

Minithoracotomy approach for redo mitral valve surgery: Feasibility, operative outcomes, and comparative analysis of myocardial protection techniques



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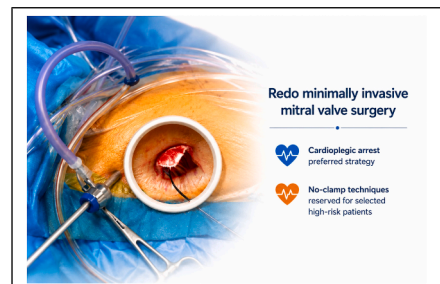
ABSTRACT

Objective: Redo mitral valve surgery (MVS) poses technical challenges and high operative risks as the result of adhesions and sternal re-entry. Right minithoracotomy has emerged as an alternative to repeat sternotomy. This study evaluated feasibility and perioperative outcomes of redo MVS through right minithoracotomy and compared 3 different myocardial protection strategies: cardioplegia, ventricular fibrillation (VF), and beating-heart.

Methods: All patients who underwent redo MVS via right minithoracotomy between 2015 and 2023 were identified from the Mini-Mitral International Registry. The primary end point was in-hospital mortality. Secondary end points included stroke, low cardiac output, bleeding requiring revision, conversion to sternotomy, and major complications. Moreover, 3 myocardial protection strategies were analyzed: cardioplegic arrest ($n = 373$), VF ($n = 105$), and beating-heart ($n = 24$).

Results: A total of 502 patients were included (median age 68 years). Overall in-hospital mortality was 7.6% (4.1% in elective and 24.4% in urgent cases). Conversion to sternotomy occurred in 3%. Stroke rate was 2.8% and reoperation for bleeding was 8.8%. After adjustment, VF was independently associated with a greater risk of low cardiac output (adjusted odds ratio, 3.5; $P = .004$). Beating-heart surgery was associated with increased in-hospital mortality (adjusted odds ratio, 6.6; $P = .02$). No significant association was observed between myocardial protection strategy and stroke or major complications.

Conclusions: Redo MVS via right minithoracotomy is feasible and safe in experienced centers. Cardioplegic arrest was associated with more favorable early outcomes and should be considered the default myocardial protection strategy whenever feasible. No-clamp techniques remain valuable in selected high-risk scenarios but are associated with trade-offs that warrant careful patient selection. (JTCVS Techniques 2026;39:102509)



Right minithoracotomy is a feasible approach for redo mitral valve surgery.

CENTRAL MESSAGE

Redo mitral surgery via right minithoracotomy is feasible in selected patients; cardioplegia offers the best myocardial protection, reducing mortality and low cardiac output compared with VF or beating heart.

PERSPECTIVE

Redo minimally invasive mitral surgery via right minithoracotomy is feasible in selected patients. Cardioplegia provides superior myocardial protection, whereas VF and beating-heart strategies should be reserved for high-risk or clamp-contraindicated patients. Patient factors and procedural complexity remain key determinants of outcomes.

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Abbreviations and Acronyms

IQR	= interquartile range
LCO	= low cardiac output
MMIR	= Mini Mitral International Registry
MVS	= mitral valve surgery
VF	= ventricular fibrillation

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Redo mitral valve surgery (MVS) remains one of the most demanding procedures in cardiac surgery.¹ Adhesions, altered anatomy, and risk of catastrophic injury during re-sternotomy contribute to increased morbidity and mortality.^{2,3} Minimally invasive right minithoracotomy approaches have gained widespread adoption because they avoid sternal re-entry, limit dissection, and may reduce transfusions and hospital stay.⁴

Despite these advantages, redo MV operations still carry notable risks, and optimal myocardial protection remains debated.⁵ Cardioplegic arrest provides excellent myocardial preservation but requires ascending aortic occlusion (either via external crossclamping or endoaortic balloon occlusion), whereas ventricular fibrillation (VF) and beating-heart strategies avoid aortic manipulation at the expense of potentially suboptimal protection. This study, on the basis of data from the Mini-Mitral International Registry (MMIR), aimed to evaluate the feasibility and perioperative outcomes of redo MVS performed via right minithoracotomy and to assess the influence of myocardial protection strategies on operative results.

