

Effect of Active Abdominal Compression-Decompression Cardiopulmonary Resuscitation on Oxygen Metabolism and Prognosis in Patients with Cardiac Arrest

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Abstract

Objective: To analysis effect of active abdominal compression-decompression cardiopulmonary resuscitation (AACD-CPR) and standard cardiopulmonary resuscitation (STD-CPR) on oxygen metabolism prognostic of cardiac arrest (CA), to evaluate treatment effect of AACD-CPR.

Methods: Breathing, cardiac arrest patients without STD-CPR and AACD-CPR contraindications was collected from October 1, 2015 to May 31, 2017 in Zhengzhou people's Hospital, CA time less than 30 minutes, and all the patients were randomly divided into STD-CPR group and AACD-CPR group. All patients were given the same rescue measures, if required to give defibrillation defibrillation. STD-CPR group in accordance with the guidelines for CPR operation (2015 Edition), AACD-CPR group recovered using abdominal lifting and compression cardiopulmonary resuscitation instrument. Recording oxygen metabolism, hemodynamics and prognosis of two-group patients in the recovery process.

Results: A total of 69 cases, STD-CPR group of 34 cases, AACD-CPR group of 35 cases. ①The oxygen metabolism: during the recovery, AACD-CPR group compared with STD-CPR group were significantly increased in arterial blood oxygen content (CaO₂):15.6±1.5 to 14.2±1.9mL/L, arteriovenous oxygen content difference (avDO₂): 8.3±1.4 to 7.3±1.3mL/L, the oxygen carrying capacity (DO₂): 248±51 to 208±54mL/min, oxygen consumption (VO₂): 134±29 to 118±32mL/min, but no significant differences in cardiac output (CO) and mixed venous oxygen content (CvO₂). ②Hemodynamics: Two groups' base value in the heart rate (HR), mean arterial pressure (MAP), pH value, pulse oxygen saturation Degree (SpO₂), arterial oxygen pressure (PaO₂), arterial partial pressure of carbon dioxide (PaCO₂), lactate (Lac) were no significant differences. In the recovery process, MAP, pH, SpO₂, PaO₂ of two groups increased, but PaCO₂ and Lac decreased. Except MAP of STD-CPR group is slightly higher than AACD-CPR group, the change tendency of AACD-CPR group was more obvious in each index obviously [pH value: 0.10±0.15 to 0.02±0.13, SpO₂ difference: 0.311±0.255 to 0.159±0.232, the difference in PaO₂ (mmHg, 1 mmHg = 0.133 kPa): 12.96±21.84 to 3.01±13.56, the difference in PaCO₂ (mmHg): -9.91±11.17 to -3.52±13.87, Lac value (mmol/L): -0.64±0.61 to -0.31±0.58]. The prognosis: compared with STD-CPR group, the restoration of spontaneous circulation (ROSC) rate of AACD-CPR group was no increased slightly (22.9% vs. 8.8%), but the ROSC time of AACD-CPR group was shortened (min: 9.59±2.67 to 11.83±3.05). Score of nerve function defect (NDS) in week 1, 2 decreased significantly (26.45±6.42 to 30.73±7.38; 19.25±6.27 to 22.64±5.63, respectively), and the two-week survival rate increased slightly (17.1% 5.9%).

Conclusion: AACD-CPR is similar to STD-CPR in improving hemodynamics of CA patients, but has advantage in the blood oxygen supply of tissues and organs, and in the prognosis of patients with neurological function is better.

