SCORING SYSTEMS IN PEDIATRIC INTENSIVE CARE UNIT

Thesis
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Degree in pediatrics

By
Shereen Abdel Monem Mohamed
M.Sc
Faculty of Medicine-Cairo University

Under Supervision of

Prof. Dr. Nabil AbdelAziz Mohsen
Professor of Pediatrics
Faculty of Medicine-Cairo University

Dr. Mohamed Saad ElBaz
Lecturer of pediatrics
Faculty of Medicine-Cairo University

Dr. Hanaa Ibrahim Rady
Lecturer of pediatrics
Faculty of Medicine-Cairo University

Faculty of Medicine
Cairo University
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Special thanks to my family for their prayers, support and continuous encouragement.
Abstract

**Background:** Little is known of the exact causes of death and the impact of general risk factors that may complicate the course of critically ill patients. Scoring systems for use in ICU patients allow an assessment.

**Objectives:** Apply commonly used scores for assessment of illness severity and determine their relation to patient outcome. And identify the combination of factors capable of predicting patient’s outcome.

**Methods:** This study included 231 patients were admitted to PICU of Cairo University Pediatric Hospital over one year. PRISM III, PIM2, PEMOD, PELOD, TISS and SOFA scores were obtained for every patient within the day of admission and patients were evaluated on follow up using SOFA score and TISS. Then each score parameter was evaluated separately.

**Results:** Significant positive correlations were found between PRISM III, PIM2, PELOD, PEMOD, SOFA and TISS on the day of admission and mortalities of PICU (p<0.0001). TISS and SOFA score had the highest discrimination ability (area under ROC curve: 0.81, 0.765 respectively). Also significant positive correlations were found between SOFA score and TISS scores on day 1, 3 and 7 and mortalities of PICU (p<0.0001). TISS had more ability of discrimination than SOFA score on day 1 (area under ROC curve 0.843, 0.787 respectively). Other factors that increase risk of mortality were longer length of stay, mechanical ventilation, vaso-active drugs and dialysis.

**Conclusion:** Scoring systems applied in our PICU had good discrimination ability. TISS was a good tool for following up patients. LOS, use of mechanical ventilation and inotropes were risk factors of mortality.
**Key words:** Scoring systems - Pediatric intensive care unit- Mortality rate- Critical care-illness severity- multiple organ dysfunction.
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List of Abbreviations

