The predictive ability of the Acute Physiology and Chronic Health Evaluation (APACHE II) score for mortality in the Intensive care unit in Kimberley hospital.

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1. Abbreviations

ICU	Intensive Care Unit
KHC	Kimberley Hospital Complex
APACHE	Acute physiology and chronic health evaluation
GCS	Glasgow coma score
SIRS	Systemic inflammatory response syndrome
APS	Acute physiology score
CHE	Chronic health evaluation
ETOVS	Ethical Committee of the University of the Free State

2. Introduction

Kimberley Hospital Complex is a provincial hospital with 583 beds (excluding the rehabilitation centre, West-End psychiatric unit and Galeshewe Day Hospital). The hospital serves as a referral hospital for the Northern Cape Province. Currently the hospital is served by a 10 bed multidisciplinary ICU. In 2004, 553 patients were admitted to ICU of which 120 died (21.6% mortality rate). In 2005, 550 patients were admitted of which 142 died (25.8% mortality rate).

As the ICU at KHC at present has no official admission protocol and only limited Intensive Care beds, ways have to be looked at to determine patients best fit to benefit from ICU care. Considering the prognostic index of the APACHE II score could possibly be of use to determine whether patients below a certain score would benefit from ICU care.

The high complexity features of intensive care unit services and the clinical situation of patients themselves render correct prognosis fundamentally important for family, physicians, hospital administrators, fund providers and controllers. (Chiavone 2003, 121(2): 53-57) Prognostic indices such as APACHE II have been developed for estimating hospital mortality rates for patients hospitalised in ICU, based on demographic, physiological and clinical data. Score based prediction of mortality may be used for quality of care (Markgraff, 2001: vol 5(1):31-36).

The APACHE II index consists of a score that takes account of patient's age, chronic health condition and physiological variables (internal temperature, heart rate, respiratory rate, respiratory rate, oxygenation, arterial pH, sodium, potassium, creatinine, hematocrit, white blood cells and GCS).

Although APACHE II was one of the first systems described, it is still the most widely used of all of them, insofar the data required for its calculation is simple, well defined, reproducible and collected on a routine basis during intensive service revision.(Markgraff, 2001: vol 5(1):31-36).

3. Problem statement

It has long been recognised that the physiological response of a patient to a stress or disease process will largely determine the outcome. To an extent this will depend on the extent of the shock and injury, but the physiological reserve of the individual is also important. (Webster 1999:386-393).

Factors increasing the risk of death during intensive care include the following:

- Increasing age
- Greater severity of acute illness
- History if severe clinical condition
- Emergency surgery immediately before admission
- Clinical condition necessitating admission

The systemic inflammatory response syndrome (SIRS) is a clinical response to an inflammatory or traumatic stimulus of unspecified aetiology (Talmor,1999,134:81-87). As defined by the American College of Chest Physicians/Society of Critical Care Medicine consensus conference in 1992, SIRS is diagnosed if 2 or more of the following criteria are met:

- Temperature more than 38°C or less than 36°C
- Heart rate more than 90 beats per minute
- Respiratory rate more than 20 breaths per minute or PaCO2 < 32 mmHg
- White cell count more than 12 x 10^9/l or less than 4 x 10^9/l or the presence of more than 10 immature bands

The consensus also stipulated that these changes should represent an acute alteration from baseline in the absence of other known causes for such an abnormalities e.g. Chemotherapy induced leucopoenia.

In order to understand the difference between SIRS, sepsis, severe sepsis and septic shock the definitions were clarified at the consensus conference.

- *Sepsis:* Criteria for SIRS have to be met in the presence of a documented infection site (documented by positive culture for organisms for that site). Blood cultures do not need to be positive (Stapczynski,2006).

- *Severe sepsis:* Sepsis associated with organ dysfunction, hypoperfusion abnormalities (e.g. Lactate acidosis, oliguria or acute alteration in mental status) or hypotension (systolic pressure < 90 mmHg).

- *Septic shock:* Sepsis-induced hypotension despite fluid resuscitation plus hypoperfusion.

These diagnostic criteria were established via consensus rather than quantitative study, but subsequent investigations have validated their usefulness in predicting groups of patients with an increased risk of mortality (Talmor,1999,134:81-87).

SIRS criteria has been proven to be a useful predictor of outcome in surgical, non-surgical, infective as well as non-infective disease. Logistic regression analysis confirmed that SIRS score was a significant independent predictor of increased mortality in trauma patients (Napolitano,2000,647-653). The consensus sepsis severity criteria can also be applied to non-infective SIRS, defining a population subset with similar high mortality and organ dysfunction incidence, although with greatly heterogeneous aetiologies (Hernandez, 1999,1339-1344).

Despite advances in diagnostic and therapeutic intervention, the mortality rate associated with sepsis remains high, especially among those who develop shock and/or organ dysfunction (Chen,2006; vol 23:281-285).