Keywords: Cardiopulmonary resuscitation, Abdominal compressure, Hemodynamics, Oxygen metabolism

1. INTRODUCTION

Cardiopulmonary resuscitation (CPR) is an important measure in the treatment of patients with cardiac arrest (CA). Since the promotion of application in the 1950s, CPR has already gone more than 60 years of clinical practice. Although the rate of spontaneous circulatory recovery (ROSC) has been increased during the years, survival discharge rate, survival rate and quality of life were no significant improvement. It has been reported that after patients with successful CA recovery discharging, the one-year survival rate was only 20% [1]. Abdominal lifting and compressure cardiopulmonary resuscitation device achieves the cardiopulmonary resuscitation effect by increasing or reducing abdomen pressure of patients, which can be used for patients with chest compressions contraindications such as thoracodental stab, Large blood vessel rupture [2]. At present, most studies focus on the change of hemodynamic indexes of abdomen CPR, but few studies on oxygen metabolism. Oxygen metabolism monitoring can observe the arterial and venous blood oxygen content, calculate the oxygen carrying capacity (DO_2) and oxygen consumption (VO_2), which reflect the metabolic status of the body, which can be used as an index to evaluate the effect of CPR [3,4]. The purpose of this study was to compare the effects of CPR on the oxygen metabolism and recovery in CA patients.

2. MATERIAL AND METHODS

Ethical Approval

The significance, safety, and constancy of the abdominal lifting and compression device used in this study have already been confirmed in animal and human experiments [5]. This study was approved by the Ethical Review Committee of Zhengzhou People's Hospital. All patients' relatives and legal guardians all received a detailed interpretation on possible risks and benefits of the study and were permitted to

request discontinuation of the study at any time. The requirements of the Declaration of Helsinki were strictly upheld throughout the research process.

Patients

From October 2015 to May 2017, 69 patients with respiratory and cardiac arrest who were treated in Zhengzhou people's Hospital. All patients were included in the following criteria: (1) loss of arterial pulsation, respiration, and consciousness, electrocardiogram showing ventricular fibrillation or straight line; (2) standard cardiopulmonary resuscitation (STD-CPR) and AACD-CPR were used; (3) the adult patients with a weight of 40~120 kg, sex unlimited; (4) CA time less than 30 min. Exclusion criteria: STD-CPR contraindications, (such as rib fractures, malignant tumor); AACD-CPR contraindications, (such as abdominal trauma, massive ascites).

Interventions

The patients were divided into STD-CPR group and AACD-CPR group according to the random digital table method. All patients were placed in tracheal intubation and Swan-Ganz catheter, artificial assisted ventilation, monitoring of vital signs, establishment of venous access, defibrillation by those who need defibrillate. Medical and nursing personnel involved in rescue and observation are strictly trained. STD-CPR group: operate according to the 2015 American Heart Association (AHA) CPR guide [6], press the frequency 100~120 times /min, press the depth of 5~6 cm. AACD-CPR group: resuscitation was performed with abdominal lifting and compressure cardiopulmonary resuscitation device (CPR-LW1000).

Termination rescue standard

According to the AHA guidelines, meet the following requirements to terminate the rescue: (1) touching neck artery pulse; (2) the ruddy complexion; (3) visible thoracic fluctuation; (4) the great bulk of the pupil light reflex recovery.

Rescue 30 min, if the patient breathing, circulation has not been restored, communication and family members of patients, to the consent of their families after the termination of treatment.

2.1. Outcome Measurement

Oxygen metabolism

Recording blood volume (CO), arterial oxygen content (CaO₂), mixed venous blood oxygen content (CvO₂), dynamic -venous blood oxygen content difference (avDO₂), DO₂ , and VO₂ in the center of resuscitation .

Blood flow dynamics

Recording resuscitation 1 min arterial blood gas as basic data , record blood pressure (BP), heart rate (HR) and arterial blood pressure every 5 minutes , and calculate mean arterial pressure (MAP) .

Table1. Comparison of baseline data of CAA patients with cardiac arrest with different resuscitation methods

Group	N	Gender (n)		Age (year, x±s)	BMI (kg/m ² ,x±s)	CA time (min, x±s)
		Male	Female			
STD-CPRgroup	34	17	17	42.4±9.3	62.16±15.49	17.29±5.73
AACD-CPRgroup	35	18	17	45.1±9.0	65.72±12.91	19.84±6.51
t /γ2 value		0.014		-1.226	-1.038	-1.725
Pvalue		0.906		0.225	0.302	0.089

STD-CPR, standard cardiopulmonary resuscitation; AACD-CPR, active abdominal compression-decompression cardiopulmonary resuscitation; BMI, body mass index.

