Resuscitation 80 (2009) 443–448

Contents lists available at ScienceDirect

Resuscitation

journal homepage: www.elsevier.com/locate/resuscitation

Clinical paper

Survey of outcome of CPR in pediatric in-hospital cardiac arrest in a medical center in Taiwan☆

En-Ting Wu[a], Meng-Ju Li[a], Shu-Chien Huang[b], Ching-Chia Wang[a], Yueh-Ping Liu[a], Frank Leigh Lu[a], Wen-Je Ko[b], Ming-Jiuh Wang[c], Jou-Kou Wang[a], Mei-Hwan Wu[a,*]

[a] Department of Pediatrics, National Taiwan University Hospital and College of Medicine, National Taiwan University, Taipei, Taiwan
[b] Department of Surgery, National Taiwan University Hospital and College of Medicine, National Taiwan University, Taipei, Taiwan
[c] Department of Anesthesiology, National Taiwan University Hospital and College of Medicine, National Taiwan University, Taipei, Taiwan

ARTICLE INFO

Article history:
Received 27 June 2008
Received in revised form 8 January 2009
Accepted 12 January 2009

Keywords:
Pediatric
Cardiopulmonary resuscitation
Cardiac arrest

ABSTRACT

Purpose of the study: While the outcomes of cardiopulmonary resuscitation (CPR) for pediatric in-hospital cardiac arrest (IHCA) are reported for many regions, none is reported for Asian countries. We report the outcomes of CPR for pediatric IHCA in a tertiary medical center in Taiwan and also identify prognostic factors associated with poor outcome.

Methods: Data were retrieved retrospectively from 2000 to 2003 and prospectively from 2004 to 2006 from our web-based registry system. We evaluated patients younger than 18 years of age who had IHCA and received CPR. The primary outcome was survival to hospital discharge, and the secondary outcomes were sustained return of spontaneous circulation (ROSC), and favorable neurological outcomes as assessed by pediatric cerebral performance categories (PCPC).

Results: We identified 316 patients and the overall hospital survival was 20.9% and 16.1% had favorable neurological outcomes. Sixty-four patients ever supported with ECMO. We further analyzed 252 patients who underwent conventional CPR only and most had cardiac disease (133/252, 52.8%). The second most common preexisting condition was hematologic or oncologic disease (43/252, 17.1%). Of the 252 patients, 153 (60.7%) achieved sustained ROSC, 50 (19.8%) survived to discharge, and 39 patients (15.5%) had favorable neurological outcomes. CPR during off-work hours resulted in inferior chances of reaching sustained ROSC. Multivariate analysis showed that long CPR duration, hematology/oncology patients, and pre-arrest vasoactive drug infusion were significantly associated with decreased hospital survival ($p < 0.05$).

Conclusions: Outcomes of CPR for pediatric patients with IHCA in Taiwan were comparable to corresponding reports in Western countries, but more hematology/oncology patients were included. Long CPR duration, hematologic or oncologic underlying diseases, and vasoactive agent infusion prior IHCA were associated with poor outcomes. The concept of palliative care should be proposed to families of terminally ill cancer patients in order to avoid unnecessary patient suffering. Also, establishing a balanced duty system in the future might increase chances of sustained ROSC.

1. Introduction

Although cardiopulmonary resuscitation (CPR) has been available for children for more than 50 years,[1] the results remain far from satisfactory. As the Utstein template is suggested as the standard for reporting the outcomes of CPR,[2] there are several studies of in-hospital cardiac arrests (IHCA) in children, such as national registry of cardiopulmonary resuscitation (NRCPR) in United States,[3,4] Canada,[5,6] South America,[7] Australia,[8] and European countries.[9–12] These data are lacking for Asian countries. The goal of this study was to report the outcomes of IHCA among pediatric patients in our institute and compare them to those of Western countries.

2. Materials and methods

2.1. Hospital setting

NTUH is a university-affiliated tertiary teaching hospital, with a 120-bed pediatric department. The hospital has a 13-bed pediatric intensive care unit (PICU). According to hospital policy, there are always manpower and monitoring devices within the PICU or emergency department in the hospital so that there is no need to call for a CPR team when IHCA occurs in these locations. Other-

☆ A Spanish translated version of the summary of this article appears as Appendix in the final online version at doi:10.1016/j.resuscitation.2009.01.006.

