Cost of Critically Ill Surgical Patients in Thailand: A Prospective Analysis of a Multicenter THAI-SICU Study

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Objective: *To quantify the total cost per admission and daily cost of critically ill surgical patients and cost attributable to Acute Physiologic Assessment and Chronic Health Evaluation (APACHE) II score, invasive mechanical ventilation and major complications in surgical intensive care unit (SICU) including sepsis, acute respiratory distress syndrome (ARDS), acute lung injury (ALI), acute kidney injury (AKI), cardiac arrest, and myocardial infarction.*

Material and Method: *A multicentre, prospective, observational, cost analysis study was carried out in SICU of five university hospitals in Thailand. Patients of age over 18 admitted to SICU (more than 6 hours) from 18 April 2011 to 30 November 2012 were recruited.The total SICU cost per admission (in Thai baht currency year 2011-2012) were recorded using hospital accounting database. Average daily SICU cost was calculated from total ICU cost divided by the ICU length of stay.The occurrence of sepsis, major cardiac and respiratory complications and duration of invasive mechanical ventilation were studied.*

Results: *A total of 3,055 patients with 12,592 ICU-days admitted to SICU during the study period. The median (IQR) ICU- length of stay was 2 (1, 4) days. The median (IQR) total SICU cost per admission was 44,055 (29,950-73,694) Thai baht. The median (IQR) daily cost was 18,777 (13,650-22,790) Thai baht. There was a variation of total and daily SICU cost across ICUs. For each of APACHE II score increases, cost increases with a median (IQR) of 1,731.755 (1,507.418-1,956.093) Thai baht. Invasive mechanically ventilated patients had higher cost than non-ventilated patients with a median (IQR) 15,873.4 (15,631.13-16,115.67) Thai baht. The patient with any complications listed here (sepsis, ARDS, ALI, AKI, myocardial infarction) had higher costs of care than ones who had none.*

Conclusion: *Cost of critically ill surgical patients in the public university hospital in Thailand was varied. The complications occurred in ICU increased the cost. To quantify the resource consumption of individual patient admitted to SICU, the costing method and cost components must be verified.*

Keywords: *Expenditure, Charge, Cost, Surgical intensive care, Critically ill surgical patient, University hospital*

J Med Assoc Thai 2016; 99 (Suppl. 6): S31-S37
Full text. e-Journal: *http://www.jmatonline.com*

An intensive care unit (ICU) is a costly unit in patient care and the expenses can reach up to 20% of a hospital's budget[1]. The total cost of critically ill patients depends on severity of illness and length of ICU stay[2,3]. The occurrence of complications required invasive mechanical ventilation lead to care by the very specialized staff which consumes a significant amount of resources[3-6]. It is crucial to identify resource consumption and cost of care for critically ill patients. There has been no study of costs for critically ill surgical patients in Thailand.

The primary objective of this study is to quantify total cost per one admission and daily cost of a patient admitted to a surgical intensive care unit (SICU). The second objective is to explore the cost attributable to complications occurring in SICU and quantify the effect of the Acute Physiology and Chronic Health Evaluation (APACHE) II score and invasive mechanical ventilation on costs. Complications occurring in SICU included sepsis, acute respiratory distress syndrome (ARDS), acute lung

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injury (ALI), acute kidney injury (AKI), cardiac arrest, and myocardial infarction (MI).

Material and Method

Studied patients

We conducted a prospective analysis in patients enrolled in the THAI-Surgical Intensive Care Unit (THAI-SICU) study. The THAI-SICU study is a multicenter, prospective, observational trial in nine Thai university-based hospital aimed to monitoring the occurrence and report adverse outcomes of Thai patients who were admitted to SICU, full details of patient characteristics and methodology of the THAI-SICU study were described elsewhere[7].

Data of this study were collected from five university hospitals including Siriraj Hospital (SI), Phramongkutklao Hospital (PMK), University of Bangkok Metropolis and Vajira Hospital (BMU), Chiang Mai University (CMU), and Prince of Songkhla University (PSU).