3.2. The oxygen metabolism index (Table 2)

During CPR , the levels of CaO₂ , avDO₂ , DO₂ and VO₂ in AACD-CPR group were significantly higher than those in STD-CPR

Clinical prognosis

Recording the ROSC rate, the time of ROSC, the clinical neurological impairment score at 1 week and 2 weeks and the 2 week survival rate.

Statistical analysis

Value were expressed as mean ±standard deviation (x ±s). T test was used to compare the data between groups and within groups, χ² test used to rate comparison .The null-hypothesis was rejected for P< 0.05.

3. RESULT

3.1. General conditions of patients (Table 1)

69 CA patients , 35 males , 34 females , 18-69 years old , average (44.8 ± 8.7) years old , AACD-CPR 35 cases , STD - CPR 34 cases . AACD-CPR group and STD-CPR group had no statistical significance (P > 0.05).

group (P < 0.05) , while there was no significant difference between CO and CvO₂ in both groups (P > 0.05) .

Table2. Comparison of oxygen Metabolism Indexes during resuscitation between two groups of patients with Cardiac arrest and Cardiac arrest with different resuscitation methods (x ± s)

Group	N	CO (L/min)	CaO ₂ (mL/L)	CvO ₂ (mL/L)
STD-CPR Group	34	2.15±0.45	142±19	69±23
AACD-CPR Group	35	1.98±0.56	156±15	73±16
tvalue		1.388	-3.402	-0.841
Pvalue		0.170	0.001	0.404
Group	N	avDO ₂ (mL/L)	DO ₂ (mL/min)	VO ₂ (mL/min)
STD-CPR group	34	73±13	208±54	118±32
AACD-CPR group	35	83±14	248±51	134±29
Tvalue		-3.072	-3.164	-2.178
P value		0.003	0.002	0.033

STD-CPR, standard cardiopulmonary resuscitation; AACD-CPR, active abdominal compression-decompression cardiopulmonary resuscitation; CO, cardiac output; CaO₂, arterial oxygen content; CVO₂, mixed venous oxygen content; avDO₂, arteriovenous oxygen content difference; DO₂, oxygen load; VO₂, oxygen consumption.

3.3. Hemodynamic indicators (Figure 1; Table 3)

Before resuscitation, the two groups in HR, MAP, pH value, SpO₂, PaO₂, PaCO₂, Lac were no significant difference (all P > 0.05). During the process of resuscitation, HR gradually recovered, the pH value, MAP, SPO₂ and PaO₂ showed an

increasing trend, but PaCO₂ and Lac showed an decreasing trend. The pH value, SPO₂ and PaO₂ of AACD-CPR group increased more rapidly and PaCO₂ and Lac decreased more rapidly (P < 0.05). The MAP of STD-CPR group was higher, but the difference was not statistically significant (P > 0.05).

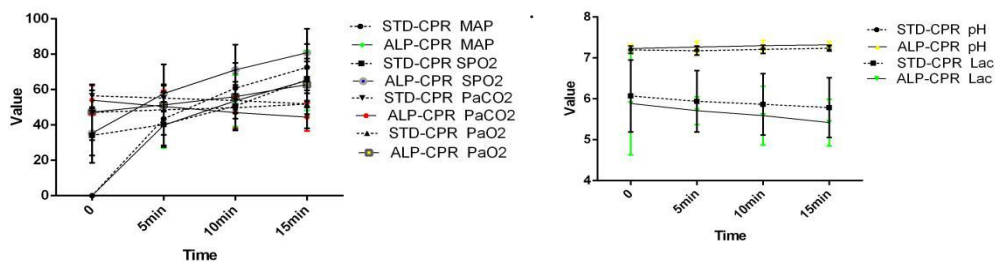


Figure1. Change trend of hemodynamics and arterial blood gas index during resuscitation in two groups of patients with cardiac arrest and CAA with different resuscitation methods

