Clinical Paper

Exploring which patients without return of spontaneous circulation following ventricular fibrillation out-of-hospital cardiac arrest should be transported to hospital?²

Dion Stub a,b,c,*, Ziad Nehme d,e, Stephen Bernard a,d,e, Marijana Lijovic d,e, David M. Kaye a,b,d, Karen Smith d,e,f

a Alfred Hospital, Australia
b Baker IDI Heart and Diabetes Institute, Australia
c University of Washington, USA
d Monash University, Australia
e Ambulance Victoria, Australia
f University of Western Australia, Australia

ARTICLE INFO

Article history:
Received 29 October 2013
Accepted 8 December 2013

Keywords:
Cardiac arrest
Transport
Resuscitation

ABSTRACT

Background: Currently many emergency medical services (EMS) that provide advanced cardiac life support (ACLS) at scene do not routinely transport out-of-hospital cardiac arrest (OHCA) patients without sustained return of spontaneous circulation (ROSC). This is due to logistical difficulties and historical poor outcomes. However, new technology for mechanical chest compression has made transport to hospital safer and extracorporeal membrane oxygenation during cardiopulmonary resuscitation (ECPR) enabling further intervention, may result in ROSC. We aimed to explore the characteristics and outcomes of patients with OHCA who were transported to hospital with ongoing CPR in the absence of ROSC, who might benefit from this new technology.

Methods and results: The Victorian Ambulance Cardiac Arrest Registry (VACAR) was searched for adult OHCA with an initial shockable rhythm between 2003 and 2012. There were 5593 OHCA meeting inclusion criteria. Analysis was performed on 3095 (55%) of patients who did not achieve sustained ROSC in the field. Of these only 589 (20%) had ongoing CPR to hospital. There was a significant decline in rates of transport over the study period. Predictors of transport with ongoing CPR included younger patients, decreased time to first shock and intermittent ROSC prior to transport. Survival to hospital discharge occurred in 52 (9%) of patients who had ongoing CPR to hospital.

Conclusion: In an EMS that provides ACLS at scene, patients without ROSC in the field who receive CPR to hospital have poor outcomes. Developing a system which provides safe transport with ongoing CPR to a hospital that provides ECPR, should be considered.

1. Introduction

Survival from out of hospital cardiac arrest (OHCA) remains poor, particularly in patients who do not achieve return of spontaneous circulation (ROSC) in the field.¹ Accordingly rules for when to terminate resuscitative efforts have been developed in an attempt to avoid transporting patients to hospital with no hope of survival.²⁻⁴ These rules include factors such as unwitnessed cardiac arrest, an initial non-shockable rhythm, and failure to achieve ROSC in-field.

Similar guidelines have been adopted by emergency medical services (EMS) in Victoria, Australia, which require that multiple criteria be fulfilled before the termination of resuscitation in-field. These include resuscitation attempts exceeding 30 min, where ROSC has not been achieved and the patient remains in a non-shockable rhythm, without signs of life such as gasping or pupil reactions.³ Most patients with refractory cardiac arrest in Victoria are not transported to hospital for two reasons. Firstly, transport to hospital with manual external chest compressions within a fast moving ambulance is both impractical and hazardous for the crew. Secondly, given that advanced life support measures have been provided at the scene by paramedics, and traditionally there have been no additional treatment options in the hospital, it
has been considered that such transport would be futile in these patients.6–8

A number of recent advances have highlighted potential new treatment pathways for patients with refractory cardiac arrest. These include portable automated CPR devices, which would facilitate safe transport of a patient with CPR in progress.2 In addition, institution of pre-hospital therapeutic hypothermia (TH) for neuro-protection.10,11 Finally extracorporeal membrane assisted CPR (ECPR) for patients with refractory OHCA,12–14 and transfer to a cardiac catheterisation laboratory for percutaneous coronary intervention (PCI) may result in ROSC.15,16 Together these therapies provide new hope in this group of patients. In the present study we aimed to review the current outcomes of patients with ongoing CPR to hospital in Victoria, to determine more precisely the characteristics of patients who might be eligible for such therapies.

2. Methods

2.1. Study design and setting

We conducted a retrospective study using population-based data from the south-eastern state of Victoria (Australia) obtained from the Victorian Ambulance Cardiac Arrest Registry (VACAR).17 The state of Victoria has a current population of approximately 5.5 million, with 75% of the population located in the state’s capital city of Melbourne. 

