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Assessment of Symptom-Free Survival and Health-Related Quality of Life After Coronary Artery Bypass Grafting for Chronic Total Coronary Occlusion

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Abstract

Background: Chronic total occlusion (CTO) of a major epicardial coronary artery is a manifestation of advanced coronary artery disease and is frequently associated with persistent myocardial ischemia, reduced functional capacity, and impaired quality of life. Although coronary artery bypass grafting (CABG) is an established revascularization strategy, evidence regarding long-term symptom-free survival and patient-reported quality-of-life outcomes among patients with CTO remains limited.

Objectives: To assess symptom-free survival among patients with CTO who underwent elective CABG and were followed up for a minimum of 24 months, and to evaluate their postoperative quality of life.

Methods: This retrospective cohort study included adult patients who underwent elective CABG for documented CTO at a tertiary cardiac center between January 2020 and December 2025, with a minimum follow-up period of 24 months. Demographic characteristics, clinical profiles, comorbidities, operative variables, and preoperative risk scores, including EuroSCORE II and SYNTAX II, were obtained from institutional medical records. Symptom-free survival was assessed through follow-up records and structured telephonic interviews. Postoperative quality of life and functional capacity were evaluated using the Seattle Angina Questionnaire and Duke Activity Status Index (DASI), respectively. Kaplan-Meier survival analysis and appropriate statistical tests were performed, with a p-value of less than 0.05 considered statistically significant.

Results: A total of 177 patients with 222 CTO lesions were included in the analysis, with most patients having single-vessel involvement. At three years of follow-up, nearly half of the patients remained free from recurrent angina. Chronic obstructive pulmonary disease was significantly associated with reduced symptom-free survival ($p < 0.05$), whereas diabetes mellitus, hypertension, left ventricular dysfunction, and preoperative risk scores did not demonstrate significant associations. DASI scores were significantly influenced by diabetes mellitus and hypertension and showed an inverse correlation with predicted mortality scores.

Conclusion: Elective CABG in carefully selected patients with CTO is associated with meaningful mid-term symptom-free survival and satisfactory postoperative quality-of-life outcomes. Chronic obstructive pulmonary disease may adversely influence postoperative symptom relief, while conventional cardiovascular risk factors demonstrated limited association with symptom-free survival. These findings highlight the importance of individualized risk assessment and multidisciplinary management when considering surgical revascularization.

Keywords: Chronic total occlusion; Coronary artery bypass grafting; Symptom-free survival; Quality of life; Duke Activity Status Index; SYNTAX score; EuroSCORE II.

Introduction

Coronary artery disease (CAD) continues to be a major contributor to global morbidity and mortality, particularly in developing countries experiencing rapid epidemiological and demographic transitions [1].

Among its complex angiographic presentations, chronic total occlusion (CTO) represents a particularly challenging form of coronary artery disease. It is defined as a complete obstruction of a coronary artery with Thrombolysis in Myocardial Infarction (TIMI) grade 0 flow persisting for more than three months [2]. CTO lesions are identified in approximately 15-20% of patients undergoing diagnostic coronary angiography and are frequently associated with multivessel coronary artery disease [3]. Histopathologically, these lesions are characterized by dense fibrotic tissue, calcification, organized thrombus, and the presence of microvascular channels, contributing to increased technical complexity during revascularization procedures [4].

Patients with CTO commonly present with chronic stable angina, exertional dyspnea, and reduced exercise tolerance due to persistent myocardial ischemia [5]. Although collateral circulation may partially compensate for the reduction in antegrade coronary blood flow, these collateral vessels often fail to provide adequate myocardial perfusion during periods of increased oxygen demand, particularly during physical exertion [6]. Persistent ischemia may contribute to myocardial hibernation, adverse ventricular remodeling, and impaired left ventricular systolic function, thereby adversely affecting functional capacity and overall quality of life [7]. Consequently, appropriate revascularization plays an important role in improving myocardial perfusion, relieving symptoms, and potentially improving long-term clinical outcomes.