STD-CPR, standard cardiopulmonary resuscitation; AACD-CPR, active abdominal compression-decompression cardiopulmonary resuscitation; HR, heart rate; MAP, mean arterial pressure; SPO₂, pulse oxygen saturation; PaO₂, arterial partial pressure of oxygen; PaCO₂, arterial partial pressure of carbon dioxide; Lac, lactate. 1 mmHg=0.133 kPa

Table3. Comparison of hemodynamic and arterial blood gas index difference before and after resuscitation in two groups of cardiac arrest (CA) patients with different resuscitation methods (x±s)

Group	N	HRdifference (次/min)	MAPdifference (mmHg)	pH value difference	SpO ₂ difference	PaO ₂ difference (mmHg)	PaCO ₂ difference (mmHg)	Lacdifferenc (mmol/L)
STD-CPR group	34	58.28±14.26	67.56±15.43	0.02±0.13	0.159±0.232	3.01±13.56	-3.52±13.87	-0.31±0.58
AACD-CPR group	35	64.58±15.61	59.27±19.23	0.10±0.15	0.311±0.255	12.96±21.84	-9.91±11.17	-0.64±0.61
t value		-1.749	1.972	-2.364	-2.584	-2.266	2.111	2.302
Pvalue		0.085	0.053	0.021	0.012	0.027	0.038	0.024

STD-CPR, standard cardiopulmonary resuscitation; AACD-CPR, active abdominal compression-decompression cardiopulmonary resuscitation; HR, heart rate; MAP, mean arterial pressure; SPO₂, pulse oxygen saturation; PaO₂, arterial partial pressure of oxygen; PaCO₂, arterial partial pressure of carbon dioxide; Lac, lactate. 1 mmHg=0.133 kPa

3.4. Clinical prognostic indicators (Table 4)

Compared with STD-CPR group, ROSC time in AACD-CPR group was significantly earlier than that in ROSC1 group. The NDS decreased

significantly at 1-week and 2-week (P < 0.05). And ROSC rate and the 2-week survival rate increased, but the difference was not statistically significant (P > 0.05).

Table4. Comparison of clinical outcomes between two groups of cardiac arrest (CA) patients with different resuscitation methods (x±s)

Group	N	ROSC rate [% (n)]	ROSC time (min, x±s)	2 - week survival rate [% (n)]
STD-CPR group	34	8.8 (3)	11.83±3.05	5.9 (2)
AACD-CPR group	35	22.9 (8)	9.59±2.67	17.1 (6)
χ ² / t value		2.535	3.249	2.133
P value		0.188	0.002	0.259

Group	N	NDS (score, $\bar{x}\pm s$)	
		one- week	two- week
STD-CPRgroup	34	30.73±7.38	22.64±5.63
AACD-CPRgroup	35	26.45±6.42	19.25±6.27
$\chi^2 / tvalue$		2.572	2.361
Pvalue		0.012	0.021

STD-CPR, standard cardiopulmonary resuscitation; AACD-CPR, active abdominal compression-decompression cardiopulmonary resuscitation; ROSC, autonomic circulatory recovery; NDS, neurological deficit score.

4. DISCUSSION

The survival rate of patients with out-hospital cardiac arrest (OHCA) from 2006 to 2010 was 8.2 % ~10.4 % [7]. According to the epidemiological investigation in developed countries, the incidence of CA was still high, but the limitation of external pressure, facial defects, one - sidedness, lack of accurate and effective operation of rescue personnel resulted in a very low ROSC rate [8, 9]. Chest in STD-CPR can not fully rebound, and not give sufficiently play to the effect of heart lung and lung pump and CPR success rate is limited [10]. Wang Lixiang 's team based on abdominal CPR, proposes the ALC-CPR new technique for restoring body size by pulling and pressing abdomen [11]; so as to achieve the effect of saving treatment .

