages. Outcome variables were categorized according to the predefined ascertainment hierarchy into documented death, documented survival, and uncertain outcome status.

Statistical Methods

All analyses were prespecified as exploratory unadjusted bivariable analyses intended to generate descriptive observations rather than establish definitive prognostic relationships. Continuous variables were compared using the Mann–Whitney U test, while categorical variables were analyzed using Fisher's exact test because of small subgroup counts and sparse data distribution. Comparative analyses were restricted to patients with confirmed documented outcomes to minimize outcome misclassification bias. Odds ratios were reported only when statistically estimable and clinically interpretable. For sparse subgroup analyses involving zero-cell counts, particularly within management categories such as device closure and surgical repair, exact p-values were reported without odds ratios because conventional Wald-based estimates become unstable or undefined under such conditions. No adjustment for multiple testing was performed due to the limited sample size and exploratory nature of the analysis; therefore, all findings were interpreted as hypothesis-generating rather than confirmatory. Missing data were managed using available-case analysis, and denominators were explicitly stated for incompletely documented variables. Statistical analyses were performed using R software within the RStudio (Posit) environment.

Results

Participants

A total of 51 consecutive patients with post–myocardial infarction (MI) ventricular septal rupture (VSR) were included in the final retrospective observational cohort during the study period from January 1, 2023, to December 31, 2024. All patients had echocardiography-confirmed VSR and fulfilled the predefined eligibility criteria. Outcome ascertainment was performed using the prespecified retrospective hierarchical framework described in the Methods section. Based on available documentation, 20 patients (39.2%) had explicitly documented death, 15 patients (29.4%) had documented discharge alive or documented survival status, and 16 patients (31.4%) had uncertain outcome status because no follow-up or definitive outcome documentation was available in the accessible records. The outcome ascertainment distribution for the full cohort is illustrated in Figure 1 and summarized in Table 3. Because nearly one-third of patients lacked confirmed outcome documentation, comparative bivariable analyses were restricted to the subgroup of 35 patients with confirmed documented outcomes in order to reduce potential outcome misclassification bias.

Descriptive Data

Baseline demographic, clinical, echocardiographic, and management-related characteristics of the cohort are summarized in Table 1. The median age of the overall cohort was 65.0 years [interquartile range (IQR), 59.5–71.0], reflecting the predominance of older patients presenting with this catastrophic post-MI mechanical complication. Female patients accounted for 22 of 51 cases (43.1%), while hypertension and diabetes mellitus were highly prevalent, documented in 44 patients (86.3%) and 38 patients (74.5%), respectively. Anterior wall MI was the predominant infarct territory, identified in 40 patients (78.4%), whereas inferior MI was documented in 10 patients (19.6%). Streptokinase administration or delayed thrombolysis was documented in 25 patients (49.0%), while 18 patients (35.3%) had no documented thrombolytic exposure and 8 patients (15.7%) had missing thrombolysis records.

Echocardiographic variables demonstrated moderate impairment of cardiac function overall. Left ventricular ejection fraction (LVEF) data were available for 49 patients, with a median LVEF of 40.0% [IQR, 37.0–45.0]. Ventricular septal rupture size was available for 41 patients and showed a median defect size of 8.0 mm [IQR, 7.0–10.0]. Apical VSR represented the most frequently documented anatomical location, occurring in 33 patients (64.7%). Management strategies demonstrated marked predominance of patients without documented definitive repair. As shown in Figure 2 and Table 2, 44 of 51 patients (86.3%) fell into the category of "no definitive repair documented," while only 2 patients

(3.9%) underwent percutaneous coronary intervention (PCI), 2 patients (3.9%) had transcatheter device closure documented, and 3 patients (5.9%) underwent surgical repair procedures. Because procedural categorization relied on retrospective chart abstraction, absence of documented intervention does not conclusively indicate receipt of conservative medical therapy alone and may reflect incomplete procedural capture, interfacility transfer, or fragmented documentation.