Data collection

Baseline characteristics include demographics data (age, gender, APACHE II scores, Sequential Organ Failure Assessment (SOFA) scores, SICU length of stay (LOS), hospital LOS, SICU mortality, 28-day mortality, the occurrence of the major cardiac and respiratory complications including sepsis, ARDS, ALI, AKI, cardiac arrest, myocardial infarction (MI) and duration of invasive mechanical ventilation.

Cost was collected in a top-down approach with a healthcare provider perspective. We used hospital charges as a proxy measure for costs. The total SICU charges during patients admitted to SICU of each hospital was retrieved from the hospital accounting database. Hospital charges post discharge from SICU was not included.

The components of cost included all direct medical care cost (e.g. consumables, prescription drugs, laboratory investigation, procedures, blood products, and staff cost), and overhead costs (basic bed cost, administrative). Direct non-medical care costs (e.g. transportation), an indirect cost (e.g. loss of productivity either of the patients or of the informal caregiver), burden to the household in terms of out-of-pocket (such as cost of informal caregiver, non-prescription drugs, herbs and vitamin, funeral), and intangible cost (e.g. pain, grief) were not included.

The SICU charges were recorded in actual Thai baht currency year 2011-2012 without adjusted by the consumer price index (CPI). Costs were presented in undiscounted form. Cost in local currency units were converted to international dollars ($) using the purchasing power parities (PPP) exchange rates developed by World Bank. The PPP conversion factor for Thai currency is 12.38 (year 2012)[8].

Statistical analysis

Variables are reported as mean (SD) or median (interquartile range or range), where appropriate. Cost attributable to complications in SICU (sepsis, ARDS, ALI, AKI, invasive mechanical ventilation) and APACHE II scores were analyzed using linear regression analysis. Statistical analyses were performed using SPSS (v.23.0; IBM Corporation, NY, USA) statistical software packages.

Results

Patient characteristics

The study consisted of 3,055 patients of mean (SD) age 61.9 (17.3) years with 59% male had a total of 12,592 ICU-days. The mean (SD) APACHE II score on the first day of ICU admission was 12.3 (7.3). The crude ICU and 28-day mortality were 11.1% and 15.5%, respectively.The median (IQR) ICU-LOS was 2 (1, 4) days. The median (IQR) hospital-LOS was 15.5 (9, 27) days. The patients were on invasive mechanical ventilation with a median (IQR) of 2 (1, 5) days. Six hundred forty-five (21%) patients had sepsis, 514 (17%) patients had AKI and 142 (4.8%) had ARDS (Table 1).

Total SICU cost for one admission

The median total SICU cost per one admission was 44,055 (IQR 29,950-73,694) Thai baht. There was a variation of total SICU costs across the centers. The total SICU cost varied from 29,950 (range 1,576-820,000) to 73,694 (range 138-891,428) Thai baht (Table 2).

Daily SICU cost per patient

The average (SD) daily SICU cost was 27,674.2 (41,968.95). The median daily SICU cost was 18,777 (IQR 13,650-22,790 Thai baht). There was variation in daily SICU costs across the centers. The daily SICU cost varied from 13,650 (range 668.6-76,830) to 22,790 (range 7.667-582,900) Thai baht (Table 3).

Cost attributable to complications during admitted to SICU

For each of APACHE II score increases, cost increased with a median (IQR) of 1,731.755 (1,507.418-1,956.093) Thai baht. Invasive mechanically ventilated

patients had higher cost than non-ventilated patients with a median (IQR) of 15,873.4 (15,631.13-16,115.67) Thai baht. Septic patients had higher cost than non-septic patients with a median (IQR) of 43,561.28 (39,806.61-47,315.94) Thai baht. Patients with ARDS caused higher cost than non-ARDS patients with a median (IQR) of 45,716.1 (38,722.8-52,709.41) Thai baht. Patients with AKI caused higher cost than patients without AKI with a median (IQR) of 39,570.36 (35,423.9-43,716.81) Thai baht. Cost contributed from other causes is shown in Table 4.