SIRS, sepsis, severe sepsis and septic shock are major reasons for ICU admission and leading causes of mortality in non-coronary ICU's (Arabi, 2004). Since the description of sepsis by Schotmuller in 1914 the amount of knowledge available on sepsis and it's pathophysiology has substantially increased (Brause,2005). Up till now however it has not been possible to significantly reduce the mortality rate of septic shock, which is as high as 50-60% worldwide (Brause,2005). In the United States on America, there are approximately 400 000 cases of sepsis or SIRS and 200 000 cases of septic shock each year. Sepsis is estimated to lead to 100 000 deaths each year, making it the thirteenth most common cause of death in the USA (Arabi, 2002).

According to the 1996 World Health Organization Health Report, infectious and parasitic diseases caused 17 million out of 50 million deaths globally (including 3.4 million deaths from lower respiratory infections, 3 million from tuberculosis, 2.5 million from diarrhoeal diseases, 1.5-2.7 million from malaria and 1.5 million from HIV/AIDS. Infectious and parasitic diseases accounted for 43% of the 40 million deaths occurring in the developing countries in 1996 (Arabi,2002).

Apart from in the West, little is known about the outcome of patients admitted to the ICU with sepsis, despite the seriousness of sepsis as a health problems in developing counties (Arabi,2002).

4. Literature review

In 1981, Knaus described APACHE, a physiologically based scoring system for measuring severity of illness in groups of critically ill patients. It was suggested it could be used for case mix, compare outcomes, evaluate new therapies and study the utilisation of ICU's. (Palazzo, 2004, 11-16)

A small panel of clinicians selected initially 34 variables that were thought to have an effect on outcome.
APACHE II, a simplified version was introduced in 1985. Variables were reduced to 12 more commonly measured variables:

- Temperature
- Mean arterial pressure
- Heart rate
- Respiratory rate
- Arterial/alveolar gradient or PaO2
- Blood sodium
- Blood potassium
- Creatinine with or without renal failure
- Hematocrit
- Leucocytes
- Glasgow coma score
- Serum HCO3

Up to 4 points were assigned to each variable. Points were also assigned for age, history of severe clinical conditions and surgical status. Total number of points gives a score ranging from 0-71 with an increasing number representing a greater severity of illness (Rowan 1999, 241-244). The model was validated in the initial studies in a subset of patients that were not used for construction of the scoring system. The performance of the system was considered adequate as it showed good discrimination in predicting hospital mortality and had a good calibration in the entire population under investigation (Benoit, 2003).

Prognostic utility of APACHE II has been extensively investigated. It has been found useful for prognosticating critically ill patients across a wide array of diagnostic categories (Khilnani, 2005).

APACHE II superseded APACHE III in 1991, but its use has been limited by the fact that clinicians must pay for knowing and using its equation for calculating death probability. (Benoit, 2003, 534-536). APACHE II has remained the most widely studied and extensively used scoring system (Palazzo, 2004, 11-160.

Why are scoring systems needed?

Intensive care has developed over the past 30 years with little rigorous scientific evidence about what is, or is not, clinically effective. Without this data, doctors delivering intensive care often have to decide which patients can benefit most. (Gunning 1999, 241-244). Scoring systems have been developed in response to an increasing emphasis on the evaluation and monitoring of health services. These systems enable comparative audit and evaluative research of intensive care (Rowan 1999, 241-244).

Health care provision is constantly challenged by the need to balance increasingly expensive medical resources with the needs and desires of a growing and aging population. In the USA in 2000, ICU expenditures represented 13.3% of hospital costs. Complex and multisystemic diseases, along with associated fluxes in physiology (e.g. Ischemia-induced cardiogenic shock), make it difficult at the time of ICU admission to predict those patients who will optimally benefit and whose care will represent appropriate use of ICU resources (Berge 2005, 166-173).

The death rate of patients admitted to ICU is much higher than that of other hospital patients. Given the relatively higher mortality among intensive care patients, death is a sensitive, appropriate and meaningful measure of outcome (Gunning 1999, 241-244).

One approach to matching available resources to patients' needs involves the use of prognostic scoring scales to identify patients who have (or alternatively do not have) a meaningful chance of hospital survival and functional recovery (Berge, 2005; 8-(20:166-173).
Mortality prediction models have been introduced as tools for assessing the performance of ICU's. If these systems (such as the APACHE) are proved to accurately predict mortality, it will have the advantage of being readily available and easily incorporated into general ICU databases without additional data collection. (Arabi, 2004)

Hence, it may be possible to favourably shift resources toward patients with a good chance of survival and away from those with a minimal chance of survival or functional recovery (Berge, 2005;8-(20: 166-173)). The APACHE II score was designed to prospectively predict mortality rates on admission.

APACHE II score and sepsis

The heterogeneity of patient groups and the variations in therapy strategies is seen as one of the main problems for sepsis trials. Therefore, commonly available scoring systems such as APACHE II are used for comparing critically ill patient groups (Brause, 2005).

As septic shock is perceptibly a leading cause of death in intensive care units, a growing demand for intensive treatment has been unveiled. Assessment of the disease process with e.g. APACHE score, regarding the survival outcome is an approach to relieve and help decision making (Sukavejvorakit).