* Corresponding author at: 7th, Chung-Shan South Road, Taipei, Taiwan. Tel.: +886 2 23123456x65126.
E-mail address: wumh@ntu.edu.tw (M.-H. Wu).

0300-9572/$ – see front matter © 2009 Elsevier Ireland Ltd. All rights reserved.
doi:10.1016/j.resuscitation.2009.01.006

wise, the pediatric CPR team helps manage any cardiorespiratory arrest outside the aforementioned areas, such as the general ward or public area in the hospital. The pediatric CPR team consists of a senior pediatric resident, a head nurse, and several registered nurses. Each member of the CPR team is certified to perform pediatric advanced life support (PALS). The CPR team responds to each emergency call and provides basic life support and PALS for patients who suffered IHCA. All patients who received CPR outside the PICU are admitted to the PICU for further post-resuscitation care and evaluation.

The study group was retrospectively identified from our pediatric database from January 2000 to December 2003. Since January 2004, patients were enrolled prospectively from a web-based registry system in the Quality Management Center in our hospital.[13] The hospital's ethical committee approved this research protocol.

2.2. Inclusion and exclusion criteria

Patients aged from 7 days to 18 years who experienced cardiac arrests in our hospital between January 2000 and December 2006 were eligible to be included in this study. Cardiac arrest was defined as any condition requiring external chest compressions or internal cardiac massage for >60 s because of profoundly low output state. For patients with multiple arrest events, only the initial index arrest/event and resuscitation were described and analyzed. We excluded premature or term neonates treated in the delivery room or neonatal ward. Furthermore, we excluded patients who only received resuscitation drugs or positive pressure ventilation without need of chest compression or defibrillation, and patients who were subject to palliative treatment or to a "do not resuscitate (DNR)" order. Patients arriving at the emergency department in cardiac arrest were not included in this study. Hypothermia was not routinely induced after resuscitation.

2.3. Outcome measures

We applied Utstein-style data reporting guidelines for cardiac arrests and CPR to describe the outcomes. The primary outcome measure was survival to hospital discharge. Secondary outcome measures included sustained return of spontaneous circulation (ROSC) of >20 min, 24-h survival, neurological outcomes at hospital discharge of the survivors and the 1-year survival. Neurological outcome was determined using pediatric cerebral performance categories (PCPC), in which category (1) represents a normal neurological state, (2) mild disability, (3) moderate disability, (4) severe disability, (5) coma or vegetative state, and (6) death. A good neurological outcome was defined by a PCPC score of 1, 2 or 3, or no changes from the baseline PCPC score. Because there are increasing reports that imply superior outcomes for extracorporeal membrane oxygenation (ECMO) support during CPR than for conventional CPR,[14–16] patients treated with ECMO during CPR or in the post-resuscitative period were considered separately and not included in the further analysis of outcomes.

2.4. Data analysis and statistical methods

Patient age, sex, condition before arrest (presence of intra-arterial blood pressure monitoring, endotracheal intubation, and continuous infusion of vasoactive drugs), location of arrest, first recorded ECG rhythm, use of cardioversion, injection of epinephrine (adrenalin), calcium compounds, and bicarbonate during CPR, and total duration of CPR were collected. The predisposing conditions before arrest were categorized as cardiac, respiratory, neurological, hematologic/oncologic, hepatic/gastrointestinal, infectious and metabolic/genetic disorders. The age of patients was categorized into newborns (<1 month), infants (1–12 months), young children (1 year to <8 years) and older children (8–18 years) in order to compare the CPR outcome. We then divided the CPR duration into five categories: <10 min, 11–20 min, 21–30 min, 31–60 min and >60 min. Furthermore, to compare the outcome of CPR during working hour and non-working hours, the arrest time was categorized into working hours if it happened from 8 a.m. to 6 p.m., Monday to Friday, or non-working hours (hours outside working hours). The above variables were analyzed to see if these factors affected the outcomes of CPR.

Pearson's chi-squared test was used for qualitative variable analysis, and Fisher's exact test was used when n was less than 20 or when any value was less than 5. Student's *t*-test was used to compare quantitative variables between independent groups and the Mann–Whitney *U*-test was used for variables without normal distribution. Multivariate logistic regression was performed to assess the influence of each one of the factors on the primary and secondary outcomes. All the individual factors with statistical significance in the univariate analysis were included in the multivariate analysis. Results are expressed as mean ± standard deviation (S.D.). *p*-Values were considered significant when they were less than 0.05 (two-sided).

