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ORIGINAL ARTICLE

The incidence of postoperative cardiac arrest and pre-resuscitation factors associated with post-cardiopulmonary resuscitation mortality: a single-center study in Thailand

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ABSTRACT:

Background: The author aimed to determine the incidence of in-hospital postoperative cardiac arrest requiring cardiopulmonary resuscitation (CPR), postoperative CPR mortality and pre-resuscitation factors associated with post CPR mortality.

Methods: A retrospective cohort study was conducted at King Chulalongkorn Memorial Hospital in Thailand from September 2018 through August 2020. A total of 34,590 adult patients underwent surgical procedures under anesthesia were recruited by electronic data recorded review. A subset of patients with postoperative CPR was collected for demographic data, comorbidities, ASA classification, operative time, functional class, types of surgery, postoperative complications, the number of deaths and survival, and SOS score at 4 hours preceding cardiac arrest.

Results: A total of 34,590 adult surgical patients were recruited. In-hospital postoperative cardiac arrest incidence was 12 patients per 10,000 surgeries and predominated in emergency operation (28 per 10,000 surgeries; $P< 0.0001$). Risk ratio of emergency operation resulted in postoperative cardiac arrest was 3.15 (95% CI 1.72-5.77; $P<0.001$). Postoperative cardiac arrest patients aged 64.07 ± 16.58. The BMI was 23.46 ± 5.83. Mostly they were in ASA category 3 (44.2%). Everyone had general anesthetic procedures. The most common comorbidity was hypertension. In-hospital postoperative CPR mortality was 62.8%. Factors possibly predisposed to it were functional class < 4 METS, colorectal surgery and SOS score at 4 hours prior to cardiac arrest of at least 8.

Conclusion: Incidence of in-hospital postoperative cardiac arrest and mortality after CPR in the study tended to be lower than that of previous studies. Emergency operations predisposed to cardiac arrest. SOS score was possibly valuable as a prognostication tool, ICU triage, as well as, a part of the early warning score to prevent the overwhelming crisis. Surveillance for patient's deterioration, effective rapid response system, and comprehensive preoperative rehabilitation should be emphasized.

Keywords: Cardiac arrest, Pre-resuscitation factor, Post CPR mortality, Postoperative cardiac arrest, SOS score

INTRODUCTION

Cardiac arrest was a catastrophic problem affected longevity, public health resource, as well as economic loss. It occurred annually among hospitalized patients and those outside the hospital. In-hospital cardiac arrest had a trend toward preventability because of increased awareness and close monitoring during admission. According to American Heart Association Guidelines for Cardiopulmonary Resuscitation (CPR) and Emergency Cardiovascular Care 2019 [1] , the key elements for success of CPR were rapid recognition, activation of emergency response system, immediate high-quality CPR, rapid defibrillation, as well as advanced life support and postcardiac arrest care.

From European Resuscitation Council (ERC) [2] , the incidence of in-hospital perioperative cardiac arrest was 4.3-34.6 patients per 10,000 surgeries. A THAI-SICU study [3] reported the incidence of in-hospital cardiac arrest in surgical intensive care unit (SICU) which was 490 patients per 10,000 surgeries. The result included the patients whom received surgical procedures and non-surgical problems needed intensive care.

In general, the primary cause of cardiac arrest was most commonly cardiac disease (50%-60%). Secondly, it was respiratory insufficiency (15%-40%) [4]. In surgical department, there were various factors that had to take into account. For instance, severity of surgical conditions, comorbidities, preoperative evaluation, type of surgery and postoperative care. These factors might result in cardiac arrest, as well as postoperative CPR mortality.

Before in-hospital cardiac arrest occurred, some warning signs and symptoms usually appeared preceding the event. This generally presented around 8 hours prior to cardiac arrest.

Rapid response system (RRS), as a part of the chain of survival, should be given special emphasis. Earlier detection, time to treatment and competency of clinical response were the cornerstone of RRS to improve patient outcomes [5].

In middle-income countries, there was scarce officially validated early warning score (EWS) created to detect patient's deterioration before in-hospital postoperative cardiac arrest, as well as, to predict post CPR mortality. However, there was a well-known score that was conducted to early detect the future crisis, especially in sepsis patients. It was SOS score. The score at least 4 at 4 hours prior to cardiac arrest was the most appropriate cut off value for crisis determination [6,7]. Though, it had no predictive ability for mortality after CPR.

