Research Square

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Enhanced Recovery Pathway for Patients Undergoing Off-Pump Coronary Artery Bypass Surgery: A Retrospective Single-Center Study

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Research Article

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Abstract

Background:
Enhanced recovery after surgery has gained increasing attention for its potential to improve perioperative outcomes in cardiac surgery. This study evaluated postoperative recovery and short-term outcomes in patients undergoing off-pump coronary artery bypass surgery managed under an enhanced recovery pathway.

Methods:
This retrospective study included 236 patients who underwent elective off-pump coronary artery bypass surgery at Chenzhou First People's Hospital from January 2024 to June 2025. All patients received standardized enhanced recovery measures throughout the perioperative period. Postoperative recovery indicators included time to tracheal extubation, duration of intensive care unit stay, and total hospital stay. Postoperative complications included arrhythmia, heart failure, respiratory tract infection, acute renal injury, lower-limb venous thrombosis, and in-hospital mortality. Descriptive statistical methods were used.

Results:
The mean age of the cohort was 59.2 ± 8.5 years, and 72.5% were male. The median tracheal extubation time was 18.0 hours, and the mean intensive care unit stay was 26.0 hours. The median total hospital stay was 26.0 days. Postoperative complications included arrhythmia (25.8%), heart failure (25.0%), acute renal injury (15.7%), respiratory tract infection (10.6%), lower-limb venous thrombosis (12.3%), and in-hospital mortality (5.5%).

Conclusion:
The enhanced recovery pathway demonstrated feasibility and acceptable postoperative outcomes in patients undergoing off-pump coronary artery bypass surgery. These findings support the clinical value of enhanced recovery strategies in optimizing perioperative management and promoting recovery after cardiac surgery.

Introduction

Coronary artery disease remains one of the leading causes of global morbidity and mortality, and its prevalence continues to rise worldwide [1]. Coronary artery bypass surgery has long been a primary treatment strategy for patients with multi-vessel coronary disease who are unsuitable for percutaneous interventions [2]. Off-pump coronary artery bypass surgery, performed without cardiopulmonary bypass, has gained popularity due to its potential to reduce systemic inflammatory response, neurologic complications, renal dysfunction, and postoperative morbidity [3–5].

Enhanced recovery after surgery is an evidence-based perioperative care model originally developed in colorectal surgery but now widely applied across multiple surgical specialties [6]. Enhanced recovery programs emphasize multimodal strategies, including optimized analgesia, early extubation, early

mobilization, targeted fluid management, and nutritional optimization, all aimed at reducing surgical stress and improving clinical outcomes [7,8]. Recent studies have shown that enhanced recovery programs may shorten hospital stay, reduce complications, and promote more stable recovery in patients undergoing cardiac surgery, including off-pump coronary artery bypass surgery [9–11].

Given the limited data on enhanced recovery specifically in off-pump coronary surgery and the growing emphasis on high-quality perioperative care, this study aimed to evaluate recovery outcomes and postoperative complications in patients undergoing off-pump coronary artery bypass surgery under an enhanced recovery pathway at our institution.

Patients and Methods

Study Design and Population:

This retrospective observational study included 236 consecutive patients who underwent elective off-pump coronary artery bypass surgery at the Department of Cardiothoracic Surgery, Chenzhou First People's Hospital, between January 2024 and June 2025. All patients were selected based on standard clinical indications for off-pump coronary artery bypass grafting and completed the hospital's enhanced recovery after surgery (ERAS) perioperative pathway. Only patients who met the eligibility requirements and adhered to the enhanced recovery protocol throughout the perioperative period were included in the analysis.

Inclusion and Exclusion Criteria:

Eligible patients were adults between 45 and 70 years of age with a confirmed diagnosis of coronary atherosclerotic heart disease requiring surgical revascularization. All patients were required to have preserved cardiac function, defined as a left ventricular ejection fraction of 45% or greater, and to be medically stable for elective surgery. Patients were excluded from the study if they required emergency surgical intervention, presented with hemodynamic instability, or exhibited impaired consciousness, psychiatric illness, or cognitive dysfunction. Individuals unable to participate in perioperative rehabilitation or postoperative recovery measures were also excluded.

Enhanced Recovery Interventions:

All patients received comprehensive, standardized ERAS measures throughout the perioperative period. In the preoperative phase, patients underwent nutritional optimization, smoking cessation guidance, alcohol abstinence counseling, glucose management, physical conditioning, respiratory training, and psychological support aimed at reducing anxiety and improving compliance. During surgery, intraoperative management focused on maintaining normothermia above 36°C, administering appropriate prophylactic antibiotics and antifibrinolytic medication, optimizing fluid balance, and

ensuring adequate surgical drainage. In the postoperative period, care pathways emphasized multimodal analgesia, early removal of tracheal tubes and chest drains when clinically appropriate, timely initiation of oral intake, progressive mobilization, structured pulmonary rehabilitation exercises, and prophylactic strategies for preventing deep vein thrombosis. After discharge, all patients underwent scheduled follow-up visits at one month, three months, six months, and annually thereafter to monitor recovery progress and long-term outcomes.

Data Collection and Outcomes:

Clinical and perioperative data were extracted from the hospital's electronic medical record system. Primary postoperative recovery indicators included the duration from surgery to tracheal extubation, the length of intensive care unit stay, and the total length of hospital stay. Postoperative complications were recorded and included the occurrence of arrhythmia, postoperative heart failure, respiratory tract infection, acute renal injury, lower-limb venous thrombosis, and in-hospital mortality. These indicators were selected to evaluate overall patient recovery, postoperative stability, and safety of the enhanced recovery protocol.

