Early Defibrillation: A Key for Successful Outcome of In-Hospital Cardiac Arrest

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Background: *The objectives of this study were to determine 1) the rate of delayed defibrillation and 2) the importance of early defibrillation in patients with cardiac arrest who need defibrillation in a large tertiary care hospital.*
Material and Method: *We analyzed data from Siriraj cardiopulmonary resuscitation (CPR) registry from January 2005 to December 2007. The registry recorded setting and cause of cardiac arrest, timing of cardiac arrest and time initiation of each step of treatment such as basic life support (BLS), advanced life support (ALS), defibrillation, medication, time of defibrillation. Outcome was recorded as return of spontaneous circulation (ROSC) which lasted at least 20 minutes and discharge from hospital.*
Results: *A total of 2160 in-hospital cardiac arrest records were sent to CPR center and were evaluated. 612 patients (28.3%) needed defibrillation. Average age was 57.1 $\pm$ 21.2 years. Among patients who needed defibrillation, 250 patients (40.8) had early defibrillation. Median time to defibrillation after the detection of cardiac arrest was 8 (3,15) minutes. Factors associated with delayed defibrillation were the patients being in non-intensive care unit (non-ICU) wards, being in wards without standby defibrillator, and female gender. 283 patients (46.2%) had ROSC after CPR and 50 patients (8.2%) survived to discharge from hospital. Time to defibrillation was the most important predictor for ROSC and survival to discharge.*
Conclusion: *Among in-hospital patients with cardiac arrest and who needed defibrillation, early defibrillation is the major key to a successful outcome.*

Keywords: *Cardiopulmonary resuscitation , Electric counter-shock , Heart arrest, Treatment outcome*

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Cardiac arrest leads to an immediate activation of chain of reaction for saving life. Chance of survival decrease 7-10% every minute between cardiac arrest and defibrillation[1]. Defibrillation should be performed within 5 minutes in those who require it[2,3]. Early defibrillation is very important for many reasons. Ventricular fibrillation (VF) and ventricular tachycardia (VT) are common initial rhythms of cardiac arrest. Defibrillation is the only treatment for cardiac arrest and can improve survival 2-3 times depending on the timing of defibrillation[4-6]. Chance of successful defibrillation significantly decreases if the procedure is delayed. VF will turn into asystole which will be more difficult to resolve by resuscitation[1].

Cardiopulmonary resuscitation (CPR) needs to be efficiently performed following a step by step protocol[7]. Although adequate chest compression is essential for a better neurological outcome[8,9], early defibrillation is always needed for VF or "pulseless" VT. After successful conversion of cardiac rhythm, patients should be evaluated for the cause of cardiac arrest and transferred to a critical care ward for post-resuscitation care[10,11].

The objectives of this study were to evaluate the 1) time to defibrillation and proportion of patients subjected to delayed defibrillation 2) factors that

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determine delayed defibrillation and 3) effects of early defibrillation on outcomes of patients. This study focused only patients with in-hospital cardiac arrest who needed defibrillation.

Material and Method

Study population

We analyzed data from the Siriraj CPR registry which recorded data of patients with in-hospital cardiac arrest in Siriraj Hospital. The registry was modified from the Utstein template[12,13]. The registry recorded setting and cause of cardiac arrest, timing of cardiac arrest and time of initiation of each step of treatment such as basic life support (BLS), advanced life support (ALS), defibrillation, medication, time of defibrillation. The data were verified and followed up by a nurse at CPR training centers. Outcome was recorded as return of spontaneous circulation (ROSC) which lasted at least 20 minutes and discharge from hospital. Responsible persons at the location of cardiac arrest need to send a CPR report within 48 hours after the event.

Personnel involved in patient care receive a certificate after they have passed CPR training which is based on american heart association (AHA) standard[7]. Siriraj hospital is a large tertiary care hospital with over 235 units: 20 of which are intensive care unit (ICU)-types ward which also include cardiac care unit, intermediate cardiac care unit and respiratory care unit. Defibrillators are available in every ICU-type ward, with sharing of one defibrillator for 2 general wards at the same floor, and sharing of one defibrillator for more than 2 wards where there is low prevalence of cardiac arrest or in out-patient care settings.