In Thailand, there was scanty data of in-hospital postoperative cardiac arrest requiring CPR specifically in the patients received anesthetic procedure which could reflect the effectiveness of postoperative care in SICU. Therefore, the author aimed to explore the incidence, postoperative CPR mortality, as well as pre-resuscitation factors influenced on this circumstance. Moreover, another aim was to explore whether the SOS score could predict post CPR mortality, specifically in postoperative patients.

Primary objective

The author aimed to determine the incidence of in-hospital postoperative cardiac arrest requiring cardiopulmonary resuscitation (CPR).

Secondary objective

The author aimed to determine postoperative CPR mortality and pre-resuscitation factors associated with post CPR mortality.

KEY MESSAGES:

- In-hospital postoperative CPR mortality was 62.8%
- Factors possibly predisposed to postoperative CPR mortality were functional class < 4 METS, colorectal surgery and SOS score at 4 hours prior to cardiac arrest of at least 8 but no statistical significance
- Emergency operations predisposed to cardiac arrest.
- Surveillance for patient's deterioration, effective rapid response system, and comprehensive preoperative rehabilitation should be emphasized

MATERIALS AND METHODS

Participants

Inclusion criteria

- Patients aged at least 18 years old.
- All surgical patients whom admitted for operation with anesthetic procedures in King Chulalongkorn Memorial Hospital (KCMH) in Thailand from September 2018 through August 2020.

Exclusion criteria

- Surgical patients whom admitted for operation without anesthetic procedures in King Chulalongkorn Memorial Hospital (KCMH) in Thailand from September 2018 through August 2020.
- Surgical patient whom admitted in King Chulalongkorn Memorial Hospital (KCMH) without need for operation.

Study design

A retrospective cohort study was conducted at King Chulalongkorn Memorial Hospital (KCMH) in Thailand from September 2018 through August 2020. Ethic approval was obtained from the Ethics Committee of Faculty of Medicine, Chulalongkorn University (IRB No.779/63), in compliance with Declaration of Helsinki, The Belmont Report, CIOMS Guidelines and The International Practice (ICH-GCP). All methods were performed in accordance with these guidelines and regulations.

Procedures

From September 2018 through August 2020, 34,590 adult surgical patients aged 18 years or older whom underwent surgery with anesthetic procedures were recruited by retrospective data recorded review from KCMH database. The author aimed to determine postoperative CPR incidence. The patients who did not receive anesthetic procedures were excluded.

Among postoperative cardiac arrest patients, demographic data, comorbidities, ASA classification, operative time, functional classification, types of surgery, postoperative complications, the number of deaths and survival, as well as SOS score at 4 hours preceding cardiac arrest were recorded.

Outcome measures

The primary outcome was the incidence of in-hospital postoperative cardiac arrest. Postoperative cardiac arrest re-

quiring CPR was determined as "the absence of cardiac rhythm or the presence of chaotic cardiac rhythm" resulted in loss of consciousness requiring cardiopulmonary resuscitation within 30 days after the end of operation or until discharge, depended on which was sooner.

The secondary outcome was the incidence of in-hospital postoperative CPR mortality within 30 days after CPR and pre-resuscitation factors associated with in-hospital post CPR mortality in postoperative patient

The SOS score (Search out severity score), as the early warning score, consisted of 5 parameters which were temperature, systolic blood pressure, pulse rate, consciousness and respiratory rate. This score was applied to evaluate the patient who would approach septic shock. The score of at least 4 at 4 hours prior to septic shock was the best cut off value to encourage closed monitoring before deteriorated events occurred. Since septic shock was one of the causes of cardiac arrest, the author performed ROC curve, area under the curve, sensitivity, specificity and the most appropriate cut off value of this score to measure how well it could predict mortality.

Statistical analysis

Based on a previous study Kazaure HS et al [14], The incidence of in-hospital postoperative cardiac arrest was 43 patients per 10,000 surgeries. The sample size was calculated using 80% power, 5% type I error, and 20% precision margin. Thus, the sample size would be at least 16,448. Statistical analyses were performed using SPSS version 22.0 software (IBM Corp., Armonk, NY, USA). Continuous variables were shown as mean with standard deviation or median with interquartile range. Risk ratio was presented with 95% confident interval. Unpaired t-test and Mann-Whitney test were used to compared two unpaired group. Chi-squared test and Fisher's exact test were used to compare categorical variables between two groups. A two-sided p-value< 0.05 was considered statistically significant. SOS score reliability was evaluated by ROC curve and area under the curve. The cut-off point of SOS score was evaluated by sensitivity, specificity. A p-value< 0.05 was considered statistically significant.