Table 1. Characteristic of the patients

Characteristics	n = 3,055
Gender (male/female)	1,805 (59)/1,250 (41)#
Age (years)	61.9±17.3*
APACHE II scores	12.3±7.3*
SOFA scores	2 (1, 5)**
SICU length of stay (day)	2 (1, 4)**
Hospital length of stay (day)	15.5 (9, 27)**
Crude SICU mortality rate	339 (11.1)#
Crude 28-days mortality	474 (15.5)#
Complication during SICU admission	
Sepsis	621 (20.3)#
ARDS	142 (4.6)#
ALI	76 (2.5)#
AKI	493 (16.1)#
Cardiac arrest	185 (6.1)#
MI	49 (1.6)#
Invasive mechanical ventilator (day)	2 (1,5)**

* Mean (SD), ** Median [IQR], # n (%)
APACHE = Acute Physiology and Chronic Health Evaluation; SOFA = Sequential Organ Failure Assessment; SICU = surgical intensive care unit; ARDS = Acute respiratory distress syndrome; ALI = Acute lung injury; AKI = acute kidney injury; MI = myocardial infarction

Discussion

This is the first study to quantify the cost of critically ill surgical patients in university hospitals of the public health sector in Thailand. All university hospitals included in this study are the tertiary care referral centers. We would expect the high complexity of the patients whom would be taken care by the very specialized staff and consume a significant amount of resources.

Our study quantified the daily SICU cost by using the total SICU cost divided by SICU-day. The method we used differed from that of the study from German and France which collect cost data on a one-day basis with the micro-costing method[9,10]. The micro-costing approach reflects more resource consumption[2]. However, cost is also affected by the day which the data collected as shown in the Data's study. Cost in ICU was highest on the first two days of admission[6]. The study from France collected the data on the fifth day[10]. Data at the very beginning of admission may over-estimate of the cost.

The median total SICU cost per one admission was 44,055 (IQR 29,950-73,694) Thai baht ($ 3,558 IQR $2,419-$5,952). Comparing to other studies, the median of ICU-length of stay in our study was 2 days (IQR 1, 4 days). ICU-LOS in our study was much less than study from USA, which mean ICU-LOS was 14.4±15.8 days and cost per admission was $31,574±42,570[6].

Compared to cost of other diseases studied in Thailand, cost of acute and sub-acute care for stroke patients was 32,372 Thai baht with average hospital-LOS 8.1 days. Cost per bed-day in acute phase was 5,546 Thai baht and in sub-acute phase was 3,039 Thai baht[12].

Cost of treatment varies among insurance schemes. Study of cost in hospitalized patients with

Table 2. Total SICU cost per patient per admission (Thai baht)

	n	ICU-day	Mean (SD)	Median (range)
SICU1	397	1,807	65,770.0 (100,908.96)	29,950 (1,576-820,000)
SICU2	770	4,571	115,457.4 (122,853.57)	73,694 (138-891,428)
SICU3	416	951	52,820.0 (54,611.377)	38,420 (844-604,300)
SICU4	499	1,397	67,360.0 (84,392.14)	37,540 (1,923-735,800)
SICU5	973	3,866	84,650.0 (132,449.91)	35,920 (1,800-1,200,000)
Total	3,055	12,592	82,803.6 (112,871.12)	44,055 (138-1,200,142)

SICU = surgical intensive care unit

Table 3. Daily SICU cost (Thai baht)

	n	ICU-day	Mean (SD)	Median (range)
SICU1	397	1,807	16,130.0 (10,569.175)	13,650.0 (668.6-76,830)
SICU2	770	4,571	35,220.0 (53,873.198)	22,790.0 (7.667-582,900)
SICU3	416	951	29,890.0 (28,386.037)	21,360.0 (844-255,200)
SICU4	499	1,397	24,920.0 (22,698.924)	19,310.0 (1,923-245,300)
SICU5	973	3,866	26,880.0 (49,783.042)	18,270.0 (993.9-938,100)
Total	3,055	12,592	27,674.2 (41,968.95)	18,776.7 (7.667-938,076)