5. Purpose of the study

The aim of this study was to assess the APACHE II prognostic index in the ICU on admission. The study was more specifically aimed at patients meeting criteria for SIRS, as patients admitted to KHC ICU frequently meet the criteria and often progress to sepsis, severe sepsis and septic shock.

SIRS can be subdivided into 'infective SIRS' (criteria for SIRS with a documented site of infection proven with blood culture) and 'non-infective SIRS' subsequent to a variety of conditions. Numerous studies comparing mortality rates between 'infective and non-infective SIRS' have proven that mortality rates however are similar (Hernandez, 2006).

Hypothesis

The APACHE II scoring system would be useful in ICU for predicting mortality, classifying and assessing severity of disease, evaluating performance and for planning departmental resource allocation. The prediction of mortality at admission would prove to be statistically valid and sufficiently reliable to justify clinical decisions made at admission

6. Methodology

- *Study design:* A cohort study was performed on 160 patients admitted to ICU meeting minimum criteria for SIRS. The study was performed as part of the academic programme set to qualify for M.Med.Sc (Critical Care) . Data was collected over a nine month period (August 2006-May 2007)
- *Inclusion criteria:*
    - Patients or their legal representatives had to complete and sign the informed consent document.
    - All patients included in the study were older than 18.
    - Patients met criteria for SIRS
- *Gathering of data:*
    - An information document was provided to each patient or person legally competent to give permission for participation in the study.
    - Consent was taken and consent and information documents were available in Afrikaans and English.
    - The doctor on duty collected all physiological and chronic health data on admission.
    - A form was filled out by ticking the relevant block. (see appendice)
    - Outcome was noted after 14 days.

- *Processing of data and statistical analysis:*

    - Data was provided to the department of Biostatistics of the UFS for processing

    .- Results were summarised by means, standard variations and percentiles(numerical variables) and frequencies and percentages (categorical variables).

- Failure to give informed consent by either the patient, him- or herself or their legal representatives, patients under the age of 18 years and patients not meeting SIRS criteria were excluded from the trial. No patients were withdrawn from the trial

7. Ethics and approval

The study method was approved by the Ethics committee of the Faculty of Health Sciences and management of KHC as part of the curriculum for qualifying for M.Med.Sc (Critical Care). ETOVS number 111/06.

8. Results

Statistical analysis was performed by the Department of Biostatistics, UFS. Results were summarised by means, standard variations and percentiles (numerical variables) and frequencies and percentages (categorical variables).

The study was performed as part of the academic programme set to qualify for M.Med.Sc (Critical Care). Data was collected over a 9-month period (August 2006 – May 2007).

The patients ranged from 16-90 years. The ages of participating patients are summarised in Table 1.

Table 1: Age of patients participating in APACHE II trial at KHC ICU between September 2006 and May 2007

Age	Frequency	Percent
<44	79	49.4%
45-54	37	23.1%
55-64	24	15.0%
65-74	17	10.6%
>75	3	1.9%

With regard to hospitalisation, 97 patients (60.6%) were non-operative (including medical patients and surgical patients who had not been operated on), 61(38.1%) were admitted post emergency surgery and 2 (0.6%) patients admitted post elective surgery had SIRS and qualified for the trial.

Among the non-operative patients the most common diagnostic categories were acute respiratory failure or insufficiency, cardiovascular failure or insufficiency and neurological emergencies accounting for 46% of non-operative admissions. (See table 2)

Table 2: Common diagnostic categories amongst non-operative patients participating in APACHE II trial at KHC ICU between September 2006 and May 2007

Diagnostic category	N	Percent
Cardiovascular insufficiency	8	19%
Respiratory insufficiency	26	57%
Neurological emergency	11	24%

Among the post emergency surgical patients most common admissions were post abdominal surgery, including perforations, GIT bleeds and bowel obstruction (accounting for 40% of surgical admissions), post surgery sepsis and neurosurgical admissions.

Table 3: Common diagnostic categories amongst surgical patients participating in APACHE II trial at KHC ICU between September 2006 and May 2007

Diagnostic category	N	Percent
Intra-abdominal perforation	9	36%
Intra-abdominal haemorrhage	4	16%
Post-surgery sepsis	2	8%
Neurosurgery	4	16%
Bowel obstruction	6	24%

Table 4 shows the distribution of the patients according to APACHE II score intervals with 50% ranging from 10-19.

Table 4: Distribution of patients participating in APACHE II trial from September 2006-May 2007.

APACHE II Score ranges	Patients N	Percent
0-9	21	13.1%
10-19	80	50%
20-29	40	25%
30+	19	11.8%

Table 5 summarises the outcome of all 160 patients meeting SIRS criteria and participating in the trial between September 2006 and May 2007. Patients discharged from the unit before 14 days were followed up in the ward until 14 days or discharge from hospital (whichever came first). 77 patients were discharged from ICU within 14 days of which 3 died in the ward within the 14-day period. 24 patients participating in the trial were still in ICU after 14 days and mortality not recorded.