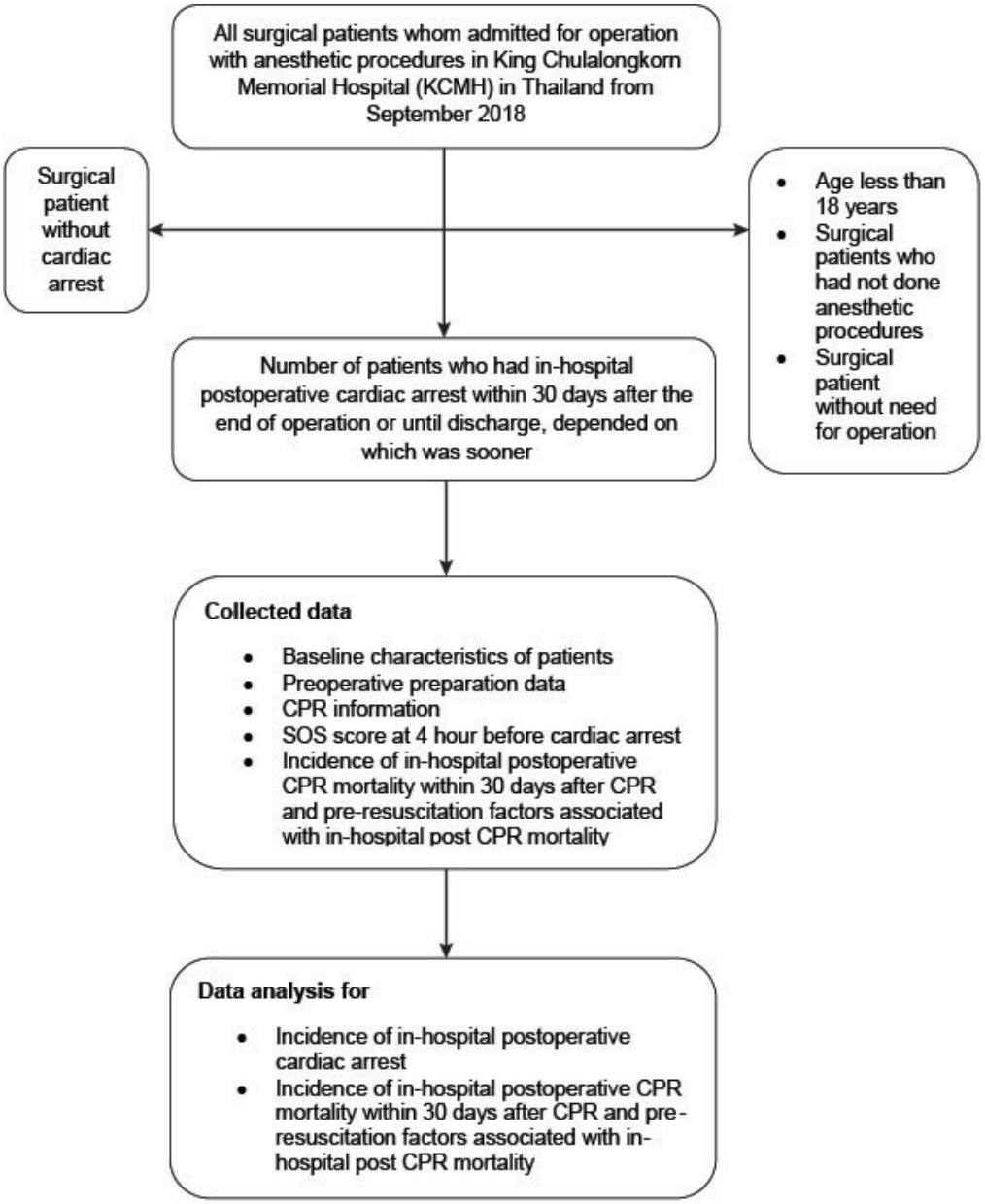


Figure 1. Study flow

RESULTS

Characteristics of patients

A total of 34,590 adult surgical patients aged 18 years or older whom received anesthetic procedures were recruited. Of these, 9 patients had intraoperative cardiac arrest and 43 patient had postoperative cardiac arrest. The incidence of in-hospital postoperative cardiac arrest was 12 patients per 10,000 surgeries (95% CI 6.20-21.00; P < 0.0001).