SICU = surgical intensive care unit

Table 4. Attributable cost due to complications during SICU admission

Characteristics	n = 3,055	Adjusted attributable cost (95% CI)
APACHE II scores	12.3±7.3*	1,731.755 (1,507.418-1,956.093)
SOFA scores	2 (1, 5)**	6,959.1 (6,331.161-7,587.039)
SICU length of stay (day)	2 (1, 4)**	14,724.91 (14,500.35-14,949.47)
Hospital length of stay (day)	15.5 (9, 27)**	5,108.857 (4,936.551-5,281.164)
Complication during ICU admit		
Sepsis	621 (20.3)	43,561.28 (39,806.61-47,315.94)
ARDS	142 (4.6)	45,716.1 (38,722.8-52,709.41)
ALI	76 (2.5)	11,784.74 (2,804.621-20,764.87
AKI	493 (16.1)	39,570.36 (35,423.9-43,716.81)
Cardiac arrest	185 (6.1)	2,085.489 (-4,298.835-8,469.812)
MI	49 (1.6)	28,680.48 (17,622.91-39,738.06)
Invasive mechanical ventilator (day)	2 (1, 5)**	15,873.4 (15,631.13-16,115.67)

* mean (SD), ** median (IQR)
APACHE = Acute Physiology and Chronic Health Evaluation; SOFA = Sequential Organ Failure Assessment; SICU = surgical intensive care unit; ARDS = Acute respiratory distress syndrome; ALI = Acute lung injury; AKI = acute kidney injury; MI = myocardial infarction

colorectal cancer in Thailand showed the average hospital charge per admission of persons with colorectal cancer to be 41,052 Thai baht. In subgroup analysis, the cost of treatment was highest in government welfare (64,241 Thai baht) and lowest in universal coverage (28,588 Thai baht)[13].

Cost studies from different countries are hard to compare because of the differences in timing, even though a standardized methodology is used. A study was conducted in four European countries using a standardized top-down method, namely the International Programme for Resource Use in Critical Care (IPOC) and found differences in resource use and cost over the four countries[11]. The average cost per patient day (international dollars; year 2000 value) was $1,512 in UK hospitals, $934 in French hospitals, $726 in German hospitals and $280 in Hungarian hospitals[11]. The daily cost in a German ICU was €1,334 (year 1998-2001 value)[14]. The daily cost in a Norwegian ICU was €2,601 (year 2001 value)[15]. The daily cost in a French ICU was €1,425 ($10,386) in year 2015[10]. Compared to our study, the average daily cost was 27,674 Thai baht ($2,235 correction with PPP conversion factor published by World Bank, year 2012 value).

There were variations in total and daily SICU costs across the participating SICUs. The variation may reflect the difference in patient consumption of resources. The characteristic of the participating SICU were difference in several aspects such as number of full time intensivists, open or closed SICU, and nursing staff. This may cause the variation in cost among SICU. Staff cost have been identified as one of the major cost generating factors. Therefore, ICU staff discrepancies among centers may contribute to the cost differences. Study from Hungary showed 30% of the budget was staff cost compared to 60% of cost in UK-ICU. While

60% were consumables cost in Hungary-ICU, whereas in UK-ICU was 28%[16]. In this study, we did not break down the cost component; therefore, we cannot identify which cost component associated with the variation in SICU costs across centers.

Complications occurring in ICU can increase ICU cost[3-5]. In this study, we found that cost of the patients who had complications were higher than the patients who had none. The patients who had complications in SICU consume more resources such as RRT required, more medications, longer length of stay, more nursing burden and more specialized staff. The study showed multiple medications prescribed in sepsis and septic shock patients are associated with high cost[17,18].