METHODS**Ethical Statement**

The study protocol was approved by the local institutional review board of all centers based on the approval of the coordinating center (no. 2020189, July 30, 2020). Consent of patients was waived for the retrospective phase, whereas it was obtained for the patients enrolled prospectively.

Study Design and Population

We retrospectively analyzed all patients who underwent redo MVS through right minithoracotomy between 2015

and 2023, as recorded in the MMIR, an independent registry involving 17 international Heart Valve Centers worldwide. Data completeness and quality control were integral components of the MMIR protocol from its inception and have been previously described.⁶ The centers combined all consecutive patients who received minimally invasive MVS with or without associated procedures. Perioperative characteristics and in-hospital outcomes of patients were collected according to the current European Society of Cardiology or American College of Cardiology/American Heart Association/Heart Rhythm Society Guidelines,⁷ European System for Cardiac Operative Risk Evaluation II model,⁸ and Mitral Valve Academy Research Consortium end-point definitions.⁹

Three myocardial protection strategies were used: (1) cardioplegia arrest in 373 cases, using either crystalloid (76%) or hematic (23%) cardioplegia, with either external clamp (53%) or endoclamp (47%); (2) VF in 105 cases, under moderate hypothermia (28 to 32 °C) without aortic clamping; and (3) beating-heart technique in 24 cases, under normothermic condition, on full cardiopulmonary bypass support without aortic crossclamping. Missing data for variables included in the main analyses were limited and did not substantially differ across myocardial protection groups. In a small subset of patients initially managed under VF, endoaortic balloon occlusion was used intraoperatively when deemed necessary to optimize exposure or surgical conditions.

End Points

The primary end point was in-hospital mortality. Secondary end points included major complications such as stroke, myocardial infarction, low cardiac output (LCO), re-exploration for bleeding, renal failure, and conversion to full sternotomy.

Statistical Analysis

Continuous variables are reported as mean $\pm$ SD and categorical variables as percentages. Continuous variables with a non-normal distribution are presented as median and interquartile range (IQR). Missing data were handled using a complete-case approach, and denominators reflect available observations. Group comparisons were performed using the unpaired *t* test or Mann-Whitney *U* test for continuous variables and the χ^2 test for categorical variables. To assess the association between myocardial protection strategy (cardioplegia, VF, and beating heart) and study

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TABLE 1. Preoperative characteristics

