



Determination of Serum Electrolyte and Calcium Abnormalities in Neonates with Birth Asphyxia

**Gnanavelu Injeti ^{a*}, Anjali Kher ^{a#}, Amar Taksande ^{a#}
and Abhilasha Singh Panwar ^{a^o}**

^a Department of Pediatrics Jawaharlal Nehru Medical College, Datta Meghe Institute of Medical Sciences, Wardha, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Introduction: Birth asphyxia and Hypoxic–ischemic encephalopathy (HIE) are significant causes of neonatal mortality and morbidity. Serum sodium, potassium, and calcium level abnormalities may occur in neonates with birth asphyxia, and their early detection and prompt treatment will improve the outcome of these neonates.

Aim: To study serum electrolyte and calcium levels and their correlation with birth asphyxia and HIE severity.

Methods: A prospective cross-sectional study was conducted in full-term neonates diagnosed with birth asphyxia, and their serum sodium, potassium, and calcium estimation were done at birth to 12 hours of birth and repeated at 24 to 48 hours of birth. Serum electrolyte and calcium level abnormalities and short-term outcomes of these neonates were studied.

Results: It was observed that at Apgar score 1 and 5 minutes, with an increase in severity of birth asphyxia serum sodium and calcium levels decreased while potassium levels increased. A significant positive correlation was observed between serum sodium levels and Apgar score at 1 and 5 minutes. Serum calcium levels showed a significant positive correlation with 5 minutes Apgar score. Serum potassium levels at < 12 hours showed a significant negative correlation with 5 minutes Apgar score.

^oSenior Resident;

[#]Professor;

*Corresponding author: E-mail: getgnana@gmail.com;

Conclusion: With increased severity of HIE and Birth asphyxia, serum sodium levels decreased, and serum potassium levels increased. Serum calcium levels decreased with the severity of birth asphyxia but did not decrease their HIE severity.

Keywords: Birth asphyxia; hypoxic-ischemic encephalopathy; serum sodium; serum potassium; serum calcium.

1. INTRODUCTION

Birth asphyxia continues to be a significant cause of mortality and morbidity in neonates despite advances in neonatal medicine. Globally, birth asphyxia accounts for 17% of neonatal deaths, and severe neurological sequelae occur in 25% of surviving infants [1]. The national neonatal-perinatal database shows that in India, birth asphyxia contributes to almost 23% of neonatal mortality [2]. Though multiorgan involvement, including kidneys, liver, and lungs, is seen in neonates with birth asphyxia, involvement of the central nervous system is more detrimental.

The incidence of birth asphyxia ranges from 0.5–2% of live births. It is often associated with multiple pathophysiological consequences, which lead to multiorgan dysfunction. Decreased perfusion leads to devastating complications both immediate and long-term [2].

Hypoxic-ischemic encephalopathy (HIE) as one of these complications is among the leading causes of neonatal brain injury and neonatal morbidity, as well as mortality. HIE causes the augmented secretion of an anti-diuretic hormone, leading to increased water retention and dilutional hyponatremia. Another possible reason for hyponatremia in HIE could be excessive sodium reabsorption in collecting tubules resulting in elevated sodium excretion. Hyperkalemia is a common finding in HIE and occurs because of increased acidosis, leading to the shift of intracellular potassium to the extracellular environment. In addition, acute kidney injury, a frequent complication due to HIE, can result in hyperkalemia. Immediately after birth, neonatal calcium level starts to fall and reaches the nadir at 24-28 hours. In response, the parathyroid hormone (PTH) level rises and maintains calcium hemostasis. It should be noted that HIE decreases the effect of PTH, which can be a potential cause of hypocalcemia [3].

The objectives of the current study were to correlate the abnormalities of serum sodium, potassium, and calcium level with severity of birth asphyxia and HIE staging, to study the

immediate short-term outcome of neonates with birth asphyxia, and correlate it with serum electrolyte and calcium levels.

2. MATERIALS AND METHODS

This study was a prospective cross-sectional study conducted in the department of paediatrics, AVBRH, Sawangi (Meghe), Wardha from August 2018 to July 2020. A total of 85 cases with a history of birth asphyxia were included in the study.

Full-term neonates with birth asphyxia admitted in the NICU of AVBRH within 12 hours of birth satisfying the following criteria [3].

