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Ventricular Septal Rupture as a Complication of Acute Myocardial Infarction: Clinical Characteristics and Prognostic Comparison of Different Treatment Methods

ORIGINAL INVESTIGATION

ABSTRACT

Background: This research aimed to investigate the clinical features exhibited by individuals diagnosed with acute myocardial infarction (AMI) complicated by ventricular septal rupture (VSR) and to compare the prognostic outcomes of different treatment modalities.

Methods: A retrospective study on a cohort of 200 patients who were diagnosed with AMI complicated by VSR at a specialized medical facility from 2018 to 2023 was conducted. The patients were categorized into 3 different treatment groups: group A received medical management, group B underwent surgical repair, and group C underwent percutaneous device closure. Our primary objective was to assess the overall mortality rate within 1 year, while secondary objectives included evaluating in-hospital mortality, mortality within 30 days, and occurrence of major adverse cardiovascular events within 1 year.

Results: Group A showed the highest in-hospital mortality rate of 37.3%. The rate for group B was only 20.6%, while group C exhibited the lowest rate of 17.4%. A similar tendency was observed for the 30-day and 1-year mortality rates. The 30-day mortality rate for group A, group B, and group C was 56.9%, 20.6%, and 22.1%, respectively. The 1-year mortality rate for group A, group B, and group C was as follows: 31.4%, 28.6%, and 25.6%. In addition, the incidence of major adverse cardiovascular events at 1 year was highest in group A (56.9%), followed by group B (28.6%) and group C (32.6%).

Conclusion: Both surgical repair and percutaneous device closure were associated with significantly better survival outcomes compared to medical management alone in patients with AMI complicated by VSR.

Keywords: Acute myocardial infarction, medical management, percutaneous device closure, prognosis, surgical repair, ventricular septal rupture

INTRODUCTION

Acute myocardial infarction (AMI), an abrupt and severe event of heart muscle damage due to reduced blood flow, is a prominent global health concern.[1] Despite advancements in diagnosis, risk stratification, and management, AMI remains a significant cause of morbidity and mortality, posing substantial societal and economic burdens worldwide. Further complicating this landscape is the occurrence of severe mechanical complications post-AMI, such as ventricular septal rupture (VSR).[2,3]

Ventricular septal rupture represents an emergency clinical scenario.[4,5] It is a catastrophic event where a hole forms in the ventricular septum, the wall separating the heart's left and right ventricles, secondary to an infarct.[6,7] The resultant left-to-right shunt leads to rapid hemodynamic compromise, placing patients at an exceedingly high risk of mortality. Even though the incidence of VSR has declined with the advent of reperfusion therapies, it still complicates 1%-2% of AMIs and carries a grim prognosis, with a mortality rate exceeding 40% even with surgical intervention.[8,9]

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The management of VSR post-AMI represents a significant clinical conundrum. Traditional medical management alone is typically insufficient due to the profound hemodynamic instability that accompanies VSR.[10] Surgical repair, though considered the gold standard for managing VSR, is fraught with significant challenges due to the poor condition of the infarcted myocardium and the critically ill state of the patients.[11] More recently, the advent of percutaneous device closure techniques offers a less invasive alternative, yet its comparative efficacy and safety remain uncertain.[12,13]

Given this backdrop, it is of utmost importance to deepen our understanding of AMI complicated by VSR to refine our management strategies further. The present study aims to explore the clinical characteristics of patients diagnosed with AMI complicated by VSR and to provide a comprehensive comparison of the prognostic outcomes following different therapeutic strategies. In particular, this study strive to delineate the survival outcomes associated with medical management, surgical repair, and percutaneous device closure.

METHODS

Participants

Our retrospective cohort study comprised patients who presented to our hospital from January 2018 to December 2023, diagnosed with AMI and complicated by VSR. The local Institutional Review Board provided ethical clearance for the study, and this study adhered strictly to the principles laid out in the Declaration of Helsinki.

Study Population and Data Collection

A total of 205 patients with complete data were recruited. According to the consultation results, 5 of them were suspected to have congenital ventricular septal defects. Finally, this study included a total of 200 patients. The inclusion criteria consisted of adults over 18 years, diagnosed with AMI, and subsequent VSR confirmed by echocardiography. WePatients with a history of congenital ventricular septal defects, those who presented more than 24 hours after symptom onset, and those with missing data were excluded.

