Predicting outcome in critical care: the current status of the APACHE prognostic scoring system

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The APACHE (Acute Physiology and Chronic Health Evaluation) prognostic scoring system was developed in 1981 at the George Washington University Medical Center as a way to measure disease severity. APACHE II, introduced in 1985, was a simplified modification of the original APACHE. The APACHE II score consisted of three parts: 12 acute physiological variables, age and chronic health status. Probability of death can be derived by using the disease category and the APACHE II score. The uses of APACHE II include risk stratification to account for case mix in clinical studies, comparison of the quality of care among ICUs, and assessment of group and individual prognoses. APACHE III, a refinement of APACHE II, will be introduced in late 1990. The APACHE III data base includes 17,457 patients from a representative sample of 40 American hospitals. Additional potential uses of APACHE III include the identification of factors in the ICU which contribute to outcome and assistance in individual patient decision-making. This article reviews the development, current uses and potential applications of the APACHE system.

L'APACHE (acute physiology and chronic health evaluation) est un système de gradation pronostique qui s'est développé en 1981 à George Washington University Medical Center afin de mesurer la sévérité de la maladie. APACHE II, introduit en 1985, fut une modification qui a simplifié l'APACHE original. L'APACHE II consiste en trois parties : 12 variables physiologiques aiguës, âge et état de santé chronique. La probabilité de la mortalité peut être déduite en utilisant la catégorie de maladie et le système d'évaluation APACHE II. Les utilisations de l'APACHE II incluent la stratification du risque afin de tenir compte de l'identification des cas dans des études cliniques mixtes, la comparaison de la qualité des soins entre les unités de soins intensifs et l'évaluation des pronostics individuel et de groupe. APACHE III, un rafinement de l'APACHE II, sera introduit vers la fin des années 1990. Les données de l'APACHE III incluent 17,457 patients d'une population représentative de 40 hôpitaux américains. Les utilisations potentielles additionnelles de l'APACHE III incluent l'identification des facteurs aux soins intensifs qui contribuent à l'issue et à l'assistance concernant les décisions sur certains patients. Cet article revoit le développement des utilisations courantes, des applications potentielles du système APACHE.

Key words
INTENSIVE CARE: APACHE, assessment.

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Contents

Recent American data indicate that intensive care unit (ICU) beds account for 7% of all hospital beds, 15–20% of hospital costs and 1% of the gross national product (GNP).[1] Improving therapeutic capabilities and increas-

ing use of monitoring technology have escalated ICU demand at a time of economic constraint and resource limitation. Precise disease classification and accurate outcome prediction can optimize ICU bed usage by reducing unnecessary low-risk monitored-only patients and futile care of terminally ill patients.

The APACHE (acute physiology and chronic health evaluation) prognostic scoring system was developed in 1981 at the George Washington University Medical Center as a way to measure disease severity.[2] The APACHE score was found to correlate directly with hospital mortality. APACHE II, introduced in 1985, was a simplified refinement of the original APACHE.[3] Probability of death can be derived by using the disease category, acute physiological score, age and the chronic health status. The uses of APACHE II include risk stratification, comparison of the quality of care, and prognosis. APACHE III, a refinement of APACHE II will be introduced in late 1990.[4] This article reviews the development, current uses and potential applications of the APACHE system.

Development of the APACHE prognostic scoring system

Although few question the need for ICUs, there is a lack of data to document their effectiveness in improving patient outcome.[5] This is because it is difficult to conduct randomized studies in patients at high risk of dying and, until recently, there was no accurate method to account for case mix in an ICU over time or among different ICUs. Therefore it was difficult to determine if outcome variations were related to therapeutic effort or to a difference in case mix. A severity-of-disease scoring system allows the investigator to risk-stratify patients and compare patient risk from different units.

A conceptual model for the APACHE prognostic scoring system was formulated in 1979.[2] The initial model involved the identification of factors that influence outcome from an acute illness (Table I). APACHE incorporated the three patient factors (disease, reserve, severity) which were treatment-independent. Disease was classified using the primary diagnostic reason for ICU admission. If a specific diagnosis could not be given, then the principle organ system dysfunction precipitating ICU admission was used. Physiological reserve was reflected by age and prior health status. Severity of disease was measured by acute physiological abnormalities, represented by clinical and laboratory measurements available at presentation to the ICU.