ACTH  Adrenocorticotropic hormone
ADH   anti-diuretic hormone
AIDS  acquired immune deficiency syndrome
APACHE Acute Physiology and Chronic Health Evaluations
ARF   acute respiratory failure
ARDS  acute respiratory distress syndrome
ARF   Acute renal failure
ATN   acute tubular necrosis
BIS    bispectral index
BMT   bone marrow transplantation
BSIs  blood stream infections
CAUTI  Catheter-associated urinary tract
CDC   Centers for Disease Control and Prevention
CFU   colony-forming units
CHD   congenital heart disease
CHF   congestive heart failure
CMP   cardiomyopathy
CMM   Cancer Mortality Model
CNS   central nervous system
CONS  coagulase negative staff
CP    Child–Pugh
CPA   Cardiopulmonary arrest
CPR   cardiopulmonary resuscitation
CRIB  Clinical Risk Index for Babies
CSEP  Clinically suspected sepsis
CSF   cerebrospinal fluid.
CVC   central venous catheter
CVP   central venous pressure
CVS   cardiovascular
DIC   disseminated intra-vascular coagulation
DKA   Diabetic keto-acidosis
DMD   Duchenne muscular dystrophy
DORA  Dynamic Objective Risk Assessment
DRGs  Diagnostic Related Groupings
DSN   Dialysis Surveillance Network
ECG   electrocardiogram
EEG   electroencephalograms
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>EENT</td>
<td>eye, ear, nose, and throat</td>
</tr>
<tr>
<td>ENT</td>
<td>Ear, Nose, &amp; Throat</td>
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<td>EtCO2</td>
<td>End-tidal CO2</td>
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<td>GCS</td>
<td>Glasgow Coma Scale</td>
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<td>GI</td>
<td>gastrointestinal</td>
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<td>HAI</td>
<td>Health care associated infection</td>
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<td>ICP</td>
<td>intracranial pressure</td>
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<td>ICU</td>
<td>Intensive Care Unit</td>
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<td>IOM</td>
<td>institute of medicine</td>
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<td>LOS</td>
<td>length of stay</td>
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<td>LRI</td>
<td>lower respiratory tract infections</td>
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<td>MODS</td>
<td>Multiple organ dysfunction syndrome</td>
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<td>MPM</td>
<td>Mortality Probability Models</td>
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<td>NaSH</td>
<td>National Surveillance System for Healthcare Workers</td>
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<td>NICU</td>
<td>neonatal ICU</td>
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<tr>
<td>MRSA</td>
<td>methicillin-resistant S aureus (MRSA)</td>
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<td>NHSN</td>
<td>National Healthcare Safety Network</td>
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<td>NMD</td>
<td>Neuromuscular disorders</td>
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<td>NNIS</td>
<td>National Nosocomial Infection Surveillance System</td>
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<tr>
<td>PaCO2</td>
<td>arterial carbon dioxide pressure</td>
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<td>PEMOD</td>
<td>PEdiatric Multiple Organ Dysfunction</td>
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<td>PELOD</td>
<td>PEdiatric Logistic Organ Dysfunction</td>
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<td>PIM</td>
<td>Pediatric Index of Mortality</td>
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<td>PICANet</td>
<td>Pediatric Intensive Care Audit network</td>
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<td>PICU</td>
<td>Pediatric intensive care unit</td>
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<td>PNE</td>
<td>pneumonia</td>
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<td>PO2</td>
<td>partial pressure of oxygen</td>
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<td>PPS</td>
<td>Prospective Payment System</td>
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<td>PRISM</td>
<td>Pediatric Risk of Mortality</td>
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<td>PSI</td>
<td>Physiologic Stability Index</td>
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<tr>
<td>PVC</td>
<td>polyvinyl chloride</td>
</tr>
<tr>
<td>RIFLE</td>
<td>Risk, injury, failure, loss and end-stage kidney classification</td>
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<td>ROC</td>
<td>receiver operating characteristic</td>
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<tr>
<td>S. aureus</td>
<td>Staphylococcus aureus.</td>
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<td>SAPS</td>
<td>Simplified Acute Physiology Score</td>
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<td>SENIC</td>
<td>Study of the Efficacy of Nosocomial Infection Control</td>
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<td>SIADH</td>
<td>syndrome of inappropriate secretion of antidiuretic hormone</td>
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<td>SIRS</td>
<td>systemic inflammatory response syndrome</td>
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<td>SLOS/R</td>
<td>standardized length of stay ratio</td>
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<td>SMA</td>
<td>spinal muscular atrophy</td>
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<tr>
<td>Acronym</td>
<td>Description</td>
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<td>SMR</td>
<td>standardized mortality ratio</td>
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<td>SNAP</td>
<td>Score for Neonatal Acute Physiology</td>
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<td>SOFA</td>
<td>Sepsis-related Organ Failure Assessment</td>
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<td>SSI</td>
<td>surgical site infections</td>
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<tr>
<td>SST</td>
<td>skin and soft tissue</td>
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<tr>
<td>TcCO2</td>
<td>transcutaneous carbon dioxide tension</td>
</tr>
<tr>
<td>TcO2</td>
<td>transcutaneous oxygen tension</td>
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<tr>
<td>TISS</td>
<td>Therapeutic Intervention Scoring System</td>
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<tr>
<td>UTI</td>
<td>urinary tract infection</td>
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<td>VAP</td>
<td>Ventilator-associated pneumonia</td>
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Introduction

One pediatric population of special interest is critically ill children requiring intensive care services, since these children are at an increased risk of death (Lopez, 2006).

In recent decades, intensive care medicine has developed into a highly specialized discipline covering several fields of medicine. Whereas the total number of hospital beds in the United States decreased by 26.4% from the year 1985 to 2000, intensive care unit (ICU) beds increased by 26.2% during the same period, underlining the high demand for intensive care medicine (Halpern, 2004). Mortality rates in the ICU strongly depend on the severity of illness and the patient population analyzed, and 6.4% to 40% of critically ill patients were reported to die (Azoulay, 2003).

Although patho-physiological processes and new treatment approaches are extensively analyzed in laboratory and clinical research, comparably less data are available on the causes of death, short- and long-term outcomes of critically ill patients, and associated risk factors (Arabi, 2004).

