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# The Role of Serum Myelin Basic Protein in Prediction of Neurological Morbidity in Critically ill Children

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## Abstract

**Background:** It is well established that white matter is more resistant than gray matter to ischemic changes. An increase in Myelin Basic Protein (MBP) represents damage to white matter and thus reflects more severe neurological injury, demonstrating its potential in predicting neurological outcome. Therefore, we aimed to assess role of MBP in prediction of neurological outcome in critically ill children.

**Methods:** The included 45 critically ill children were divided into two groups according to Pediatric Cerebral Performance Category (PCPC) score into: Group 1: Patients with favorable neurological outcome with a PCPC score of 1-3. Group 2: Patients with unfavorable neurological outcome with a PCPC score of 4-6. Serum MBP of patients was performed on admission and 7 days later.

**Results:** Serum MBP was significantly elevated in patients with unfavorable neurological outcome after 1 week. Multivariate logistic regression analysis demonstrated that MBP after 7 days is the most important independent risk factor for predicting neurological deterioration. Poor baseline PCPC had the largest Area Under the Curve (AUC) for predicting poor neurological outcome followed by MBP after 7 days and then GCS at admission, add to this, poor baseline PCPC had the largest AUC to predict mortality followed by GCS at admission then PRISM and pSOFA and finally MBP after 7 days.

**Conclusion:** MBP after 7 days was superior to conventional laboratory markers and clinical scoring systems as the most important independent risk factor for predicting neurological deterioration. Also, GCS at admission, PRISM, pSOFA scores, and platelet counts were significantly associated with unfavorable neurological outcomes.

**Keywords: Children; Critical; Myelin basic protein; Neurological outcomes**

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## Introduction

Survivors of critical illness in the Pediatric Intensive Care Unit (PICU) are at risk of suffering from some disabilities, including physical, mental or cognitive, which can last for many months or even years [1-3]. The sequelae of the critical illness are called the post-intensive care syndrome, which necessitates the search for new and updated approaches used in diagnosis, treatment, as well as prevention. Most of the research related to the impact of critical illness is confined to adult ICU patients compared to pediatric patients, in addition to the paucity of data available on functional outcomes among survivors [4].

Given the recent high rate of survival in pediatric intensive care units, which in turn was reflected in the increased interest in the impact of disease after critical illness, as these children who survived tend to survive for long periods [5]. It is assumed that many diseases that require admission to the pediatric intensive care unit and concomitant therapies often lead to new morbidity [6-10]. Neurological morbidity exists among children through diagnoses that require admission to intensive care and may consist of physical, neurocognitive and socio-psychological impairments [11].

It was found that 10.3% of critically ill pediatrics obtained global functional impairment as assessed by changing in the pediatric overall performance category, while 3.4% gained impairment of cognition assessed using Pediatric Cerebral Performance Category (PCPC) after intensive care admission in the United States [12].

Molecular and cellular biomarkers may help monitor disease progression in critical care, track basic organ function, and thus improve accuracy of disease progression. The use of cellular

biomarkers in neurocritical care is influenced by presence or injury of the blood-brain barrier [13]. Since the eighties, the use of vital and cellular indicators has increased more than in previous decades [14].

Serum cellular biomarkers have been widely used due to their efficiency in prediction of the outcomes after acute brain damage such as severe stroke, traumatic brain injury, and subarachnoid and intracerebral hemorrhage [13]. One of the most abundant proteins in the white matter is the myelin basic protein, which accounts for 30% of the protein in myelin. The myelin basic protein contains many positively charged amino acid residues, which in turn make up the compact sheath of myelin [15,16]. Therefore, in the current study, we assessed the predictive value of a serum biomarker of brain damage called myelin basic protein in predicting neurological morbidity in children with diverse critical illnesses in the Pediatric Critical Care Unit.

## Patients and Methods

### Study design

In this research, we enrolled 45 critically ill children who were randomly admitted to the Pediatric Intensive Care Unit at Menoufia University Hospital from September 2018 to April 2019. The study protocol was approved by the Scientific and Ethical Committee of Menoufia University and informed consent taken from parents before participating their children in this research and approval number was 8/2018 PEDI 20.

