

Seven Years Single Center Experience of Combined Coronary Artery Bypass Surgery with Aortic Valve Replacement: retrospective cohort Study

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Abstract

Background and aims: Combined coronary artery bypass graft (CABG) with aortic valve replacement (AVR) surgery (CABG-AVR) is considered high-risk compared with isolated CABG and AVR. This study aims to report on a seven-year single-center experience of the outcome of combined CABG-AVR surgery.

Methods: This is a retrospective review of institutional data from July 2016 to June 2023. All elective cases of concomitant CABG-AVR surgery were included. The preoperative, intraoperative, postoperative, mortality before discharge, early and late mortality data were collected and then analyzed in R 4.4.2. Software.

Results: A total of forty-three patients underwent CABG-AVR surgery in seven years, out of which 9 (20.93%) were female. The mean age (in years) was 61.37 ± 10.09 . The mean left ventricular ejection fraction (%) was 55.58 ± 10.07 . Twenty-six had severe aortic stenosis, eight had severe aortic regurgitation, and nine had a mixed lesion. Ten of these had triple vessel disease (VD), 16 had double VD, and 17 had single VD. The mean postoperative intensive care unit stay was 4.65 ± 4.80 days, and the mean postoperative hospital stay was 8.47 ± 6.06 days. In-hospital mortality was 4 (9.3%) patients. The maximum follow-up was 98 months, and the minimum follow-up for two months, with a mean follow-up of 35 months. The follow-up was completed by 93%. The cumulative survival rate at 8.1 years was 0.73 (CI: 0.56-0.94).

Conclusion: Although small sample size may limit statistical significance for some analysis, this study suggests that combined CABG-AVR surgery can be performed with acceptable outcomes in our context.

Keywords: combined CABG-AVR surgery, operative mortality, preoperative risk factors

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Introduction:

As the age of patients undergoing coronary artery bypass grafting (CABG) or degenerative valve disease surgery increases, the incidence of combined coronary and valve surgery rises¹. When indicated, performing CABG alongside aortic valve replacement (AVR) in a single session is generally safe, with satisfactory early outcomes and complications². Combined CABG-AVR is considered a viable surgical approach. The most common procedure performed in conjunction with AVR is CABG². Despite the increased risks,

CABG-AVR remains a frequently repeated procedure after isolated CABG surgery and surgery for valve¹. With optimal myocardial protection, minimal cross-clamp and cardiopulmonary bypass (CPB) times, and meticulous surgical techniques, the results of combined CABG-AVR can be comparable to those of isolated CABG or AVR in leading centers¹. Although an increasing number of studies are available on CABG surgery in Nepal, there is limited evidence on complex diseases like CAD with valvular involvement and the outcome of CABG-AVR surgery. In our context, concomitant



CABG-AVR is considered a high-risk procedure compared to isolated CABG or AVR. This study, representing the first report from Shahid Gangalal National Heart Center, a tertiary-level cardiac referral center in Kathmandu, Nepal, with aims to provide an overview of the outcomes associated with combined CABG-AVR surgeries at this center.

Materials and methods

This study is a retrospective, observational review of institutional data, conducted with approval from the Institutional Review Committee of Shahid Gangalal National Heart Centre. This study was registered with the Reference No: SGNHC/IRC No: 1-2024. The study encompasses data from all consecutive patients who underwent elective combined coronary artery bypass grafting (CABG) and aortic valve replacement (AVR) between July 2016 and June 2023 (7 years) at the a tertiary level cardiac referral centre in Nepal and met the inclusion criteria. The inclusion criteria were all patients who underwent elective combined CABG-AVR surgery during the study period. Patients with infective endocarditis, prior sternotomy, aortic root abscesses, aortic valve repair surgeries, or those who required rescue CABG were excluded from the study. Data were collected from the hospital registry and analyzed for preoperative, intraoperative, and postoperative variables. Preoperative variables were age at the time of operation, gender, associated diseases, findings from coronary angiography, findings from transthoracic echocardiography related to valve lesions, and left ventricular ejection fraction. Intra-operative variables comprise the size of the valve prosthesis, type of valve prosthesis, coronary lesion details, type of grafts used, aortic cross-clamp time, and cardiopulmonary bypass time. Postoperative variables were postoperative mechanical ventilator support time after the transfer to the intensive care unit (ICU), length of ICU stay in days, postoperative hospital stays in days, and all causes of early mortality (defined as mortality before hospital discharge). The choice of cardiac valve prosthesis was made based on patient preference and age. Coronary artery disease was defined as the presence of stenosis greater than 50% in at least one epicardial artery. Follow-up data, including early and mid- to long-term information regarding survival, were gathered through records of surgical outpatient department visits and telephone interviews with patients or their family members. Patients' and or their family members' phone numbers were obtained from the patient's hospital record file. Survival data were collected prospectively. All information was retrospectively reviewed and analyzed. This manuscript has been reported in line with the STROCSS criteria³.

