ISSN- O: 2458 - 868X, ISSN–P: 2458 – 8687
National Library of Medicine - ID: 101731606

International Journal of Medical Science and Innovative Research (IJMSIR)
IJMSIR : A Medical Publication Hub
Available Online at: www.ijmsir.com
Volume – 8, Issue – 2, March – 2023 , Page No. : 148 – 156

A comprehensive study on clinical correlation of altered sensorium, vital signs and electrolytes abnormalities as marker of outcome from Pediatric intensive care unit (PICU) - A prospective observational study

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Citation this Article: Jeffy Joy. K, Pukhraj Garg, Priya Jhajhra, "A comprehensive study on clinical correlation of altered sensorium, vital signs and electrolytes abnormalities as marker of outcome from Pediatric intensive care unit (PICU) - A prospective observational study", IJMSIR- March - 2023, Vol – 8, Issue - 2, P. No. 148 – 156.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Sudden deterioration of sensorium is seen commonly among critically ill children admitted in Pediatric Intensive Care Units (PICU). There is limited evidence to show the association between electrolyte abnormalities, level of consciousness, vital signs and the clinical outcome among children, especially who are admitted in PICU from India. Such studies will be of great help for clinicians to anticipate the clinical outcome among children who present with varied levels of consciousness and electrolyte disturbances to the PICU. From our single Centre study, we found children with GCS scores (3-8) and those with AVPU score unresponsive to stimuli had more chances of mortality than others (<0.001). There was significant association between distribution of potassium levels (p value 0.034) and chloride levels (p value <0.001) with the outcome of study participants, that is, more mortality among children with higher potassium levels and higher chloride levels. We observed significant difference between the distribution of blood pressure, heart rate and respiratory rate of the study participants with GCS scores (p value <0.05) and with AVPU status (p value <0.05). We noticed that lower GCS scores (3-8) were found among people with brady cardia, bradypnoea and hypertension. Thus, our study concluded emphasizing the importance of electrolyte imbalance, GCS scores and AVPU levels as an important prognostic indicator of determining mortality among sick children admitted in PICU.

Keywords: PICU; Altered sensorium; GCS; AVPU; Electrolyte abnormalities.

Introduction

Sudden deterioration of sensorium is seen commonly among critically ill children admitted in Pediatric Intensive Care Units (PICU). There could be several reasons behind the altered conscious ranging from reversible causes such as hypoglycaemia, to irreversible and life-threatening causes like stroke. It can also be due to benign reasons such as drug intoxication to potentially serious conditions such as meningoencephalitis (1). A clear knowledge on the importance of accurate, reliable, and valid evaluation techniques are vital for the manage ment of such cases of altered sensorium in PICU. Consciousness can be viewed as a state of being wakeful,

being aware or alert, which most functions happen, or from which the can be awakened (2). While altered consciousness is more complex to define and chara cterize, various terms such as clouding of conscious ness, confused state, stupor, dementia, hypersomnia, vegetative state akinetic-mutism, locked-in syndrome, coma and brain death have been extensively used to refer to it. A decreased consciousness majorly occurs owing to disruption in ascending reticular activating system, that controls arousal, or it might also be due to a lesion or trauma to bilateral cortices, which usually responds as awareness (3).

Levels of consciousness are often measured using Glasgow Coma Scale (GCS) across all PICUs. GCS is used due to its simplicity, reliability, and easiness in administering as it involves documenting a patient's response like eye opening, verbal and motor response (4). It was primarily designed to access and estimate the general level of consciousness among traumatic brain injury patients and to define broad categories of head injury. GCS can be applied to describe impairment of consciousness from any cause. No modification is needed for more than 5 years old. Another scale measure the level of consciousness, is the AVPU score (Alert, Verbal or voice responsive, Pain responsive, Unresponsive). But, AVPU score has the issue of being a one which cannot be utilised for long term follow up of neurological status (5). Alterations in sodium and potassium imbalance in general diffusely affect specific neurons causing damage, especially affecting the thalamic and cortical neurons that are metabolically sensitive.

This is often seen as derange ment of biochemical parameters and enzymes involving brain activity and is manifested as clinical manifestations like coma and altered consciousness (6).

The five accepted mechanism explaining the incidence of electrolyte imbalances in critically sick children are the end organ injury, underlying pathology, imbalances in fluid and electrolyte imbalances, medication use and finally use of positive pressure ventilation (7).