Outcome Data

Documented mortality remained substantial within the cohort. In the overall population, 20 of 51 patients (39.2%) had documented death recorded either during hospitalization or within available follow-up documentation. Among the subgroup of patients with confirmed documented outcomes, mortality accounted for 20 of 35 patients (57.1%), emphasizing the severe short-term burden associated with post-MI VSR in this tertiary-care setting. Figure 1 demonstrates the distribution of confirmed death, documented survival, and uncertain outcomes according to the retrospective ascertainment hierarchy, while Table 3 provides the detailed breakdown of outcome-classification tiers. The high proportion of uncertain outcomes highlights the challenges associated with retrospective follow-up ascertainment in critically ill cardiovascular populations, particularly in resource-constrained referral systems where transfer patterns, incomplete follow-up, and fragmented documentation may limit reliable outcome capture. Accordingly, the reported mortality proportion should be interpreted as the burden of documented mortality within the accessible dataset rather than a definitive estimate of true population-level 3-month mortality.

Main results

Comparative analyses between patients with documented discharge/survival and those with documented death were restricted to the 35 patients with confirmed outcomes and are presented in Table 1. No variable demonstrated a statistically robust unadjusted bivariable association with short-term outcome. Median age was numerically higher among patients with documented discharge/survival compared with those who died (68.0 [IQR, 65.0–73.5] vs 64.5 [IQR, 55.8–70.0] years), although this difference did not reach statistical significance (p=0.069). Similarly, median LVEF was modestly higher in surviving patients (42.0% [IQR, 39.5–45.0]) than in patients with documented death (38.0% [IQR, 36.0–44.0]), but this association also failed to demonstrate statistical significance (p=0.149). VSR size showed no meaningful difference between groups (p=0.979).

Among categorical variables, female sex, hypertension, diabetes mellitus, infarct territory, thrombolytic exposure, and apical VSR location likewise did not show statistically robust associations with documented outcome status (all p≥0.144). Distribution of infarct territory according to confirmed outcome status is illustrated in Figure 3, where anterior MI predominated in both survivors and non-survivors. Management-category analyses are presented in Table 2. Due to sparse subgroup counts and several zero-cell comparisons, stable estimation of odds ratios was not statistically reliable for procedural categories such as PCI, device closure, and surgical repair. Accordingly, Fisher's exact test p-values were reported without odds-ratio estimation where appropriate. No statistically significant association was identified between documented management category and confirmed outcome status. However, interpretation of these comparisons should remain cautious because treatment allocation in post-MI VSR is strongly influenced by patient stability, timing of presentation, referral logistics, tissue friability, anatomical suitability, and institutional capability. The findings demonstrate a considerable burden of documented early mortality among patients with post-MI VSR in this Pakistani tertiary-care cohort. However, incomplete follow-up ascertainment, limited procedural subgroup sizes, and absence of several important hemodynamic and timing-related variables substantially restricted inferential strength. Consequently, all observed associations should be interpreted as exploratory, descriptive, and hypothesis-generating rather than definitive prognostic indicators.

