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Selection of paediatric patients for intensive care

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Objectives. To determine characteristics of older infants and children admitted to the paediatric intensive care unit (PICU) at Johannesburg Hospital; and to evaluate an admission score based on the PRISM score (an index of severity of illness) as a possible means for selection of patients for admission to the PICU.

Design. Retrospective review of patient records and calculation of admission score from data.

Setting. Paediatric intensive care unit at Johannesburg Hospital.

Subjects. All patients older than 3 months of age admitted to the PICU from July 1993 to 31 March 1994.

Results. There were 117 admissions during the study period with a mean age of 4,6 years. The mortality rate was 29,1%. The mean duration of ICU stay was 4,2 days. A review of requests for admission showed that over a 7-month period, 53 patients (> 3 months) could not be accommodated. In 71 patients with complete data, the admission score was significantly higher in non-survivors than survivors. The area under the ROC curve for predicting mortality from the admission score was 0,73 (SE 0,054). An admission score ⩾ 16 predicted mortality with a sensitivity of 42% and a specificity of 98%.

Conclusions. PICU facilities at Johannesburg Hospital are insufficient to meet the demand. An admission score based on the PRISM score could assist in the selection of patients for these limited PICU facilities.

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Financial limitations and the current emphasis on primary health care demand that the limited tertiary care facilities available, particularly intensive care, be used to best advantage in terms of cost and patient outcome. Selection criteria need to be developed to provide intensive care to those patients who will have the best prognosis and utilise resources optimally. This has already prompted the introduction of a cut-off weight of 1 000 g for admission to a neonatal intensive care unit (NICU) in public sector hospitals in South Africa, as recommended at the 10th Conference on Priorities in Perinatal Care. Johannesburg Hospital does not have separate ICU facilities for neonatal and older paediatric patients requiring ICU; all are admitted to a single paediatric ICU (PICU). There is no specified admission criterion like the neonatal cut-off weight for admission of older infants and children; these patients are accepted on the basis of prognosis, the latter being subjectively assigned in most cases.

Several scores of illness severity have been developed to predict mortality in the ICU patient. The most widely used scores are based either on the degree of therapeutic intensity, e.g. TISS,[1] or the derangement of patient-based physiology, e.g. APACHE.[2] More recently, scores have been developed for use in paediatric and neonatal patients, e.g. PRISM,[3] CRIB[4] and SNAP.[5] These scores have been used to compare the performance of different units, to standardise multicentre trials and to determine resource allocation; they have not been used specifically to select patients for ICU care.[6] Decisions about the initiation of ICU support need to be made at the time of admission of the patient, using readily available information. A major problem with the use of severity of illness scores for such triage is that these scores are computed after 12 - 24 hours of therapy and often require non-routine investigations. This would necessitate admission of the patient to the ICU for at least 24 hours, with additional investigations being done for the purpose of the score followed by withdrawal of therapy if the patient's condition were judged to warrant it. This approach is more costly in terms of time and resources than a defensible decision to withhold ICU support at the time of admission.

The aims of this study were: (*i*) to determine the characteristics of the older infants and children admitted to Johannesburg Hospital PICU; and (*ii*) to investigate an admission score using those components of the PRISM score[3] (Table I) available at the time of admission as a possible basis for selecting patients for PICU care.

Subjects and methods

This study was conducted at Johannesburg Hospital on patients who qualified for PICU care between 1 July 1993 and 31 March 1994. As there are very limited facilities, only patients requiring ventilation are admitted to the unit. Very occasionally, a patient requiring intensive observation and inotropic support is admitted. Selection of patients for ICU is based on subjective assessment of long-term prognosis. Patients with asthma and pneumonia would be admitted to the ICU for ventilation for respiratory failure. Those with infectious diseases, including gastro-enteritis, would be admitted for management of shock, severe acidosis and hypoxia. These patients are usually ventilated. Although therapy is withdrawn in certain circumstances such as brain death, this was not always clearly stated in the records and was therefore not included in this analysis.

Case records of all PICU admissions over the age of 3 months were reviewed for demographic details, diagnosis and outcome. According to the policy of the unit, patients less than 3 months of age are included in the 'neonatal statistics'. Therefore, for the purposes of this study, PICU patients include those infants and children of 3 months or

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older and NICU patients those younger than 3 months of age. From the case records of study infants, an admission score was determined for each patient based on the PRISM score (Table I). Only those patient files with complete information were included. The admission score was then correlated with mortality and duration of ICU stay.