Demographic data, including age, sex, and comorbidities, were obtained from the hospital's electronic health record system. Clinical presentation, AMI characteristics, echocardiographic findings, treatment details, and outcomes were systematically recorded.

HIGHLIGHTS

- Patients with AMI and VSR receiving medical management had the highest in-hospital mortality of 37.3%, 30-day mortality of 56.9%, and 1-year mortality of 31.4%.
- Patients undergoing surgical repair experienced an in-hospital mortality of 20.6%, a 30-day mortality of 20.6%, and a 1-year mortality of 28.6%.
- Patients undergoing percutaneous device closure had the lowest in-hospital mortality of 17.4%, 30-day mortality of 22.1%, and 1-year mortality of 25.6%.

Treatment Stratification

Clinical practice guideline recommendations for patients with VSR stem from the American College of Cardiology and American Heart Association Task Force on Practice Guidelines. (1) Patients were categorized into 3 groups according to the primary treatment for VSR. (2) Medical management (group A): consisting of patients who received only medical therapy, including inotropic support, afterload reduction, and intra-aortic balloon pump when required. (3) Surgical repair (group B): comprising patients who underwent surgical repair of VSR, either with a patch technique or direct suture closure. (4) Percutaneous device closure (group C): including patients where VSR was managed with a percutaneous septal occluder device.

Outcomes Assessment

The main focus of the study was the 1-year all-cause mortality rate. Secondary endpoints included in-hospital mortality, 30-day mortality, and major adverse cardiovascular events (MACEs) at 1 year, including recurrent MI, heart failure hospitalization, stroke, and the need for re-intervention.

Surgical Techniques

Median sternotomy was performed in all cases. The myocardium was protected by moderate hypothermia cardiopulmonary bypass and intermittent anterograde cold crystal arrest. If needed, coronary artery bypass grafting was performed first, followed by VSD repair. The bovine pericardial patch described by David et al[14] was used to exclude infarction in all cases. According to the location of the ventricular septal defect, the left ventricle was incised in the infarct area. The bovine pericardial patch was large enough in size, typically 1.5 cm wider than the VSD edge, to provide sufficient support to hold the suture to healthy muscle without tearing. The patch was first sutured to healthy heart muscle 1.5 cm from the perforated edge using continuous 4-0 polypropylene sutures. Sutures maintained proper tension to avoid tearing the fragile heart muscle. The extra break 4-0 guaranteed that polypropylene sutures were used to enhance VSD repair. For patients with anterior ventricular septal defects, the ventricle incision was closed directly with long felt and 2-0 polypropylene sutures. In patients with posterior ventricular septal defects, a triangular bovine pericardial patch was used to close the incision to prevent tension on the fragile heart muscle.

Percutaneous Device Closure Procedure

The basic procedure refers to the common views of Chinese medical experts on interventional treatment of ventricular septal defect.[15] Except for patients with acute ST segment elevation myocardial infarction combined with VSR and hemodynamic instability who required immediate surgery, surgery was generally delayed until 2-4 weeks after myocardial infarction. Procedure steps: A 6F pigtail catheter was delivered into the left ventricle near the apex of the heart, and left ventricle angiography was performed at the left anterior oblique position of 35°-50° and a cephalad position of 10° to evaluate the morphology, location, and diameter of the defect. A pigtail catheter at the cutting end or a JR 4.0 contrast catheter was used to help place the super-slip guidewire through the defect and establish an arteriovenous track. Digital subtraction angiography confirmed a smooth trajectory and avoided the annular tendon bundle. The delivery sheath was conveyed to the left cardiac system along the venous track side, and the occluder was released after being transported along the delivery sheath to the appropriate location. A left ventriculogram was performed again to confirm that the occluding device was fixed and well blocked, and then the occluding device was released. The closure device used here (A7B3H10) is from Shanghai Shape Memory Alloy Co., Ltd.

Statistical Analysis

Statistical analyses were conducted using SPSS software (version 24.0, IBM Corp., Armonk, NY, USA). Categorical variables were presented as percentages, while continuous variables were expressed as mean ± SD. The Kolmogorov–Smirnov test was used to determine the normality of distribution of the continuous variables. Group differences in outcomes were assessed using chi-square tests for categorical variables and 1-way ANOVA for continuous variables. Statistical significance was set at a *P*-value of less than .05.

Statement

The research and content presented in this manuscript were completed without the utilization of artificial intelligence.

