Received: 01 August 2025 / Accepted: 11 November 2025 / Published online: 30 December 2025

DOI 10.34689/SH.2025.27.6.028

UDC 616.132.2-008.6:616.1:615.273.53:615.38

CORONARY ARTERY STENTING UNDER ECMO SUPPORT: A CASE SERIES DESCRIPTION

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Abstract

Objective: The use of Veno-Arterial Extracorporeal Membrane Oxygenation (VA-ECMO) is a potentially life-saving strategy for patients with refractory cardiogenic shock (CS) secondary to ST-segment elevation myocardial infarction (STEMI)for whom standard therapy is ineffective. Data on the implementation of this method are scarce in the Republic of Kazakhstan (RK).

Aim of the Study To evaluate the feasibility and initial clinical outcomes of emergency percutaneous coronary intervention (PCI) supported by VA-ECMO under a unified protocol in patients with refractory cardiogenic shock in the Republic of Kazakhstan.

Methods A retrospective, single-center study was conducted, including a series of six consecutive patients with refractory CS due to STEMI who underwent emergency coronary artery stenting at the Pavlodar Regional Cardiology Center during the period from October 2024 to September 2025. PCI was performed with active peripheral VA-ECMO support via a femoral approach. The primary endpoint was survival to hospital discharge, and the secondary endpoint was the frequency of major complications.

Results The mean age of the patients was 71.3 years (men — 83.3%). Multivessel coronary artery disease was recorded in 100% of patients. The PCI procedure was technically successful in all 6 cases, achieving TIMI 3 flow. The mean duration of ECMO support during the intervention was 56 minutes (30–90 minutes). Hospital survival was 83.3%(5 out of 6 patients were discharged in satisfactory condition). Among discharged patients, 30- and 90-day survival was 100%. A complication in the form of femoral artery dissection was recorded in 1 patient (16.7%).

Conclusions The application of a unified perioperative management protocol allows for the successful performance of emergency PCI with VA-ECMO support in patients with refractory cardiogenic shock. The method is technically feasible and provides a high level of early survival comparable to international data, confirming its potential as a life-saving option.

Keywords: *Cardiogenic Shock, STEMI, VA-ECMO, PCI, Revascularization, Kazakhstan.*

For citation:

Antikeev A.M., Ordabayev E.T., Abiltayev A.M., Antikeyev D.A., Abiltayeva A.A., Tleuova A.K., Izguttinov D.E. Coronary Artery Stenting Under ECMO Support: A Case Series Description // *Nauka i Zdravookhranenie* [Science & Healthcare]. 2025. Vol.27 (6), pp. 251-257. *doi 10.34689/SH.2025.27.6.028*

Резюме

СТЕНТИРОВАНИЕ КОРОНАРНЫХ АРТЕРИЙ В УСЛОВИЯХ ЭКМО: ОПИСАНИЕ СЕРИИ КЛИНИЧЕСКИХ СЛУЧАЕВ

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Использование вено-артериальной экстракорпоральной мембранной оксигенации (ВА-ЭКМО) является потенциально жизнесберегающей стратегией для пациентов с рефрактерным кардиогенным шоком (КШ) на фоне инфаркта миокарда с подъемом сегмента ST (ИМпST), для которых стандартная терапия неэффективна. В Республике Казахстан (РК) данные о внедрении данной методики отсутствуют.

Цель исследования: Оценить реализуемость и первоначальные клинические исходы экстренного чрезкожного коронарного вмешательства (ЧКВ) под поддержкой ВА-ЭКМО в условиях единого унифицированного протокола у пациентов с рефрактерным кардиогенным шоком на территории РК.

Методы: Проведено ретроспективное, одноцентровое исследование, включающее серию из шести последовательных пациентов с рефрактерным КШ на фоне ИМпST, которым было выполнено экстренное стентирование коронарных артерий в Павлодарском Областном Кардиологическом Центре в период с октября 2024 года по сентябрь 2025 года. ЧКВ выполнялось при активной периферической ВА-ЭКМО поддержке через бедренный доступ. Первичной конечной точкой была выживаемость до выписки из стационара, вторичной — частота основных осложнений.