Operative Technique

All procedures were performed through a complete median sternotomy by six different consultant cardiac surgeons. The operative technique and steps were more consistent for all surgeons. The left internal mammary artery (LIMA) was harvested as a pedicle graft, while the saphenous vein was harvested as a free graft. All patients underwent standard cardiopulmonary bypass (CPB) with heparinization.

Systemic moderate hypothermia was used in all cases, and during cardiac arrest, myocardial protection was achieved with crystalloid hyperkalemic cardioplegia. In cases where the aortic valve was competent, cardioplegia was infused into the aortic root; in cases of aortic valve regurgitation, it was infused retrogradely through the coronary sinus and directly into the coronary ostia. Additionally, cold saline was applied for topical cooling of the arrested heart.

After the aortic valve was excised via aortotomy, the distal anastomoses of the coronary artery grafts were performed. The

aortic prosthesis was implanted using interrupted horizontal mattress sutures with felt pledgets to replace the pathological native valves. Once the aortotomy was closed and the heart was deaired, the aortic cross-clamp was removed. Proximal anastomoses of the coronary grafts were performed under a partial aortic clamp. After completing the proximal anastomosis, the partial clamp was removed, and the patient was gradually weaned off CPB. Subsequently, sternotomy along with incision was closed in layers. The patient was then transferred to the ICU under mechanical ventilatory respiratory support for postoperative care.

Statistical Analysis

Data on preoperative findings (such as age, sex, aortic valve lesion, coronary lesion, and left ventricular ejection fraction), intraoperative variables (including cardiopulmonary bypass time, aortic cross-clamp time, type of valve, and the number along with type of grafts), and postoperative outcomes (mechanical ventilation time, length of intensive care unit stay, postoperative hospital stay, and mortality) were collected from the hospital registry. These data were analyzed using R 4.4.2 software.

Demographic and clinical characteristics were summarized as frequencies (percentages) for categorical variables and as means $\pm$ standard deviations for continuous variables. Pearson's Chi-square Test was used to analyze categorical variables. Kaplan-Meier analysis was used to obtain survival probability.

Results

A total of 43 patients were included in the study. The mean age was 61.37 ± 10.10 years, and the mean body mass index (BMI) was 23.78 ± 3.29 kg/m². The mean left ventricular ejection fraction (LVEF) was $55.58 \pm 10.07\%$, indicating a predominantly preserved ventricular function in the cohort.

Among the participants, 34 (79.1%) were male and 9 (20.9%) were female. Hypertension was present in 12 patients (27.9%), while 10 patients (23.3%) had diabetes mellitus. Regarding coronary artery disease (CAD), 17 patients (39.5%) had single-vessel disease, 16 (37.2%) had double-vessel disease, and 10 (23.3%) had triple-vessel involvement.

Aortic valve (AV) involvement was categorized as follows: 26 patients (60.5%) had predominant stenosis, 9 (20.9%) had mixed involvement, and 8 (18.6%) had predominant regurgitation.

Table No. 1 Baseline Characteristics of the Study Population (n = 43)

Characteristic	Value
Total Patients	43
Age (years), mean $\pm$ SD	61.37 ± 10.10
BMI (kg/m ²), mean $\pm$ SD	23.78 ± 3.29
LVEF (%), mean $\pm$ SD	55.58 ± 10.07
Gender	
Male	34 (79.1%)
Female	9 (20.9%)

Hypertension	
Yes	12 (27.9%)
No	31 (72.1%)
Diabetes Mellitus	
Yes	10 (23.3%)
No	33 (76.7%)
Coronary Artery Disease	
Single Vessel (SV)	17 (39.5%)
Double Vessel (DV)	16 (37.2%)
Triple Vessel (TV)	10 (23.3%)
AV Involvement	
Stenosis	26 (60.5%)
Mixed	9 (20.9%)
Regurgitation	8 (18.6%)