2.1 For Inborn Babies

Birth asphyxia: Apgar score at 1 minute < 7, Moderate birth asphyxia: Apgar score between 4 to 6 at 1 minute of age, Severe birth asphyxia: Apgar score ≤ 3 at 1 minute of age.

For outborn babies: Moderate birth asphyxia: Gasping breathing at 1-minute of age, Severe birth asphyxia: No breathing at 1-minute of age. After including the neonate with birth asphyxia in this study, a detailed history with a sequence of events was noted.

Neonates with significant lethal congenital anomalies, suspected metabolic diseases, and born to mothers on antiepileptic drugs, antihypertensive drugs or treated with magnesium sulfate, mothers with diabetes mellitus, and abnormal serum electrolyte values were excluded. After inclusion of the neonate with birth asphyxia in this study a detailed maternal history, antenatal history, detailed birth history with a sequence of events, resuscitation details, Apgar score at 1 and 5 min, gestational age assessment based on modified Ballard score and management at birth were noted. A thorough general examination of the neonates with a pulse, respiratory rate, CRT (capillary refill time), temperature, screening for clinical signs of sepsis, screening for congenital anomalies was done followed by a detailed systemic

examination. After obtaining informed consent from parents of these neonates, Serum sodium, potassium and calcium estimation was done at birth to 12 hours of birth and repeated at 24 to 48 hours of birth. An automated machine used ion-selective electrode method Reference to analyze the serum samples for electrolytes and calcium. In the proforma, all investigations along with serum sodium, potassium, calcium, serum creatinine, blood urea, blood sugar, ABG, NUSG, EEG etc. were noted along with the treatment given. Immediate short-term outcome of the neonate at discharge with neurological evaluation was done. This data was entered in the Microsoft Excel sheets and then statistically analyzed. Descriptive and inferential statistical analysis was done using Stata software (Stata 10, Stata corporation Texas, USA). Mean, median, and standard deviation were used to analyze quantitative data. Qualitative were summarized using percentage, and proportions differences in proportion were compared using the chi-square test and Fischer's exact test. Differences between means were compared by unpaired student's 't' test. ANOVA test used to compare mean values of different electrolytes with different severity of birth asphyxia. The correlation coefficient was calculated by using the Pearson test. Median and quartiles of serum sodium, potassium, and calcium concerning Apgar scores were shown using a box plot. A P-value less than 0.05 is considered a the level of significance

3. RESULTS

In this study, 53 (62.35%) were males, and 32 (37.65%) were females. 68(80%) neonates were inborn, and 17(20%) were outborn. 42 (49.41%) neonates were delivered through the regular vaginal route, 42 (49.41%) were via LSCS, and 1 (1.18%) was delivered through forceps (Table no.1).

Out of 85 neonates with birth asphyxia, at 1 minute of life, 8(9.41%) had Apgar score <4, and 77 (90.59%) had Apgar score 4-6. Out of 68 inborn neonates, 7 (10.29%) had Apgar score <4, 61 (89.70%) were having 4-6 at 1 minute of life. Out of 17 outborn neonates, 1 (5.88%) had an Apgar score <4,16 (94.12%) had an Apgar score of 4-6 at 1 minute of life(Table no.2).

Out of 8 neonates with Apgar score < 4 at one minute, 7 (87.5%) were inborn and 1 (12.5%) was outborn. Out of 77 neonates with Apgar score, 4-6 at one minute, 61 (79.22%) were inborn and 16 (20.77%) were outborn.

Out of 85 neonates with birth asphyxia, five neonates had Apgar score <4 at 5 minutes out of which 4(80%) were inborn, 1 (20%) were outborn. Seven neonates had Apgar score 4-6, 6(85.71%) were inborn, 11 (14.28%) were outborn. 73 neonates had Apgar score \geq 7, out of which 58 (79.45%) were inborn, 15 (20.54%) were outborn (Table no.3).