What cost studies of ICUs are of most interest may be the variables predicting total cost in ICU. Several tools were used to predict the total ICU cost such as therapeutic intervention scoring system (TISS) score, Omega scoring system, APACHE II and APACHE III score[14,19-21]. TISS and Omega scoring systems for assessment of intensive care activity seem to be relevant for a better estimation of the direct costs[19,20]. The variable cost per TISS point was £25 in UK[20].

In this study, APACHE II score was used to assess the severity of the patient. Although testing for correlation between APACHE II score and total cost is not our objective in this study. We found that each of APACHE II score increased the median (IQR) total cost of 1,731.755 (1,507.418-1,956.093) Thai baht.

Benefits of this study or contribution to policy makers or health care providers

This is the first study to quantify costs of critically ill surgical patients in public university hospital in Thailand. The financial management of the hospital is to keep balancing between cost and reimbursement. The reimbursement for the public healthcare sector was controlled by a standard cost list from the Comptroller General's Department.

Health insurance schemes can affect the estimation of cost as showed in study of cost in colorectal cancer patients[13]. In Thailand, there were three major health insurance schemes; (civil servant medical benefit scheme (CSMBS), universal coverage (UC) and social security (SS). Cost of the hospitalized colorectal cancer patients with CSMBS was double that of patients with UC. In our study, most of the patients (50-60%) were UC except one hospital (60% were CSMBS). The cost related to health insurance scheme should be considered and further investigated.

Limitation of the study

First, our study used hospital charges as a proxy measure for actual costs. This does not reflect resource consumption of individual patient. Second, we collected data from the cost recorded on accounting database of each hospital for which we did not control the cost component of each hospital. Therefore, the cost component may have varied from one hospital to another. Third, we did not adjust for the co-morbidities. The impact of confounding variables such as the complexities of a patient, severity of the illness had to be adjusted for.

We considered other factors that may confound estimation of cost in our study, such as complex procedures in SICU (such as renal replacement therapy, aortic balloon pump), and the stage of diseases. We did not do subgroup analysis when the patient's stage of diseases had changed. For example, in acute lung injury (ALI), the patient can progress to ARDS. Patients with acute kidney injury (AKI) can turn to be renal failure and need renal replacement therapy or more care. We did not analyze costs separately between different stages. This may cause an over-estimated cost of an illness.

Conclusion

Cost of critically ill surgical patients in the public university hospital in Thailand was varied. The complications occurred in ICU increase costs. To quantify the resource consumption of an individual patient admitted to SICU, the costing method and cost components must be verified.

Acknowledgements

The study was supported by the Royal College of Anesthesiology of Thailand, National Research Council of Thailand (NRCT), Mahidol University, Chulalongkorn University, Chiang Mai University, Khon Kaen University, Prince of Songkla University, Navamindradhiraj University, Phramongkutklao Hospital and Srinakharinwirot University. Data processing was performed by the Thai Medical Schools Consortium (MedResNet).The publication was supported by Medical Association of Thailand (Prasert Prasarttong-osoth research fund).

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Potential conflicts of interest

None.

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ต้นทุนการรักษาผู้ป่วยหนักทางศัลยกรรมในประเทศไทย: การศึกษาแบบสังเกตการณ์ไปข้างหน้าในการศึกษาสหสถาบัน THAI-SICU

สุนิสา ฉัตรมงคลชาติ, กวีศักดิ์ จิตตวัฒนรัตน์, โอสรี อัครบวร, ชณัฐี กิจศิริพันธ์, กลุ่มศึกษา THAI-SICU

วัตถุประสงค์: *เพื่อศึกษาต้นทุนการรักษาทั้งหมดต่อ 1 ครั้งและค่ารักษาต่อวัน ของผู้ป่วยที่เข้ารับการรักษาในหออภิบาลผู้ป่วยหนักศัลยกรรม และค่ารักษาที่เกิดจากคะแนน APACHE II การใช้เครื่องช่วยหายใจ และการมีภาวะแทรกซ้อนที่สำคัญในหออภิบาลผู้ป่วยหนักศัลยกรรมได้แก่ เหตุพิษติดเชื้อ การหายใจล้มเหลวเฉียบพลันชนิด ARDS และ ALI ไตวายเฉียบพลัน กล้ามเนื้อหัวใจตาย*