Результаты: Средний возраст пациентов составил 71,3 года (мужчины — 83,3%). У 100% пациентов было зафиксировано многососудистое поражение. Процедура ЧКВ была технически успешной во всех 6 случаях, с достижением кровотока TIMI 3. Средняя длительность ЭКМО-поддержки во время вмешательства составила 56 минут (30–90 минут). Госпитальная выживаемость составила 83,3% (5 из 6 пациентов выписаны в удовлетворительном состоянии). Среди выписанных пациентов 30- и 90-дневная выживаемость составила 100%. Осложнение в виде диссекции бедренной артерии зафиксировано у 1 пациента (16,7%).

Выводы: Применение унифицированного протокола периоперационного ведения позволяет успешно проводить экстренное ЧКВ под поддержкой ВА-ЭКМО у пациентов с рефрактерным кардиогенным шоком. Методика технически реализуема и обеспечивает высокий уровень ранней выживаемости, сопоставимый с международными данными, что подтверждает ее потенциал в качестве жизнесберегающей опции.

Ключевые слова: *Кардиогенный шок, ИМпST, ВА-ЭКМО, ЧКВ, Реваскуляризация, Казахстан.*

Для цитирования:

Антикеев А.М., Ордабаев Е.Т., Абильтаев А.М., Антикеев Д.А., Абильтаева А.А., Тлеуова А.К., Изгуттинов Д.Е. Стентирование коронарных артерий в условиях ЭКМО: описание серии клинических случаев // Наука и Здравоохранение. 2025. Vol.27 (6), С.251-257. *doi 10.34689/SH.2025.27.6.028*

Түйіндеме

ЭКМО ЖАҒДАЙЫНДАҒЫ КОРОНАРЛЫҚ АРТЕРИЯЛАРДЫ СТЕНТТЕУ: КЛИНИКАЛЫҚ ЖАҒДАЙЛАР СЕРИЯСЫНЫҢ СИПАТТАМАСЫ

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Вено-артериялық экстракорпоралдық мембраналық оксигенацияны (ВА-ЭКМО) қолдану стандартты терапия тиімсіз болған ST сегментінің көтерілуімен болатын миокард инфарктісі (МКСК) аясындағы рефрактерлік кардиогенді шок (КШ) бар пациенттер үшін өмірді сақтауға қабілетті стратегия болып табылады. Қазақстан Республикасында (ҚР) осы әдісті енгізу туралы деректер жоқ.

Зерттеу мақсаты: ҚР аумағында рефрактерлік кардиогенді шок бар пациенттерде бірыңғай стандартталған хаттама жағдайында ВА-ЭКМО қолдауымен шұғыл тері арқылы коронарлық араласудың (ТКА) іске асырылуын және бастапқы клиникалық нәтижелерін бағалау.

Әдістер: 2024 жылдың қазан айынан 2025 жылдың қыркүйегіне дейінгі кезеңде Павлодар облыстық кардиологиялық орталығында шұғыл коронарлық артерия стенттеуі жүргізілген рефрактерлік КШ-пен 6 пациентті қамтитын ретроспективті, бір орталықты зерттеу жүргізілді. ТКА шұғыл перифериялық ВА-ЭКМО қолдауымен

(сандық қолжетімділік арқылы) орындалды. Негізгі соңғы нүкте стационардан шыққанға дейінгі өмір сүру ұзақтығы болды, ал екіншісі — негізгі асқынулардың жиілігі.