At Apgar score 1 minute, they were comparing mean sodium levels between Apgar score <4 and 4-6 were statistically significant both at <12, 24-48 hours with p values<0.017 and <0.005, respectively. Potassium and calcium levels were statistically significant at<12 hours with p values<0.021, 0.000 respectively (Table 4). At Apgar score 5minute, comparing mean potassium levels between Apgar scores was statistically significant at 24-48 hours with p value<0.001. sodium and potassium levels were statistically insignificant (Table no.5)—correlation coefficient calculated using Pearson test. Median and quartiles of serum electrolytes with respect to Apgar scores was shown by Box plot. A positive correlation was present between serum sodium levels and Apgar score at 1 and 5 minutes which was statistically significant. With increased severity of asp, hypoxia serum sodium levels decreased at <12 and 24-48 hours (Fig. 1). A significant negative correlation was noted between serum pot of potassium levels at <12 hours and Apgar score five minutes the. With increased severity of asp, hypoxia serum potassium levels decreased at <12 and 24-48 hours (Figs. 3 & 4). A significant positive correlation was present between serum calcium levels at<12 hours and Apgar score one and 5min. And the calcium levels at 24-48 hours have a significant correlation with Apgar score of five min. with an increase in severity of asphyxia serum calcium levels decreased both at <12 and 24-48 hours.

When the means of sodium, potassium, and calcium levels were compared with stages of HIE, sodium levels were statistically significant at<12 hours with p value<0.032, and potassium levels were statistically significant at<12 and 24-48 hours with p values<0.037, <0.003 respectively (Table no.6). As the HIE increased increased from 1 to 3, serum sodium levels decreased (Fig. 2), which was statistically significant, and the serum calcium levels also decreased, which was statistically not significant. At the same time, potassium levels increased at<12 and 24-48 hours (Fig. 5) which was statistically significant.

There was a statistically significant difference in potassium ($p=0.000$) and calcium levels ($p=0.025$) at 24-48 hours of the life of neonates who got discharged, died and went discharged against medical advice.

4. DISCUSSION

In the current study, out of all 85 cases with birth asphyxia, neonates having severe birth asphyxia showed fewer sodium levels when compared with moderate birth asphyxia, which was statistically significant. Similar results were seen in Kumar SD et al. [4], where 1min. Apgar score was shown to have a positive significant correlation with sodium. In Islam A et al. [5], Narbir Yadav et al. [6]. compared with the controls, neonates with asphyxia were found to have less serum sodium, and the sodium levels were positively correlated with the Apgar score.

Whereas in Mudet al. k et al [7], serum sodium levels were less in controls than cases that were similar and statistically not significant.

In this study five-min, Apgar score showed a significant positive correlation with sodium levels at <12 and 24-48 hours. This finding was similar to studies conducted by Allam Bhat J et al. [8], Kumar SD et al [4], Thakur et al. [9], Najaf Masood et al [10], Pallab Basu et al.[11] Where as in Nilesh V. Ahire et al. [12] serum sodium(hyponatremia) had no significant linear correlation with severity of asphyxia.

Our study revealed?? that as the severity of HIE increased, sodium levels decreased and sodium levels compared between various stages of HIE were significant at <12 hours. Other authors [8,9,13,14] also found similar results with the present study.

Table 1. Baseline characteristics of neonates

Characteristics of cases	Number of cases	Percentage
Sex		
Male	53	62.35
Female	32	37.65
Mode of Delivery		
NVD	42	49.41
LSCS	42	49.41
ASSISTED	1	1.18
Place of Delivery		
Inborn	68	80
Outborn	17	20
APGAR at 1min.		
<4	8	9.41
4-6	77	90.59
APGAR at 5min.		
<4	5	5.88
4-6	7	8.23
≥7	73	85.88

Table 2. Apgar score at 1 minute in neonates with birth asphyxia

Apgar at 1 min.	INBORN (n=68) (%)	OUTBORN (n=17) (%)	TOTAL (%)
<4	7 (10.29)	1 (5.88)	8(9.41)
4-6	61 (89.7)	16 (94.11)	77(90.59)
TOTAL	68 (80)	17 (20)	85(100)

Table 3. Apgar scores at 5 minutes in neonates with birth asphyxia

Apgar @ 5 min.	INBORN (%)	OUTBORN (%)	TOTAL (%)
<4	4 (5.88)	1 (5.88)	5 (5.88)
4-6	6 (8.82)	1 (5.88)	7(8.23)
≥7	58 (85.2)	15 (88.2)	73(85.88)
TOTAL (%)	68(80)	17(20)	85(100)

