Původní sdělení | Original research article

Surgical Repair of Post-Infarction Ventricular Septal Rupture with or without Concomitant Coronary Artery Bypass Grafting: A Systematic Review and Meta-Analysis of Outcomes and Prognostic Implications

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ARTICLE INFO

Article history:
Submitted: 21. 9. 2025
Accepted: 13. 10. 2025
Available online: 4. 12. 2025

Klíčová slova:
Intervence po infarktu myokardu
Kardiochirurgie
Koronární bypass
Ruptura komorového septa

SOUHRN

Úvod: Ruptura komorového septa (ventricular septal rupture, VSR) po infarktu myokardu představuje vzácnou, nicméně fatální komplikaci vyžadující urgentní chirurgické řešení. Přínos současného provedení koronárního bypassu (CABG) je sporný. Zatímco u pacientů s ischemickou chorobou srdeční může CABG zachránit životaschopný myokard, zvyšuje CABG náročnost celé chirurgické intervence a prodlužuje dobu ischemie. Cílem tohoto přehledu bylo zjistit, jak ovlivní provedení CABG během korekce VSR prognózu.
Metody: Podle doporučených postupů PRISMA byl proveden systematický přehled literatury v databázích PubMed, ScienceDirect, BMC a Springer. Do přehledu byly zařazeny studie popisující výsledky chirurgického řešení VSR se současným provedením CABG, případně bez tohoto výkonu. Primárním sledovaným parametrem bylo přežití, hodnocené pomocí metaanalýzy; pozornost byla věnována i prognostickým proměnným.
Výsledky: V uvedených databázích vyhledal systematický přehled 12 retrospektivních studií zahrnujících 2 050 pacientů; z tohoto počtu byl u 857 z nich současně proveden CABG, zatímco u 1 193 pacientů provedena pouze korekce VSR. Vstupní demografické údaje byly víceméně srovnatelné, i když u pacientů s CABG bylo častěji přítomno postižení několika tepen současně. Převládající technikou intervence byl uzávěr záplatou. Provedení CABG sice bylo spojeno s delší dobou zasvorkování, ne však s vyšší incidencí perioperačních komplikací. Příhody související s přežitím se vyskytly u 547/857 (63,8 %) pacientů s CABG oproti 780/1193 (65,4 %) pacientů bez CABG. Souhrnný poměr šancí pro přežití byl 1,02 (95% interval spolehlivosti [CI] 0,84–1,24; p = 0,83) při zanedbatelné heterogenitě (I^2 = 0 %). Z uvedených zjištění vyplývá, že provedení CABG během korekce VSR je bezpečné a u pacientů s komplexní ischemickou chorobou srdeční je potenciálně přínosné, i když delší doba operace může u starších jedinců nebo osob v nestabilizovaném stavu znamenat jisté riziko.
Závěr: Provedení CABG během korekce VSR sice není z hlediska přežití obecně významně přínosné, je však bezpečné, zvláště u pacientů s postižením několika tepen současně. O konkrétním postupu je třeba rozhodovat individuálně a pro další zdokonalení léčebných strategií je nutno provést další prospektivní studie.

Keywords:
Cardiac surgery
Coronary artery bypass grafting
Post-myocardial infarction
Ventricular septal rupture

ABSTRACT

Introduction: Post-myocardial infarction ventricular septal rupture (VSR) is a rare but fatal complication that requires urgent surgical repair. The benefit of adding concomitant coronary artery bypass grafting (CABG) remains controversial. While CABG may protect viable myocardium in patients with coronary artery disease, it also increases operative complexity and ischemic time. This review evaluates the prognostic impact of concomitant CABG during VSR repair.
Methods: A systematic literature search was conducted in PubMed, ScienceDirect, BMC, and Springer databases according to PRISMA guidelines. Studies reporting surgical VSR repair with and without CABG were included. The primary endpoint was survival, analysed through meta-analysis, and prognostic variables were also reviewed.
Results: Twelve retrospective studies involving 2,050 patients were identified, including 857 who underwent concomitant CABG and 1,193 who had isolated VSR repair. Baseline demographics were broadly comparable, although CABG patients more frequently presented with multivessel disease. Patch closure was the predominant repair technique. CABG was associated with longer cross-clamp times but not with higher

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DOI: 10.33678/cor.2025.108

Please cite this article as: Irawan E, Sembiring YE. Surgical Repair of Post-Infarction Ventricular Septal Rupture with or without Concomitant Coronary Artery Bypass Grafting: A Systematic Review and Meta-Analysis of Outcomes and Prognostic Implications. Cor Vasa 2025;67:677–685.

perioperative complications. Survival events occurred in 547/857 (63.8%) of CABG patients versus 780/1,193 (65.4%) without CABG. The pooled odds ratio for survival was 1.02 (95% CI, 0.84–1.24; $p = 0.83$), with negligible heterogeneity ($I^2 = 0\%$). These findings suggest concomitant CABG can be performed safely, with potential value in patients with complex coronary disease, although increased operative time may pose risk in elderly or unstable individuals.