Table 5: Outcome of patients participating in APACHE II trial at KHC ICU between September 2006 and May 2007

Outcome	Frequency	Percent
Died	59	36.9%
Died in ward	3	1.9%
Discharge	74	46.3%
Alive in ICU after 14 days	24	15%

The actual and expected mortality rates via APACHE II for different score intervals are summarised in Table 6. The actual mortality in patients scoring 30+ was significantly lower than the predicted mortality. This could possibly be due to the severity of illness on admission, frequently due to trauma, with several reversible factors, leading to a lower mortality rate than predicted.

Table 6: APACHE II score ranges and deaths, compared to the predicted mortality among 160 patients participating in APACHE II trial at KHC ICU between September 2006 and May 2007

APACHE II Score ranges	Patients N	Deaths N	Actual mortality %	Predicted mortality
0-9	21	1	4.8%	0%
10-19	80	25	31.3%	22%
20-29	40	21	52.5%	58%
30+	19	12	63.2%	90%
Total:	160	59	36.9%	

The comparison between APACHE II intervals and the mortality rate (table 6) shows a meaningful association between APACHE II increases and increase in mortality. The median APACHE score for all patients was 16.5 (25%=12; 75%=23). Median scores of the different categories are summarised in Table 7:

Table 7: Median Apache scores from patients participating in APACHE II trial form September 2006-May 2007.

Patient outcome	Patients N	Median	Lower quartile	Upper quartile
Alive	24	14	13	19
Discharged alive	74	13	10	20
Died in ward	3	15	15	23
Died in ICU	59	22	15	28

Maximum scores for emergency surgery, elective surgery and non-operative patients can be summarised as follows in table 8:

Table 8: Maximum APACHE scores for patients participating in APACHE II trial at KHC ICU between September 2006 and May 2007

Type	N	Score
Elective surgery	2	10
Emergency surgery	61	37
Non-operative	97	48

Median scores for emergency surgery, elective surgery and non-operative patients can be summarised as follows in table 9.

Table 9: Median APACHE scores for patients participating in APACHE II trial at KHC ICU between September 2006 and May 2007

Type	N	Median	Lower quartile	Upper Quartile
Elective surgery	2	8	6	10
Emergency surgery	61	14	10	20
Non-operative	97	18	13	25

The average ICU mortality was 36.9%, with the highest mortality among the non-operative patients (44.3%), followed by the elective surgical patients with mortality rate of 50% and post emergency surgery patients with mortality rate of 24.5% (See Table 10).

Table 10: Actual mortality rate of patients meeting SIRS criteria in the Intensive Care Unit of Kimberley Hospital complex form September 2006-May 2007.

	Patients N	**Deaths N**	**Actual mortality %**
Non-operative	97	43	44.3
Emergency surgery	61	15	24.5
Elective surgery	2	1	50

The counting of patients who survived and those who died, for each level of death risk predicted, allowed the calculation of sensitivity, specificity and the percentage of correct predictions for each level of predicted death risk.
Table 11 shows that the sensitivity of the calculated death risk was higher at scores below 8, gradually decreasing as scores increased, reaching 50.9% at score >21. Conversely the specificity increased from 1% for scores <5, reaching 79.2% for death risk at scores >21. The most accurate combination of sensitivity and specificity was found at scores of 16-18, with the positive prediction value ranging from 51.3-54.4% and the negative prediction value ranging from76.1-77.5%. These values are summarised in Table 11.

Table 11: Sensitivity, specificity, positive and negative prediction values of 160 patients meeting SIRS criteria in the Intensive care unit of Kimberley Hospital from September 2006-May 2007.

Score	Sensitivity	Specificity	Positive prediction value	Negative prediction value
>3	100%	1.0%	37.1%	100%
>4	100%	1.0%	37.1%	100%
>5	100%	3.0%	37.6%	100%
>6	100%	5.9%	38.3%	100%
>7	100%	7.9%	38.3%	100%
>8	100%	14.9%	38.8%	100%
>9	98.3%	19.8%	40.7%	95.2%
>10	91.5%	26.7%	41.7%	84.4%
>11	88.1%	29.7%	42.2%	81.1%
>12	84.8%	35.6%	42.3%	80%
>13	79.7%	45.5%	43.5%	79.3%
>14	76.3%	51.5%	46.1%	78.8%
>15	74.6%	58.4%	51.2%	79.7%
>16	69.5%	61.4%	51.3%	77.5%
>17	64.4%	63.4%	50.7%	75.3%
>18	62.7%	69.3%	54.4%	76.1%
>19	55.9%	74.3%	55.9%	74.3%
>20	55.9%	79.2%	61.1%	75.5%
>21	50.9%	79.2%	58.8%	73.4%

9. Discussion

The analysis of the population studied showed that there were a higher percentage of non-operative patients (medical as well as surgical patients) 60.6% in comparison to post-operative patients (38%). It is important to note that the 'non-operative' patients also included politrauma patients who were admitted to ICU to establish hemodynamic stability and had surgery a couple of days later. This compared to the study by Knaus et al., in which higher frequency (47%) of admissions were non-operative admissions.

