Factors Predicting Outcome of Cardiopulmonary Resuscitation in a Developing Country: The Siriraj Cardiopulmonary Resuscitation Registry

Rungroj Krittayaphong MD*,
Panisara Saengsung RN**, Tanawin Chawaruechai RN**,
Ahthit Yindeengam BSc (Public Health)*, Suthipol Udompunturak MS***

** Division of Cardiology, Department of Medicine, Siriraj Hospital, Mahidol University, Bangkok, Thailand*
*** CPR Training Center, Siriraj Hospital, Mahidol University, Bangkok, Thailand*
**** Department of Research Promotion, Siriraj Hospital, Mahidol University, Bangkok, Thailand*

Background: *Outcomes of cardiac arrest and cardiopulmonary resuscitation (CPR) are not usually evaluated or monitored extensively in developing countries.*
Objective: *To determine the outcome of CPR and the factors predicting its outcome.*
Material and Method: *Siriraj Hospital is a 2,400-bed, 17-building, university hospital. Data were analyzed from the Siriraj CPR registry which was modified from the Utstein template. Data entry consisted of demographic data, reason for cardiac arrest, rhythm causing cardiac arrest, type of ward, type of department, status of patients before the event as well as sequence of action including the use of medications and outcome of CPR. The primary outcomes were rated to return of spontaneous circulation (ROSC) and survival to discharge. Univariate and multivariable logistic regression analysis were performed.*
Results: *Approximately 95,000 patients were admitted to the hospital each year. There were a total of 2,747 CPR reports during the time frame from January 2003 to December 2006. Of these 57.9% were males. The average age was 53.3 $\pm$ 25.2 years. Most cardiac arrests occurred in the medicine, surgery and pediatric wards. Basic life support (BLS) was started within 1 minute in 83.1% and advanced life support (ALS) was started within 4 minutes in 78.6%. Of 516 (18.8%) patients were terminal cases. Outcomes of CPR were as follows: 49.8% had ROSC, 21% survived at 24 hours, and 7.4% survived to discharge. From a logistic regression analysis, predicting factors for both ROSC and survival to discharge included non-terminal cases, witnessed arrest, non-cardiac, non-sepsis causes, and arrest during daytime.*
Conclusion: *The rate of ROSC and survival to discharge from the Siriraj CPR registry were 49.8% and 7.4% respectively. Several factors can be used to predict the immediate outcome of CPR. The present analysis should help monitor the quality of CPR and post-resuscitation care and aid in the strategic planning to improve CPR outcomes.*

Keywords: *Cardiopulmonary resuscitation, Coronary circulation, Heart arrest, Treatment outcome*

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In hospital cardiopulmonary arrest is an emergency situation that requires teamwork and the appropriate sequential action to rescue patients[1]. Although guidelines for Cardiopulmonary resuscitation (CPR) have been reported and updated, there are still gaps between these guidelines and clinical practice[2,3]. CPR performance for hospitalized and out-of-hospital cardiac arrests does not meet standard guidelines, mainly due to inadequate chest compression[4,5]. Reasons for suboptimal CPR performance may be related to lack of knowledge and skills[6,7]. The Utstein guideline and template has been developed for uniform registry of CPR performance and outcomes[8,9]. Utstein-style templates have been used in many previous

Correspondence to: Krittayaphong R, Division of Cardiology, Department of Medicine Siriraj Hospital, Bangkok 10700, Thailand. Phone: 081-805-9992, 0-2419-7000 ext. 6104-5, Fax: 0-2412-7412, E-mail: sirkt@mahidol.ac.th

studies[10,11]. CPR outcomes are varied among studies which may be due to differences in the circumstance of cardiac arrest, availability of CPR equipment, and performance of the CPR team. Many predictors for CPR outcomes have been reported such as age[11], time to defibrillation[10-13], mode of cardiac arrest[11], initial rhythm[10-12], time to basic life support[14,15], types of ward[16], time of cardiac arrest[11, 14, 17], as well as others.

Siriraj Hospital is a large-size tertiary-care hospital in Bangkok with 17 buildings, 2,400 beds and more than 90,000 hospital admissions each year. The CPR training center organizes training programs based on the American Heart Association (AHA) standard for all levels of medical personnel in the hospital and including some programs for outsiders as well. The center also arranges CPR audits to service units 1-2 times per year.