Characteristics	Overall (n = 502) n (%)	Cardioplegia (n = 373) n (%)	VF (n = 105) n (%)	Beating-heart (n = 24) n (%)	P value
Age, y, median (IQR)	68 (59-75)	68 (58-74)	71 (63.5-77)	69.5 (66-76.5)	.03
Male	277 (55.3)	197 (53)	66 (62.9)	14 (58)	.2
NYHA class III-IV	319 (70.7)	233 (68.9)	64 (71.9)	22 (91.7)	.06
Hypertension	288 (70.8)	193 (67.2)	74 (76.3)	21 (91.3)	.02
Diabetes	86 (17.2)	55 (14.8)	25 (23.8)	6 (25)	.06
Obesity (BMI >30)	95 (19)	71 (19.1)	21 (20.2)	3 (12.5)	.7
Preoperative AF	191 (47)	136 (47.4)	42 (43.8)	13 (56.5)	.5
Chronic lung disease	73 (14.6)	52 (14)	15 (14.4)	6 (25)	.3
Pacemaker	54 (10.8)	37 (9.9)	14 (3.3)	3 (12.5)	.6
Severe renal impairment (CC <50 mL/min)	135 (27.2)	100 (27.1)	30 (28.8)	5 (20.8)	.7
Dialysis	17 (3.4)	13 (3.5)	4 (3.8)	0 (0)	.6
CAD	171 (35.3)	110 (30.6)	50 (50)	11 (45.8)	.001
Active endocarditis	31 (6.2)	25 (6.7)	6 (5.7)	0 (0)	.4
Cerebrovascular arteriopathy	20 (4.4)	12 (3.5)	5 (5.7)	3 (12.5)	.1
Peripheral arteriopathy	50 (10)	32 (8.6)	16 (15.2)	2 (8.3)	.1
Previous cardiac surgery					
Previous MVS	287 (57.2)	233 (62.5)	45 (42.9)	9 (37.5)	<.001
Isolated MV	186 (38.9)	165 (46.7)	18 (17.8)	3 (12.5)	<.001
Previous AV surgery	153 (30.5)	109 (29.2)	38 (36.2)	6 (25)	.3
Previous CABG	143 (28.5)	79 (21.2)	49 (46.7)	15 (62.5)	<.001
Previous root/ascending aorta surgery	47 (10.5)	32 (9.4)	13 (15.7)	2 (8.3)	.2
Previous cardiac surgery access					.013
Full sternotomy	329 (73.8)	238 (70.2)	68 (81.9)	23 (73.8)	
Right minithoracotomy	58 (13)	53 (15.6)	5 (6)	0 (0)	
Other MICS	59 (13.2)	48 (14.2)	10 (12)	1 (4.2)	
MV disease etiology					.005
Degenerative	100 (23.2)	80 (24.2)	18 (22.7)	2 (8.3)	
Functional	73 (16.9)	42 (12.7)	20 (25.7)	11 (45.8)	
Rheumatic	42 (9.7)	35 (10.6)	5 (7.1)	2 (8.3)	
Endocarditis	35 (8.2)	29 (8.8)	6 (7.7)	0 (0)	
Previous MVS failure	171 (39.7)	137 (41.7)	25 (32)	9 (37.5)	
MV insufficiency					<.001
Mild	56 (11.2)	40 (10.8)	12 (11.4)	4 (16.7)	
Moderate	109 (21.8)	83 (22.3)	13 (12.4)	13 (54.2)	
Severe	294 (58.7)	214 (57.5)	75 (71.4)	5 (20.8)	
MV stenosis (moderate to severe)	80 (20.8)	60 (22.1)	14 (15.5)	6 (26.1)	.4
Pulmonary hypertension	273 (59.2)	205 (59.8)	47 (50)	21 (87.5)	.004
Tricuspid regurgitation					<.001
Mild	137 (28)	106 (29.2)	24 (23.3)	7 (29.2)	
Moderate	106 (21.6)	68 (18.7)	23 (22.3)	15 (62.5)	
Severe	63 (12.9)	43 (11.8)	19 (18.4)	1 (4.2)	
Critical preoperative state	52 (11.6)	42 (12.4)	9 (10.8)	1 (4.2)	.5
Reduced LVEF (<50%)	155 (32)	103 (28.7)	43 (42.2)	9 (37.5)	.03
Urgency	86 (17.1)	55 (14.8)	25 (23.8)	6 (25)	.06

(Continued)

TABLE 1. Continued

Characteristics	Overall (n = 502) n (%)	Cardioplegia (n = 373) n (%)	VF (n = 105) n (%)	Beating-heart (n = 24) n (%)	P value
European System for Cardiac Operative Risk Evaluation II, median (IQR)	6.74 (3.24-11.98)	5.91 (2.89-11.46)	7.51 (4.37-14.95)	10.13 (6.43-15.63)	<.001

VF, Ventricular fibrillation; IQR, interquartile range; NYHA, New York Heart Association; BMI, body mass index; AF, atrial fibrillation; CC, cubic centimeters; CAD, coronary artery disease; MVS, mitral valve surgery; AV, aortic valve; CABG, coronary artery bypass grafting; MICS, minimally invasive cardiac surgery; MV, mitral valve; LVEF, left ventricular ejection fraction.

outcomes, mixed-effects binary logistic regression models with a random intercept for center were used. Models were adjusted for a prespecified set of clinically relevant covariates, including age, sex, chronic lung disease, dialysis, peripheral arteriopathy, reduced left ventricular ejection fraction, urgency, active endocarditis, and concomitant tricuspid surgery. Backward stepwise selection was applied to derive a parsimonious final model. Internal validation was performed using a bootstrap resampling approach, which did not indicate substantial overfitting. Results are reported as adjusted odds ratios with 95% CIs. Multicollinearity was assessed using the variance inflation factor. Statistical analyses were performed using IBM SPSS Statistics, version 29.0 (IBM Corp, Armonk, NY). The data underlying this article will be shared on reasonable request to the corresponding author.