Conclusion: Concomitant CABG during VSR repair does not provide a universal survival advantage but remains a safe option, particularly for patients with multivessel disease. Surgical decisions should be individualized, and further prospective studies are needed to refine treatment strategies.

Introduction

Post-myocardial infarction ventricular septal rupture (VSR) is a rare but life-threatening mechanical complication that carries very high operative mortality. Prompt surgical repair remains the standard therapy for post-infarction VSR. The role of adding concomitant coronary artery bypass grafting (CABG) to VSR repair is controversial. On one hand, revascularization may provide long-term myocardial protection in patients with significant coronary artery disease. On the other hand, CABG entails additional grafting and ischemic time, potentially increasing operative complexity and risk, particularly in hemodynamically unstable patients. This study evaluates concomitant CABG that provides additional clinical improvement in terms of survival outcome undergoing surgical repair of post-infarction VSR considering prognostic implications.

Materials and methods

Search strategy and data sources

A comprehensive literature search was conducted in accordance with PRISMA 2020 guidelines. PubMed, Science Direct, BMC, and Springer databases were systematically searched for studies published between January 1, 2000, and March 31, 2024, using the following search terms: "ventricular septal rupture", "post-myocardial infarction", "CABG", "coronary artery bypass", "surgical repair", and "outcomes". Boolean operators („AND", „OR") were applied to optimize the search. The full search strategy is available in the **Supplementary Table 1**. Only studies published in English were considered.

Eligibility criteria

Studies were included if they: (1) Reported patients undergoing surgical repair of post-infarction VSR, (2) compared outcomes with and without concomitant CABG, (3) provided perioperative and survival data. Exclusion applied to non-original studies, case reports, editorials, reviews, abstracts without full-text, and animal studies; paediatric cohorts, and those lacking relevant outcome measures.

Study selection and quality assessment

Two reviewers independently extracted study characteristics and patient-level data, which were cross-verified by a third reviewer. Extracted variables included: study design, country of origin, sample size, and baseline demographics, surgical details (type of VSR repair, concomitant CABG, cross-clamp time, number of bypass grafts), angiographic data, preoperative ventricular function, and postoperative outcomes.

Risk of bias was assessed using the Newcastle-Ottawa Scale (NOS) for cohort studies. Studies scoring ≥7 were considered high quality.

Outcome measures

The primary endpoint was in-hospital survival. Secondary outcomes included: long-term mortality, residual VSR rate, relationship of CABG with operative duration and LVEF, prognostic factors including comorbidities and coronary anatomy.

Statistical analysis

Statistical analyses were conducted using RevMan version 5.4. Risk ratios (RR) with 95% confidence intervals (CI) were calculated for dichotomous outcomes, applying a random-effects model (DerSimonian–Laird method). Heterogeneity was quantified using I^2, with >50% considered significant. Sensitivity analyses were performed by sequential exclusion of individual studies. Funnel plots and Egger's regression were applied to assess publication bias.

Results

Study selection

The systematic search identified 1,934 records: ScienceDirect (n = 1,413), PubMed (n = 97), BMC (n = 27), and Springer (n = 397). After removal of 696 duplicates, 1,228 records were screened. A total of 1,198 were excluded due to study design (n = 383), population (n = 281), intervention (n = 365), publication type (n = 157), or language (n = 12). Thirty full-text reports were sought for retrieval; 7 were not accessible, and 11 were excluded for irrelevant outcomes or interventions. Finally, twelve studies involving 2,050 patients were included in the systematic review and meta-analysis (**Fig. 1**). Moreover, all included studies were scored ≥7 in NOS and considered high quality studies (**Supplementary Table 1**).

Study characteristics

Twelve studies comprising 2,050 patients were included in the review (**Table 1**). Of these, 857 (41.8%) underwent concomitant CABG, while 1,193 (58.2%) underwent isolated VSR repair. Most were retrospective observational studies, with one registry-based analysis.[1] Study sizes ranged from 10 to 1,397 patients, with geographic distribution across Europe,[1–5] Asia,[1,5–7] Australia (Wiemers et al., 2012),[8] and multi-institutional cohorts.[9,10]

