APACHE II in a Postoperative Intensive Care Unit in Thailand

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Abstract

In order to evaluate the effectiveness of an intensive care unit (ICU), the case-mix has to be considered. This was a cohort study. By using Acute Physiology and Chronic Health Evaluation scores (APACHE II score), we evaluated the case-mix and mortality rate of 282 patients who were treated in our postoperative ICU. The overall mortality rate was 10.6 per cent. Higher Acute physiology scores and emergency surgery in the presence of chronic health status were related to higher mortality, but age was not. However, the original APACHE II model could not precisely predict the mortality of Thai patients. We used stepwise logistic regression to determine the predictors of death and found the prediction model to be -7.24 + 0.37 (APACHE II score) + 1.46 (postemergency surgery). The actual mortality for patients with APACHE II score > 15 in our ICU was higher than that predicted by the original APACHE II model. The causes of this difference might be difference in methodology, characteristics of ICU and the quality of care.

An intensive care unit (ICU) is a very contentious area of medicine, as it involves seriously ill patients, uses expensive drugs and equipment, while producing questionable outcome(1). In developed countries, many research studies have tried to develop scoring systems or models to predict the outcome of intensive therapy patients in order to identify those who will benefit from this kind of therapy. These systems include APACHE (acute physiology and chronic health evaluation)(2,3), patient-disease interaction(4-6), TISS (therapeutic intervention scoring system)(7,8), MPM (mortality prediction model)(9,10). After the result of APACHE II was published in 1985(3), it has been

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widely used and validated both in the U.S.A.[11,12] and in various countries[13,14]. In addition, the capacity of the APACHE II to control case mix in the ICU was considered by some as its most valuable contribution[14], to allow the evaluation of the effectiveness and quality control of an ITU. In Thailand, the resources are much more limited than in developed countries. The major problems that we are facing are a shortage of health care personnel especially nurses, and adequate funding. At Siriraj Hospital, which is a tertiary care, teaching hospital in the capital of Thailand, the Department of Anesthesia is responsible for the 6-bed postoperative ICU. We wanted to audit our quality of care. Therefore, we had to gather information on the severity of our patients, how well they fared, how effective we were compared to other ICUs and how we could use these data to improve our performance.

Objectives

The objectives of the study were :

1. To determine whether variables in APACHE II scoring system are related to the mortality of Thai ICU patients.
2. To find the APACHE II scores of patients admitted to the postoperative ICU of Siriraj Hospital.
3. To find a prediction model in Thai patients.
4. To compare the actual outcome of Siriraj and other hospitals.

Method

This was an observational cohort study. We collected the data from the anaesthetic postsurgical ICU at Siriraj Hospital from October 1991 to April 1992. The data concerned were : APACHE II scores[3] at the time of ICU admission, duration of stay in ICU and the outcome of treatment as survival or death. The diagnosis and type of operation (elective or emergency) were also recorded. The APACHE II score is composed of points for acute physiology (APS), age and chronic health status (severe organ system insufficiency).

The acute physiology score consists of 11 variables assigned from 0 to 4 points, depending on a defined degree of abnormality, the weights for each variable were initially set by a panel of experts and subsequently modified empirically and by statistical analyses[3]. In this ICU, our policy was to deliberately ventilate and sedate patients after major surgery, so the Glasgow Coma Score was considered to be 15 for all patients unless there was a reason for suspicion of CNS problem. Points for age vary from 0 (age less than 45 years old) to 6 (age more than 75 years old). The presence of severe organ system insufficiency adds 2 points if the surgery was elective and 5 points if the patient had emergency surgery. To obtain the estimated probability of death. Knaus et al[3] added the diagnostic category weight to their original APACHE II model to improve their prediction in death rate caused by different types of diseases.

The data of APS, age points, chronic health points and outcome as survived or died were analysed by chi-square test for univariate analysis. The comparison of APS, APACHE II score and duration of stay between those who survived and those who died were done by using the *t* test. Variables were then analysed by logistic regression analysis computed from SPSS/PC version 4.0 with death or survival as the dependent variable. The equation derived from logistic regression analysis provided an estimated probability of death for each patient which was then used with decision criterion to derive a classification matrix[3,15]. By varying criteria from 0.1-0.9 we calculated the sensitivity and the specificity of each model in our data and constructed the ROC curve for each model. We also added the diagnostic category weight from the original APACHE II model to our model to see whether they would improve predictions for variations in death rate caused by different diseases. To compare the outcome of Siriraj and other hospitals, we used the original APACHE II model to predict the mortality in our patients for comparison with our actual mortality[3,11].