RESULTS

Baseline Characteristics and Clinical Presentation

A total of 200 patients diagnosed with AMI complicated by VSR were included in the study. The mean age of these patients was more than 60 years, with a majority being male. Several prevalent comorbidities of these patients were also observed, such as hypertension, diabetes, and a history of smoking. The weighted mean results were as follows: the time from AMI to VSR was 3.2 days and the time to VSR closure was 20.4 days.

Treatment Outcomes

These patients were categorized into 3 groups according to their primary treatment for VSR: group A (medical management, n = 51), group B (surgical repair, n = 63), and group C (percutaneous device closure, n = 86). They show a similar distribution in age, sex, percentage of hypertension, diabetes, smoking, VSR size, frequency of VSR location, number of coronaries involved, and the time from AMI to VSR (Table 1).

In-hospital mortality varied significantly across the groups: group A had the highest rate at 37.3%, compared to group B and group C, with mortality rates of 20.6% and 17.4%, respectively (Figure 1, Table 2).

The mortality rates observed during the in-hospital phase revealed a noticeable difference among the groups. This trend persisted during the 30-day follow-up, with group A's mortality rate rapidly increasing to 56.9%. However, there was no change for group B and a slight upregulation for group C, with mortality rate of 20.6% for group B and 22.1% for group C (Figure 2, Table 2). By the end of the 1-year follow-up, group A's mortality rate decreased to 31.4%, yet it remained the highest among the groups. Group B and group C's 1-year mortality rates were observed at 28.6% and 25.6%, respectively (Figure 3, Table 2).

Major Adverse Cardiovascular Events

When evaluating the incidence of MACEs at the 1-year mark, group A again demonstrated the highest rate at 56.9%. Group C followed with an incidence rate of 32.6%, and group B reported the lowest incidence at 28.6% (Figure 4, Table 3). This further underscores the potential risks associated with

Table 1. Demographics, Baseline Characteristics, and Clinical Presentation of the Study Population

Characteristic	Group A	Group B	Group C			
Number of Patients (n)	**51**	**63**	**86**	***F***	χ^2	***P***
Average age (years)	65.392 ± 12.562	63.476 ± 11.132	65.919 ± 11.118	0.856		.426
Percentage male (%)	58.824	61.905	54.651		0.804	.669
Hypertension (%)	70.588	74.603	70.930		0.311	.856
Diabetes (%)	50.980	58.730	44.186		3.083	.214
Smoking history (%)	49.020	33.333	43.023		3.00	.223
VSR size (mm)	8.721 ± 7.902	9.525 ± 4.804	7.542 ± 6.802	1.238		.953
Location of VSR						
Anterior (%)	62.745	58.730	53.488		1.180	.555
Posterior (%)	37.255	41.270	46.512			
Number of coronaries involved						
Single (%)	37.255	36.508	41.860		2.914	.572
Double (%)	23.529	26.984	31.395			
Triple (%)	39.216	36.508	26.744			
Time from AMI to VSR (days)	2.504 ± 0.812	3.001 ± 1.698	3.815 ± 1.207	0.442		.246

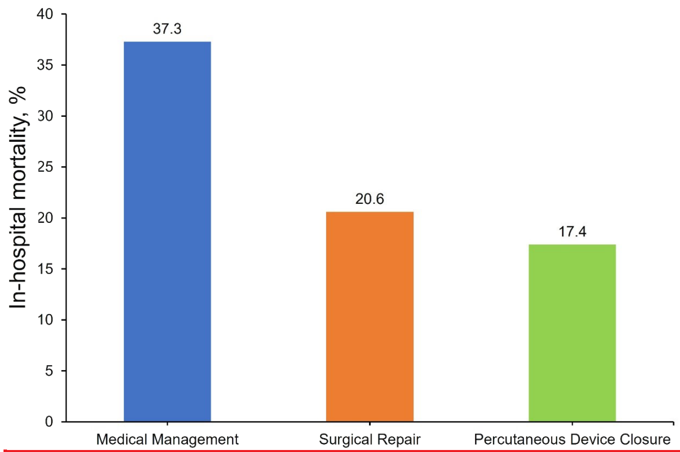

Figure 1. In-hospital mortality across the 3 treatment groups.