Table No.2 Intra and Post-operative Characteristics of the Study Population (n = 43)

Characteristic	Value
Total Patients	43
Cross Clamp Time (min), mean $\pm$ SD	107.19 $\pm$ 27.65
CPB Time (min), mean $\pm$ SD	149.88 $\pm$ 40.38
Post-op Ventilation (hrs), mean $\pm$ SD	13.51 $\pm$ 15.09
ICU Stay (days), mean $\pm$ SD	4.65 $\pm$ 4.81
Hospital Stay (days), mean $\pm$ SD	7.42 $\pm$ 2.47
Intra-aortic Balloon Pump Insertion	1 (2.3%)
Type of Valve Used:	
Bioprosthetic (n, %)	22 (51.2%)
Mechanical (n, %)	21 (48.8%)

Intraoperative and postoperative parameters were analyzed for all 43 patients. The mean cross-clamp time was 107.19 $\pm$ 27.65 minutes,

while the mean cardiopulmonary bypass (CPB) time was 149.88 $\pm$ 40.38 minutes. The average duration of postoperative mechanical ventilation was 13.51 $\pm$ 15.09 hours. The mean ICU stay duration was 4.65 $\pm$ 4.81 days, and the total postoperative hospital stay averaged 7.42 $\pm$ 2.47 days. Out of the 43 patients, there were 4 (9.3%) cases of mortality, with the causes of death being acute renal failure (n=1, 2.3%), coagulopathy (n=1, 2.3%), and congestive heart failure (n=2, 4.7%). Out of the four cases of mortality, three were female, three had an LVEF $\leq$ 40%, and three had severe aortic stenosis.

Statistical analysis revealed that postoperative mortality was inclined toward female gender and LVEF $\leq$ 40% ($p \leq 0.005$), though it was not significantly associated with the type of valvular lesion and a number of coronary artery involvement ($p > 0.05$). The comparisons are shown in Table 3.

Data are expressed as numbers and percentages. P-values were obtained using Pearson's Chi-square test. N = total number of patients; n = number of subjects in each group.

Table 3: Comparison of Postoperative Mortality by Gender, LVEF, Aortic valve pathology, and Number of Coronary Artery Bypass (N=43).

Group	Post-operative Mortality	No Post-operative Mortality	p-value
Gender			
Male (n=34)	1	33	<0.005
Female (n=9)	3	6	
Left ventricular ejection fraction (LVEF)			
LVEF $\leq$ 40% (n=6)	3	3	<0.001
LVEF > 40% (n=37)	1	36	
Valve Pathology Type			
Stenosis (S) (n=26)	3	23	>0.05
Regurgitation(R) (n=8)	0	8	
Mixed (M) (n=9)	1	8	
Coronary artery lesion			
Single Vessel (n=17)	1	16	>0.05
Double Vessel (n=10)	2	14	
Triple Vessel (n=16)	1	9	

Results of Follow-up

Hospital survivors (39 patients) were followed during a maximum follow-up of 98 months. On the 10th postoperative month, one patient died due to metastatic lung carcinoma. Two patients died of a stroke in the second year after the operation. The cumulative

duration of follow-up was 127 patient-years (py). Follow-up was completed in 93%. Maximum follow-up was 98 months, and minimum follow-up was two months, with a mean follow-up of 35 months. The cumulative survival rate at one year was 0.88 (CI: 0.78-0.98), two years was 0.84 (CI: 0.74- 0.96), and eight years was 0.73 (CI: 0.56- 0.94).