Critically ill children in the pediatric intensive care unit aged one month to eighteen years were included in this study. Exclusion criteria included 1) children with a past history of central nervous diseases such as cerebral palsy and epilepsy. 2) Patients admitted with an initial diagnosis of neurological diseases such as cerebral infarction, meningitis and encephalitis. 3) Cases of head injuries. 4) Cardiac arrest before admission. The patients included were 18 males and 27 females.

All patients were classified into two groups according to the cerebral performance category score for children; Group (1) involved patients with the favorable neurological outcome who had a cerebral performance category score from 1 to 3 degrees and included 17 patients. Group (2) included patients with an unfavorable neurological outcome whose cerebral performance category score ranged from 4 to 6 degrees and included 28 patients.

All patients were followed up on admission and 7 days after discharge. All children who were included in this study underwent complete history taking including age, sex, data of admission, stay length in the intensive care unit and inward department. Vital manifestations, anthropometric parameters and examination of all organs were also assessed. The mental state was assessed to ascertain the presence or absence of any disturbances in the level of consciousness (lethargy, confusion, coma), in addition to a comprehensive neurological assessment, including examination of the cranial nerves, as well as the motor, sensory and autonomic systems.

The following scoring systems in PICU were used involving 1) The modified Pediatric Glasgow Coma Scale (GCS) to assess the consciousness level (score +13 indicates mild brain injury, 9-12 indicates moderate brain injury and 8-3 indicates severe brain injury [17]. 2) Pediatric Risk of Mortality Scale (PRISM) to assess mortality. The PRISM score was estimated within 24 h of admission for each patient, using 14 clinical and laboratory variables where data were entered on the website: http://www.sfar.org/scores2/prism2.php that automatically calculates the expected death rate [18]. 3) The Pediatric Sequential Organ Failure Assessment Scale (pSOFA) to assess dysfunction of organs and relying on baseline risk level of the patient, a pSOFA score of >2 identified a 2 to 25-fold increased death risk compared to patients whose pSOFA score was <2 [19]. 4) Pediatric Cerebral Performance Category Scale (CPCS) to assess child cognitive impairment and neurological morbidity [20]. Established on a 6-point scale, where 1 means normal, 2 means mild disability, 3 means moderate disability, 4 means severe disability, 5 means coma or vegetative state, and 6 means death. The outcome is favorable if the PCPC equals 1 to 3 points, and the outcome is unfavorable if the PCPC equals 4 to 6 points. Radiological evaluation of the various organs of the body, including X-rays, CT scans, MRI scans, and others were done whenever needed.

### Procedures

A 2 ml blood sample obtained from the central venous access available at PICU entry or by peripheral venipuncture is placed in each of the EDTA vacutainer tube, plain tube and citrated tube for various analyzes such as complete blood count, serum potassium, serum sodium, serum phosphorous, serum calcium, blood glucose, liver and kidney function tests, C-reactive protein, prothrombin time and international normalized ratio. Various body cultures, including blood culture, by taking a blood sample of 10 ml and cultivating it with BACTEC technology, which is fully automated. Serum MBP was performed upon admission to the intensive care unit and after 7 days where 2 ml of venous blood was drawn from each patient and transferred to a plain tube, and the serum was obtained by centrifugation for 10 min at 4,000 rpm and then kept frozen at -20°C until the time of the MBP measurement. Human MBP was tested using the SUN RED ELISA Kit. This kit uses a dual-antibody ELISA assay to check the level of human MBP in samples. The sample is added to an enzyme monoclonal antibody pre-coated with human MBP monoclonal antibody, then incubated, then add biotin-labeled MBP antibody that combines with Streptavidin-HRP to form an immunocomplex, then incubated and washed again to remove the unsustainable enzyme. Then a solution of chromogen A, B is added, which causes the color of the liquid to change to a blue color, and with the influence of acid, the color finally becomes yellow. The color density and MBP concentration of the sample are positively correlated. Finally, the optical density under 450 nm wave length is measured within 15 min after the addition of the stop solution.