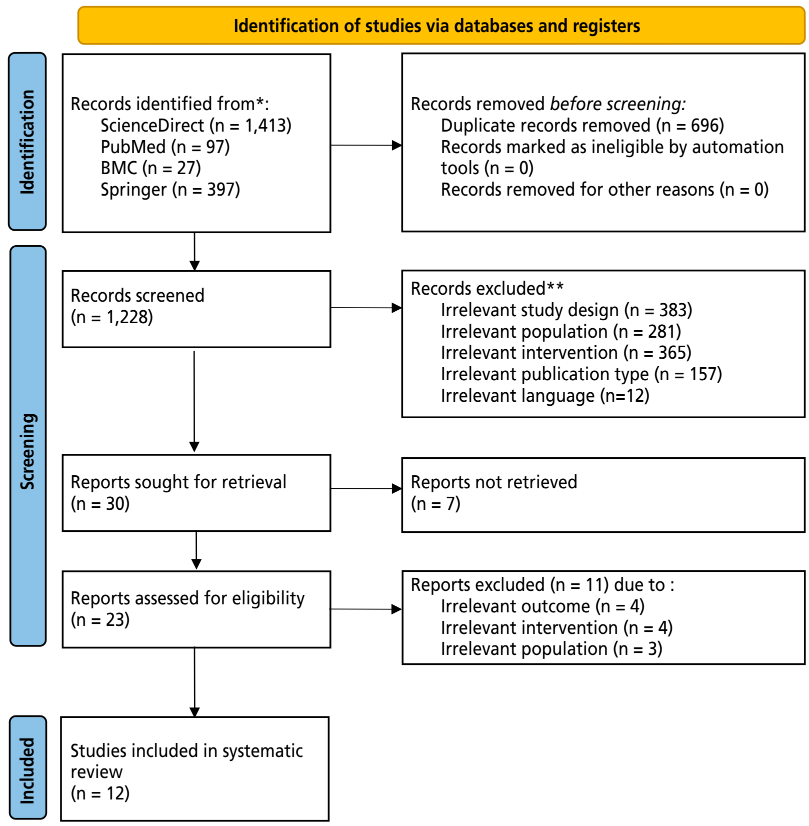


Fig. 1 – PRISMA 2020 flow diagram for included studies[20]
* Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers).
** If automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools.

Baseline demographics and clinical characteristics

The mean age of patients ranged from 61 to 74 years, and women accounted for 28–66% of study populations. Comorbidities were frequent: diabetes was reported in 16–50%, hypertension in 43–74%, hyperlipidemia in 15–46%, and smoking history in 19–35% of patients (**Table 1**).

Several studies reported comparable baseline risk factors between groups.[2,3,6–8] By contrast, Fukushima[4] and Huang[5] observed that multivessel CAD was significantly more common in CABG patients (up to 69%) compared with those undergoing isolated repair. Similarly, Sakaguchi[1] showed that CABG patients had a greater coronary disease burden, while age, sex distribution, and other comorbidities remained balanced across groups.

Surgical procedures and operative findings

Surgical procedures and the outcomes were demonstrated differently in every studies (**Table 2**). Patch closure was used in approximately 80–90% of cases, whereas infarct exclusion was performed in about 10–12% and direct closure in less than 5% [7,10]. The addition of CABG was associated with longer operative times: Fukushima (2010)[4] reported a mean cross-clamp time of 92 minutes with CABG vs. 68 minutes without, while Huang (2015)[5] observed 108 vs. 82 minutes, both reaching statistical significance. Takahashi (2015)[11] confirmed that although CABG prolonged ischemic time, this did not translate into higher operative mortality.

The rate of residual VSR after repair ranged from 9–12%, with no significant difference between CABG and non-CABG groups[6,8]. Reoperation and complication rates were also comparable in the registry analysis[1]. Overall, the data suggest that CABG adds technical complexity but does not increase early postoperative complication rates.

Prognostic factors

Fukushima (2010) identified preoperative shock and low LVEF (<40%) as significant predictors of mortality, while CABG was not independently associated with outcome. In line with this, Huang (2015)[5] reported that cardiogenic shock on admission carried a mortality exceeding 60%, whereas CABG status itself was not prognostic.

Takahashi (2015) demonstrated that advanced age (>70 years) and impaired ventricular function were significantly linked with long-term mortality, independent of surgical strategy. Malhotra (2017) emphasized surgical timing, noting that early repair (within 7 days) was associated with operative mortality above 50%, while delayed repair after stabilization yielded improved survival.

In a high-risk cohort, Vondran[9] found that patients requiring mechanical circulatory support had survival rates of only 30–40%, making circulatory support the dominant prognostic factor. Meanwhile, CABG did not emerge