The principal revascularization strategies for CTO include percutaneous coronary intervention (PCI) and coronary artery bypass grafting (CABG). Although technological advancements and improved interventional techniques have increased the success rates of PCI, complex anatomical characteristics, including extensive calcification, long occlusion segments, and unfavorable coronary anatomy, continue to present significant procedural challenges [8]. CABG remains an important revascularization option, particularly in patients with multivessel coronary artery disease and anatomically complex lesions, including those with elevated SYNTAX scores [9]. By providing blood flow to the distal coronary circulation beyond the occluded segment, surgical revascularization can restore myocardial perfusion without requiring direct recanalization of the obstructed lesion [10].

Although perioperative outcomes, graft patency, and survival following CABG have been extensively investigated, relatively limited evidence is available regarding long-term symptom-free survival and patient-reported quality-of-life outcomes specifically among patients undergoing CABG for CTO [11,12]. Symptom-free survival is an important clinical outcome because it reflects sustained relief from ischemic symptoms following revascularization. Furthermore, validated assessment instruments, such as the Seattle Angina Questionnaire and the Duke Activity Status Index (DASI), provide a structured approach to evaluating angina-related symptoms, physical limitations, functional capacity, and health-related quality of life following surgical intervention [13-15].

In the Indian healthcare setting, evidence regarding mid-term symptom-free survival and health-related quality of life following CABG for CTO remains limited. Considering the increasing burden of advanced coronary artery disease and the growing complexity of revascularization procedures performed at tertiary care centers, evaluating both clinical outcomes and patient-centered measures of recovery is essential. Therefore, the present study was undertaken to assess symptom-free survival among patients with chronic total occlusion of major epicardial coronary arteries who underwent elective CABG, with a minimum follow-up period of 24 months. The secondary objective was to evaluate postoperative quality of life and functional capacity using validated assessment instruments, thereby providing a comprehensive understanding of mid-term clinical and patient-reported outcomes in this population.

Materials and Methods

Study Setting and Design

This retrospective cohort study was based on institutional medical records of patients who underwent coronary artery bypass grafting (CABG) for chronic total occlusion (CTO) of one or more major epicardial coronary arteries at the Department of Cardiothoracic and Vascular Surgery, Jawaharlal Institute of Postgraduate Medical Education and Research (JIPMER), Puducherry, India. The study was academically contextualized within the Department of General Medicine, Duke-NUS Medical School, Singapore. Medical records of eligible patients who underwent CABG from January 2020 and December 2025 onwards were reviewed to assess postoperative clinical outcomes, symptom-free survival, and quality of life.

Study Population

Adult patients aged 20-65 years who underwent their first CABG for angiographically documented CTO and had a minimum follow-up period of 24 months were considered eligible for inclusion. CTO was defined as complete obstruction of a significant epicardial coronary artery with no antegrade flow, as documented by coronary angiography. Patients who underwent concomitant cardiac surgical procedures, those with life-limiting non-cardiac illnesses, and those unwilling to participate in follow-up assessments were excluded.

Sampling Technique and Sample Size

Universal sampling was adopted, and all patients fulfilling the eligibility criteria during the study period were included. The sample size was calculated based on an anticipated symptom-free survival proportion of 65%, an absolute precision of 7%, and a 95% confidence level, yielding a minimum required sample size of 178 patients.

Data Collection and Clinical Assessment

Data were collected using a structured data collection proforma from departmental databases and medical records maintained by the Medical Records Department. Information regarding demographic characteristics, clinical presentation, comorbidities, angiographic findings, operative details, and postoperative outcomes was retrieved. Preoperative surgical risk was assessed using the European System for Cardiac Operative Risk Evaluation II (EuroSCORE II). Long-term prognostic assessment was performed using the SYNTAX II score and predicted three-year CABG mortality estimates wherever available.