3. Results

During the study period, 316 cardiac arrests occurred that resulted in CPR; the incidence was 0.9% out of 35,497 pediatric admissions and 5.7% out of 5514 PICU admissions, which was higher than the report from Australia (0.1 and 2.4%, respectively)[8] and Canada (0.94% for PICU admissions),[6] but lower than in Finland (0.7 and 7.5%)[12] and Brazil (2.14 and 19%).[7] In this cohort, 228 patients (72.2%) ever achieved ROSC, 174 patients (55.1%) had 24-h survival, 66 patients (20.9%) survived to discharge and 51 patients (16.1%) had good neurological outcomes (PCPC = 1, 2, or 3). Sixty-four patients underwent ECMO during active chest compression (ECPR) or underwent ECMO within 24 h of CPR. In the ECMO group, 25% survived to hospital discharge and 17.8% had good neurological outcomes. We studied 252 children (142 boys and 110 girls) who received conventional CPR. Their mean age was 44.9 ± 58.4 months (median: 15.5 months, range: 0–205 months). The mean CPR duration was 39.5 ± 50.9 min (median: 20.5 min, range: 5–124 min). The outcome of CPR was recorded using the Utstein template (Fig. 1). Of the 252 patients analyzed, 164 achieved ROSC (65.1%), which was temporary in 11 patients. Therefore, 153 patients achieved sustained ROSC (60.7%) and 121 patients (48.0%) survived 24 h after CPR. Thereafter, 71 (28.1%) died 19 ± 32 days (median: 8 days) after CPR, and only 50 (19.8%) survived to hospital discharge. Only 39 patients (15.5%) had good neurological outcomes at discharge. Five patients died 195 ± 86 days (median: 230 days) after discharge and the causes of death included uncontrolled underlying disease ($n = 2$) and septic shock ($n = 3$). Therefore, only 45 patients (17.9%) survived to 1 year after the IHCA event.

3.1. The first-monitored rhythm

In this cohort, the most common first-monitored rhythm was bradycardia or asystole ($n = 182$, 72.2%), followed by pulseless electrical activity ($n = 33$, 13.1%). Shockable ventricular tachycardia or ventricular fibrillation (VT/VF) was seen in only 11 patients (4.4%), and 26 ECG rhythms were missing (no data). The first monitored rhythm did not affect the outcome ($p = 0.91$).

3.2. Age category and outcome of CPR

Most patients were 1–8 years of age ($n = 81$, 32.1%), followed by infants ($n = 78$, 31.0%). In this study, infants (1 month to 1 year of age) showed a trend toward increased survival to discharge ($n = 23$,