Table 4. Correlation of serum electrolytes at <12 hours and 24-48 hours with APGAR score at 1 min

APGAR @1min (n)	Na (MEAN ± S.D)		K (MEAN ± S.D)		Ca (MEAN ± S.D)	
	<12 hours	24-48 hours	<12 hours	24-48 hours	<12 hours	24-48 hours
<4 (8)	134.5±6.09	132.2±8.01	6.11±0.30	6.11±0.49	7.4±0.41	8.1±0.99
4-6 (77)	140.2±6.37	140±7.36	5.47±0.75	5.53±1.19	8.6±0.89	8.6±0.88
p value	0.017	0.005	0.021	0.180	0.000	0.160

Table 5. Correlation of serum electrolytes at <12 hours and 24-48 hours with APGAR score at 5 min

APGAR @5min (n)	Na (MEAN ± S.D)		K (MEAN ± S.D)		Ca (MEAN ± S.D)	
	<12 hours	24-48 hours	<12 hours	24-48 hours	<12 hours	24-48 hours
<4(5)	131.2±5.35	129±8.60	6.10±0.40	6.4±0.29	7.2±0.27	7.4±0.46
4-6 (7)	138±4.43	139.4±5.94	5.7±1.00	5.5±0.41	8.1±0.80	8.8±0.64
≥7(73)	140.4±6.38	140±7.39	5.4±0.73	5.5±1.21	8.6±0.88	8.6±0.89
p value	0.528	0.721	0.194	0.001	0.067	0.220

Table 6. Correlation of serum electrolytes at <12 hours and 24-48 hours with HIE stage

HIE stage (n)	Na (MEAN ± S.D)		K (MEAN ± S.D)		Ca (MEAN ± S.D)	
	<12 hours	24-48 hours	<12 hours	24-48 hours	<12 hours	24-48 hours
1 (51)	141.2±5.13	139.9±7.25	5.4±0.61	5.5±1.36	8.6±0.78	8.7±0.83
2 (23)	138.1±7.91	138.8±9.16	5.4±0.96	5.6±0.71	8.2±1.01	8.4±0.95
3 (11)	135.9±7.47	137±6.67	5.8±0.82	5.7±0.87	8.1±1.17	8.2±1.02
p value	0.032	0.341	0.037	0.003	0.137	0.593

Note: Serum sodium and potassium values are in mEq/L, and serum calcium values are in mg/dL.

