Effects of Extracorporeal Membrane Oxygenation Combined with Emergency PCI in Resuscitating Acute Myocardial Infarction-Related Cardiac Arrest

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Abstract: Objective: To analyze resuscitation strategies for cardiac arrest following acute myocardial infarction, focusing on the treatment effects of extracorporeal membrane oxygenation (ECMO) combined with emergency percutaneous coronary intervention (PCI). Methods: From January 2023 to June 2024, 100 cases of cardiac arrest following acute myocardial infarction were included and randomly divided into two groups: the control group (50 cases) received conventional cardiopulmonary resuscitation (CPR) combined with emergency PCI, while the observation group (50 cases) received ECMO combined with emergency PCI. The resuscitation effects, return of spontaneous circulation (ROSC) rate, Glasgow Coma Scale (GCS) score, vital signs, and complication rates were compared between the two groups. Results: The observation group had a survival rate of 90.00% and ROSC rate of 94.00%, which were higher than the control group's 70.00% and 76.00% ($P < 0.05$). The GCS scores on postoperative days 1, 2, and 3 were higher in the observation group ($P < 0.05$). The heart rate on postoperative days 1, 2, and 3 was lower in the observation group ($P < 0.05$), while the mean arterial pressure was higher ($P < 0.05$). The complication rate was lower in the observation group ($P < 0.05$). Conclusion: The combination of ECMO and emergency PCI for cardiac arrest following acute myocardial infarction significantly improves survival rates and ROSC rates, enhances consciousness levels and vital signs, and reduces complications.
Keywords: cardiac arrest after acute myocardial infarction; extracorporeal membrane oxygenation; conventional cardiopulmonary resuscitation; emergency percutaneous coronary intervention

1. Introduction

Cardiac arrest is one of the most severe manifestations of acute myocardial infarction and is also a common and serious issue in pre-hospital emergency treatment[1]. Studies have indicated that patients with pre-hospital cardiac arrest have a high mortality rate, and even if resuscitated, their cardiac function often suffers significant negative impacts[2]. Due to limitations in medical technology, the overall level of resuscitation for cardiac arrest patients in China is notably lower compared to developed countries. Currently, emergency percutaneous coronary intervention (PCI) is commonly performed after diagnosing cardiac arrest following acute myocardial infarction. This minimally invasive procedure can rapidly relieve the occluded vessels and restore blood flow[3]. However, the effectiveness of emergency PCI following conventional cardiopulmonary resuscitation (CPR) is generally moderate, with some patients having poor outcomes. Extracorporeal membrane oxygenation (ECMO) is a new type of extracorporeal respiratory and circulatory support device that plays a significant role in the treatment of cardiac arrest. This study aims to clarify the treatment effects of emergency PCI and ECMO, as detailed in the following report.

2. Materials and Methods

2.1 General Information

From January 2023 to June 2024, a clinical study was conducted on 100 patients with acute myocardial infarction followed by cardiac arrest, with cases divided into two groups of 50 each using a random draw method. In the control group, there were 31 male and 19 female patients, with an age range of 22-76 years and a mean age of (48.37 ± 5.62) years, and an onset time range of 0.5-3.5 hours with a mean of (2.27 ± 0.51) hours. In the observation group, there were 29 male and 21 female patients, with an age range of 20-79 years and a mean age of (48.85 ± 5.74) years, and an onset time range of 0.5-4.0 hours with a mean of (2.59 ± 0.56) hours. No significant differences were observed between the two groups' relevant data ($P > 0.05$).

Inclusion Criteria:

(1) Diagnosis of acute myocardial infarction confirmed by coronary angiography with subsequent cardiac arrest.

(2) Indication for emergency PCI and successful completion of the procedure.

(3) Informed consent obtained from patients and their families.

Exclusion Criteria:

(1) Liver or renal dysfunction.

(2) Irreversible brain death.

(3) Multiple organ failure.

