Cardiopulmonary arrest on arrival due to penetrating trauma

YOSHIHIRO MORIWAKI, MITSUGI SUGIYAMA, HIROSHI TOYODA, TAKAYUKI KOSUGE, YOSHIO TAHARA, NORIYUKI SUZUKI

Critical Care and Emergency Center, Yokohama City University Medical Center, Yokohama, Japan

ABSTRACT

INTRODUCTION The aim of this study was to clarify the outcome of patients with cardiopulmonary arrest on arrival due to penetrating trauma (PT-CPA) and to establish the treatment strategy.

PATIENTS AND METHODS The clinical course of 29 patients with PT-CPA over the past 10 years was examined. We have taken three approaches to these patients: (i) an aggressive treatment strategy; (ii) an in-hospital system supporting this aggressive resuscitation; and (iii) the pre-hospital emergency medical service (EMS) system in our city.

RESULTS Although the return of spontaneous circulation (ROSC) was established in 59% of patients, only 17% survived for 7 days, 14% were discharged, and 7% were neurologically intact. Of 10 patients showing pulseless electrical activity (PEA) on the scene, ROSC was established in 100% and 30% were discharged; however, of 12 patients showing asystole, ROSC was established in 33% and no patient could be discharged. There was no difference in the time interval from the arrival at the emergency department to ROSC between discharged patients and patients who died. The time interval from collapse to arrival at the emergency department in discharged patients and patients who went to the intensive care unit was shorter than that of patients who died in the emergency department with and without ROSC.

CONCLUSIONS We cannot decide to give up and terminate resuscitation in any PT-CPA patients and cannot define salvageable patients. However, our data show that 30-min resuscitation is thought to be relevant and that we should not give up on resuscitation because of the time interval without ROSC after arrival at the hospital.

KEYWORDS

Cardiopulmonary arrest – Penetrating trauma – Emergency medical service system – Resuscitation – Emergency department – Thoracotomy

CORRESPONDENCE TO

Moriwaki Yoshihiro MD PhD, Critical Care and Emergency Center, Yokohama City University Medical Center, 4-57, Urafune-cho, Minami-ku, Yokohama 232-0024, Japan

T: +81 45 261 5656; F: +81 45 243 3677; E: qqc3@yokohama-cu.ac.jp or qqc3@urahp.yokohama-cu.ac.jp

The outcome of postinjury cardiopulmonary arrest on arrival (CPA-OA) is very poor.^{1–8} Indeed, there are few strategies and procedures for treating this condition, and these are not always effective. As there is little data concerning the outcome of this condition, it is difficult to determine which therapeutic procedure should be performed. On the other hand, it is known that the outcome of postinjury CPA is different between blunt trauma and penetrating trauma,⁵ and that the outcome of CPA due to penetrating cardiac injury is not so poor.⁹ The aim of this study was to clarify the outcome and to establish the survival rate of patients with CPA-OA due to penetrating trauma (PT-CPA-OA) treated with our strategy including emergency department thoracotomy (EDT).

Patients and Methods

This study is a case series observational study. The clinical course of patients with PT-CPA-OA was examined. We have taken three approaches to these patients: (i) a private aggressive treatment strategy; (ii) an in-hospital system supporting this aggressive resuscitation; and (iii) the pre-hospital emergency medical service (EMS) system in our city. These patients were treated by our strategy for PT-CPA established in 1994, as follows: aggressive advanced resuscitation for 30 min beginning on arrival at the hospital; the insertion of a 7-Fr sheath introducer into the subclavian vein for aggressive infusion; epinephrine administration every 3 min; and EDT (the left 5th intercostal anterolateral

thoracotomy) including intrathoracic haemostasis, open cardiac massage and cross-clamping of the descending thoracic aorta (Fig. 1).^{2,4,6} In Japan, there is no legal and ethical guideline concerning the treatment strategy for patients without vital signs or signs of life. We usually have to resuscitate CPA-OA patients independent of their vital signs or signs of life, which often proves fruitless. Patients with signs of death (rigor mortis, congestion, and decapitation) are not resuscitated.

Second, we have also established an in-hospital system for supporting aggressive resuscitation. This system covers logistical issues such as the close proximity of the emergency department (ED) to the room for catheter intervention (transcatheter arterial embolisation room or TAE room), having CT and X-ray examination areas on the same floor, direct entrance to the operation room (OR) by exclusive lift, and the presence of common instruments that are interchangeable between the ED and OR including a bed for surgery.¹⁰ We can operate just after the arrival of the patient in the OR without transferring the patient from the ED stretcher to the operation bed. At the same time, we can do all types of operation in the ED using the same instruments as in the OR, such as major abdominal surgery and open thoracic surgery.