Table 1 –Study characteristics

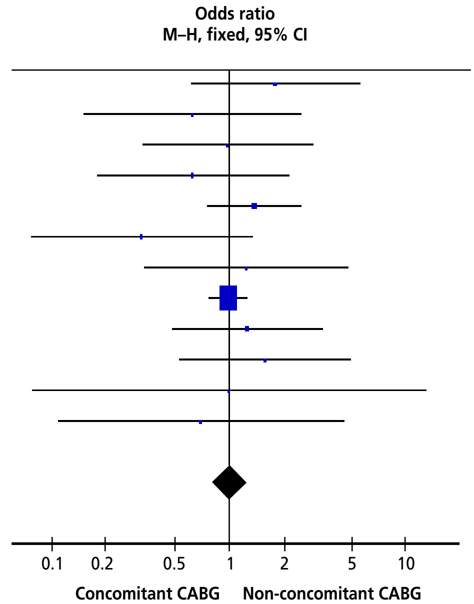
No	Study	Study type	Country	Sample (n)	Participant		Female (n/%)		Mean age at enrollment	BMI >30 (kg/m²)		Diabetes mellitus		Hypertension		Hyperlipidemia		Smoker		Concomitant CABG	
					Survivor	Non--survivor	Survivor	Non--survivor		Survivor	Non--survivor	Survivor	Non--survivor	Survivor	Non--survivor	Survivor	Non--survivor	Survivor	Non--survivor	Survivor	Non--survivor
1	Takashi et al., 2014	Retrospective study	Germany	52	33 (63.6%)	19 (36.54%)	19 (66%)	6 (32%)	67 ± 10	N/A	N/A	13 (39%)	8 (42%)	24 (73%)	13 (68%)	N/A	N/A	N/A	N/A	17 (59%)	16 (84%)
2	Fukushima et al., 2010	Prospective study	Australia	68	44 (64.71%)	24 (35.29%)	14 (32%)	5 (21%)	66.3 ±9.2	N/A	N/A	7 (16%)	6 (25%)	28 (64%)	13 (54%)	N/A	N/A	N/A	N/A	31 (71%)	17 (71%)
3	Huang et al., 2015	Retrospective study	Taiwan	47	30 (63.83%)	17 (36.17%)	12 (40%)	7 (41,2%)	68.9 ± 9.5	N/A	N/A	15 (50%)	6 (35.3%)	21 (70%)	8 (47.1%)	N/A	N/A	7 (23.3%)	7 (41.2%)	16 (53.3%)	11 (64.7%)
4	Dogra et al., 2019	Retrospective study	India	35	19 (54.29%)	16 (45.71%)	6 (32%)	10 (63%)	61±10	N/A	N/A	7 (37%)	8 (50%)	14 (74%)	14 (88%)	N/A	N/A	N/A	N/A	11 (58%)	11 (69%)
5	Wiemers et al., 2012	Retrospective study	Australia	10	4 (40.00%)	6 (60.00%)	5 (50%)		65.3 ± 7.6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2 (50%)	3 (50%)
6	Sakaguchi et al., 2019	Retrospective study	Japan	1397	936 (67.00%)	461 (33.00%)	470 (50.2%)	256 (55.5%)	74.1±9.3	31 (3.3%)	21 (4.6%)	316 (33.8%)	165 (35.8%)	625 (66.8%)	296 (64.2%)	342 (36.5%)	126 (27.3%)	217 (23.2%)	87 (18.9%)	317 (33.9%)	158 (34.3%)
7	Pang et al., 2013	Retrospective study	Singapore	38	23 (60.53%)	15 39,47%	12 (52.1%)	6 (40%)	65.7 ± 9.4	N/A	N/A	8 (34.8%)	4 (26.7%)	16 (69.6%)	10 (66.7%)	9 (39.1%)	5 (33.3%)	8 (34.8%)	8 (53.3%)	12 (52.2%)	7 (46.7%)
8	Vondran et al., 2020	Retrospective study	Germany	53	23 (43.40%)	30 (56.60%)	8 (15.1%)	15 (28.3%)	68.9 ± 9.1	N/A	N/A	5 (9.4%)	7 (13.2%)	19 (35.8%)	21 (39.6)	11 (20.8%)	10 (18.9%)	8 (15.1%)	3 (5.7%)	8 (15.1%)	13 (24.5%)
9	Malhotra et al., 2017	Retrospective--prospective study	India	40	19 (47.50%)	21 (52.50%)	3 (15.7%)	11 (52.3%)	61.6 ± 7.5	N/A	N/A	6 (31.6%)	10 (47.6%)	9 (47.4%)	12 (57.1%)	N/A	N/A	8 (42.1%)	5 (23.8%)	11 (57.8%)	17 (80.9%)
10	Yam et al., 2013	Retrospective--prospective study	China	40	32 (80.00%)	8 (20.00%)	24 (60%)		68.5 ± 6.9	N/A	N/A	14 (35%)		21 (53%)		8 (20%)		12 (30%)		6 (19%)	2 (25%)
11	Barker 2003	Retrospective--prospective study	UK	65	45 (69.23%)	20 (30.77%)	25 (38.4%)		64.2 ± 3.7	N/A	N/A	8 (12.3%)		28 (43%)		10 (15.3%)		17 (26.1%)		31 (68.9%)	11 (55.0%)
12	Jeppsson et al., 2005	Retrospective--prospective study	Sweden	189	112 (59.3%)	77 (40.7%)	41 (36.6%)	29 (37.7%)	69±8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	74 (66%)	45 (58%)

Table 2 – Study Outcomes of concomitant versus non-concomitant CABG in post-infarction VSR repair