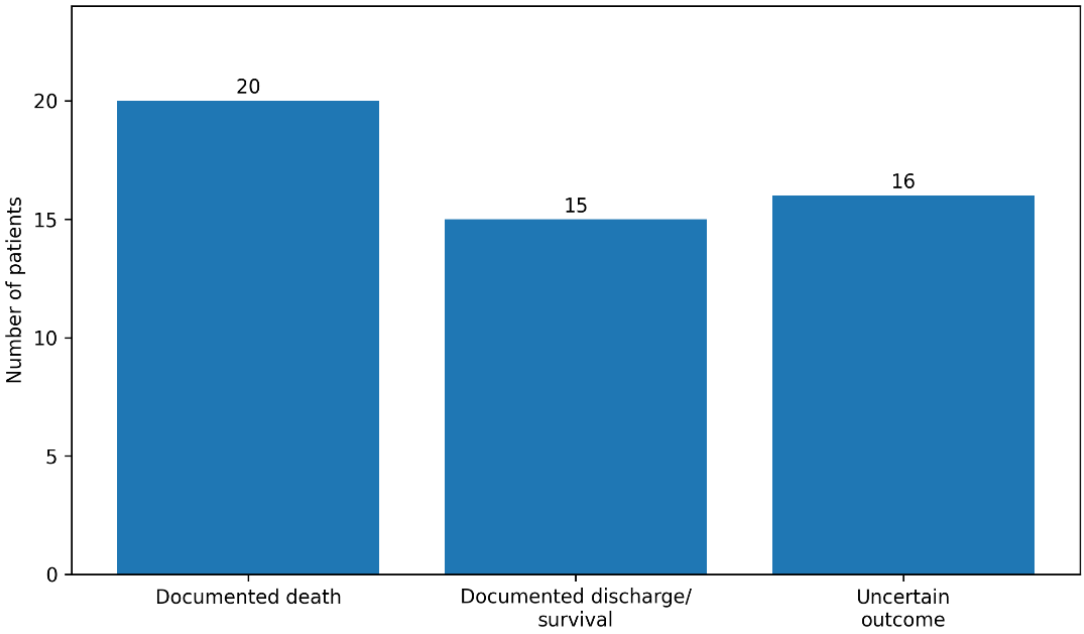

Figure 1: Outcome ascertainment in the full cohort (N=51).

Table 1: Baseline characteristics overall and by confirmed outcome status.

Variables	Overall (N=51)	Discharged/Survived (n=15)	Died (n=20)	p-value
Age, years	65.0 [59.5–71.0]	68.0 [65.0–73.5]	64.5 [55.8–70.0]	0.069
LVEF, % (n=49)	40.0 [37.0–45.0]	42.0 [39.5–45.0]	38.0 [36.0–44.0]	0.149
VSR size, mm [(n=41)	8.0 [7.0–10.0]	9.0 [5.0–10.0]	8.0 [7.0–9.5]	0.979
Female sex	22(43.1)	5(33.3)	9(45.0)	0.728
Hypertension	44(86.3)	13(86.7)	15(75.0)	0.672
Diabetes mellitus	38(74.5)	8(53.3)	16(80.0)	0.144
Anterior MI	40(78.4)	12(80.0)	17(85.0)	1.000
Inferior MI	10(19.6)	3(20.0)	3(15.0)	1.000
Streptokinase given or late	25(49.0)	8(53.3)	10(50.0)	1.000
Apical VSR location	33(64.7)	9(60.0)	14(70.0)	0.721

IQR, interquartile range; LVEF, left ventricular ejection fraction; MI, myocardial infarction; OR, odds ratio; VSR, ventricular septal rupture.

Continuous variables are presented as median [IQR]. Categorical variables are presented as n (%). Comparative columns include only the 35 patients with confirmed documented outcome status; 16 patients with uncertain outcomes were excluded from bivariable analyses. LVEF was available in 49 of 51 patients, and VSR size in 41 of 51 patients.