The objectives of the present study were to 1) assess CPR outcomes for hospitalized cardiac arrest cases in a large-size tertiary-care hospital in a developing country such as Thailand and 2) determine major predictors for CPR outcome. The ultimate purpose and goal, regarding the objectives, were to assess any areas of weakness of CPR performance in the hospital so that the strategies to improve CPR outcomes could be developed and addressed.

Material and Method

Study population

All patients who had CPR attempted during January 2003 to December 2006 were included in the present study.

CPR registry

Siriraj Hospital has a total of 235 service units: 20 units are Intensive Care Unit (ICU) type wards, 91 are general wards, 52 are out-patient clinics and 36 are procedural units. Forty-two units have standby physicians and nurses present on the wards. CPR is covered by code Adult (A) which includes either medical resident or fellow or an anesthesia resident and a CPR nurse in 171 units and by code Pediatrics (P) which includes a pediatric resident and a pediatric CPR nurse in 123 units. There are a total of 149 defibrillators. Defibrillators are distributed according to level of risk in the units as follows: 1 for each unit in 126 units, 1 for 2 units in 38 units, 1 for 3 units in 8 units, and 1 for 4 or more units in 5 units.

Siriraj CPR registry had been set up. The Registry form was modified from the Utstein template. The following information was filled out in the report: demographic data, cause, location and time of cardiac arrest, status of patients before cardiac arrest, underlying illnesses, terminal state of disease, intravenous access, use of intubation, use of a mechanical ventilator, initial cardiac rhythm, type of ward, departments, sequence of action and CPR outcomes. The report was sent to the CPR center within 48 hours of cardiac arrest. CPR outcomes were assessed. Time to basic life support (BLS), advanced life support (ALS) to be comparable to advanced airway management, electrical therapy or medication), and defibrillation were assessed. The primary outcomes of the present study were the rate to return of spontaneous circulation (ROSC) lasting at least 20 minutes and survival to discharge.

Table 1. Baseline characteristics

Variables		Count (%) or mean $\pm$ SD
Male gender		1,591 (57.9)
Age (years)		53.3 $\pm$ 25.2
Department	- Surgery	510 (18.6)
	- Medicine	1,935 (70.4)
	- Pediatrics	269 (9.8)
	- Others	33 (1.2)
Terminal cases	- Yes	516 (18.8)
	- No	1,701 (61.9)
	- Unknown	530 (19.3)
Ward	- General	2,674 (97.3)
	- Special	73 (2.7)
Ward	- ICU type	1,394 (50.7)
	- General	1,336 (48.6)
	- Outpatient	17 (0.6)
Witnessed	- Yes	2,458 (89.5)
	- No	245 (8.9)
	- Unknown	44 (1.6)
Mode of cardiac arrest	- Cardiac	485 (17.7)
	- Respiratory	720 (26.2)
	- Sepsis	599 (21.8)
	- Metabolic	375 (13.7)
	- Others	133 (4.8)
	- Unknown	341 (12.4)
Initial cardiac rhythm	- VT	205 (7.5)
	- VF	152 (5.5)
	- Asystole	1,185 (43.1)
	- PEA	299 (10.9)
	- Bradycardia	689 (25.1)
	- Others	157 (5.7)
	- Unknown	60 (2.2)

SD = standard deviation, ICU = intensive care unit, VT = ventricular tachycardia, VF = ventricular fibrillation, PEA = pulseless electrical activity

Statistical analysis

The mean and standard deviation (SD) were used to describe parametric and non-parametric continuous data, and number and percentages to describe categorical data. Univariate logistic regression analysis was performed for the possible factors that might influence CPR outcomes. Variables with a p-value ≤ 0.1 from the univariate analysis were chosen for multivariable logistic regression analysis using a forward likelihood ratio method. The results of logistic regression analysis were displayed as Odds ratio (OR), 95% confidence interval (CI) and p value. A p-value of ≤ 0.05 was considered significant.

