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· Original article ·

Characteristics and outcome of patients after successful prolonged cardiopulmonary resuscitation

GUAN Jun, YANG Xing-Yi*, LIN Zhao-Fen, ZHAO Liang, XU Yong-Hua, GUO Chang-Xing (Department of Emergency, Changzheng Hospital, Second Military Medical University, Critical Care Medicine Center of PLA, Shanghai 200003, China)

[**ABSTRACT**] **Objective**: To retrospectively analyze the demographics and the final outcome of patients after successful prolonged cardiopulmonary resuscitation (CPR). **Methods**: Totally 12 patients, who were admitted to our ICU for further treatment after successful CPR between January 1996 and December 2002, were enrolled into this study. They all had return of spontaneous circulation after prolonged (> 30 min) CPR and remained hemodynamically stable for more than 6 h. There were 10 males and 2 females, with a mean age of (53.5±19.7) years. **Results**: The median duration of BLS/ACLS in the 12 patients was 45 min (range: 31-120 min). Four died from circulatory failure and multiple organ failure, 3 survived with Cerebral Performance Categories 3 or 4 and 5 with 2 or 1 (normal or near normal). There were no significant relation between hospital outcome and age (Spearman's correlation test, $P > 0.05$) and between hospital outcome and duration of CPR attempt ($P > 0.05$). Consciousness within 48 h after return of spontaneous circulation (ROSC) was significantly related with good hospital outcome (Fisher's exact test, $P < 0.01$). **Conclusion**: The prognosis for patients who achieved spontaneous circulation after prolonged CPR is not necessarily bleak. The advice to give up further resuscitation attempt from the family or related people should be carefully dealt with after ROSC. The prediction of the hospital outcome 48 h later after ROSC is much more accurate and the advice given to the family would be more valuable.

[**KEY WORDS**] cardiac arrest; cardiopulmonary resuscitation; return of spontaneous circulation; outcome

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Duration of cardiopulmonary resuscitation (CPR) is one of the key predictors for the final outcome[1-6]. International guidelines 2000 recommended that "in the absence of mitigating factors, prolonged resuscitation efforts for adults and children are unlikely to be successful and can be discontinued if there is no return of spontaneous circulation at any time during 30 min of cumulative Advanced Cardiac Life Support (ACLS)"[4]. On the other hand, if patients achieved spontaneous circulation, the chances for recovery with intact neurologic functions did not seem to be ignorable. There were a few reports of sporadic cases who recovered with favorable outcome after successful prolonged CPR[7-15]. Serving as a busy emergency medicine center that provides intensive post-resuscitation care to all CPR patients hospital-wide, our center had received and treated 12 patients who achieved spontaneous circulation after prolonged CPR and remained hemodynamically stable for at least 6 h. The seemingly good outcome of this group of patients prompted us to explore whether there were certain unique factors that improved the outcome. It is also possible that the heart and brain were well preserved during CPR in these patients, as indicated by the fact that spontaneous circulation was achievable. If this is the case, the standard resuscitation protocol should be strictly followed to ensure the best possible recovery in any patients with similar history. Clinically, medical professionals and families are wondering if there is any data to justify full-extent resuscitation efforts for patients after prolonged CPR. Therefore, we believed analysis of such a unique group of patients is of great clinical interests.

1 MATERIALS AND METHODS

1.1 Setting Changzheng Hospital is a 1 200-bed university teaching hospital with tertiary care located in Shanghai, China. Our department is mainly consisted of emergency room, 12 bed general ICU and a general ward for convalescence. Most of the cardiac arrest (CA) patients would be transferred to this ICU after successful CPR wherever CA occur.