TABLE I Factors influencing outcome for an acute illness

Patient factors (before treatment)	*Treatment factors (post-treatment)*
Type of disease	Type of therapy
Physiologic reserve	Amount of therapy
– age	Response to therapy
– chronic disease	
Severity of illness	

The original APACHE consisted of two parts: the APS (acute physiology score) representing the degree of acute illness and CHE (chronic health evaluation) indicating physiological reserve before the acute illness. The APS variables were developed by a panel of physicians from medicine, surgery and anaesthesia. Thirty-four variables were selected and relative weights (0–4) were assigned according to the clinicians' clinical experience and a review of the literature. The greatest degree of abnormality (worst value) of each variable within the first 32 hr after admission was used. The CHE consisted of a questionnaire inquiring about the number of recent physician visits, activities of daily living and the presence of carcinoma. Patients were then classified into A for excellent health to D for severely failing health. The final score consisted of an APS and a CHE (e.g., 25-D). Probability calculations were not part of the original APACHE system.

Results from the initial study group indicated a direct relationship between the APS score and the probability of death. However, with the CHE, only class D was found to be independently associated with mortality. The predictive ability of the APACHE score was subsequently validated in new populations of patients.[6–8] Criticisms of the APACHE included the large number of variables and the 32 hr allowed for data collection. Further analysis and modifications led to the development of the APACHE II.

APACHE II[3] which was introduced in 1985 incorporated a number of important changes. First, the number of APS variables was reduced from 34 to 12 (Figure 1). This was accomplished by eliminating infrequently measured variables (e.g., serum lactate, osmolality) and redundant variables (e.g., BUN). Subsequently, using multivariate analysis, the smallest number of variables that reflected physiological derangement yet maintained statistical precision was found to be 12.[3] In addition, the threshold and weights of variables were modified according to their statistical correlation to hospital mortality. Particularly, the Glasgow Coma Scale was given an increased weight of 12 and acute renal failure was double-weighted with a maximum score of 8. The most abnormal APS values within the first 24 hr of ICU admission were used. Chronic health points were assigned only for severe organ system dysfunction. Nonoperative and emergency surgery were given additional weight and age was incorporated into the APACHE II score.

With these modifications, APACHE II then consisted

THE APACHE II SEVERITY OF DISEASE CLASSIFICATION SYSTEM

PHYSIOLOGIC VARIABLE	HIGH ABNORMAL RANGE					LOW ABNORMAL RANGE			
	+4	+3	+2	+1	0	+1	+2	+3	+4
TEMPERATURE — rectal (°C)	≥ 41°	39°-40.9°		38.5°-38.9°	36°-38.4°	34°-35.9°	32°-33.9°	30°-31.9°	≤ 29.9°
MEAN ARTERIAL PRESSURE — mm Hg	≥ 160	130-159	110-129		70-109		50-69		≤ 49
HEART RATE (ventricular response)	≥ 180	140-179	110-139		70-109		55-69	40-54	≤ 39
RESPIRATORY RATE — (non-ventilated or ventilated)	≥ 50	35-49		25-34	12-24	10-11	6-9		≤ 5
OXYGENATION: A-aDO$_2$ or PaO$_2$ (mm Hg) a. FiO$_2$ ≥ 0.5 record A-aDO$_2$,	≥ 500	350-499	200-349		≤ 200				
b. FiO$_2$ < 0.5 record only PaO$_2$,					PO$_2$ > 70	PO$_2$ 61-70		PO$_2$ 55-60	PO$_2$ < 55
ARTERIAL pH	≥ 7.7	7.6-7.69		7.5-7.59	7.33-7.49		7.25-7.32	7.15-7.24	< 7.15
SERUM SODIUM (mMol/L)	≥ 180	160-179	155-159	150-154	130-149		120-129	111-119	≤ 110
SERUM POTASSIUM (mMol/L)	≥ 7	6-6.9		5.5-5.9	3.5-5.4	3-3.4	2.5-2.9		< 2.5
SERUM CREATININE (mg/100 ml) (Double point score for **acute** renal failure)	≥ 3.5	2-3.4	1.5-1.9		0.6-1.4		< 0.6		
HEMATOCRIT (%)	≥ 60		50-59.9	46-49.9	30-45.9		20-29.9		< 20
WHITE BLOOD COUNT (total/mm3) (in 1,000s)	≥ 40		20-39.9	15-19.9	3-14.9		1-2.9		< 1
GLASGOW COMA SCORE (GCS): Score = 15 minus actual GCS									
[A] Total ACUTE PHYSIOLOGY SCORE (APS): Sum of the 12 individual variable points									
Serum HCO$_3$ (venous-mMol/L) (Not preferred, use if no ABGs)	≥ 52	41-51.9		32-40.9	22-31.9		18-21.9	15-17.9	< 15