Results

A total of 2,747 patients with attempted CPR were reported. Baseline characteristics are shown in Table 1. The average age was 53.3 $\pm$ 25.2 years. The list of medications used during the CPR process was as follows: adrenaline in 2,559 (93.2%), atropine in 1,324 (48.2%), amiodarone in 328 (11.9%), lidocaine in 176 (6.4%), sodium bicarbonate in 1,268 (46.2%), and isoproterenol in 5 (0.2%). Transcutaneous pacing was used in 298 (10.8%) patients. BLS was started within 1 minute in 2,282 (83.1%) patients and ALS was started within 4 minutes in 2,159 (78.6%) patients. A total of 516 (18.8%) patients were terminal cases. Outcomes of CPR were as follows: ROSC in 1,369 (49.8%) patients, survival at 24 hours in 578 (21%) patients and survival to discharge in 204 (7.4%) patients. Univariate predictors for ROSC and survival to discharge are shown in Table 2. Multivariable logistic regression analysis was performed from the selected variables that had a $p < 0.1$ from the univariate analysis. Independent predictors for ROSC and survival to discharge including their odds ratio and 95% CI are shown in Table 3. Predicting factors for both ROSC and survival to discharge included non-terminal cases, witnessed arrest, non-cardiac, non-sepsis causes, and arrest during daytime.

Discussion

The results of the present study showed that the rate of ROSC in our hospital was 49.8% but survival to discharge was only 7.4%. The rate of ROSC is not much different from previous studies of in-hospital cardiac arrest. Such ROSC rate is lower than some previous reports[10,11] but higher than others[4,7,14]. However, the discharge rate after attempted CPR was somewhat lower than previous studies, reported from

Table 2. Univariate predictors of ROSC and survival to discharge

	ROSC	p-value	Survival to discharge	p-value
Female gender	1.19 (1.02-1.38)	0.026	0.82 (0.61-1.10)	0.193
Age < 60 years	0.93 (0.80-1.08)	0.351	1.56 (1.16-2.08)	0.003
Non-terminal cases	1.58 (1.26-1.98)	<0.001	3.03 (1.66-5.52)	<0.001
ICU wards	1.50 (1.29-1.74	<0.001	1.62 (1.21-2.18)	0.001
Non-surgical wards	1.37 (1.13-1.66)	0.002	0.66 (0.47-0.92)	0.015
Medicine wards	1.06 (0.90-1.24)	0.521	0.49 (0.37-0.66)	<0.001
Witnessed arrest	2.05 (1.59-2.65)	<0.001	1.96 (1.08-3.55)	0.027
Intravenous access	1.13 (0.97-1.32)	0.104	0.82 (0.61-1.09)	0.162
ECG Monitor	1.31 (1.12-1.51)	<0.001	1.29 (0.97-1.72)	0.082
Intubation	1.07 (0.92-1.25)	0.373	0.47 (0.35-0.63)	<0.001
Mechanical ventilator	1.24 (1.07-1.44)	0.005	0.65 (0.48-0.87)	0.003
Non-cardiac causes	1.31 (1.07-1.59)	0.008	1.44 (0.95-2.19)	0.087
Respiratory causes	1.38 (1.16-1.63)	<0.001	1.35 (0.99-1.83)	0.057
Non-sepsis	1.40 (1.17-1.69)	<0.001	4.80 (2.66-8.67)	<0.001
Metabolic causes	1.33 (1.07-1.66)	0.010	0.63 (0.39-1.03)	0.063
VT/VF arrest	1.40 (1.12-1.76)	0.003	2.51 (1.79-3.52)	<0.001
MD or RN as first CPR person	1.44 (1.22-1.70)	<0.001	2.37 (1.60-3.50)	<0.001
Time to BLS $\leq$ 1 minute	1.11 (0.91-1.35)	0.322	1.15 (0.77-1.71)	0.493
Time to ALS $\leq$ 4 minutes	1.20 (1.00-1.44)	0.050	0.88 (0.63-1.23)	0.442
Time of arrest 6am to midnight	1.41 (1.19-1.68)	<0.001	1.48 (1.03-2.12)	0.036

Values are expressed as Odd ratio (95% CI)

ROSC = return of spontaneous circulation, ICU = intensive care unit, VT = ventricular tachycardia, VF = ventricular fibrillation, MD = physician, RN = registered nurse

