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Application of different scoring systems and their value in pediatric intensive care unit

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KEYWORDS

Scoring systems;
Pediatric intensive care unit;
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Multiple organ dysfunction

Abstract *Background:* Little is known on the impact of risk factors that may complicate the course of critical illness. Scoring systems in ICUs allow assessment of the severity of diseases and predicting mortality.

Objectives: Apply commonly used scores for assessment of illness severity and identify the combination of factors predicting patient's outcome.

Methods: We included 231 patients admitted to PICU of Cairo University, Pediatric Hospital. PRISM III, PIM2, PEMOD, PELOD, TISS and SOFA scores were applied on the day of admission. Follow up was done using SOFA score and TISS.

Results: There were positive correlations between PRISM III, PIM2, PELOD, PEMOD, SOFA and TISS on the day of admission, and the mortality rate ($p < 0.0001$). TISS and SOFA score had the highest discrimination ability (AUC: 0.81, 0.765, respectively). Significant positive correlations were found between SOFA score and TISS scores on days 1, 3 and 7 and PICU mortality rate ($p < 0.0001$). TISS had more ability of discrimination than SOFA score on day 1 (AUC: 0.843, 0.787, respectively).

Conclusion: Scoring systems applied in PICU had good discrimination ability. TISS was a good tool for follow up. LOS, mechanical ventilation and inotropes were risk factors of mortality.

Introduction

Mortality rate in the intensive care unit (ICU) depends on the severity of illness and the patient population analyzed, and 6.4–10.3% of critically ill patients were reported to die.[1]

Although the total number of hospital beds in the United States decreased by 26.4% from the year 1985 to 2000; the ICU beds increased by 26.2% during the same period.[2]

As a fact, we know little on the exact causes of death and the impact of risk factors that may complicate the course of critical illness irrespective of the underlying disease.[3]

The work was performed at the Pediatric Intensive Care Unit (PICU) of Cairo University Children Hospital, Cairo, Egypt.

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Knowledge of such determinants of outcome in critically ill would not only help improve prognostic evaluation of patients, but also indicate what therapy and research should focus on to improve the short and long term outcomes of those patients.[4]

Scoring systems for use in ICU patients have been introduced over the last 30 years. They allow assessment of the severity of disease and provide an estimate of in-hospital mortality by gathering routinely measured data specific to a patient.[5]

The aim of this study was to apply commonly used scores, in adults and children, for assessment of illness severity and determine their relation to patient's outcome in a developing country.

Patients and methods

This is a prospective study including all patients admitted to pediatric ICU (PICU) in Cairo University Mounira Pediatric Hospital, over one year.

Inclusion criteria

All patients must be from the age of 1 month to the age of 14 years (As pubertal children are referred to adult ICU).

Exclusion criteria

Patients who died in the first 24 h.

Intervention

Clinical examination and full investigations including: complete blood count (CBC), arterial blood gases (ABG), full chemistry, coagulation profile, cerebrospinal fluid (CSF) if needed, cultures (blood culture, urine culture, others if needed), Radiology (X-ray, CT scan, others if needed).

Assessment of the severity of illness and mortality risk adjustment on admission of the patient using the parameters of the following scores:

- Pediatric risk of mortality (PRISM) III.[6]
- PEdiatric Multiple Organ Dysfunction (PEMOD) scoring system.[7]
- PEdiatric Logistic Organ Dysfunction (PELOD) scoring system.[7]
- Pediatric Index of Mortality2 (PIM2).[8]

Follow up of the patient progression and level of intervention using:

- Sepsis-related Organ Failure Assessment (SOFA) score.[9] SOFA score was previously been used in children.[10,11]
- Therapeutic Intervention Scoring System (TISS).[9] Although TISS score was used only in adults, we found its parameters not assessed in other scores and we were interested in its parameters.

Assessments of the outcome of the patients at the end of PICU stay, regarding length of stay (LOS) and survival to discharge.

Statistical analysis

Results were tabulated and statistical significance was tested using the student-*t* test for quantitative values and chi square test was used for qualitative values, other tests of significance were used depending on results.

Results

Two hundred thirty one patients admitted to PICU in Mounira Pediatric Hospital, over 1 year, were enrolled in a prospective observational study.

One hundred and eleven (48.1%) were females and 120 (51.9%) were males, deaths in both sexes were almost equal (26.1% and 25.8% respectively).

The mortality rate was 25.9% (60 patients). Mortality rate was higher in infants (< 1 year) than in children (27%, 23% respectively).

Respiratory problems were the highest admission diagnoses (40.6%), followed by central nervous system (CNS) (15.1%) and cardiovascular system (CVS) (10.8%), but the highest percentage of mortalities was in patients with septicemia and multiple organ dysfunction syndrome (MODS) (66.7%) and neurological disease (51.4%).