[B] AGE POINTS:
Assign points to age as follows:

AGE(yrs)	Points
≤ 44	0
45-54	2
55-64	3
65-74	5
≥ 75	6

[C] CHRONIC HEALTH POINTS
If the patient has a history of severe organ system insufficiency or is immuno-compromised assign points as follows:
a. for nonoperative or emergency postoperative patients — 5 points
or
b. for elective postoperative patients — 2 points

DEFINITIONS
Organ insufficiency or immuno-compromised state must have been evident prior to this hospital admission and conform to the following criteria:

LIVER: Biopsy proven cirrhosis and documented portal hypertension; episodes of past upper GI bleeding attributed to portal hypertension, or prior episodes of hepatic failure/encephalopathy/coma.

CARDIOVASCULAR: New York Heart Association Class IV.

RESPIRATORY: Chronic restrictive, obstructive, or vascular disease resulting in severe exercise restriction, i.e., unable to climb stairs or perform household duties; or documented chronic hypoxia, hypercapnia, secondary polycythemia, severe pulmonary hypertension (*>40mmHg*), *or respirator dependency.*

RENAL: Receiving chronic dialysis

IMMUNO-COMPROMISED: The patient has received therapy that suppresses resistance to infection, e.g., immuno-suppression, chemotherapy, radiation, long term or recent high dose steroids, or has a disease that is sufficiently advanced to suppress resistance to infection, e.g., leukemia, lymphoma, AIDS

APACHE II SCORE
Sum of [A] + [B] + [C] :
[A] APS points _____
[B] Age points _____
[C] Chronic Health points _____
Total APACHE II _____

FIGURE 1 The APACHE II severity of disease classification system.[3]

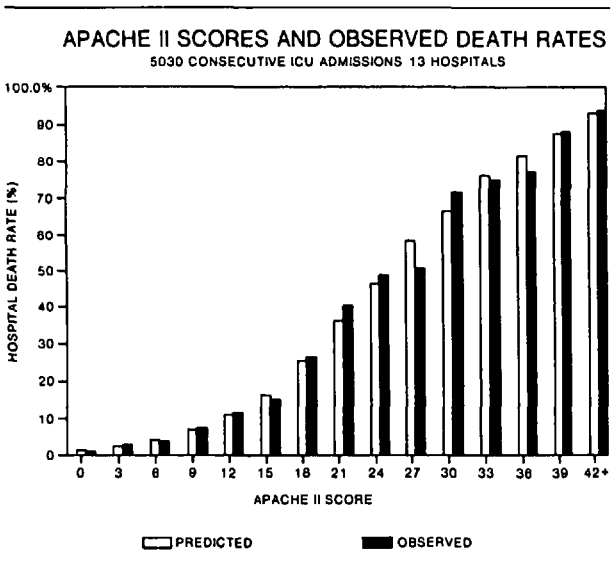

FIGURE 2 The relationship between predicted and observed hospital mortality rate for varying levels of APACHE II scores.[9]

of three parts: APS (12 variables; creatinine: 0–8 points, Glasgow Coma Scale: 0–12 points, other 10 variables: 0–4 points each; maximum 60 points), age points (0–6) and chronic health points (0–5) for a maximum total score of 71. The patients were assigned a specific diagnosis according to the principal reason for admission. Coronary artery bypass surgery patients were placed in a separate category and eliminated from the overall analysis due to their unique situation of high initial APS and very low mortality rate.