RESULTS

Complete data were obtained from 282 consecutive patients who stayed in the ICU for a total of 1,079 days. Thirty (10.64%) patients died during their ICU admission. The APS, APACHE II score, duration of stay and outcome are shown in Table 1. The differences in APS, APACHE II scores and duration of stay between those who survived and those who died were statistically significant ($p<0.001$), while age was not. The stratification of patients and their motality by APS, age, chronic health, types of operation and APACHE II scores are shown in Tables 2, 3, 4, 5, 6 and Fig. 1 respectively. The mortality rate increased signifi-

Table 1. Comparison of APS, age, APACHE II scores and duration of ICU stay between those who survived and those who died. All the differences between these two groups except age are significant at p<0.001 (*)

	Patients who died (mean±S.D) (range)	Patients who survived (mean±S.D) (range)	Total group of patients (mean±S.D) (range)
Age (years)	59.7±19.9	56.3±19.7	56.6±19.8
	(18-88)	(1-93)	(1-93)
APS	10.7±4.3*	4.5±3.2*	5.1±3.9
	(4-20)	(0-18)	(0-20)
APACHE II score	16.6±5.0*	8.1±4.0*	8.8±5.0
	(5-25)	(0-23)	(0-25)
Duration of stay (days)	9.4±7.6*	3.1±5.0*	3.8±5.6
	(1-23)	(1-45)	(1-45)

Table 2. The total number of patients, the number of patients who died and the mortality rate in ICU according to their APS. Mortality rates increased significantly with APS (p<0.0001). (As there was only one patient who had the APS = 20-24, we combined the last two groups for analysis). All differences between each group were significant at p<0.0001, except between group of APS of 10-14 and 15-24 (p = 0.76).

APS scores	Total no. of patients	No.of deaths (% mortality rate)
0-4	143	1 (0.7)
5-9	103	11 (10.7)
10-14	25	11 (44.0)
15-19	10	6 (60.0)
20-24	1	1 (100)
Total	282	30 (10.6)

Table 3. The total number of patients, the number of patients who died and the mortality rate in ICU according to their age groups. There was no significant difference in mortality among patients in different age groups.

Age band	No. of patients	No.of deaths (% mortality rate)
< 44	65	4 (6.2)
45-54	47	6 (12.8)
55-64	58	7 (12.1)
65-74	68	8 (11.8)
> 75	44	5 (11.4)
Total	282	30 (10.6)

Table 4. The total number of patients, the number of patients who died and the mortality rate in ICU according to their chronic health status groups. There was a significant difference in mortality between those with and without severe organ insufficiency when not considering the type of surgery (p<0.0001). However, there was no significant difference in mortality between those who had severe organ insufficiency with elective surgery and those who did not have severe organ insufficiency.

Severe organ system insufficiency	Total no. of patients	No. of deaths (% mortality rate)
Absent	217	14 (6.5)
Present, elective surgery	39	2 (5.1)
Present, emergency surgery	26	14 (53.8)
Total	282	30 (10.6)

Table 5. The total number of patients who died and the mortality rate according to the urgency of operation. There was a significant difference in mortality between those who had elective or emergency surgery (p<0.0001)

Type of operation	Total no. of patients	No. of deaths (% mortality rate)
Elective	204	9 (4.4)
Emergency	78	21 (26.9)
Total	282	30 (10.6)

Table 6. The total number of patients, the number of patients who died and mortality rate in ICU according to their APACHE II scores. There was a significant difference in mortality rates especially among those whose APACHE II scores which were < 9 and those whose scores were > 9 (p<0.0001). It also shows the predicted hospital mortality rate estimated by the original APACHE II model for each range of APACHE II scores.

APACHE II scores	Total no. of patients	No. of deaths	Actual ICU mortality rate (%)	Predicted hospital mortality rate (%)
0-4	43	0	0	3.4
5-9	130	3	2.3	6.2
10-14	69	6	8.7	12.9
15-19	30	13	43.3	23.9
20-24	8	6	75.0	43.4
25-29	1	1	100.0	57.2
Total	282	30	10.6	10.7