วัสดุและวิธีการ: *เป็นการศึกษาสหสถาบัน ชนิดแบบสังเกตการณ์ไปข้างหน้า วิเคราะห์ต้นทุนจากหออภิบาลศัลยกรรมของโรงพยาบาลมหาวิทยาลัย 5 แห่ง ในประเทศไทยประชากรศึกษาคือ ผู้ป่วยอายุตั้งแต่ 18 ปี ขึ้นไปที่เข้ารับการรักษาในหออภิบาลศัลยกรรม (มากกว่า 6 ชั่วโมง) ระหว่างวันที่ 18 เมษายน พ.ศ. 2554 ถึงวันที่ 30 พฤศจิกายน พ.ศ. 2555 โดยบันทึกต้นทุนการรักษาทั้งหมดต่อ 1 ครั้งที่เข้ารับการรักษาในหออภิบาลผู้ป่วยหนักศัลยกรรมจากระบบบัญชีของโรงพยาบาล คำนวณต้นทุนต่อวัน โดยใช้ต้นทุนการรักษาทั้งหมดหารด้วยจำนวนวันที่อยู่ในหออภิบาลและศึกษา อัตราการเกิดเหตุพิษติดเชื้อ ภาวะแทรกซ้อนที่สำคัญทางระบบหัวใจและระบบหายใจ และระยะเวลาการใช้เครื่องช่วยหายใจ*

ผลการศึกษา: *ผู้ป่วยทั้งหมด 3,055 ราย อายุเฉลี่ย 61.9±17.3 ปี มีจำนวนวันอยู่ในหออภิบาลผู้ป่วยหนักศัลยกรรมทั้งหมด 12,592 วัน ค่าเฉลี่ยของคะแนน APACHE II ในวันแรกที่เข้ารับการรักษาในหออภิบาลคือ 12.3±7.3 อัตราตายในหออภิบาลและอัตราตายใน 28 วัน เท่ากับ 11.1% และ 15.5% ตามลำดับ ค่ารักษาทั้งหมดต่อ 1 ครั้งที่อยู่ในหออภิบาลผู้ป่วยหนักศัลยกรรมเท่ากับ 44,055 บาท (29,950-73,694 บาท) ระยะเวลาที่อยู่ในหออภิบาลศัลยกรรม 2 (1, 4) วัน ค่ารักษาต่อวันเฉลี่ยเท่ากับ 27,674.2±41,968.95 บาท ค่ารักษาของทั้ง 5 โรงพยาบาล มีความแตกต่างกัน เมื่อคะแนน APACHE II เพิ่มขึ้น ต้นทุนเพิ่มขึ้น 1,731.755 บาท (1,507.418-1,956.093 บาท) ผู้ป่วยที่มีภาวะแทรกซ้อน (เหตุพิษติดเชื้อ การหายใจล้มเหลวเฉียบพลันชนิด ARDS และ ALI ไตวายเฉียบพลัน กล้ามเนื้อหัวใจตาย) มีต้นทุนการรักษามากกว่าผู้ป่วยที่ไม่มีภาวะแทรกซ้อน*

สรุป: *ต้นทุนของผู้ป่วยหนักศัลยกรรมในโรงพยาบาลมหาวิทยาลัยแตกต่างกัน ภาวะแทรกซ้อนที่เกิดขึ้นทำให้ต้นทุนการรักษาสูงขึ้น เพื่อศึกษาการใช้ทรัพยากรของผู้ป่วยแต่ละรายที่เข้ารับการรักษาในหออภิบาล จะต้องมีการหาวิธีการและองค์ประกอบในการศึกษาต้นทุน*