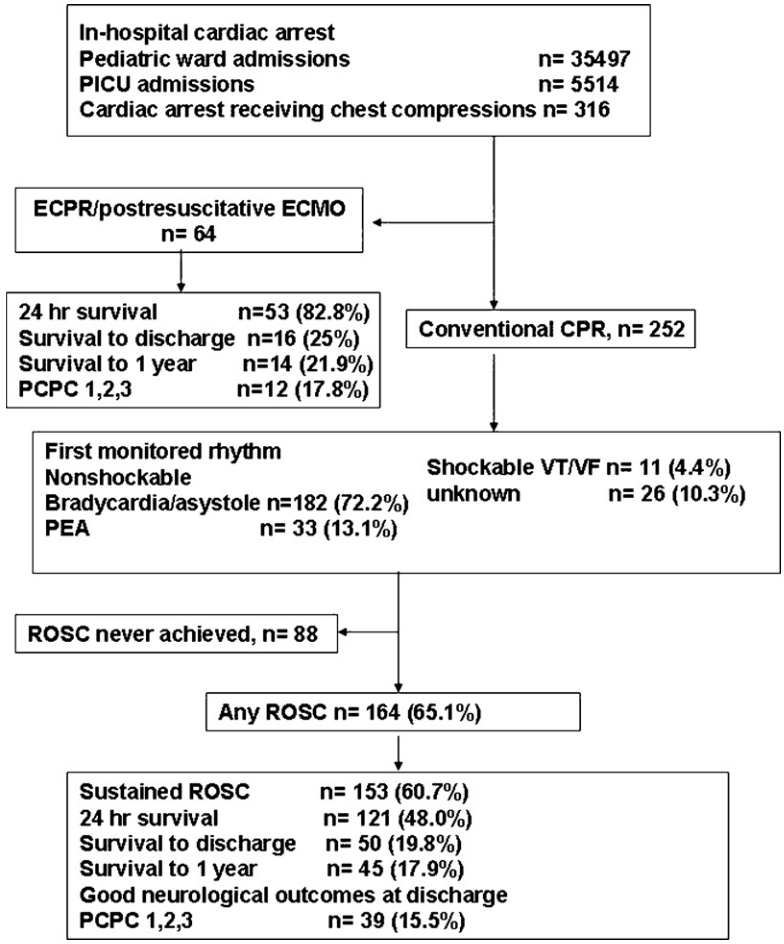

Fig. 1. Pediatric Utstein template for recording outcomes of in-hospital CPR. PICU: pediatric intensive care unit, ECMO: extracorporeal membrane oxygenation, PEA: pulseless electrical activity, ROSC: return of spontaneous circulation and PCPC: pediatric cerebral performance category.

29.5%, $p = 0.07$) and had more favorable neurological outcomes ($n = 20$, 25.6%, $p = 0.03$) than any other age category (Table 1).

3.3. Locations of arrest

In this study, 218 (86.5%) patients arrested in the PICU, 22 (8.7%) in the general wards, and 12 (4.8%) in other areas such as diagnostic rooms (cath lab, computer tomography room) and outpatient clinics. The outcomes of CPR in this study were not influenced by locations of IHCA (Table 2).

3.4. Preexisting disease

Most patients who underwent IHCA had cardiac disease (133/252, 52.8%). The second most common preexisting condition was hematologic or oncologic disease (43/252, 17.1%). Among the patients with hematologic or oncologic disease, only two survived to hospital discharge (4.7%) and only one had good neurological function (2.3%). This group had the worst among all patients ($p < 0.05$) (Table 3).

Table 2
Locations and outcomes.

	ICU	Ward	others	*p*
Number (%)	218 (86.5%)	22 (8.7%)	12 (4.8%)	
Primary outcome				0.40
Survival to discharge	44 (20.2%)	3 (13.6%)	3 (25.0%)	
Secondary outcomes				
Sustained ROSC	130 (59.6%)	13 (59.1%)	10 (83.3%)	0.45
24 h survival	107 (49.1%)	6 (27.3%)	8 (66.7%)	0.09
Good neurological outcome	33 (15.1%)	3 (13.6%)	3 (25.0%)	0.29

Table 1
Age category and outcomes.

	<1 month	1–12 months	1–8 years	9–18 years	*p*
Number (%)	44 (17.5%)	78 (31.0%)	80 (31.7%)	50 (19.8%)	
Primary outcome					
Survival to discharge	6 (13.6%)	23 (29.5%)	14 (17.5%)	7 (14.0%)	0.07
Secondary outcome					
Sustained ROSC	27 (61.4%)	47 (60.3%)	52 (65.0%)	27 (54.0%)	0.67
24 h survival	20 (45.5%)	42 (53.8%)	42 (52.5%)	17 (34.0%)	0.13
Good neurological outcome	5 (11.4%)	20 (25.6%)	9 (11.3%)	5 (10.0%)	0.03

Table 3
Preexisting condition and outcomes.

	Cardiac	Hematology/oncology	Neurology	GI/hepatic	Infection	Respiratory	Metabolic/genetic disorder	p
Number (%)	133 (52.8%)	43 (17.1%)	19 (7.5%)	18 (7.1%)	14 (5.6%)	4 (1.6%)	21 (8.3%)	
Primary outcome								
Survival to discharge	29 (21.8%)	2 (4.7%)	6 (31.6%)	4 (22.2%)	2 (14.3%)	1(25%)	6 (28.6%)	0.01
Secondary outcome								
Sustained ROSC	79 (59.4%)	27 (62.8%)	13 (68.4%)	12 (66.7%)	5 (35.7%)	3(75%)	14 (66.7%)	0.51
24 h survival	69 (51.9%)	14 (32.6%)	11 (57.9%)	9(50%)	4 (28.6%)	3(75%)	11 (52.4%)	0.16
Good neurological outcome	24 (18.0%)	1 (2.3%)	4 (21.1%)	4 (22.2%)	1 (7.1%)	1(25%)	4 (19.0%)	0.01