Ambulance Victoria are the sole provider of the state’s emergency medical services (EMS) and is described in detail elsewhere.17 Emergency call taking is performed using the medical priority dispatch system (MPDS), with advanced life support and intensive care paramedics dispatched to the majority of suspected cardiac arrests. Basic life support trained fire-fighters, equipped with automatic defibrillators, co-responded across parts of Melbourne.18 Paramedics operate under Ambulance Victoria Clinical Practice Guidelines, which follow the Australian Resuscitation Council Guidelines.5 Paramedics may withhold or cease resuscitation under specific circumstances, including clear evidence of prolonged arrest (e.g. rigour mortis, decomposition). Patients are transported to the nearest appropriate facility.

2.2. Victorian Ambulance Cardiac Arrest Registry (VACAR)

The VACAR captures all OHCA attended by the EMS in the state. The VACAR collects Utstein elements13 including demographics, arrest features, resuscitation care and hospital outcome data. The aetiology of cases is considered presumed cardiac when no other cause is apparent (e.g. trauma, hanging, drowning, exsanguination and other obvious non-cardiac causes). The VACAR has been approved by the Human Research Ethics Committee (HREC) at the Department of Health in Victoria. Approval for this specific data analysis was obtained from the Alfred Hospital HREC and the Research Committee of Ambulance Victoria.

2.3. Participants

The VACAR was searched for adult (aged ≥18 years) OHCA that received an attempted resuscitation by EMS between January 2003 and June 2012. Included in the analysis were patients with an initial shockable rhythm (ventricular fibrillation or pulseless ventricular tachycardia), who did not achieve ‘sustained ROSC’ in the field. Sustained ROSC was defined as the restoration of circulation and a palpable pulse at the time of scene departure.19 Cases of OHCA witnessed by paramedics were excluded.

2.4. Data analysis

The primary outcome measure was rate of transport to hospital with ongoing CPR. Survival to hospital discharge and discharge direction to home, rehabilitation or nursing facility were secondary outcome measures. Patient and arrest characteristics were tabulated with descriptive statistics and compared between patients who were transported to hospital with ongoing CPR to those declared deceased in the field. Patient characteristics in those transported with ongoing CPR who survived to hospital discharge were also compared to those transport patients who did not survive. Unadjusted analyses between groups were performed using the chi-squared test, the Mann–Whitney U test and the Student’s t test as appropriate. Separate multivariate models were constructed identifying factors predictive of hospital transport with ongoing CPR and survival to hospital discharge. Predictors included in the model were considered statistically significant at a p value <0.05, and are reported as odds ratios with 95% confidence intervals and

![Fig. 1. Transport status of patients and field resuscitation times during study period. P for trend <0.01 for resuscitation time, rate of transport with ongoing CPR and overall rate of ROSC. *Patients transported with ROSC analysed from entire cohort of patients with out of hospital cardiac arrest and initial shockable rhythm.](image-url)
associated $p$ values. All statistics were performed with SPSS version 19 (SPSS Incorporated, Chicago, IL, USA).

3. Results

3.1. Baseline and arrest characteristics

During the study period there were 5593 OHCA with an initial shockable rhythm. Analysis was performed on the 3095 (55%) of patients who did not achieve sustained ROSC in the field. Of these, 589 (20%) patients had ongoing CPR to hospital with the remainder declared deceased at scene. During the study period, the proportion of patients transported with ongoing CPR declined significantly. In 2003, 22.1% of patients were transferred with ongoing CPR compared to 5.6% in 2012 ($p$ for trend < 0.01) (Fig. 1). On the other hand, there was increased scene resuscitation times in patients not achieving ROSC during the study period with a median resuscitation time in 2003 of 30 IQR (23–39) min compared to 38 IQR (31–47) min in 2012 ($p < 0.01$).

Compared with patients declared deceased at scene, patients transported with ongoing CPR were younger (median 63 vs. 68 years, $p < 0.01$) with slightly more arrests of presumed cardiac etiology (95% vs. 93%, $p = 0.03$). Patients transported with CPR were also more likely to arrest in a public place (Table 1).

3.1.2. Factors associated with a patient being transported with ongoing CPR

Independent predictors of a patient being transported to hospital with ongoing CPR are outlined in Table 2. The strongest predictor of transport with ongoing CPR was intermittent ROSC in the field with an odds ratio 3.3 (95%CI 2.5–4.3, $p < 0.01$). Other independent predictors included younger patients, those who arrested in public places, and those who received longer periods of resuscitation (Table 2).

