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Audit in intensive care. The APACHE II classification of severity of disease

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SUMMARY

The Acute Physiology and Chronic Health Evaluation System (APACHE II) was used in 451 patients admitted to the intensive care unit, Belfast City Hospital, in 1988 and 1989. Mortality in the patients studied was 15·5% which is slightly less than that predicted for patients with equal severity of disease (18·8%). Within the limitations discussed the APACHE II system has valuable potential both in terms of predictive power and as a means of audit.

INTRODUCTION

The need for a reliable means of predicting outcome in intensive care units was pointed out in this unit 10 years ago.[1] The Acute Physiology and Chronic Health Evaluation (APACHE) system was introduced by Knaus and colleagues about that time but required the collection of large amounts of data, and was later simplified to APACHE II (pronounced Apache Two). This depends on 12 physiological variables derived from vital signs and standard laboratory blood tests to determine the acute severity of disease, and combines this with the patient age and the presence of severe chronic diseases to create a risk severity score that normally varies from 0 to 50. A high score at the time of admission to intensive care implies a higher acute risk of death. The undoubted popularity and widespread use of APACHE II are due to its relative simplicity in terms of data collection and the availability of computer software to simplify analysis of data. The aim of this study was to validate APACHE II for our patient population and to compare our overall mortality with that predicted by the computer programme.

METHODS

From 1st January 1988 to 31st December 1989 636 patients were admitted to the intensive care unit, of which 451 were included in this study. Those excluded were patients discharged in 24 hours or less (132), those who died within a few hours of admission (25), and those in whom data collection was inadequate (28). Biographic and administrative information was recorded, and the "worst over 24 hours" physiological data required for entry at the computer keyboard collected. The bulk of data collection and all keyboard entries were performed by the authors. Data collection in 1988 was restricted to the first day only (214 patients) and in 1989 daily or alternate day assessments were made where it was considered appropriate. (80 out of 237 patients). Day to day changes in scores

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are reputed to reflect the changing patterns of illness which affect patients in intensive care. The software was APACHE II Version 1.0 (1986) supplied by Knaus and colleagues, Intensive Care Research Unit, the George Washington Medical Center, Washington DC, and was run using an IBM compatible Hewlett Packard Vectra personal computer with a 20 Mbyte hard disc. Depending on the admission data, the programme divides patients into an active treatment group (which includes those who require artificial ventilation, vasoactive drug infusion, aggressive intravenous fluid or blood replacement, and many other interventions), or a monitor group. Monitor patients with a less than 10% predicted risk of active intervention are called low-risk monitor patients while those with a greater than 10% risk are labelled high-risk monitor patients.

RESULTS

Of the 451 patients studied, 158 (35%) were female; the age range was 16–91 years, mean 58·2 years. Details of the admission groups, first day APACHE II scores and number of deaths are shown in Table I. Seventy patients died, 66 in the unit, four after transfer to the ward; the interval between transfer and death was one day to three months. Four patients in the high-risk monitor group eventually required active therapy and two subsequently died. The mortality in the intensive care unit was 13·7% and the overall mortality 15·5%. This compares with a predicted hospital death rate of 18·8% using a computer derived multiple logistic regression analysis of mean APACHE II scores which requires a minimum number of 200 patients. Table II shows a general breakdown of admissions into broad diagnostic groups and some of these are considered in more detail.

TABLE I

Patients entered into the APACHE II study 1988–89. Mean first day APACHE II scores reflect group severity of illness

Admission group	*No*	*Mean first day APACHE II score (± SD)*	*Range*	*Deaths*
Active treatment	327	16·6 ± 6·6	2–41	68
High-risk monitor	36	14·0 ± 6·4	5–32	2
Low-risk monitor	88	8·4 ± 4·7	0–22	0
All patients	451	14·9 ± 4·7	0–41	70
Active treatment on admission — died	68	23·7 ± 6·6	9–41	68
Active treatment on admission — survived	259	14·7 ± 6·5	2–33	0