The APACHE II system was extensively evaluated in an initial study population of 5815 patients from 13 medical centres.[9] There was a direct correlation between the APACHE II score and hospital mortality (Figure 2). Each three-point increase in APACHE II was associated with an increase in hospital mortality ($P < 0.05$). The overall risk of hospital mortality also varied according to the primary diagnosis. An APACHE II score of ten in patients with septic shock was associated with a higher mortality rate than the same score in patients with acute

TABLE II Calculation of the predicted hospital mortality for an individual patient

$$\text{Ln}(R/1\text{-}R) = -3.517 + (\text{APACHE II} \times 0.146) + D + S$$

where

R = Risk of hospital mortality
D = Disease weight according to relative risk imposed by a specific disease. (range: −3.35 to +0.89)
S = Additonal weight (0.603) for emergency surgery
Ln = Log e

gastrointestinal bleeding. The prime determinants of hospital mortality were the disease category and the APACHE II score.

From multivariate analysis of the APACHE II data, an equation allowing calculation of an estimate of an individual patient's hospital mortality was derived. The three variables necessary for this calculation were APACHE II score, disease category and the presence or absence of emergency surgery as shown in Table II. For example, given a non-operative patient with a diagnosis of sepsis and an APACHE II score of 25, the disease weight (D) is 0.113 and the surgery weight (S) is zero. Using the equation in Table II,

$$\text{Ln}(R/1 - R) = -3.517 + (25 \times 0.146) + 0.113 + 0 = 0.246$$

Therefore, the calculated risk of hospital mortality (R) is 0.561 or 56%. In a large number of ICU patients, the predicted hospital mortality using this equation was shown to correlate closely with the observed mortality (Figure 2).[9]

The accuracy and validity of the APACHE II has since been demonstrated in several studies using independent groups of new patients.[6–8] APACHE thus fulfilled its original objectives of providing an accurate measure of the severity of illness and the ability to predict mortality in an individual or groups in a wide variety of disease categories.

Current uses of APACHE II

Control for case mix

A central problem in conducting clinical studies is the inability to make the control and treatment groups comparable. Randomized allocation will randomly allocate patients but not necessarily the risk of death between the control and treatment groups. For example, in the evaluation of a new therapy for peritonitis, potential patients may include a 15-yr-old with a ruptured appendix and an 80-yr-old with perforated cancer of the colon. Conclusions about treatment efficacy are invalid unless the patients and their associated pretreatment risk can be quantified and evenly distributed between the control and treatment groups. A prognostic scoring system allows the investigator to estimate individual patient risk and thereby determine the exact risk distribution in the two groups.

Knaus[10] conducted a simulated clinical trial of 50 consecutive patients with respiratory failure. Two groups were randomly chosen and their mean values of demographic, clinical and physiological variables were similar. Despite the apparent comparability of the two groups, the mortality rates were 35 and 25%. When APACHE was applied to predict group mortality, values of 37 and 25% were obtained which matched the observed mortality. The use of APACHE to risk-stratify patient groups unmasked the different inherent risk within the two randomized patient groups.

Many groups have used APACHE II to risk-stratify patients in order to control case mix so that appropriate comparisons of therapy could be made. APACHE was utilized in studies that investigated the effect of naloxone infusion in septic shock,[11] the rates of nosocomial pneumonia in intubated patients given sucralfate, antacid or histamine-2 blocker[12] and the ability of topical antibiotics in preventing mucosal colonization and nosocomial bacterial infection.[13] The APACHE system has also been used extensively in assessing different therapies in patients with intra-abdominal sepsis.[14–16]

Quality assurance in ICUs

Comparing mortality statistics in a given ICU over a period of time can be misleading due to a change in patient population. Also it is inappropriate to evaluate the performance among different ICUs based on mortality rates alone.[17] The mortality risks of patients in a tertiary cancer centre and in a suburban trauma centre are very different. Therefore a prognostic scoring system should be used to adjust for the differences in case mix between institutions as well as over time to allow valid comparisons.