Нәтижелер: Пациенттердің орташа жасы 71,3 жасты құрады (ерлер — 83,3%). Пациенттердің 100%-ында көп тамырлы зақымдану тіркелді. ТКА процедурасы барлық 6 жағдайда техникалық тұрғыдан сәтті өтті, TIMI 3ағынына қол жеткізілді. Араласу кезіндегі ЭКМО қолдаудың орташа ұзақтығы 56 минутты (30–90 минут) құрады. Ауруханадағы өмір сүру ұзақтығы 83,3% (6 пациенттің 5-і қанағаттанарлық жағдайда шығарылды). Шығарылған пациенттер арасында 30 және 90 күндік өмір сүру ұзақтығы 100% құрады. Сандық артерияның диссекциясы түріндегі асқыну 1 пациентте (16,7%) тіркелді.

Қорытындылар: Периоперациялық жүргізудің бірыңғай хаттамасын қолдану рефрактерлік кардиогенді шок бар пациенттерде ВА-ЭКМО қолдауымен шұғыл ТКА-ны сәтті жүргізуге мүмкіндік береді. Әдіс техникалық тұрғыдан іске асырылады және халықаралық деректермен салыстыруға болатын ерте өмір сүрудің жоғары деңгейін қамтамасыз етеді, бұл оның өмірді сақтау мүмкіндігі ретіндегі әлеуетін растайды.

Түйін сөздер: *Кардиогенді шок, МКСК, ВА-ЭКМО, ТКА, Реваскуляризация, Қазақстан.*

Дәйексөз үшін:

Антикеев А.М., Ордабаев Е.Т., Абильтаев А.М., Антикеев Д.А., Абильтаева А.А., Тлеуова А.К., Изгуттинов Д.Е. ЭКМО жағдайындағы коронарлық артерияларды стенттеу: клиникалық жағдайлар сериясының сипаттамасы // Ғылым және Денсаулық сақтау. 2025. Vol.27 (6), Б. 251-257. *doi 10.34689/SH.2025.27.6.028*

Introduction

Ischemic heart disease (IHD) remains a leading cause of mortality and disability worldwide, particularly among the working-age population. Its most critical manifestation is ST-segment elevation myocardial infarction (STEMI), which requires urgent restoration of coronary blood flow [11].

Despite advancements in reperfusion therapy (percutaneous coronary intervention (PCI), thrombolysis), the development of cardiogenic shock (CS) occurs in 5%–10% of patients with acute myocardial infarction, carrying an extremely poor prognosis. In-hospital mortality reaches 40%–50% and often higher [10, 14, 16].

Cardiogenic shock is defined as a critical condition resulting from an abrupt reduction in cardiac output and subsequent impairment of end-organ perfusion, unresponsive to standard treatments (inotropes, vasopressors). Patients with refractory cardiogenic shock present a particular challenge, as mortality approaches 100% without the application of mechanical circulatory support (MCS). It is this patient population—typically older, with low left ventricular ejection fraction (LVEF), multi-vessel coronary disease, and severe comorbidities—that is at maximum risk [5, 6, 8, 9, 12].

One potential solution is the use of Veno-Arterial Extracorporeal Membrane Oxygenation (VA-ECMO), which provides temporary circulatory and respiratory support. This allows therapeutic interventions to be performed in a setting of stabilized circulation. Several publications have demonstrated that combining ECMO and PCI can be life-saving for patients with severe myocardial dysfunction and high anatomical risk (e.g., left main coronary artery disease, chronic total occlusions) [3, 13, 15].

However, despite these technological advances, such interventions are associated with considerable risks. Hospital mortality in these complex patients can be as high as 23%, and long-term survival rarely exceeds 45%–50% [10]. Notably, successful PCI in this setting achieves complete revascularization rates of over 90%, and ECMO weaning is often feasible [13].

Published data remain limited to small case series and isolated retrospective studies. Crucially, no studies have been conducted or published within the Republic of Kazakhstan on this topic. Furthermore, randomized clinical trials directly comparing PCI under ECMO support versus coronary artery bypass grafting (CABG) in high-risk patients are lacking [2, 7]. Key questions remain unresolved, including optimal patient selection criteria, ideal timing for ECMO placement, anticoagulant management strategies, and long-term outcomes.

