

Evaluation of the impact of aortic cross-clamp duration on postoperative clinical outcomes in patients presenting to the emergency department with a history of isolated coronary artery bypass surgery

İzole koroner arter bypass cerrahisi öyküsü olan ve acil servise başvuran hastalarda aortik kros-klamp süresinin postoperatif klinik sonuçlar üzerindeki etkisinin değerlendirilmesi

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Abstract

Purpose: Cardiovascular diseases are a leading cause of death worldwide, with coronary artery disease (CAD) being the most prevalent. Isolated coronary artery bypass grafting (CABG) remains an effective treatment for multivessel CAD. The duration of aortic cross-clamp (ACC) during surgery may influence postoperative outcomes, yet its impact in patients presenting to the emergency department with a history of CABG has not been fully explored. This study aimed to evaluate the effect of aortic cross-clamp duration on postoperative clinical outcomes in patients presenting to the emergency department with a history of isolated CABG.

Materials and methods: This retrospective cohort study included 167 adult patients who underwent elective isolated CABG under cardiopulmonary bypass (CPB) between January 2022 and January 2025. Patients were divided into two groups based on median ACC time (63 minutes): Group I (≤ 63 min, $n=86$) and Group II (>63 min, $n=81$). Postoperative outcomes, including 24-hour drainage, transfusion requirements, extubation time, atrial fibrillation, cerebrovascular events, low cardiac output syndrome, and renal replacement therapy, were analyzed. Statistical analyses included univariate linear regression to assess the associations between ACC duration and postoperative parameters.

Results: Patients in Group II exhibited significantly longer CPB and ACC durations, higher 24-hour drainage volumes, greater transfusion requirements, and prolonged extubation times compared to Group I ($p<0.001$). Univariate regression analysis demonstrated positive correlations between ACC time and 24-hour drainage ($\beta=3.872$, $p<0.001$), red blood cell transfusion volume ($\beta=8.205$, $p<0.001$), and extubation time ($\beta=0.129$, $p<0.001$).

Conclusions: Prolonged aortic cross-clamp duration adversely affects postoperative outcomes, including increased bleeding, transfusion needs, and mechanical ventilation time, even in patients with isolated CABG. Monitoring and minimizing ACC time is critical, particularly in emergency department patients with prior CABG, to reduce perioperative morbidity and optimize hospital resource utilization. Further prospective studies in larger populations are warranted.

Keywords: Aortic cross-clamp, coronary artery bypass grafting, postoperative outcomes, emergency department, cardiopulmonary bypass.

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Öz

Amaç: Kardiyovasküler hastalıklar, dünya genelinde önde gelen ölüm nedenlerinden biridir ve koroner arter hastalığı (KAH) en yaygın olanıdır. İzole koroner arter bypass grefti (CABG), çok damarlı KAH tedavisinde etkili bir yöntem olmaya devam etmektedir. Cerrahi sırasında aortik kros-klamp (ACC) süresi, postoperatif sonuçları etkileyebilir; ancak, acil servise CABG öyküsü ile başvuran hastalarda bu etkinin kapsamı henüz tam olarak araştırılmamıştır. Bu çalışma izole CABG öyküsü olan ve acil servise başvuran hastalarda aortik kros-klamp süresinin postoperatif klinik sonuçlar üzerindeki etkisini değerlendirmeyi amaçlamıştır.

Gereç ve yöntem: Bu retrospektif gözlemsel çalışmaya, Ocak 2022 ile Ocak 2025 tarihleri arasında kardiyopulmoner bypass (CPB) altında elektif izole CABG yapılan 167 yetişkin hasta dahil edilmiştir. Hastalar, ACC süresinin medyanına (63 dakika) göre iki gruba ayrılmıştır: Grup I (≤ 63 dk, $n=86$) ve Grup II (>63 dk, $n=81$). Postoperatif sonuçlar arasında 24 saatlik drenaj, transfüzyon gereksinimleri, ekstübasyon süresi, atriyal fibrilasyon, serebrovasküler olaylar, düşük kardiyak output sendromu ve renal replasman tedavisi analiz

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edilmiştir. İstatistiksel analizlerde, ACC süresi ile postoperatif parametreler arasındaki ilişkiyi değerlendirmek için tek değişkenli lojistik regresyon kullanılmıştır.