Vascular surgery. This comprised a major part of the work of the unit and of the 123 patients, 69 had surgery to repair abdominal aortic aneurysms. Thirty-two operations were elective and there were two deaths, one following graft infection (which led to a review of antibiotic policy in these patients), the other in a confused elderly man who removed his naso-gastric tube on return to the ward and

TABLE II

A breakdown of admissions into diagnostic groups with percent of total admissions in each group, mean APACHE II scores and number of deaths for each group

Admission group	*No (% of admissions)*	*Mean APACHE II score (± SD)*	*Deaths (% of group)*
Vascular surgery	123 (27)	13·3 ± 6·0	10 (8)
Abdominal and renal surgery	93 (21)	14·9 ± 5·8	15 (16)
Medical and self-overdose	88 (20)	18·3 ± 7·9	28 (32)
Trauma (multiple and head only)	49 (11)	14·7 ± 8·3	8 (16)
Thoracotomy (lung or oesophageal neoplasm)	37 (8)	8·7 ± 3·4	0
Renal failure (primary reason for admission)	17 (4)	18·4 ± 5·6	1 (6)
Sepsis (primary diagnosis)	9 (2)	24·7 ± 6·8	3 (33)
Postoperative respiratory failure	22 (5)	10·9 ± 3·3	2 (9)
Post cardiac arrest	6 (1·3)	22·2 ± 10·4	3 (50)
Others	7 (1·6)	9·3 ± 4·6	0

aspirated gastric contents. The figures for ruptured aortic aneurysm (Table III) do not truly reflect the disastrous consequences of this disease. Here, mean APACHE II scores were substantially higher than in elective cases; the patients spent much longer in intensive care, and while only four deaths are listed, six others occurred in the first few hours after admission and are therefore not included in the analysis, while six more died on the operating table. Aorto-femoral grafting was performed in 30 patients (3 deaths) and carotid endarterectomy in 16 (two suffered major stroke).

TABLE III

Numbers of patients undergoing certain procedures or satisfying selected diagnostic categories with mean APACHE II scores and the number of deaths

Diagnosis	*No*	*Mean APACHE II score (± SD)*	*Deaths*
Elective abdominal aortic aneurysm	37	12·7 ± 4·6	2
Emergency ruptured aortic aneurysm	32	17·4 ± 6·8	4
Respiratory infection	17	18·5 ± 7·3	6
Chronic obstructive airways disease	9	21·8 ± 8·0	1
Head trauma only	12	18·1 ± 11·1	6
Self-overdose	10	19·7 ± 8·6	3
Intracranial haemorrhage	7	21·4 ± 4·0	7

Abdominal and renal surgery. The 16% mortality in this group is an indication of the seriousness of intra-abdominal disease in elderly patients and the continuing high mortality in those with peritonitis and sepsis from perforation or rupture of bowel is to be noted. Sixty-six percent of these operations were emergency.

Medical and self-overdose. This is a heterogeneous group of patients suffering from such diverse complaints as respiratory infection, chronic obstructive airways disease, asthma, leukaemia, neurological problems including intracranial haemorrhage, and self overdose. APACHE II scores are high and the mortality in some of the sub-groups is also high (Table III). Some of these patients suffered from progressive pulmonary disease which proved to be irreversible; others developed infection due to immunosuppression. Remarkably, survival from acute infection in patients with chronic obstructive airways disease is good; this is presumably due to careful assessment of the likely outcome before agreeing to admission. Twenty percent of all admissions were patients with medical problems, and their illnesses which were often protracted occasionally put a considerable strain on the smooth running of the unit. Surgeons were unable to do elective operations and this led to frustration and criticism. One partially tetraplegic patient with severe respiratory problems occupied a bed for 174 days before being discharged home to continue a regimen of oxygen and suction.

Trauma. Of 37 patients admitted with multiple fractures, some associated with severe chest trauma and multiple rib fractures, only two elderly patients died. In contrast, when trauma was confined to the head, six out of twelve died.

Renal failure. This hospital is the Regional Centre for nephrology. Seventeen patients were admitted with a primary diagnosis of renal failure, many being referrals from other hospitals. A total of thirty-one patients required haemodialysis or ultrafiltration, while a further seven patients were managed with peritoneal dialysis only.

