Journal of Rare Cardiovascular Diseases
ISSN: 2299-3711 (Print) | e-ISSN: 2300-5505 (Online)
www.jrcd.eu
RESEARCH ARTICLE

Symptom-free survival and quality of life among patients undergoing elective coronary artery bypass grafting for chronic total occlusion of a major epicardial coronary artery – A retrospective cohort study

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Article History
Received: 13.10.2025
Revised: 10.11.2025
Accepted: 15.11.2025
Published: 01.12.2025

Abstract: ***Background***: N Chronic total occlusion (CTO) of a major epicardial coronary artery represents advanced coronary artery disease and is commonly associated with persistent ischemia and impaired quality of life. While coronary artery bypass grafting (CABG) is an established revascularization strategy, data on long-term symptom-free survival and patient-reported outcomes in CTO remain limited. ***Objectives:*** To estimate symptom-free survival among CTO patients followed for at least 24 months after elective CABG and to assess postoperative quality of life. ***Methods:*** This retrospective cohort study included adults who underwent elective CABG for documented CTO at a tertiary cardiac center between January 2013 and December 2020, with a minimum follow-up of 24 months. Clinical characteristics, comorbidities, operative variables, and risk scores, including EuroSCORE II and SYNTAX II were retrieved from institutional records. Symptom-free survival was assessed through follow-up documentation and structured telephonic interviews. Quality of life was evaluated using the Seattle Angina Questionnaire and Duke Activity Status Index (DASI). Kaplan–Meier analysis and appropriate statistical tests were applied, with $p < 0.05$ considered significant. ***Results***: A total of 177 patients with 222 CTO lesions were analyzed, most with single-vessel involvement. At three years, nearly half remained free from recurrent angina. Chronic obstructive pulmonary disease was significantly associated with reduced symptom-free survival ($p < 0.05$), whereas diabetes, hypertension, left ventricular dysfunction, and preoperative risk scores were not. DASI scores were significantly influenced by diabetes and hypertension and showed an inverse correlation with predicted mortality scores. ***Conclusion***: Elective CABG in CTO patients provides meaningful mid-term symptom-free survival and satisfactory quality-of-life outcomes. Pulmonary comorbidity negatively affects postoperative symptom relief, while traditional cardiovascular risk factors show limited impact on survival duration. These findings support surgical revascularization in carefully selected patients with individualized risk assessment.

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) remains one of the leading causes of morbidity and mortality worldwide, particularly in developing nations undergoing rapid epidemiological transition[1]. Among its complex angiographic manifestations, chronic total occlusion (CTO) represents a challenging subset, defined as complete coronary artery obstruction 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, CTO segments consist of dense fibrotic tissue, calcification, organized thrombus, and microvascular channels, all of which increase procedural complexity during revascularization[4].

Clinically, patients with CTO often present with chronic stable angina, exertional dyspnea, or reduced exercise tolerance resulting from persistent myocardial ischemia[5]. Although collateral circulation may partially compensate for reduced antegrade flow, collateral vessels frequently fail to meet myocardial oxygen demand during physical stress[6]. Prolonged ischemia can lead to myocardial hibernation, ventricular remodeling, and impaired systolic function, ultimately affecting quality of life[7]. Consequently, effective revascularization is essential to restore myocardial perfusion and improve both symptomatic status and long-term prognosis.

Revascularization strategies for CTO include percutaneous coronary intervention (PCI) and coronary artery bypass grafting (CABG). Technological advancements have enhanced PCI success rates; however, heavily calcified lesions, long occlusion segments, and complex coronary anatomy continue to pose limitations[8]. CABG remains the preferred modality in patients with multivessel disease or high anatomical complexity, especially those with elevated SYNTAX

scores[9]. Surgical revascularization restores distal coronary perfusion beyond the occluded segment, independent of lesion characteristics, thereby ensuring sustained myocardial blood supply[10].

While perioperative outcomes and graft patency following CABG have been widely investigated, fewer studies have focused specifically on long-term symptom-free survival and patient-reported quality-of-life outcomes in individuals undergoing CABG for CTO[11]. Symptom-free survival represents a clinically meaningful endpoint, reflecting durable ischemia relief and effective myocardial revascularization. In addition, validated instruments such as the Seattle Angina Questionnaire and the Duke Activity Status Index provide structured evaluation of functional capacity, physical limitation, and overall well-being after surgical intervention[12].

