

ORIGINAL RESEARCH

Effect of Interposed Abdominal Compression on Cardiopulmonary Resuscitation Outcomes; a Randomized Clinical Trial

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Abstract: **Introduction:** Standard cardiopulmonary resuscitation (STD-CPR) is successful in only 10-15% of cases in emergency department (ED). This study aimed to determine the effect of interposed abdominal compression (IAC) during resuscitation on outcomes of ED cardiac arrests. **Methods:** In this randomized clinical trial study, non-trauma patients aged 18-85 years, patients with in-hospital cardiac arrest hospitalized in the ED were randomly assigned into two either STD-CPR or IAC-CPR group on a 1:1 basis and using computer-generated random numbers. Participants in the intervention group, received abdominal compression during the diastole phase of STD-CPR. The rate of return of spontaneous circulation (ROSC), heart rate (HR), respiratory rate (RR), arterial blood gas (ABG) indicators, and survival rate were compared between the two groups. **Results:** Ninety patients were enrolled (45 in each group). There were no differences between the two groups regarding age ($p = 0.76$), sex ($p = 0.39$), employment status ($p = 0.62$) and Charlson comorbidity scale ($p = 0.46$). Abdominal compression had a positive effect on heart rate ($p < 0.001$), mean arterial pressure ($p = 0.003$), arterial blood oxygen pressure ($p = 0.001$), and arterial blood carbon dioxide pressure ($p = 0.001$) as well as a negative effect on arterial blood oxygen saturation ($p = 0.029$) 30 minutes after resuscitation. Out of the 90 CPR cases, 8 (17.7%) cases in intervention group and 8 (17.7%) cases in control group were successful, among which all of the 8 patients in the intervention group and 5 of the patients in the control group had been discharged from hospital without any complications. **Conclusion:** The results showed that abdominal compression during CPR can improve resuscitation outcomes in patients with cardiac arrest. Therefore, in order to use this technique, further research is recommended.

Keywords: Heart Arrest; Cardiopulmonary Resuscitation; Treatment Outcome; Clinical trial

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1. Introduction

Sudden cardiac arrest is one of the main causes of death around the world (1, 2). According to global statistics, in the United States, about 350,700 adults over the age of 18 experience in-hospital cardiac arrest each year (3). Standard cardiopulmonary resuscitation (STD-CPR) is one of the meth-



ods used to save the lives of these people. STD-CPR involves applying pressure to the chest of a patient with cardiac arrest and ventilation with an Ambu bag, which causes an increase in the patient's probability of survival before performing advanced life-saving procedures (4, 5). According to the latest revision of the American Heart Association (AHA) Guidelines, rapid and effective chest massage is a key component of STD-CPR (6, 7). But chest massage is less successful in some patients and in certain conditions, such as patients with pneumothorax or chest trauma, and other alternative methods should be used (8, 9). According to conducted studies, it has been found that although STD-CPR is widely used, the survival rate of patients undergoing this method is not completely desirable (3). Also, based on a study in Iran, it has been found that following STD-CPR, the mortality rate is over 90% and the discharge rate from hospital is less than 7% (10). For reasons such as presence of an underlying disease, patient's age, or delay in starting CPR, the final result of STD-CPR may not be desirable. Therefore, it may be necessary to use more effective and alternative methods for resuscitation in some patients (10). Interposed abdominal compression CPR (IAC-CPR) is one of the methods that may be able to make up for existing STD-CPR defects (11-13). Some clinical studies have reported that using IAC-CPR for patients with cardiopulmonary arrest is more effective than STD-CPR (8, 9, 14). On the other hand, a number of studies have shown that there is no difference between these two techniques regarding patient consequences and conducting more research is required (10, 15).