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[**Biography**] GUAN Jun (1967-), male (Han nationality), MD, lecturer, attending doctor. E-mail: drguanjun@citiz.net

* Corresponding author. E-mail: yxyprofessor@126.com

1.2 Data source Retrospectively collected data concerning all the 51 patients who underwent CA and successful CPR and were transferred to our ICU for further treatment between January 1996 and December 2002. Successful CPR defined as return of spontaneous circulation (ROSC) and lasted for more than 6 h. Following items were extracted from case chart and emergency record: age, sex, hospital outcome, primary underlying disease, arrest site, direct provocation factor, duration of CPR attempt, defibrillation or not, total epinephrine dosage, consciousness within 48 h after ROSC or not, hospital death cause. CPR attempt includes following resuscitation effort but not limited: defibrillation, chest compression, endotracheal intubation, vascular access and reasonable drugs. Duration of cardiopulmonary resuscitation defined as the interval between the start of BLS and ROSC which last for more than 5 min. If ROSC were present during the CPR attempt and can not be lasted for more than 5 min, then the time of ROSC would be counted into duration of CPR attempt. Consciousness within 48 h after ROSC means the patient can act according the orders, for example, lift arm, stretch tongue and wink. Because of incompletion of chart data, we can not determine the initial rhythm of cardiac arrest. However, we can make sure that if the cardiac arrest patient had received defibrillation, the patient must had a ventricular fibrillation or pulseless ventricular tachycardia rhythm. If the patient received no defibrillation, the reason could be that either initial rhythm is non-VF/VT or defibrillator not available in time. Totally 12 patients whose duration of CPR were $\geq$30 min were enrolled into our study. ACLS were all performed in hospital in the 12 patients according to ACLS protocol, 4 of them whose CA occurred out-of-hospital received no Basic Life Support (BLS) and transferred to our emergency department directly. Hospital outcome were recorded and rated as: (1) death; (2) survival with severe central nerves system deficits or vegetable state, Cerebral Performance Categories (CPC)[16] 4 or 3; (3) survival without or with minor central nerves system deficits, patient can communicate meaningfully, CPC 2 or 1. We define the first 2 outcomes as poor hospital outcome and the third one as good hospital outcome.

1.3 Statistical analysis Age was expressed as means plus standard deviations. Duration of CPR attempt was expressed as median and range. The relation between hospital outcome and age, duration of CPR attempt were analyzed by Spearman's correlation test. The relation between hospital outcome and consciousness within 48 h after ROSC was analyzed by Fisher's exact test. The null hypothesis was rejected if the probability of it were equal to or less than one in 20 ($P \leq 0.05$).

2 RESULTS

2.1 Overall characteristics and outcome Of the 12 patients, 10 were male and 2 were female, the mean age was (53.5$\pm$19.7) years. The median duration of CPR attempt was 45 min with considerable variation (31-120 min). For arrest site, 8 occurred in hospital, 4 occurred out of hospital and received no BLS. For inducement of cardiac arrest, 6 were unknown while the other 6 were heart failure, hypoxemia, suffocation, electrolyte abnormality, electrical injury, myocardial infarction respectively. For hospital outcome, 4 died from circulatory failure and multiple organ failure, 3 survived with CPC 3 or 4, 5 survived with no or minor central nervous system deficits, CPC 2 or 1 (see Tab 1).

2.2 Relationship between hospital outcome and age For the 12 prolonged CPR attempt patients, there is no significant relation between hospital outcome and age, Spearman Correlation Coefficient is -0.391, P = 0.209.

2.3 Relationship between hospital outcome and duration of CPR attempt For the 12 prolonged CPR attempt patients, there is no significant relation between hospital outcome and duration of CPR attempt, Spearman Correlation Coefficient is -0.077, P = 0.812.

2.4 Relationship between hospital outcome and consciousness within 48 h after ROSC The result by Fisher's exact test showed that P = 0.001, which means that early consciousness after ROSC

is very significantly related with good hospital outcome.