Brown,[18] a retrospective study, assessed the ICU mortality in the periods before and after acquiring a new full-time critical care specialist. The distribution and mean APACHE score were comparable between the two periods. There was a 52% ($P < 0.01$) reduction in ICU mortality in the second period. The application of APACHE II to control for case mix allowed the valid conclusion of a real reduction in ICU mortality.

The utilization and outcome of ICUs in New Zealand and the United States were compared in a recent study by Zimmerman.[19] The results indicated a major difference in patient selection between the two countries. Using APACHE II to control for differences in case mix, the mortality rates in New Zealand were found to be comparable to the United States.

In 1986, Knaus[9] evaluated the performance of 13 ICUs in the care of 5030 patients using the APACHE II system. The patients were risk-stratified by their diagnosis and the APACHE II scores. The predicted and the observed death rate for each hospital were compared. There were no significant differences between the observed and the predicted mortality in 11 hospitals. However, one hospital performed significantly better with 40% fewer deaths than predicted and one hospital was significantly worse with 60% more deaths. Analysis of the structure and process of the ICUs indicated the variation in performance appeared to be most related to the interaction and coordination of the hospital staff, rather than the administrative structure, type of therapy and the teaching status of the hospital. The ability to identify superior and inferior performance of ICUs and factors that contribute to such variations have major implications and is currently being addressed in the ongoing APACHE III study.

Non-ICU patients

Can the success of APACHE II in predicting death in ICU patients be extrapolated to a non-ICU setting? A recent study[20] evaluated death rates and the quality of care in 93 American hospitals for patients with four diagnoses: cerebral vascular accident, pneumonia, myocardial infarction and congestive heart failure. Initial analysis revealed 20 hospitals with death rates higher or lower than expected. Using the principles of APACHE II to stratify patient risk, the exact disease and severity at admission were determined for each patient. After these factors were taken into consideration, almost all (70–90%) the variations in expected versus observed death rate among hospitals were accounted for.[21]

At a time of economic constraint, there is increasing interest in evaluating hospital performance by comparing hospital mortality figures. It is important to appreciate that hospital mortality statistics must be interpreted in the light of the severity of illness of the patient population.

Resource allocation

There are two groups of patients whose requirement for ICU admission needs to be scrutinized. The first group of patients are those admitted for low-risk monitoring where active treatment is rarely necessary. The second group consists of severely ill patients whose death will likely ensue regardless of treatment.

About 20–30% of ICU admissions consist of monitoring patients who are extremely unlikely to require active treatment.[22,23] These patients are admitted for conditions such as post-neurosurgery, peripheral vascular surgery, drug overdose or syncope. An objective method to identify low-risk patients might be useful in triage situations where bed availability is limited.

TABLE III Low-risk thresholds for APS of APACHE II

Primary category of ICU admission	*APS level at which an initially monitored ICU admission is at <10% risk of requiring subsequent active treatment*
Postoperative elective surgery	≤14
Postoperative emergency surgery	≤8
Nonoperative	≤4

Wagner[24] studied 1941 monitored-only patients admitted to ICUs. One thousand three hundred and fifty-eight (70%) were predicted to have less than a 10% chance of requiring active treatment based on a multivariate logistic regression equation using the APS score, surgical status and diagnostic category. Only 58 (4.3%) of these predicted low-risk patients received treatment, none for life-threatening problems. Wagner established low-risk APS threshold for the three main diagnostic categories (Table III). For example, a postoperative elective surgical patient with an APS score of 14 or less was predicted to have a low risk of requiring active treatment. The low risk APS threshold can provide a useful objective criterion to prioritize ICU admissions.

At the other end of the spectrum, there is the group of severely ill patients requiring burdensome intensive treatment yet have little chance of recovery.