According to the AHA Guidelines for CPR and Emergency Cardiovascular Care, IAC-CPR can be an effective method of CPR when staff are adequately trained. The level of evidence for IAC-CPR is divided as Class IIB13, which means that although using this technique is not certainly recommended, further research is suggested due to many benefits of IAC-CPR (15). The current study has been conducted with the purpose of determining the effect of interposed abdominal compression on outcome of CPR for patients with cardiac arrest in emergency department (ED).

2. Methods

2.1. Study design and setting

This is a two-group randomized clinical trial, which was conducted from June 2021 to May 2022 on patients with cardiac arrest, referring to Razi Hospital in Rasht, Iran. Before selecting patients to enter the study and due to the emergency nature of CPR, the necessary explanations were given to the patient's family members and informed consent was obtained. All patients with cardiopulmonary arrest were transferred to the resuscitation room of ED and all medical procedures were performed for them in this room. Our data collection

was done in this room, too.

This research has been approved by the ethics committee of Guilan University of Medical Sciences (ethics code: IR.GUMS.REC.1399.665) and it complies with the statements of the Declaration of Helsinki. Also, the trial has been registered in the Iranian Registry of Clinical Trials (code: IRCT20080901001174N14).

2.2. Participants

All adult patients aged 18-85 years with in-hospital cardiac arrest in ED were enrolled in this study. Inclusion criteria were non-trauma patients hospitalized in the ED who had in-hospital cardiac arrest in the presence of a nurse and their cardiopulmonary arrest was confirmed by a doctor and the presence of a resuscitation team including nurses, anesthesiologists, emergency medicine specialists, and the main researcher after announcing CPR code. Exclusion criteria were liver cirrhosis, abdominal surgery in the past two weeks, active gastrointestinal bleeding based on nurse and physician's explanations or report of patient's family, history of pulmonary embolism, abdominal aortic aneurysm, significant abdominal ascites, abdominal cirrhosis, and a history of coagulation disorders. Our eligibility criteria were defined according to previous studies. It should be noted that our methods did not change after initiation of trial. The patient enrollment process is shown in figure 1. According to studies by Reynolds and Zhou (16, 17) and considering the $\alpha = 0.05$, and power = 80% the sample size was calculated as 45 people in each group.

2.3. Study protocol

Eligible patients were randomly assigned to either STD-CPR or IAC-CPR group on a 1:1 basis. Randomization of patients into two groups was done using a computer-generated random allocation sequence. The co-researcher (S.P) enrolled patients in the study and allocated patients to either group according to the random allocation sequence. When a cardiac arrest happened, a code (99) was announced and the resuscitation team was notified by pocket beeper. The resuscitation team included two nurses, an anesthesiology nurse, and an emergency medicine physician. All of patients underwent resuscitation based on AHA2020 advanced cardiac life support protocol. Chest compression was performed at a rate of 100 times per minute at a depth of 5 cm and ventilation rate was 8-10 times per minute. Cardiac arrest was confirmed by physician and endotracheal intubation was performed as soon as possible. The intervention group received STD-CPR plus IAC-CPR and the control group received STD-CPR only. In patients who received IAC-CPR, abdominal compression was performed with open hands, fused together in center of abdomen between the xiphoid and the umbilicus during the relaxation phase of chest compression.



Depth, rhythm, and rate of abdominal compressions were similar to chest compressions and force on the abdomen was maintained until the beginning of next chest compression. We used a bag-valve-mask apparatus attached to the endotracheal tube and performed ventilation at a rate of 8-10 breaths/minute. Oxygen was delivered at 100% FiO₂ in both groups. During resuscitation, 1 mg of epinephrine was injected intravenously every 3-5 minutes and other drugs were injected as needed based on the AHA2020 guideline (such as amiodarone or lidocaine, atropine, epinephrine) (6).

In compliance with AHA guidelines, termination of CPR was considered with the appearance of an autonomous Carotid pulse, moist facial complexion, the appearance of autonomous respiration, and shrinking pupils and reappearance of a light reflex, or the appearance of eyeball motion and limb spasms (7). If after continued CPR for at least 30 minutes no Carotid pulse or autonomous breathing was noted, CPR was terminated after obtaining informed consent from family members.