Study Variables

The independent variables included demographic characteristics, clinical risk factors, and associated comorbidities such as diabetes mellitus, systemic hypertension, obesity, and preoperative risk scores. Additional clinical and procedural variables included carotid and peripheral vascular disease, anatomical SYNTAX scores, surgical technique (on-pump or off-pump CABG), the number of CTO vessels revascularized, and coronary arterial dominance.

Outcome Measures

The primary outcome was symptom-free survival, defined as the absence of recurrent anginal symptoms during the follow-up period following CABG. Secondary outcomes included the duration of symptom-free survival, major adverse cardiac events, cardiac mortality, repeat revascularization, and postoperative quality of life. Quality of life and functional capacity were assessed using validated instruments, namely the Seattle Angina Questionnaire and the Duke Activity Status Index (DASI).

Statistical Analysis

Categorical variables were summarized as frequencies and percentages, while continuous variables were expressed as mean with standard deviation or median with interquartile range, depending on the distribution of the data. Associations between categorical variables were assessed using the Chi-square test or Fisher's exact test, as appropriate. Differences in median values were evaluated using the Kruskal-Wallis test. Correlations between continuous and ordinal variables were examined using Spearman's rank correlation analysis. Symptom-free survival was estimated using the Kaplan-Meier method, and potential predictors of symptom recurrence were evaluated using Cox proportional hazards regression analysis. A p-value of less

than 0.05 was considered statistically significant.

Results

Table 1. Association of Gender with Symptom-Free Survival (3-year follow-up)

Gender	No Symptoms	<1 Year	≥1 Year	p-value
Female (n=34)	16 (47.1%)	12 (35.3%)	6 (17.6%)	0.66
Male (n=142)	72 (50.7%)	53 (37.3%)	17 (12.0%)	

There was no statistically significant association between gender and symptom-free survival at three-year follow-up (Chi-square test, p = 0.66). The proportion of patients remaining asymptomatic was comparable between females (47.1%) and males (50.7%), with similar distributions of symptom recurrence within and beyond one year.

Table 2. Association of Number of CTO Vessels with Symptom-Free Survival

CTO Vessels	No Symptoms	<1 Year	≥1 Year	p-value
Single (n=134)	66 (49.3%)	51 (38.1%)	17 (12.7%)	0.37
Double (n=41)	23 (56.1%)	13 (31.7%)	5 (12.2%)	
Triple (n=2)	0	1 (50%)	1 (50%)	

There was no statistically significant association between the number of CTO vessels and symptom-free survival at three years (p = 0.37). Although patients with double-vessel CTO showed a slightly higher proportion of complete symptom relief (56.1%) compared to single-vessel disease (49.3%), the differences were not statistically significant.

Table 3. Association of COPD with Symptom-Free Survival

COPD	No Symptoms	<1 Year	≥1 Year	p-value
No (n=165)	87 (52.4%)	60 (36.1%)	19 (11.4%)	0.02*
Yes (n=11)	2 (18.2%)	5 (45.5%)	4 (36.4%)	

*Statistically significant.

Chronic obstructive pulmonary disease showed a statistically significant association with symptom-free survival (Chi-square test, p = 0.02). Patients without COPD had a substantially higher proportion of complete symptom relief (52.4%) compared to those with COPD (18.2%). Conversely, recurrence beyond one year was more frequent among COPD patients (36.4%), indicating that pulmonary comorbidity significantly and adversely affected long-term postoperative symptomatic outcomes.

Table 4. Severity Scores and Symptom-Free Survival

Score	No Symptoms Median (IQR)	<1 Year Median (IQR)	≥1 Year Median (IQR)	p-value
EuroSCORE II	0.95 (0.72–1.24)	0.95 (0.67–1.5)	0.87 (0.57–1.5)	0.66
SYNTAX II	18.2 (14–24.45)	17.6 (12.65–22.85)	20.2 (12.4–23.9)	0.89
3-year Mortality Score	2.7 (1.8–4.4)	2.4 (1.5–3.7)	2.8 (1.8–4.9)	0.40

Preoperative severity scores, including EuroSCORE II, SYNTAX II, and predicted three-year mortality score, were not significantly associated with symptom recurrence (p > 0.05 for all).