3.5. Condition before CPR and CPR management

Before IHCA, 174 of the 252 (69.0%) patients had already undergone intra-arterial blood pressure monitoring, 202 (80.2%) had been intubated for assisted ventilation, and 165 (65.5%) had continuous intravenous infusions of vasoactive drugs. Cardiac patients had a greater percentage of the latter two pre-CPR measures than other groups (117/134, 87.3%, and 99/134, 73.9%, respectively, both $p < 0.05$). During CPR, 171 of 252 patients (67.9%) received calcium compound injections and 168 (66.7%) had bicarbonate injections. Only 39 patients (15.5%) underwent cardioversion. Furthermore, calcium or bicarbonate injections were associated with longer CPR durations ($p = 0.001$ and 0.0009, respectively). Comparing the survivors and non-survivors, non-survivors had longer CPR durations, more pre-CPR intra-arterial monitoring ($p = 0.022$), endotracheal intubation ($p = 0.052$), and continuous infusion of vasoactive drug ($p < 0.001$) (Table 4).

3.6. CPR duration

Survivors had significantly shorter CPR duration than non-survivors (15.1 ± 12.7 min vs. 44.3 ± 53.2 min, $p = 0.001$) (Table 4). Longer CPR duration is associated with the worse outcomes (for both survival to discharge and good neurological survival), especially when CPR lasted for more than 20 min ($p = 0.000$). Forty-nine patients received CPR for more than 60 min and none survived (Fig. 2).

3.7. Cardiac arrest during nights and weekends

Only 75 indexed events happened during nights and weekends. Among patients who had CPR during nights and weekends, fewer achieved sustained ROSC compared to those who had CPR during working hours (45.3% vs. 67.2%, respectively, $p = 0.001$), but the chances of survival to discharge (14.7% vs. 22.0%, respectively) and good neurological outcomes (10.7% vs. 17.5%, respectively) did not differ significantly between patients who had CPR on nights/weekends and working hours (Fig. 3).

Table 4
Comparisons between survivors and non-survivors.

	Survivor (n = 50)	Non-survivor (n = 202)	p
Sex (M/F)	28/22	114/88	0.956
Age (months)	30.4 ± 47.3	48.6 ± 60.4	0.048
CPR duration (minutes)	15.1 ± 12.7	44.3 ± 53.2	0.002
Pre-CPR condition			
Intraarterial BP monitoring	28 (56.0%)	146 (72.3%)	0.026
Endotracheal intubation	35 (70.0%)	167 (82.7%)	0.037
Continuous infusion of vasoactive drugs	21 (42.0%)	144 (71.3%)	0.000
CPR management			
Epinephrine > 0.02 mg/kg	18 (36.0%)	123 (60.9%)	0.002
Calcium injection	28 (56.0%)	143 (70.8%)	0.031
Bicarbonate injection	29 (58.0%)	139 (68.8%)	0.147
Cardioversion	7 (14.0%)	32 (15.8%)	0.747

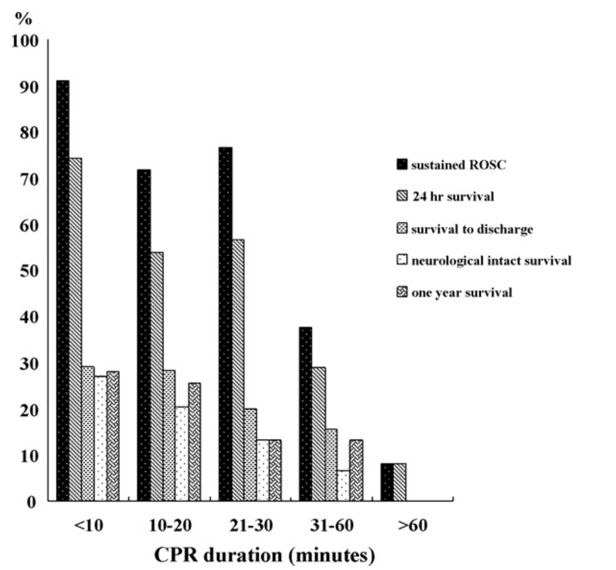

Fig. 2. CPR duration and outcome. ROSC: return of spontaneous circulation.

3.8. Factors associated with poor outcome

Multivariate analysis showed that patients who had vasoactive drug infusions before CPR, hematologic or oncologic diseases, and longer CPR durations had decreased chances of surviving to hospital discharge ($p < 0.05$).