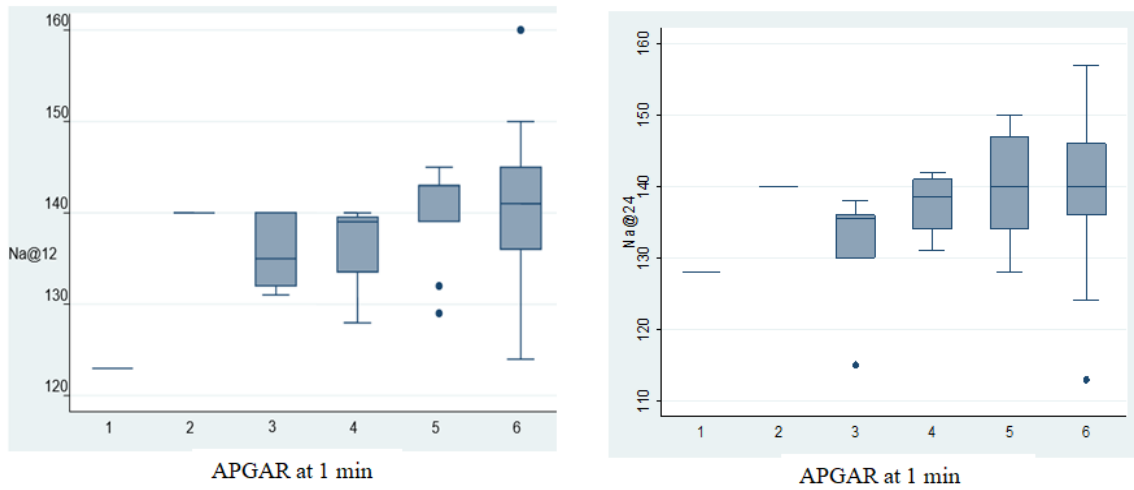


Fig. 1. Showing median and quartiles of serum sodium at 1 min Apgar

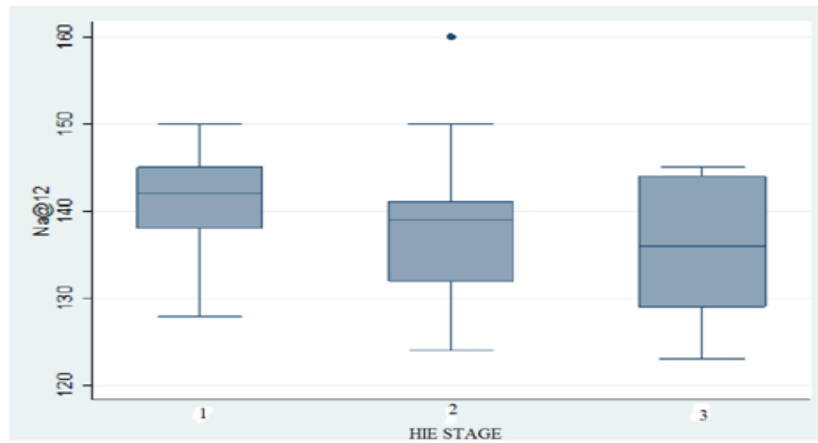


Fig. 2. Showing median and quartiles of serum sodium at <12 hours at different stages of HIE

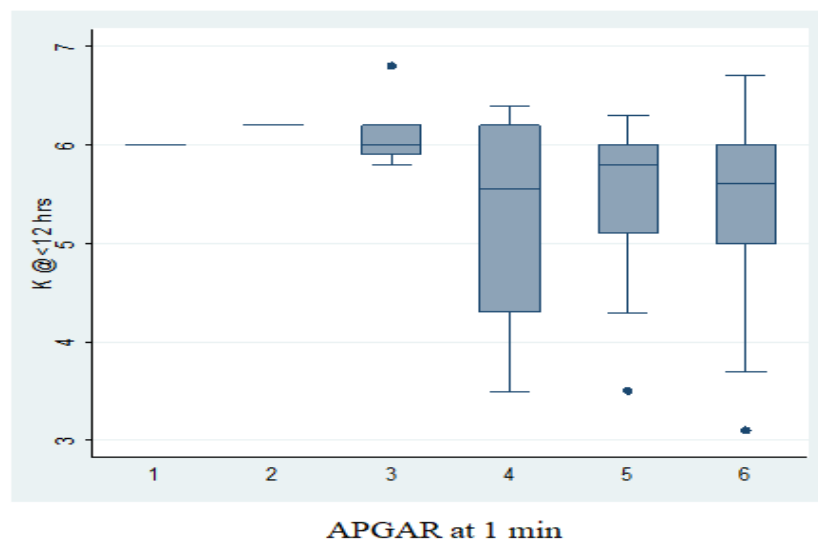


Fig. 3. Showing median and quartiles of serum potassium levels at <12 hours 1min Apgar