Table 1 Scores done for the patients on admission.

	Outcome	Mean	SD	95% CI	*p* value	AUC
PRISM III	Died	12.9	±9.27	10.55–15.24	$p < 0.0001$	0.751
	Survived	5.73	±4.86	5.00–6.46		
PIM2	Died	0.22	±0.29	0.15–0.3	$p < 0.0001$	0.747
	Survived	0.06	±0.10	0.04–0.07		
PEMOD	Died	7.05	±3.88	6.07–8.03	$p < 0.0001$	0.732
	Survived	4.13	±2.82	3.70–4.55		
PELOD	Died	15.17	±14.25	11.56–18.77	$p < 0.0001$	0.762
	Survived	4.96	±8.31	3.71–6.20		
SOFA	Died	10.55	±4.50	9.41–11.69	$p < 0.0001$	0.765
	Survived	6.34	±3.47	5.82–6.86		
TISS	Died	23.62	±8.52	21.46–25.77	$p < 0.0001$	0.811
	Survived	14.94	±5.16	14.17–15.72		

AUC: area under the curve, PELOD: PEdiatric Logistic Organ Dysfunction scoring system, PEMOD: PEdiatric Multiple Organ Dysfunction scoring system, PIM2: revised Pediatric Index of Mortality score, PRISM III: pediatric risk of mortality score, SOFA: Sepsis-related Organ Failure Assessment, TISS: Therapeutic Intervention Scoring System.

Table 2 Following up patients on days 1, 3 and 7 using TISS and SOFA score.

	Outcome	Mean	SD	95%CI	*p* value
SOFA d1	Died	4.4	±2.98	3.65–5.15	$p < 0.0001$
	Survived	1.52	±2.08	1.21–1.83	
SOFA d3	Died	3.88	±3.00	3.07–4.70	$p < 0.0001$
	Survived	1.03	±1.68	0.75–1.31	
SOFA d7	Died	4	±3.22	2.95–5.05	$p < 0.0001$
	Survived	0.74	±1.29	0.42–1.05	
TISS d1	Died	21.93	±8.70	19.73–24.13	$p < 0.0001$
	Survived	11.88	±5.22	11.10–12.67	
TISS d3	Died	18.8	±10.23	16.21–21.39	$p < 0.0001$
	Survived	8.32	±5.93	7.43–9.21	
TISS d7	Died	12.18	±11.23	9.34–15.02	$p < 0.0001$
	Survived	3.90	±5.52	3.07–4.72	

Correlation is significant at the 0.05 level.

Significant positive correlations were found between PRISM III, PIM2, PELOD and PEMOD on the day of admission and mortalities ($p < 0.0001$). TISS and SOFA score had the highest discriminatory power (area under ROC curve (AUC): 0.81 and 0.765, respectively) (Table 1).

Also significant positive correlations were found between SOFA score and TISS scores on days 1, 3 and 7 and mortalities ($p < 0.0001$) (Table 2). TISS had more ability of discrimination than SOFA score on day 1 (AUC: 0.843, 0.787, respectively).

There were significant correlations between LOS and TISS on admission, day 1 and day 3 ($p = 0.004$, $p = 0.0001$ and $p < 0.0001$, respectively). And the longer the LOS, the higher the mortality risk [$p = 0.004$; odds ratio (OR) = 5.6 in patients who stayed more than 15 days; 95% CI: 10.14–22.75]. While evaluating our patients with PIM2 score, those defined as "high risk diagnosis" had the highest risk of mortality (54.17%, OR = 4.02).

Table 3 presents the parameters used for evaluation of different systems:

Patients who were intubated had higher risk of mortality (OR = 12). ABG derangement increased risk of mortality, especially PaO_2. Death was 100% in the patients with $PaO_2 < 42$ mmHg.

Risk of mortality was almost doubled in infants with systolic blood pressure (SBP) ⩽44 mmHg or child with SBP ⩽57 mmHg and adolescent with SBP ⩽66 mmHg (OR = 2.2–2.4). Also risk of mortality was doubled in infants with heart rate ⩽50 beat/min or a child with heart rate ⩽40 beat/min (OR = 1.9). Risk of mortality was elevated in patients on inotropes (OR = 8.5). Also insertion of central venous line reflected the severity of the case because risk of mortality was elevated (OR = 6.9).

Risk of mortality was high in patients with liver enzymes >250 IU/L (OR = 3.6; ALT 95% CI: 47.86–155; AST 95% CI: 74.96–395.28); elevated bilirubin >6 mg/dL (OR = 12.8; 95% CI: 1.93–12.1); and low albumin (OR = 4.4; 95% CI: 3.1–3.39).