In the subgroup analysis, the incidence of in-hospital postoperative cardiac arrest was significantly higher in emergency surgery compare with non-emergency surgery (28 patients per 10,000 surgeries (95% CI 18.61-40.44) versus 9 patients per 10,000 surgeries (95% CI 4.12-17.08); P < 0.0001) (Table.1 and Figure 2). Crude risk ratio of emergency operation resulted in postoperative CPR was 3.15 (95% CI 1.72-5.77; P < 0.001).

Among the postoperative cardiac arrest patients, the age was approximately 64. Female was more predominant than male (53.5% versus 46.5%). The BMI was averagely 23. Mostly they were classified as ASA category 3 (44.2%). All of them received general anesthetic procedures and the number of deaths was 27 (62.8%). Non-emergency surgery was preponderant (58.1% versus 41.9% in emergency surgery group). The average operative time was 123 minutes. The most common comorbidity was hypertension, followed by cardiovascular disease, diabetes mellitus and renal failure respectively. Generally, they had functional class more than 4 METS. Smoking and alcoholic drinking were infrequent (Table.1).

The mortality rate of in-hospital postoperative CPR was 62.8% (Figure 3). Pre-resuscitation factors were shown in Table 1. According to the result, functional class which was less than 4 METS had a trend toward increasing postoperative CPR mortality but no statistically significant (P=0.087). Other factors shown in Table 1 were also unassociated with significant postoperative CPR mortality.

Although postoperative cardiac arrest most commonly occurred in cardio-thoracic operation (n=16, 37.2%), colorectal surgery had the highest predisposition to affect postoperative CPR mortality (n= 9, 33.3%) (Table 1). However, when compared with other types of surgery, there were no statistically significant.

Most common postoperative complication was cardiac arrhythmia, followed by sepsis and septic shock (Table 1).

Everyone was able to be evaluated for SOS score. The author performed the ROC-AUC plot of SOS score at 4 h prior to cardiac arrest for mortality prediction. Area under the curve was 0.634 (95%CI: = 0.463 – 0.806); P=0.145) (Figure 4). Despite non-significant postoperative CPR mortality measured by the SOS score at 4 h, the result revealed that the most informative cut off value of SOS score at 4 h prior to postoperative cardiac arrest to predict mortality was at least 8 (P=0.042) (Table 2).

In this study, the median time of cardiac arrest was on the fifth day after the end of operation (IQR: 2,12) (Figure 5). Although this result was not included in the objectives of this study but this information showed that postoperative cardiac arrest might not be the consequence of intraoperative factors.

Table 1. Pre-resuscitation factors associated with in-hospital postoperative CPR mortality.