The percentage of post-emergency surgery admissions was higher than recorded by most other studies. The patient distribution in the APACHE II score intervals showed highest concentrations in the intermediate ranges, coinciding with findings from other authors.

The percentage of patients with APACHE II scores less than 10 (13.13%) and thus less severe illness conditions were much lower than that for the US study (56%) and Brazilian study (22.4%) (Chiavone. 2003; 121(2): 53-57)

For the study purposes, patients were not divided into 'infective' and 'non-infective' SIRS, as data was collected at time of admission and infective SIRS could not be proven by blood culture on admission. Previous studies have shown that results between the 2 patient groups are similar.

There was a meaningful connection between APACHE II scores and the mortality rate, for all patients and each diagnostic group. In each successive APACHE II score interval the mortality rate was higher than that of the preceding interval. Thus, the result has confirmed the capability of this index to stratify such patients according to the degree of severity of their health condition, as seen in the study by Knaus et al. and in Brazil.

Important differences can be observed between our study's patients and those of other studies that have assessed the applicability of APACHE II. The most relevant of these are: lower average age, higher percentage of post emergency surgery patients, lower percentage of post elective surgery patients, higher percentage trauma and higher average APACHE II score and lower percentage of patients with APACHE II scores <10. Thus this study's patients were younger with a higher frequency of multiple trauma and acute surgical diseases that were more severe than those of the studies referred to.

On account of such differences, it has become important to assess the predictive capability of this prognostic index for particular patient populations. The ability of this gradational system to predict mortality rates of different patient groups has been

assessed in several countries. In this study the 2x2 decision matrix was used to assess the predictive capability. (see table 7)

In the assessment, the most accurate classification assessment was obtained at scores 16-18 with a negative prediction value of 75.3 %-77.5 % and a positive prediction value 50.7-54.4%.

This correct classification was not accurate enough to predict these patients mortality, and substantially less accurate than the classification found in other countries for similar decision criteria.

The APACHE II system showed good capability for stratifying this patient population according to mortality, with good discriminating power, good calibration, reasonable sensitivity and specificity and correct classification rate, but still with insufficient accuracy for predicting the mortality rate with precision.

The total mortality rate recorded was 36.9%. Mortality rates in other countries have ranged from 16.95-40.5%.

The predicted mortality was substantially lower than actually recorded, except for patients scoring 30+, which had a substantially lower actual mortality rate than predicted.

Many factors may explain the difference between the predicted mortality and what was actually recorded. These may include the limitations of APACHE II, differences between this population and those of the studies that validated the index (some patient features like nutritional, ethnic, social, cultural and economic conditions) and it's use in circumstances not applied by Knaus et al (e.g. Following revascularisation of the myocardium). Other criteria may include the criteria for selecting intensive care patients, the amount and availability of beds and the area served by the particular unit.

10. Conclusion

At the hospital at which this study was conducted, the ratio of intensive care unit beds to total amount of hospital beds is substantially lower than in other countries, particularly the United States, where the APACHE II system was developed. Thus, at the time of the study by Knaus et al, the percentage of intensive care unit beds in relation to total number of beds in US hospitals, were 5.6%, increasing to 10% by 1992. In Europe, the percentage ranged from 2.6%-3.8%, Japan 2 % and in Brazil, it was 2.5%, in this hospital it was 1.7%, demonstrating the limited availability of intensive care beds. The characteristics of such a provincial hospital, which serves as a referral centre for multiple trauma patients and complex procedures, underline the need for more intensive care unit beds. Some other relevant differences with the countries involved, which have an influence on the results, relate to health, cost and staff policies, as well as financial conditions and resources made available.

Although the APACHE II score was not assessed for developing individual prognoses, intensive care physicians have yearned for such a predictive ability. Many studies have attempted to assess the use of this index with this purpose in mind. In this study, absence of specificity for individual cases was noticed, especially in patients scoring high APACHE II scores. Therefore, for individual procedures, we cannot depend only on this index and it's formula for calculating death risk. Other issues that underlie these decisions, including those of ethical and religious nature, must be respected. However, APACHE II has in our hospital proven to be a useful instrument for backing up clinical decisions.

This study showed, that in this population, APACHE II was capable of stratifying patients according to illness severity in relation to mortality. It was however, not as accurate as in other studies. It has good discriminating power for distinguishing patients who survived, from those who died. It also has good calibration, but was generally not sensitive, specific and accurate enough to predict patients' individual mortality.

Therapy influences the disease process and APACHE II does not take into account the standard of care and it would be dangerous to exclude patients based on scoring alone. For ICU daily scoring is needed to discriminate daily response to treatment or progress.

On account of the differences amongst Intensive Care Unit patients, each unit needs to have a prediction system that is validated for it's own needs and specific kind of patients.

11. Recommendations

Some factors for calculating mortality corrections also need to be established, in order to help estimate the mortality of similar patient groups in the same intensive care unit.