Tab 1　Characteristics and outcome of patients after successful prolonged cardiopulmonary resuscitation

Patient	Age	Sex	Hospital outcome	Primary diagnosis	Arrest site	Inducement of CA	Duration of CPR attempt (t/min)	Defibrillation	Consciousness within 48 h	Hospital death cause
1	60	M	3	Coronary heart disease	General ward	Unknown	120	Y	Y	N
2	44	M	2	Viral encephalitis	General ward	Unknown	90	Y	N	N
3	71	F	1	Hypertension	General ward	Acute heart failure	80	N	N	Circulatory failure
4	45	M	1	Cervical vertebra paraplegia	General ward	Hypoxemia	65	N	N	Multiple organ failure
5	46	M	3	Dilated congestive cardiomyopathy	ICU	Unknown	65	Y	Y	N
6	51	M	2	Coronary heart disease	Home	Unknown	50	Y	N	N
7	27	M	2	Electrical injury	Working place	Electrical injury	40	N	N	N
8	78	M	1	Dementia	Home	Suffocation	40	N	N	Multiple organ failure
9	73	M	3	Myocardial infarction	Emergency room	Myocardial infarction	40	Y	Y	N
10	29	M	3	Uremia	Operation room	Unknown	37	Y	Y	N
11	85	F	1	Pneumonia	Home	Electrolyte abnormalities	33	N	N	Circulatory failure
12	33	M	3	Lumbar vertebra paraplegia	Operation room	Unknown	31	Y	Y	N

3　DISCUSSION

This study describes the characteristics and hospital outcome among patients who had ROSC after prolonged (> 30 min) CPR and remained hemodynamically stable for more than 6 h. As unexpected, we found that the outcome after successful prolonged CPR is not necessarily bleak and the prediction of the ultimate outcome of this group patients is much more accurate 48 h later after ROSC.

In this report, 5 of the 12 patients who underwent > 30 min CPR were discharged with no or minor neurologic deficit, this result is in good agreement with previeous experiences on those who were hospitalized alive after CPR[17, 18]. Among 12 patients, 4 had possible favorable factors for good outcome, including 2 in the operating room, 1 in the ICU, 1 electrical injury, 1 electrolyte abnormality. In addition, 7 patients were younger than 60 years old. However, the favorable factors and age were not closely related to the final outcome. These findings suggested that prediction of CPR outcome based on previously identified favorable factors during CPR is not always reliable. Furthermore, vigorous chest compression with other resuscitation efforts may preserve the heart and the brain over a long period of time in certain cases. As long as patients remain hemodynamically stable after return of spontaneous circulation, a relatively good hospital outcome can still be expected. Intensive post-resuscitation should not be discouraged by a history of prolonged CPR.

A number of studies suggested that duration of CPR was adversely associated with final outcome after cardiac arrest. Khalafi *et al* suggested that if spontaneous circulation was not achieved by 25 min of CPR, resuscitation could be abandoned unless cardiac arrest was associated with drug intoxication, hypothermia, electrolyte abnormality, or young age, *etc*, which were considered as favorable factors for good outcome after CPR[2]. Hamill suggested if CPR continued for more than 30 min, there were no survivors[19]. However, satisfactory outcome after prolonged (> 30 min) CPR were not uncommon[7-15], including those who did not have co-existence of favorable factors as mentioned above. Recently, a case of complete neurologic recovery after more than 5 h CA was reported[15].

Surprisingly, our study did not show that the final outcome was compromised by the prolonged CPR they received before ROSC. This finding apparently differs from most of other studies in which longer duration of CPR inevitably led to poor outcomes. The possible explanations for such a discrepancy may first come from the difference in

patient inclusion criteria. In our study, the patients were enrolled into our study only when they achieved spontaneous circulation and remained hemodynamically stable for 6 h. In contrast, most other studies included all cardiac arrest patients whose immediate CPR outcome were still unknown. Duration of CPR attempt has a significant effect on the chance of ROSC, thereby has a significant effect on ultimate CPR outcome. However, it may not have such a significant effect on the hospital outcome after successful CPR. This conclusion is in agreement with 2 other authors[20, 21], and seems to be supported by several case reports[10, 12, 14, 15].