There is limited evidence to show the association between electrolyte imbalance, level of consciousness, vital signs and the clinical outcome among children, especially who are admitted in PICU from India(8).Such studies will be of great help for clinicians to anticipate the clinical outcome among children who present with electrolyte disturbances and with varied levels of consciousness to the PICU. It is often hypothesized many a times interventions are linked to the consciousness level and in sometimes it is the estimate of prognosis based on scores. Thus there is a need for such a scale to be simple to learn, understand and implement. Thus we conducted this study to prove the association between electrolyte imbalances, levels of consciousness, vital signs and the clinical outcome among PICU admission in our hospital.

Materials and Methods

The prospective observational study commenced after obtaining Institutional Ethics Committee clearance. The study was conducted at a tertiary care PICU in Rajasthan, India from July 2020 to June 2021.A study group comprising of 100 consecutively admitted children with altered sensorium and altered electrolyte status were selected.

After the consent, the parents or guardians were explained regarding the study, then history, clinical examination including GCS, AVPU, brainstem reflexes, vital signs recorded. Electrolytes samples were send and follow up was done for outcome.

All information were filled in designed proforma.

The GCS was administered based on:

PEDIATRIC GLASGOW COMA SCALE (PGCS)				
	> 1 Year		< 1 Year	Score
EYE OPENING	Spontaneously		Spontaneously	4
	To verbal command		To shout	3
	To pain		To pain	2
	No response		No response	1
MOTOR RESPONSE	Obeys		Spontaneous	6
	Localizes pain		Localizes pain	5
	Flexion-withdrawal		Flexion-withdrawal	4
	Flexion-abnormal (decorticate rigidity)		Flexion-abnormal (decorticate rigidity)	3
	Extension (decerebrate rigidity)		Extension (decerebrate rigidity)	2
	No response		No response	1
	> 5 Years	2-5 Years	0-23 months	
VERBAL RESPONSE	Oriented	Appropriate words/phrases	Smiles/coos appropriately	5
	Disoriented/confused	Inappropriate words	Cries and is consolable	4
	Inappropriate words	Persistent cries and screams	Persistent inappropriate crying and/or screaming	3
	Incomprehensible sounds	Grunts	Grunts, agitated, and restless	2
	No response	No response	No response	1
TOTAL PEDIATRIC GLASGOW COMA SCORE (3-15):				

While, AVPU is used rapidly to grade a patient's gross level of consciousness, responsiveness, or mental status. And uses the following:

(A)Alert: The child is awake, and interactive with care providers

(V) Verbally Responsive: Responds only if the care provider calls by name or speak loudly

(P) Painfully Responsive: The child responds only to painful stimuli

(U) Unresponsive: Unresponsive to all stimuli

Data was entered in Excel and analyzed using SPSS version 20 and graphs were depicted using Microsoft excel/SPSS.

Continuous variables like the age, sodium levels were summarized as Mean ± Standard deviation or median with inter quartile range based on normality. The percentage of individuals with a clinical outcome was sum marized as frequency and proportions.

The association between the demographic parameters, and other biochemical and examination findings with the outcome variable was assessed using the chi square test or Fischer's exact test. P value of <0.05 was taken statistically significant.

Results and Discussion

We could see that almost half (44%) of the study participants were belonging to the age group of <5 years, with the mean age of 6.8 (4.8) years. Around 54% of the children were males by gender. We found that more than half 53% (15%) of the children had GCS scores (13-15) according to the Glasgow coma scale, while with respect to the AVPU scale for the level of alertness among the children, we found that around 78% were responsive to verbal stimuli. When the serum electrolytes (Sodium, Potassium and Chloride values) were considered, we found that majority of the PICU admission had hyponatremia (84%), followed by hypernatremia (13%), while for potassium we found that hyperkalemia was seen among 26%, and hypokalemia among only 3%, and the rest had normal potassium values. With respect to chloride values, we found that around 79% had normal chloride values, while 15% had low chloride and 6% had high chloride values. The most common diagnosis among the PICU admissions that were taken into the study were acute diarrhea diseases (16%), followed by meningitis / meningoencephalitis (14%), lower respiratory tract infections (13%), the children also had other diagnosis such as with diabetic ketoacidosis and simple febrile seizures. This finding from our study is also supported by other research evidences from other studies from varied clinical settings (9). This finding also underscores the impact of these diagnosis on the electrolyte imbalances among the children. All children had intact brainstem reflexes and were euglycemic on admission.