Bulgular: Grup II'deki hastalar, Grup I'e kıyasla anlamlı şekilde daha uzun CPB ve ACC süreleri, daha yüksek 24 saatlik drenaj hacmi, daha fazla transfüzyon gereksinimi ve uzamış ekstübasyon süresi göstermiştir ($p<0,001$). Tek değişkenli regresyon analizinde ACC süresi ile 24 saatlik drenaj ($\beta=3,872$, $p<0,001$), eritrosit transfüzyon hacmi ($\beta=8,205$, $p<0,001$) ve ekstübasyon süresi ($\beta=0,129$, $p<0,001$) arasında pozitif korelasyonlar bulunmuştur.

Sonuç: Uzamış aortik kros-klamp süresi, izole CABG hastalarında dahi postoperatif sonuçları olumsuz yönde etkileyerek kanama, transfüzyon ihtiyacı ve mekanik ventilasyon süresinde artışa yol açmaktadır. ACC süresinin izlenmesi ve minimize edilmesi, özellikle CABG öyküsü olan acil servis hastalarında perioperatif morbiditeyi azaltmak ve hastane kaynak kullanımını optimize etmek için kritik öneme sahiptir. Daha büyük hasta gruplarında yapılacak ileriye dönük çalışmalar gereklidir.

Anahtar kelimeler: Aortik kros-klamp, koroner arter bypass grefti, postoperatif sonuçlar, acil servis, kardiyopulmoner bypass.

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Introduction

Cardiovascular diseases are among the leading causes of death worldwide, with coronary artery disease (CAD) being the primary and most prevalent contributor [1]. Coronary artery bypass grafting (CABG) is an effective treatment modality for patients with multivessel CAD [2]. This surgical procedure typically requires cardiopulmonary bypass (CPB) support using a heart-lung machine [3]. Evidence from various studies on CPB suggests that the procedure triggers an inflammatory response, resulting in increased oxidative stress that significantly impacts mortality and postoperative morbidity [4]. Blood contact with the non-endothelial surface of the CPB circuit, surgical trauma, endotoxemia, blood loss, and ischemia-reperfusion injury are all factors contributing to a systemic inflammatory response [5-7]. Postoperative outcomes after coronary artery surgery are influenced by multiple factors, including patient age, sex, comorbidities, surgical characteristics, CPB duration, and aortic cross-clamp (ACC) time. Prolonged cross-clamp duration may lead to adverse clinical outcomes and irreversible myocardial injury. Extended ischemic times have been associated with increased mortality and major complications after valve surgery [6-9]. The aim of this study was to assess the effect of aortic cross-clamp duration on postoperative clinical outcomes and complications in patients presenting to the emergency department and undergoing isolated CABG. These findings

may provide emergency physicians with insight into risk stratification and early postoperative management.

Materials and methods

This retrospective cohort study was conducted using data from adult patients who underwent open-heart surgery between January 2022 and January 2025. The study was approved by the Ethics Committee of Bandırma Onyedi Eylül University Faculty of Medicine (decision date: 13.06.2024, decision no: 2024-158). This study utilized clinical data from patients with a history of isolated CABG who presented to the emergency department with postoperative symptoms or complications. The emergency department served as the initial point of clinical evaluation, triage, and data acquisition for these patients. Although the surgical procedures themselves were elective and performed under scheduled conditions, all postoperative outcome data analyzed in this study were obtained from patients presenting to the emergency department. Therefore, the link between emergency department admission and the assessment of postoperative outcomes was explicitly integrated into the study design.

Inclusion criteria

- Adult patients who underwent elective isolated coronary artery bypass grafting (CABG) under cardiopulmonary bypass (CPB).

Exclusion criteria

- Patients who underwent off-pump CABG,
- Patients who underwent additional procedures alongside coronary surgery,
- Patients requiring re-sternotomy,
- Patients undergoing emergency surgery.

A total of 219 patient records were initially evaluated. Fifty-two patients who did not meet the inclusion criteria were excluded. The final analysis included 167 patients. Patients were divided into two groups based on the median aortic cross-clamp duration of 63 minutes:

- Group I: ≤ 63 minutes (n=86)
- Group II: >63 minutes (n=81) (Figure 1).