Secondly, our patients may have transient ROSC during CPR. In our study, we defined the duration of CPR as the interval between the start of CPR and the ROSC, which must sustain for at least 5 min. Therefore, by definition, short (< 5 min) episode of ROSC did not disqualify the patients for enrollment into the study. It is reported, however, even a very short episode of ROSC (< 5 min) may contribute to a favorable outcome after prolonged CPR, compared to patients who did not have any ROSC[9]. Based on this, the guideline suggests an extended CPR for those who had any episodes of spontaneous circulation[4]. Unfortunately, the retrospective nature of the current study does not allow us to extract related data to clarify if there was any spontaneous circulation during CPR.

Our study also showed that consciousness within 48 h after ROSC strongly suggested a favorable outcome. Hamill in his review article suggested that neurological status was of more prognostic values 48 h after ROSC than immediately after ROSC[19]. Attila and Cook suggested that the prognosis for adults who remained deeply comatose (Glasgow Coma Score < 5) after cardiac arrest can be predicted with accuracy after 2-3 d in most cases[22]. Together with our results, it is thus suggested that prediction of the hospital outcome at this time is much more accurate and the advice to the family would be more appropriate.

The relationship between patient ages and outcome after CPR is not clear[18]. While some studies showed that old age was a risk factor of poor CPR outcome[18, 23], others did not[24-26]. Age is much less predictive of survival than other factors such as initial cardiac rhythm[27]. Our study supports the notion that age is not a critical factor in determining outcome after prolonged CPR. Age alone should not be taken into consideration when deciding whether aggressive life support be given after successful CPR.

In summary, based on the results of this study and our clinical experiences, we believe that accurate prediction of CPR outcome is still very difficult. Termination of resuscitation efforts should be very cautious, especially when some favorable factors are present, such as hypothermia, intoxication, ventricular fibrillation, ventricular tachycardia, or brief spontaneous circulation during CPR. Once ROSC is achieved, prediction of the ultimate outcome 48 h later after arrest is much more accurate. Finally, as long as patients can achieve spontaneous circulation after prolonged CPR, they still have a decent chance for favorable outcome. Effective resuscitation efforts, such as hypothermia, should be provided without hesitation.

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超长时心肺复苏成功后患者的特征与预后

管　军, 杨兴易*, 林兆奋, 赵　良, 许永华, 郭昌星

(第二军医大学长征医院急救科, 解放军急救医学中心, 上海 200003)

[**摘要**] **目的**: 回顾分析超长时心肺复苏成功后患者的人口学特征及最终结局。**方法**: 回顾分析 1996 年 1 月至 2002 年 12 月在我院心跳骤停心肺复苏持续 30 min 以上、自主循环恢复并维持 6 h 以上后收入我科 ICU 进一步救治的病例, 共 12 例, 男性 10 例, 女性 2 例。平均年龄(53.5±19.7)岁。**结果**: 本组 12 例患者, 心肺复苏持续时间的中位数时间为 45 min (31～120 min)。出院时死亡者(CPC 评分 5 分) 4 例, 分别死于循环衰竭和多器官功能衰竭; 严重脑功能障碍者(CPC 评分 3 分或 4 分) 3 例; 痊愈或轻微中枢神经系统缺陷者(CPC 评分 1 分或 2 分) 5 例。年龄和心肺复苏持续时间未显示出与出院结局有显著相关关系($P > 0.05$)。心肺复苏成功后 48 h 内患者是否清醒与出院结局有非常显著关系($P < 0.01$)。**结论**: 在自主循环建立后, 超长时心肺复苏患者的出院结局并不总是很糟糕, 应慎重对患者家属或相关人员作出放弃进一步救治的建议。在自主循环建立 48 h 后对患者出院结局进行预测将更加可靠, 对家属作出的建议也更有价值。

[**关键词**] 心跳骤停; 心肺复苏; 自主循环恢复; 治疗结果

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