Mostly, data on specific prognostic criteria for single diseases have been published (Bernieh, 2004). However, little is known of the exact causes of death and the impact of general risk factors that may uniformly complicate the course of critically ill patients irrespective of the underlying disease (Khouli, 2005). Knowledge of such general determinants of outcome in a critically ill patient population would not only help improve prognostic evaluation of ICU patients, but also indicate what therapy and research
should focus on to improve the short and long term outcomes of critically ill patients (Chang, 2006).

Scoring systems for use in ICU patients have been introduced and developed over the last 30 years. They allow an assessment of the severity of disease and provide an estimate of in-hospital mortality. This estimate is achieved by collating routinely measured data specific to a patient. Weighing is applied to each variable, and the sum of the weighed individual scores produces the severity score (Le Gall, 2005).

Scoring systems such as the Pediatric Risk of Mortality (PRISM) score and Pediatric Index of Mortality (PIM) are widely used in pediatric intensive care. These are third generation scoring systems that allow assessment of the severity of illness and mortality risk adjustment in heterogeneous groups of patients in an objective manner, enabling conversion of these numbers into a numerical mortality risk based on logistic regression analysis (van Keulen, 2005).
**Aim of work:**

This study was designed to:

- Describe the profile of patients admitted to PICU over one year in terms of underlying condition, system failure, as well as the supportive services provided.

- Apply commonly used scores for assessment of illness severity and determine their relation to patient outcome.

- To identify the combination of factors capable of predicting patient’s outcome.
Review of literature

Historical background:

In 1854, Florence Nightingale left for the Crimean War, where triage was used to separate seriously wounded soldiers from the less-seriously wounded. It was reported that Nightingale reduced mortality from 40% to 2% on the battlefield. Although this was not the case, her experiences during the war formed the foundation for her later discovery of the importance of sanitary conditions in hospitals, a critical component of intensive care (Manni, 2007).

In 1950, anesthesiologist Peter Safar established the concept of "Advanced Support of Life," keeping patients sedated and ventilated in an intensive care environment. Safar is considered to be the first practitioner of intensive-care medicine (Grossman et al, 2007).

Intensive care dates from the polio epidemic in Copenhagen in 1952. Doctors reduced the 90% mortality in patients receiving respiratory support with the cuirass ventilator to 40% by a combination of manual positive pressure ventilation provided by medical students and by caring for patients in a specific area of the hospital instead of across different wards. Having an attendant continuously at the bedside improved the quality of care but increased the costs and, in some cases, death was merely delayed (Bennette et al, 2009).

Bjørn Aage Ibsen established the first intensive care unit in Copenhagen in 1953 (Grossman et al, 2007). The first application of this
idea in the United States was by Dr. William Mosenthal, a surgeon at the Dartmouth-Hitchcock Medical Center. In the 1960s, the importance of cardiac arrhythmias as a source of morbidity and mortality in myocardial infarctions (heart attacks) was recognized. This led to the routine use of cardiac monitoring in ICUs, especially after heart attacks (Bennette et al, 2009).

Goran Haglund established the first pediatric intensive care unit, which he called a "pediatric emergency ward", in 1955 (Morton et al, 1997). Infants were first kept intubated for long periods in the early 1960s. Breathing tubes made out of polyvinyl chloride (PVC) allowed clinicians to avoid performing tracheostomy in more children who required prolonged mechanical ventilation (Duke et al, 2008).
Patterns of PICU admission:

Data from the Pediatric Intensive Care Audit network (PICANet), published in 2006, show that children under one year comprise 48% of admissions, 30% of which are for respiratory conditions. Overall, a third of the patients admitted have a primary cardiovascular diagnosis, 26% with respiratory diagnoses. Neurological and gastrointestinal diagnoses are also significant. Congenital disease and sepsis are more common in younger children, malignancy and trauma in older children (*PICANET, 2007*).

a) Cardiopulmonary arrest (CPA):

All patients with pediatric emergencies are susceptible to CPA because of physiological instability. Patients with respiratory and circulatory failure are particularly more susceptible because of the resultant tissue hypoxia and acidosis. For such patients cardiopulmonary resuscitation (CPR) is indicated, often followed by ICU admission for adequate stabilization and monitoring (*El-Naggar, 2009*).

b) Cardiovascular system:

Among the causes of infant mortality in the United States, congenital anomalies account for the largest diagnostic category. Structural heart disease leads the list of congenital malformations. More than 4 million children born each year in the United States, nearly 40,000 have some form of congenital heart disease (CHD). Approximately half of these children appear for therapeutic intervention within the first year of life, and the vast majority of them require critical care expertise. Patients with congenital or acquired heart disease compose a major diagnostic category for admissions
in large PICUs across the country, representing 30% to 40% or more of ICU admissions in many centers (*Arias et al, 2003*).