RESULTS

Baseline Characteristics

Baseline demographics and comorbidities are reported in Table 1. Median age was 68 years (IQR, 59-75 years), and 55% were male. Patients undergoing VF or beating-heart surgery had greater surgical risk profiles: greater European System for Cardiac Operative Risk Evaluation II (7.5 and 10.1 vs 5.9, $P < .001$), greater prevalence of hypertension (91.3% in beating-heart group, $P = .02$), and more frequent New York Heart Association class III-IV symptoms (91.7%, $P = .06$). Previous MVS was present in 57.2% overall, more frequent in the cardioplegia group (62.5%, $P < .001$). Previous coronary artery bypass grafting was most common in the VF (46.7%) and beating-heart groups (62.5%, $P < .001$).

Operative Details

Operative data are summarized in Table 2. Most procedures were performed totally endoscopic (41%) or video-assisted (31%), whereas 28% were under direct vision. Femoral cannulation was predominant (arterial 89.6%, venous 51.6%), with jugular adjuncts in 45.8% of cases. MV repair was achieved in 151 patients (30.1%), with a lower rate in the VF group (21%) compared with cardioplegia (32.2%) and beating-heart (37.5%) strategies. Concomitant tricuspid surgery was performed in 25.5% overall but significantly more frequently in the beating-heart cohort

(58.3%, $P < .001$). Median cardiopulmonary bypass time was 155 minutes (IQR, 121-195 minutes), longest in VF and beating-heart cases ($P = .009$). Technical success exceeded 95% across all groups, and conversion to sternotomy was required in 15 patients (3%), mainly because of pleural adhesions ($n = 8$), vascular complications ($n = 4$), bleeding ($n = 2$), and inadequate exposure ($n = 1$).

In-Hospital Outcomes

Postoperative outcomes are detailed in Table 3. Overall mortality was 7.6%, with elective mortality at 4.1% and urgent at 24.4%. No significant difference in mortality was observed between protection groups ($P = .6$), although mortality tended to be greater in beating-heart cases (12.5%). Stroke occurred in 2.8%, reoperation for bleeding in 8.8% (significantly greater in VF, $P = .02$), and LCO in 9.2% (VF 16.2%, $P = .01$). Median in-hospital stay was 9 days (IQR, 7-14 days).

In adjusted models, compared with cardioplegia, the beating-heart strategy was associated with greater operative mortality (OR, 6.6), whereas VF was independently associated with an increased risk of LCO (odds ratio, 3.5; $P = .004$). No significant associations were found between myocardial protection strategy and stroke, bleeding, or respiratory complications (Table 4).

DISCUSSION

This large, multicenter experience provides evidence that minimally invasive redo MVS via right minithoracotomy is both feasible and safe. Beyond demonstrating technical success, the study emphasizes the pivotal role of cardioplegia as the optimal strategy for myocardial protection. These findings reinforce the value of minimally invasive approaches as a reliable alternative to conventional re-sternotomy, potentially improving perioperative outcomes and accelerating recovery.

According to the regional Society of Thoracic Surgeons database, Mehaffey and colleagues² reported a 30-day operative mortality of 11.1% in patients undergoing redo MVS. In our experience, the overall 30-day mortality was slightly lower at 7.6%, with elective procedures showing a relatively low rate of 4.1%, whereas urgent cases faced a markedly greater mortality of 24.4%. These findings compare favorably with previously reported outcomes for traditional