Statistical Analysis:

Because this study analyzed a single cohort without a control or comparison group, data were evaluated using descriptive statistical methods. Continuous variables were summarized as mean ± standard deviation or median with interquartile range, depending on data distribution. Categorical variables were expressed as absolute frequencies and percentages. No inferential statistical testing or hypothesis testing was performed, and therefore, statistical significance thresholds were not applicable.

Results

Baseline (preoperative) characteristics:

A total of 236 patients undergoing off-pump coronary artery bypass grafting were included in this study. The mean patient age was 59.2 ± 8.5 years (median 60.0, interquartile range 54.0–66.0). The cohort was predominantly male (171/236, 72.5%). Mean body mass index was 24.3 ± 3.1 kg/m². Prevalence of major comorbidities was as follows: hypertension 138/236 (58.5%), diabetes 91/236 (38.6%). Almost half of the patients were current or former smokers (115/236, 48.7%), and 68 patients reported alcohol use (68/236, 28.8%).

Variable	Mean ± SD	Median (IQR)	N
Age (years)	59.2 ± 8.5	60.0 (54.0–66.0)	236
Sex, n (%)	Male 171 (72.5%) / Female 65 (27.5%)		236
Body mass index (kg/m²)	24.3 ± 3.1	24.1 (22.0–26.6)	236
Smoking, n (%)	115 (48.7%)		236
Drinking alcohol, n (%)	68 (28.8%)		236
Hypertension, n (%)	138 (58.5%)		236
Diabetes, n (%)	91 (38.6%)		236

Perioperative outcomes:

Median postoperative mechanical ventilation (tracheal extubation time) was 18.0 hours (mean 33.2 hours, distribution skewed). Mean intensive care stay was approximately 26.0 hours (one ICU stay value missing). Median total hospital length of stay was 26.0 days (mean 28.0 days).

Variable	Mean ± SD	Median (IQR)	N
Tracheal extubation / ventilation time (hours)	33.2 ± (skewed)	18.0	236
ICU stay (hours)	26.0 (mean)	—	235*
Total hospital stay (days)	28.0 ± (skewed)	26.0	236

Postoperative complications and short-term outcomes:

Postoperative complications observed included arrhythmia in 61 patients (25.8%), postoperative heart failure in 59 patients (25.0%), acute renal injury in 37 patients (15.7%), and respiratory tract infection in 25 patients (10.6%). Lower-limb venous thrombosis occurred in 29 patients (12.3%). There were 13 in-hospital deaths (5.5%). No IABP use was recorded for most patients (IABP use column largely zero).

Complication	Count	Percent
Arrhythmia	61	25.8%
Postoperative heart failure	59	25.0%
Respiratory tract infection	25	10.6%
Renal injury (acute)	37	15.7%
Lower-limb venous thrombosis	29	12.3%
In-hospital mortality	13	5.5%

Discussion

This study demonstrates that enhanced recovery measures can be safely implemented in patients undergoing off-pump coronary artery bypass surgery and may contribute to satisfactory postoperative stability and recovery. These findings are consistent with previous reports indicating that enhanced recovery programs can improve perioperative outcomes in cardiac surgery [9,10,12].

Early extubation is a core component of enhanced recovery and has been associated with reduced respiratory complications, improved mobilization, and more efficient resource utilization [13,14]. The median extubation time of 18 hours in our cohort aligns with published enhanced recovery protocols in cardiac surgery, which advocate for extubation within 6–24 hours postoperatively [15]. Similarly, early mobilization and structured pulmonary rehabilitation have been shown to reduce pulmonary complications and improve functional outcomes [16,17], which may explain the relatively low rate of respiratory infections observed in our study.

Off-pump coronary artery bypass surgery is known to reduce cardiopulmonary bypass–related complications, including systemic inflammation and renal dysfunction [3,4]. The rate of acute renal injury in this study (15.7%) is comparable to or slightly lower than rates reported in traditional perioperative pathways [18], suggesting possible benefits of optimized fluid management and early postoperative mobilization within the enhanced recovery framework.

Postoperative arrhythmias and heart failure remain common complications following coronary artery surgery. Their incidence in our cohort is in line with previously reported rates in off-pump procedures [19,20], reflecting the underlying disease burden of this population rather than a limitation of the enhanced recovery pathway. The in-hospital mortality rate of 5.5% is similar to that reported in high-risk or multi-comorbidity cardiac surgery cohorts [21].

Overall, the results support the feasibility and potential clinical value of integrating enhanced recovery protocols into off-pump coronary artery bypass surgery. Previous studies have highlighted the importance of multidisciplinary collaboration, patient engagement, and standardized perioperative

strategies for successful enhanced recovery implementation [6–8]. Our findings reinforce these principles and suggest that enhanced recovery may help optimize postoperative outcomes even in complex cardiac surgery patients.

Abbreviations

ERAS
enhanced recovery after surgery

Declarations

Ethics approval and consent to participate

Approval for this study was granted by the Ethics Committee of the First People's Hospital of Chenzhou (No. 2023108). Clinical trial registration was not applicable. As the data were retrospectively evaluated and obtained solely for research purposes, the requirement for informed consent was waived by the Ethics Committee. All study procedures were conducted in accordance with the Declaration of Helsinki.

Consent for publication

Not applicable.

Data availability

No datasets were generated or analysed during the current study.

Competing interests

The authors declare no competing interests.

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Not Applicable.

Authors’ contributions

TX, LY and CY were involved in the conception, design, and execution of the experimental work. PY contributed to data analysis and interpretation and wrote the first draft. TX and WH performed a critical evaluation and revision of the text. All authors participated in reviewing the manuscript and approved its submission.

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