All patients with successful CPR were followed for their 24-hour survival. For evaluation of complications of IAC-CPR, patients were followed for 24 hours and the presence of any abdominal pain, tenderness in abdomen, and need for abdominal surgery after CPR, which could be signs and symptom of internal bleeding, were assessed in these patients. Also, all patients in both groups were monitored and assessed in terms of any complication such as rib fracture, arrhythmia, or post-resuscitation syndrome.

2.4. Data collection

Demographic (age, sex, body mass index (BMI), height, and weight) and clinical (Charlson comorbidity Index, underlying diseases) information of patients at the time of cardiac arrest were recorded. The Charlson comorbidity Index (CCI) was used to examine the presence of comorbidities in patients. The CCI assesses 19 diseases and conditions, and rates the probability of the patient's mortality based on them. The scores obtained from CCI can be adjusted with age, so that each decade of age (starting from the age of 50) is considered as an additional score. Scores range from zero to 37 in case of age mismatch and from zero to 43 in case of age match.

Finally, the scores are ranked as four degrees of illness: zero, 1-2, 3-4 and 5, where a higher score indicates the presence of more comorbidities (18).

Primary outcome measured in this study was return of spontaneous circulation (ROSC). ROSC was defined as the presence of a palpable carotid arterial pulse and a systolic blood pressure above 80 mmHg for longer than 3 minutes.

Secondary outcomes were heart rate (HR), respiratory rate (RR), mean arterial pressure (MAP), peripheral capillary oxygen saturation (SPO₂), partial pressure of carbon dioxide (PaCO₂) and potential of hydrogen (pH) of arterial blood gas

(ABG). All of the outcomes were measured in the intervention and control groups immediately and half an hour after the start of CPR.

The presence of ROSC was assessed based on the Carotid pulse. The PaCO₂, pH, and SPO₂ were measured via ABG test. For ABG test, one of co-researcher (S.P) took an arterial blood sample and sent it to laboratory department of hospital as soon as possible and they used MEDICA Easy Blood Gas analyzer for ABG analysis.

For calculating MAP of patients, we measured systolic and diastolic blood pressures of patients with a cuff that was attached to a monitor. Then it was estimated using a formula in which the diastolic blood pressure is doubled and added to the systolic blood pressure and that composite sum is then divided by 3 (19).

The heart rate and respiratory rate were measured by the monitoring device. It should be mentioned that all of the patients who received CPR, in either group, were monitored using OMNICARE monitoring device. Before starting the study, monitoring and MEDICA Easy Blood Gas analyzer devices had been calibrated and approved by the medical engineering team of hospital.

In addition, during CPR in both groups, the emergency medicine physician was present and in case of any problems such as presence of any signs of internal bleeding, abdominal pain or tenderness, organ injury or rib fracture, he immediately examined the patient and requested emergency surgical counseling. Also, we followed survived patients after CPR and assessed the survival to hospital discharge in order to assess the long-term survival of patients with successful CPR in each group. All of the primary and secondary outcomes were measured and recorded by one of the co-researchers (S.P).

2.5. Data analysis

After entering data in the Statistical Package for the Social Sciences (SPSS) software (version 25.0, Armonk, NY: IBM-Corp.), data analysis was performed using descriptive statistics (mean, standard deviation, frequency) and inferential tests (Independent t test, Chi-Square). The significance level of the tests was considered less than 0.05.

3. Results

3.1. Baseline characteristics

Initially, 105 patients with cardiac arrest were assessed for eligibility in the study. Finally, 90 cardiac arrest victims were enrolled (50 male and 40 female) and allocated into IAC-CPR or STD-CPR (each group 45 patients) during the period of June 2021 to May 2022. Out of the 90 cases, 74 (82.22%) of CPR attempts was unsuccessful and only 8 (17.77%) cases in each group had successful resuscitation (a total of 16 patients).