There was a significant relation between BUN and mortalities ($p = 0.01$). The highest risk of mortality was found with serum creatinine >5 mg/dL (OR = 17 and specificity 98.8; 95% CI: 0.67–1.29).

Risk of mortality increased with platelet count from 100,000 to 149,999 per μL (OR = 3.7; 95% CI: 276.21–371.26). And also risk of mortality doubled in patients with PT >22 s or PTT >57 s (OR = 6.5; PT 95% CI: 20.22–42.67; PTT 95% CI: 39.69–132.58) and was 100% in patients who needed anti-coagulation treatment (e.g. those of post-cannulation thrombosis).

Risk of mortality was high in patients with potassium ⩾8 mEq/L (OR = 12.1; 95% CI: 4.08–4.91) or calcium from 5 to 6.9 mg/dL (OR = 5.5; 95% CI: 8.17–9.03).

Moreover, risk of mortality increased in patients with metabolic acidosis (OR = 12.7; specificity 97.7; pH 95% CI: 7.2–7.33), fever and hypothermia (OR = 5.9; specificity 99.4) and patients who needed to insert more than one peripheral line (OR = 6; specificity 84.4).

Discussion

Regarding the admission diagnoses, our results were similar to a study in Barbados, showing that respiratory illnesses were (33%) followed by CNS (22%) and CVS problems (14%).[12] Also, Typpo et al. and Costa et al. demonstrated that the presence of MODS on the first day of hospitalization was related to higher mortality.[13,14]

In our study mean PRISM III was higher in non-survivors than in survivors (12.9 ± 9.2 and 5.7 ± 4.8 respectively). El-Nawawy and colleagues found similar results.[15] In many studies, PRISM III showed satisfactory performance in differentiating survivors from non-survivors, supporting the conclusion that higher scores are correlated with increased risk of death.[14,16] In contrast some authors have shown that the PRISM score overestimated mortality.[17]

In our study PELOD score was significantly higher in non-survivors than in survivors and there was a significant correlation between the score and the mortalities.

Similarly, another study found that the risk of mortality was directly proportional to the degree of organ dysfunction and PELOD score increased with the number of organ dysfunction.[18]

Our results regarding PEMOD score were consistent with Graciano and colleagues as they found progressive increase in PEMOD score yielded stepwise increase in overall mortality rate.[19]

In the present study we found a positive correlation between SOFA score (and TISS scores) on the day of

Table 3 Parameters used for evaluation of different systems.

	Number of patients	Mortality *n* (%)	Odds ratio	Sensitivity (%)	Specificity (%)
Respiratory					
Intubations	62	39 (62.9%)	12	65	86.5
PaO_2					
• ⩾60 mmHg	212	46 (21.7%)			
• 50–59 mmHg	12	8 (66.7%)	10.1	23.3	97.1
• 42–49 mmHg	5	4 (80%)	18.9	10	99.4
• < 42 mmHg	2	2 (100%)		3.33	100
Cardiovascular					
PRISM III (SBP)					
• Infant > 65 mmHg, child > 75 mmHg, adolescent > 85 mmHg	196	48 (24.5%)			
• Infant 45–65 mmHg, child 55–75 mmHg, adolescent 65–85 mmHg	10	2 (20.0%)	1.6	20	86.5
• Infant < 45 mmHg, child < 55 mmHg, adolescent < 65 mmHg	25	10 (40%)	2.4	16.7	92.4
AND > 205 bpm OR adolescent (> 155 bpm)					
Dopamine/Dobutamine					
No inotropes	185	31 (16.8%)			
• ⩽5 μg/kg/min	4	2 (50.0%)	8.5	48.3	90.1
• > 5–10 μg/kg/min	16	10 (62.5%)	8.5	45	91.2
• > 10–15 μg/kg/min	15	9 (60.0%)	7.1	28.3	94.7
• > 15 μg/kg/min	11	8 (72.7%)	8.6	13.3	98.2
Central venous line	18	12 (66.7%)	6.9	20	96.5
Liver functions					
Alanine Aminotransferase					
Normal	112	20 (17.9%)			
Elevated	80	22 (27.5%)	2.3	66.7	53.8
• ⩾100–250 IU/L	20	8 (40.0%)	3.1	30	87.7
• ⩾250–800 IU/L	14	8 (57.1%)	3.6	16.7	94.7
• ⩾800 IU/L	5	2 (40.0%)	1.9	3.3	98.2
Bilirubin (mg/dL)					
• ⩽1.2	24	6 (25%)			
• > 1.2–2	2	2 (100%)	4	57.1	75
• > 2–3.5	2	0 (0%)	2.3	42.9	75
• > 3.5–6	4	1 (25%)	3.8	42.9	83.3
• > 6–12	4	3 (75%)	12.8	35.7	95.8
• > 12	2	2 (100%)		14.3	100
Albumin (g/dL)					
• > 3	191	39 (20.4%)			
• 2–3	35	18 (51.4%)	4.3	35	88.9
• 1.2–2	5	3 (60%)	4.4	5	98.8
• ⩽1.2	0	0			
Kidney function					
SOFA (serum creatinine)					
• < 1.2 mg/dL	178	30 (16.9%)			
• 1.0–1.9 mg/dL	5	1 (20%)	6.4	50	86.5
• 2.0–3.4 mg/dL	1	1 (100%)	7.5	48.3	88.9
• 3.5–4.9 mg/dL	30	14 (46.7%)	7	46.7	88.9
• > 5.0 mg/dL	17	14 (82.4%)	17	23.3	98.2
Hematological system					
SOFA (Platelets)					
• ⩾150,000 per μL	204	46 (22.5%)			
• 100,000–149,999 per μL	8	5 (62.5%)	3.7	23.3	92.4
• 50,000–99,999 per μL	11	7 (63.6%)	2.8	15	94.2
• 20,000–49,999 per μL	8	2 (25%)	0.9	3.3	96.5
• < 20,000 per μL	0	0 (0%)			
PT or PTT					
• Normal	6	0 (0%)			
• 1.5 Normal	13	5 (38.5%)		100	35.3
• PT > 22 s or PTT > 57 s	10	7 (70%)	6.5	58.3	82.4
Electrolyte					
Potassium (mEq/L)					
• 3.1–6.4	197	43 (21.8%)			
• 6.5–6.9	22	9 (40.9%)	3.6	28.3	90.1