It is also important to develop and perfect indices that not only estimate mortality, but also morbidity.

In our unit we have been using this prognosis index to improve the capacity for estimating patient prognosis and possibly improving decision making regarding which patients would benefit most from ICU admission, keeping in mind that a limited amount of beds are available.

The mortality rate amongst non-operative patients was lower than the Brazilian study, but higher than the predicted mortality. The mortality rate amongst the post emergency surgery patients compared well to the Brazilian study. (Chiavone 2003; 121(2): 53-57)

The APACHE II scoring system is a useful system to predict mortality on admission and monitor treatment, evaluate treatment and study the utilisation of ICU.

In our setting we have however not found it suitable for basing decisions regarding admission of patients to the unit.

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Addendum I

Inligtingsdokument

The predictive ability of the Acute Physiology and Chronic Health Evaluation (APACHE II) score for mortality in the Intensive Care Unit in Kimberley Hospital.

Inleiding: Ek, Dr. Colleen Krog, doen navorsing om die voorsspellingswaarde van die APACHE II (Acuthe Physiology, Chronic Health Evaluation) in kritiek siek pasiente in die ISE te bepaal

Die doel van die studie is om die pasient se kliniese toestand met opname te vergelyk met die eindelike uitkoms binne 14 dae. Met opname sal alle roetiene observasies en bloedondersoeke gedoen word en resultate deur die dokter aan diens gedokumenteer word. Volgens die APACHE II formule, sal ‘n mortaliteitsvoorspellingswaarde bereken word en vergelyk word met die eindelike uitkoms binne 14 dae.

Die uitslag van die studies sal dan van waarde wees om behandeling en die gebruikvan die ISE te evalueer.

Uitnodiging om deel te neem:

Ons nooi U vriendelik uit om deel te neem in die navorsingstudie nadat alle prosedures aan U verduidelik is.

Wat is betrokke by die studie?

Nadat ingeligte toestemming verkry is, sal U ingesluit word by die studie. Die prosedure van die studie sal aan U verduidelik word. Indien U toestem om deel te neem, sal U gevra word om die toestemmingsdokument te teken.. Nadat die prosedure aan u verduidelik is en U die toestemmingsdokument onderteken het, sal U by die studie ingesluit word. Die duur van die studie is 14 dae, of tot iets gebeur wat die kliniese toestand binne die tyd verander.

160 pasiente word ingesluit in die studie. Kriteria vir insluiting word gebasseer op kriteria vir Sistemiese Inflammatoriese Responssindroom.

Risikos:

Geen addisionele risiko's bestaan, behalwe die geassosieer met normale behandeling en uitvoer van prosedures in die eenheid nie.

Voordele:

Insluiting in die studie het geen bykomende voordele buiten die van normale behandeling in die Intensiewe eenheid nie. Geen kompensasie word aangebied vir betrokkenheid by die studie nie.

Die pasient sal op hoogte gehou word van belangrike inligting rakende die studie terwyl hy/sy betrokke is by die studie en ook nadat die uitslae bekend is.

Deelname is vrywillig en pasient sal geen voordele verloor indien hy/sy besluit om nie deel te neem nie.

Vertroulikheid:

Pogings sal aangewend word om persoonlike inligting vertroulik te hou. Absolute vertroulikheid kan egter nie verseker word nie. Persoonlike inligting mag beskikbaar gestel word indien so vereis deur die wet. Pasientdata en rekords sal gebruik word as deel van die studie.

Kontakbesonderhede van navorser: Dr. C. Krog, A6, ICU, KHC.

Information document

The predictive ability of the Acute Physiology and Chronic Health Evaluation (APACHE II) score for mortality in the Intensive Care Unit in Kimberley Hospital.

Introduction: I, Dr Colleen Krog, am doing research on the predictive ability of the APACHE II scoring system (Acute Physiology and Chronic Health Evaluation) in critically ill patients admitted to ICU.

The aim of the study is to compare the patient's clinical condition on admission to eventual outcome within 14 days. On admission all routine observations and blood investigations will be performed and results will be recorded by the doctor on duty at the time of admission. According to the APACHE II formula, a mortality prediction rate will then be calculated and eventually compared to the outcome within 14 days.

The results of the study will enable us to evaluate therapy and actual outcome within 14 days.

Invitation to participate:

We are inviting you to participate in a research study after all study procedures were explained to you.

What is involved in the study?

After informed consent was obtained, you will be included in the study. During this process, we will verbally explain the the study procedure to you. If you agree to participate, you will be required to sign the informed consent document. Only after the procedure was explained to you and you have signed the consent document, you will be entered into the study. The duration of the study will be 14 days unless anything happens to alter the clinical condition within 14 days.

The study consists of 160 patients that will be selected according to the criteria for Systemic Inflammatory Response syndrome

Risks:

No additional risks exists for inclusion in the study, other than the risks associated with normal treatment and procedures performed in the unit.

Benefits:

Inclusion in the study has no additional benefits for the patient, except the normal treatment in Intensive Care Unit. No compensation will offered for study involvement.

