Cost Effectiveness Analysis of an Initial ICU Admission as Compared To a Delayed ICU Admission in Patients with Severe Sepsis or in Septic Shock

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Objective: *To assess the cost effectiveness of an initial ICU admission for patients with severe sepsis or those in septic shock following the initial resuscitation in the emergency department.*

Material and Method: *Mortality data was generated through retrospective data obtained from 1,048 adult patients with severe sepsis or in septic shock from one tertiary care and eight community hospitals in Phitsanulok during the period of October 2010 to September 2011. These patients were categorized into two groups; as either admitted from the emergency department directly to the ICU (stated as an immediate ICU admission) or admitted from the emergency department to the general hospital ward due to an unavailability of ICU beds (stated as a delayed ICU admission). The overall direct costs and characteristics were simulated from a second group of 994 adult patients, admitted a year later from selected data by the ICD-10 codes [International Classification of Diseases, 10th edition] with the same conditions of severe sepsis and septic shock (September 2011 through September 2012), as there was no collection of costs and characteristics during the first period (October 2010 through September 2011). A decision tree model and an incremental cost-effectiveness ratio (ICER) were used for the analyses of the cost-effectiveness.*

Results: *There were no significant differences in either the mean ages or lengths of stay between both groups. All-cause mortality rates have shown an incidence of 22.2% for the immediate ICU admission group and an incidence of 46.3% in the delayed ICU admission group (odds ratio for the immediate ICU admission group was 0.479 with a 95% confidence interval, 0.376-0.611). Total costs (mean, 95% CI) of the immediate ICU admission group [37,194 baht (32,389-44,926)] were higher than had been seen in the delayed ICU admission group [26,275 (24,300-27,936)]. Incremental cost was 10,919 baht. ICER for the immediate ICU admission group was 45,307 baht per life saved.*

Conclusion: *Immediate ICU admission for patients with severe sepsis or in septic shock following the initial resuscitation in the emergency department has shown a satisfactory cost-effectiveness profile in low-to-middle income countries.*

Keywords: *Severe sepsis, Septic shock, ICU admission, Hospital mortality, Cost effectiveness*

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Severe sepsis is one of the most serious healthcare problems, worldwide, and the financial burdens of sepsis are escalating and this is contributing to increased pressure on national health care resources[1-5]. An ICU admission is recommended for patients with severe sepsis or patients in septic shock due to the high demands of the care for these patients and the necessity for expeditious treatment[5]. In Thailand, intensive care unit (ICU) admission directly from the emergency department following the initial resuscitation is limited to the severity of the illness and treatments for specific co-morbid conditions such as strokes or acute myocardial infarctions[6-8]. Due to resource limitations from what is termed 'ICU bed sparing', some patients could not be initially admitted to the ICU. Although previous studies had demonstrated that a significant proportion of patients with severe sepsis could initially receive care in areas other than the ICU[3,9], there is now contrary evidence that has revealed that early admission to the ICU for patients with severe sepsis is more likely to produce positive outcomes[10-13]. Additionally, economic studies are still only rarely available[4]. With the considerations mentioned previously, this study's aim is to assess the cost-effectiveness of an initial admission for patients

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with severe sepsis or in septic shock to an ICU or a general ward following the initial resuscitation in the emergency department.

Material and Method

Commencing December of 2009, implementation of the initial resuscitation protocol and fast track system for all patients with severe sepsis or in septic shock has been practiced in the emergency departments of eight community hospitals (30-90 beds) and one tertiary-care hospital (900 beds). The initial resuscitation protocol and fast track system comprised of a checklist for early recognition, early resuscitation and early ICU admission (if ICU beds were available). After having implemented the initial resuscitation protocol and the fast track system for a period of 2 years, a sepsis data registry was used to assess the cost-effectiveness of an initial admission between patients who were admitted directly to the ICU from the emergency department (the immediate ICU admission group) and those who were required to wait for an ICU bed to become available with an admission into a general hospital ward (the delayed ICU admission group). The present study was approved by the Human Research, Ethics Committee of Buddhachinaraj Phitsanulok Hospital.

Effects or outcome estimation

All-causes mortality rates were evaluated from the sepsis data registry of the 1,048 adult patients from eight community hospitals and one tertiary care hospital in the Phitsanulok who were admitted from the emergency department to the ICU or a general hospital ward during the period of October 2010 to September 2011. During that period, all of the hospitals were encouraged to establish jointly and promote a set of achievable goals. All patients had initiated resuscitation in the emergency department prior to being admitted to the general ward or the ICU.