Table 5. Association of Duke Activity Status Index with Comorbidities

Variable	Duke Score Median (IQR)	p-value
Diabetes – No	33.2 (29.2–37.2)	0.003*

Diabetes – Yes	29.2 (23.7–37.2)	
Hypertension – No	29.2 (29.2–37.2)	0.006*
Hypertension – Yes	29.2 (23.7–37.2)	

*Statistically significant.

Diabetes and hypertension demonstrated statistically significant associations with postoperative quality of life as measured by the Duke Activity Status Index. Patients without diabetes had a higher median Duke score of 33.2 (IQR 29.2–37.2) compared to 29.2 (IQR 23.7–37.2) in diabetic patients, indicating significantly reduced functional capacity in diabetics ($p = 0.003$). Similarly, hypertension was associated with lower Duke scores, and the difference reached statistical significance ($p = 0.006$)

Table 6. Correlation of Duke Score with Continuous Variables

Variable	Spearman Correlation (ρ)	p-value
EuroSCORE II	-0.085	0.326
SYNTAX II	-0.408	<0.001*
3-year Mortality Score	-0.365	<0.001*

Spearman analysis showed no significant correlation between Duke Activity Status Index and EuroSCORE II ($\rho = -0.085$, $p = 0.326$). However, Duke score demonstrated a moderate and significant negative correlation with SYNTAX II ($\rho = -0.408$, $p < 0.001$) and predicted three-year mortality score ($\rho = -0.365$, $p < 0.001$).

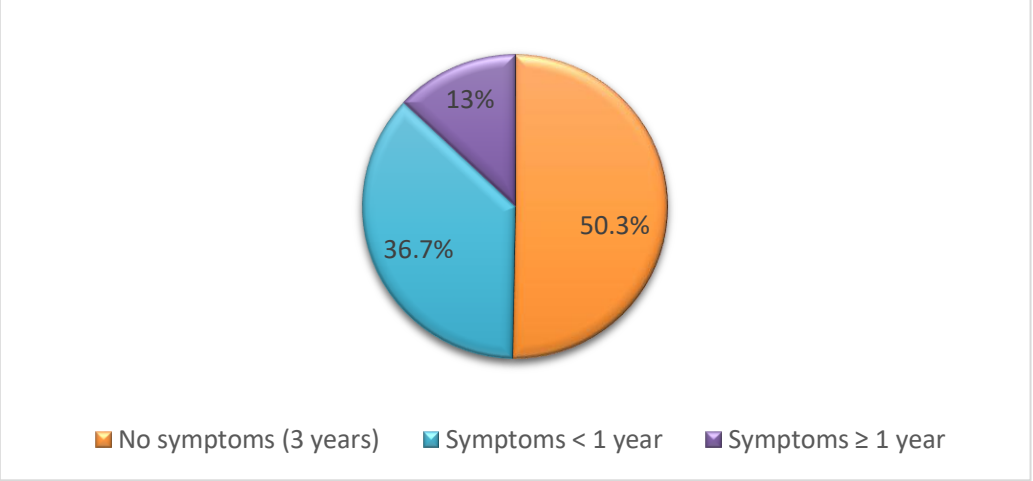


Figure 1. Three-Year Symptom-Free Survival After Elective CABG

Among the 177 patients studied, 89 (50.3%) remained free from anginal symptoms at three-year follow-up, indicating meaningful mid-term symptom relief after elective CABG. Symptom recurrence within the first year was observed in 65 patients (36.7%), while late recurrence beyond one year occurred in 23 patients (13.0%).