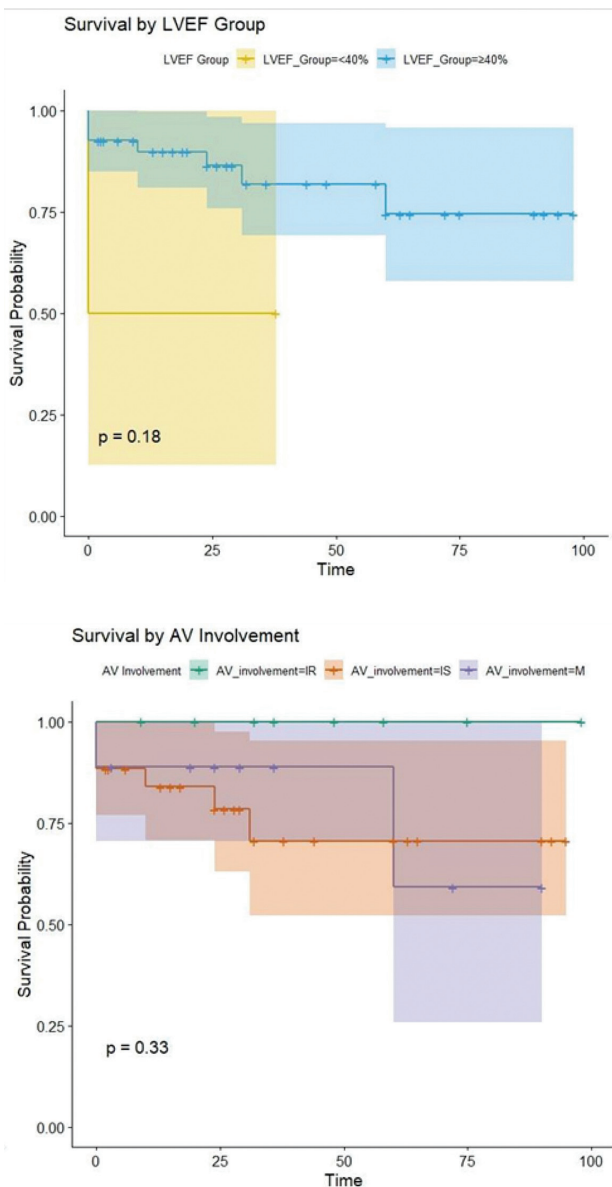


Figure 1. Kaplan-Meier survival curves stratified by (A) Left Ventricular Ejection Fraction (LVEF) and (B) Aortic Valve (AV) involvement subtype.

Kaplan-Meier survival curves were generated to assess overall survival based on LVEF and AV involvement patterns. When stratified by LVEF, patients with preserved ejection fraction (LVEF $\geq 40\%$) demonstrated a trend toward improved survival compared to those with reduced LVEF ($<40\%$). However, this difference was not statistically significant (log-rank $p = 0.18$). Median survival time was lower in the $<40\%$ group, and the confidence interval bands were wider, suggesting increased variability and possibly limited statistical power due to sample size.

Stratification by AV involvement subtype revealed no statistically significant differences in survival probabilities among patients

classified as R, S, or M types (log-rank $p = 0.33$). While the R group appeared to have slightly better outcomes, overlapping confidence intervals and nonsignificant p-values indicate that the survival differences observed may not be robust.

These findings suggest that while there are observable trends in survival based on LVEF and anatomical AV involvement, the current sample may be underpowered to detect statistically significant differences. Future studies with larger cohorts are warranted to further explore the prognostic value of these clinical factors.

Discussion

Combined coronary artery bypass grafting (CABG) with aortic valve replacement (AVR) is a significant cardiac surgical procedure performed worldwide. As life expectancy continues to rise in Western countries, the incidence of CABG-AVR procedures has also increased. We have observed a steady annual rise in the number of combined CABG-AVR surgeries at our center as well. However, only 43 combined CABG-AVR surgeries met our study's inclusion criteria, resulting in a relatively small sample size.

In our study, the predominant gender was male, comprising 79% of cases. This male predominance in combined CABG-AVR surgeries is consistent with findings from similar studies conducted by Ahmed et al., with a 61% male population¹.

The use of the left internal mammary artery (LIMA), as a conduit, in our study was 30%, which is on the lower end of the previously reported range of 30-80%⁴⁻⁹. This lower percentage might be attributed to our surgeons' preferences for using venous conduits during concomitant surgeries at our center.

The most common aortic valve lesion in our study was stenosis, which occurred in 60% of cases. This finding is in line with a study by Gunay et al., which reported a similar prevalence of 65% for aortic stenosis in a combined CABG-AVR procedure¹⁰.

Traditionally, operative mortality has been used as a quality measure for evaluating hospital performance in value-based care. In our study, the overall operative mortality for combined CABG and AVR surgery was 9%.

Reports on mortality risk for combined CABG-AVR vary widely, ranging from 1.3% to 14.1%. These figures are generally higher than the mortality risks associated with CABG alone (0.8% to 3.1%) or valve surgery alone (3.7%)¹.