### Statistical analysis

Data were collected, tabulated and statistically analyzed using an IBM personal computer using version 19 of the Statistical Package for the Social Sciences (SPSS 19, Inc, Chicago, Illinois, USA). Descriptive statistics included quantitative data in the form of arithmetic mean (X-), Standard Deviation (SD), and range, while qualitative data were included in the form of numbers and percentages. Analytical statistics included the Chi-square ($\chi^2$) test, Student's t-test, Mann-Whitney test, and Fisher's exact test. We used logistic regression models to determine the ability of MBP to estimate potential neuromorbidity. Variables were tested in univariate analysis (e.g., age, sex, admission GCS, poor baseline PCPC) using Spearman's correlation (r). Next, multivariate logistic regression models for the MBP biomarker were generated using covariates with a p value of 0.013. This resulted in the inclusion of a poor baseline PCPC in the models. Receiver operating

characteristics analysis of peak MBP biomarker level adjustment models were performed for poor baseline PCPC as an indicator of poor neurological outcome at hospital discharge. Statistical calculations were performed using Sigma Plot 11.0. A subgroup analysis was performed comparing the initial admission diagnosis and baseline PCPC. A P value <0.05 was considered statistically significant.

## Results

Admission demographics and clinical characteristics of the studied groups are shown in Table 1. Seventeen patients (37.8%) had favorable neurological outcome with median age of 36 months and 58.8% were females. While; twenty-eight (62.2%) patients had unfavorable neurological outcome with median age of 14.5 months and 60.7% were females. Unfavorable neurological outcome patients had lower significantly Glasgow coma score than favorable neurological outcome patients (P=0.009). PCPC score was significantly higher among patients with unfavorable neurological outcome on admission and discharge rather than favorable neurological outcome group (P<0.001).

Unfavorable neurological outcome group were significantly increased regarding to PICU and hospital stay comparing to favorable neurological outcome group (P=0.012 and 0.018). PRISM

**Table 1:** Demographic and clinical characteristics of the studied groups.

| Studied variables | The studied groups | | Test of significance | P Value |
|---|---|---|---|---|
| | Favorable neurological outcome (n=17) | Unfavorable neurological outcome (n=28) | | |
| **Age (month)** | | | U | |
| Mean ± SD | 49.1 ± 53.8 | 38.3 ± 49.7 | 0.094 | 0.925 |
| Median (IQR) | 36 (3.00-84) | 14.5 (8.00-54.0) | | |
| **Sex** | N (%) | N (%) | $X^2$ | |
| Male | 7 (41.2) | 11 (39.3) | 0.016 | 0.9 |
| Female | 10 (58.8) | 17 (60.7) | | |
| **BMI (kg/m²)** | | | U | |
| Mean ± SD | 16.2 ± 3.68 | 15.1 ± 3.36 | 0.808 | 0.419 |
| Median (IQR) | 16 (13.5-18.1) | 15.4 (12.5-16.5) | | |
| **GCS on admission** | | | $X^2$ | |
| (3–8) | 0 (0.00) | 4 (14.2) | 9.34 | **0.009*** |
| (9–12) | 2 (11.8) | 12 (42.9) | | |
| (13–15) | 15 (88.2) | 12 (42.9) | | |
| **Admission PCPC score** | | | U | |
| Mean ± SD | 1.88 ± 0.92 | 4.03 ± 0.74 | 5.23 | **<0.001*** |
| Median (IQR) | 2.00 (1.00–3.00) | 4.00 (3.25–5.00) | | |
| **Discharge PCPC score** | | | U | |
| Mean ± SD | 2.11 ± 0.99 | 5.00 ± 1.01 | 5.78 | **<0.001*** |
| Median (IQR) | 3.00 (1.00–3.00) | 5.00 (4.00–6.00) | | |
| **Mechanical ventilation** (hrs) | | | U | |
| Mean ± SD | 14.6 ± 6.84 | 380.3 ± 708.2 | 3.22 | **0.001**** |
| Median (IQR) | 12 (6.00–23.0) | 192 (48–2712) | | |
| **PICU stay/day** | | | U | |
| Mean ± SD | 7.12±5.34 | 14.6±20.1 | 2.5 | **0.012*** |
| Median (IQR) | 6 (6.00–8.50) | 10 (6.25–17.7) | | |
| **Hospital stay/day** | | | U | |
| Mean ±SD | 7.88 ± 4.18 | 16.3 ± 20.4 | 2.36 | **0.018*** |
| Median (IQR) | 8 (5.00–10.0) | 12 (7.00–18.0) | | |
| **PRISM** | | | U | |
| Mean ± SD | 7.47 ± 3.59 | 11.2 ± 4.67 | 2.61 | **0.009*** |
| Median (IQR) | 7 (4.50–9.00) | 11 (7.20–15.0) | | |
| **pSOFA** | | | U | |
| Mean ± SD | 5.05 ± 1.91 | 7.25 ± 2.93 | 2.76 | **0.006*** |
| Median (IQR) | 4 (4.00–6.00) | 6 (5.00–10.0) | | |
| **Mortality** | N (%) | N (%) | $X^2$ | |
| Yes | 0 (0.00) | 14 (50.0) | 12.3 | **<0.001*** |
| No | 17 (100) | 14 (50.0) | | |