Knaus[25] studied prospectively the prognosis of patients with acute organ system failure (OSF) in 5677 ICU admissions. They found a strong correlation between mortality and the increase in number and/or duration of OSFs. Mortality for 99 patients with greater than three OSFs persisting for more than three days was 96% (Figure 3). Using the equation derived, the next patient who has ≥3 OSFs for the fourth day has a predicted mortality of 96 ± 5%. Can this information be applied to an individual patient? First, estimates of individual outcome demand great precision, especially when they are used to supplement clinical decisions to withdraw therapy. Secondly, the number of patients upon which these outcome estimates are based is important. Statistically it is impossible to be certain whether a patient will die based on information only from records of past patients. As the data base upon which these estimates are based expands, the confidence level of prediction will narrow and the ability to discriminate survivors from non-survivors will improve.

Computer versus clinicians

Numerous studies have compared clinical judgement with statistical prediction using prognostic scoring systems.

HOSPITAL MORTALITY ACCORDING TO NUMBER AND DURATION OF ORGAN SYSTEM FAILURE

Number of OSF		Day of Failure 1st	2nd	3rd	4th	5th	6th	7th
1	Percent Mortality*	22%	31%	34%	35%	40%	42%	41%
	No. Deaths	450	261	204	159	142	118	80
	No. Patients	2070	847	607	455	356	279	195
2	Percent Mortality*	52%	67%	66%	62%	56%	64%	68%
	No. Deaths	239	147	103	118	96	78	56
	No. Patients	458	219	156	191	171	122	82
≥3	Percent Mortality*	80%	95%	93%	96%	100%†	100%†	100%†
	No. Deaths	152	70	50	50	38	33	32
	No. Patients	191	74	54	52	38	33	32

*To calculate confidence level: 95% confidence level (± 2 standard deviation [std. dev.])

1 std. dev. = $\sqrt{N P Q}$
N = total number; P = percent death rate; Q = 1 − P

For a patient with ≥3 OSF on the 4th day of OSF,
N = 52, P = .96, Q = .04; therefore, 1 std. dev.
= 1.4 and 1.4/52 = 2.7%, so ± 2 std. dev. = 96% ± 5.4%.

Therefore, the next patient to have ≥ 3 OSF on the 4th day of OSF has a projected death rate from 90.6 to 100%.
(Use of poisson distribution yields equivalent results)

FIGURE 3 Hospital mortality according to the number and duration of organ system failure (OSF). Columns indicate the number of days with OSF and rows indicate the number of OSFs. The hospital mortality in percentages are shown in the rectangular boxes.[25]

Kruse[26,27] and McClish[28] compared the accuracy of mortality prediction using APACHE II scores with clinical assessment by critical care physicians and nurses. Both studies found no differences in accuracy between the two methods. The ability to predict death based on clinical assessment was compared with computer analysis of daily APACHE II values and the number and duration of OSFs.[30] The computer model was shown to be more accurate and specific than clinicians in predicting death. Larvin[29] found APACHE superior to other prognostic scoring systems and to clinical judgement in predicting organ system failure and complications in acute pancreatitis.

Outcome prediction by prognostic scoring systems appears to be at least as good as, and occasionally superior to, clinical judgement.

Individual patient decisions

Can the APACHE II prognostic scoring system be useful in making individual patient decisions? Although the outcome predictions with prognostic scoring will never be entirely accurate, we believe a risk estimate for death of 80–95% with narrow confidence limits can be useful to the clinician.

Let us consider the frequent argument that group statistics do not apply to a single individual patient. Individual prognostic estimates derived from a scoring system provide an objective risk assessment based on statistics of past patients with the same diagnosis and similar degree of illness. Clinicians frequently make treatment decisions based on subjective past experiences. It has been demonstrated that physicians' estimations of patient outcome is altered by a number of biases.[32] It is difficult for a physician to determine if a particular patient is representative of a past group of patients; his judgement is disproportionately influenced by recent experience; and he may be anchored in his initial-risk estimate and fail to adjust it with subsequent data. A properly constructed prognostic scoring system can overcome these biases. Thus, in comparative studies of outcome prediction, prognostic scoring systems have been shown to be as least as good as and occasionally superior to clinical judgement.[26–30]

Chang[33] used the APACHE II score predicted mortality to identify patients who would not benefit from total parenteral nutrition (TPN). Patients referred for TPN were predicted to live or die based on an equation using their admission and subsequent APACHE II scores.