Study Hypothesis: We hypothesize that describing a series of clinical cases using a unified protocol will demonstrate that PCI under VA-ECMO support is a technically feasible and potentially life-saving procedure. Furthermore, this analysis will allow us to identify the key factors determining success in this patient cohort.

Aim of the Study: The aim of this study is to evaluate the feasibility and initial clinical outcomes of emergency percutaneous coronary intervention (PCI) with VA-ECMO support, utilizing a single unified protocol in patients with refractory cardiogenic shock within the Republic of Kazakhstan.

Materials and Methods

Study Design and Population

This retrospective, single-center study included six consecutive patients with refractory cardiogenic shock (CS) secondary to STEMI. All patients underwent emergency percutaneous coronary intervention (PCI) with active VA-ECMO support via femoral access at the Pavlodar Regional Cardiac Center (PRCC) between October 2024 and September 2025. All procedures were conducted in the hospital's third-level hybrid operating room.

Veno-Arterial ECMO Protocol and Procedure: ECMO was established peripherally via femoral access, guided by a unified institutional protocol (Figure 1). The procedure was performed jointly by interventional cardiologists, X-ray vascular surgeons, cardiac surgeons, and intensive care specialists.

ECMO Cannulation and Initiation: Patients presenting with hypotension, hemodynamic instability, clinical signs of CS, and/or requiring ongoing cardiopulmonary resuscitation (CPR) were immediately moved to the X-ray vascular operating room.

1. Anticoagulation: Intravenous heparin was administered at a dose of 150–200 IU/kg (e.g., 10,500–

14,000 IU for a 70 kg patient) prior to cannulation to maintain the Activated Clotting Time (ACT) control.

2. Surgical Access: Under sterile conditions (Figure 1A), a vertical incision (up to 7 cm) was made in the inguinal crease to expose the femoral artery and vein.

3. Arterial Cannulation: A purse-string suture (3 by 4 mm patches) was placed on the pulsatile femoral artery. An arterial cannula was inserted (Figure 1B, C), and the line was purged of air and secured with a Murphy clamp.

4. Venous Cannulation: A second purse-string suture was placed on the femoral vein, medial to the artery. The soft guidewire was advanced into the superior vena cava, ensuring the cannula tip reached the right atrium or stopped just short of the atrial roof to prevent injury (Figure 1D, E).

5. Circuit Connection: After clamping the ECMO circuit lines, the arterial cannula was connected to the red (arterial) line and the venous cannula to the blue (venous) line. Physiological saline was used to flush the connection sites to meticulously remove all air before removing the clamps.

6. ECMO Activation: The ECMO console was activated by turning the knob to a rotational speed of 6,500 rpm (Figure 1F). Oxygen flow was set to 2–3 L/min, with FiO2 maintained at 90%–100%. The heat exchanger was set to 37.3◦C.

7. Post-Procedure: Following successful PCI and ECMO stabilization, patients were transferred to the Critical Care Unit (CCU). Decisions regarding ECMO weaning were made by a multidisciplinary heart team.

Endpoints: Primary endpoints included successful revascularization (TIMI 3 flow) and survival rates until ECMO weaning and hospital discharge. Secondary endpoints included the incidence of major in-hospital complications (bleeding, stroke, limb ischemia) and survival at 30 and 90 days.