4. Discussion

We describe the outcomes of CPR for pediatric IHCA at National Taiwan University Hospital, based on Utstein template. The overall hospital survival was 20.9% and 16.1% of the patients had favorable good neurological outcomes. Of the 252 patients who received con-

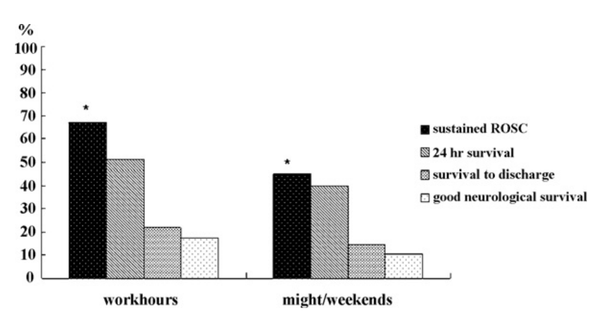

Fig. 3. The CPR timing and outcome. ROSC: return of spontaneous circulation. (*) Means statistical significance ($p < 0.05$).

ventional CPR, 60.7% had sustained ROSC, 48.0% had 24 h survival, 19.8% survival to discharge, 17.9% survived 1 year and only 15.5% had good neurological outcomes. We also identified the risk factors that were associated with poor outcomes, including hematologic or oncologic disease, prolonged CPR duration, and pre-CPR vasoactive drug requirements.

According to the NRCPR,[3] 52% of pediatric patients who underwent CPR had sustained ROSC, 36% had 24-h survival, 27% survived to discharge, and 15.4% had good neurological outcomes. Furthermore, the NRCPR reported that the most common first-documented pulseless cardiac arrest rhythm was asystole (40%) followed by pulseless electrical activity (24%), then VT/VF (13.6%). Also, survival rates were highest among patients in whom VT/VF was present initially than among those in whom it developed subsequently.[4] Outcomes of CPR and first-documented rhythms in this Asian cohort are comparable to those reported by the NRCPR. Nonetheless, we could not proceed with further analysis of VT/VF due to incomplete data recording.

We found that infants (1 month to 1 year of age) showed a trend toward better survival ($p = 0.07$) and had better neurological outcomes ($p = 0.03$) in comparison to other age groups (Table 1). This phenomenon has been mentioned in NRCPR.[17] Besides, the NRCPR identified that improved 24-h survival for children receiving CPR was associated with the presence of pediatric residents and fellows.[18] Most of our patient's cardiac arrests occurred in the PICU (86.2%) where pediatric residents or fellows, even attending physicians were always present. Survival outcomes did not differ by CPR location in our study (Table 2).

In this series, before IHCA, 174 patients (69.0%) already had received intra-arterial blood pressure monitoring, 202 (80.2%) had been intubated for assisted ventilation, and 165 (65.5%) had intravenous continuous infusion of vasoactive drugs. The percentages of the above interventions were higher in our study than those in previous reports, and most cardiac arrests were due to progressive deterioration of the underlying disease, rather than sudden arrest.[4,9,10] In the report by the Spanish Study Group for Cardiopulmonary Arrest in Children, 68.1% of the patients were supported with mechanical ventilation and 59.4% with vasoactive drugs, and the risk of mortality was significantly higher in these patients, which is consistent with our findings.[10] The NRCPR data showed that 29.5% (295/855) of patients had arterial catheters, while 39.3% (336/855) had vasoactive infusions before cardiac arrest; the use of vasoactive infusion was associated with increased mortality, which was also observed in our study.[4]

We noticed that injection of calcium compounds was associated with inferior outcomes, which was also observed in other studies.[6,19] In the NRCPR study, calcium was more likely to be used in the settings of pediatric facilities, ICUs, cardiac surgery, CPR duration of ≥15 min, asystole, and concurrently with other advanced life support medications. We also observed increased calcium use with prolonged CPR ($p = 0.001$). Although the AHA has published guidelines limiting the recommended use of calcium to selected resuscitation circumstances, physicians in our hospital tended to inject calcium more liberally to try all possible therapies during CPR. This could have reflected the medical futility of the situation.

