

# Left Ventricular End-Diastolic Dimension as an Outcome After Combined Mitral Valve Surgery and CABG

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**How to cite this paper:** Hammad, W., Mansour, A.H., Moussa, M.E., Zahra, A.I. and Eliwa, S.S. (2025) Left Ventricular End-Diastolic Dimension as an Outcome After Combined Mitral Valve Surgery and CABG. *World Journal of Cardiovascular Surgery*, 15, 12-21.

<https://doi.org/10.4236/wjcs.2025.151002>

**Received:** October 4, 2024

**Accepted:** January 23, 2025

**Published:** January 26, 2025

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## Abstract

**Background:** Left ventricular size is a factor independently associated with increased mortality in mitral surgery, particularly, in the setting of ischemic mitral regurgitation (IMR). In some patients with dilated ventricles, reverse remodeling does not occur, with a high risk of residual or recurrent mitral regurgitation and therefore associated with worse outcome. We conducted multi-centers retrospective observational study on a cohort of patients who had combined CABG and mitral surgery for moderately severe IMR to correlate a relationship between perioperative left ventricular dimensions to postoperative mortality rates in both genders. **Results:** 287 patients had combined CABG and mitral valve surgery. The exclusion criteria were patients with very low function <20%, mild to moderate MR, patients for redo surgery, non-ischemic mitral regurgitation, or association of any other valve lesion. All patients underwent complete revascularization with posterior and lateral wall grafts. An early postoperative echo during the first 7 days after surgery correlated with the preoperative study was done. The mean age was 62.36 years. 68.6% males and 31.35% female were included. Most of these patients' cohort had evidence of previous infarction, symptoms of congestive heart failure with dyspnea on exertion, and Anginal symptoms. Mitral valve replacement was done in 37.63%, while mitral repair was possible in 62.37% of the patients. The average preoperative and early postoperative left ventricular ejection fractions were 33.84% and 34.44%, respectively. In both genders, statistically significant persistent elevated left ventricular end systolic dimensions postoperatively were associated with a higher mortality rate. While persistent elevated left ventricular end diastolic dimensions were only associated with a higher mortality

rate in female patients. **Conclusion:** Failure of early ventricular remodeling with persistently elevated end systolic dimensions is a risk factor for postoperative death in both genders. Females gender will have an additional higher risk if the end diastolic dimensions remain elevated.

### Keywords

Left Ventricular Dimensions, End Systolic Dimension, End Diastolic Dimension

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## 1. Introduction

Left ventricular (LV) dimensions are critical measures of cardiac function that offer insights into patient outcomes following combined coronary artery bypass grafting (CABG) and mitral valve (MV) surgery [1]. LV dimensions were found to be an important predictor of reverse remodelling after mitral valve surgery. Some cases may lead to sustained improvements in LV dimensions, while others may experience continued ventricular remodeling and progression of congestive symptoms. Failure of reverse remodelling in some patients with dilated LV is associated with a high risk of residual or recurrent mitral regurgitation and, therefore, a worse outcome [1] [2]. Mitral valve surgery can significantly affect left ventricular function and structure, including changes in both postoperative Left ventricular end diastolic dimensions (EDD) and end systolic dimensions (ESD) [1]-[3]. Combining this with CABG would participate in significant changes into the LV EDD that alter the outcomes [1]. On one hand, mitral valve surgery can influence LV EDD in various ways depending on the underlying condition. For example, mitral valve repair or replacement can reduce volume overload on the left ventricle, leading to a decrease in LV EDD [3]. CABG, on the other hand, can influence LV EDD by improving blood flow to the heart muscle and reducing cardiac workload. As the heart receives improved perfusion, left ventricular function may stabilize, and LV EDD may be affected. Additionally, CABG can lead to a reduction in ischemic damage, which may positively impact LV EDD. The outcomes after CABG on LV EDD may depend on factors such as the extent of coronary artery disease, the number of grafts performed, and the patient's overall health. Studies suggest that CABG can lead to improvements in LV EDD in some cases, though variability exists depending on patient-specific factors [4]. Several studies have related the increased mortality following combined CABG and mitral valve surgery to the persistent severe LV dilatation [4]-[7]. For instance, Yamaguchi and colleagues have reported a development of congestive heart failure and reduced survival rates postoperatively in patients who had a preoperative LV end-systolic volume index greater than 100 mL/m<sup>2</sup> [5].