The mean age of the patients in control and intervention



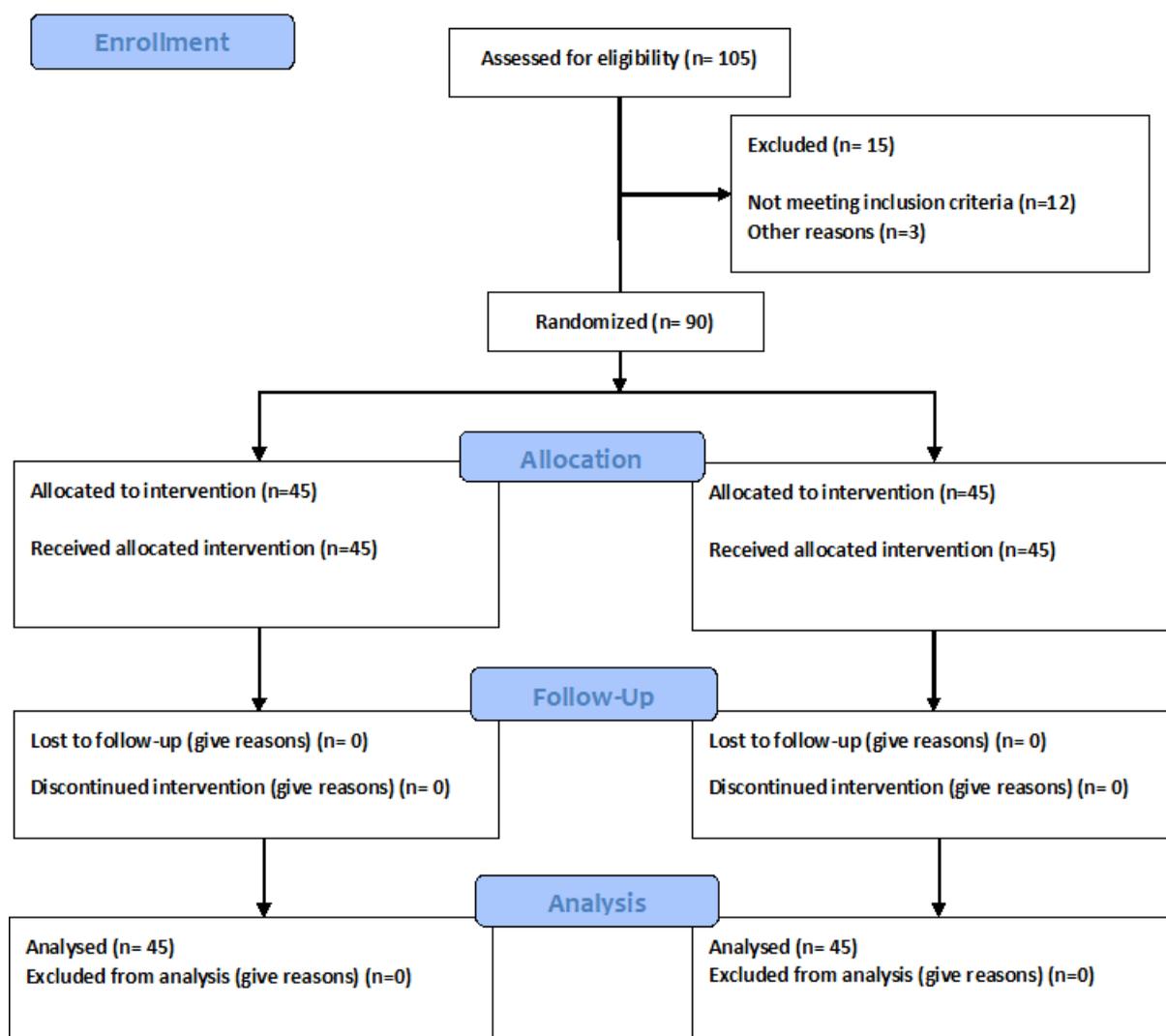


Figure 1: Patients' enrollment and allocation.