TABLE 2. Operative data and myocardial protection details

Characteristics	Overall (n = 502) n (%)	Cardioplegia (n = 373) n (%)	VF (n = 105) n (%)	Beating-heart (n = 24) n (%)	P value
Surgical approach					.02
Direct vision	140 (27.9)	105 (28.2)	26 (24.8)	9 (37.5)	
Video-assisted	154 (30.7)	119 (32)	35 (33.3)	0 (0)	
Totally endoscopic	207 (41.2)	148 (39.8)	44 (41.9)	15 (62.5)	
Robotic	0	0	0	0	
Conversion to full sternotomy	15 (3)	14 (3.8)	1 (1)	0 (0)	.2
Arterial cannulation site					<.001
Femoral	450 (89.6)	344 (92.2)	83 (79)	23 (95.8)	
Axillary	23 (4.6)	6 (1.6)	16 (15.2)	1 (4.2)	
Ascending aorta	10 (2)	10 (2.7)	0 (0)	0 (0)	
Other	19 (3.8)	13 (3.5)	6 (5.7)	0 (0)	
Venous cannulation site					.007
Femoral	259 (51.6)	175 (46.9)	66 (62.9)	18 (75)	
Femoral + jugular	230 (45.8)	186 (49.9)	39 (37.1)	5 (20.8)	
Femoral + SVC	5 (1)	5 (1.3)	0 (0)	0 (0)	
Other	8 (1.6)	7 (1.9)	0 (0)	1 (4.2)	
Myocardial protection					
Cardioplegia	373 (74.3)	—	—	—	
VF	105 (20.9)	—	—	—	
Beating-heart	24 (4.8)	—	—	—	
Cardioplegia type					<.001
Blood	92 (18.3)	86 (23.1)	6 (5.7)	0 (0)	
Crystalloid	293 (58.4)	284 (76.1)	9 (8.6)	0 (0)	
Aortic crossclamping type					<.001
External clamp	216 (43.1)	197 (52.8)	18 (17.3)	1 (4.2)	
Endoclamp	180 (35.9)	175 (46.9)	5 (4.8)	0 (0)	
Type of surgery					.04
MV repair	151 (30.1)	120 (32.2)	22 (21)	9 (37.5)	
MV replacement	351 (69.9)	253 (67.8)	83 (79.1)	15 (62.5)	
Due to unsuccessful repair	10 (2)	5 (1.3)	5 (4.8)	0 (0)	
Concomitant procedure					
Tricuspid surgery	128 (25.5)	92 (24.7)	22 (20.9)	14 (58.3)	<.001
AF surgery	56 (11.2)	47 (12.6)	7 (6.7)	2 (8.3)	.2
LAA closure	30 (6.7)	27 (7.9)	3 (3.6)	0 (0)	.4
Repeated crossclamping due to unsuccessful repair	5 (1.1)	3 (0.9)	2 (2.4)	0 (0)	.4
CPB time, min, median (IQR)	155 (121.25-195)	150 (120-187)	174 (127-221)	168.5 (140-210)	.009
Technical success	414 (95.6)	313 (94.8)	78 (97.5)	23 (100)	.3

VF, Ventricular fibrillation; SVC, superior vena cava; MV, mitral valve; AF, atrial fibrillation; LAA, left atrial appendage; CPB, cardiopulmonary bypass; IQR, interquartile range.

redo sternotomy (8-12%)^{10,11} and emphasize that, in experienced centers, a minimally invasive approach can be performed safely. Importantly, the striking difference between elective and urgent cases highlights the impact of patient status and timing on surgical risk. The increased mortality observed in urgent cases should therefore be interpreted in light of patient-related factors rather than the surgical approach itself, given that urgent/emergent presentation has been consistently identified as an independent predictor of mortality.²

In redo MVS, increased bleeding is expected, as dissection and separation of pericardial adhesions may lead to inadvertent injuries. Uncontrolled intraoperative bleeding is more difficult to manage via a minimally invasive approach and may necessitate conversion to sternotomy. In our study, we observed a 3% conversion rate to sternotomy, highlighting the reliability of the minimally invasive approach even in complex reoperative anatomy. Moreover, perioperative bleeding requiring surgical revision occurred in 8.8% of cases, further supporting the safety of the technique. These results are