Costs estimation

Costs estimation has been taken from the providers' perspectives, from detailed billing records and discharge costs of 994 adult patients who were admitted from the emergency department to the ICU or general hospital ward during the period from September 2011 to September 2012. Data were selected with the use of the ICD-10 codes (International Classification of Diseases, Edition 10) for sepsis as a principal diagnosis and in the co-morbidity category. The present study focuses on the direct treatment costs and does not intend to measure indirect costs. The direct treatment costs include the charges for; hospitalization, staff and treatments. Finally, the median, geometric mean costs and standard deviations were calculated. Costs per patient were multiplied by the estimated incidence range to obtain the total direct costs for each group by a decision-analytical model. Incremental costs were measured by the difference in discharge costs between the immediate ICU admission group and delayed ICU admission group. Costs were calculated using the current 2012 prices. In the year 2012, the gross domestic product (GDP) per capita in Thailand was 5,474 US dollars and the exchange rate of Thai baht to the US dollar was 1 baht = 0.0314. We did not apply a 3% annual discount rate to the costs because the timing of the current study is for a short-term analysis.

Cost-effective analysis

A decision-analytical model was used as a hypothetical cohort that was constructed using the decision analysis by Tree Age, DATA Professional, Version 4.0 (TreeAge Software, Williams town, MA, USA). This model has compared the costs and the outcomes of patients with severe sepsis or in septic shock between the immediate ICU admission and delayed ICU admission groups. The incremental survival cases were computed with the number of surviving cases from the immediate ICU admission group less the number of surviving cases from the delayed ICU admission group. The incremental cost effectiveness ratio (ICER) was measured from the ratio of the incremental cost per the incremental survival effects of the immediate ICU admission group over the delayed ICU mission groups. A sensitivity analysis was conducted to determine the point of indifference in net health benefit between two groups with different levels of the probability of death in the delayed ICU admission group using a fixed threshold of willingness to pay (WTP) equal to 300,000 baht.

Statistical analysis

The Wilcoxon's rank-sum test was used for the comparison of continuous data and the Chi-square test for the comparison of categorical data as appropriate. To estimate the distributions around the cost-effectiveness ratios for the data in its entirety and for each group, simulated data in sets of 1,000 using bootstrapping with replacements were generated. A 95% confidence interval has been used for describing the distribution and estimated probability that the CE ratios fell below the illustrative thresholds. SPSS was

used for conducting statistical analyses and simulations.

Results

Patient characteristics

One hundred thirty-eight of 994 adult patients with severe sepsis or in septic shock were admitted directly from the emergency department into the ICU. More than half of the patients were elderly, more than 60 years of age. The average length of stay and age for the immediate ICU admission group and the delayed ICU admission group did not show any statistical differences (Table 1).

Outcomes

All-cause mortality rates have shown an incidence of 22.2% for the immediate ICU admission group and an incidence of 46.3% in the delayed ICU admission group (odds ratio for the immediate ICU admission group was 0.479 with a 95% confidence interval, 0.376-0.611). From the 46.3% of the mortalities in the delayed ICU admission group, 18% died after being admitted to a general hospital ward (died before an ICU bed was available) and 28.3% died in the ICU after being transferred from a general hospital ward.

Economic evaluations

The total costs of the immediate ICU admission group were higher than has been seen in the delayed ICU admission group and the incremental cost was 10,919 baht. The cost-effectiveness ratio in the immediate ICU admission group (47,807 baht/life saved) was less than those in the delayed ICU admission group (48,929 baht/life saved). The ICER for the immediate ICU admission from emergency department was 45,307 baht per additional life saved (Table 2) .

Sensitivity analysis

Given the WTP of 300,000 baht, if the mortality rates in the delayed ICU admission group were equal to or greater than 6.4%, the immediate ICU admission for adult patients with severe sepsis or those in septic

Table 1. Parameters of patients with severe sepsis or in septic shock in the immediate ICU admission group and the delayed ICU admission group

	Immediate ICU group (n = 138)	Delayed ICU group (n = 856)	p-value
Age (yrs)			
Mean (SD)	62.15 (16.29)	62.47 (16.67)	0.83
Median (IQR)	63 (24)	64 (24)	
Range(min-max)	25-92	15-96	
Age more than 60 yrs (%)	55.1	56.3	0.79
LOS (days)			
Mean (SD)	10.07 (12.09)	9.11 (12.09)	0.67
Median (IQR)	6 (11)	5 (8)	
Range (min-max)	1-66	1-122	
Total costs (baht)			
Mean (SD)	37,194 (70,813.17)	26,275 (58,601.19)	< 0.01
Median (IQR)	34,216 (60,267)	24,976.50 (37,046)	
Range (min-max)	5,103-335,429	2,060-553,202	

Table 2. Economic evaluations between the immediate ICU admission group and the delayed ICU admission group of patients with severe sepsis or in septic shock

	Immediate ICU group	Delayed ICU group
Total costs (baths) (mean, 95% CI)	37,194 (32,389-44,926)	26,275 (24,300-27,936)
Survival rate (%)	77.8	53.7
Incremental cost (baht)	10,919	
Incremental effectiveness (%)	24.1	
Cost-effective ratio (baht/life saved)	47,807	48,929
Incremental cost-effectiveness ratio (baht per additional life saved)	45,307	

shock will have received better net health benefits when compared to the delayed ICU admission approach. However, if the mortality rates in the delayed ICU group were less than 6.4%, a delayed ICU admission approach has been shown to provide better net health benefits (Fig. 2).