Risk stratification tools including EuroSCORE II and SYNTAX II are routinely used to estimate perioperative mortality and guide revascularization decisions[13,14]. However, their predictive utility in determining long-term symptom recurrence and functional outcomes among CTO patients remains uncertain. Furthermore, comorbid conditions such as diabetes mellitus, systemic hypertension, chronic obstructive pulmonary disease, and left ventricular dysfunction may significantly influence postoperative recovery and quality of life[15].
In the Indian context, literature examining mid-term symptom-free survival and health-related quality of life following CABG for CTO is limited. With the increasing prevalence of advanced CAD and the growing number of complex revascularization procedures performed in tertiary centers, evaluating both survival and patient-centered functional outcomes is crucial.

The present study was therefore undertaken to estimate the duration of symptom-free survival among patients with chronic total occlusion of major epicardial coronary arteries who underwent elective CABG and were followed for a minimum of 24 months. A secondary objective was to assess postoperative quality of life using validated assessment tools, thereby providing comprehensive insight into mid-term outcomes in this high-risk population.

MATERIALS AND METHODS

This retrospective cohort study was conducted in the Department of Cardiothoracic and Vascular Surgery at Jawaharlal Institute of Postgraduate Medical Education and Research (JIPMER), Puducherry. Institutional medical records were reviewed to identify adult patients who underwent coronary artery bypass grafting (CABG) for chronic total occlusion (CTO) of one or more major epicardial coronary arteries from January 2013 onwards. CTO was defined as complete obstruction of a significant epicardial coronary artery documented on coronary angiography. Patients aged 20 to 65 years with a minimum follow-up of 24 months after their first CABG were included. Patients undergoing concomitant cardiac procedures, those with life-limiting non-cardiac illness, and those unwilling to participate in follow-up were excluded.

Universal sampling was adopted, and all eligible patients during the study period were included. The sample size was calculated assuming a 65% symptom-free survival rate with 7% absolute precision at 95% confidence level, yielding a minimum requirement of 178 patients. Data were collected using a structured proforma from departmental databases and Medical Records Department files. Preoperative risk was assessed using EuroSCORE II, and long-term prognostic estimation was evaluated using SYNTAX II score and predicted three-year CABG mortality score where available.

Independent variables included demographic factors and comorbidities such as diabetes mellitus, systemic hypertension, obesity, and preoperative risk scores. Dependent variables comprised carotid and peripheral vascular disease, SYNTAX scores, surgical technique (on-pump or off-pump), number of CTO vessels operated, and coronary dominance. Primary outcome was symptom-free survival, defined as absence of anginal symptoms during follow-up. Secondary outcomes included duration of symptom-free survival, major adverse cardiac events, cardiac mortality, repeat revascularization, and quality of life assessed using the Seattle Angina Questionnaire and Duke Activity Status Index.

Categorical variables were summarized as frequency and percentage, while continuous variables were expressed as mean with standard deviation or median with interquartile range as appropriate. Associations were analyzed using Chi-square or Fisher's exact test, and median differences were compared using the Kruskal–Wallis test. Correlation was assessed using Spearman rank analysis. Symptom-free survival was estimated using Kaplan–Meier analysis and evaluated with Cox proportional hazards modeling. A p-value < 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.