Table 7. Overall Duke Activity Status Index (DASI) Distribution

Measure	Value
Median DASI Score	29.2
Interquartile Range (IQR)	23.7 – 37.2

The median Duke Activity Status Index score of 29.2 (IQR 23.7–37.2) reflects moderate postoperative functional capacity among CTO patients undergoing CABG.

Discussion

In the present study, gender was not significantly associated with three-year symptom-free survival ($p = 0.66$), with comparable asymptomatic rates observed among females (47.1%) and males (50.7%). These

findings indicate similar postoperative symptomatic outcomes between sexes. Previous research has also reported no significant gender-based differences in long-term outcomes following coronary revascularization, supporting the observation that biological sex may not substantially influence mid-term symptomatic recovery after CABG in patients with CTO [18].

The number of CTO vessels did not demonstrate a statistically significant association with symptom-free survival in the present study ($p = 0.37$). Complete symptom relief was observed in 49.3% of patients with single-vessel CTO and 56.1% of those with double-vessel CTO. Previous findings have similarly indicated that the presence of CTO and anatomical disease burden may not independently predict long-term survival following CABG, emphasizing the importance of an appropriate revascularization strategy rather than lesion count alone [16].

A significant association was observed between chronic obstructive pulmonary disease (COPD) and reduced symptom-free survival in our cohort ($p = 0.02$). Only 18.2% of patients with COPD remained asymptomatic compared with 52.4% of those without COPD. Previous studies have also demonstrated that COPD adversely influences long-term outcomes following CABG, highlighting the importance of pulmonary comorbidity as a potential determinant of postoperative functional recovery [17]. Preoperative risk assessment scores, including EuroSCORE II ($p = 0.66$) and SYNTAX II ($p = 0.89$), were not significantly associated with symptom recurrence. Existing evidence suggests that revascularization risk prediction models primarily estimate mortality and major adverse cardiovascular events rather than long-term symptomatic outcomes, which is consistent with the findings of the present study [19].

With regard to quality of life, diabetes mellitus ($p = 0.003$) and systemic hypertension ($p = 0.006$) were significantly associated with lower Duke Activity Status Index (DASI) scores. Previous research has demonstrated that preoperative comorbidities may adversely influence postoperative functional capacity and quality-of-life outcomes following CABG [20]. Furthermore, DASI scores demonstrated significant negative correlations with SYNTAX II ($\rho = -0.408$; $p < 0.001$) and predicted mortality scores ($\rho = -0.365$; $p < 0.001$). Previous studies have also reported associations between higher SYNTAX scores and poorer functional outcomes, while anatomical complexity has been linked to differences in quality-of-life measures among patients undergoing CTO revascularization [21,22].

Strength & Limitation: The major strength of this study is the inclusion of 177 patients with 222 CTO lesions and a minimum follow-up of 24 months, allowing assessment of both symptom-free survival and postoperative quality of life using validated instruments such as the Seattle Angina Questionnaire and Duke Activity Status Index. Evaluation of clinical comorbidities and established risk scores further provides a comprehensive understanding of postoperative outcomes. However, the retrospective, single-center design may have introduced selection and information bias, limiting generalizability. Reliance on medical records and telephonic interviews may have resulted in incomplete data and recall bias. The absence of a comparison group and the possibility of residual confounding also limit the interpretation of the findings.

Conclusion

Chronic total occlusion of a coronary artery leads to scarred myocardium interspersed with areas of viable but hibernating tissue. Surgical revascularization through CABG restores perfusion to these viable regions, thereby reducing the risk of progression to congestive cardiac failure, a major cause of mortality in advanced coronary artery disease. CABG in CTO patients has been associated with long-term survival benefit, and persistent postoperative symptoms often reflect underlying disease severity rather than graft inadequacy. In some cases, residual angina may be attributable to microvascular dysfunction, which can be effectively managed with optimal medical therapy while maintaining acceptable quality of life.

Declaration

Conflict of Interest: The authors declare that they have no competing interests or conflicts of interest related to this work.

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