Table I. PRISM score[4]

Variable	Infants	Children	Score
Systolic blood pressure	130 - 160	150 - 200	2
	55 - 65	65 - 75	2
	> 160	> 200	6
	40 - 54	50 - 64	6
	< 40	< 50	7
Diastolic blood pressure	> 110	> 110	6
Heart rate/min	> 160	> 150	4
	< 90	< 80	4
Respiratory rate/min	61 - 90	51 - 70	1
	> 90	> 70	5
	Apnoea	Apnoea	5
PaO_2/FiO_2	All ages	200 - 300	2
		< 300	3
$PaCO_2$ (kPa)	Ages	6,8 - 8	1
		> 8,66	5
Glasgow Coma Scale	All ages	< 8	6
Pupil reactions	All ages	Fixed and dilated	10
		Unequal or dilated	4
Potassium (mmol/l)	All ages	3,0 - 3,5	1
		6,5 - 7,5	1
		< 3	5
		> 7,5	5
Glucose (mmol/l)	All ages	2,2 - 3,3	4
		13,9 - 22,2	4
		< 2,2	8
		> 22,2	8
Standard bicarbonate	All ages	< 16	3
(mmol/l)		> 32	3
PI/PTT	All ages	1,5 x control	2
Total bilirubin (mg/dl)	> 1 month	> 3,5	6
Calcium (mg/dl)	All ages	7,0 - 8,0	2
		12,0 - 15,0	2
		< 7,0	6
		> 15,0	6

The admission score only included those components of the PRISM score that were readily available at the time of admission to the ICU. Many patients were admitted via the computed tomography department or via the theatre, where they had received neuromuscular blocking agents. The Glasgow Coma Scale was therefore the only measurement taken from the time of admission to hospital rather than to the ICU. Respiratory rate was excluded as it could not be determined on admission to ICU in those patients already paralysed and was usually not recorded at the time of admission to hospital. Determination of the full PRISM score requires admission of the patient to the unit for at least 24 hours and certain investigations being done for the purpose of the score. Those investigations which were not routinely available from the time of admission included bilirubin, calcium and prothrombin time and were therefore excluded from the admission score. The weighting of different components was unchanged from the original PRISM score.

Descriptive statistics were determined for the whole sample and the PRISM subgroup. Continuous variables were compared using unpaired *t*-tests, while Fisher's exact test was used for categorical variables. The correlation between the modified score and outcome was explored, viz. duration of ventilation and ICU. Sensitivity and specificity were calculated for different values of the admission score and the receiver-operating characteristic (ROC) curve[7] for the admission score in predicting mortality was derived. A cut-off value of the admission score most predictive of outcome was determined, using the sensitivity and specificity of different values. The area under the ROC curve and the corresponding standard error were determined. These give an indication of the predictive value of the score. A score which cannot predict better than chance would have an area under the ROC curve of 0,5, whereas a score with perfectly accurate prediction would have an area under the ROC curve of 1,0.[5] Thus, the closer the area under the ROC curve is to 1, the better the predictive ability of the score. Statistical analysis was done on a personal computer using STATPAK version 4.1 (NWA, Portland, Oregon, USA).

Results

The sample included 117 PICU admissions older than 3 months who comprised 33% of the total 351 admissions during the study period (including neonates). There were 34 deaths (29,1%) in the paediatric group. There was a slight male predominance with 64 boys and 51 girls being admitted (gender was not recorded in 2 cases). The mean age of all paediatric admissions was 4,6 years (SD 4,3; range 3 months to 17,8 years) and the mean duration of ICU stay was 4,2 days (SD 4,5; range 0,3 - 36 days). There was no difference in the demographic characteristics or duration of ICU stay between survivors and non-survivors (Table II).

Table II. Characteristics of survivors and non-survivors

	Survivors	Non-survivors	
	Mean (SD)	Mean (SD)	*P*-value
Age (yrs)	4,67 (4,38)	4,52 (4,18)	NS
Duration of ICU (days)	4,39 (4,87)	3,81 (3,34)	NS
Male/female	46:36	18:15	NS

The overall mortality rate was 29,1%. However, deaths tended to occur mainly in relation to certain types of illness, particularly near-drowning, cardiomyopathy, gastro-enteritis and complicated infectious illness (Table III). Cardiorespiratory resuscitation prior to ICU admission was associated with increased mortality (7/11 v. 27/106, $P < 0,05$, two-tailed Fisher's exact test). There were no deaths in patients with polytrauma without head injury or in patients admitted for postoperative ventilation.