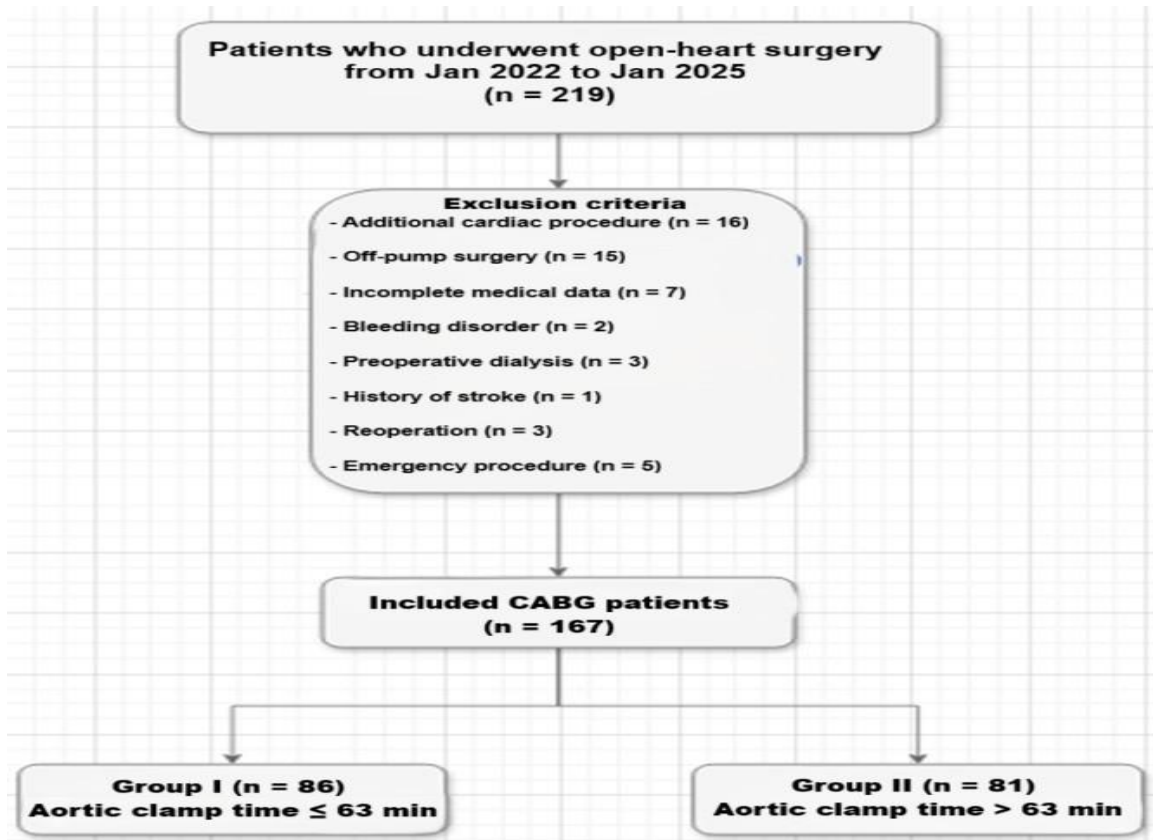


Figure 1. Flowchart of the study

Surgical procedure

All patients underwent standard median sternotomy under general anesthesia. Anticoagulation was achieved with 400 IU/kg of heparin, followed by cannulation of the ascending aorta and right atrium to initiate CPB. Moderate hypothermia (28-32°C) was maintained, and myocardial protection was provided using combined antegrade-retrograde blood cardioplegia. Mean arterial pressure during CPB was maintained between 60-80 mmHg. At the conclusion of the procedure, after the patient's body temperature reached 37°C, CPB was discontinued, heparin was neutralized with protamine, and decannulation was performed.

Definitions

- Atrial fibrillation: any atrial arrhythmia documented for >30 seconds on multi-lead electrocardiography.
- Cerebrovascular event: a transient neurological deficit lasting less than 24 hours.
- Low cardiac output syndrome: requirement for inotropes and/or intra-aortic balloon pump (IABP) and extracorporeal membrane oxygenation (ECMO)
- Continuous hemodiafiltration: need for renal replacement therapy due to postoperative acute kidney injury.

Statistical analysis

All data were analyzed using SPSS version 27 (SPSS Inc, USA). Normality of continuous variables was assessed using the Kolmogorov-Smirnov or Shapiro-Wilk tests, histograms, and box plots. Continuous data were expressed as mean \pm standard deviation or median with interquartile range, while categorical variables were analyzed using the Chi-square test. Comparisons between two groups were performed using the Mann-Whitney U test for non-normally distributed continuous variables and the independent samples t-test for normally distributed variables. Categorical variables were compared using the Pearson Chi-square test. Univariate linear regression analysis was performed to evaluate the association between aortic cross-clamp duration and continuous

postoperative outcomes. Regression coefficients (β), 95% confidence intervals (CI), and p-values were reported. A p-value <0.05 was considered statistically significant.