Third, we are establishing a pre-hospital and interhospital EMS system for severe patients, including CPA patients,

in our city. Yokohama is the second largest city in Japan, and our institute is located in the centre of Yokohama, south of Tokyo. The surface area of Yokohama is 434 km². The population of Yokohama is 3.37 million. Both the number of CPA patients and the number of transferred CPA patients has increased. Concerning the aetiology of CPA-OA patients, 74.9% of 2030 CPA calls were due to illness, 11.5% were caused by trauma other than traffic accidents, and 7.5% were from trauma due to traffic accidents. We selected 11 hospitals that can receive and treat patients with the most severe conditions, including CPA patients, and which have to receive patients with CPA independent of their capacity. One emergency director (medical doctor) from one of the 11 hospitals for all 11 hospitals is always conducting his duties in the central operation centre in the fire department of the city. This director advises and orders treatments for emergency life-saving technicians (ELSTs) to carry out, and notifies the hospitals of the transfer of the CPA patients. In Yokohama, CPA patients are transferred in about 7 min to the nearest of these 11 hospitals from the scene.¹¹

Results

Over the past 10 years, 29 PT-CPA-OA patients were treated using our strategy. Fifty patients were witnessed, and 9 were CPA-OA after scene. Initial cardiac rhythm on the scene was pulseless electrical activity (PEA) in 10 patients,

asystole in 12 and not confirmed in 7, and there was no victim with VF/pulseless VT on the scene. Initial rhythm on arrival at the ED was PEA in 9 patients, asystole in 20. Twenty-three patients underwent EDT and 19 patients underwent cross-clamping of the descending thoracic aorta. The other six patients did not undergo EDT; three because their bleeding point was not in the thorax and was thought to be easily controlled without thoracotomy, two because their bleeding was from the right chest, massive, and continuous, and the other case, involving a gunshot, did not undergo EDT because bleeding was massive, continuous and uncontrollable (Fig. 2).

Although the return of spontaneous circulation (ROSC) was established after the administration of 2.7 mg of epinephrine (mean) in 17 (59%) patients, most died within 24 h of arrival at the hospital. Only 11 patients (38%) went to the ICU or OR. Only five patients (17%) survived for more than 7 days, and four patients (14%) were discharged, all of whom were free from ventilators and two of whom were neurologically intact (Fig. 2). In two survivors with neurologically good condition, ROSC was established within 3 min and without administration of any epinephrine before preparing EDT, whose injured points were upper extremity and neck.

Of the 15 witnessed patients, ROSC was established in 11 (73%), 7 of whom (47%) went to the ICU or OR, and two of

whom were discharged (13%; Fig. 3A). Of the 9 CPA-OA-after-scene patients, all reached ROSC (100%), six went to the ICU or OR (67%), and two were discharged (22%; Fig. 3B). Of 10 patients showing PEA on the scene, ROSC was established in all cases (100%) and three patients were discharged; however, of 12 patients showing asystole as an initial rhythm on the scene, ROSC was established in four (33%) and there was no patient who could be discharged (Fig. 4). Of nine patients showing PEA on arrival at the ED, ROSC was established in all cases (100%) and three patients were discharged; however, of 20 patients showing asystole as an initial rhythm in the ED, ROSC was established in eight (40%) and one patient was discharged with good neurological condition. There were 10 penetrating cardiac injury patients; one was a neurologically poor survivor and another entered the ICU but died there, while the other eight died in ED.

There was no difference in the time interval from arrival at the ED to ROSC between discharged patients and patients who died in the ED, OR, TAE room, or ICU. The longest time interval from the arrival at the ED to ROSC of discharged patients was 12 min (Fig. 5). On the other hand, the time interval from collapse to arrival at the ED in discharged patients and patients who went to the ICU, TAE room, or OR was shorter than that of patients who died in ED with and without ROSC. The longest time interval from collapse to arrival at the ED was 24 min in discharged patients and 26 min in patients who went to the ICU, TAE room, or OR (Fig. 6).