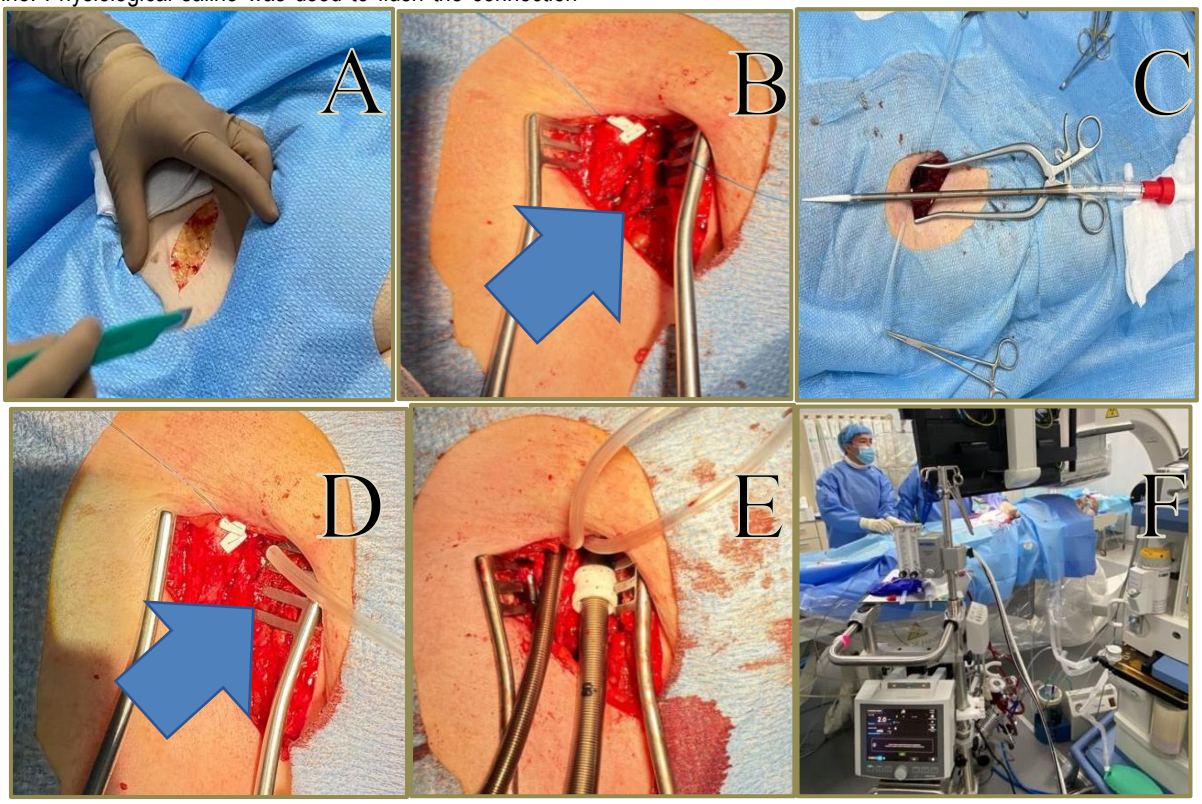

Figure 1. Stages of preparation for PCI under VA-ECMO support: (A) Access for peripheral VA cannulation, (B) Visual confirmation of cannulae, (C) Preparation and purse-string suture placement on the femoral artery (blue arrow), (D)Preparation and purse-string suture placement on the femoral vein (blue arrow), (E) Cannulation of the femoral artery and vein, (F) Team activity during the VA-ECMO procedure.

Results

Patient Characteristics and Baseline Data

This study included six patients, the majority of whom were male (83.3%). Their baseline characteristics are summarized in Table 1. The mean age of the cohort was 71.3 years (range: 59–84 years). Patients generally presented with overweight status, with a mean BMI of 25 kg/m2 (range: 19–29 kg/m2).

A significant portion of the cohort (83.3%) had a history of, or were admitted with, a previous MI. Three patients (50%) had undergone prior surgical revascularization in the form of Coronary Artery Bypass Grafting (CABG), and one patient (16.7%) had a history of Aorto-Femoral Bypass (AFB).