Outcome measurement

Outcome was recorded as return of spontaneous circulation (ROSC) which lasted at least 20 minutes and discharge from hospital. For patients who required defibrillation time to defibrillation and early defibrillation was defined as defibrillation within 5 minutes as recommended by AHA guideline[7]. This time was recorded.

Statistical analysis

We described data with mean $\pm$ standard deviation for normal distribution data and median (25^{th} and 75^{th} percentile) for non-normal distribution data. We described categorical data by count (percentages). Appropriate statistics for parametric and nonparametric data were used as appropriate. Chi-square test was used for comparison of categorical data. Univariate analysis and multiple logistic regression analysis were performed for the determination of independent variables that were associated with ROSC and survival to discharge and were presented as odds ratio (95% confidence interval or 95% CI). A p-value of ≤ 0.05 was considered significant.

Results

From January 2005 to December 2007, a total of 2160 in-hospital cardiac arrest records were sent to CPR center and were evaluated. 612 patients (28.3%) needed defibrillation. Their average age was 57.1 ± 21.2 years. Among patients who needed defibrillation, 250 patients (40.8%) had early defibrillation. Baseline characteristics of patients with early and delayed defibrillation are shown in Table 1. Factors associated with delayed defibrillation were being in non-ICU wards, in wards without standby defibrillator, and female gender. Terminal cases also had a tendency to receive delayed defibrillation. Analysis for independent predictors of delayed defibrillation showed that a patient being located in a non-ICU ward is the strongest predictor for delayed defibrillation with odds ratio 1.58 (95% confidence interval or 95% CI = 1.12-2.23), p = 0.008 followed by being in wards without standby defibrillator, odds ratio 2.45 (95% CI = 1.14-5.24), p = 0.022 and female gender, odds ratio 1.45 (95% CI = 1.04-2.01), p = 0.029.

Median time to BLS, ALS, defibrillation after the detection of cardiac arrest were 0 (0,1), 0 (0,1), and 8 (3,15) minutes respectively. Time to BLS was within 1 minute in 530 (86.6%), time to ALS was within 4 minutes in 564 (92.2%).

283 patients (46.2%) had ROSC after CPR and 50 patients (8.2%) survived to discharge from hospital. 29% of patients remained under ICU care after having ROSC. Univariate and multivariable associations with ROSC and survival to discharge are shown in Table 2 and 3. Time to defibrillation was the most important predictor for ROSC and survival to discharge.

Discussion

The results of our study showed that early defibrillation is the most important key to a successful outcome of in-hospital patients with cardiac arrest who need defibrillation. However, the rate of delayed defibrillation remains high.

VF/VT is the major initial rhythm of out-of hospital cardiac arrest[7,14]. Previous reports have shown that, for in-hospital cardiac arrest, VF/VT may

Table 1. Baseline characteristics of patients with early and delayed defibrillation

	All n = 612	Early defibrillation n = 250	Delayed defibrillation n = 362	p-value
Male gender	331 (54.1)	148 (59.2)	183 (50.6)	0.035
Age ≥ 60	314 (51.3)	132 (52.8)	182 (50.3)	0.539
Terminal cases - yes	91 (14.9)	29 (11.6)	62 (17.1)	0.059
Ward - ICU	222 (36.3)	108 (43.2)	114 (31.5)	0.003
Department - medicine	465 (76.0)	191 (76.4)	274 (75.7)	0.840
Witness - yes	554 (90.5)	223 (89.2)	331 (91.4)	0.353
Mode - cardiac	153 (25.0)	67 (26.8)	86 (23.8)	0.393
- sepsis	90 (14.7)	34 (13.6)	56 (15.5)	0.521
Time of arrest - night	137 (22.4)	49 (19.6)	88 (24.3)	0.169
Defibrillator in ward	567 (92.8)	241 (96.4)	326 (90.3)	0.004

Values are expressed as count (percentages)