TABLE 3. In-hospital outcomes and postoperative complications

Characteristics	Overall (n = 502) n (%)	Cardioplegia (n = 373) n (%)	VF (n = 105) n (%)	Beating-heart (n = 24) n (%)	P value
In-hospital mortality	38 (7.6)	26 (7)	9 (8.6)	3 (12.5)	.6
Elective	17 (4.1)	10 (3.2)	6 (7.1)	1 (4.5)	.3
Urgent	21 (24.4)	16 (25)	3 (15)	2 (100)	.03
Stroke	14 (2.8)	9 (2.4)	4 (3.9)	1 (4.2)	.7
Delirium	18 (5.1)	15 (5.9)	1 (1.4)	2 (8.7)	.2
Ventilation >24 h	81 (20.7)	57 (20.5)	18 (19.8)	6 (27.3)	.7
Respiratory insufficiency	98 (24.4)	69 (24)	21 (22.8)	8 (34.8)	.5
Bleeding (requiring revision)	44 (8.8)	27 (7.9)	15 (18.1)	2 (8.3)	.02
New-onset AF	71 (17.5)	48 (16.7)	16 (16.7)	7 (30.4)	.2
Definitive PM	24 (5.4)	19 (5.6)	4 (4.9)	1 (4.2)	.9
Myocardial infarction	3 (0.6)	3 (0.8)	0	0	.6
LCO	46 (9.2)	26 (7)	17 (16.2)	3 (12.5)	.01
AKI	39 (11.1)	25 (9.8)	11 (14.9)	3 (13)	.5
Dialysis	32 (9)	22 (8.5)	8 (10.5)	2 (8.7)	.9
Transfusions unit, median (IQR)	1 (0-4)	1 (0-3)	2 (0-4)	1 (0-3)	.06
Vascular complications					.4
Major	9 (2.2)	6 (2)	3 (3.9)	0 (0)	
Minor	8 (2)	7 (2.3)	0 (0)	1 (4.2)	
Wound complications					
Thoracic	6 (1.2)	5 (1.3)	1 (1)	0 (0)	.8
Groin	17 (3.4)	14 (3.8)	1 (1)	2 (8.4)	.3
Residual MR after repair					.3
None/trivial	264 (80.5)	189 (78.4)	58 (89.2)	17 (77.3)	
Mild	56 (17.1)	46 (19.1)	5 (7.7)	5 (22.7)	
Moderate	6 (1.8)	4 (1.7)	2 (3.1)	0 (0)	
Severe	2 (0.6)	2 (0.8)	0 (0)	0 (0)	
Moderate-severe PVL after replacement	1 (0.5)	0	1 (1.1)	0	.6
Hospital stay, d, median (IQR)	9 (7-14)	9 (7-15)	8 (7-11.25)	9.5 (7-19.75)	.09

VF, Ventricular fibrillation; AF, atrial fibrillation; PM, permanent pacemaker; LCO, low cardiac output; AKI, acute kidney injury; IQR, interquartile range; MR, mitral regurgitation; PVL, periventricular leukomalacia.

consistent with previous single-center reports¹²⁻¹⁴ and confirm that right minithoracotomy provides reproducible surgical exposure while minimizing tissue dissection and reducing the risk of major complications.

The incidence of perioperative stroke in our series was 2.8%, slightly greater than the 1.3% reported in a previous study from the MMIR, which specifically examined the incidence and predictors of stroke after minimally invasive MVS.¹⁵ Nevertheless, this rate remains relatively low, especially given the increased complexity and risk associated with redo MVS. Comparable rates have been reported in other series of redo MVS, with perioperative stroke ranging from 2.1% in minimally invasive approaches¹⁶ to 4.9% in conventional redo MVS,¹⁷ and 5% in a multicenter European registries.¹⁸ These findings support the notion that, when performed in experienced centers, redo MVS can be

carried out with a relatively low risk of neurologic complications.

Regarding the myocardial protection strategies, our data provide the largest comparative assessment of cardioplegia, VF, and beating-heart techniques in redo minimally invasive MVS. Cardioplegia yielded superior results, associated with lower mortality and reduced LCO. Both external and endocamp approaches were safe and widely applicable.

Conversely, VF and beating-heart strategies were used in greater-risk cohorts. Despite adjustment, VF remained associated with a 3-fold greater risk of LCO. However, this association should be interpreted with caution, because patients in this group more frequently presented with previous coronary artery bypass grafting and impaired ventricular function, suggesting the presence of residual confounding. The beating-heart approach was

TABLE 4. Adjusted models for the association between myocardial protection strategy and hospital outcomes