	Total CPR (n=43)	Death (n=27)	Alive (n=16)	p-value
Age	64.07 ± 16.58	67.04 ± 16.73	59.06 ± 15.5	0.129
<45	5 (11.6%)	2 (7.4%)	3 (18.8%)	0.272
45-64	14 (32.6%)	8 (29.6%)	6 (37.5%)	
65-85	19 (44.2%)	12 (44.4%)	7 (43.8%)	
>85	5 (11.6%)	5 (18.5%)	0 (0%)	
Sex				
Female	23 (53.5%)	14 (51.9%)	9 (56.3%)	0.78
Male	20 (46.5%)	13 (48.1%)	7 (43.8%)	
BMI	23.46 ± 5.83	23.52 ± 6.13	23.36 ± 5.48	0.934
<18.5	6 (14%)	4 (14.8%)	2 (12.5%)	0.765
18.5-24.9	27 (62.8%)	18 (66.7%)	9 (56.3%)	
25-29.9	7 (16.3%)	3 (11.1%)	4 (25%)	
>30	3 (7%)	2 (7.4%)	1 (6.3%)	
ASA median (IQR)	3 (2, 4)	3 (2, 4)	3 (2, 3)	0.488
1	3 (7%)	1 (3.7%)	2 (12.5%)	0.672
2	10 (23.3%)	7 (25.9%)	3 (18.8%)	
3	19 (44.2%)	11 (40.7%)	8 (50%)	
4	10 (23.3%)	7 (25.9%)	3 (18.8%)	
5	1 (2.3%)	1 (3.7%)	0 (0%)	
Types of surgery According to the patient's condition				
Emergency	18 (41.9%)	11 (40.7%)	7 (43.8%)	0.847
Non-emergency	25 (58.1%)	16 (59.3%)	9 (56.3%)	
Operative time median (IQR)	123 (86, 300)	123 (86, 300)	150 (92.5,310)	0.763
<120	18 (41.9%)	13 (48.1%)	5 (31.3%)	0.234
120-179	8 (18.6%)	3 (11.1%)	5 (31.3%)	
≥180	17 (39.5%)	11 (40.7%)	6 (37.5%)	
Comorbidities				
Cardiovascular disease	18 (41.9%)	10 (37%)	8 (50%)	0.405
Respiratory disease	6 (14%)	4 (14.8%)	2 (12.5%)	1
Diabetes mellitus	12 (27.9%)	7 (25.9%)	5 (31.3%)	0.737
Hypertension	28 (65.1%)	18 (66.7%)	10 (62.5%)	0.782
Renal failure	12 (27.9%)	9 (33.3%)	3 (18.8%)	0.484
Malignancy	8 (18.6%)	7 (25.9%)	1 (6.3%)	0.223
None	5 (11.6%)	2 (7.4%)	3 (18.8%)	0.344
Functional class				
<4METS	15 (34.9%)	12 (44.4%)	3 (18.8%)	0.087
≥4METS	28 (65.1%)	15 (55.6%)	13 (81.3%)	
Smoking	6 (14%)	4 (14.8%)	2 (12.5%)	1
Alcohol drinking	4 (9.3%)	2 (7.4%)	2 (12.5%)	0.621

Table 1. (Continued) Pre-resuscitation factors associated with in-hospital postoperative CPR mortality.

	Total CPR (n=43)	Death (n=27)	Alive (n=16)	p-value
SOS score at 4 h before CPR	4 (3, 7)	4 (3, 8)	4 (1, 6)	0.142
Postoperative ICU admission	25 (58.1%)	15 (55.6%)	10 (62.5%)	0.655
Postoperative WARD admission	18 (41.9%)	12 (44.4%)	6 (37.5%)	
Types of Surgery				
CVT	16 (37.2%)	8 (29.6%)	8 (50%)	0.124
Neuro	4 (9.3%)	4 (14.8%)	0 (0%)	
Ob & gyn	2 (4.7%)	1 (3.7%)	1 (6.3%)	
Colorectal	12 (27.9%)	9 (33.3%)	3 (18.8%)	
ENT	2 (4.7%)	2 (7.4%)	0 (0%)	
General surgery	2 (4.7%)	2 (7.4%)	0 (0%)	
Trauma	4 (9.3%)	1 (3.7%)	3 (18.8%)	
Plastic surgery	1 (2.3%)	0 (0%)	1 (6.3%)	
Postoperative complication				
Sepsis/septic shock	9 (20.9%)	8 (29.6%)	1 (6.3%)	0.121
Acute renal failure	2 (4.7%)	2 (7.4%)	0 (0%)	0.522
Respiratory failure	10 (23.3%)	6 (22.2%)	4 (25%)	1
Massive bleeding	2 (4.7%)	2 (7.4%)	0 (0%)	0.522
Myocardial infarction	3 (7%)	2 (7.4%)	1 (6.3%)	1
Arrhythmia	19 (44.2%)	9 (33.3%)	10 (62.5%)	0.063
Massive pulmonary embolism	3 (7%)	2 (7.4%)	1 (6.3%)	1

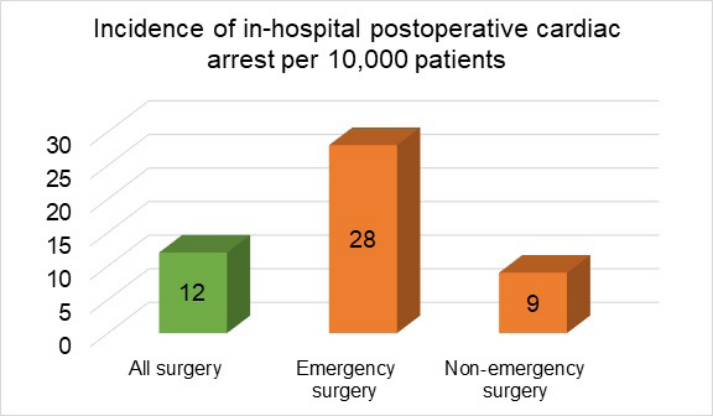


Figure 2. Incidence of in-hospital postoperative cardiac arrest per 10,000 patients