We found that patients with preexisting hematologic and oncologic diseases had inferior outcomes, with only 2 (4.6%) surviving to discharge and one (2.3%) good neurological outcome. These patients comprised the second majority (43/252, 17.1%) of this study group, only outnumbered by cardiac patients. In the NRCPR study, cancer patients comprised only 4.7% (40/855) of the patient population, and their outcomes were also poor.[4] This is a unique phenomenon, which is the result of cultural differences. In another report from Taiwan mentioning these circumstances among 101 pediatric patients with cancer, 35 (34%) patients underwent CPR and they all died.[20] Taiwanese parents tended to insist on 'resuscitating until the last second'. Furthermore, no patient had 'do not resuscitate' orders, even as teenagers. This reflects how Taiwanese patients are often overprotected and precluded from knowing the reality of their terminal illness. The idea of palliative care should be proposed in such circumstances.

We found that longer CPR durations were associated with poor outcomes. Among 94 patients who were resuscitated for more than 30 min, 7 (7.4%) survived to discharge and only 3 (3.2%) had good neurological outcomes. None of the patients who were resuscitated for more than 60 min survived. Similar findings are also reported in the literatures.[7,9,10,12] Lopez-Herce et al. reported that a life-support time period of more than 20 min predicted a final mortality of 78%, and more than 60 min predicted 100% mortality.[9] Rodriguez-Nunez et al. also mentioned the mortality rate was 72.7% if the CPR duration was 10–19 min and approached 100% if CPR lasted >20 min.[10] ECMO should be considered in some patients with potentially reversible diseases when they are unresponsive to conventional CPR,[14–16] but further prospective investigation may be needed to establish guidelines.

We noted that CPR required during nights or weekends resulted in inferior chances of reaching sustained ROSC, but the percentage of patients surviving to hospital discharge did not differ significantly between working hours and nights or weekends. Survival rates for IHCA among adults are reportedly lower during nights and weekends.[21,22] In our hospital, no attending physician is available during off-work hours, and the shifts are shared by "unfixed" residents. Therefore, the residents might be unfamiliar with patients' conditions and may be less available to individual patient because of increased volume of cross coverage. Additionally, the cumulative effect of low manpower during the weekend in the hospital could eventually lead to poor CPR quality and also an overwhelming workload on Monday, explaining the Monday peaks in adult IHCA in our hospital.[13] Herlitz et al. also showed that decreased health care worker preparedness for IHCA was associated with worse outcomes.[23] Re-establishing a balanced duty system or developing an adequate response mechanism, such as medical emergency teams[24,25] is helpful to enable early detection of potentially correctable events and to provide high CPR quality.

5. Conclusions

In conclusion, about 20.9% of the children who had IHCA at National Taiwan University Hospital survived to discharge and 16.1% had good neurological outcomes at discharge. This is comparable to previous reports, but more hematologic/oncologic patients are included than previous studies. Several factors are associated with poor outcomes, including hematologic and oncologic disease, long CPR duration, and vasoactive infusions before IHCA. Besides, CPR during off-work hours resulted in inferior chances of reaching sustained ROSC. Therefore, the concept of palliative care should be proposed to families of terminally ill cancer patients. Also, establishing a balanced duty system or an adequate response mechanism in the future might increase chances of sustained ROSC.

Conflict of interest

There is no financial or personal relationship with other people or organizations that could inappropriately influence our work in this report.

Acknowledgments

We thank Dr. Fu-Chang Hu, National Center of Excellence for General Clinical Trial and Research, National Taiwan University Hospital and College of Public Health, National Taiwan University, for his help in the statistical computing and logistic regression analysis of the data.