The subject will be given pertinent information on the study while involved in the project and after results are available.

Participation is voluntary and refusal to participate will involve no penalty or loss of benefits to which the subject is entitled.

Confidentiality:

Efforts will be made to keep personal information confidential. Absolute confidentiality cannot be guaranteed/ Personal information may be disclosed if required by law, Undisclosed patient data and records will be used as part of the study.

Contact details of researcher: Dr C. Krog, A6,ICU, KHC.

Addendum II

Consent document

You have been asked to participate in a research study.

The predictive ability of the Acute Physiology and Chronic Health Evaluation (APACHE II) score for mortality in the Intensive Care Unit in Kimberley Hospital.

You have been informed about the study by Dr C. Krog.

You may contact Dr Krog at any time at 0733069068 if you have any questions regarding the research.

You may contact the secretariat of the Ethics Committee of the Faculty of Health Sciences, UFS, at telephone number 0514052812 if you have any questions regarding your rights as a research subject.

Your participation is voluntary and you will not be penalised or lose any benefits if you refuse to participate or decide to terminate participation. Consent may be withdrawn at any time during the study at the discretion of the patient.

If you agree to participate, you will be given a signed copy of this document as well as the participant information sheet, which is a summary of the research.

The research study has been verbally explained to me. I understand what my involvement in this study means and I voluntary agree to participated.

I also give consent that Dr Krog may inspect my medical records and use collected data for the purpose of the study.

_____	_____
Signature of participant	Date
_____	_____
Signature of witness	Date
_____	_____
Signature of person Legally competent to Give consent	Date

_____
Signature of translator

Toestemmingsdokument

U is versoek om deel te neem in ‘n navorsingstudie.

The predictive ability of the Acute Physiology and Chronic Health Evaluation (APACHE II) score for mortality in the Intensive Care Unit in Kimberley Hospital.

U is ingelig rakende die studie deur Dr. C. Krog.

U mag Dr. Krog enige tyd skakel by 0733069068 indien U enige navrae het, rakende die studie.

U mag ook die Sekretariaat van die Etiekkomitee van die Fakulteit van Gesondheidswetenskappe, UV, by 0514052812, kontak indien U enige navrae het rakende U regte .

U deelname is vrywillig en U sal geen voordele verloor indien U besluit om deelname aan die studie te beeindig nie. Toestemming om deelname mag ter enige tyd teruggetrek word.

Indien U toestem tot deelname, sal U ‘n getekende afskrif van die dokument sowel as die deelnemerinligtingstuk kry, wat ‘n opsomming van die navorsing is.

Die navorsingstudie is aan my verduidelik en ek verstaan wat my betrokkenheid by die studie beteken en ek stem vrywillig in om deel te neem.

Ek gee ook toestemming dat Dr. Krog my mediese rekords nagaan en ingesamelde data vir studie doeleindes gebruik.

_____	_____
Handtekening van deelnemer	Datum
_____	_____
Handtekeining van getuie	Datum
_____	_____
Handtekening van persoon wettiglik gemagtig	Datum

Addendum III

The predictive ability of the Acute physiology and Chronic Health Evaluation (APACHE II) score for mortality in the Intensive Care Unit in Kimberley Hospital

Patient	*APS*	*CHE*	*AGE*	*Total score*	*Outcome*

Addendum IV

Abstract

Introduction:

The aim of this study was to assess the Acute Physiology and Chronic Health Evaluation (APACHE II) prognostic index in the Intensive Care Unit of Kimberley Hospital Complex (KHC) on admission. The study was more specifically aimed at patients meeting criteria for the Systemic Inflammatory Response Syndrome (SIRS), as patients admitted to KHC ICU frequently meet the criteria and often progress to sepsis, severe sepsis and septic shock.

Design:

A cohort study on South African patients meeting SIRS criteria, including all races and gender.

Setting:

Intensive Care Unit of Kimberley Hospital Complex, provincial hospital in the Northern Cape province, South Africa.

Patients and measurements:

Consecutive patients meeting the criteria for SIRS on admission to ICU between August 2006 and May 2007 were included. For each patient the diagnosis, physiological and chronic health data necessary for the APACHE score was gathered and recorded by the doctor on duty on time of admission.

Predicted and actual mortality rates were calculated. Data was provided to the department of Biostatistics of the UFS for processing. Results were summarised by means, standard variations and percentiles (numerical variables) and frequencies and percentages (categorical variables).

Results

Of the 160 patients included in the study, 59 died (36.9%). Patients discharged from the unit before 14 days were followed up in the ward until 14 days or discharge from hospital (whichever came first). 77 patients were discharged from ICU within 14 days of which 3 (1.9%) died in the ward within the 14-day period. 74 of the discharged patients (46.3%) were alive after 14 days. 24 patients (14%) participating in the trial were still in ICU after 14 days and mortality not recorded.

The counting of patients who survived and those who died, for each level of death risk predicted, allowed the calculation of sensitivity, specificity and the percentage of

correct predictions for each level of predicted death risk.