Discussion

Effective access to health care systems is comprised of three components: care, timing, and location. All of these must be equally sufficient. The present study shows the necessity of early (timing) of an ICU admission (care and location) for patients with severe sepsis or those in septic shock by demonstrating that late admission to the ICU has been associated with an increased mortality rate. It is noteworthy that the mortality rate continues to be high in patients who waited for an ICU bed in a general hospital ward and who were transferred to the ICU. These results emphasize that patients with severe sepsis and those in septic shock should receive early intensive resuscitation and continuous monitoring.

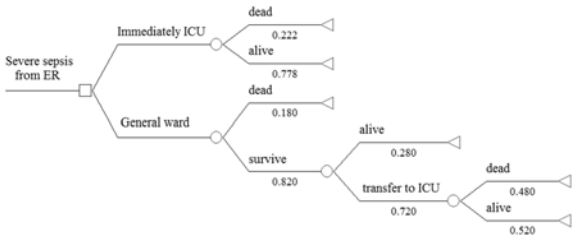
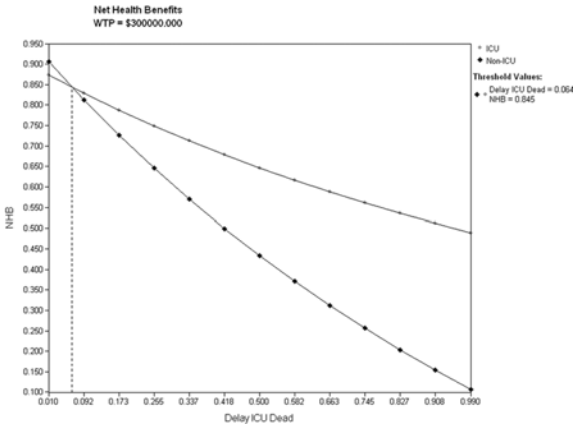


Fig. 1 Decision tree model to estimate cost and outcomes probability of patients with severe sepsis or in septic shock in the immediate ICU admission group as compared to the patients in the delayed ICU admission group.



ICU = immediate ICU admission; Non-ICU = delayed ICU admission; NHB = net health benefit

Fig. 2 Expected net health benefits between immediate ICU admission group and delayed ICU admission group with different levels of the probability of death in the delayed ICU admission group. This was with using a fixed threshold of willingness to pay (WTP) = 300,000 baht.

The demand for ICU beds is increasing globally and delays in ICU admissions are becoming an issue of greater frequency[11-13]. ICU bed availability does not meet the demand for critically ill patients and continues to be a persistent problem in low-to-middle income countries. It is very difficult to monitor the critically ill patients in general hospital wards[14,15]. Strategies and integrated programs for the management of patients with severe sepsis and in septic shock in general wards are required to improve outcomes in low-to-middle income countries[10,16].

In the future, if the staff in general hospital wards can resuscitate and monitor critically ill patients more effectively and the mortality rates are lower than has been seen presently, the net health benefits from immediate ICU care will be lower as has been shown in sensitivity analyses. Although the data of the present study was generated from a large, observational, actual practice, some limitations remain. First, the data have been analyzed from only one province so the external validity is low. Secondly, although observational studies are susceptible to selection bias, this study's selection bias was minimized due to the fact that ultimately all patients with severe sepsis or those in septic shock had to be admitted from the emergency department directly to the ICU if beds were available (first come, first served) as is referenced in the resuscitation protocols. Third, hospital charges were used instead of costs in the analyses when evaluating the cost-effectiveness so the generalization of data was limited. However, almost 40% of the economic evaluations of the ICUs used charges instead of costs in the analyses. Many studies have demonstrated that, although the difference in the magnitude of costs and charges is large, the main conclusions have been based on incremental cost-effectiveness ratios, and not been significantly altered[17]. Finally, the present study makes use of simple assumptions, and does not necessarily reflect the accurate probabilities, costs, or utilities. This present study has been evaluated on a short-term basis. Thus, further studies should be generated for long-term reference cases based on lifetime estimates of costs and effects as per the guidelines of the U.S. Public Health Service Panel on Cost-Effectiveness in Health

and Medicine (PCEHM)[18].