Table 2. Univariate predictors of ROSC and survival to discharge

	ROSC	p-value	Survival to discharge	p-value
Male gender	1.08 (0.79-1.49)	0.632	1.19 (0.66-2.14)	0.562
Age < 60 years	0.95 (0.69-1.31)	0.770	1.50 (0.84-2.70)	0.172
Non-terminal cases	1.62 (1.02-2.57)	0.040	2.91 (0.89-9.55)	0.078
ICU wards	1.59 (1.14-2.22)	0.006	2.41 (1.35-4.33)	0.003
Medicine wards	1.04 (0.71-1.50)	0.853	1.00 (0.51-1.97)	0.997
Witnessed arrest	2.04 (1.14-3.64)	0.016	2.66 (0.63-11.22)	0.184
Non-cardiac causes	1.58 (1.08-2.29)	0.017	2.16 (0.95-4.90)	0.067
Non-sepsis	1.59 (1.00-2.52)	0.050	4.46 (1.06-18.67)	0.041
Time of arrest 6am to midnight	1.23 (0.84-1.80)	0.298	0.72 (0.38-1.38)	0.322
Time to BLS ≤ 1 min	1.18 (0.74-1.89)	0.488	0.95 (0.41-2.18)	0.896
Time to ALS ≤ 4 min	1.48 (0.81-2.71)	0.208	0.98 (0.34-2.84)	0.966
Time to defibrillation ≤ 5 min	1.84 (1.33-2.56)	<0.001	2.56 (1.41-4.64)	0.002

Values are expressed as odds ratio (95% CI)

Table 3. Independent predictors of ROSC and survival to discharge from multiple logistic regression analysis

	OR (95% CI)	p-value
ROSC		
Time to defibrillation ≤ 5 min	1.89 (1.35-2.64)	<0.001
Witnessed arrest	2.38 (1.31-4.32)	0.004
Non-cardiac causes	1.71 (1.16-2.51)	0.006
Non-sepsis	1.72 (1.07-2.76)	0.026
Non-terminal cases	1.61 (1.00-2.59)	0.048
Survival to discharge		
Time to defibrillation ≤ 5 min	2.31 (1.25-4.24)	0.007
ICU wards	2.27 (1.24-4.13)	0.008
Non-sepsis	5.04 (1.19-21.33)	0.028
Non-cardiac causes	2.29 (1.00-5.26)	0.050

Values are expressed as odds ratio (95% CI)

not be the major initial rhythm. Many of these patients were found to have "pulseless" electrical activity (PEA) or asystole as their initial rhythm. Defibrillation is the procedure to convert VF/VT into normal rhythm. Chest compression can only maintain perfusion to vital organs but cannot convert VF/VT into normal rhythm. Chest compression has to be efficient during the wait for defibrillation in order to have a good neurological outcome after successful resuscitation[3,8,15].

Defibrillation has to be performed as early as possible before VF/VT changes into asystole and before irreversible damage of the vital organs. AHA recommended early defibrillation within 5 minutes after the detection of cardiac arrest[7]. Our study showed that this recommendation was achieved in only 40.8% of cardiac arrest who needed defibrillation. The rate is relatively low when compared to previous reports[16]. Some experts recommended that defibrillation for in-hospital cardiac arrest with VF/VT should be performed within 2 minutes[17]. Independent predictors for delayed defibrillation were patients being in non-ICU wards, in wards without standby defibrillator, and female gender. The availability of defibrillators as well as experience and expertise of the personnel may determine the earliness of defibrillation. However, for the factor of female gender, the reason is still unclear. Although previous study showed suboptimal reaction time to cardiac arrest at night, we cannot show that this nighttime factor is associated with delayed defibrillation.

Outcomes of cardiac arrest in our study are determined by underlying disease of the patients, mode of cardiac arrest, witnessed status at the time of cardiac arrest and most importantly, time to defibrillation. The predictors for ROSC are in parallel with predictors for survival discharge. The rate of survival to discharge in our study is relatively low compared to previous studies[13,16] but the predictors for outcomes are similar. Although some studies found that nighttime cardiac arrest had a poor reaction time[13,18], our study cannot confirm this finding. Suboptimal post-resuscitation care may be an important factor since only 29% of patients were under ICU care after successful resuscitation. This is a problem for large tertiary-care hospitals that have to take care of a significant proportion of sick patients, have too few ICU wards, and, especially in government hospitals, suffer from a lack of medical personnel.