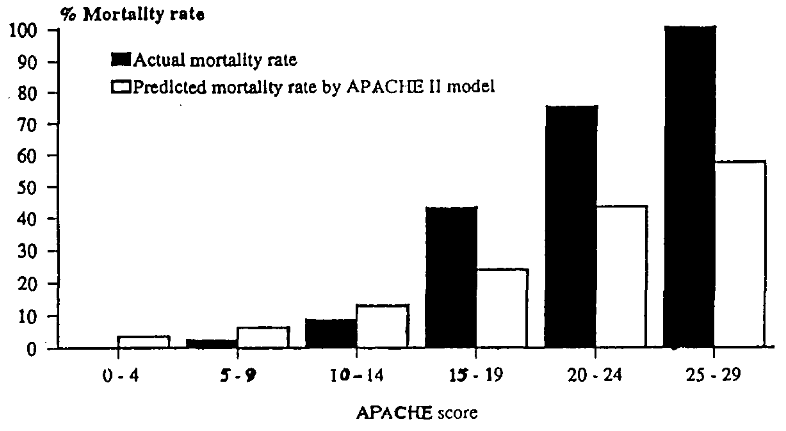

Fig. 1. This figure shows the difference between our actual mortality and the mortality predicted by the original APACHE II model.

Table 7. The complete model when the dependent variable is ICU death and the reference group is the patients who were under 45, did not have severe organ system failure and had elective surgery
Y = -6.36 + 0.37 (APS) + 1.16 (Age 55 to 64) + 1.35 (postemergency surgery), model chi-square = 90.03 and per cent cases correctly classified = 92.55%

Variables	Coefficient
APS	0.3713
Age-between 55 to 64	1.1588
Chronic health status	
severe organ insufficiency and emergency surgery	2.4077
Type of surgery (elective or surgery)	1.3489
Constant	-6.3585

Table 8. The simplified model when the dependent variable is ICU death and independent variables were APACHE II score and post-emergency surgery. The reference group is the same as in Table 7.
Y = -7.24 + 0.37 (APACHE II score) + 1.46 (postemergency surgery), model chi-square = 84.84 and per cent cases correctly classified = 92.55%

Variables	Coefficient
APACHE II score	0.3658
Type of surgery (elective or surgery)	1.4611
Constant	-7.2390

cantly with APS and APACHE II but not with increasing chronological age. There was a significant difference in mortality between those who had elective or emergency surgery (p<0.0001).

The results of multivariate analysis using multiple logistic regression are summarised in Table 7. We found in the complete model that APS, type of surgery (as elective or emergency), chronic health status (only the group of patients who had severe organ insufficiency and were subjected to emergency surgery) and the age group of between 55 to 64 were statistically significantly independent predictors of outcome. When total APACHE II scores and the type of surgery were used in the simplified model as the only 2 independent variables for logistic regression analysis as in the original APACHE II model, both variables were found to be statistically significant-as shown in Table 8. At the criterion of 0.50 which means that every patient with a probability greater than 0.50 is predicted to die, we found that the overall correct classification was 92.55 for both the complete and the simplified models.

Fig 2. showed the Receiver Operator Characteristic (ROC) curves of complete and simplified models both with and without the diagnostic category weight which were not much different from one another while the ROC curve derived from the original APACHE II model was flatter than the others. This means that the original APACHE II model cannot predict well the outcome in our cohorts as also shown in Table 6 and Fig.1 by the marked difference in the predicted mortality rate and the actual mortality especially when APACHE II score was more than 15.

DISCUSSION

Our ICU is a postoperative ICU with 1 consultant anesthesiologist during office hours and at least 1 resident anesthesiologists in the unit during night time. The ratio of nurse : ICU bed was 3:5. We had more patients booked in than beds available and some cases had to be turned away or the planned operations were postponed. Our patients did not include post cardiothoracic, neuro, pediatric and trauma surgery. We had the facilities