Variable	Unadjusted analysis			Adjusted analysis		
	OR	95% CI	P value	OR	95% CI	P value
In-hospital mortality						
Myocardial protection categories		—	—	—	—	—
Cardioplegia (reference)	—	—	—	—	—	—
VF	1.3	0.6-2.8	.6	3.5	0.9-12.9	.07
Beating-heart	1.9	0.5-6.8	.3	6.6	1.2-34.1	.02
Stroke						
Myocardial protection categories		—	—	—	—	—
Cardioplegia (reference)	—	—	—	—	—	—
VF	1.7	0.5-5.6	.4	0.4	0.06-2.5	.3
Beating-heart	1.8	0.2-14.4	.6	0.4	0.04-3.9	.4
Major complications (dialysis, stroke, AMI)						
Myocardial protection categories		—	—	—	—	—
Cardioplegia (reference)	—	—	—	—	—	—
VF	1.1	0.5-2.4	.7	1.1	0.3-3.7	.9
Beating-heart	1.1	0.3-3.8	.9	1.1	0.2-5.3	.9
Low cardiac output						
Myocardial protection categories		—	—	—	—	—
Cardioplegia (reference)	—	—	—	—	—	—
VF	3.7	1.8-7.5	<.001	3.5	1.5-8	.004
Beating-heart	1.8	0.5-6.4	.4	1.3	0.3-5.2	.7
Conversion to full sternotomy						
Myocardial protection categories		—	—	—	—	—
Cardioplegia (reference)	—	—	—	—	—	—
VF	0.3	0.03-1.9	.2	1.3	0.1-16	.8
Beating-heart	—	—	—	—	—	—
Bleeding						
Myocardial protection categories:		—	—	—	—	—
Cardioplegia (reference)	—	—	—	—	—	—
VF	2.6	1.3-5.1	.007	1.6	0.6-4.6	.3
Beating-heart	1.06	0.24-4.74	.9	0.9	0.2-5	.9
Respiratory insufficiency						
Myocardial protection categories		—	—	—	—	—
Cardioplegia (reference)	—	—	—	—	—	—
VF	0.9	0.5-1.6	.8	1.1	0.5-2.3	.8
Beating-heart	1.7	0.7-4.1	.3	1.7	0.6-5	.3
Hospital stay						
	Standardized β			Standardized β		
Myocardial protection categories		—	—	—	—	—
Cardioplegia (reference)	—	—	—	—	—	—
VF	−0.5	−2.7 to 0.7	.2	−1.5	−2.9 to 0.4	.1
Beating-heart	0.009	−1.45 to 1.76	.9	−0.5	1.5-0.9	.6

Bold values indicates statistical significance. VF, Ventricular fibrillation; AMI, acute myocardial infarction.

independently linked to mortality, likely reflecting both patient selection and technical constraints (limited visualization, incomplete deairing, suboptimal protection). Our findings differ from those reported in a recent study by Salman and colleagues,¹⁸ in which patients undergoing redo MIMVS with hypothermic VF did not experience worse outcomes or more serious adverse events compared with those receiving routine conventional cardioprotection. Thus, although no-clamp strategies are valuable in extreme

cases—such as dense adhesions or prior grafts—they should remain reserved for selected indications.

Limitations

This is a retrospective registry analysis, with inherent selection and reporting bias. Surgical and perfusion strategies were center-dependent. Detailed information regarding the management of patent internal mammary artery grafts was

not systematically available and therefore could not be analyzed. The lower preoperative LVEF observed in the VF and beating-heart groups likely reflects a greater-risk patient profile and may have influenced postoperative outcomes despite statistical adjustment. The beating-heart subgroup was small and likely reflects highly selected clinical scenarios; therefore, findings related to this strategy should be considered exploratory and interpreted with caution.

Long-term survival and valve durability were not assessed. Despite these limitations, the dataset represents the largest contemporary multicenter experience focusing specifically on myocardial protection during minimally invasive redo MVS.

CONCLUSIONS

Redo MVS via right minithoracotomy is a feasible option when performed in experienced centers. In this setting, cardioplegia emerged as the most favorable myocardial protection strategy, being associated with lower mortality and superior myocardial recovery. In contrast, VF and beating-heart approaches were primarily used in greater-risk patients and were associated with less-favorable outcomes. Accordingly, no-clamp techniques should be reserved for specific scenarios in which crossclamping is contraindicated. Overall, whenever feasible, cardioplegia should remain the default myocardial protection technique.

Webcast

You can watch a Webcast of this AATS meeting presentation by going to: <https://www.aats.org/resources/minimally-invasive-approach-fo-11344>.



Conflict of Interest Statement

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