The following comorbidities were noted in the patient history: Arterial Hypertension (AH) – 6 patients (100%), Multifocal Atherosclerosis (MFA) – 5 patients (83.3%), Diabetes Mellitus (DM) – 1 patient (16.7%), Mitral Regurgitation (MR) – 2 patients (33.3%), Tricuspid Regurgitation (TR) – 4 patients (66.7%), Cardiac Rhythm Disorder (CRD) – 2 patients (33.3%), Chronic Venous Insufficiency (CVI) and Abdominal Aortic Aneurysm (AAA) – 1 patient (16.7%) each.

All six patients (100%) presented with multivessel coronary artery disease. Left Main Coronary Artery (LMCA)

involvement was noted in four cases (66.7%). The majority of patients had lesions in the Left Anterior Descending (LAD) artery (83.3%), the Circumflex Artery (Cx) (66.7%), and the Right Coronary Artery (RCA) (83.3%).

As detailed in Table 1, the mean Left Ventricular Ejection Fraction (LVEF) was 36.67% (range: 23%–57%). The average Glomerular Filtration Rate (GFR) was slightly reduced at 73.8 mL/min/1.73 m2 (range: 59–85 mL/min/1.73 m2). Laboratory markers indicated liver function near the upper limit of normal (ALT: 83 U/L, range 12–365 U/L), renal function also near the upper limit of normal (creatinine: 88.33 μmol/L, range 72–105 μmol/L), while cardiac markers (AST) were within the normal range (33.83 U/L, range 15–94 U/L).

Table 1.

Patient Characteristics.

Variable	Value
Male, n (%)	5 (83,3)
Age, mean (min-max) [years]	71,33 (59-84)
BMI,kg/m2	25 (19-29)
Ischemic Heart Disease (IHD), n (%)	6 (100)
History of Acute MI, n (%)	5 (83,3)
Prior Coronary Artery Bypass Grafting (CABG), n (%)	3 (50)
Arterial Hypertension (AH), n (%)	6 (100)
Multifocal Atherosclerosis (MFA), n (%)	5 (83,3)
Prior Aorto-Femoral Bypass (AFB), n (%)	1 (16,7)
Diabetes Mellitus (DM), n (%)	1 (16,7)
Mitral Regurgitation (MR), n (%)	2 (33,3)
Tricuspid Regurgitation (TR), n (%)	4 (66,7)
Cardiac Rhythm Disorder (CRD), n (%)	2 (33,3)
Chronic Venous Insufficiency (CVI), n (%)	1 (16,7)
Abdominal Aortic Aneurysm (AAA), n (%)	1 (16,7)
Left Main Coronary Artery (LMCA), n(%)	4 (66,7)
Left Anterior Descending Artery (LAD), n (%)	5 (83,3)
Circumflex Artery (Cx), n (%)	4 (66,7)

Procedure and Initial Outcomes

Complete coronary revascularization was successfully achieved in all six cases (100%) under ECMO support and hemodynamic stabilization.

The duration of ECMO support was remarkably short (Table 2), with a mean duration of only 56 minutes (range: 30 to 90 minutes), indicating its use as a temporary prophylactic/stabilizing tool during the PCI procedure.

Table 2.

VA-ECMO Parameters and Duration.

Variable	Value
ECMO Support Duration <1 day, n (%)	6 (100)
ECMO Support Duration, hours, mean (min-max)	0:56 (0:30-1:30)

Primary Outcomes (Table 3): Successful revascularization (achieving TIMI 3 flow) was observed in all 6 patients (100%) without major procedural complications. The mean length of hospital stay was 16 days (range: 3–31 days), with a mean stay in the Intensive Care Unit (ICU) of 3 days (range: 3–6 days). Five out of six patients were discharged from the hospital in a satisfactory condition.

Secondary Outcomes (Table 3): Thirty-day and ninety-day survival among the discharged patients was 100%. Only one complication was recorded in the entire cohort: a femoral artery dissection, which was managed successfully. No other complications were observed.

Table 3.

Primary and Secondary Outcomes.