No	Study	Type of VSR repair	Concomitant CABG		Angiographic data		LVEF <40%		Number of bypass		Residual VSD	
			With	Without	Survivor	Non-survivor	Survivor	Non-survivor	Survivor	Non-survivor	Survivor	Non-survivor
1	Takashi et al., 2014	Ventricular septal defects were closed with buttressed mattress sutures without a patch: 7 Dacron or polytetrafluoroethylene patches: 40	43	9	3VD: 8 (24%)	3VD: 11 (58%)	19 (58%)	16 (84%)	1.0 ± 0.2	1.4 ± 0.9	N/A	N/A
2	Fukushima et al., 2010	Patch	48	20	3VD: 16 (37%) Complete occlusion of LAD: 23 (54%)	3VD: 6 (27%) Complete occlusion of LAD: 7 (32%)	14 (32%)	16 (67%)	Greater than 3 bypass grafts: 3 (7%)	Greater than 3 bypass grafts: 2 (8%)	N/A	N/A
3	Huang et al., 2015	Septal patch	27	20	SVD: 12 (40%) DVD: 4 (13.3%) TVD: 14 (46.7%)	SVD: 4 (23.5%) DVD: 6 (35.3%) TVD: 7 (41.2%)	LVEF: 51 ± 13.7	LVEF: 36.6 ± 6.4	N/A	N/A	9 (30%)	7 (41.2%)
4	Dogra et al., 2019	Direct closure: 2 Septal patch: 7 Infarct exclusion: 26	22	13	Culprit vessel LM: 0 Culprit vessel LAD: 16 (84%) Culprit vessel LCX: 0 Culprit vessel RCA No. of diseased vessels: 2 (11%)	Culprit vessel LM : 0 Culprit vessel LAD: 13 (81%) Culprit vessel LCX: 1 (6%) Culprit vessel RCA No. of diseased vessels: 3(19%)	LVEF: 33 ± 7	LVEF: 33 ± 12	N/A	N/A	N/A	N/A
5	Wiemers et al., 2012	Septal patch: 6 Infarct exclusion : 4	5	5	N/A	N/A	(LVEF) >60%: 6 LVEF 30–45%: 2 LVEF < 30%: 2		N/A	N/A	3(75%)	3(50%)
6	Sakaguchi et al., 2019	N/A	475	922	3VD: 126 (13.5%) Culprit vessel LM: 43 (4.6%)	3VD: 103 (22.3%) Culprit vessel LM: 31 (6.7%)	128 (13.7%)	120 (26.0%)	N/A	N/A	N/A	N/A
7	Pang et al., 2013	Infarct exclusion + septal patch: 35 Direct closure: 2	19	18	Multi-vessel coronary artery disease: 13 (56.5%)	Multi-vessel coronary artery disease: 9 (69.2%)	LVEF: 40.3 ± 11.0	LVEF: 39.1 ± 9.4	1.5 ± 0.7		9 (23.7%)	
8	Vondran et al., 2020	N/A	21	24	N/A	N/A	6 (11.3%)	3 (5.7%)	2.0 ± 1.2	1.5 ± 0.7	4 (7.5%)	6 (11.3)
9	Malhotra et al., 2017	Septal patch using Daggett's technique	28	12	SVD: 11 (57.9%) DVD: 6 (31.6%) TVD: 2 (10.5%)	SVD: 7 (33.3%) DVD: 9 (42.9%) TVD: 5 (23.8%)	37.10 ± 7.3	36.90 ± 7.8	N/A	N/A	2 (10.52%)	1 (4.76%)
10	Yam et al., 2013	Septal patch	8	32	Non-single vessel disease: 8 (25%)	Non-single vessel disease: 6 (75%)	55.6	56.0	N/A	N/A	8 (25%)	2 (25%)
11	Barker 2003	Septal patch	42 (64.6%)	23 (35.4%)	One-vessel disease: 19 (29.2%) Two-vessel disease: 22 (33.9%) Three-vessel disease: 24 (37.0%)		<30%: 18 (27.7%)		N/A	N/A	N/A	N/A
12	Jeppsson et al., 2005	N/A	119 (63%)	70 (37%)	N/A	N/A	N/A	N/A	1.3±1.2	1.0±1.1	29 (26%)	14 (29%)

Fig. 2 – Forest plot of survival comparing concomitant versus non-concomitant CABG in post-infarction VSR repair

	Concomitant events		Non-concomitant CABG		Weight	Odds ratio	
Study or subgroup	**Events**	**Total**	**Events**	**Total**		**M–H**	**Fixed, 95% CI**
Barker, 2003	31	42	14	23	2.3 %	1.81	[0.61, 5.35]
Dogra et al., 2019	11	22	8	13	2.4%	0.63	[0.15, 2.52]
Fukushima et al., 2010	31	48	13	20	3.1%	0.98	[0. 33, 2.93]
Huang et al., 2015	16	27	14	20	3.1%	0.62	[0.18, 2.12]
Jeppsson et al., 2005	74	119	38	70	8.7%	1.38	[0.76, 2.52]
Malhotra et al., 2017	11	28	8	12	3.3%	0.32	[0.08, 1.34]
Pang et al., 2013	12	19	11	19	1,9%	1.25	[0.34, 4,59]
Sakaguchi et al., 2019	317	475	619	922	67.3%	0.98	[0.78, 1.24]
Takashi et al., 2014	17	33	16	35	3.6%	1.26	[0.49, 3.27]
Vondran et al., 2020	19	31	11	22	2.4%	1.58	[0.52, 4.78]
Wiemers et al., 2012	2	5	2	5	0.6%	1.00	[0.08–12.56]
Yam et al., 2013	6	8	26	32	1.2%	0.69	[0.11–4.32]
Total (95% CI)		857		1 193	100%	1.02	[0.84, 1. 24]
Total events	547		780				