2.2 Methods

Control Group: Conventional cardiopulmonary resuscitation (CPR) + emergency PCI. Conventional CPR included artificial respiration, defibrillation, chest compressions, and intravenous adrenaline. After performing conventional CPR and restoring spontaneous circulation, emergency PCI was carried out. Preoperative medications included 180 mg of ticagrelor, 300 mg of enteric-coated aspirin, 40 mg of atorvastatin calcium, and 3000 units of heparin subcutaneously. Coronary angiography and emergency PCI were then performed, with 1% lidocaine administered intravenously for local anesthesia. The right radial artery was located, accessed via a needle, and a 6F radial sheath was inserted upon successful puncture. Coronary angiography was performed to identify the infarct-related artery, followed by PCI with 10,000 units of heparin administered intravenously. Based on the coronary artery lesion characteristics, appropriate catheters, balloons, guidewires, and stents were selected. After PCI, the radial sheath was promptly removed, and postoperative treatment included subcutaneous low molecular weight heparin for 5-7 days, 100 mg of enteric-coated aspirin once daily, and lifelong ticagrelor therapy, with actual medication time adjusted based on patient condition and stent type.

Observation Group: Extracorporeal membrane oxygenation (ECMO) + emergency PCI. ECMO was performed first, followed by emergency PCI, which was conducted similarly to the control group. The ECMO procedure involved preparing the ECMO machine, locating the right femoral artery and vein, and performing cannulation under physician guidance, with 0.96 ml of heparin sodium injection administered before cannulation. Then, the left femoral artery and vein were accessed for arterial and venous cannulation to establish a venous-arterial ECMO circuit. The circuit was primed with 1000 ml of artificial colloid, and blood flow was initiated through the femoral vein, centrifugal pump, ECMO, and femoral artery, with an initial ECMO flow rate set at 4.0 L/min.

2.3 Observation Indicators

(1) Rescue Effectiveness: The number of patients who survived and completed the rescue plan within 28 days of admission was counted, and the survival rate was calculated.

(2) Rate of Spontaneous Circulation Recovery: The number of patients who regained spontaneous circulation after completing the rescue plan was counted, and the recovery rate was calculated.

(3) Consciousness Status: Assessed using the Glasgow Coma Scale (GCS) [4], which includes evaluation of eye-opening response (total score 1-4), motor response (total score 1-6), and verbal response (total score 1-5). The total GCS score ranges from 3 to 15, with higher scores indicating better consciousness.

(4) Vital Signs: Monitored using a multifunctional monitor, with evaluation indicators including heart rate and mean arterial pressure.

(5) Complication Rate: Incidences of angina, heart failure, arrhythmias, and recurrent myocardial infarction were recorded.

2.4 Statistical Methods

Data were analyzed using SPSS 26.0 software. Count data, including rescue effectiveness, rate of spontaneous circulation recovery, and complication rate, were expressed as [n (%)], and χ^2 test was used. Measurement data, including consciousness status and vital signs, were expressed as ($x \pm s$) and analyzed using t-test if they followed a normal distribution. A p-value of <0.05 was considered statistically significant.

3. Results

(1) The comparison of rescue effectiveness between the two groups is shown in Table 1.

Table 1. Rescue Effectiveness (n/%)

Group	Survival	Death
Observation Group (n=50)	45(90.00%)	5(10.00%)
Control Group (n=50)	35(70.00%)	15(30.00%)
X^2-Value	6.723	
P-Value	0.001	

(2) The comparison of the rate of spontaneous circulation recovery between the two groups is shown in Table 2.

Table 2. Rate of Spontaneous Circulation Recovery (n/%)

Group	Spontaneous Circulation Recovered	Spontaneous Circulation Not Recovered
Observation Group (n=50)	47(94.00%)	3(6.00%)
Control Group (n=50)	38(76.00%)	12(24.00%)
X^2-Value	6.348	
P-Value	0.001	

(3) The comparison of consciousness status between the two groups is shown in Table 3.

Table 3. Consciousness Status ($\overline{x}+s$, Score)

Group	Postoperative Day 1	Postoperative Day 2	Postoperative Day 3
Observation Group (n=50)	9.06±0.82	10.02±0.79	11.57±0.76
Control Group (n=50)	8.15±0.74	9.10±0.71	10.43±0.70
T-Value	5.422	5.782	5.998
P-Value	0.001	0.001	0.001

(4) The comparison of vital signs between the two groups is shown in Table 4.