Table III. Diagnostic categories (primary admission diagnosis)

Diagnosis	Admissions	Deaths	Percentage
Postoperative	25	0	0
Trauma without head injury	4	0	0
Near drowning	7	4	57,1
Head injury	24	6	25
Gastro-enteritis	4	3	75
Oncology patients with complications*	4	2	50
Upper airway obstruction	3	0	0
Cardiomyopathy	2	2	100
Epilepsy	4	2	50
Burns	4	2	50
Poisonings	3	1	33,3
Post cardiac arrest	4	2	50
Asthma	2	1	50
Complicated infectious diseases†	13	10	76,9
Other	5	0	0
Pneumonia	9	0	0

* Cases of pancytopenia with suspected septicaemia.
† These included septicaemia (staphylococcal, shigella, candida) and specific infections (typhoid, malaria, infectious mononucleosis) with multiple organ involvement.

The files of 71 paediatric patients had complete information and were included in the determination of the modified PRISM admission score. The mean age of these patients was 4,7 years (SD 4,4), duration of ICU stay was 4 days (SD 3,8) and there were 28 girls and 42 boys (1 patient's sex was not recorded). There were 21 deaths in the group. These characteristics are not different from the whole group of PICU admissions. The maximum possible admission score was 62. A low admission score was associated with survival; there were no deaths in those with an admission score of < 2 (Fig. 1). The mean admission score in survivors was 6,73 (SD 5,6) versus 14,68 (SD 9,82) in non-survivors ($P < 0,0001$). An admission score ⩾ 10 predicted mortality with a sensitivity of 61% and a specificity of 70%, while a score ⩾ 16 was much more specific (98%) but less sensitive (42%). The ROC curve for the admission score is shown in Fig. 2. The area under the ROC curve was 0,73 (SE 0,054). There was a weak but significant correlation between the duration of ICU stay and the admission score (correlation coefficient = 0,2209, $P < 0,05$).

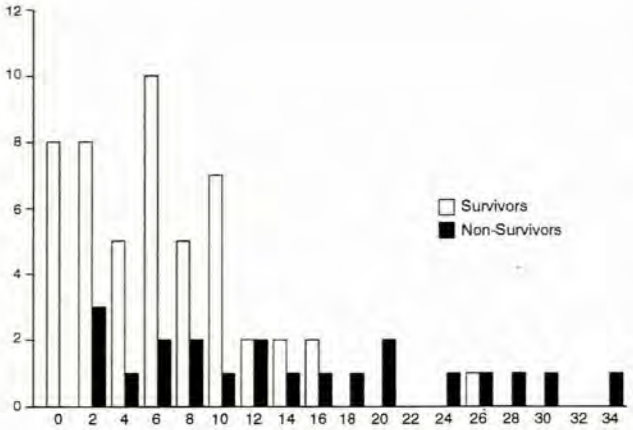
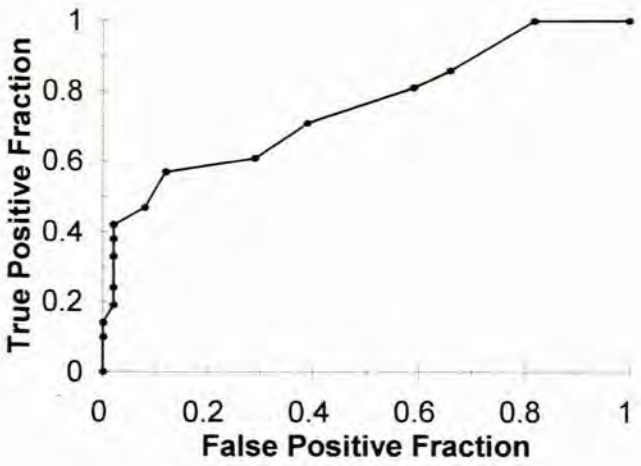


Fig. 1. Admission score — survivors v. non-survivors.



NB: True-positive fraction = sensitivity; false-positive fraction = 1 – specificity"

Fig. 2. ROC curve for admission score.