GCS: Glasgow Coma Scale; PCPC: Pediatric Cerebral Performance Category Scale; PICU: Pediatric Intensive Care Unit; PRISM: Pediatric Risk of Mortality; pSOFA: Pediatric Sequential Organ Failure Assessment score; IQR: Inter Quartile Range; U: Mann Whitney test; * Significant

**Table 2:** Serum myelin basic protein of the studied patients on admission and after one week.

| Studied variables | The studied groups | | Test of significance | P Value |
|---|---|---|---|---|
| | Favorable outcome (n= 17) | Unfavorable outcome (n=28) | | |
| **Admission Serum MBP (ng/L)** | | | U | |
| Mean ± SD | 267.9 ± 137.6 | 248.1 ± 179.6 | 0.831 | 0.406 |
| Median (IQR) | 273 (148.5–377.5) | 216.5 (100.5–340) | | |
| **After one week Serum MBP (ng/L)** | | | U | |
| Mean ± SD | 2090.4 ± 2137.6 | 6673.8 ± 4854.1 | 4.06 | **<0.001*** |
| Median (IQR) | 1114 (414.5–3758.5) | 6773 (3285–8660.5) | | |

MBP: Myelin Basic Protein; IQR: Inter Quartile Range; U: Mann Whitney test

**Table 3:** Correlation between serum MBP with clinical and laboratory variables.

| Studied variables | Serum MBP (ng/L) On admission | | Serum MBP (ng/L) after 7 days | |
|---|---|---|---|---|
| | r | P value | r | P value |
| **Age, Months** | 0.041 | 0.788 | 0.103 | 0.517 |
| **Weight, Kg** | -0.094 | 0.541 | 0.111 | 0.484 |
| **Admission GCS** | -0.241 | 0.111 | -0.47 | **0.002**** |
| **Poor baseline PCPC** | -0.072 | 0.639 | 0.498 | **0.001**** |
| **On discharge PCPC** | -0.069 | 0.653 | 0.666 | **0.001**** |
| **PRISM** | -0.157 | 0.302 | 0.235 | 0.133 |
| **pSOFA** | 0 | 0.998 | 0.19 | 0.229 |
| **Mechanical ventilation duration (hours)** | 0.064 | 0.836 | 0.675 | **0.016*** |
| **Length of PICU stay, days** | 0.014 | 0.926 | 0.389 | **0.011*** |
| **Length of hospital stay, days** | 0.007 | 0.962 | 0.323 | **0.037*** |
| **Hb, g/dL** | 0.225 | 0.137 | -0.052 | 0.744 |
| **WBC, 1000/uL** | -0.201 | 0.185 | 0.216 | 0.17 |
| **Platelets, 1000/uL** | -0.088 | 0.566 | -0.147 | 0.353 |
| **CRP, mg/dL** | -0.222 | 0.142 | -0.027 | 0.865 |
| **Creatinine, mg/dL** | -0.025 | 0.873 | -0.142 | 0.377 |
| **Albumin, g/dL** | 0.008 | 0.969 | -0.286 | 0.157 |