Several disease conditions could underlie the reason for sudden deterioration of sensorium of which electrolyte imbalances are the commonest among paediatric children. The frequently encountered electrolyte disturb ances among children include imbalances in serum sodium, potassium and chloride levels. We found that of

the selected study participants, hyponatremia was the most common electrolyte derangement, followed by hyper kalaemia and hypo chlor aemia. This finding was also found to be similar to a study by Mayank et al, from India (10). These electrolyte imbalances are often associated with varied degrees of presentations which can lead on to substantial morbidity and mortality, especially among critically ill children (11).We undertook our study to determine the levels of consciousness assessed through GCS, AVPU scores among the children admitted in PICU. We also intended to analyse the effect of bio chemical rearrangements on the level of consciousness, and also to determine the effect of heart rate, blood pressure and respiratory rate on GCS scores and AVPU status of the critically ill children with altered sensorium admitted in our hospital PICU during the study period. We did not find any significant association between the sex of the participants and the distribution of sodium levels among the study participants with the clinical outcome of patients (p value 0.688). We also observed a significant association between distribution of potassium levels and chloride levels with the outcome of study participants, where distribution of potassium had p value of 0.034 (more mortality among children with high potassium values) while chloride levels also were also statistically found to be determinants of the outcome, with more mortality observed among the participants with hyperchloremia levels (p value <0.001).This finding from our study was also found to be in line with other studies. With respect to be distribution of electrolytes across the GCS score groups, we found that there was statistically significant found across the GCS subgroups. We also observed that children with hypernatremia and hyperkalemia were associated with poor GCS scores. A study by Safder et al, also has showed a statistically significant difference across the distribution of serum electrolytes with GCS scores, with lower GCS scores correlating with higher electrolyte levels. (12-15). Our study showed a significant difference with respect to the distribution of serum sodium and chloride levels with the AVPU status of children admitted in PICU. (p value <0.05). This finding was also found to be similar to other studies (16). We also observed that children with hyper natremia and hypo chlor aemia were more often unresponsive.

We noted that there was a significant difference between the distribution of sodium, potassium and chloride levels of the study participants with GCS scores (p value <0.05). In our study we found that majority of the children admitted in PICU had GCS score of between 13-15, AVPU level of responsiveness showed that around 4/5th of the children were verbally responsive. This finding was found to be similar to other studies published from India. (17,18). Our findings were found to differ from a few studies from varied clinical settings, the reasons could be differences in study population, study settings, the co-morbidity, and underlying diseases among the children who were included for the study.

With respect to the follow up of outcomes, we found that around 10 children out of the 100 study participants expired, mortality rate of 10% among the critically admitted children admitted in PICU. This finding was found to be in line with others studies done among children admitted in PICU from various study settings (19,20). When the association or impact of clinical characteristics with the outcome was studied, we found that age category, GCS scores, AVPU status were found to be determinants of the outcome i.e., mortality. These findings are also further supported by other studies by Ghaffar as and et al, who have also showed that incidence of mortality is more common among children with more worse GCS scores and who were either

responsive to pain or unresponsive (21). We noted that there was a significant difference between age of children and the outcome (p value 0.042) with older children having more mortality. We found that GCS scores were found to be significant determinants of the clinical outcome were we noticed that children with GCS (3-8) had more chances of mortality and it was found to be statistically significant (p value <0.001). Taking level of consciousness into account we found that children who were unresponsive to stimuli had more chances of mortality than others (p value 0.001).

Moderate to severe brain injuries usually require prolonged hospital stay, especially for children their stay in PICU is crucial, despite which the outcome remains quite erratic. Despite, several scoring systems are in place to access the outcomes, the commonly accepted ones are the GCS and AVPU scores. Several factors such as age, gender, type of brain injury, comorbidity could influence the mortality pattern, and also the severity of injury as assessed by GCS scores (22,23). In many instances, the prognosis and outcome of children admitted with unconsciousness, depends on the age of presentation, extent of brain injury, diagnosis, com or bidity status and imbalance in biochemical parameters. Studies have shown that children with altered electrolyte pattern especially hyponatremia, hypernatremia, hypo kalmia, and hyper chloremia have adverse outcomes (24).The incidence of critically ill children hav in electrolyte abnormalities were also found to be in line with studies from Muralitharan et al, Subba Roa et al and Prasad et al. Subba Roa et al concluded stating that the incidence of mortality to be the maximum i.e., 25% among the children with hyper kalaemia, which is again similar to our study findings, thus making our study findings comparable to other studies from similar study settings. Our study showed a increased incidence of mortality among the children with hypernatremia and hyper chloremia, when compared to studies by Prasad et al and Mayank et al, the reason behind could be accounted by variations in study settings, study population, sampling and the clinical characteristics of the children included in both the studies (25-27).