General management. Almost all patients received additional oxygen. Mechanical ventilation was employed in 240 patients (53%) for periods varying from hours to many days. An additional 30 patients required airway support using continuous positive airway pressure by mask, or in a few cases endotracheal intubation or formal tracheostomy, so that a total of 270 patients (60%) received some form of airway management. This figure would be even higher but for the liberal use of thoracic epidural analgesia to provide post-operative pain relief in many patients who had had either major abdominal surgery, thoracotomy, or were suffering from multiple fractured ribs. In the three final categories in Table III a number of patients were declared brain dead; six became kidney donors and one a multiple organ donor.

DISCUSSION

The aims of this study were to assess our performance and to validate the APACHE II system. We had initial problems with the software which were resolved (Appendix). The programme required us to convert SI units to traditional units for blood gas tensions and serum creatinine. The APACHE II system was originally developed for quality assurance on the day of admission using "worst over 24 hours" values. It was based on a study of treatment and outcome of 5030 patients

in 13 intensive care units in the United States, and from that study the predicted death rate according to the mean overall APACHE II score was calculated for a wide range of mean scores.[2] Our predicted death rate was only 15·5%. Although a mathematical prediction cannot be entirely precise, Knaus and colleagues did comment on the wide difference in mortality rates between hospitals. In one well staffed unit the senior nurse on duty had the power to cancel elective major surgery if adequate unit nursing was not available, and the mortality there was 41% less than predicted. We have adopted this principle. In another hospital where there was chronic under staffing and poor communication between physicians and nurses, mortality was 58% greater than predicted. The number of non-operation (medical) cases may also have an effect on prediction since the same authors noted that when medical and surgical patients with similar scores were compared, mortality in the former was twice as high. The numbers in our groups were too small and the mean scores too varied for us to confirm this assertion. Overall, using these criteria, we judge our performance as slightly better than the USA average.[2] First-day APACHE II scores cannot be used to make individual outcome predictions although they may be of value in making group analyses according to the particular disease process being studied. Trend analysis on a day-to-day basis is much more useful, and it was evident in our 80 patients subjected to trend analysis that a rapid rise in the daily score to levels greater than 30 was usually a poor prognostic sign, while a quick fall in score was most likely to be reflected in a satisfactory outcome.

The Riyadh group[3,4] have claimed relative success in using computerised trend analysis of daily scores corrected for organ system failure to identify with some certainty those patients least likely to survive. Unfortunately, such systems are fallible, and the Figure shows a plot of daily scores in two successive patients (uncorrected for organ failure) where those criteria would have predicted one

