# Cardiopulmonary resuscitation and termination of resuscitation on out-of-hospital cardiac arrest in China

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*To the Editor:* Out-of-hospital cardiac arrest (OHCA) is a major public health challenge. Early initiation, good quality cardiopulmonary resuscitation (CPR), and the use of an automated external defibrillator (AED) have been reported to significantly improve the survival and long-term outcomes in survivors of OHCA.[1]

Pre-hospital emergency personnel is often the first to be able to provide professional CPR in patients with OHCA, and their on-site availability often determines the outcomes of these patients. CPR in patients with OHCA ends either death, return of spontaneous circulation (ROSC), or referral to the hospital emergency department to continue resuscitation until the patient achieve ROSC or die. The American Heart Association published the guidelines for the termination of cardiopulmonary resuscitation (TOR) efforts in 2010, and the European CPR Guidelines were likewise published in 2015. The advanced life support (ALS) TOR rules recommend that when all of the following criteria are met: the cardiac arrest was unwitnessed, no bystander CPR occurred, no shock was delivered, and efforts did not result in ROSC. However, there is currently no Chinese guideline/consensus for terminating CPR, thus all pre-hospital emergency personnel must make decisions based on their knowledge and skills of CPR, and their understanding of related international CPR guidelines.

The purpose of this study is to understand the current knowledge level of pre-hospital emergency personnel regarding basic CPR and current standards for TOR, to further improve the efficiency of the pre-hospital emergency service system, standardize the role of TOR in China.

In February 2021, we administered a survey questionnaire to emergency care services (EMS) personnel in 23 provinces, five autonomous regions, and four municipalities in China. Two members of the study group were responsible for the follow-up of the questionnaire, which was completed within 4 weeks.

The content of the questionnaire includes the demographic information of the pre-hospital emergency personnel, such as gender, age, religion, employment, work years, and education background, and pre-hospital CPR treatment options. The design of the questionnaire was developed by an expert group from the Beijing Emergency Medical Center after collective discussion, and emergency clinical experts were invited to guide the revision. The study was approved by the Ethics Committee of Beijing Emergency Medical Center (No. 2021-001), and the written informed consent was waived.

Questionnaires were conducted on the Questionnaire Star (https://www.wjx.cn). Two personnel tracked and reviewed the data to avoid repeated data input and abnormal data generation. Data were analyzed using statistical product and service solutions software version 26.0 (IBM, Armonk, NY, USA). Univariate analysis, hierarchical analysis according to the background and demographic factors, and multivariate analysis were used.

A total of 4318 valid questionnaires were collected within 4 weeks. Of these, the ratio of male and female was 47.27% *vs.* 52.73%, the most common age was 30 to 40 years old (47.27%), the majority of respondents were from Han ethnicity. In terms of education, the largest groups of the personnel reported having a bachelor's degree (44.51%) and a junior professional title (46.80%); 35.66% had formal training in emergency medicine. The vast majority worked in municipal (41.08%) or county (30.96%) emergency centers. The majority of the staff (45.39%) had been working in their positions for <5 years. The proportions of personnel who had participated in adult basic life support training, adult ALS training, child life

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support training, and pregnant women's life support training were 94.40%, 66.33%, 39.07%, and 21.31%, respectively.

In terms of their everyday exposure to OHCA, 74.02% of the pre-hospital emergency personnel reported encountering <5 cases of cardiac arrest per month, while 2.25% reported encountering >20 cases of cardiac arrest per month. Such differences may be associated with differences in local factors such as diet and climate. The majority ofthe personnel (72.86%) encountered fewer than three resuscitation cases per month; 81.80% terminated one or fewer resuscitation cases per month due to ROSC, which is in accordance with the current success rate of out-of-hospital CPR in China. The majority (91.43%) of participants terminated 0–5 cases per month due to do-not-resuscitate (DNR) determination by a family member. Most personnel (68.06%) terminated 0 to 1 resuscitation case per month due to the need for hospital referral for further treatment. Only 2.96% of respondents reported resuscitating cardiac arrest patients until arrival at the emergency department without termination regardless of the condition of the patients.

Only 32.98% of the personnel reported considering age when deciding whether to perform resuscitation. The majority (69.66%) believed that the decision to terminate resuscitation should be made by the emergency doctor, while 29.74% thought that a family member should make such decisions. Respondents indicated that they typically limit the length of CPR to 20 min (2.73%), 30 min (72.58%), 40 min (9.29%), 60 min (4.26%), and >60 min (11.14%). The reasons given for termination of prehospital CPR included lengthy pre-hospital CPR (>30 min) without ROSC, DNR orders from a family member, long-term low (<10 mmHg) end-tidal carbon dioxide ($ETCO_2$) partial pressure, posterior sternum or rib fractures due to compressions, serious effect on the quality of life after resuscitation, and organ donation. $ETCO_2$ was used by 25.22% of pre-hospital emergency personnel to monitor the quality of CPR; $ETCO_2$ <10 mmHg after 10 min (15.79%), 20 min (9.46%), 30 min (62.99%), 40 min (3.86%), and 60 min (7.90%) was used as an indicator for termination of chest compressions. The reasons provided for failure to recover to ROSC were given as: emergency response time was too long; no CPR was given by bystanders; the patient had certain underlying conditions; CPR had lasted too long; multiple electrical defibrillations had failed; the quality of chest compressions had decreased; CPR guidance was not given over the phone; AED had not been used; too few emergency personnel were on-site; and the team cooperation was poor [Supplementary Table 1, http://links.lww.com/CM9/A733].