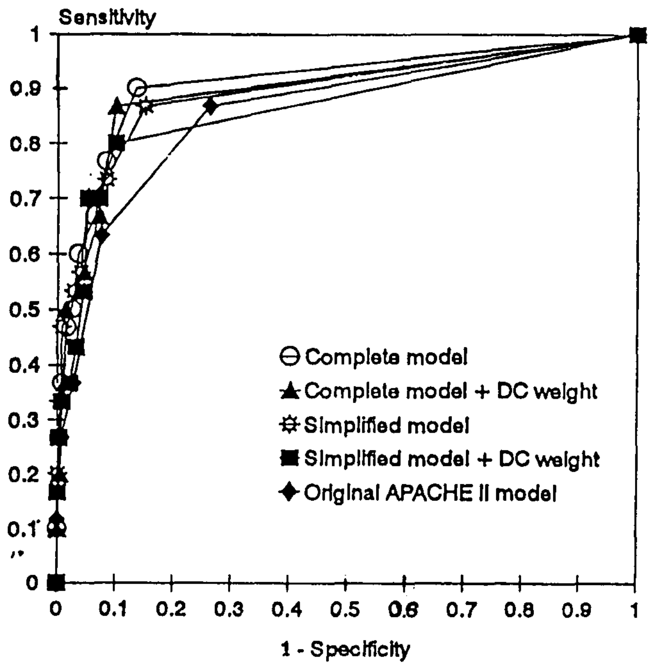

Fig. 2. ROC curves derived by varying the decision criterion using the complete model, complete model plus diagnostic category weight, simplified model, simplified model plus diagnostic category weight, and the original APACE II model.

of bedside EKG, oximetry, pulmonary capillary wedge pressure measurement.

In the study we found that the APS, chronic health point, types of surgery and APACHE II score were significant predictors of outcome in our ICU but the age score was not. We would have needed at least 862 patients to be able to detect the difference in mortality between the patients whose ages were below or equal to 44 (6.2%) and above 44 (11.98%) at alpha = 0.05 and beta = 0.20[16]. Sixty-one per cent of our patients were admitted with APACHE II scores of less than 10, compared with 28.48 per cent of patients in a report from the UK[17]. They were shown to have significantly lower mortality rate than those who scored 10 upwards. This probably reflected our lack of intermediate care or 24 hour recovery unit so the patients who were low risk monitored patients[18,20] were admitted to the ICU. The establishment of an intermediate care or high dependency unit[1,21] would probably be cost-effective in our hospital.

There were some differences in methodology of our study from the original APACHE II study[2]. We collected the first admission scores instead of the worst scores in 24 hours. This is not only for the sake of feasibility of this study in our setting, but also because we believed that to evaluate the effectiveness of a process, a base-line value should be collected at the beginning of that process, i.e., the severity of the patients on admission into the ICU. After the treatment, the outcome will be influenced by the treatment itself so the first admission score seems to be a better measurement for evaluation of effectiveness of treatment while the worst score within the first 24 hours may be a better one for predicting death as it also takes the treatment and the response of the patient to the treatment into account. Although 88 per cent of the worst values over 24 hours in the original APACHE II study were the ICU admission values[3], the difference was believed to affect the predicting ability of the APACHE II scores[22]. Since we reported the mortality of patients with their first admission scores but Knaus et al reported the mortality and their worst admission scores, we would have compared patients at different points of time with Knaus's scores being worse or equal (but never better) to our scores and therefore the evaluation of effectiveness of ICU would be biased against our ICU. When the patient died, he would seem to die with a lower score in our ICU but with a higher score in the original APACHE II study.

We reported ICU death instead of hospital death because we consider it to be a better outcome measurement of ICU performance ; the course of treatment at wards and other problems not related to the need for ICU admission in the first place may affect hospital death. The mortality rate in any ICU also depends on the triage and discharge policy in individual hospital[23]. In our ICU there is a tendency to keep the patients in ICU until they get better or die. The reasons for this are probably our culture and the belief that ordinary ward care is inadequate. However, choosing ICU death as outcome meant that we underestimated the mortality rate because some patients died in wards.

In order to evaluate the performance of our ICU, we used the orginal APACHE II model to predict our mortality rate for each level of APACHE II score as shown in Table 6. We found that it could not predict our ICU mortality well especially when the APACHE II score was more than 15, the predicted mortality rates were much lower than our actual ones. There are several possibilities for this discrepancy. The difference in the methodology of the study as mentioned above might explain part of the discrepancy. Most importantly it might be the result of quality of care, i.e., fewer nurses per ICU bed, less aggressive monitoring and the quality of treatment; if our patients were admitted into the APACHE II study hospitals they might have survived.