groups were 40.60 ± 16.80 and 60.04 ± 14.97 years, respectively (Range=19-72 years; $p = 0.76$). The most common cause of cardiopulmonary arrest in both groups were cardiac, cerebrovascular accident (CVA), and respiratory reasons. In-hospital complications in both groups included: bruising and abrasions in the face and neck, airway injuries, rib fracture, sternal fracture, and pneumothoraxes. There were not any significant differences between the two groups regarding cause of cardiopulmonary arrest or in-hospital complications.

The most common underlying diseases in both groups were hypertension (32.22%), diabetes (16.66%), and CVA (14.44%). There were not significant differences between the groups re-

garding underlying disease. Sex distribution was not different between the two groups ($p = 0.396$). BMI was not different between the two groups ($p = 0.432$). CCI was not different between the two groups ($p = 0.463$). Table 1 compares demographic and clinical characteristics between the two groups.

3.2. Outcomes

3.2.1. ROSC

The number of patients who had ROSC immediately after the start of resuscitation was zero in both groups ($p = 0.999$). Comparison of ROSC from immediately to half an hour after the start of resuscitation had a significant increase in both the intervention group ($p < 0.001$) and the control group ($p <$

Table 1: Comparing the baseline characteristics of patients between the two studied groups

Variable	STD-CPR (n=45)	IAC-CPR (n=45)	P-Value
Age (year)	40.60±16.80	60.04±14.97	0.916 *
BMI (Kg/m ²)	25.2± 4.1	25.8± 3.6	0.432*
Height (cm)	167.01±5.1	166.12±6.2	0.674*
Weight (Kg)	71.1±9.2	72.03±8.9	0.712*
Charlson Comorbidity Scale	3.13±2.25	3.49±2.35	0.463*
Sex			
Male	27 (60.0)	23 (51.11)	0.396**
Female	18 (40.0)	22 (48.88)	
Cause of cardiopulmonary arrest			
Cardiac	24 (53.33)	20 (53.33)	0.912*
Cerebrovascular accident	6 (13.33)	8 (17.77)	0.916*
Respiratory	5 (11.11)	6 (13.33)	0.891*
Renal	4 (8.88)	5 (11.11)	0.456*
Cancer	3 (6.66)	3 (6.66)	0.876*
Bleeding	2 (4.44)	3 (6.66)	0.897*
Infection	1 (2.22)	0 (0.00)	0.345*
In-hospital complications			
Bruising and abrasions in face/neck	16 (35.55)	15 (33.33)	0.786*
Airway injuries	12 (26.66)	9 (22.22)	0.567*
Rib fracture	8 (17.77)	7 (15.55)	0.862*
Sternal fracture	3 (6.66)	2 (4.44)	0.457*
Pneumothoraxes	2 (4.44)	1 (2.22)	0.347*
Underlying disease			
Hypertension	15 (33.33)	14 (31.11)	0.456**
Cancer	7 (15.55)	8 (17.77)	0.678**
Diabetes	7 (15.55)	6 (13.33)	0.377**
MI	4 (8.88)	4 (8.88)	0.321**
COPD	4 (8.88)	4 (8.88)	0.561**
Renal failure	3 (6.66)	4 (8.88)	0.423**
Hepatitis	2 (4.44)	2 (4.44)	0.345**
CVA	2 (4.44)	3 (6.66)	0.423**
Asthma	1 (2.22)	0 (0.00)	0.781**

Data are presented as mean ± standard deviation or frequency (%). CPR: cardiopulmonary resuscitation; STD-CPR= standard CPR; IAC-CPR= interposed abdominal compression CPR; BMI= body mass index; COPD = chronic obstructive pulmonary disease; CVA = cerebral vascular accident; MI = myocardial infarction. *Independent t test. ** Chi-Square

0.001) and in both groups, 8 patients (17.77%) had ROSC (Table 2).