Clinical decisions were not influenced by the patients' outcome predictions. In a group of 26 patients, all eight predicted to die died. Of the 18 patients predicted to live, seven died. Since the positive predictive value (PPV) for death was 100%, it was suggested that TPN could be withheld from the eight patients predicted to die without affecting their eventual outcome.

With a similar methodology, Dobkin[34] used the APACHE II predicted mortality to identify patients who would not benefit from haemodialysis. In a group of 146 patients referred for haemodialysis, using a risk criterion of >70% on the first day of dialysis, all 35 patients predicted to die died. The PPV for death was 100%. The author suggested that if dialysis were withheld from this group of patients this would not change their outcome but would achieve considerable cost reduction.

Chang[35] proceeded to study the prediction of outcome based on computerized analysis of the absolute value and the rate of change of daily organ failure scores. Organ failure scores were derived from APACHE II scores modified by the number and duration of organ system failure (Figure 4). Predictions by the model were not used to influence clinical decisions. Eight hundred and thirty-one ICU patients in Saudi Arabia were subjected to analysis. Of 109 patients predicted to die, all died. Of the 722 patients whose outcome predictions were unknown, 181 died. There were no false positive predictions of death.

Advancement in computerized ICU data entry and analysis has made rapid availability of patient prognostic estimates a clinical reality. Physicians may make clinical decisions based on objective prognostic estimates in addition to their clinical impression.

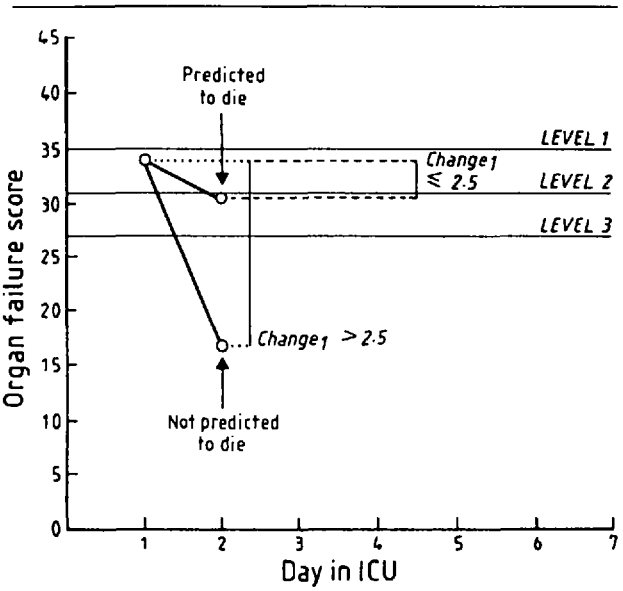

FIGURE 4 ICU patient outcome prediction using trend analysis of organ failure score (OFS) over time.[31] Based on computerized trend analysis of OFS from a criteria defining group of 100 patients, absolute values and patterns of change of OFS were established that allowed prediction of survivors and non-survivors. Here, level 1, level 2 and level 3 corresponded to OFS of 35, 31 and 27. For 731 patients studied prospectively, those with a day one score >35 (level 1) were predicted to die. For patients whose day one scores were between 35 (level 1) and 31 (level 2) and the day two score decreased by less than 2.5, they were also predicted to die.

Future uses

APACHE III

Although APACHE II has been used and validated internationally and has yielded accurate estimates of patient outcome, there is still room for improvement. The current development of APACHE III is being undertaken with the following objectives:

1 to improve the statistical predictive power of the APACHE score by redefining the variables and their weights in the APS score and by improving the precision of disease classification;[36]
2 to identify and quantify the factors in ICU care that contribute to the variations in ICU outcome;[37]
3 to obtain a large nationally representative data base from which individual outcome prediction with narrow confidence limits can be based.[38]

In 1988 and 1989, 17457 consecutive ICU patients were collected from 40 American medical centres, 26 of which were randomly selected to be representative nationwide. The major changes of the APACHE III are outlined below.