Results

A total of 167 patients (116 men and 51 women; mean age 65.1 ± 9.5 years, range 33-89 years) who underwent elective CABG were included. Descriptive analysis of patient sociodemographics and medical histories is shown in Table 1. There were no significant differences between the two groups in terms of age, sex, body surface area (BSA), body mass index (BMI), EuroSCORE II, ejection fraction (EF), hypertension, diabetes, chronic obstructive pulmonary disease (COPD), or peripheral artery disease (PAD) ($p > 0.05$, Table 1).

Table 1. Demographic characteristics of patients

Variables		Group 1 (n=86)	Group 2 (n=81)	p
Age	Mean \pm SD	63.8 \pm 8.9	66.5 \pm 9.8	0.069 (t=1.82)
Sex				
Male	n (%)	55(47.4)	61 (52.6)	0.111 ($\chi^2=2.53$)
Female		31(60.8)	20(39.2)	
BSA	Mean \pm SD	1.87 \pm 0.17	1.91 \pm 0.15	0.127 (t=1.54)
BMI	Mean \pm SD	28.1 \pm 3.16	28.6 \pm 3.12	0.376 (t=0.88)
Euroscore-II	Mean \pm SD	6.4 \pm 3.42	7.48 \pm 4	0.063 (t=1.90)
EF	Mean \pm SD	49.2 \pm 5.1	48 \pm 5.8	0.150 (t=1.45)
Hypertension	n (%)	55 (64)	62 (76.5)	0.076 ($\chi^2=3.15$)
Diabetes Mellitus	n (%)	54 (62.8)	57 (70.4)	0.301 ($\chi^2=1.07$)
COPD	n (%)	10 (11.6)	10 (12.3)	0.886 ($\chi^2=0.02$)
PAD	n (%)	11 (12.8)	17 (21)	0.156 ($\chi^2=2.01$)

BSA: Body surface area, BMI: Body Mass Index, EF: Ejection Fraction, COPD: Chronic Obstructive Pulmonary Disease, PAD: Peripheral Artery Disease, t: Independent samples t-test, χ^2 : Pearson Chi-square test, * $p < 0.05$ statistically significant

Operative data comparison revealed that Group II had significantly longer CPB duration [median 128 minutes (IQR: 117-146.5)] and aortic cross-clamp time [median 77 minutes (IQR: 69.5-86.5)] ($p < 0.001$). Additionally, the number of bypass grafts [median 3 (3-4)],

postoperative 24-hour drainage [median 500 mL (IQR: 400-600)], transfused blood product volume [median 600 mL (IQR: 400-850)], and extubation time [median 12 hours (IQR: 10-14)] were significantly higher in Group II compared to Group I ($p < 0.001$, Table 2).

Table 2. Operative data of patients

Variables		Group 1 (n=86)	Group 2 (n=81)	p
CPB duration (min)	Median (IQR)	101.5 (91.5-118)	128 (117-146.5)	<0.001* (z=-5.12)
ACC time (min)	Median (IQR)	51 (43.75-58)	77 (69.5-86.5)	<0.001* (z=-5.12)
Number of CABG	Median (IQR)	3 (2-3.25)	3 (3-4)	<0.001* (z=-5.12)
Postoperative 24-hour drainage (mL)	Median (IQR)	400 (300-562.5)	500 (400-600)	0.001* (z=-3.45)
Transfused blood products (mL)	Median (IQR)	300 (250-625)	600 (400-850)	<0.001* (z=-5.12)
MV duration (hours)	Median (IQR)	8.5 (7-10)	12 (10-14)	<0.001* (z=-4.90)
ICU stay (days)	Median (IQR)	2 (2-3)	3 (2-3)	0.069 (z=-1.82)
Development of PoAF	n (%)	18 (20.9)	26 (32.1)	0.102 ^b ($\chi^2=2.66$)
Cerebrovascular event	n (%)	2 (2.3)	3 (3.7)	0.601 ^b ($\chi^2=0.27$)

CPB: Cardiopulmonary Bypass, ACC: Aortic Cross-Clamp, CABG: Coronary Artery Bypass Graft, MV: Mechanical Ventilation
 ICU: Intensive Care Unit, PoAF: Postoperative Atrial Fibrillation, z: Mann-Whitney U test, χ^2 : Pearson Chi-square test
 * $p<0.05$ statistically significant

Univariate linear regression analysis demonstrated a significant positive correlation between cross-clamp duration and postoperative parameters (Table 3). Cross-clamp duration was positively associated with 24-hour postoperative drainage ($\beta=3.872$, $p<0.001$, 95% CI: 2.433-5.312) and red blood cell transfusion volume ($\beta=8.205$, $p<0.001$, 95% CI: 5.750-10.660).