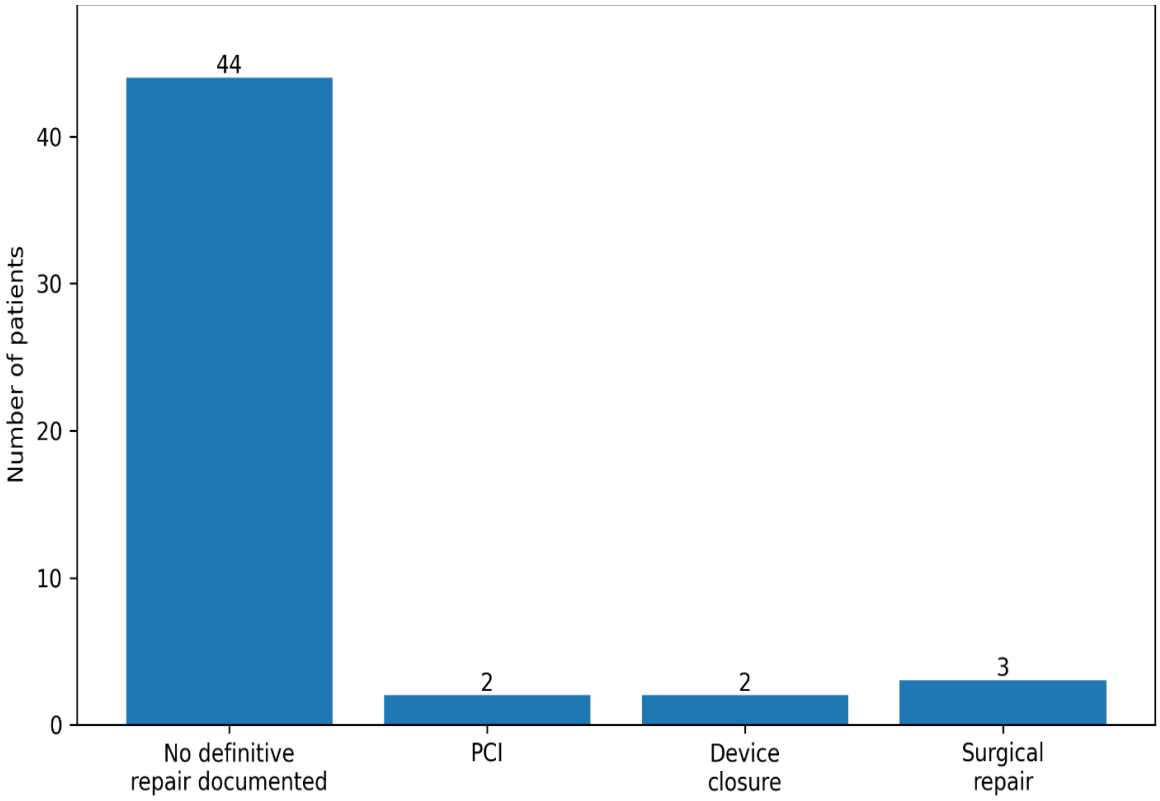

Figure 2: Management categories in the full cohort (N=51).

Table 2: Management categories and confirmed outcomes.

Variables	Overall (N=51)	Discharged/ Survived (n=15)	Died (n=20)	p-value
No definitive repair documented	44 (86.3)	13 (86.7)	20 (100.0)	0.176
Percutaneous coronary intervention (PCI)	2 (3.9)	1 (6.7)	0 (0.0)	0.429
Device closure	2 (3.9)	0 (0.0)	0 (0.0)	1.000
Surgical repair	3 (5.9)	1 (6.7)	0 (0.0)	0.429

Procedural data were sourced from discharge summaries and available catheterization or surgical records. "No definitive repair documented" indicates that PCI, device closure, or surgery was not recorded in the available dataset and should not be interpreted as confirmed medical-only management. For zero-cell comparisons, odds ratios were not estimable and Fisher's exact p-values are reported.