Discussion

As many authors have reported an extremely poor prognosis for traumatic CPA-OA patients (survival rates of 0–3.7%),^{5,12–15} some of these authors and many other physicians have thought that resuscitation of traumatic CPA-OA patients was futile, an inappropriate use of precious social resources, and that the risks to the rescuer and financial burden should be also considered.^{5,13,14,16,17} The National Association of EMS Physicians Standards and Clinical Practice Committee (NAEMSP) and the American College of Surgeons Committee on Trauma (ACSCOT) published guidelines for the withholding or termination of resuscitation in prehospital traumatic cardiopulmonary arrest in a joint position paper.¹² This guideline showed the importance of triaging traumatic CPA patients at the scene to preserve resources and to maximise benefit.

On the other hand, some experts emphasised that adoption of this guideline remained controversial and that this guideline was not applicable for rapid transport systems outside the US.^{2,4,6,18} Indeed, some articles demonstrated successfully resuscitated traumatic CPA patients who might not have been resuscitated if the NAEMSP/ACSCOT guideline was strictly applied to them. Although some authors demonstrated extremely poor outcomes for blunt traumatic CPA patients,¹² the NAEMSP/ACSCOT guideline and some other authors demonstrated relatively good outcomes for PT-CPA patients,^{19,20} and Pickens *et al.*¹⁵ demonstrated successful resuscitation PT-CPA patients whose initial rhythm was asys-

tole, and who received CPR for more than 15 min. Lockey *et al.*¹ showed a 7.9% survival rate of PT-CPA patients with on-scene bilateral thoracotomy. We should consider that the optimal goal of attempting resuscitation for traumatic CPA-OA patients is not for them to merely survive but to survive with good neurological function. There has been controversy concerning the indication of aggressive resuscitation for PT-CPA-OA. We can save 17% of PT-CPA-OA patients, which simply means we should not give up on resuscitating any PT-CPA-OA patient.

The indication of emergency thoracotomy for PT-CPA-OA, including EDT and prehospital thoracotomy, has been also controversial. Emergency thoracotomy is thought to allow for direct control of pericardiac tamponade and intrathoracic haemorrhage, open cardiac massage, and cross-clamping of the aorta. The NAEMSP/ACSCOT guideline showed that recent survival rates range from 0–2% for blunt trauma and 2–2.5% for penetrating trauma. In some specific situations and in some specific EMS systems, such as the London Helicopter Emergency Medical Service (HEMS), prehospital resuscitative thoracotomy for PT-CPA was reported as a useful procedure resulting in 10% survival and 7% good recovery.^{1,7} On the other hand, Kennedy and Sharif²¹ suggested that the variability of an individual surgeon's indications, aggressiveness, or surgical expertise may have an effect on the outcome. In our cases, there were no survivors with good neurological condition who underwent EDT, even EDT for patients with thoracic penetration. Although only one patient survived after EDT, he

was discharged from our hospital with a poor consciousness level (E4VtracheostomyM5). And survivors with good neurological condition did not undergo EDT because ROSC was established before preparation of EDT. Our data do not show the usefulness of EDT for PT-CPA-OA patients.

Because the prehospital EMS system is thought to be important, some hospitals including our centre in Yokohama have established a special EMS system managing all types of CPA-OA patients described above.^{10,11} Although non-CPA emergency patients in Japan are commonly transferred to the hospital that the patient desires to go to, all CPA patients are not transferred to these hospitals but to the nearest of the 11 suitable hospitals, depending on the location of the scene, and independent of the patient's wishes. This EMS system can support our result and affect our data. Of course, differences in the prehospital EMS system in each region and in the treatment strategy bundles in each institute result in limitations in the data used in each study, including our study.

In this series in our centre, we cannot decide to give up and terminate resuscitation of any PT-CPA-OA patients, and we cannot define salvageable patients. However, patients with cardiac arrest after the scene should be aggressively resuscitated, and after ROSC they would benefit from blood transfusion and other medical resources, operative procedures, and intensive care. However, at present, our strategy including EDT is not suitable and not sufficient to save PT-CPA-OA patients. It is necessary to try to add other strategies such as early thoracotomy in the ambulance or on the scene before a patient becomes CPA. It is also necessary to try to perform thoracotomy as soon as possible after collapse such as at the scene or in the ambulance. We believe medical doctors have to go to the scene with the ambulance for these strategies to be best implemented.

Conclusions

The outcomes of PT-CPA-OA were extremely poor, the survival rate is 14% of all PT-CPA-OA in this part of Yokohama. We cannot decide to give up and terminate resuscitation of any PT-CPA patients, and we can not define salvageable patients. However, our data show that 30-min resuscitation is thought to be relevant. Our data also show that we should not give up on resuscitation because of the time interval without ROSC from the arrival at the hospital. It may be meaningful to perform thoracotomy at the scene or in the ambulance.

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