The sensitivity of the calculated death risk was higher at scores below 8, gradually decreasing as scores increased, reaching 50.9% at score >21. Conversely the specificity increased from 1% for scores <5, reaching 79.2% for death risk at scores >21. The most accurate combination of sensitivity and specificity was found at scores of 16-18, with the positive prediction value ranging from 51.3-54.4% and the negative prediction value ranging from 76.1-77.5%.

There was a meaningful connection between APACHE II scores and the mortality rate, for all patients and each diagnostic group. In each successive APACHE II score interval the mortality rate was higher than that of the preceding interval. Thus, the result has confirmed the capability of this index to stratify such patients according to the degree of severity of their health condition.

Conclusion

The APACHE II scoring system may be usefully applied in Intensive Care Units for predicting mortality, classifying and assessing severity of disease and evaluating performance. It must however be used with caution for planning department resource allocation and decision making regarding admission of patients to Intensive Care.

Keywords

APACHE II
SIRS
Sepsis
Intensive Care
Resource allocation
Bed utilisation in Intensive Care
Mortality prediction
Scoring systems

Abstrak

Inleiding:

Die doel van die studie was om die *Acute Physiology and Chronic Health Evaluation (APACHE II)* prognostiese indeks in die Intensiewe Sorg Eenheid van Kimberley Hospital Kompleks (KHC) tydens opname van pasiente te evalueer. Die studie was meer spesifiek gemik op pasiente wat voldoen aan kriteria vir die Sistemiese Inflammatoriese Respons Sindroom(SIRS), siende pasiente opgeneem in die Intensiewe Sorg Eenheid (ISE) van KHC telkemaal aan die kriteria voldoen en dan ook gereeld sepsis, erge sepsis en septiese skok ontwikkel.

Studie-ontwerp:

'n Kohort studie met Suid-Afrikaanse pasiente wat aan SIRS kriteria voldoen. Pasiente van enige ras en geslag is ingesluit by die studie.

Plek:

Intensiewe Sorg Eenheid, Kimberley Hospitaal kompleks, provinsiale hospitaal in Noordkaap-provinsie van Suid-Afrika.

Pasiente en studiemetodes:

Opeenvolgende pasiente wat voldoen het aan SIRS kriteria met toelating tot die ISE tussen Augustus 2006 en Mei 2007 is ingeluit. Met opname is die diagnose, fisiologiese en chroniese gesondheid data ingesamel en aangeteken deur die betrokke dokter aan diens.

Voorspelde en ware mortaliteit is bereken. Data is voorsien aan die Departement van Biostatistiek aan die Universiteit van die Vrystaat vir verwerking. Resultate is opgesom deur middel van mediane, standaardafwykings en persentiele(numeriese veranderlikes), frekwensies en persentiele (kategoriese veranderlikes).

Resultate

59 (36.9%) van die 160 pasiente ingesluit by die studie het gesterf. Pasiente ontslaan uit die eenheid voor 14 dae, is opgevolg in die saal tot 14 dae of ontslag. 77 pasiente is ontslaan uit die eenheid binne 14 dae, waarvan 3 (1.9%) oorlede is in die saal binne die 14 dae periode. 74(46.3%) van die pasiente wat ontslaan is, het nog gelewe na 14 dae. 24 pasiente (14%) was na 14 dae steeds in die eenheid en die mortaliteit is nie aangeteken nie.

Die rekordhouding van pasiente wat gesterf het en oorleef het vir elke vlak van

mortaliteitsrisiko voorspel, het voorsiening gemaak vir die berekening van sensitiwiteit, spesifisiteit en persentasie van akkurate voorspellings vir elke vlak van voorspelde doodsrisiko.

Die sensitiwiteit en berekende mortaliteitsrisiko was hoer met tellings <8, geleidelik afnemende soos wat tellings toeneem, met sensitiwiteit van 50.9% by telling >21. Die spesifisiteit het toegeneem vanaf 1% vir tellings <5 met spesifisiteit van 79.2% vir doodsrisiko met tellings >21. Die mees akkurate kombinasie van sensitiwiteit en spesifisiteit is gevind met tellings 16-18, met ‘n positiewe voorspellingswaarde van 51.3-54.4% en negatiewe voorspellingswaarde van 76.1-77.5%.

‘n Betekenisvolle vergelyking kon getref word tussen APACHE II tellings en mortaliteit vir alle pasiente en elke diagnostiese groep. Vir elke opeenvolgende APACHE II waarde interval, was die mortaliteit hoer as vir die voorafgaande interval. Die resultaat het die vermoe van die APACHE II om pasiente volgens die erns van hul siektetoestand te klassifiseer bevestig.

Samevatting:

Die APACHE II klassifikasiestelsel kan suksesvol in ISE’s gebruik word om mortaliteit te voorspel, siektes te klassifiseer en graad van erns te bepaal en prestasie te evalueer. Dit moet egter baie versigtig gebruik word wanneer departementele hulpbron toekenning beplan word en besluite geneem word rakende toelating van pasiente tot Intensiewe Sorg.