Table 3. Independent predictors of ROSC and survival to discharge

	OR (95% CI)	p-value
ROSC		
Non-terminal cases	1.61 (1.27-2.03)	<0.001
ICU wards	1.46 (1.21-1.76)	<0.001
Non-surgical wards	1.70 (1.34-2.16)	<0.001
Witnessed arrest	2.00 (1.46-2.74)	<0.001
Non-cardiac causes	1.49 (1.17-1.88)	0.001
Non-sepsis	1.76 (1.41-2.21)	<0.001
MD or RN as first CPR person	1.39 (1.06-1.82)	0.018
Time of arrest 6 am to midnight	1.40 (1.13-1.72)	0.002
Survival to discharge		
Non-terminal cases	2.39 (1.30-4.41)	0.005
Non-medicine wards	1.81 (1.29-2.54)	0.001
Witnessed arrest	2.27 (1.14-4.53)	0.020
ECG Monitor	2.22 (1.47-3.36)	<0.001
Non-Intubation	2.87 (1.91-4.31)	<0.001
Non-cardiac causes	1.86 (1.14-3.04)	0.013
Non-sepsis	3.10 (1.67-5.75)	<0.001
VT/VF arrest	1.81 (1.20-2.71)	0.004
Time of arrest 6 am to midnight	1.64 (1.06-2.52)	0.026

Values are expressed as Odd ratio (95% CI)

Western countries[10,11,17], although this rate is higher than some[14]. The primary reason for a lower rate of survival to discharge after cardiac arrest is due to sub-optimal post-resuscitation care which is very essential for better outcomes[16,18]. The survival to discharge is not considered to be evaluated as the primary endpoint since it depends on many other factors related to post cardiac arrest care. As the hospital is a very large tertiary-care hospital, overwhelming with severely and chronically ill patients the survival to discharge, a medium-term indicator, may not reflect the outcome of CPR, in the situation of facility and human resource limitation.

There were a number of predictors, representing the outcome of CPR in the study as shown in Table 2. Age was not an independent factor although a better outcome of pediatric cardiac arrests had been reported[11]. Patients with a terminal state of illness and concurrent underlying disease or co-morbid conditions had accounted bad outcomes. Witnessed cardiac arrests had better outcomes than non-witnessed arrests because they obviously had a shorter detected-resuscitation time. Cardiac arrest due to a respiratory mode had good outcomes whereas cardiac and sepsis mode arrests had worse outcomes. A better strategy and important option for the optimal care of cardiac patients is to identify high risk groups to stay in cardiac care units or ICUs[16]. As expected, patients with ventricular fibrillation (VF) or ventricular tachycardia (VT) as the initial rhythm had a better prognosis than those with asystole or non-pulse electrical activity (PEA) which had previously been reported[10-12]. However, the proportion of VF/VT as the initial rhythm was somewhat lower than what the authors usually expected. This also has been confirmed previously in that most in-hospital cardiac arrests had asystole or PEA as the initial rhythms[4,7,10-12,17]. It may be related to the inpatient and outpatient status of patients before the occurrence of cardiac arrest which has shown a higher rate of VF as the initial rhythm for outpatients[5,19]. Also noteworthy and interesting were that nighttime cardiac arrests had a worse outcome than daytime cardiac arrests. It may be related to delayed detection and management at night[17]. Experience of the first person performing CPR is a predictor for ROSC. The collected data indicated that when physicians or registered nurses started CPR, ROSC rate will be better than having practical nurses or medical students as the first person. The management for change has led to standardize and strengthen the CPR training program for medical students and practical nurses. Wards with better monitoring equipment and on-ward physicians and nurses such as ICU wards had a good ROSC outcome. Therefore, patients at high risk of cardiac arrest or post cardiac arrest should stay in ICU-type wards[16]. However, ICU ward was not an independent predictor for survival to discharge. Surgical wards had a worse ROSC outcome but better rate of survival to discharge which was in contrast to medical wards which indicated that post-resuscitation care of surgical wards was better than that of medical wards. The standardization of life-saving facilities and supports among various settings are crucial towards CRP outcomes, as well as the job rotation, transposition, and description should be committed and arranged appropriately.

In conclusion, an analysis of the CPR registry is helpful to provide a quality-improvement CPR program that enables the planning and implementation to to improve outcomes of in-hospital cardiac arrest.