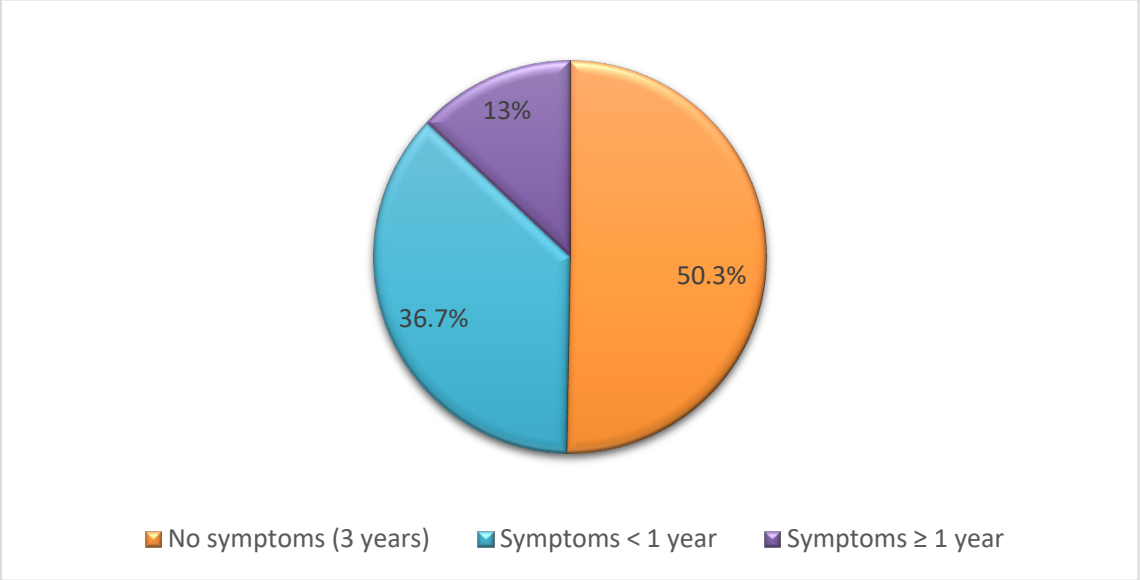
Diabetes and hypertension demonstrated statistically significant associations with postoperative quality of life as measured by the Duke Activity Status Index. Patients without diabetes had a higher median Duke score of 33.2 (IQR 29.2–37.2) compared to 29.2 (IQR 23.7–37.2) in diabetic patients, indicating 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 (ρ = −0.085, p = 0.326). However, Duke score demonstrated a moderate and significant negative correlation with SYNTAX II (ρ = −0.408, p < 0.001) and predicted three-year mortality score (ρ = −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 in females (47.1%) and males (50.7%), indicating similar postoperative outcomes between sexes. Liu et al[18] similarly reported no significant gender-based difference in long-term outcomes following coronary revascularization, supporting the observation that biological sex does not significantly influence mid-term symptomatic recovery after CABG in CTO patients.

The number of CTO vessels did not demonstrate a statistically significant association with symptom-free survival in our study ($p = 0.37$). Complete symptom relief was observed in 49.3% of single-vessel and 56.1% of double-vessel CTO cases. Fagu et al[16] also reported that the presence of CTO and anatomical burden did not independently predict long-term survival after CABG, emphasizing that successful revascularization strategy plays a more important role than lesion count.

A significant association was observed between COPD and reduced symptom-free survival in our cohort ($p = 0.02$), with only 18.2% of COPD patients remaining asymptomatic compared to 52.4% of non-COPD individuals. Wang et al[17] similarly demonstrated that COPD adversely affects long-term outcomes following CABG, highlighting pulmonary comorbidity as an important determinant of postoperative functional recovery.

Preoperative severity scores including EuroSCORE II ($p = 0.66$) and SYNTAX II ($p = 0.89$) were not significantly associated with symptom recurrence. Lawton et al[19] emphasized that revascularization risk stratification models primarily predict mortality and major adverse events rather than long-term symptomatic status, which aligns with our findings.

Regarding quality of life, diabetes ($p = 0.003$) and hypertension ($p = 0.006$) were significantly associated with lower Duke Activity Status Index scores. Koch et al[20] reported that preoperative comorbidities significantly influence postoperative functional capacity and quality-of-life outcomes after CABG. Furthermore, the Duke score demonstrated significant negative correlations with SYNTAX II ($\rho = -0.408$; $p < 0.001$) and predicted mortality score ($\rho = -0.365$; $p < 0.001$). Scala et al. [21] similarly showed that higher SYNTAX scores are associated with poorer functional outcomes, while highlighting the relationship between anatomical complexity and quality-of-life measures in patients undergoing CTO revascularization.

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. Careful patient selection and comprehensive preoperative assessment are essential to optimize symptom-free survival in this high-risk population.

Conflict of Interest: Nil
Source of funding: Nil

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