Lastly in our study we also found a statistically significant difference between the distribution of blood pressure, heart rate, respiratory rate with various GCS scores and AVPU status. (p value <0.05). This shows the impact of variations vital signs on the conscious level of the children. Our finding again confirms the finding by Reisner et al, which proposed the predictive nature of blood pressure, respiratory rate, heart rate on the GCS scores of children and adults admitted in ICU. (28)

Strengths

Our study had several strengths

1. Ours was one among the very few studies that has evaluated the association of Glasgow Coma Scale, AVPU, and clinical profile of patients admitted in PICU with their survival.
2. Our study was also one among of the few literatures that has evaluated the effect of Biochemical electrolytes (Na+, K+, Cl-), and vital signs with GCS scores and AVPU status

Limitations

Despite all, our study had certain limitations

1. We had a smaller sample size to evaluate the effect of various electrolyte imbalances on GCS, AVPU status and mortality.
2. Our analyses may overestimate or underestimate the incidence of electrolytes, based on the type of definition that is used in various other studies.
3. We were unable to distinguish or consider the special forms of pseudo-hyperkalaemia, pseudo-hyponatremia etc.

4. Limitations of this study are generally attributed to observational nature of this study and the constraints of the ability to establish causal relationships between the exposure and outcome.

5. The electrolyte levels were evaluated only at baseline and follow up investigations were not made.

6. The findings can be only generalised to similar study settings, as the study was conducted only on one single Centre from India.

Tables and Figures

Table 1: Association of general characteristics and clinical characteristics of the study participants with the clinical outcome (N=100)

Characteristics	Total, n	Survived n (%)	Death n (%)	P value
Age group				
<5 years	44	41 (93.1)	3 (6.8)	0.042
6-10 years	29	28 (96.5)	1 (3.4)	
11-16 years	27	21 (77.8)	6 (22.2)	
Sex				
Male	54	48 (88.8)	6 (11.1)	0.688
Female	46	42 (91.3)	4 (8.7)	
GCS score				
Scores (3-8)	16	10 (62.5)	6 (37.5)	<0.001
Scores (9-12)	31	28 (90.3)	3 (9.6)	
Scores (13-15)	53	52 (98.2)	1 (1.8)	
Level of responsiveness				
Alert	0			
Verbal response	78	75 (96.1)	3 (3.8)	0.001
Pain	16	11(68.7)	5(31.2)	
Unresponsive	6	4(66.6)	2(33.6)	
Sodium levels				
Hyponatremia (<135)	84	77 (91.6)	7 (8.3)	0.216
Normal (135-145)	3	3 (100)	0 (0)	
Hypernatremia (>145)	13	10 (76.9)	3 (23.1)	
Potassium levels				
Hyperkalemia (>5.5)	26	20 (76.9)	6 (23.1)	0.034
Normal (3.5-5.5)	71	67 (94.3)	4 (5.3)	
Hypokalemia (<3.5)	3	3 (100)	0 (0)	
Chloride levels				
Hypo chloremia (<95)	15	13 (86.7)	2 (13.3)	
Normal (95-105)	79	75 (94.9)	4 (5.1)	
Hyperchloremia (>105)	6	2 (33.3)	4 (66.6)	<0.001

Figure1: Disease status among participants

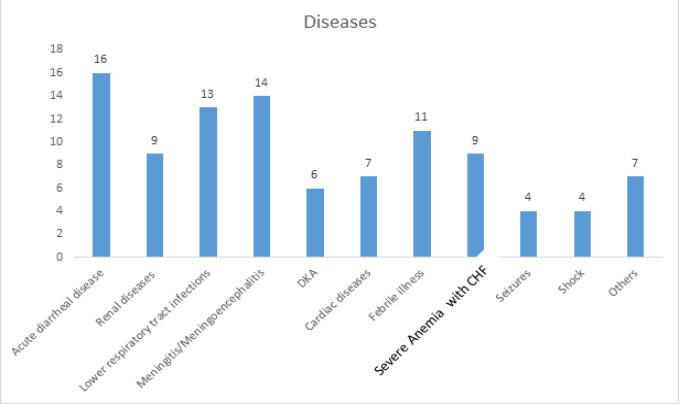

Table 2: Association of distribution of electrolyte levels with the GCS status of the study participants (N=100)