GCS: Glasgow Coma Scale; PCPC: Pediatric Cerebral Performance Category Scale; PICU: Pediatric Intensive Care Unit; PRISM: Pediatric Risk of Mortality; pSOFA: Pediatric Sequential Organ Failure Assessment Score; Hb: Hemoglobin; WBC: White blood cell count; CRP: C-reactive protein; * Significant

and pSOFA scores were significantly increased in unfavorable neurological outcome group than favorable neurological outcome group (P=0.009 and 0.006) respectively. Mortality was 50% in unfavorable neurological outcome group with highly significantly increased (P<0.001) (Table 1).

Regarding to serum myelin basic protein of the studied patients; our result showed that mean MBP level was significantly elevated in children with unfavorable neurological outcome comparing with those with favorable neurological outcome after 7 days [2090.4 ± 2137.6 ng/ml *vs.* 6673.8 ± 4854.1 ng/ml (P<0.001)]. No statistically significant differences between the two groups regarding mean MBP level on admission (Table 2).

Correlation between serum MBP with clinical and laboratory variables are shown in Table 3. Serum MBP after 7 days was positively correlated with poor baseline and discharge PCPC, mechanical ventilation duration, length of PICU stays and length of hospital stays. On the other hand, it was negatively correlated with admission GCS. Serum MBP on admission wasn't correlated with any clinical and laboratory variables.

Univariate and multivariate analyses for the association of the risk factors with unfavorable neurological outcome are shown in Table 4. Univariate logistic regression analysis showed that admission GCS, PRISM, pSOFA, platelet count and MBP level after 7 days were significantly associated with unfavorable neurological outcome. Multivariate logistic regression analysis showed that serum MBP level after 7 days was the most independent predictor risk factor for neurological deterioration (P=0.013; OR 1.00, 95% CI = 1.00–1.00).

Area under the curve for serum MBP and clinical variables to predict poor neurological outcome and mortality; poor baseline PCPC had the largest Area Under the Curve (AUC) for predicting poor neurological outcome followed by MBP after 7 days and then GCS at admission, add to this, poor baseline PCPC had the largest AUC to predict mortality followed by GCS at admission then PRISM and PSOFA and finally MBP after 7 days (Table 5 and Figure 1, 2).

## Discussion

Brain damage is widespread in infancy. Five times more pediatrics die from brain damage than children tumor [21]. Reported experiences in pediatric neurocritical care consultation services indicate that approximately one quarter of patients are admitted to the pediatric intensive care unit have or are risky for severe neurological

**Table 4:** Univariate and multivariate logistic regression analysis for the risk factors associated with unfavorable neurological outcome.