Interestingly, it may mean that the predicting value of APACHE II is not consistent when applied across some boundaries. The higher actual/predicted mortality can occur when we attempt to compare ICUs across countries or even among hospitals in the same country because of ICUs' characteristics. Non-operative patients were different from postoperative patients. The original APACHE scoring system was intended to assess the patient independent of therapy[2,3], but the surgical patients almost always have pre-ICU therapy. The treatment that patients received before they were admitted into ICU, their quality and the time interval from those treatments to the ICU admission would affect the admission APACHE II score[19,24], During surgery, the constant attention of anesthesiologists and their objective to maintain the best possible physiological status of the patients will tend to keep the APACHE score lower and less varied[3,19], As our patients were the postoperative ones so the role of anesthesiologist might be one of the factors for lower admission scores[19]. Of note was the fact that sepsis was the diagnosis of nine patients who died in this study. This led us to speculate that nutritional status and infection risk in our patients might not be the same as in devoloped countries ; the "sepsis syndrome" which is a common cause of death in surgical patients is difficult to define and is not addressed directly by APACHE II components[19]. Besides, decisions on whether to operate, and to request or accept ICU care differ between cultures and countries. These considerations led Civetta et al[19] to raise the issue about the limitations of applying the APACHE scoring system to quality assurance and cost containment for postsurgical ICUs.

Indications for ICU admission vary between ICUs. Trauma (operative and non operative), drug overdose and asthma accounted for about half (50.8%) of New Zealand admissions while major vascular surgery, trauma and craniotomy for neoplasm accounted for 24.3 per cent of US admissions[24]. However, the hospital death rates were remarkably similar for US (19.7%) and New Zealand (18%) patients and the actual number of deaths among New Zealand ICU patients did not differ significantly from the number predicted using the aggregate US experience.

The differences in organization (which means the intensity of staff interaction, co-ordination and use of protocols for care) and quality of care were believed to be the explanation of the differences between actual and predicted mortality rates[11]. The difference in mortality rates between 2 ICUs of the Mayo Clinic has been reported to be due to the fact that patients who needed haematology-oncology and hepatology services were included in one ICU although the organization, personnel and treatment prolocols of the two ICUs were similar[12]. They concluded that case-mix must be examined in detail before concluding that differences between actual and predicted mortality are caused by differences in quality of care.

This study was an assessment of the effectiveness of an intensive therapy unit. Apart from answering our objectives, the study of scoring system enabled us to gain insight into the complexity of ICU process, e.g., need postoperative high dependency unit, the influence of anesthesiologists in the pre-ICU period, the appropriateness of ICU admission, the severity and infection risk of our patients and lack of available data for feed back and improvement. We realized that our patients at high APACHE II scores did not fare well compared to the expectation of their counterparts in developed countries. It should raise interest in ICU personnel to answer more clearly what the results of their time, effort and spending are. It can be used to evaluate the improvement of this ICU's performance across time and familiarity with the scoring system is necessary for proper patient comparison in future clinical trials of drugs and new technologies.

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APACHE II ในหออภิบาลผู้ป่วยหลังผ่าตัดในประเทศไทย

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การที่จะสามารถประเมินประสิทธิภาพการรักษาพยาบาลหรือทำนายการตายของผู้ป่วยในหออภิบาลจำเป็นต้องพิจารณาความรุนแรงของโรค. ผู้วิจัยได้ทำการติดตามผลการรักษา โดยบันทึก การคะแนนความผิดปกติทางสรีร, อายุและสุขภาพเดิม ตาม Acute Physiology and Chronic Health Evaluation หรือที่เรียกว่า APACHE Score เพื่อประเมินความรุนแรงและอัตราตายของผู้ป่วย 282 ราย ซึ่งได้รับการรักษาในหออภิบาลซึ่งดูแลผู้ป่วยหลังผ่าตัดในโรงพยาบาลศิริราช. พบอัตราการตายทั้งหมดร้อยละ 10.6 โดยคะแนนความผิดปกติทางสรีรสูงและ การผ่าตัดฉุกเฉินร่วมกับสุขภาพเดิมมีโรคเรื้อรังเป็นปัจจัยทำนายการตายที่มีนัยสำคัญ ส่วนอายุไม่มีนัยสำคัญ. การใช้สมการ APACHE II ของต่างชาติทำนายการตายของผู้ป่วยไทยได้ไม่เที่ยงตรงนัก. จากการใช้ stepwise logistic regression เพื่อหาปัจจัยทำนายการตาย พบว่าได้สมการ –7.24 + 0.37 (APACHEscore) + 1.46 (การผ่าตัดฉุกเฉิน) อัตราตายของผู้ป่วยที่มี APACHE score สูงกว่า 15 ในหออภิบาลที่ศึกษาสูงกว่าที่คาดจากการใช้สมการ APACHE II ของต่างชาติ ทั้งนี้อาจเนื่องจากวิธีการศึกษา, ลักษณะเฉพาะของผู้ป่วยซึ่งเป็นผู้ป่วยหลังผ่าตัดในหออภิบาลนี้และประสิทธิภาพการรักษา

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