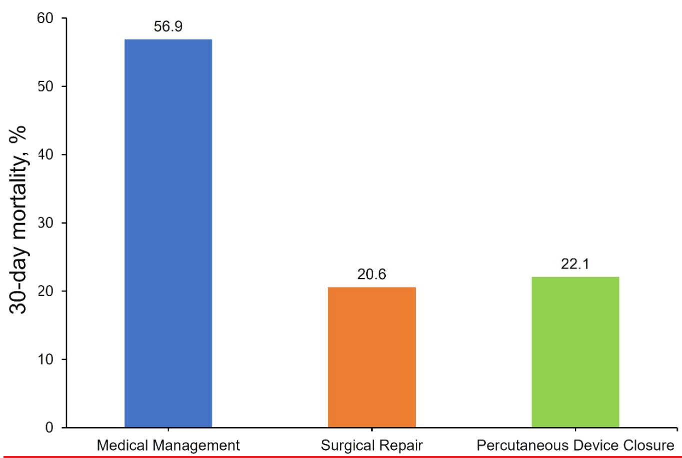

Figure 2. 30-Day mortality across the 3 treatment groups.

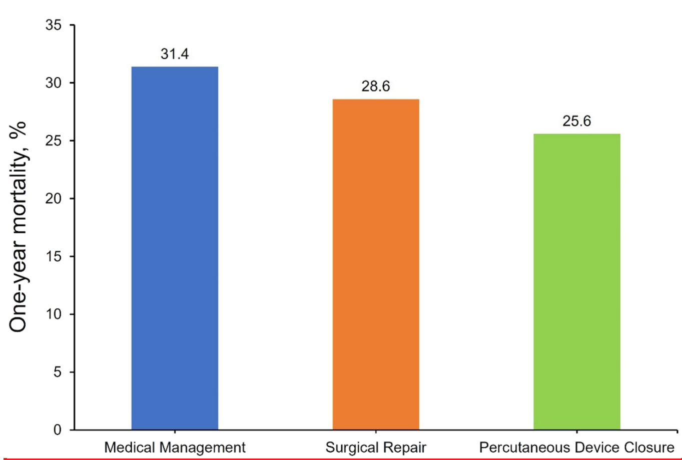

Figure 3. One-year mortality across the 3 treatment groups.

group A, suggesting a more pronounced adverse cardiac event profile when compared to the other groups.

Association of the Clinical Factors with the Outcomes in Each Group

The factors having an association with the outcomes (in-hospital mortality, 30-day mortality, 1-year mortality, MACEs,

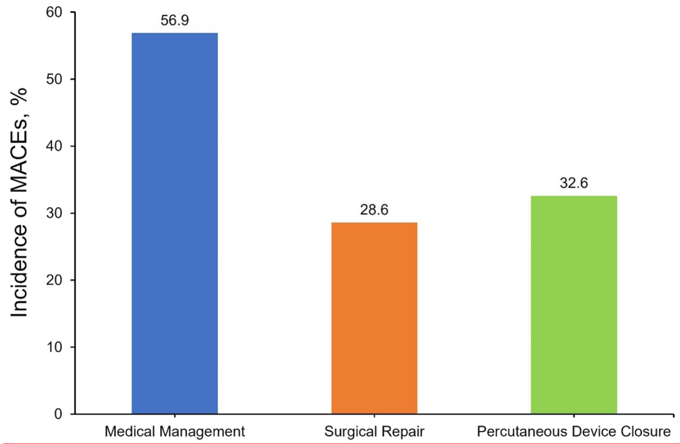

Figure 4. The incidence of MACEs across the 3 treatment groups.

Table 2. Frequency of Mortality

Characteristic	Group A	Group B	Group C	χ^2	*P*
In-hospital mortality (%)	37.255	20.635	17.442	7.411	.025
30-day mortality (%)	56.863	20.635	22.093	22.482	<.0001
1-year mortality (%)	31.373	28.571	25.581	0.5475	.761

Table 3. Frequency of MACEs

Characteristic	Group A	Group B	Group C	χ^2	*P*
MACEs (%)	56.863	28.571	32.558	11.202	.004

hypertension, diabetes, smoking, and VSR size) in each group are described in Tables 4-6, respectively. Hypertension and smoking had a good association with 30-day mortality in group A. Besides, there was no significant correlation among them.

DISCUSSION

The implications of VSR as a dire complication post-AMI have been long acknowledged in cardiological literature. Our study has further amplified this sentiment by providing a detailed, retrospective analysis of different treatment modalities for AMI patients experiencing VSR at a tertiary care center. The emphasis on outcomes not only enhances our understanding of these therapeutic strategies but also highlights critical areas of improvement in the management of these patients.