The aim of our study is to correlate the relationship between perioperative LV dimensions to mortality rates following combined CABG and MV surgery.

## 2. Methods

This is a multi-centers retrospective observational study conducted on a cohort of patients who had combined CABG and MV surgery for moderately severe IMR between 2009 and 2022. All patients had preoperative echocardiography study which was repeated within the first 7 days after surgery, early postoperative period. A correlation with the preoperative and early postoperative LV dimensions was done. The normal reference value for the LV EDD and ESD dimensions were set at 59 and 42 mm for males while a 53 and 39 for females were considered. Evidence of myocardial viability was assessed by myocardial perfusion scintigraphy with thallium and technetium agents in 12.54% of the study cohort. The remaining number had either angina symptoms or echo evidence of absence of akinesia or dyskinesia. All patients undergone complete revascularization with posterior and lateral wall grafts. A preoperative echocardiogram and repeat early postoperative study within 7 days postoperatively were done in all patients. Parasternal and apical views were obtained. Left ventricular dimensions and ejection fraction were measured. Other echocardiographic parameters were also detected with a main focus on the residual Mitral regurgitation, Pulmonary artery pressure and right ventricular systolic pressure (RVSP) and function.

The primary end points were all-cause mortality including operative mortality. The exclusion criteria were patients with very low function <20%, mild to moderate MR, patients for redo surgery, nonischemic mitral regurgitation, or association of any other valve lesion. For elaboration, the primary non-ischemic mitral regurgitation pathology was excluded to avoid mixed adverse outcomes of secondary pulmonary arterial pressure on this cohort of patient in addition to rule out the added risk of prolonged repair or repair revision. For similar reasons, patients who had redo surgery for combined CABG and mitral surgery were also excluded from the study.

## 3. Results

It is a retrospective data analysis of 287 patients who had combined CABG and MV surgery after presentation with CAD and associated +3 or +4 IMR. The mean age was 62.36 years. 68.6% males and 31.35% female were included. 65.5% has evidence of previous MI, with ECG confirmed of MI in 16.02%, 10.10%, 2.09% at the inferior, anterior, and lateral walls respectively. Symptoms of CHF with dyspnea on exertion dominated the presentation with 63.7% NYHA III and 18.5% class IV. On the other hand, Angina was not reported in 16.37% of the cases. The remaining reported variable degrees of anginal pain. Mitral valve replacement was done in 37.63%, while mitral repair was possible in 62.37% of the patients.

**Table 1.** Demographic characteristics, preoperative data, and type of surgery performed.

Gender		
•	Males	197 62.6%
•	Females	90 31.35%

**Continued**

<b>Age</b>			
•	Range	35 - 88 yrs	
•	Mean	62.36 yrs	
<b>MI</b>			
•	No evidence of previous MI	99	34.5%
•	Inferior MI	46	16.02%
•	Anterior MI	29	10.10%
•	Lateral MI	6	2.09%
<b>Preop NYHA</b>			
•	VI	53	18.46%
•	III	182	63.41%
•	II	50	17.77%
•	I	2	0.007%
<b>Preop Angina</b>			
•	VI	32	11.14%
•	III	90	31.35%
•	II	86	29.96%
•	I	34	11.85%
•	0	47	16.37%
<b>Viability assessment</b>			
•	No	251	87.45%
•	Yes	36	12.54%
<b>Mitral Valve surgery</b>			
<b>MVR</b>			
	(t) MVR	86	29.96%
	(m) MVR	20	6.96%
	Total	108	37.63%
<b>MV repair</b>			
	Physio ring	6	2.09%
	Cosgrove	8	2.78%
	SMB	119	41.46%
	Duran	45	15.68%
	Annuloplasty	1	0.35%
	Total	179	62.37%
<b>SVR</b>			
•	No	242	84.32%
•	Yes	45	15.68%

Demographic characteristics (gender, age), preoperative data (NYHA, angina status, viability assessment), and type of surgery (mitral repair or replacement, revascularization, surgical ventricular restoration) were obtained from medical records (**Table 1**). The mean age was 62.36 years. 68.6% males and 31.35% female were included. 65.5% has evidence of previous MI, with ECG confirmed of MI in 16.02%, 10.10%, 2.09% at the inferior, anterior, and lateral walls respectively. Symptoms of CHF with dyspnea on exertion dominated the presentation with 63.7% NYHA III and 18.5% class IV. On the other hand, Angina was not reported in 16.37% of the cases. The remaining reported variable degrees of anginal pain. Mitral valve replacement was done in 37.63%, while mitral repair was possible in 62.37% of the patients (**Table 1**).