| Univariate logistic regression analysis | | |
|---|---|---|
| **Variable** | **Odds ratio (95% CI)** | **p-value** |
| **Age, Months** | 0.004 (0.984–1.00) | 0.485 |
| **Sex (Male Vs. Female)** | 0.079 (0.317–3.69) | 0.9 |
| **Weight (Kg)** | 0.026 (0.907–1.04) | 0.479 |
| **Admission GCS** | 0.498 (0.304–0.815) | **0.006**** |
| **PRISM** | 1.24 (1.04–1.47) | **0.014*** |
| **pSOFA** | 1.47 (1.06–2.05) | **0.019*** |
| **Mechanical ventilation duration (hours)** | 0.327 (0.01–2.38) | 0.993 |
| **Admission Serum MBP (ng/dL)** | 0.001 (0.996-1.00) | 0.691 |
| **Serum MBP after 7 days (ng/dL)** | 1.00 (1.00–3.24) | **0.002**** |
| **Hb (gm/dL)** | 0.166 (0.655–1.09) | 0.204 |
| **CRP (mg/dL)** | 0.008 (0.996–1.02) | 0.183 |
| **WBC (1000/uL)** | 0.001 (0.958–1.04) | 0.969 |
| **Platelet count, (1000/uL)** | 0.995 (0.991–0.999) | **0.023*** |
| **Albumin (gm/dL)** | 0.508 (0.180–1.43) | 0.2 |
| **Multivariate logistic regression analysis** | | |
| **Admission GCS** | 0.258 (0.372–1.61) | 0.491 |
| **PRISM** | 0.081 (0.838–1.40) | 0.54 |
| **pSOFA** | 0.240 (0.742–2.18) | 0.382 |
| **Serum MBP after 7 days (ng/dL)** | 1.00 (1.00-1.00) | **0.013*** |
| **Platelet count** | 0.003 (0.989– 1.00) | 0.997 |

PRISM: Pediatric Risk of Mortality; SOFA: Pediatric Sequential Organ Failure Assessment score; CRP: C-Reactive Protein; WBC: White Blood Cell Count; OR (95% CI): Odds Ratio and 95% Confidence Interval; * significant

**Table 5:** Area under the curve for serum MBP and clinical variables to predict poor neurological outcome and mortality.

| Area under curve for MBP and clinical variables to predict poor neurological outcome. | | | | | |
|---|---|---|---|---|---|
| **Variable** | **AUC (95% CI)** | **P value** | **Cutoff level** | **Sensitivity (%)** | **Specificity (%)** |
| **Admission MBP** | 0.425 | 0.406 | 279 | 53% | 39% |
| **After 7 days MBP** | 0.873 | **0.001**** | 2538 | 82% | 65% |
| **Poor baseline PCPC** | 0.956(0.905 – 1.00) | **0.001**** | 3.5 | 100% | 65% |
| **Area under curve for Serum MBP and clinical variables to predict mortality.** | | | | | |
| **Admission MBP** | 0.508(0.320 – 0.697) | 0.932 | 287 | 50% | 68% |
| **After 7 days MBP** | 0.761(0.606 – 0.916) | **0.011*** | 4039 | 64% | 68% |
| **Poor baseline PCPC** | 0.903(0.816 – 0.990) | **0.001**** | 3.5 | 100% | 35% |
| **PRISM** | 0.825(0.681 – 0.969) | **0.001**** | 9.5 | 93% | 61% |
| **pSOFA** | 0.786(0.631 – 0.940) | **0.002**** | 5.5 | 86% | 68% |

AUC (95% CI): Area under the Receiver Operating Characteristic Curve and 95% Confidence Interval

injury [22].

Pediatric ICU patients with a neurological damage also have elevated mortality rate, long standing morbidity, and prolonged hospital stay [23]. So, in this study; Twice blood measurements of serum MBP were withdrawn to predict neurological morbidity in children with diverse critical illnesses in the Pediatric Critical Care Unit. We found that the serum MBP biomarker increased after brain injury. Importantly, after 7 days; the biomarker has potential value to clinicians in grading the severity of brain injury. As a statistically significant increase in serum MBP level was observed in children with unfavorable neurological outcome comparing with those with favorable neurological outcomes. Patients who died make up half of those with an unfavorable neurological outcome. However, the other half of the patients in the unfavorable outcome group survived.

Interestingly, unfavorable neurological outcomes are not limited to children admitted with a neurological diagnosis. But patients in our study who were declared to have a brain injury were not admitted with a primary neurological diagnosis. This suggests the need for close neurological monitoring among all patients admitted to the Pediatric Intensive Care Unit (PICU) and the potential for using of serum biomarkers of brain injury as screening tools across the PICU. The Pediatric Critical Care Research Collaborative Network found new morbidities in 4.8% of patients at hospital discharge after ICU admission, with the highest new morbidity rate in children with a neurological diagnosis (7.3%) [24].