Table 4. Vital Signs ($\overline{x}+s$)

Time	Group	Heart Rate (beats/min)	Mean Arterial Pressure (mmHg)
Observation Group (n=50)	Postoperative Day 1	74.52±4.52	88.10±5.67
	Postoperative Day 2	77.61±4.73	87.15±5.54
	Postoperative Day 3	80.78±4.89	86.03±5.48
Control Group (n=50)	Postoperative Day 1	86.02±5.11[b]	78.75±5.98b
	Postoperative Day 2	89.01±5.27[b]	74.31±5.86b
	Postoperative Day 3	91.47±5.46[b]	70.01±5.72b

Note: compared with the Observation Group, [b]P<0.05.

(5) The comparison of complication rates between the two groups is shown in Table 5.

Table 5. Complication Rates (n/%)

Group	Angina Episodes (n)	Heart Failure (n)	Arrhythmias (n)	Recurrent Myocardial Infarction (n)	Complication Rate (%)
Observation Group (n=50)	1	1	0	0	4.00
Control Group (n=50)	3	3	2	1	18.00
X^2-value	-	-		-	5.187
P-value	-	-		-	0.001

4. Discussion

Due to the aggravation of aging, deterioration of the ecological environment, changes in people's lifestyles, and increased social survival pressure, the incidence of cardiovascular diseases has been rising annually. Cardiac arrest after acute myocardial infarction (AMI) is a severe cardiovascular disease with an extremely high mortality rate. The condition of such patients progresses rapidly and is highly complex. Once the disease occurs, immediate professional treatment is required to save the patient's life and improve the prognosis[5]. Currently, there are many treatment options for cardiac arrest after AMI, but most methods have certain limitations, making it difficult to ensure effective treatment. In the past, conventional cardiopulmonary resuscitation (CPR) and emergency percutaneous coronary intervention (PCI) were often performed after diagnosing cardiac arrest following AMI, which could help quickly control the condition and improve the return of spontaneous circulation (ROSC) rate. However, even after ROSC, the patient's overall blood circulation may not be restored, leading to cerebral ischemia and hypoxia and potentially inducing poor prognosis, thus necessitating the search for more ideal treatment plans[6].

Emergency PCI is the main treatment for AMI, capable of rapidly clearing infarcted vessels, restoring blood flow, and improving circulation[7]. If the patient also experiences cardiac arrest, immediate CPR is required to effectively stabilize the patient's condition and promote ROSC, ensuring the efficacy of PCI and further improving the patient's prognosis. While conventional CPR can maintain good circulation and ventilation, it cannot provide ideal coronary perfusion pressure, making ROSC difficult and resulting in significant hemodynamic fluctuations. Extracorporeal membrane oxygenation (ECMO) is primarily used for the treatment of severe cardiopulmonary failure and is also known as extracorporeal life support. It is a lifesaving device for critically ill patients, functioning as an external circulatory support device. ECMO has the function of an artificial lung and can fully play the role of an artificial heart. It can simulate the oxygen transport process of the human lung, inhale oxygen, accelerate the expulsion of carbon dioxide, and improve lung ventilation function.

The study by Wei Youquan and Huang Junzhang[8]analyzed 70 patients with cardiac arrest after AMI, comparing the rescue effects of the control group (emergency PCI combined with conventional CPR) and the observation group (emergency PCI combined with ECMO). The ROSC rate in the observation group was 100%, higher than the control group's 85.71%. The GCS scores of the observation group on the 1st and 3rd postoperative days were also higher than those of the control group, indicating that emergency PCI combined with ECMO has a higher rescue success rate and improves brain function, demonstrating significant clinical value. This study supports the above viewpoint, conducting a relevant study on 100 patients with cardiac arrest after AMI. The ROSC rate in the observation group was 94.00%, higher than the control group's 76.00%. The GCS scores of the observation group on the 1st, 2nd, and 3rd postoperative days were all higher than those of the control group. Further analysis of the 28-day survival rate, complication rate, and vital signs of patients showed that the observation group was better than the control group in all three indicators, suggesting that the combined application of emergency PCI and ECMO is more effective.

In conclusion, the combined application of emergency PCI and ECMO for patients with cardiac arrest after AMI has significant effects.

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