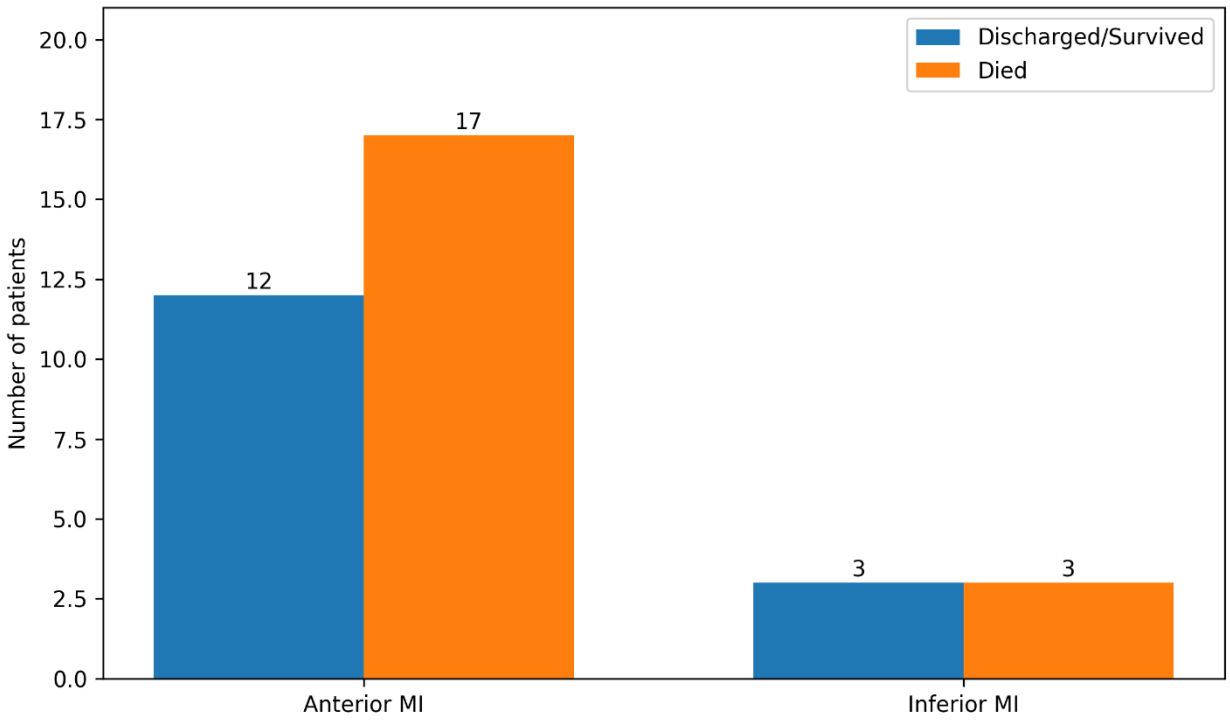

Figure 3: Myocardial infarction territory by confirmed outcome status (n=35).

Table 3: Outcome ascertainment tiers in the full cohort.

Outcome tier	n	%	Interpretation
Tier 1 – Confirmed (died)	20	39.2	Death explicitly documented
Tier 1 – Confirmed (discharged/survived)	15	29.4	Discharge alive or survival explicitly documented
Tier 2 – Uncertain	16	31.4	No documented outcome in the available record; excluded from comparative analyses

Tier 1 indicates explicitly documented death or documented discharge alive/survival status.
Tier 2 indicates that no outcome was documented in the available record.

Discussion

In this retrospective observational cohort from a tertiary cardiac center in Pakistan, post–myocardial infarction (MI) ventricular septal rupture (VSR) was associated with a substantial burden of documented early mortality despite contemporary tertiary-care management pathways. Although post-MI VSR has become less frequent in the reperfusion era, it remains one of the most catastrophic complications of acute MI because of its abrupt hemodynamic consequences, rapid progression to cardiogenic shock, and persistently high mortality even in advanced healthcare systems. The findings of the present study therefore remain clinically important, particularly within the context of a low- and middle-income healthcare setting where delayed presentation, referral barriers, limited access to advanced circulatory support, and restricted availability of definitive repair may further complicate management and influence outcomes[1-4,8-12].

The overall burden of documented mortality observed in this cohort is consistent with contemporary international literature demonstrating persistently poor short-term survival among patients with post-MI VSR. Large registries and systematic reviews continue to report high mortality despite improvements in surgical

techniques, transcatheter closure approaches, and multidisciplinary cardiac critical care[3,4,8,11,12]. However, interpretation of the mortality proportion reported in this study requires caution because nearly one-third of patients had uncertain outcome status due to incomplete retrospective follow-up documentation. Consequently, the reported mortality rate should be interpreted as the burden of documented mortality within the accessible institutional record rather than a definitive estimate of population-level 3-month mortality. This distinction is methodologically important because retrospective cohorts involving critically ill cardiovascular patients are particularly vulnerable to incomplete follow-up, transfer-related data fragmentation, and survival misclassification[8-10].

To address this concern, comparative analyses were intentionally restricted to patients with confirmed documented outcomes. While this strategy reduced the effective analytic sample size and statistical power, it represented a more transparent and methodologically defensible approach than assuming survival among patients lacking reliable follow-up documentation. In resource-constrained referral systems, patients discharged alive may subsequently deteriorate at outside facilities or may be lost to follow-up entirely, making retrospective survival assumptions potentially misleading. Similar challenges in outcome ascertainment have also been recognized in other observational studies evaluating post-MI mechanical complications[5,8-10].

Within the confirmed-outcome subgroup, no demographic, clinical, echocardiographic, or management-related variable demonstrated a statistically robust unadjusted bivariable association with short-term outcome. Although variables such as age, left ventricular ejection fraction (LVEF), diabetes mellitus, and infarct territory demonstrated numerical differences between survivors and non-survivors, these findings did not reach statistical significance and should not be interpreted as evidence of absent clinical relevance. Rather, the absence of robust statistical associations likely reflects a combination of limited sample size, sparse subgroup distributions, incomplete physiologic characterization, and residual confounding[8-12].