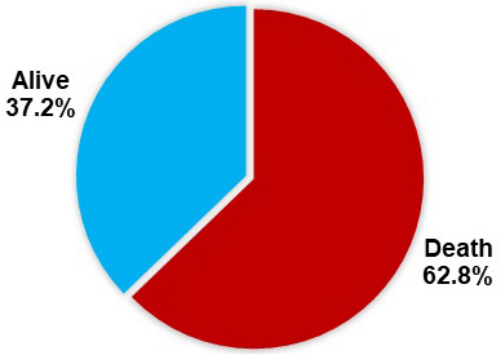


Figure 3. Mortality rate of in-hospital postoperative CPR

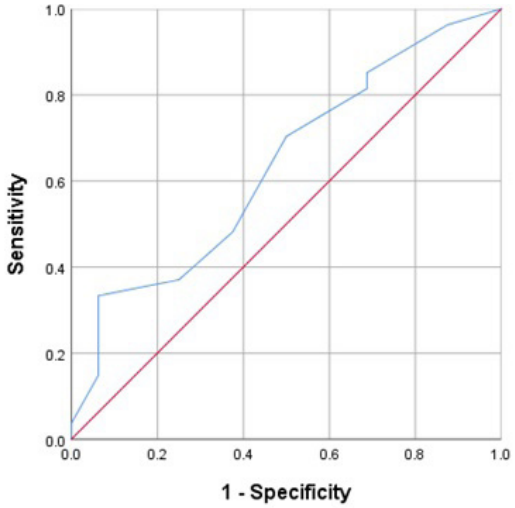
Table 2. Cut off value of SOS score at 4 h prior to in-hospital postoperative cardiac arrest to predict postoperative CPR mortality.

Cut off SOS ≥	Sensitivity	Specificity	PPV	NPV	Accuracy	p-value
1	96.3%	12.5%	65.0%	66.7%	65.1%	0.274
2	85.2%	31.3%	67.6%	55.6%	65.1%	0.200
3	81.5%	31.3%	66.7%	50.0%	62.8%	0.340
4	70.4%	50.0%	70.4%	50.0%	62.8%	0.182
5	48.1%	62.5%	68.4%	41.7%	53.5%	0.497
7	37.0%	75.0%	71.4%	41.4%	51.2%	0.416
8	33.3%	93.8%	90.0%	45.5%	55.8%	0.042
9	14.8%	93.8%	80.0%	39.5%	44.2%	0.397
12	3.7%	100.0%	100.0%	38.1%	39.5%	0.436

Table 3. The incidence of in-hospital postoperative cardiac arrest, in-hospital postoperative CPR mortality, pre-resuscitation factors affected to postoperative cardiac arrest and postoperative CPR mortality compared with previous studies.

Study	Year	Incidence of in-hospital postoperative cardiac arrest n (per 10,000 patients)	Incidence of in-hospital postoperative CPR mortality (%)	Pre-resuscitation factors affected to postoperative cardiac arrest	Pre-resuscitation factors affected to postoperative CPR mortality
Braz LG et al.[18] (n= 53,718)	2006	186 (34.6)	61.5	Extreme age ASA at least III Poorer FC class	
Kazaure HS et al.[14] (n= 6382) (Non-trauma)	2013	31 (50)	73.1	ASA class V Postoperative arrest Postoperative coma	
Ellis SJ et al.[19] (n= 217,365)	2014	160 (7.36)*	70	Aortic surgery Airway problem	
Siriphuwanun V et al.[20] (n= 751) (Trauma)	2014	NR	85		Surgery of upper abdomen ASA at least III Shock prior to cardiac arrest
Siracuse JJ et al.[21] (n= 123,581) (Vascular)	2015	1234 (1)	73.4	Thoracic aortic surgery Open abdominal procedure Dependent functional status	
Chanthawong S et al.[3] (n= 4,652)	2016	226 (490)**	91.6	ASA at least III High APACHE II score High SOFA score	
Vakil K et al.[22] (n= 6,979)	2016	182 (260)	51		Postoperative coma Hospital discharge other than home eGFR at discharge
Siriphuwanun V et al.[16] (n= 19,683)	2018	332 (160)	Not report	Alcoholism ASA at least III Shock prior to anesthesia	
Kaiser HA et al.[17] (n= 1,859,917) (Exclude cardiac and ENT surgery)	2019	6,183 (33)	1.25	High ASA Intraoperative CPR Septic shock Dialysis	Postoperative CPR High ASA Intraoperative CPR
Chomchoey C et al.*** (n= 34,590)	2020	43 (12)	62.8	Emergency operation	