3.2.2. Vital signs

After CPR, almost all patients in both groups had heart rate and MAP, but fewer patients in both groups had respiratory rate. Patients in the IAC-CPR group had higher heart rate and lower MAP compared to the STD-CPR group. The two groups had the same mean respiratory rate immediately ($P = 0.611$) and half an hour ($P = 0.476$) after CPR. Although the respiratory rate in the IAC-CPR group increased slightly more than the STD-CPR group, and the rate of increase was 0.31 ± 1.06 in the STD-CPR group and 0.76 ± 33.40 in the IAC-CPR group, the difference was not statistically significant (Table 2).

3.2.3. Change of Blood Gas Measurements

There was no significant difference in SPO₂ between control and intervention groups immediately ($p = 0.887$) and also half an hour ($p = 0.292$) after the start of CPR, but there was

a significant increase in SPO₂ between these two times in both control ($p < 0.001$) and intervention ($p < 0.001$) groups. This increase was more in IAC-CPR in comparison to STD-CPR group. The mean PaO₂ was not significantly different between the two groups immediately after the start of CPR, but it was significantly different half an hour after the start of CPR. The rate of change in the control group was not significant for this variable from immediately to half an hour after CPR, but there was a significant increase in the intervention group ($p < 0.001$). This increase was more in IAC-CPR in comparison to STD-CPR group. Arterial blood pH was not significantly different between the two groups immediately after the start of CPR, but it was significantly different half an hour after the start of CPR ($P < 0.001$). Both groups had a significant decrease in pH from immediately to half an hour after the start of CPR ($P < 0.001$), but the rate of decrease in arterial blood pH in the intervention group was greater than



Table 2: Comparing the vital signs and arterial blood gas parameters between the two groups at baseline and 30 minutes after CPR

Variable	STD-CPR (n=45)	IAC-CPR (n=45)	P-Value	Effect size
Heart Rate (beat/minute)				
Baseline	65.31±19.40	98.42±14.86	< 0.001	
30 minutes after CPR	60.69±20.82	99.58±18.93	< 0.001	0.094
Change from baseline	-4.62±7.11	1.16±10.65	0.010	
Respiratory Rate				
Baseline	3.58±7.82	4.47±8.51	0.611	
30 minutes after CPR	3.89±8.49	5.22±9.30	0.476	0.008
Change from baseline	0.31±1.06	0.76±3.40	0.959	
MAP				
Baseline	51.04±11.61	65.60±8.17	< 0.001	
30 minutes after CPR	48.24±10.41	63.87±8.56	< 0.001	0.009
Change from baseline	- 2.80±5.81	- 1.73± 5.49	0.641	
pH				
Baseline	7.27±0.09	7.24±0.08	0.102	
30 minutes after CPR	7.16±0.10	7.00±0.47	<0.001	0.037
Change from baseline	- 0.11±0.06	-0.24± 0.47	<0.001	
SPO2				
Baseline	68.34±16.71	66.45±19.18	0.878	
30 minutes after CPR	71.69±15.93	76.89±17.79	0.292	0.361
Change from baseline	13.35±4.29	14.44±3.62	<0.001	
PaO2				
Baseline	55.76±38.91	55.43±25.65	0.373	
30 minutes after CPR	59.21±38.92	68.71±26.16	0.002	0.361
Change from baseline	3.45±7.52	13.28±3.45	<0.001	
PaCO2				
Baseline	51.33±13.84	56.02± 10.99	0.106	
30 minutes after CPR	51.33±13.21	51.80±10.96	0.932	0.383
Change from baseline	- 0.01±2.85	- 4.22± 2.50	<0.001	