Our cohort of 200 patients echoed the age and gender trends often observed in the context of cardiovascular disease, with a slightly male-predominant presentation and a mean age in the mid-60s.[16] Notably, the high prevalence of risk factors like hypertension, diabetes, and smoking history, as observed in our study, has been similarly reported in earlier studies, drawing attention to the critical role these factors play in AMI and its complications.[17-19]

Table 4. Association of the Clinical Factors with the Outcomes for Group A

Association of the Clinical Factors with the Outcomes	OR value (95% CI)	P
Age and in-hospital mortality	1.000 (0.955-1.048)	.990
Age and 30-day mortality	0.984 (0.939-1.029)	.475
Age and 1-year mortality	0.989 (0.940-1.037)	.641
Age and MACEs	1.012 (0.968-1.061)	.592
Sex and in-hospital mortality	0.667 (0.208-2.119)	.490
Sex and 30-day mortality	0.981 (0.313-3.033)	.973
Sex and 1-year mortality	0.406 (0.117-1.347)	.144
Sex and MACEs	0.981 (0.313-3.033)	.973
Hypertension and in-hospital mortality	0.848 (0.247-3.027)	.794
Hypertension and 30-day mortality	4.000 (1.156-15.430)	.034
Hypertension and 1-year mortality	0.880 (0.247-3.374)	.846
Hypertension and MACEs	0.559 (0.149-1.909)	.364
Diabetes and in-hospital mortality	1.558 (0.499-5.026)	.448
Diabetes and 30-day mortality	0.563 (0.179-1.712)	.315
Diabetes and 1-year mortality	0.944 (0.286-3.120)	.925
Diabetes and MACEs	2.046 (0.671-6.486)	.213
Smoking and in-hospital mortality	0.316 (0.090-1.013)	.059
Smoking and 30-day mortality	3.506 (1.121-11.850)	.036
Smoking and 1-year mortality	1.527 (0.466-5.172)	.486
Smoking and MACEs	1.778 (0.584-5.594)	.315
VSR size and in-hospital mortality	0.576 (0.275-2.654)	.483
VSR size and 30-day mortality	0.642 (0.125-1.427)	.254
VSR size and 1-year mortality	1.923 (0.483-4.111)	.668
VSR size and MACEs	0.951 (0.2727-4.231)	.944

A striking observation was the considerable mortality disparity across different treatment groups. Medical management, a conservative approach, was associated with the highest rates of in-hospital, 30-day, and 1-year mortalities. This observation contrasts with the considerably more favorable outcomes in the surgical repair and percutaneous device closure groups. The underlying premise for this observation could be multifactorial. Medical management, in the face of such a severe mechanical complication, might only provide symptomatic relief without addressing the root cause, whereas both surgical and percutaneous interventions aim to repair the defect and restore hemodynamic stability.[20-22]

Table 5. Association of the Clinical Factors with the Outcomes for Group B

Association of the Clinical Factors with the Outcomes	OR Value (95% CI)	P
Age and in-hospital mortality	0.956 (0.899-1.011)	.128
Age and 30-day mortality	1.040 (0.983-1.107)	.184
Age and 1-year mortality	1.021 (0.971-1.076)	.430
Age and MACEs	1.012 (0.968-1.061)	.592
Sex and in-hospital mortality	0.656 (0.189-2.320)	.503
Sex and 30-day mortality	0.442 (0.124-1.527)	.195
Sex and 1-year mortality	1.333 (0.433-4.425)	.623
Sex and MACEs	1.333 (0.433-4.425)	.623
Hypertension and in-hospital mortality	2.357 (0.545-16.440)	.269
Hypertension and 30-day mortality	2.437 (0.842-5.440)	.459
Hypertension and 1-year mortality	4.000 (0.964-27.410)	.057
Hypertension and MACEs	0.946 (0.286-3.447)	.929
Diabetes and in-hospital mortality	1.159 (0.337-4.302)	.817
Diabetes and 30-day mortality	1.159 (0.337-4.302)	.817
Diabetes and 1-year mortality	0.441 (0.141-1.334)	.147
Diabetes and MACEs	0.607 (0.199-1.841)	.375
Smoking and in-hospital mortality	1.328 (0.354-4.650)	.662
Smoking and 30-day mortality	1.328 (0.354-4.650)	.662
Smoking and 1-year mortality	1.000 (0.299-3.130)	>.999
Smoking and MACEs	0.697 (0.195-2.228)	.555
VSR size and in-hospital mortality	0.866 (0.278-1.624)	.635
VSR size and 30-day mortality	1.804 (0.857-3.579)	.601
VSR size and 1-year mortality	2.002 (0.825-4.181)	.668
VSR size and MACEs	0.785 (0.227-6.511)	.824