Heterogeneity $\chi^2 = 6,85$; df 11 (p = 0.81) $I^2 = 0$
Test for overall effect: Z = 0,21 (p = 0.83)

as independently significant in multivariable models. National data from Japan further confirmed that CABG was not an independent predictor once adjusted for confounders, though it was commonly performed in patients with multivessel disease.[1]

Collectively, the prognostic evidence highlights that age, hemodynamic status, LVEF, timing of surgery, and need for mechanical support consistently determined outcomes, while CABG was selectively applied to patients with extensive coronary involvement and may have contributed to stabilizing outcomes in this subgroup.

Survival outcomes

Survival outcomes were reported across all 12 studies and analysed quantitatively. A total of 547/857 (63.8%) patients in the CABG group and 780/1,193 (65.4%) in the non-CABG group survived to discharge or follow-up. Meta-analysis (**Fig. 2**) demonstrated no significant difference in survival between groups with 2% higher odds of survival with concomitant CABG (OR 1.02, 95% CI 0.84–1.24; $p = 0.83$). Statistical heterogeneity was negligible ($I^2 = 0\%$), suggesting consistent results across studies. The pooled analysis indicates that concomitant CABG does not confer a significant survival advantage in the overall population but may remain justified in selected patients with multivessel coronary artery disease.

Despite the neutral pooled effect, several individual studies observed trends favoring CABG in patients with multivessel coronary disease. Fukushima (2010)[4] noted that revascularization improved outcomes in patients with diffuse ischemia, and registry data from Japan indicated that CABG patients tended to have better adjusted outcomes when severe coronary involvement was present[1]. These findings suggest that CABG may provide incremental value in selected patients, even if a uniform survival benefit was not demonstrated across all populations.

Discussion

Ventricular septal rupture (VSR) is an uncommon yet well-documented mechanical consequence of acute myocardial infarction (AMI). The prognosis for VSR remains to be unfavourable, even with the advent of reperfusion treatment.[5] After an initial percutaneous coronary intervention (PCI), VSR was observed to occur in 0.23% to 0.71% of patients.[12]

The management of ventricular septal rupture (VSR) following acute myocardial infarction (AMI) presents a surgical challenge, with a persistently high surgical mortality rate associated with post-infarction VSR. The objective of surgical intervention is to enhance systolic heart function and attain hemodynamic stability. While postinfarction VSR repair has been reported to have a favourable long-term survival rate, congestive cardiac failure and ventricular tachyarrhythmia are known to frequently impede quality of life in the long-term.[4] The mortality rate has remained comparatively consistent at 34–54% over the past two.[5,13] The debate on the necessity of performing coronary artery bypass grafting (CABG) concurrently with the repair of the ventricular septal defect (VSD) has persisted. Evidence indicates that CABG is advantageous in this context.[2,4,7] Nonetheless, findings from other researchers indicate otherwise.[14,15] The current guidelines of the American College of Cardiology and the American Heart Association advocate for prompt surgical intervention in patients with postinfarction ventricular septal rupture, unless further intervention is deemed futile due to the patient's preferences or contraindications to further invasive treatment.[16] The intricate interplay of several parameters, including as the patient's preoperative hemodynamic condition, the location of the VSD, and the diverse surgical procedures employed, constitutes complicating variables in assessing the efficacy of concomitant CABG.

Prognostic factors in surgical management of ventricular septal rupture with and without concomitant coronary artery bypass grafting

A. Cardiogenic shock and left ventricular function

The development of cardiogenic shock remains one of the strongest predictors of short-term mortality in VSR patients. As in Coskun et al.[13] and Fukushima et al.[4], nearly all patients presenting in shock die within 30 days, emphasizing the necessity for early detection and urgent surgical repair before hemodynamic. Similarly, poor left ventricular (LV) function preoperatively has been identified as an independent risk factor for poor outcomes.[4] This suggests that strategies aimed at improving or preserving LV contractility—such as myocardial revascularization via CABG—might improve survival when feasible. In sum, VSR repair outcomes may be substantially improved in patients without cardiogenic shock, and in those with preoperative LV dysfunction, the addition of CABG when coronary anatomy and stability permit could offer an incremental benefit.

B. Surgical timing

Several of the included studies highlight that the timing between myocardial infarction (MI) or ventricular septal rupture (VSR) and surgical repair is a critical determinant of mortality Fukushima et al.[4] report that a short interval from MI onset to surgery is associated with increased 30-day mortality; early presentation likely reflects more extensive myocardial necrosis and poorer tissue quality. Labrousse et al.[15] also recommend early repair in post-infarction ventricular septal defect (VSD), even in patients presenting with cardiogenic shock, though they acknowledge the technical challenges of operating on fragile tissue.