The lack of a clear association between echocardiographic variables such as VSR size or LVEF and outcome deserves particular consideration. In post-MI VSR, structural anatomy alone rarely determines prognosis in isolation. Contemporary evidence suggests that early mortality is heavily influenced by hemodynamic severity, degree of left-to-right shunting, right ventricular involvement, systemic hypoperfusion, renal dysfunction, timing of rupture, and feasibility of intervention[8,11-18]. Accordingly, echocardiographic findings should ideally be interpreted alongside physiologic parameters and shock severity rather than as independent prognostic indicators. The inability to include several of these important variables in the current dataset likely limited the capacity to detect clinically meaningful associations.

The management profile observed in this cohort also reflects important real-world challenges encountered in resource-constrained cardiovascular systems. Most patients were categorized as having "no definitive repair documented," whereas PCI, transcatheter device closure, and surgical repair were infrequently recorded. Importantly, this category was intentionally phrased to reflect documentation status rather than confirmed conservative management alone. In retrospective datasets, particularly within fragmented referral pathways, absence of documented intervention may reflect incomplete procedural capture, transfer to outside facilities, or missing records rather than absence of treatment itself[5,8,10].

Interpretation of management-related comparisons must therefore remain highly cautious. Patients undergoing surgery or transcatheter intervention are often fundamentally different from those who do not receive definitive repair because treatment allocation depends heavily on survival to referral, hemodynamic stability, tissue friability, anatomical suitability, procedural accessibility, and institutional

expertise[11-14,18-20]. Consequently, observational comparisons between procedural and non-procedural groups are highly vulnerable to survivor bias, referral bias, and treatment-selection bias. The sparse procedural subgroup counts and multiple zero-cell comparisons in the present study further limited statistical interpretability and prevented stable estimation of effect measures in several analyses.

The present findings also highlight broader systems-level implications relevant to cardiovascular care in low- and middle-income settings. Delayed MI presentation, limited public awareness, variability in reperfusion access, restricted availability of mechanical circulatory support, and logistical referral delays may all contribute to adverse outcomes in post-MI VSR. Contemporary international recommendations increasingly emphasize multidisciplinary Heart Team management, rapid hemodynamic stabilization, early recognition of mechanical complications, and individualized decision-making regarding timing of repair[1,2,8,11,12]. In resource-constrained settings, pragmatic improvements such as earlier referral pathways, standardized documentation systems, prospective recording of shock severity, and enhanced follow-up mechanisms may substantially improve both patient care and future observational research quality. Importantly, the findings of this study should not be interpreted as establishing independent predictors or definitive risk-stratification markers. Instead, they provide descriptive insight into the real-world presentation, management patterns, and documented short-term outcomes of post-MI VSR within a tertiary-care Pakistani setting. The exploratory nature of the analysis underscores the need for larger prospective multicenter registries incorporating standardized outcome ascertainment, detailed hemodynamic characterization, timing-related variables, and more comprehensive procedural documentation. Such efforts would allow more reliable evaluation of prognostic determinants and may help guide evidence-based management strategies in regions with limited healthcare resources [8-20].

Limitations

This study has several limitations. The retrospective single-center design introduces risks of selection, referral, survivor, and documentation bias. Outcome ascertainment was incomplete in a substantial proportion of patients, creating the possibility of misclassification and limiting statistical power. Several clinically important prognostic variables, including cardiogenic shock severity, renal function, vasopressor requirement, mechanical circulatory support use, and timing-related variables, were inconsistently documented and therefore unavailable for analysis, increasing the likelihood of residual confounding. In addition, the relatively small sample size and sparse subgroup distributions limited statistical precision and precluded stable estimation in some comparisons. Because no adjustment for multiple testing was performed, all findings should be considered exploratory and hypothesis-generating rather than confirmatory. Management classifications were based on available retrospective documentation and may not fully capture interventions performed outside the institutional record. Finally, as a tertiary-care single-center cohort, the findings may not be generalizable to all healthcare settings or patient populations.

Conclusion

In this retrospective observational cohort from a tertiary cardiac center in Pakistan, post–myocardial infarction ventricular septal rupture remained associated with a substantial burden of documented early mortality despite contemporary tertiary-care management pathways. However, incomplete outcome ascertainment, limited sample size, and absence of several key hemodynamic and timing-related variables substantially restricted definitive interpretation of outcome correlates.

Acknowledgment

We are thankful to the staff of Cardiology Department Peshawar Institute of cardiology for providing us a platform to conduct this study.

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