Dilated cardiomyopathy CMP is the most common form of CMP. Patients present to the intensive care unit with acute or chronic symptoms secondary to low cardiac output or congestive heart failure (CHF). Hypertrophic CMP may first present by an episode of sudden death (*Christopher, 2006*).

Shock is an acute, complex state of circulatory dysfunction that results in failure to deliver sufficient amounts of oxygen and other nutrients to meet tissue metabolic demands. If prolonged, it leads to multiple organ failure and death. That is why these patients should be managed in PICU (*De Bruin et al, 1992*).

Arrhythmias are commonly observed in critically ill pediatric patients. A given arrhythmia may represent the primary disease process, occur secondary to another disorder (e.g., recent cardiac surgery or myocarditis), or represent a complication of management. Close monitoring of these patients is a must (*Valsangiacomo et al, 2002*).

Hypertensive crises are designated as hypertensive urgencies or hypertensive emergencies. *Hypertensive urgencies* are characterized by markedly increased blood pressure but no evidence of end-organ damage. *Hypertensive emergencies* are defined as elevations of blood pressure resulting in hypertension-related end-organ damage. Organs most affected include the central nervous system (hypertensive encephalopathy, retinal vasculopathy-induced visual changes, cerebral infarction and hemorrhage); the cardiovascular system (congestive heart failure, myocardial ischemia,
aortic dissection); and the kidneys (proteinuria, pyuria, and hematuria with or without acute renal insufficiency). Hypertensive emergencies require immediate intervention to reduce the blood pressure to prevent progression of end-organ damage, whereas hypertensive urgencies are treated using an approach designed to control blood pressure over several hours. Both conditions should be managed in PICU (Cherney et al, 2002).

c) **Respiratory system:**

Respiratory distress or failure is the primary diagnosis in close to 50% of children admitted to PICUs and is a common cause of cardiopulmonary arrests in children. Pneumonia, acute bronchiolitis, and acute asthmatic attack are by far the most common causes of lung failure in pediatrics. Respiratory failure can result from central nervous system (CNS), neuromuscular, or muscular dysfunction (Department of health services, state of California, 2000).

Severe upper airway obstruction is also a common cause for PICU admission. Upper airway obstructions in children are much more commonly due to infections than any other cause. Of importance is the syndrome of acute respiratory distress (ARDS). It is diagnosed in 2.5-3% of children in the PICU and these children account for about 8% of total patient days and 33% of the deaths (Frankle, 2008).

d) **Neurologic system:**

Acute neurological deterioration may be a life-threatening event, with numerous causes and a few typical clinical presentations (coma, seizures, weakness, altered mental status). The clinician must act quickly to stabilize
the child with an evolving neurological illness to reverse the process and avoid further permanent neurological injury (*Hanhan et al, 2001*).

The most common causes of acute global neurological dysfunction in children are head trauma, hypoxia-ischemia, CNS infection, and encephalopathy from endogenous metabolites or exogenous toxins (*Frankle, 2008*).

Regardless of the cause, one of the most common clinical neurological conditions requiring PICU management is refractory status epilepticus. This case is considered an emergency because several respiratory (air way obstruction and apnea), cardiovascular (cardiac arrest) and metabolic complications (hypoglycemia, acid-base and electrolyte abnormalities) can be the immediate cause of death if not treated promptly (*Hanhan et al, 2001*).

Comatose patients should also ideally be transferred to an ICU where facilities for continuous monitoring and mechanical ventilator support are available if needed. And finally, an acute rise in intracranial pressure due to any cause and with impending or frank brain herniation is an emergency requiring PICU care for early prevention of secondary complications and management of cerebral ischemia and convulsions (*Shapiro et al, 1999*).

e) **Hematologic system:**

Common hematological conditions seen in pediatric critical care include severe acute anemia, hemolytic uremic syndrome, disseminated intra-vascular coagulopathy (usually occurring secondary to another severe critical illness) and several oncologic emergencies. These patients often