A total of 26 mortalities were detected during the first year from the date of primary operation (**Table 2**). Eight early mortalities within the 30 days postoperatively. The remaining 28 deceased cases happened after 30 days and up to the end of the 12 months after the index procedure. The Causes of early and late death are listed in **Table 2**.

**Table 2.** Causes of early and late death.

Cause of death	Mortality <30 days	Mortality >30 days
Cardiac	5	5
Noncardiac	3	13
• Sepsis	1	8
• Aspiration pneumonia		2
• Anoxic encephalopathy		1
• Bleeding	1	1
• Stroke		1
• HIT	1	
<b>Total</b>	<b>8</b>	<b>18</b>

In the survival group, no statistical difference was found between the LV dimensions in preoperative and early postoperative studies. While in the mortality group, and in both genders, a statistically highly significant persistent elevated LV ESD dimensions postoperatively was associated with higher mortality rate demonstrated with P value < 0.001 in both genders. The mean preoperative and postoperative ESD in deceased males were 47.46 and 46.78 respectively. Similarly, in the deceased female patients, the mean preoperative and postoperative ESD were 38.90 and 40.91 respectively. On the other hand, a statistically significant elevated LV EDD postoperatively was only noted in the deceased female patient. The mean preoperative and postoperative EDD were 50.18 and 52.00 respectively with a P value <0.001. In contrast to the male gender who had an estimated mean EDD of 58.53 preoperatively and 54.50 postoperatively with a P value of >0.05 (**Table 3**). Off note, a statistically non-significant difference in the average

preoperative and early postoperative LVEF were 33.84% and 34.44% respectively in the mortality group (P value of >0.05).

**Table 3.** Pre and postoperative LV dimensions in survival and mortality groups. In both genders, a statistically significant persistent elevated LV ESD dimensions postoperatively was associated with higher mortality rate. While a significant elevated LV EDD was only noted in female patient.

Mortality group 26 (9.05%)	Preop	Postop	P value
Male 15 (%)			
• EDD	58.53	54.50	>0.05
• ESD	47.46	46.78	<0.001
Female 11 (%)			
• EDD	50.18	52.00	<0.001
• ESD	38.90	40.91	<0.001
Survival group			
Male 182 (%)			
• EDD	59.39	55.98	>0.05
• ESD	46.76	44.34	>0.05
Female 79 (%)			
• EDD	55.49	52.02	>0.05
• ESD	40.13	39.24	>0.05

#### 4. Discussion

There have been reports of increased risk of mortality and morbidity associated with the combined procedure (MVR + CABG) compared with isolated procedures. The Society of Thoracic Surgeons (STS) reported an 8.6% risk of in-hospital mortality with the combined procedure compared with 1.8% and 3.9% risk seen with isolated CABG and MVR, respectively [1]. Despite this, the combined procedure has largely been utilized with no large-scale data on its safety and efficacy. In our study, the mortality rate was 9.05%.

Ullah W *et al.*, Ahmed OF *et al.*, and Heijmans JH *et al.* partially attributed the increased mortality following combined CABG and MV surgery to challenging procedural factors and multiple preoperative criteria. Adding to the increased complexity of a combined procedure, other complications could arise from longer CPB and aortic cross-clamp duration. This longer duration increased the incidence of microemboli, coagulation defects and hemodilution which increase transfusion requirements and suppress immunity [1] [8] [9]. Ullah w *et al.* reported the worst outcome where associated with failure to use internal mammary

artery, valve replacement surgery and emergency surgery [1].