3.2. Mortality

Survival to hospital discharge occurred in 52 (9%) of patients who received ongoing CPR during transportation to hospital. Of the survivors, 44 (85%) were discharged directly home and 2 (3%) of patients were discharged to a nursing home (Table 3).
Table 4
Characteristics stratified by survival.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Transport with CPR did not survive (n = 521)</th>
<th>Transport with CPR survived to hospital discharge (n = 52)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median age (IQR), years</td>
<td>64 (49–75)</td>
<td>60 (53–72)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>18–29 years</td>
<td>24 (5)</td>
<td>2 (4)</td>
<td>0.09</td>
</tr>
<tr>
<td>30–39 years</td>
<td>35 (7)</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>40–49 years</td>
<td>72 (14)</td>
<td>7 (14)</td>
<td></td>
</tr>
<tr>
<td>50–59 years</td>
<td>89 (7)</td>
<td>16 (31)</td>
<td></td>
</tr>
<tr>
<td>60–69 years</td>
<td>110 (21)</td>
<td>12 (23)</td>
<td></td>
</tr>
<tr>
<td>70–79 years</td>
<td>105 (20)</td>
<td>11 (21)</td>
<td></td>
</tr>
<tr>
<td>80+ years</td>
<td>86 (17)</td>
<td>4 (8)</td>
<td></td>
</tr>
<tr>
<td>Patient ≤65 years of age</td>
<td>276 (53)</td>
<td>31 (60)</td>
<td>0.36</td>
</tr>
<tr>
<td>Male gender, n (%)</td>
<td>431 (82)</td>
<td>47 (90)</td>
<td>0.16</td>
</tr>
<tr>
<td>Location, n (%)</td>
<td></td>
<td></td>
<td>0.31</td>
</tr>
<tr>
<td>Home</td>
<td>234 (45)</td>
<td>18 (34)</td>
<td></td>
</tr>
<tr>
<td>Public</td>
<td>161 (31)</td>
<td>17 (33)</td>
<td></td>
</tr>
<tr>
<td>Metropolitan location</td>
<td>251 (48)</td>
<td>35 (67)</td>
<td>0.009</td>
</tr>
<tr>
<td>Witnessed arrest, n (%)</td>
<td>385 (48)</td>
<td>42 (81)</td>
<td>0.244</td>
</tr>
<tr>
<td>Bystander CPR, n (%)</td>
<td>290 (58)</td>
<td>33 (70)</td>
<td>0.112</td>
</tr>
<tr>
<td>Median EMS response time (IQR), min</td>
<td>7 (5–10)</td>
<td>6 (4–7)</td>
<td>0.002</td>
</tr>
<tr>
<td>Time to first defibrillation</td>
<td>11 (8–14)</td>
<td>9 (6–12)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Median resuscitation time (IQR), min</td>
<td>42 (32–57)</td>
<td>39 (31–59)</td>
<td>0.34</td>
</tr>
<tr>
<td>Median time at scene (IQR), min</td>
<td>33 (25–42)</td>
<td>31 (22–42)</td>
<td>0.74</td>
</tr>
<tr>
<td>Median number of shocks mean (IQR)</td>
<td>7 (3–11)</td>
<td>5 (1–8)</td>
<td>0.006</td>
</tr>
<tr>
<td>Any ROSC in the field</td>
<td>137 (26)</td>
<td>34 (65)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Median time from arrival to first ROSC</td>
<td>22 (16–32)</td>
<td>11 (8–19)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Intubation</td>
<td>407 (78)</td>
<td>36 (69)</td>
<td>0.144</td>
</tr>
<tr>
<td>Transport time</td>
<td>8 (5–13)</td>
<td>10 (5–16)</td>
<td>0.22</td>
</tr>
<tr>
<td>Transport to a PCI capable hospital, n (%)</td>
<td>214 (41)</td>
<td>36 (69)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Rhythm on arrival to hospital, n (%)</td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Pulse present</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VF/VT</td>
<td>222 (43)</td>
<td>45 (86)</td>
<td></td>
</tr>
<tr>
<td>Asystole</td>
<td>43 (8)</td>
<td>1 (2)</td>
<td></td>
</tr>
<tr>
<td>PEA</td>
<td>63 (12)</td>
<td>1 (2)</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>60 (12)</td>
<td>3 (6)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>133 (25)</td>
<td>2 (4)</td>
<td></td>
</tr>
</tbody>
</table>

3.2.1. Comparison of survivors vs. non-survivors in patients transported with ongoing CPR

Patient and arrest characteristics of survivors to hospital discharge and non-survivors in patients transported with ongoing CPR are compared in Table 4. The strongest independent predictor of poor outcome was the patient’s first recorded rhythm at hospital arrival being asystole compared with other cardiac rhythms (odds ratio, 0.12, 95% CI 0.02–0.19). Independent predictors of improved survival in a multivariable model included shorter time to first EMS shock, achieving intermittent ROSC and being transported to a hospital with percutaneous coronary intervention capabilities (Fig. 2).