Variable	Value
Primary Outcomes	
Successful Revascularization, n (%)	6 (100)
Length of Hospital Stay, days, mean (min-max)	16 (3-31)
Length of ICU Stay, days, mean (min-max)	3 (1-6)
Discharged, n (%)	5 (83,3)
Secondary Outcomes	
30-day Survival Rate, n(%)	5 (83,3)
90-day Survival Rate, n (%)	5 (83,3)
Femoral Artery Dissection, n(%)	1 (16,7)
Bleeding Events, n (%)	0
Stroke, n (%)	0
Limb Ischemia, n (%)	0

Discussion

The current study describes a sequential series of six patients with refractory cardiogenic shock (CS) secondary to STEMI, who underwent emergency percutaneous coronary intervention (PCI) with VA-ECMO support. The principal finding demonstrates that this complex intervention was technically feasible in all cases, leading to successful revascularization (TIMI 3 flow) and, crucially, the possibility of successful ECMO weaning in the majority of the cohort.

These results align favorably with previously published international data. Specifically, studies by Shaukat et al. (2018), Huang et al. (2022), and Bai et al. (2022) have reported high success rates (90%–100%) for PCI performed under ECMO support in patients presenting with severe multivessel disease and low LVEF [3, 4, 13]. Our findings further validate that the use of ECMO effectively stabilizes hemodynamics, permitting complete revascularization even in critically ill patients.

Consistent with the literature, we observed a measurable rate of complications (16.7%), which is characteristic of such high-risk procedures. The most significant complication encountered was vascular in nature, stemming from the percutaneous ECMO insertion. These observations are consistent with large retrospective registries where bleeding rates approach 20% and vascular complications reach up to 10% [7]. In our small series, we were able to minimize these complications through the implementation of a unified management protocol (strict ACT control, standardized access selection, and early detection of limb ischemia). However, the inherent risk remains substantial.

A key achievement was that the standardized protocol for anticoagulation and access site care allowed us to avoid fatal bleeding events and strokes, underscoring the vital importance of a multidisciplinary approach and patient management within a specialized center. These conclusions strongly echo the recommendations put forth by Zuin et al. (2019) and Griffioen et al. (2022), who emphasize the necessity of concentrating these complex interventions in tertiary care facilities [1, 17].

The practical significance of this study lies in confirming that PCI with ECMO support offers a viable pathway to acceptable clinical outcomes (hospital survival rate of approximately 83.3%), even in patients facing an extremely unfavorable prognosis (advanced age, multivessel disease, low LVEF). This evidence supports the view that the methodology should be considered a real alternative to surgical revascularization (CABG) for patients deemed non-candidates for conventional surgery.

Limitations

Our study is subject to several limitations. Firstly, the small sample size restricts the ability to draw statistically significant conclusions. Secondly, as a single-center study, the generalizability of these results is inherently limited. Thirdly, the absence of a dedicated control group (e.g., patients undergoing CABG or PCI without ECMO) prevents a direct assessment of the method's advantages.

Nevertheless, the data collected highlight the potential and promise of this approach and clearly demonstrate the need for further investigation. Future research should prioritize the optimization of patient selection criteria, refinement of the timing for ECMO placement, and the development of unified protocols for anticoagulation and perioperative management. These steps are crucial for the design of future multicenter studies and, ultimately, randomized clinical trials.

Conclusion

Revascularization performed with VA-ECMO support is a life-preserving procedure that necessitates a multidisciplinary approach, along with meticulous patient selection and management strategies. The feasibility and promising initial outcomes demonstrated here underscore the urgent requirement for further investigation, ideally in the form of multicenter randomized clinical trials.

Acknowledgments: *None.*

Conflict of Interest: *The authors declare no conflicts of interest.*

Author Contributions: *All authors contributed equally to the preparation of this material.*

Publication Information: *This material has not previously been submitted for publication elsewhere and is not under consideration by other publishers.*

Funding: *This study was not funded.*

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