* = Incidence of in-hospital intraoperative and postoperative cardiac arrest, ** = Included the patients who were not experienced anesthetic procedure, *** = This study



Area under the curve = 0.634 (95%CI: = 0.463 – 0.806), p-value = 0.145

Figure 4. ROC curve and Area under the curve of SOS score at 4 hours prior to in-hospital postoperative cardiac arrest to predict postoperative CPR mortality.

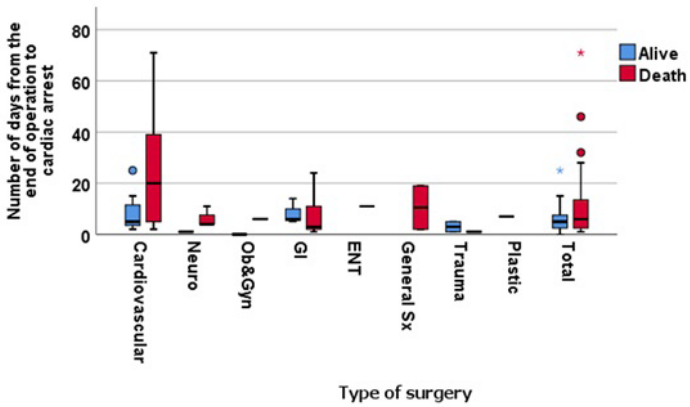


Figure 5. Number of days from the end of operation to cardiac arrest

DISCUSSION

Over 3 decades ago, the incidence of in-hospital postoperative cardiac arrest was reported by some studies. The data varied by the definition of intraoperative and postoperative cardiac arrest. In Thailand, this is the first retrospective cohort study from large populations that identified the incidence of in-hospital postoperative cardiac arrest specifically in the patients experienced anesthetic procedures. In this study, the incidence of in-hospital postoperative cardiac arrest was 12 patients per 10,000 surgeries which almost resemble to the study of Ellis SJ et al [19]. However, it was lower than several previous studies. This might imply that postoperative care has been improved in Thailand, especially in the university hospital, as well as, the palliative care strategy that was developed throughout the decade to mitigate the inappropriate CPR.

In the subgroup analysis, the incidence of in-hospital postoperative cardiac arrest was significantly higher in emergency surgery compare with non-emergency surgery. The result was correlated with the study of Myrna C et al. [23].

Generally, the reasons of high postoperative CPR rate in emergency surgery group were inadequate preoperative evaluation, as well as the severity of diseases itself. The 30-day mortality of in-hospital postoperative CPR was 62.8% which was almost resemble to the study of Ellis SJ et al [19] and Braz LG et al [18]. However, it was lower than the previous study in Thailand [3 ,16,20] as shown in Table 3. This might be because of the better development of health care facilities, effective monitoring systems, as well as clinician skills.

Pre-resuscitation factors affected to postoperative cardiac arrest requiring CPR and postoperative CPR mortality were diverse corresponded to the data in Table 3 throughout two decades ago. Mostly, the factors were old age, high ASA classification, poor functional status, renal failure, cardio-thoracic surgery, emergency operation and preoperative sepsis. In this study, the patients were approximately 65 years old. Although it was not a significant factor that influenced on mortality but oldest old age could be the factor that contributed to death. Gender, BMI, ASA classification, operative times, smoking and alcoholic drinking did not show statistically significance to incur mortality after CPR.

Despite no significance in terms of statistics, poor functional status had a trend toward in-hospital postoperative CPR mortality. Small cardiac arrest populations could explain this consequence. Thus, it was not obviously distinguished between two groups.

Common types of surgery that caused postoperative CPR mortality were colorectal surgery, followed by cardio-thoracic surgery. (n= 9, 33.3% versus n=8, 29.6%) (Table 1) The result was difference from previous data [14] which cardio-thoracic surgery was typically engendered it. The reason was because colorectal operation was done mostly in high grade malignant conditions with bowel obstruction and perforation. The patients already had poor performance status and cardiopulmonary reserve that might not be thoroughly detected and completely corrected before surgery. These factors resembled to previous study mentioned [24] that these overall factors could increase mortality. Another reason was the complications of those malignancy which affected to other vital organs. Although, when compare with other types of surgery the mortality was not significantly difference (P= 0.124).