References

1. Thaler MM. External cardiac compression. Method, results, and complications. Pediatrics 1963;31:303–10.
2. Cummins RO, Chamberlain D, Hazinski MF, et al. Recommended guidelines for reviewing, reporting, and conducting research on in-hospital resuscitation: the in-hospital 'Utstein style'. American Heart Association. Circulation 1997;95:2213–39.
3. Nadkarni VM, Larkin GL, Peberdy MA, et al. First documented rhythm and clinical outcome from in-hospital cardiac arrest among children and adults. JAMA 2006;295:50–7.
4. Samson RA, Nadkarni VM, Meaney PA, Carey SM, Berg MD, Berg RA. Outcomes of in-hospital ventricular fibrillation in children. N Engl J Med 2006;354:2328–39.
5. Guay J, Lortie L. An evaluation of pediatric in-hospital advanced life support interventions using the pediatric Utstein guidelines: a review of 203 cardiorespiratory arrests. Can J Anaesth 2004;51:373–8.
6. de Mos N, van Litsenburg RR, McCrindle B, Bohn DJ, Parshuram CS. Pediatric in-intensive-care-unit cardiac arrest: incidence, survival, and predictive factors. Crit Care Med 2006;34:1209–15.
7. Reis AG, Nadkarni V, Perondi MB, Grisi S, Berg RA. A prospective investigation into the epidemiology of in-hospital pediatric cardiopulmonary resuscitation using the international Utstein reporting style. Pediatrics 2002;109:200–9.
8. Tibballs J, Kinney S. A prospective study of outcome of in-patient paediatric cardiopulmonary arrest. Resuscitation 2006;71:310–8.
9. Lopez-Herce J, Garcia C, Dominguez P, et al. Characteristics and outcome of cardiorespiratory arrest in children. Resuscitation 2004;63:311–20.
10. Rodriguez-Nunez A, Lopez-Herce J, Garcia C, et al. Effectiveness and long-term outcome of cardiopulmonary resuscitation in paediatric intensive care units in Spain. Resuscitation 2006;71:301–9.
11. Horisberger T, Fischer E, Fanconi S. One-year survival and neurological outcome after pediatric cardiopulmonary resuscitation. Intensive Care Med 2002;28:365–8.
12. Suominen P, Olkkola KT, Voipio V, Korpela R, Palo R, Rasanen J. Utstein style reporting of in-hospital paediatric cardiopulmonary resuscitation. Resuscitation 2000;45:17–25.
13. Shih CL, Lu TC, Jerng JS, et al. A web-based Utstein style registry system of in-hospital cardiopulmonary resuscitation in Taiwan. Resuscitation 2007;72:394–403.
14. Alsoufi B, Al-Radi OO, Nazer RI, et al. Survival outcomes after rescue extracorporeal cardiopulmonary resuscitation in pediatric patients with refractory cardiac arrest. J Thorac Cardiovasc Surg 2007;134, 952–59, e952.
15. Thiagarajan RR, Laussen PC, Rycus PT, Bartlett RH, Bratton SL. Extracorporeal membrane oxygenation to aid cardiopulmonary resuscitation in infants and children. Circulation 2007;116:1693–700.
16. Huang SC, Wu ET, Chen YS, et al. Extracorporeal membrane oxygenation rescue for cardiopulmonary resuscitation in pediatric patients. Crit Care Med 2008;36:1607–13.
17. Meaney PA, Nadkarni VM, Cook EF, et al. Higher survival rates among younger patients after pediatric intensive care unit cardiac arrests. Pediatrics 2006;118:2424–33.
18. Donoghue AJ, Nadkarni VM, Elliott M, Durbin D. Effect of hospital characteristics on outcomes from pediatric cardiopulmonary resuscitation: a report from the national registry of cardiopulmonary resuscitation. Pediatrics 2006;118:995–1001.
19. Srinivasan V, Morris MC, Helfaer MA, Berg RA, Nadkarni VM. Calcium use during in-hospital pediatric cardiopulmonary resuscitation: a report from the National Registry of Cardiopulmonary Resuscitation. Pediatrics 2008;121:e1144–1151.
20. Jaing TH, Tsay PK, Fang EC, et al. "Do-not-resuscitate" orders in patients with cancer at a children's hospital in Taiwan. J Med Ethics 2007;33:194–6.
21. Jones-Crawford JL, Parish DC, Smith BE, Dane FC. Resuscitation in the hospital: circadian variation of cardiopulmonary arrest. Am J Med 2007;120:158–64.
22. Peberdy MA, Ornato JP, Larkin GL, et al. Survival from in-hospital cardiac arrest during nights and weekends. JAMA 2008;299:785–92.
23. Herlitz J, Bang A, Alsen B, Aune S. Characteristics and outcome among patients suffering from in hospital cardiac arrest in relation to whether the arrest took place during office hours. Resuscitation 2002;53:127–33.
24. Jones D, Opdam H, Egi M, et al. Long-term effect of a Medical Emergency Team on mortality in a teaching hospital. Resuscitation 2007;74:235–41.
25. Tibballs J, van der Jagt EW. Medical emergency and rapid response teams. Pediatr Clin North Am 2008;55, 989–1010, xi.