Conclusion

Initial ICU admission following resuscitation in the emergency department should be provided for patients with severe sepsis or those in septic shock by the ICU triage system. Costs of approximately 45,307 baht for each additional life saved has helped to develop a cost-effectiveness profile that helps guide the ICU's resource allocations for patients with severe sepsis or those in septic shock. Future studies of the long-term impacts of an initial ICU admission for patients with severe sepsis or in septic shock will also be beneficial.

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Potential conflicts of interest

None.

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การวิเคราะห์ต้นทุนประสิทธิผลของการย้ายผู้ป่วยติดเชื้อในกระแสเลือดแบบรุนแรงเข้าหอผู้ป่วยไอซียูทันทีเทียบกับการย้ายเข้าหอผู้ป่วยสามัญ

รัฐภูมิ ชามพูนท, ธรรมศักดิ์ ทวิชศรี, นาตยา คำสว่าง, วิษณุ ศิริโชติ, เชิดชัย นพมณีจำรัสเลิศ

วัตถุประสงค์: *วิเคราะห์ต้นทุนประสิทธิผลจากการย้ายผู้ป่วยติดเชื้อในกระแสเลือดแบบรุนแรงเข้าหอผู้ป่วยไอซียูทันที หลังจากมีการดูแลเบื้องต้นในแผนกฉุกเฉิน*

วัสดุและวิธีการ: *อัตราตายได้มาจากการวิเคราะห์ข้อมูลผู้ป่วยผู้ใหญ่ที่มีภาวะติดเชื้อในกระแสเลือดแบบรุนแรง จำนวน 1,048 ราย ที่ได้รับการรักษาเบื้องต้นในแผนกฉุกเฉินในโรงพยาบาลชุมชนแปดแห่งและโรงพยาบาลระดับตติยภูมิ หนึ่งแห่งในจังหวัดพิษณุโลก ในช่วงระหว่างเดือนตุลาคม พ.ศ. 2553 ถึงเดือนกันยายน พ.ศ. 2554 โดยเปรียบเทียบ 2 กลุ่ม คือ กลุ่มที่ได้รับการย้ายเข้าหอผู้ป่วยไอซียูโดยทันทีและกลุ่มที่ต้องรออยู่ในหอผู้ป่วยสามัญเนื่องจากเตียงในไอซียูเต็ม (กลุ่มย้ายเข้าไอซียูล่าช้า) การประมาณต้นทุนทางตรงและลักษณะของผู้ป่วยวิเคราะห์จากแบบบันทึกเวชระเบียนผู้ป่วยผู้ใหญ่ที่มีภาวะติดเชื้อในกระแสเลือดแบบรุนแรงจำนวน 994 ราย ในช่วงระหว่างเดือนกันยายน พ.ศ. 2554 ถึงเดือนกันยายน พ.ศ. 2555 โดยใช้รหัส ICD-10 เนื่องจากในช่วงระหว่างเดือนตุลาคม พ.ศ. 2553 ถึงเดือนกันยายน พ.ศ. 2554 ไม่ได้มีการเก็บข้อมูลลักษณะของผู้ป่วยและค่าใช้จ่าย การวิเคราะห์ต้นทุนประสิทธิผล ใช้แบบจำลองทางเลือกการตัดสินใจและอัตราส่วนต้นทุนประสิทธิผลส่วนเพิ่ม*

ผลการศึกษา: *อายุเฉลี่ยและระยะเวลานอนโรงพยาบาลเฉลี่ยของทั้งสองกลุ่มไม่มีความแตกต่างกันทางสถิติ กลุ่มย้ายเข้าไอซียูทันที มีอัตราตายจากทุกสาเหตุเท่ากับ ร้อยละ 22.2 และกลุ่มย้ายเข้าไอซียูล่าช้าเท่ากับ ร้อยละ 46.3 (odds ratio 0.479; 95% confidence interval, 0.376-0.611) ค่าใช้จ่าย (ค่าเฉลี่ย 95% CI) ของกลุ่มย้ายเข้าไอซียูทันที [37,194 บาท (32,389-44,926)] สูงกว่ากลุ่มย้ายเข้าไอซียูล่าช้า [26,275 (24,300-27,936)] ค่าใช้จ่ายที่เพิ่มขึ้นคิดเป็น 10,919 บาท อัตราส่วนต้นทุนประสิทธิผลจากการย้ายผู้ป่วยติดเชื้อในกระแสเลือดแบบรุนแรง เข้าไอซียูทันทีเท่ากับ 45,307 บาท ต่อผู้ป่วยที่รอดชีวิตเพิ่มขึ้นหนึ่งราย*

สรุป: *การย้ายผู้ป่วยติดเชื้อในกระแสเลือดแบบรุนแรงเข้าไอซียูทันทีหลังจากมีการดูแลเบื้องต้นในแผนกฉุกเฉิน มีรายละเอียดต้นทุนประสิทธิผลที่น่าพอใจสำหรับประเทศที่มีรายได้ต่ำถึงปานกลาง*