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ปัจจัยทำนายผลที่ได้รับของการกู้ชีพหัวใจและปอดในประเทศกำลังพัฒนา: การลงทะเบียนการกู้ชีพหัวใจและปอดของศิริราช

รุ่งโรจน์ กฤตยพงษ์, ปาณิสรา แสงสังข์, ธนวิน ชวฤาชัย, อาทิตย์ ยินดีงาม, สุทธิพล อุดมพันธุรักษ์

ภูมิหลัง: *ผลที่ได้รับของหัวใจหยุดและการกู้ชีพหัวใจและปอดโดยปกติไม่ได้รับการประเมินและตรวจวัดอย่างกว้างขวางในประเทศกำลังพัฒนา*

วัตถุประสงค์: *เพื่อหาผลที่ได้รับของการกู้ชีพหัวใจและปอดและปัจจัยทำนายผลที่ได้รับ*

วัสดุและวิธีการ: *โรงพยาบาลศิริราชเป็นโรงพยาบาลมหาวิทยาลัย อาคาร 17 หลัง เตียงผู้ป่วย 2,400 เตียง วิเคราะห์ข้อมูลจากแบบข้อมูลที่ปรับปรุงจากแบบข้อมูลของ Utstein ในการลงทะเบียนการกู้ชีพหัวใจและปอดของศิริราช ประกอบด้วยข้อมูลประชากร เหตุผลของหัวใจหยุด เหตุจังหวะของหัวใจหยุด ชนิดหอผู้ป่วยและภาควิชา สภาวะผู้ป่วยก่อนเหตุการณ์ รวมถึงลำดับการดำเนินการ การใช้ยา และผลที่ได้รับของการกู้ชีพหัวใจและปอด ผลที่ได้รับปฐมภูมิคืออัตราการไหลเวียนเป็นธรรมชาติ และอัตราการมีชีพกลับบ้าน ดำเนินการด้วยการวิเคราะห์แบบถดถอยด้วยตัวแปรเดี่ยวและตัวแปรต่าง ๆ นานา*

ผลการศึกษา: *โรงพยาบาลศิริราชมีผู้ป่วยในโรงพยาบาลประมาณ 95,000 คนต่อปี มีรายงานการกู้ชีพหัวใจและปอดจำนวน 2,747 ราย ระหว่างเดือนมกราคม พ.ศ. 2546 ถึงเดือนธันวาคม พ.ศ. 2549 ในจำนวนนี้ร้อยละ 57.9 เป็นชาย อายุเฉลี่ย 53.3 $\pm$ 25.2 ปี หัวใจหยุดส่วนใหญ่เกิดในหอผู้ป่วยอายุรศาสตร์ ศัลยศาสตร์และกุมารเวชศาสตร์ การช่วยชีวิตพื้นฐานร้อยละ 83.1 เริ่มได้ภายใน 1 นาที ส่วนการช่วยชีวิตขั้นสูงร้อยละ 78.6 เริ่มได้ภายใน 4 นาที ผู้ป่วยจำนวน 516 ราย (ร้อยละ 18.8) เป็นผู้ป่วยระยะสุดท้าย ผลที่ได้รับของการกู้ชีพหัวใจและปอด อัตราการไหลเวียนเป็นธรรมชาติร้อยละ 49.8 มีชีพที่ 24 ชั่วโมงร้อยละ 21 และมีชีพกลับบ้านร้อยละ 7.4 จากการวิเคราะห์แบบถดถอยปัจจัยทำนายของทั้งอัตราการไหลเวียนเป็นธรรมชาติและอัตราการมีชีพกลับบ้าน ประกอบด้วย ผู้ป่วยที่ไม่ใช่ระยะสุดท้าย หัวใจหยุดโดยมีพยานรู้เห็น สาเหตุที่ไม่ใช่หัวใจ สาเหตุที่ไม่ใช่ภาวะพิษเหตุติดเชื้อ และหัวใจหยุดระหว่างกลางวัน*

สรุป: *อัตราการไหลเวียนเป็นธรรมชาติและอัตราการมีชีพกลับบ้านจากการลงทะเบียนการกู้ชีพหัวใจและปอดเท่ากับร้อยละ 49.8 และร้อยละ 7.4 ตามลำดับ ปัจจัยหลายอย่างมีประโยชน์ในการทำนายผลที่ได้รับทันทีของการกู้ชีพหัวใจและปอด การวิเคราะห์นี้ช่วยตรวจจับคุณภาพของการกู้ชีพหัวใจและปอด และการดูแลหลังการกู้ชีพและช่วยในการวางแผนทางยุทธศาสตร์ในการปรับปรุงผลที่ได้รับของการกู้ชีพหัวใจและปอด*