We concluded that the rate of delayed defibrillation is still high although early defibrillation is the confirmed key for a successful outcome. From our findings, we suggest that, to improve the rate of early defibrillation and successful outcome, we should implement a strategy to increase availability of defibrillation, transfer potential cardiac arrest patients into ICU care, emphasize the significance of early defibrillation in the CPR training program and to patient care teams, and improve post-resuscitation care.

Limitations of the study

This study did not include every factor that might influence outcome of CPR such as knowledge or experience of physicians, nurses and medical personnel and the system for early detection of cardiac arrest.

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ความรวดเร็วในการทำ defibrillation: ปัจจัยสำคัญของการปฏิบัติการช่วยชีวิตในโรงพยาบาล

รุ่งโรจน์ กฤตยพงษ์, ปาณิสรา แสงสังข์, ธนวิน ชวฤาชัย, สุทธิพล อุดมพันธุรักษ์, ยงยุทธ สหัสกุล

***ภูมิหลัง**: การปฏิบัติการช่วยชีวิต (cardiopulmonary resuscitation หรือ CPR) เป็นส่วนสำคัญที่ทำให้ผู้ป่วยที่มีหัวใจหยุดเต้นกะทันหัน (cardiac arrest) กลับคืนเป็นปกติ*

***วัตถุประสงค์**: เพื่อ 1) ศึกษาอัตราการได้รับการช็อกไฟฟ้า (defibrillation) ช้าและ 2) ศึกษา ความสำคัญของการทำ defibrillation ต่อผลของ CPR*

***วัสดุและการ**: คณะผู้นิพนธ์ทำการวิเคราะห์ข้อมูลผู้ป่วยที่มี cardiac arrest ในโรงพยาบาลตั้งแต่ มกราคม พ.ศ. 2548 ถึง ธันวาคม พ.ศ. 2550 จากฐานข้อมูล CPR ซึ่งประกอบด้วยรายละเอียดของการปฏิบัติการช่วยชีวิต ได้แก่ ข้อมูลพื้นฐานของผู้ป่วย สาเหตุของ cardiac arrest, จังหวะหัวใจขณะเกิด cardiac arrest, ลักษณะของหอผู้ป่วย, ภาควิชา, ข้อมูลผู้ป่วยก่อนเกิดเหตุการณ์, ระยะเวลาของขั้นตอนต่าง ๆ ในการช่วยชีวิต, การใช้ยา และผลลัพธ์ของการช่วยชีวิตได้แก่อัตราการรอดชีวิตหลังการปฏิบัติการและอัตราการรอดชีวิตกลับบ้าน รวมถึงเวลาที่ทำ defibrillation*

***ผลการศึกษา**: ข้อมูลผู้ป่วย 2,160 ราย อายุเฉลี่ย 57.1 $\pm$ 21.2 ปี มีผู้ป่วย 612 ราย (28.3%) ที่ต้องทำ defibrillation ในจำนวนนี้ 250 ราย (40.8%) ได้รับ defibrillation เร็ว คือ ภายใน 5 นาที หลัง cardiac arrest ค่า median ของเวลาที่ทำ defibrillation เป็น 8 นาที ปัจจัยที่สัมพันธ์กับการทำ defibrillation ช้า ได้แก่ หอผู้ป่วยไม่วิกฤต, หอผู้ป่วยที่ไม่มีเครื่อง defibrillator และเพศหญิง ผู้ป่วย 283 ราย (46.2%) รอดชีวิตหลังการ ปฏิบัติการและ 50 ราย (8.2%) รอดชีวิตกลับบ้าน ความรวดเร็วในการทำ defibrillation เป็นปัจจัยที่สำคัญที่สุดในการทำนายโอกาสรอดชีวิตหลังการปฏิบัติการ และรอดชีวิตกลับบ้าน*

***สรุป**: ความรวดเร็วในการทำ defibrillation เป็นปัจจัยสำคัญที่มีผลต่อการรอดชีวิตหลังการปฏิบัติการช่วยชีวิตของผู้ป่วยที่มี cardiac arrest ในโรงพยาบาล*