Supplementary Table 2, http://links.lww.com/CM9/A733 presents the average comprehensive score of the options, calculated based on the ranking of the options given by all respondents (a-f and g-o are the original orders of the questionnaire options). It reflects a comprehensive ranking of the options, with a higher score representing a higher ranking. For each option, the calculation method is as follows: the average comprehensive score = (Σ frequency × weight)/the total number of people choosing the option in their ranking.

The weight is determined by the ranking of the option; for example, if a responder chose three options in his/her ranking list, the weight of the first option is three, the weight of the second option is two, and the weight of the third option is one.

The respondents' educational background, professional title, the major of the highest degree attained, adult ALS training, maternal life support training, and the initial treatment of the patients with OHCA were independent factors predictive of $ETCO_2$ use by pre-hospital emergency personnel as an index to terminate CPR. Gender, age, level of the employer, unit operation mode, and the major of the highest degree were independent factors predictive of use of patient age as an index to TOR.

Unlike the emergency medical services in Europe and the United States, China's pre-hospital emergency personnel generally require systematic and multi-year medical education and training. Such high professional training demands and the vast number of pre-hospital first aid professionals in need can cause great pressure. These factors combine to negatively affect the stability and professionalism of pre-hospital emergency teams in China.

The current situation of outcomes from OHCA is very serious in China. Only in-depth, detailed, and comprehensive analysis of the reasons for lagging behind the results in other countries, such as lack of social impetus to improve CPR, inadequate pre-hospital CPR skills, different underlying conditions of enrolled cases, and uneven distribution of emergency resources, can begin to address the low success rate of CPR in China.

Pre-hospital emergency response time is greatly affected by the local economic environment, as found in studies from Republic of Korea.[2] Choosing the right modes for prehospital emergency treatment and improving the response time of pre-hospital first aid in China, a country with a large land area and huge regional economic differences, are enormous challenges. Although different modes of cardiac arrest responses in rescue situations have different success rates due to the large land area of China, uneven distribution of regional population, and large differences in socioeconomic levels, pre-hospital emergency centers/ stations/points adapted to the local situation should be capable of meeting the people's first aid needs. The proportion of personnel with related training is very high, but the educational background of the personnel is less satisfactory, and the majority of emergency personnel are young and relatively inexperienced. Team quality and stability still need improvement. A comparison of dispatcher-assisted CPR (DA-CPR), no CPR, and spontaneous initiation of CPR found that the 30-day survival rate of OHCA patients who underwent DA-CPR was higher than that without CPR, but lower than that with spontaneous initiation of CPR.[3] A study in North Carolina and the state of Washington found that the application of CPR by bystanders increased in both urban and non-urban areas.[4] We can improve the ability of emergency medical services in China by strengthening the ability of pre-hospital emergency teams and increasing first aid training among the public.

We also found that pre-hospital emergency personnel can perform standardized CPR for patients with cardiac arrest, and the recovery effect is basically consistent with the success rate of CPR in the literature in China, but there is still a gap compared with the international counterparts. Glober *et al*[5] found that the Non-shockable initial rhythm, Unwitnessed arrest, Eighty years or older (NUE) rule correctly identified 7.20% of OHCA patients unlikely to survive hospital discharge; this NUE rule could be used in EMS protocols and policies to identify OHCA patients who are very unlikely to benefit from aggressive resuscitation. However, China's pre-hospital emergency personnel appear to make decisions on the timing, indications, and indicators of TOR that are subjective and inconsistent; some even do not have the correct concept of ineffective CPR and CPR termination. Prehospital emergency personnel can master the rescue skills of CPR, but their understanding of life support training is not comprehensive, and evidence-based and effective implementation of CPR is not always fully accomplished, especially in the termination of CPR.

A protocol for termination of CPR utilizing longer resuscitation time and $ETCO_2$ monitoring criteria was implemented for EMS providers in an urban pre-hospital system in 2017. A significant decrease in the rate of arrivals to the emergency department with ROSC was seen afterward, particularly for bystander-witnessed OHCA.[6] The hierarchical analysis in this study exposed problems in the pre-hospital first aid field disposal process; further multivariate analysis regarding $ETCO_2$ as a factor in considering TOR found that education background, professional title, the major of the highest degree attained, adult ALS training, and maternal life support training are independent factors. Multivariate analysis regarding age as a factor for the termination of CPR found that gender, age, employer level, unit operation mode, and the major of the highest degree are independent factors. These problems are all concerns related to medical responsibility rather than questions of CPR skills. In fact, an unnecessary continuation of CPR not only wastes the hospital's precious rescue resources but also transfers any potential medical disputes to the hospital emergency department. Resolution of such disputes may require significant time and further use of resources.

In conclusion, existing emergency systems and personnel in China are capable of meeting the basic requirements for pre-hospital emergency services. Our survey of emergency personnel found that neither $ETCO_2$ nor patient age was consistently considered as an indicator for TOR.

## Conflicts of interest

None.

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