Lee Sooman et al's [12] showed that the AACD-CPR group ROSC rate and the survival rate at sufficient was significantly higher than that of STD-CPR group. Liu Qing et al's [13] reported AACD-CPR ROSC rate was 20%, and no abdominal organ injury, regurgitation and aspiration during the CPR; Zhu Jiang and Yang Guihua et al's [14] reported STD-CPR rate of ROSC 11%, and the results of Zhang Zhenyu and Yu Xiaofan et al's [15] of ROSC 10.7%. Several research results showed that AACD-CPR recovery effect is good, but more concentrated in the hemodynamics [16,17]. The premise of successful rescue of CA patients is to restore blood supply and correct abnormal oxygen metabolism. Therefore, the oxygen supply of the body and the oxygenation of tissues should not be ignored. Wu et al's [18] evaluated the effect of hypothermia on cerebral microcirculation after

CPR in Lac difference and CO2 difference of Internal jugular vein and its conclusion was that the high oxygen uptake rate indicated the microcirculation of the brain and the prognosis of the patients were good. Solevg et al's [19] showed the tissue oxygen saturation, pH and Lac as indicators of anaerobic metabolism may reflect the oxygenation and results of important organs. Oxygen metabolism monitoring reflected tissue hypoperfusion and tissue oxygenation function [20], and Li JW et al's [21] used oxygen metabolism index to reflect tissue oxygen supply, thereby to evaluate the effect of ECMO in treating ARDS, so it can be used as a method of evaluating the effect of resuscitation.

The results of this study show that STD-CPR CO is slightly higher than those of AACD-CPR, suggesting that pressing the thoracic cardiac ejection effect may be better. Previous studies have shown that compared with AACD-CPR, STD-CPR can provide higher MAP [22]. In this study, although MAP of STD-CPR group was slightly higher, but the AACD-CPR group in CaO₂, DO₂, pH value. SpO₂, PaO₂ was significantly higher than that of the STD-CPR, PaCO₂, Lac decreased significantly, suggesting that AACD-CPR can provide better oxygen supply, which may be related to AACD-CPR's "four pump". The diaphragm moves up and down, the heart flexes and shrinks, reflecting the second pump of the heart and chest; At the same time, the changes of thoracic pressure, both breathing and blood circulation, reflect the lung and abdomen pump [10]. Wang LX et al's [23] showed that AACD-CPR can provide higher tidal volume and the effect of auxiliary ventilation was better. Under pathological

conditions, the oxygen demand of the body is increased greatly, and AACD-CPR can provide higher CaO_2 , DO_2 , $avDO_2$. The results suggest that the utilization rate of oxygen in AACD-CPR group is higher than that in STD-CPR group, so AACD-CPR may be superior to STD-CPR in improving microcirculation. Liu Q et al's [24] also found that AACD-CPR can provide good hemodynamic and oxygen supply support. Spronk et al's [25] proposed the concept of "oxygen resuscitation in shock cells", emphasized the improvement of body microcirculation and oxygen uptake, so AACD-CPR may be a new method of treating traumatic shock.

This study showed that AACD-CPR group ROSC earlier than in STD-CPR group, but no difference in the rate of ROSC, suggesting that recovery effect of the two way is quite similar to Wang Guotao et al's [26] research results. In addition, the AACD-CPR group's NDS score at one-week and two-week was significantly lower in group STD-CPR, indicating AACD-CPR on the prognosis of patients with neurological injury may be more excellent than STD-CPR.

5. CONCLUSION

In summary, this study shows that AACD-CPR can achieve uninterrupted blood circulation and respiratory support both in hemodynamics and restoration of spontaneous circulation and the effect of STD-CPR is. AACD-CPR, to make up for the defects of STD-CPR can not take into account the breath, the tissue microcirculation oxygen supply and clinical prognosis has more advantages. But due to the limited number of cases collected less that part may be affected as a result, we need a multicenter clinical study further confirmed.

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