Several other studies have shown that some preoperative criteria are important predictors of operative mortality. These include recent acute ischemia, severity of the coronary disease and mitral regurgitation, advanced congestive heart failure (CHF) symptoms, and impaired EF [1] [8] [9]. While reports from a recent study concluded CHF is the only preoperative risk factor for in-hospital mortality in combined CABG and MV surgery. Age, severity of the coronary lesion or MR did not influence on in-hospital mortality [8]. Our study has introduced a different perspective which is the failure to reverse remodeling postoperatively is the key factor that adversely affected the cardiac function with direct reflection on the in-hospital and early mortality. Our analysis was done after determining the adjusted impact of all baseline comorbidities on mortality using regression analysis. It showed a consistently higher relative risk of complications with the combined procedure. Furthermore, surgery for combined IMR and CABG was associated with worse outcomes if the LV failed to reverse remodel in the early postoperative period. Similarly, female patients undergoing combined procedures have a gender related risk of higher in-hospital or early post operative death compared with males if the LV failed to regain near normal dimensions. Some suggested that female patients would also be frailer and have lower cardiac reserve.

In analysis of the data of 42 patients, Pompeu *et al.* noticed no difference in the operative mortality of MVR and CABG (6.3%) compared with CABG alone (7.7%;  $P = 0.679$ ). They reported no significant difference in cardiac, renal, or neurological complications in both groups [10]. Similarly, Bonacchi *et al.* reported no significant difference in the outcomes of combined procedures to single procedure after analysis of the outcomes of 196 patients with chronic ischaemic MR and left LV dysfunction [11]. We believe that major limitations to some research would possibly be small sample sizes and unadjusted estimates of the outcomes. By contrast to the former studies, Wang *et al.* found that combined procedures solely were an independent risk factor of increased both operative and composite morbidity when adjusted other predictors compared with MVR alone. They also demonstrated increased hospital stay, stroke rate and pacemaker implantation with combined procedure [12].

Khaled *et al.* provided a larger study on the safety and efficacy of isolated vs. combined procedures [5]. The combined procedure was associated with 13% higher adjusted odds of MACE compared with CABG alone. This ratio was seriously higher to 96% when compared the combined to the isolated Mitral procedure. However, and interestingly, they reported a gender difference similar to our study findings of higher risk in female gender along with elderly patients, redo CABG, and patients with ESRD. Their pooled estimates of MACE in combined procedures remained invariant on sensitivity analysis restricted to female gender, patients older than 75, redo CABG or ESRD. They also reported, in relative terms, males and younger patients undergoing combined procedures had a lower risk of complications.

## 5. Conclusion

The results of this study suggest that, in both genders, statistically significant persistent elevated left ventricular end systolic dimensions postoperatively were associated with a higher mortality rate. While persistent elevated left ventricular end diastolic dimensions were only associated with a higher mortality rate in female patients. Therefore, failure of postoperative ventricular remodeling with persistent elevated end systolic dimensions is a risk factor for postoperative death in both genders undergoing combined CABG and MV surgery. Females gender will have an additional higher risk if the end diastolic dimensions remain elevated.

## Declarations

The authors declare that the abstract for this research was presented at the Society for Cardiothoracic Surgery in Great Britain and Ireland (SCTS) meeting in Birmingham, UK, on 19 - 21 March 2023. Therefore, the abstract of this paper was published *in the Journal of Cardiothoracic Surgery* in the section for SCTS Annual Meeting 2023 Abstracts Meeting abstracts. Author index Hammad, W 324.

## Authors' Contributions

**Walid Hammad:** Conceptualization, Investigation, Methodology, Data curation, Formal analysis, Resources, Supervision, Validation, Writing—review & editing.

**Aboubaker Hasan:** Writing—review & editing.

**Ashraf Ibrahim Zahra:** Acquisition of data & visualization.

**Sherif Eliwa:** Writing—review & editing.

## Funding

This work is not supported by any external funding.

## Data Availability Statement

The data supporting the outcome of this research work has been reported in this manuscript and is available from the corresponding author on reasonable request.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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## List of Abbreviations

CABG:	coronary artery bypass grafting
CAD:	coronary artery disease
CHF:	congestive heart failure
CPB:	cardiopulmonary bypass
ECG:	electrocardiogram
EDD:	end diastolic dimensions
EF:	ejection fraction
ESD:	end systolic dimension
ESRD:	end stage renal disease
IMR:	ischemic mitral regurgitation
LV:	left ventricle
MACE:	major adverse cardiac events
MI:	myocardial infarction
MR:	mitral regurgitation
MV:	mitral valve
MVR:	mitral valve replacement
NYHA:	New York Heart Association
RVSP:	right ventricular systolic pressure
SCTS:	Society for Cardiothoracic Surgery in Great Britain and Ireland
STS:	Society of Thoracic Surgeons