Discussion

The allocation of ICU facilities when financial resources are limited is determined by cost/benefit and patient outcome. The Witwatersrand area has approximately half the required number of NICU beds,[6] without taking the needs of older infants and children into consideration. A review of requests for ICU admissions for the 7-month period from 1 February 1994 to 31 August 1994 revealed that there were 156 patients who could not be accommodated. Of these, 103 (66%) were below 3 months of age and 53 (33%) were 3 months or older, indicating a greater demand for PICU facilities in the Johannesburg area than currently exist. This would justify the expansion of PICU facilities and possibly the establishment of separate facilities for neonates and older children, instead of having paediatric patients from birth to 18 years competing for the same beds. Although this is ideal, the creation of a separate PICU would create a problem in terms of physical and human resources, i.e. purchase of equipment and employment of trained medical and nursing staff.

A significant increase in ICU facilities is, however, extremely unlikely given financial constraints and the emphasis on primary health care. Selection of patients for ICU is therefore an important issue. Admission of patients with poor prognosis and/or prolonged use of the ICU facility results in other patients with a better prognosis being denied care; many of these die as a result.

The admission diagnosis is an important determinant of patient selection. In the present study, patients with complicated infectious illness, near-drowning, gastro-enteritis and cardiomyopathy had a high mortality rate.

There was also an increased risk of mortality in those patients who had a cardiac arrest prior to ICU admission. Certain other diagnostic categories, particularly postoperative patients, had no mortality, which raises the question of whether all these patients actually required ICU admission.

The use of an index of severity of illness, in addition to the admission diagnosis, would improve the accuracy of patient selection for ICU care. Decisions about the initiation of ICU support are simpler and more cost-effective if made at the time of admission. All current severity of illness scores are calculated after 12 - 24 hours of ICU admission, which entail initiation of ICU care for at least 24 hours and then possible withdrawal of therapy. Many scores also use investigations which are not routinely available. In an attempt to address these problems, this study derived an admission score based on the PRISM score, using data readily available at the time of admission. Non-survivors had significantly higher scores than survivors. Overall, the predictive ability of the admission score was reasonably good with an area under the ROC curve of 0,73. If a score is used as a basis for withholding therapy, very high specificity is required, despite some loss of sensitivity, to avoid denying a potential survivor care. An admission score of $\geqslant 10$ predicted mortality with a sensitivity of 61% and a specificity of 70%. Increasing the cut-off point to $\geqslant 16$ improved specificity to 98% but sensitivity fell to 42%. An admission score $\geqslant 16$ would therefore appear to be more suitable as an ICU admission criterion. The admission score could possibly be used to determine which patients need ICU care less, i.e. no patients with a score < 2 died.

Whether or not the use of a severity of illness score is better than clinical judgement is debatable: a recent study found excellent correlation between the SNAP score and clinical estimation of mortality.[9] Although this may well be the case, clinical judgement is affected by individual expertise and experience. Decisions about the admission of patients to ICU are often taken out of normal working hours, when senior staff members are not immediately available, and an objective score may therefore aid less experienced staff in difficult decision-making. It would also allow different units to adopt a more standardised approach (cf. the cut-off birth weight for NICU).

There are certain limitations to the present study. It was retrospective and the sample size was relatively small. The weighting of the originally described score was used and the value of each of the different components in predicting mortality in our own population was not assessed. Also, the weighting referred to the worst value obtained in a 24-hour period, while we used the admission value. However, very often, the worst value obtained is on admission, before the introduction of measures to correct the derangement. The exclusion of certain variables has been investigated by other researchers who found that only five variables from the PRISM scale were predictive of mortality.[10] Despite these limitations, the overall admission score had an area under the ROC curve of 0,73. A score $\geqslant 16$ predicted mortality with 98% specificity and 42% sensitivity and could be used as a cut-off point for ICU admission.

In South Africa today, there is an imbalance between the number of paediatric patients requiring ICU and the availability of ICU facilities. It is unlikely that there will be expansion of PICU facilities; patients should therefore be carefully selected so that the scarce resources are utilised to the best advantage. A combination of an illness severity score done at the time of admission (as discussed above), and consideration of the diagnostic category would provide a guide to assist in this difficult task. Further prospective and blinded research is necessary to establish and refine the predictive value of the score in our population.

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