Data are presented as mean ±standard deviation; CPR: cardiopulmonary resuscitation; STD-CPR= standard CPR; IAC-CPR= interposed abdominal compression CPR; MAP=Mean arterial pressure; PH= potential of hydrogen; SPO2= Peripheral capillary oxygen saturation; PaO2= partial pressure of oxygen; PaCO2= partial pressure of carbon dioxide.

the control group. The mean PaCO₂ immediately after the start of CPR (P = 0.106) and half an hour after that (P = 0.932) was not significantly different between the two groups, but the changes in PaCO₂ in the intervention group were greater than the control group (P <0.001). (Table.2)

3.2.4. Long-term outcomes

After successful CPR, we followed survived patients (8 cases in intervention and 8 cases in control group) and all of the 8 patients in IAC-CPR and 5 of the patients in STD-CPR had long-term survival and were discharged from hospital without any complications such as dysrhythmia or CPR-related side effects, including fracture or internal bleeding.

4. Discussion

The quality of CPR, as assessed by appropriate cardiac output, is often low and less than desirable level (20). The amount of cardiac output after a desired STD-CPR is usually more than 30% of the normal cardiac output, and coronary blood flow during CPR is often less than 35% of the normal coronary blood flow, because of different reasons (21). So, it

is recommended to use alternative methods for CPR such as IAC-CPR.

The results of the current study showed that IAC-CPR can improve CPR-related outcomes in patients with cardiopulmonary arrest. Also, significant changes in arterial blood gas levels were observed in both groups and these outcomes were not affected by age, sex, and BMI.

According to the results of the current study, no difference was found between the two groups regarding the number of people who had ROSC, and in both groups, 8 people had ROSC half an hour after the start of resuscitation. Based on the study by Movahedi et al., which was conducted for comparing the effect of STD-CPR and IAC-CPR on ROSC and the amount of end-expiratory carbon dioxide in patients with in-hospital cardiopulmonary arrest, the results showed that ROSC levels were significantly different between the two groups (10), which is not consistent with the present study. Also, in the study by Mateer et al., there was no significant difference in terms of ROSC between the two groups (22), which is consistent with the current study.

In terms of respiratory rate, although its increase among patients in the intervention group was slightly greater than the control group, but they were not statistically significant. In the study by Zhang et al., no significant difference was reported between the two groups (11), which is consistent with the findings of the present study. Also, in the study by Wang et al., it was found that IAC-CPR increased the number of RR in patients with cardiopulmonary arrest (23), which is in line with the findings of the present study. Considering that the RR in the intervention group increased more than the control group, it can be argued that in the IAC-CPR method, applying intermittent pressure on the abdomen causes the diaphragm to move up and down, and the pressure in the chest changes, thus facilitating the entry and exit of air into the lungs. In this method, intermittent abdominal massage causes the diaphragm to move downward, allowing the lungs to expand, and the upward movement of the diaphragm also causes air to drain from the lungs.

In terms of MAP, both groups had significant changes and these changes in the control group had a more decreasing course than the intervention group. However, this difference in decrease between the two groups was not statistically significant ($P = 0.641$). In the study by Zhang et al., all patients and in both groups, MAP changes were negative, i.e., due to performing CPR in both groups, the amount of MAP was increased, but patients in the intervention group had lower MAP compared to the control group ($p = 0.003$), which is consistent with the findings of the current study. Also, according to a study by Gu et al., all patients had MAP after CPR in both intervention and control groups, but the amount of MAP in the intervention group was not different from the control group (23), which are inconsistent with the findings of the present study. To justify this finding, it can be argued that applying abdominal pressure in the intervention group increased blood circulation and blood pressure, and as a result, the amount of MAP in the intervention group decreased less than the control group.