The most common comorbidity in CPR patients was hypertension (n= 28, 65.1%). Secondly, it was cardiovascular disease (n= 18, 41.9%). However, none of them in Table 1 significantly increased mortality after CPR. CPR in intensive care unit (ICU) had a trend toward higher survival rate than that in general ward (Table 1). This outcome could be explained by the adequate facilities and effective monitoring system in ICU.

In this study, cardiac arrest occurred around 5 days after the end of operation. From the previous study [25,26,27] anesthesia related cardiac arrest was mostly defined as cardiac arrest that occurred within 1 to 3 days after operation. Therefore, in-hospital postoperative cardiac arrest in this study might not be associated with the intraoperative factors. Although there were some patients who experienced cardiac arrest within 3 days after the operation, this consequence was affected by severity of disease and multiple organ injury from severe trauma.

The most common postoperative complication was cardiac arrhythmia (Table 1), however, the trend of survival rate was high in this group. Because most of the patients had shockable EKG rhythm (ventricular tachycardia, ventricular fibrillation).

Finally, rapid response system, the important part in the chain of survival, was evaluated in this study by SOS score. The author chose SOS score at 4 hours because it was the most accurate tool to early detect patients prior to the future overwhelming crisis [6]. In Thailand, this score was well-known, especially for monitoring in sepsis patients. It was applied generally in many centers as a part of sepsis evaluation. Sepsis/septic shock was one of postoperative complications that might affect mortality. Therefore, the author preferred to evaluate this score whether it could predict mortality either, specifically in postoperative patients. Unfortunately, As shown in Table 2, mostly the score was 4 but no significance in terms of mortality prediction. The limitation might be small cardiac arrest populations. The author performed the ROC-AUC plot. Area under the curve was 0.634 (95%CI 0.463 – 0.806); P=0.145) (Figure 4). The result revealed that SOS score did not precisely predict mortality.

Clinical implications

1. Emergency operation was the risk factor of cardiac arrest that should be taken in to consideration. Although, it was unavoidable but early detected patients' deterioration and prompt resuscitation was the cornerstone to prevent postoperative cardiac arrest. This should be done before underwent operation.

2. Poor functional status was needed to be emphasized during preoperative evaluation. The role of preoperative rehabilitation might be beneficial to reduce postoperative CPR mortality.

3. Unstable bradyarrhythmia or tachyarrhythmia, though it was fatal, but the good health care personnel' skill of EKG interpretation was very important. Early detection and appropriate treatment could effectively revive the patients during high-quality CPR.

4. This is the first study designed to determine postoperative CPR mortality by SOS score. However, SOS score was not quite precise in terms of mortality prediction in postoperative cardiac arrest.

Limitations

1. This was a single-center study in the university hospital. Thus, the result might not be applied to other hospitals in different settings.

2. The number of cardiac arrest patients were small, hence some of pre-resuscitation factors (i.e., functional status, age, SOS score) were not obviously significant in term of statistics to predict mortality. If the data was collected retrospectively for several years, the lucid result might be presented.

3. This study did not show the details of CPR that might be the factors of postoperative mortality because of the large amount of missing data. This might produce errors of analytic outcomes.

CONCLUSION

In summary, postoperative cardiac arrest requiring CPR was a very important issue in surgical intensive care unit. The incidence of in-hospital postoperative cardiac arrest was 12 patients per 10,000 surgeries. Overall mortality rate after CPR was around two-third of postoperative CPR patients.

According to the study's result, emergency operation was an unavoidable situation affected postoperative cardiac arrest but it might be attenuated by high quality of care. Several factors tended to increase postoperative CPR mortality were probably preventable and reversible. For example, non-shockable EKG rhythm, functional impairment and high SOS score. Therefore, early detected for worsening clinical presentation, effective rapid response system and comprehensive preoperative rehabilitation should be emphasized.

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AUTHORS' CONTRIBUTIONS

C.C. and T.T. contributed to the design of this study. C.C. collected, analyzed and interpreted the data and drafted this manuscript. T.T. reviewed the final manuscript. All authors read, approved and agreed on the final manuscript.

SUPPLEMENTARY MATERIALS

none

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