The comparable efficacy of percutaneous device closure with the more traditional surgical repair route is a testament to the evolving landscape of interventional cardiology.[23,24] While surgical repair has been a trusted modality, the risks associated with surgery, especially in the backdrop of recent AMI, are significant. The similar outcomes observed with percutaneous device closure suggest its potential as a safer, less invasive alternative, particularly for patients deemed high-risk for surgical intervention.[25,26]

Our study also indicated a significant rate of MACEs at the 1-year mark, particularly in the medically managed group. This observation underscores the chronic repercussions of VSR post-AMI and the overarching need for comprehensive, long-term follow-up, encompassing pharmacotherapy and lifestyle modifications.[27]

There was no difference in the VSR size and location of VSR among the 3 groups in our study. Consistent with a previous study,[28] this study also observed no significant relation between VSR size and in-hospital mortality. A

Table 6. Association of the Clinical Factors with the Outcomes for Group C

Association of the Clinical Factors with the Outcomes	OR Value (95% CI)	*P*
Age and in-hospital mortality	0.954 (0.901-1.005)	.086
Age and 30-day mortality	1.002 (0.956-1.050)	.934
Age and 1-year mortality	1.012 (0.968-1.058)	.595
Age and MACEs	0.965 (0.922-1.006)	.093
Sex and in-hospital mortality	0.701 (0.227-2.208)	.535
Sex and 30-day mortality	1.157 (0.411-3.458)	.785
Sex and 1-year mortality	1.564 (0.575-4.579)	.393
Sex and MACEs	1.016 (0.406-2.601)	.974
Hypertension and in-hospital mortality	7.149 (1.314-133.3)	.065
Hypertension and 30-day mortality	1.191 (0.395-4.084)	.765
Hypertension and 1-year mortality	1.126 (0.395-3.532)	.830
Hypertension and MACEs	0.804 (0.304-2.198)	.663
Diabetes and in-hospital mortality	0.813 (0.249-2.496)	.720
Diabetes and 30-day mortality	0.368 (0.109-1.081)	.082
Diabetes and 1-year mortality	1.071 (0.399-2.841)	.890
Diabetes and MACEs	0.923 (0.367-2.288)	.863
Smoking and in-hospital mortality	0.419 (0.108-1.355)	.167
Smoking and 30-day mortality	1.254 (0.444-3.510)	.666
Smoking and 1-year mortality	0.890 (0.325-2.363)	.816
Smoking and MACEs	1.888 (0.760-4.767)	.171
VSR size and in-hospital mortality	1.257 (0.885-2.854)	.657
VSR size and 30-day mortality	1.268 (0.823-3.128)	.488
VSR size and 1-year mortality	0.882 (0.685-1.179)	.567
VSR size and MACEs	0.932 (0.726-1.532)	.862

OR: odds ratio.

similar phenomenon was also detected between VSR size and 30-day mortality or 1-year mortality, respectively.

There were several limitations in our study. The retrospective design raises concerns regarding potential biases and a lack of causal interpretations. The lack of randomization in treatment modality selection might have introduced treatment selection bias. Additionally, the findings, based on a single tertiary center's experience, could have limitations in generalizability.

CONCLUSION

Our study provides critical insights into the clinical outcomes associated with different therapeutic interventions for AMI complicated by VSR. Notably, both surgical repair and device closure were associated with significantly better survival outcomes compared to medical management alone, emphasizing the crucial role of timely and appropriate interventions. Moreover, our results underscore the importance of robust, long-term follow-up strategies to manage the high risk of MACEs in this patient population. While the primary focus should be on providing immediate and effective intervention for VSR, equal emphasis should be placed on long-term management to prevent future cardiovascular events.

Ethics Committee Approval: The study received approval from the Ethics Committee of Changsha First Hospital, approval number 2023LY150 (November 8, 2023).

Informed Consent: Written informed consent was obtained from the patients who agreed to take part in the study.

Peer-review: Externally peer-reviewed.

Author Contributions: Z.C.H. and Z.F.W. designed the study, conducted the experiments, and prepared the manuscript. B.D. and Q.X.L. collected and analyzed the data. All authors reviewed and approved the final manuscript.

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