In terms of SPO₂ rate, there was no significant difference between the two groups immediately ($P = 0.887$) and also half an hour after ($P = 0.292$) the start of resuscitation, but the rate of change between these two times in the two groups was statistically significant and the control group had a higher increase in SPO₂ than the intervention group. In Zhang et al.'s study, it was found that the level of SPO₂ after STD-CPR increased more than IAC-CPR (11), which is in line with the results of the present study.

In terms of PaO₂ levels, there was no significant difference between the two groups immediately after the start of CPR, but there was a significant difference at half an hour after the start of CPR. The changes of PaO₂ in the control group from immediately to half an hour after CPR was not significant, but in the intervention group it had significantly increased (P

<0.001). In the study by Zhang et al. it was found that PaO₂ levels increased half an hour after IAC-CPR (from 45.15 to 60.68), but no change was reported in the STD-CPR method and the change in the intervention group was significant (11), which is consistent with the findings of the present study. In justifying this finding, it can be argued that by applying abdominal pressure in the intervention group, the rate of general and pulmonary circulation increased and, therefore, it caused a greater increase in arterial blood oxygen pressure in the intervention group compared to the control group.

In terms of arterial blood pH immediately after CPR, there was no significant difference between the two groups ($P = 0.102$), but the difference was significant half an hour after the start of CPR ($P < 0.001$) and both groups had a significant decrease and the rate of decrease was greater in the intervention group. According to the study by Zhang et al., the pH level in both intervention and control groups had decreased after CPR and this decrease was more in the intervention group ($P = 0.037$). Also, in this study, the intervention group's pH (7.06) was lower than the control group (11); the findings of the current study are in line with their findings. To justify this finding, it can be argued that applying abdominal pressure in the resting phase of chest massage improves perfusion and blood flow to the heart muscle and increases cardiac output; therefore, by increasing cardiac output and blood flow to tissues, the amount of arterial blood CO₂ decreased, so the decrease in PaCO₂ was compensated by the decrease in serum bicarbonate, as a result, arterial blood pH in the intervention group decreased more than the control group.

In terms of PaCO₂, it was found that there was no significant difference between the two groups immediately ($P = 0.106$) and half an hour ($P = 0.932$) after the start of CPR. In the control group, the change in PaCO₂ from immediately to half an hour after the start of CPR was not statistically significant ($P = 0.199$), but in the intervention group it was significant and more than the control group ($P < 0.001$). According to the study by Zhang et al., the rate of PaCO₂ had significantly reduced in the intervention group after CPR, while this parameter had not changed in the control group ($P = 0.009$) (11), which is in line with the findings of the current study.

Finally, all of the 8 patients who had survived after IAC-CPR had been discharged from hospital, but in the STD-CPR group, only 5 out of the 8 patients had been discharged from hospital.

5. Strength and Limitations

So far, very few studies in this field have been done in Iran and doing this study was one of our strengths. Also, our study had some limitations. Firstly, since this study has been conducted on a limited number of samples, in order to generalize



its results, it is necessary to conduct more studies in various centers and on a larger number of patients with cardiopulmonary arrest. Secondly, no neurological assessment of survived patients had been done.

6. Conclusion

The findings of the current study show that IAC-CPR has had a positive effect on CPR-related outcomes. So in this regard, it is recommended to conduct more extensive research and on a larger sample size to increase the generalizability of the present findings and include this technique in CPR guidelines in the future.

7. Declarations

7.1. Acknowledgments

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7.2. Authors' contributions

A. Gh: Design of study, supervision of research process, data analysis, preparing final manuscript.

M.M: Design of study, supervision of research process, data analysis, preparing final manuscript.

L.P: Design of study, data collection, data analysis, preparing final manuscript.

S.P: Design of study, data collection, data analysis, preparing final manuscript.

M.AG: Design of study, data collection, preparing final manuscript.

E.KL: Design of study, data analysis, preparing final manuscript.

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None.

7.4. Conflict of interest

There are no conflicts of interest in this study.

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