4. Discussion

This study has found that in Victoria, the majority of patients with OHCA and an initial shockable rhythm who do not achieve sustained ROSC in the field are declared deceased rather than transported to hospital. Of the 589 patients who were transferred with ongoing CPR, 267 (47%) had a pulse on initial rhythm check at hospital. Survival in patients transported with ongoing CPR was low, with only 9% of patients making a good outcome at hospital discharge. The study also found a decrease over time in patients transported with ongoing CPR with only 5% of patients without ROSC transported to hospital in 2012 compared to 22% in 2003.

There are several reasons for the low rate of transport with ongoing CPR. The transportation of a patient with ongoing CPR is potentially hazardous to the EMS crews and requires significant resource allocation in the emergency department. The outcomes of such patients has also previously been considered poor with reported rates of survival less than 2% in 8.20 The outcomes of such patients has also previously been considered poor with reported rates of survival less than 2% in 8.20 and transport could therefore be regarded as futile care. On the other hand, a study by Hoeven et al. of 216 patients transported to hospital with ongoing CPR reported a survival to discharge rate of 13% in patients with persistent VF.21

A number of termination of resuscitation rules in the field, designed to discourage futile transport of patients with ongoing CPR, have been developed and validated.22 Key factors in these decision rules are patients with unwitnessed cardiac arrests, those who do not receive any shocks in the field and those who do not obtain any episodes of ROSC.3 Ambulance Victoria Clinical Practice Guidelines utilise a broader rule for termination of treatment, deeming that resuscitation efforts in the field may be ceased after 30 min if ROSC has not been achieved and the patient is in a non-shockable rhythm without signs of life such as gasping or pupil reactions.5

Our reported survival rate of 9% to hospital discharge with 85% of these patients being discharged with potentially good neurological outcome indicates that transport may be indicated for a higher proportion of patients with an initial shockable rhythm and failed pre-hospital ROSC. Identifying which patients should receive transport and subsequent hospital intervention, however, is difficult. Major predictors of survival in the patients transported with active CPR in our cohort included shorter time to initial shock, patients with intermittent ROSC and patients transported to a centre with PCI capabilities (Fig. 2).

The introduction of mechanical CPR could potentially facilitate safe transport to hospital with on-going CPR. Whilst there is no evidence that routine automated CPR is superior to manual CPR,23 the use of automated devices allows for potentially safe and effective CPR during patient transport.9

Once at the hospital, cardiac arrest refractory to treatment is commonly due to acute coronary occlusion. As a bridge to support
the patient during PCI, extracorporeal membrane oxygenation during cardiopulmonary resuscitation (ECPR) has been used. The largest experience with ECPR to treat patients with refractory OHCA has been in Japan. One of the first reports of a system of care for patients with refractory OHCA utilising ECPR was by Nagao and colleagues, in a single centre experience from Tokyo. In this prospective study of 50 patients with prolonged OHCA, 32 patients had failure of ROSC on arrival to hospital and were initiated on ECMO. Therapeutic hypothermia was induced and maintained for 48 h and coronary angiography was performed after being established on ECMO support. This ECPR protocol achieved ROSC in 46/50 (92%) of patients and survival to discharge with good neurological recovery in 12/50 (24%). The use of ECPR in Japan has subsequently expanded widely. A recent systematic review of 1282 cases of OHCA managed with ECPR, at over 30 Japanese centres, found a survival rate of 26%.

A limitation of our analysis is the lack of available data for transported patients regarding in-hospital treatment thought to be associated with survival including use of therapeutic hypothermia, haemodynamic and metabolic optimisation and procedures such as coronary intervention or use of cardiac support devices. Other limitations to our study include the possibility of bias in selection of patients for transport with ongoing CPR to hospital, the lack of detail regarding patient’s rhythm on arrival to hospital in 25% of patients and missing survival data in 2.6% of patients transported to hospital.

5. Conclusion

Few patients with OHCA and an initial shockable rhythm who do not achieve ROSC in the field are currently transported to hospital with ongoing CPR in Victoria and survival is low in those patients who are transported. New technology such as mechanical CPR during transport and ECPR at the hospital has recently become available. Further research into identifying which patients may benefit from prolonged resuscitative efforts including transport to hospital with mechanical CPR and facilities for ECPR should be considered in Victoria.

Conflict of interest statement

Dr Dion Stub—Supported by a Victoria Fellowship, Royal Australian and New Zealand College Physician Foundation scholarship and Cardiac Society of Australia and New Zealand Award.

Prof. David Kaye, Prof. Stephen Bernard and A.Prof. Karen Smith have research projects supported by National Health and Medical Research Council of Australia grants.

The study was supported by a Centre of Research Excellence Grant from the National Health and Medical Research Council of Australia.

References