APS

In an attempt to improve the statistical power of the APS, five new physiological variables (albumen, bilirubin, glucose, BUN, urine output) have been added and the thresholds and weights of existing variables changed. The predictive accuracy of APACHE II will serve as a standard against which this new version will be measured.

TIMING

Currently the most abnormal physiological measurements recorded in the first 24 hr in the ICU are used. These measured values are treatment-dependent.[39] Appropriate treatment will decrease the APACHE score. Also the amount of time that patients are treated in the emergency room before transfer to ICU could affect the ICU APACHE score.[39,40] APACHE III will address these issues by comparing the admission and worst 24 hr ICU data and by incorporating the origin of the patient before ICU transfer in the analysis. Daily ICU APACHE data up to seven days as well as on the day of ICU discharge are also collected.

CHS

The role of age, comorbidity (assessment of organ dysfunction) and functional health (activities of daily living) will be assessed and their relationship to outcome determined.

DISEASE

The reliability and accuracy of outcome prediction is dependent on the precision of disease classification. APACHE III will increase the number of specific diagnostic categories to improve the homogeneity within each diagnostic group.

PROCESS OF CARE

From 1985, the analysis of outcome from 13 ICUs indicated that the variation in performance is related most to interaction and coordination of the hospital staff. In APACHE III, ICU organization and management issues such as staff communication, coordination, conflict resolution and job satisfaction are evaluated in each hospital initially by questionnaires to ICU staff and subsequently by an on-site team visit. The ICU factors identified to be correlated to outcome may have a major impact on improvement in the effectiveness of ICU care.

INDIVIDUAL PATIENT DECISIONS

With a large nationally representative data base and a more precise disease classification system, outcome prediction with narrow confidence limits can be achieved. For the low-risk monitoring group mentioned previously, APACHE threshold values can be established to help with triage decisions. For severely ill patients with little chance of recovery, predicted individual outcome based on data from patients with the same diagnosis and degree of illness can be used to support the clinician in making difficult but increasingly unavoidable patient care decisions.

Prediction over time

Chang[30] utilized a computer model based on trends of daily APACHE II scores and OSFs to predict patient outcome more accurately than with day one score alone. Larvin[29] showed that the APACHE II score at 48 hr was more accurate than the admission score in predicting outcome in acute pancreatitis. Wong[41] showed that an APACHE II score of 10–19 on ICU days three to six was associated with a higher hospital mortality than when the same score was obtained on day one. Bion[42] also demonstrated that analysis of proportional change of Sickness Score (modification of APACHE II) over time enhanced the power to predict outcome. It is intuitively obvious that normalization of physiological variables indicate effective therapy or a reversal of disease processes while worsening of physiology implies the opposite. Thus, both the absolute value of the APACHE score and its rate and degree of change over time are important in outcome prediction. The best criteria in predicting outcome by evaluating APACHE score over time has yet to be established.

Automation

Most of the physiological data (e.g., heart rate, blood pressure, respiratory rate) are available from ICU monitors and most of the laboratory data (haemoglobin, PO_2, creatinine) are available from computerized laboratory systems. By electronically interfacing with the ICU monitor and the laboratory system, the APS can be entered automatically into the computer. With automated patient data entry, the APACHE score and individual patient risk prediction can be made available to the clinician daily in a printout similar to a laboratory report. An automated APACHE III data management system is expected to be available in early 1991.

Conclusion

Since its introduction in 1981, the APACHE prognostic scoring system has gained acceptance as a measure of disease severity and in outcome prediction. It has been used extensively in controlling for case mix in clinical studies and assessing quality of care among ICUs. In the future, the APACHE system will produce individual prognostic estimates that could be used to assist clinicians in deciding ICU admissions, discharges, therapeutic changes and withholding or withdrawing life support.

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