A previous study clarified that more than half of the children who

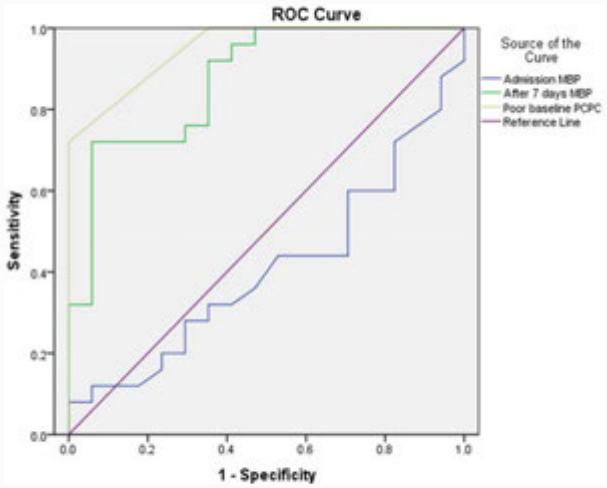


**Figure 1:** Area under curve for MBP and clinical variables to predict poor neurological outcome.

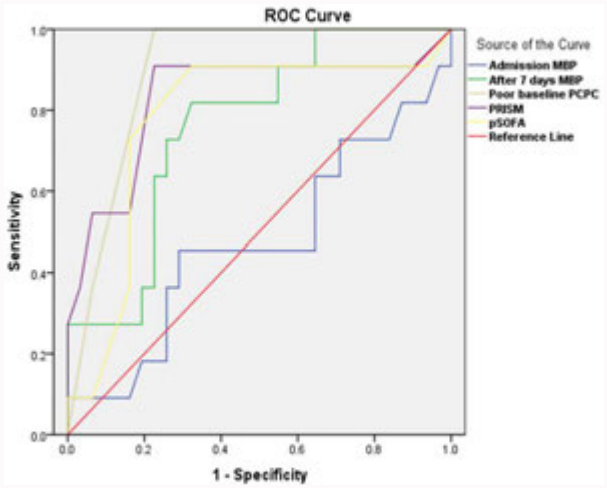


**Figure 2:** Area under curve for Serum MBP and clinical variables to predict mortality.

died in a pediatric intensive care unit had a severe brain damage. In 90% of these children, brain damage was considered the immediate cause of mortality [25].

Regarding the Glasgow coma score, we showed that children with unfavorable neurological outcome had a significantly lower Glasgow coma score, but we did not do this as a standardized approach to evaluate, follow up and classify patients with neurological damage. This may be explained by the admission GCS score which may reflect the neurological status incompletely, and can be influenced by the use of pharmacological anesthesia/neuromuscular blockage and PCPC status [26].

Serum MBP was significantly elevated in children with unfavorable neurological outcome after 7 days versus favorable neurological outcome. An increase in serum MBP may indicate a traumatic or ischemic nerve injury with subsequent secondary injuries. It is already proven that the white matter is more resistant than the gray matter to ischemia, so the level of MBP increases in the case of damage of white matter and in severity of neurological injuries, and then its greater ability in prediction of favorable and unfavorable neurological outcomes [27,28].

In line with these findings, Au et al., [5] showed that a Peak biomarker level of MBP was significantly increased in children with unfavorable neurological outcome in comparison with those with favorable neurological outcome. In adults, levels of serum are increased for two weeks after Traumatic Brain Injury (TBI) and are correlated with three-month outcome [29].

In children TBI, MBP has been correlated with GOS, GOS-Extended Pediatric, Vineland Adaptive Behavior Scale, and Intelligence Quotient [30,31], and cardiac arrest in pediatrics can predict the survival [32].

## Conclusion

In this study, we showed that serum MBP after 7 days is predictive for unfavorable neurological outcome of children with diverse critical illnesses in the Pediatric Critical Care Unit and clinically, it was superior to conventional laboratory markers and clinical scoring systems as the most important independent risk factor for predicting neurological deterioration.

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