Extubation time was also significantly correlated with cross-clamp duration ($\beta=0.129$, $p<0.001$, 95% CI: 0.059-0.199). These findings suggest that prolonged cross-clamp duration may increase postoperative bleeding, transfusion requirements, and mechanical ventilation duration.

Table 3. Univariate analysis of aortic cross-clamp duration and postoperative outcomes

Variables	p	β	95% CI
Postoperative 24-hour drainage (mL)	<0.001*	3.872	2.433-5.312
Transfused red blood cells (mL)	<0.001*	8.205	5.750-10.660
Extubation time (hours)	<0.001*	0.129	0.059-0.199

CI: Confidence Interval, t: Linear regression coefficient test, * $p<0.05$ statistically significant

Discussion

CABG is a commonly performed surgical procedure for treating coronary artery disease [7-10]. Aortic cross-clamp duration represents a critical phase of surgery, providing a bloodless and motionless field for graft anastomosis. Our study investigated the impact of cross-clamp duration on postoperative clinical outcomes, including data relevant to patients presenting to the emergency department with postoperative complications.

Prolonged cross-clamp time is known to increase the risk of adverse postoperative events. One significant aspect is its potential to prolong postoperative mechanical ventilation due to an increased risk of respiratory complications. Previous studies have shown that longer aortic cross-clamp duration correlates with extended postoperative mechanical ventilation [3]. In our cohort, patients with cross-clamp duration >64 minutes had significantly longer median extubation times (12 hours vs. 8.5 hours, $p < 0.001$). Other studies suggest that each one-minute increase in aortic clamp duration increases mortality risk by 2% and is associated with prolonged mechanical ventilation (>60 minutes) [3]. Univariate regression analysis in our study similarly indicated a significant positive correlation between cross-clamp duration and extubation time ($\beta = 0.129$; 95% CI: 0.059-0.199; $p < 0.001$), supporting the role of cross-clamp time in postoperative respiratory outcomes.

Prolonged intensive care unit (ICU) stays after cardiac surgery predict both short- and long-term outcomes [4, 11, 12]. In our study, the group with longer cross-clamp duration had longer ICU stays, although the difference was not statistically significant, likely due to the homogeneity of patient groups and relatively less complex procedures. Prior research has shown that in complex cardiac surgeries, extended cross-clamp duration significantly increases ICU length of stay and adversely affects both short- and long-term mortality [5].

Postoperative bleeding in cardiac surgery prolongs ICU and hospital stays, increases healthcare costs, and is associated with higher mortality [9]. In our cohort, both 24-hour postoperative drainage and transfused blood volume were significantly higher in the

prolonged cross-clamp group. Univariate analysis demonstrated that each one-minute increase in cross-clamp duration was associated with a 3.8 mL increase in 24-hour drainage and an 8.2 mL increase in red blood cell transfusion, suggesting that prolonged clamp time negatively impacts recovery by increasing bleeding and transfusion requirements.

Limitations of this study include its retrospective design and single-center setting, leading to a relatively limited sample size. Nevertheless, these findings may provide a basis for further research and contribute to clinical understanding of the impact of cross-clamp duration.

In conclusion, prolonged aortic cross-clamp duration adversely affects key postoperative clinical outcomes, including mechanical ventilation time, bleeding, and transfusion requirements. Even in isolated CABG procedures, these effects are observed, highlighting the critical need for careful intraoperative monitoring of clamp time. These results are particularly relevant for emergency department physicians, enabling early identification and management of patients at risk for postoperative complications. Optimization of surgical strategies can reduce perioperative morbidity and improve hospital resource utilization. Further prospective studies with larger cohorts are warranted to provide stronger evidence for clinical guidance.

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Conflict of interest: No conflict of interest was declared by the authors.

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