Takahashi et al. (2015) present data showing that survivors had a much longer mean interval between MI and surgery (≈27 ± 25 days) compared to non-survivors (≈5 ± 6 days, p <0.01). In line with this, non-survivors also had shorter hospital admission-to-surgery intervals (~4.9 ± 7.9 days vs ~11.0 ± 8.6 days, p = 0.010), and shorter AMI-to-surgery intervals (~7.9 ± 9.7 days vs ~16.9 ± 9.7 days, p = 0.002), with emergency surgery being much more frequent among non-survivors.[9]

Jeppsson et al.[3] identify "urgent repair" (i.e. surgery performed early after diagnosis) as an independent predictor of 30-day mortality (RR ~4.2, 95% CI ~2.0–8.9; p <0.001), illustrating that earlier surgeries are associated with poorer early survival.

These observations suggest a paradox: while delaying surgery may allow for scar formation and improved tissue quality, prolonged delay is often not possible in unstable patients. Thus, timing represents a trade-off: operating too early carries high risk due to fragile ischemic myocardium and poor patient physiologic reserve; too late, and patients may deteriorate or develop complications (e.g. shock) that worsen outcomes.

C. VSR characteristics

Several studies indicate that the location of the ventricular septal rupture (anterior vs posterior) influences both early mortality and long-term functional outcomes. For example, Jeppsson et al. [3] identified posterior rupture as an independent predictor of increased 30-day mortality (risk ratio ~2.1, p = 0.002), even when adjusting for other variables, whereas anterior ruptures had lower early mortality. Fukushima et al.[4] found that posterior septal rupture was independently associated with higher risk of long-term congestive heart failure, suggesting that posterior defects may cause more complex structural and functional impairment, possibly due to effects on ventricular geometry or the subvalvular apparatus. Other studies, such as Pang et al. ,[7] report that defect location did not significantly influence survival (early or late), or residual/recurrent defect rates, indicating that while posterior location carries greater anatomical challenge, its prognostic impact may be moderated by other factors (e.g. LV function, timing, comorbidities).

From pooled data, posterior VSR tends to carry a higher risk of both early mortality and longer-term cardiac failure, but this risk is not uniform across studies. Therefore, in surgical decision making, defect location should be considered along with timing of surgery, ventricular function, and patient stability. For meta-analysis, it would be informative to stratify subgroups by anterior vs posterior location to assess effect modification.

The role of concomitant coronary artery bypass grafting (CABG) during surgical repair of post-infarction ventricular septal rupture (VSR) remains controversial. Several studies[13,17] found no significant survival benefit from adding CABG, either in early or late outcomes. Similarly, Pang et al.[7] reported no statistically significant survival advantage, although they note that many authors still advocate concomitant CABG when feasible, particularly in patients with multivessel coronary artery disease, with the aim of reducing further ischaemic events through improved collateral flow.

Conversely, Barker[2] demonstrated a marked survival benefit in a multicentre regional cohort: after adjustment for baseline characteristics, the four-year survival rate was 88.2% in patients undergoing VSR repair with CABG compared with 32.2% without, corresponding to a hazard ratio of 0.17 (p = 0.019). In contrast, Takahashi et al.[11] observed no significant influence of CABG on long-term survival, and suggested that the higher baseline severity of coronary lesions and ventricular dysfunction in patients selected for CABG may have offset potential benefits. They nevertheless recommended performing CABG when possible, as a means of limiting future ischaemic risk. Similarly, Yam, Au & Cheng[6] found no survival difference in their small subgroup of patients with multivessel disease.

Taken together, these studies suggest that while routine concomitant CABG does not consistently translate into survival benefit across all patients, selected individuals—particularly those with extensive multivessel disease and preserved stability—may derive long-term advantages. The conflicting evidence highlights the importance of individualized decision-making, balancing the potential benefits of revascularization against the increased operative complexity and risk.

This meta-analysis compared surgical repair of post-infarction ventricular septal rupture (VSR) with and without concurrent coronary artery bypass grafting (CABG), revealing a non-significant 2% increase in survival odds in the CABG cohort (OR ≈ 1.02; 95% CI 0.84–1.24; $p = 0.83$). The heterogeneity was minimal ($I^2 = 0\%$), indicating that the findings were uniform across studies. Thus, in suitably selected patients, concurrent CABG does not appear to compromise mortality and may yield outcomes that are comparable, if slightly superior, to VSR repair alone. The findings correspond with recent literature; Ronco et al.[18] identified no statistically significant difference in early or late mortality when coronary artery bypass grafting (CABG) was incorporated into the surgical care of post-infarction mechanical sequelae, including ventricular septal rupture (VSR). Yousef et al. [19] also observed that long-term outcomes following VSR repair exhibit a slight difference with or without concurrent CABG, though the data are restricted

Complications following surgical repair of post-infarction ventricular septal rupture with and without concomitant coronary artery bypass grafting

Surgical repair of post-infarction ventricular septal rupture (VSR) is lifesaving, but is associated with significant risk of postoperative complications and long-term morbidity. Key complications include arrhythmias (particularly ventricular tachyarrhythmia), residual or recurrent interventricular communication (residual shunt/VSD), and the development or worsening of heart failure. These adverse outcomes not only impact short-term survival but also influence quality of life and long-term prognosis. Understanding the incidence, predictors, and implications of these complications is essential, especially when evaluating the added effect of concomitant coronary artery bypass grafting (CABG) during VSR repair.