Characteristics	GCS (3-8)	GCS (9-12)	GCS (13-15)	P value
Sodium levels				
Hyponatremia (<135)	10 (11.9)	23 (27.3)	51 (60.7)	0.001
Normal (135-145)	0 (0)	3 (100)	0 (0)	
Hypernatremia (>145)	6 (46.1)	5 (38.5)	2 (15.4)	
Potassium levels				
Hyperkalemia (>5.5)	6 (23.1)	16 (61.5)	4 (15.9)	0.034
Normal (3.5-5.5)	10 (14.1)	14 (19.7)	47 (66.2)	
Hypokalemia (<3.5)	0 (0)	1 (33.3)	2 (66.7)	
Chloride levels				
Hypochloremia (<95)	5 (33.3)	4 (26.7)	6 (40.0)	<0.001
Normal (95-105)	7 (8.8)	26 (32.9)	46 (58.2)	
Hyperchloremia (>105)	4 (66.6)	1 (16.7)	1 (16.7)	

Table 3: Association of distribution of electrolyte levels with AVPU status of the study participants (N=100)

Characteristics	Verbal	Pain	Unresponsive	P value

Sodium levels				
Hyponatremia (<135)	69 (82.1)	12 (14.3)	3 (3.5)	0.019
Normal (135-145)	3 (100)	0 (0)	0 (0)	
Hypernatremia (>145)	6 (46.1)	4(30.7)	3 (23.1)	
Potassium levels				
Hyperkalemia (>5.5)	18 (69.2)	6 (23.1)	2 (7.7)	0.687
Normal (3.5-5.5)	57 (80.3)	10 (14.1)	4 (5.6)	
Hypokalemia (<3.5)	3 (100)	0 (0)	0 (0)	
Chloride levels				
Hypochloremia (<95)	10 (66.7)	3 (26.7)	2 (40.0)	0.036
Normal (95-105)	66 (83.5)	10 (12.6)	3 (3.8)	
Hyperchloremia (>105)	2 (33.3)	3 (50.0)	1 (16.7)	

Table 4: Association of blood pressure, heart rate and respiratory rate with the GCS status of the study participants (N=100)

Characteristics	GCS (3-8)	GCS (9-12)	GCS (13-15)	P value
Heart rate				
Bradycardia	4 (100)	0 (0)	0 (0)	0.001
Normal	6 (14.6)	11 (26.8)	24 (58.4)	
Tachycardia	6 (10.9)	20 (36.4)	29 (52.7)	
Respiratory rate				
Bradypnoea	10 (100)	0 (0)	0 (0)	0.001
Normal	2 (3.3)	20 (36.4)	38 (63.3)	
Tachypnoea	4 (13.3)	11 (26.8)	15 (50)	
Blood pressure				
Hypotension	2 (7.1)	6 (21.7)	20 (71.4)	0.002
Normal	10 (15.5)	25 (32.9)	31 (46.9)	
Hypertension	4 (66.7)	0 (0.0)	2 (33.3)	

Table 5: Association of blood pressure, heart rate and respiratory rate with AVPU status of the study partici pants (N=100)

Characteristics	Verbal	Pain	Unresponsive	P value
Heart rate				
Bradycardia	0 (0)	1 (25.0)	3 (75.0)	0.001
Normal	32 (78.1)	6 (14.6)	3 (7.3)	
Tachycardia	46 (83.6)	9 (16.4)	0 (0)	
Respiratory rate				
Bradypnoea	0 (0.0)	5 (50.0)	5 (50.0)	0.001
Normal	54 (90.0)	5 (8.3)	1 (1.7)	
Tachypnoea	24 (80.0)	6 (20.0)	0 (0)	
Blood pressure				
Hypotension	25 (89.3)	3 (10.7)	0 (0.0)	0.012
Normal	51 (77.3)	11 (16.7)	4 (6.1)	
Hypertension	2 (33.3)	2 (33.3)	2 (33.3)	

Conclusion

Of the 100 participants we enrolled in our study, the mortality rate was found to be 10%. We also found that in our study age category, GCS scores, and AVPU levels at the time of admission were found to be significant determinants of mortality among critically ill children admitted in PICU. We observed a statistically significant difference with respect to the distribution of electrolyte levels (Na+, K+, Cl-) with GCS scores and AVPU status. There was also significant difference observed among the distribution of vital signs with GCS scores and AVPU status. Thus, our study concluded emphasizing the importance of electrolyte imbalance, GCS scores and AVPU levels as an important prognostic indicator of determining mortality among paediatric children admitted in PICU.

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