In a study by Patrick G. Chan et al., operative mortality for combined CABG-AVR surgery was reported to be 15.5%¹¹. Additionally, the 4th European Association for Cardiothoracic Surgery Adult Cardiac Surgery 2010 database indicates that mortality for isolated valve surgery is 3.7% while for the combined CABG-AVR procedure, it increases to 6.2%¹². Wijns W. and colleagues reported that mortality for combined CABG-AVR ranges from 2% to 10%¹³.

Patients undergoing combined procedures are typically older, have greater functional impairments, and are more likely to experience angina. They also have a higher incidence of previous myocardial infarctions and are more prone to hemodynamic instability compared to those undergoing isolated aortic or coronary surgeries. Additionally, these patients often experience longer cross-clamp and cardiopulmonary bypass time. These factors collectively contribute to an increased mortality risk following the combined operations¹⁰.

Out of the four cases of mortality, three were female, three had an LVEF $\leq 40\%$, three had severe aortic stenosis, and three had received

mechanical valve implantation. In this study Postoperative mortality was statistically significant for both female gender and LVEF $\leq 40\%$ ($p \leq 0.005$), but limited power due to small sample size. However, in this study, mortality was not significantly related to aortic stenosis, similar to findings in a study conducted by Gunay et al.¹⁰.

The impact of female gender on outcomes after cardiac operations remains unclear. Factors such as estrogen receptor variations, ovarian dysfunction, premature menopause, and the proinflammatory effects of hormone replacement therapy may contribute to higher mortality rates among female patients following cardiac surgery^{14,15}.

It is worth noting that the early higher mortality observed in females may be attributed to the fact that women often present later in their disease progression and tend to have poorer preoperative risk profiles compared to men¹⁶. Additionally, female anatomy can present more surgical challenges, including smaller, tortuous coronary arteries, narrower conduits, more diffuse patterns of coronary disease, and smaller diameter cardiac valves^{17,18}.

A retrospective analysis of a national database in the United States revealed that while women still experience higher mortality rates after CABG, the gender gap is gradually narrowing¹⁹. In contrast, other national databases have not found significant sex-related differences in mortality following cardiac surgery^{20,21}. Additionally, contradicting our findings, an Australian study on combined aortic valve replacement and CABG reported similar short-term and long-term outcomes for both genders²¹. A publication from the United Kingdom using data from the National Adult Cardiac Surgery Audit concluded that despite advances in cardiac surgery, females have an increased risk of short-term mortality after cardiac surgery compared to males²².

The optimal prosthesis for aortic valve replacement (AVR) combined with concomitant coronary artery bypass grafting (CABG) is not established. While we have not specifically investigated postoperative outcomes in patients with either biological or mechanical prostheses, our data show a higher mortality rate associated with mechanical valve implantation in CABG-AVR procedures.

The severity of either single or triple-vessel CAD had no relation to mortality in our study. Hence, the number of bypass grafts does not adversely affect survival; a similar finding was in a study by Kobayashi et al.⁵. In our study, eight years of survival was 73.2 %, which was a bit lower compared to the study conducted by Spiliopoulos et al. where late survival was 83.9%²³.

Although combined CABG-AVR surgery is considered a high-risk cardiac procedure, it remains a valuable option for improving longevity in patients with both conditions when clinically indicated

Limitations

This study has several limitations. Firstly, it is a single-center, retrospective observational study that relies solely on hospital records data. This introduces potential concerns about the accuracy and completeness of the data. Additionally, this study is based on a small sample size, which may limit the generalizability of the findings. Like larger recent studies on the outcome of CABG surgery, where the inclusion of the female gender population is between 20-30%, this study could only include 20% of the female population. Biased results of poor outcomes in females are possible. Furthermore, major limitation of this study is not able to utilize well-established preoperative risk assessment tools, such as the European System for Cardiac Operative Risk Evaluation (EuroSCORE) or the

Society of Thoracic Surgeons (STS) risk scoring. We recommend larger prospective studies with balanced gender representation and application of standardized risk scores to internally validate the findings of the study.

Conclusion

Our seven-year single-center experience with combined coronary artery bypass grafting (CABG) and aortic valve replacement (AVR) demonstrates that this high-risk procedure can be performed with acceptable outcomes. The study highlights that female gender and left ventricular dysfunction are significant predictors of worse postoperative prognosis. While mortality rates vary widely in the literature, our findings align with existing data showing that preoperative risk factors, rather than the severity of coronary artery disease or the type of pathology of the valve, are more critical in determining patient outcomes.

Conflict of Interest:

None.

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