A. Arrhythmia

In Fukushima et al.,[4] about 27% of patients who survived to 30 days developed ventricular tachyarrhythmias. Predictors of long-term ventricular tachyarrhythmia included concomitant left ventricular aneurysmectomy and occlusion of the left anterior descending artery, suggesting that extensive infarction with full-thickness scar formation is a critical substrate for arrhythmogenesis.

B. Residual or recurrent shunts / re-intervention

Residual interventricular communication is relatively common. For example, in Fukushima et al.,[4] 32% of patients had residual shunts, of whom about half required further intervention. The risk is that progressive necrosis near the patch suture line may lead to dehiscence and recurrent shunting. Wiemers et al.[8] similarly reported 60% residual VSD postoperatively in a subgroup, with half the patients dying within 30 days; of those surviving to discharge, some required reoperation. Yam, Au & Cheng[6] also found residual shunts in 25% of patients, though redo operations were rare; they noted emergency operations had a trend (though not statistically significant) toward more frequent residual defects.

C. Heart failure

One of the consistent findings across studies is that pre--operative patient factors such as hypertension, residual interventricular communication (residual shunt), depressed left ventricular ejection fraction (LVEF <40%), and incomplete coronary revascularization are strong predictors of both early mortality and long-term heart failure after surgical repair of ventricular septal rupture (VSR). Fukushima et al. reported that among 30-day survivors, 46 % went on to develop congestive cardiac failure; key predictors of long-term failure included a history of hypertension, presence of residual interventricular communication, and pre-operative LVEF less than 40 %—likely reflecting existing myocardial disease or necrotic/hibernating myocardium (Fukushima et al., 2010). In Takahashi et al.,[11] which evaluated 52 surgically-repaired VSR patients over 30 years, incomplete coronary revascularization was identified via multivariate analysis as the only independent risk factor for 30-day mortality, among several univariate predictors including three-vessel disease, significant stenoses, emergency surgery, protean ischemia and bypass

These results suggest that, while surgical repair is mandatory, outcomes may be substantially improved in patients with less comorbidity, better pre-operative ventricular function, no residual shunt, and in whom complete revascularization is achievable. In the context of concomitant CABG, maximizing completeness of revascularization may be especially important. Thus, patient selection—and optimizing revascularization strategy—are likely critical determinants of whether CABG adds survival benefit beyond VSR repair alone.

A key strength of this meta-analysis lies in its sizeable combined sample (approximately 2,050 patients from twelve retrospective studies), which enhances statistical power relative to individual single-centre investigations. Baseline characteristics between the CABG and non-CABG groups were largely comparable, which mitigates selection bias, and the observed low heterogeneity in survival outcomes supports the robustness of the pooled estimate.

Nevertheless, several limitations warrant consideration. All included studies were retrospective, rendering them susceptible to selection bias—for example, surgeons may have been more likely to perform CABG in patients with more favourable anatomy or lower operative risk. Important prognostic data were variably reported or missing, such as interval from myocardial infarction to VSR repair, severity of cardiogenic shock, use of mechanical circulatory support, myocardial viability assessment, and degree of revascularization. Moreover, definitions of survival differed across studies (in-hospital, 30-day, long term), as did durations of follow-up. Late mortality and long-term morbidity (e.g. heart failure, recurrent ischemic events) were often inadequately captured. Finally, there was substantial variability across studies in surgical technique, myocardial protection strategies, perioperative care, and the operative era, all of which may influence outcomes even when early survival appears similar.

Conclusion

In conclusion, this meta-analysis shows that concomitant CABG with surgical VSR repair yields a non-significant but slightly higher survival compared to repair alone. CABG does not appear to detract from early survival when patients are appropriately selected. Nevertheless, given the trade-offs in operative complexity, the decision should be individualized, considering coronary anatomy, ventricular function, and patient stability. Further high-quality, prospective research is needed to clarify which patient subgroups derive the most benefit and to develop more precise clinical guidelines.

Supplementary material is available online.

Conflict of interest
The authors declare that they have no conflicts of interest related to this study.

Funding
This research received no external funding.

Ethical statement
This study is a systematic review and meta-analysis using previously published data. Therefore,
ethical approval was not required as no individual patient data were accessed or analyzed.

Informed consent
Informed consent was not required for this study because all data were obtained from
previously published articles with no identifiable patient information.

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