Table 3 (*continued*)

	Number of patients	Mortality *n* (%)	Odds ratio	Sensitivity (%)	Specificity (%)
• 7–7.49	6	4 (66.7%)	6.4	13.3	97.7
• 7.5–7.9	1	0 (0%)	6	6.7	98.8
• ⩾8	5	4 (80%)	12.1	6.7	99.4
Calcium (mg/dL)					
• 8–11.9	193	42 (21.8%)			
• 7–7.9 or ⩾12	27	11 (40.7%)	3.2	30	88.3
• 5–6.9	6	5 (83.3%)	5.5	11.7	97.7
• <5	5	2 (40%)	1.9	3.3	98.2

admission and mortalities. And we found a strong correlation between SOFA score, PELOD and PEMOD scores on admission. Muehler and colleagues reported that TISS score was higher in patients who died. But the mean TISS score on the day of ICU admission was much higher than in our study. This difference was because they included more surgical patients who needed more procedures which increase the value of this score.[20]

Contrary to our results, Ho and colleagues found no significant relation between SOFA on the day of admission and mortality ($p = 0.437$).[21] This difference was due to high mortality rate in our patients from sepsis.

We found a significant correlation between TISS on admission, day 1, day 3 and day 7 and SOFA score on admission, day 1, day 3 and day 7. Several studies have also reported a good correlation between TISS score and SOFA score.[20,22,23]

We found a significant positive relation between LOS and deaths. Two studies found that the mean LOS was longer in non-survivors when compared with survivors, but with no statistical significance between LOS and mortalities.[12,18]

In our study, the use of vaso-active drugs was a risk factor for death, corroborating the findings of other authors who showed higher mortality rates in patients using these drugs.[24]

Graciano and colleagues, 2005 study was similar to our results regarding the absence of relation between bilirubin and mortality rate; and the presence of positive correlation between BUN and mortality rate.[19]

High potassium was a risk of mortality, this may be explained by the fact that hyper-kalemia is a potential cause for lethal arrhythmias.[25] Same was found with hypo-calcemia, which may cause tetany, seizures and may be complicated by life threatening laryngospasm and cardiac arrhythmias.[26]

Conclusions and recommendations

PRISM III, PIM2, PELOD, PEMOD, SOFA and TISS applied in our PICU were significantly correlated to risk of mortality. SOFA score and TISS had better discrimination ability on admission. TISS was a good tool for following up patients and predicting mortality. LOS, mechanical ventilation and inotropes increased risk of mortality.

We recommend:

- The use of SOFA score and TISS in PICU for evaluating the patients on admission and predicting risk of mortality.
- The use of TISS can be enough for follow up.
- We recommend gathering different important risk factors in a new score including PaO2/FiO2, use of mechanical ventilation, MAP (mean air way pressure), use of inotropes, glasgow coma scale (GCS), papillary reflex, pH, serum Ca and K level, bilirubin level, coagulation profile, albumin, urine output, dialysis, arrest and defibrillation.

Authors' contribution

SM: recruitment of patients and data analysis; HR: analysis of data and writing the paper; ME: revision of the written paper; NM: revision of the written paper. All authors read and approved the final manuscript.

Conflict of interest

The authors declare that they have no competing interests.

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