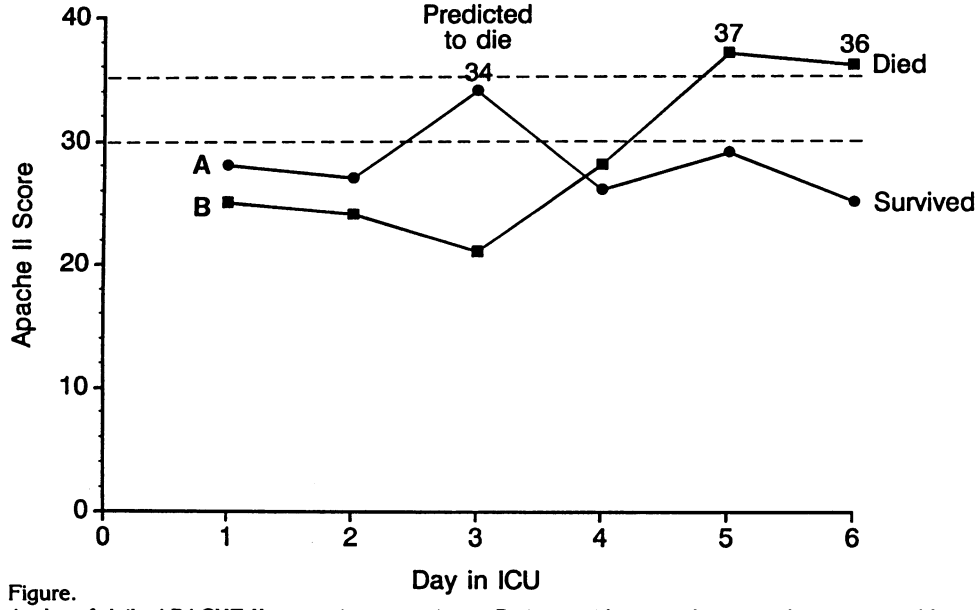

Figure.
A plot of daily APACHE II scores in two patients. Patients with scores between the interrupted lines (30–35) are likely to die while patients with scores greater than 35 are almost certain to die. Patient A deteriorated initially but ultimately survived. Patient B appeared to improve but subsequently died.

patient to die, the other to survive; in fact the converse was true. No patient admitted with a first day score greater than 33 survived, but the dangers of computer-based predictions which influence therapy are well recognised, since they may lead to therapeutic nihilism and therefore be self-fulfilling. The alternative argument is that needless and futile prolongation of life in patients with end stage disease is just as undesirable. One group of workers have indicated that clinical observation is as accurate as machine-based figures in deciding whether the patient will survive his illness.[5]

Interpretation of the Glasgow coma score is of critical importance in obtaining accurate figures for APACHE II. The Glasgow coma score can vary from 3 (worst possible) to 15 (normal), and the difference from normal is added to the APACHE II score. The lowest score given to a fatal outcome (9) was in a patient admitted with intracranial bleeding who died within 48 hours; it seems evident that an over-optimistic Glasgow coma score was given to this patient which resulted in a misleadingly low APACHE II score. We have noted that young patients who have suffered catastrophic intracranial bleeding score relatively low on the APACHE II system simply because the Glasgow coma score is the only abnormal parameter when cardiovascular, respiratory and renal systems are being supported as effectively as possible while brain-stem function is being tested with a view to seeking permission for organ retrieval (Table III). Heavily sedated patients or those curarised with muscle relaxants may also be given an inappropriately low Glasgow coma score when underlying brain function is near normal. It is our practice in these cases, where neurological assessment is difficult, to award a normal or near normal Glasgow coma score to reduce the chance of producing a misleadingly high APACHE II score.[6] The recent report on intensive care units by the King's Fund panel received general approval.[7] They correctly identified the major problem areas of costs and benefits, the need for individual and collective responsibility, and the requirement for proper audit procedures and prospective research. They have had a major input into the Intensive Care Society's UK APACHE II study which was completed in 1990 with 11,000 patient data sets. The American intensive care physicians have also expanded their data base (Knaus and colleagues, personal communication) which should give ample opportunity for comparison of the American and United Kingdom intensive care populations. Published reports[6] indicate a distinct difference between the United States and Saudi Arabia in terms of reasons for admission to an intensive care unit and the presence and type of severe chronic disease which may be observed. Whatever the outcome of these studies, we can expect to see a fine tuning of the APACHE system in the future. Modified systems are available for developing countries using clinical data only, where biochemical analyses are either unreliable or unavailable.[8]

Finally, consideration should be given to the long-term future of those patients who survive their experience in an intensive care unit. The expectation of life to one year seems to lie between 60–75%,[9, 10] with further survival after one year being almost the same as for the general population, and the quality of life determined by the health status prior to the acute illness. Other workers have reported a much higher mortality associated with intensive medical care in a predominantly geriatric patient population, but again emphasise that quality of life before admission is an important predictor of survival from critical illness and of the subsequent life-style.[11]

We have looked at one method of monitoring the quality of care, but have not touched on the question of "production costs", or the financial implications of intensive care. In a recent editorial [12] Knaus made the point that few if any doctors received training in outcome prediction, cost efficiency and quality of life assessment, and yet these issues may be among the most important considerations for meeting the challenges of tomorrow.

APPENDIX

Initial problems with the software were due to computer illiteracy on the part of the operators. In addition, the 'Backup' function on the 5¼" disc was unreliable so that information was not stored on hard disc and copies could not be made. These problems were resolved by writing two short programmes in MS–DOS which allow 'backup' and 'restore' functions to operate. These difficulties may well be historical, since an updated version is now available, and APACHE III will be available in late 1990.

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