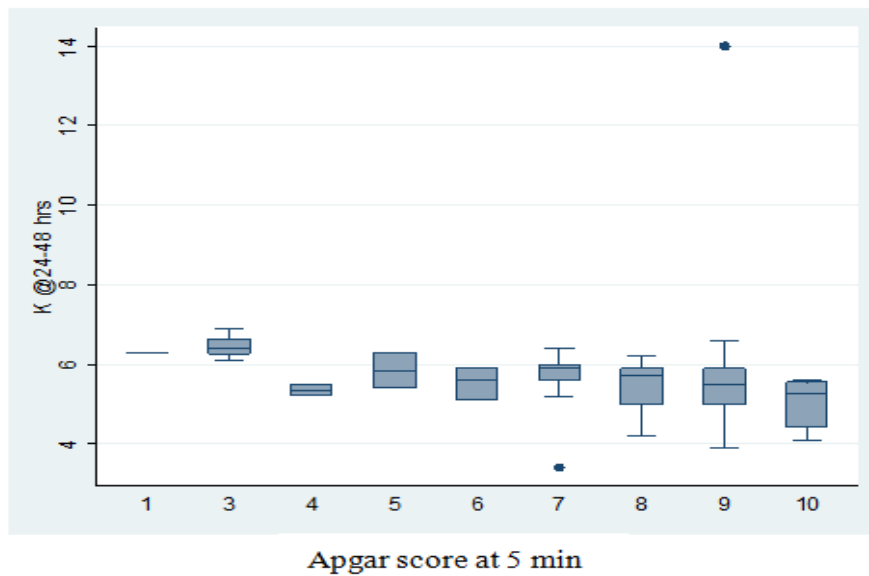


Fig. 4. Showing median and quartiles of serum potassium at 5 min Apgar

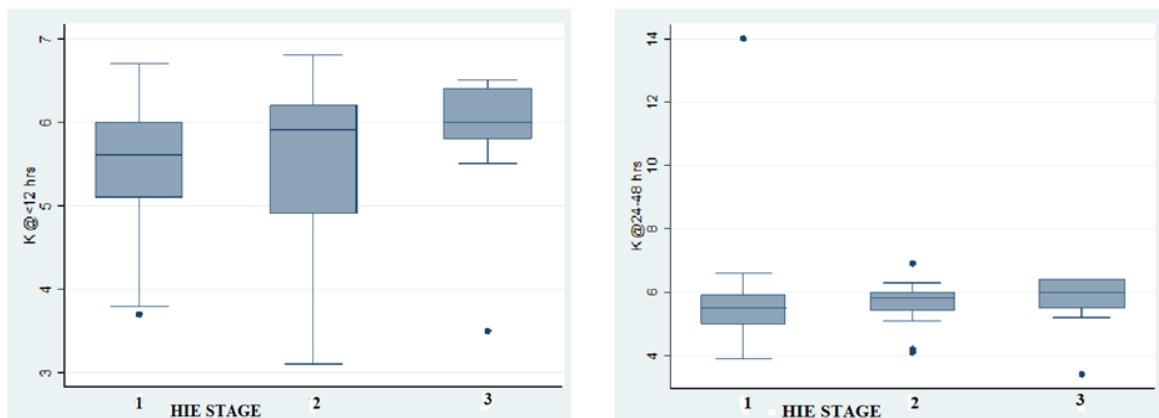


Fig. 5. Showing median and quartiles of serum potassium at different stages of HIE

Similar to the current study, In Islam A et al [5]. and Kumar SD et al. [4]. In their study found that severely asphyxiated neonates had higher serum potassium levels when compared with mild/moderate cases and controls, and a negative correlation was observed with Apgar score at one minute. Where as in Muduli Jk et al. [7]. serum potassium levels in controls and cases were almost similar and statistically not significant.

The Similar to the current study, other authors 8,4,9,11 found a significant negative correlation of serum potassium levels with 5 minutes Apgar score.

Similar to our study, in Allam Bhat J et al [8], Thakur et al [9]. and Shah et al. , as the severity

of HIE increased, potassium levels increased, and potassium levels comparison between various stages of HIE was statistically significant. Where as in Jayaprakash K et al [14]. Potassium levels were decreased in the HIE-3 stage, which was statistically not significant.

Similar to calcium levels at 24-48 hours in the current study, Islam A et al. [5]. and Kumar SD et al. [4]. In their study found that serum calcium levels in severely asphyxiated neonates were lower when compared to mild/moderate cases and controls which was not showing significant correlation with Apgar score at one minute.

Similar to the current study, Najaf Masood et al. [10]. and Pallab Basu et al. [11] described that serum calcium levels in cases were significantly

lower than in controls, and hypocalcemia showed a significant linear correlation with Apgar score at 5 minutes. Contradicting to this study, In studies conducted by Allam Bhat J et al. [8]. and Thakur et al. [9]., calcium showed no significant correlation with Apgar score at 5min.

Similar to the current study, in the study conducted by Allam Bhat J et al. [8]., as the severity of HIE increased, calcium levels decreased, and the comparison of serum calcium levels between various stages of HIE showed no statistical significance. They were contradicting to this study, in the studies conducted by Thakur et al. [9], Shah et al. [13] and Jayaprakash K et al. [14] Calcium levels showed significant differences when compared between various stages of HIE.

In the current study, out of all 85(82.3) cases with birth asphyxia, 70 neonates were discharged/survived, and 11(12.9%) died. A similar outcome was observed in the study conducted by Islam A et al. [5]. Whereas in the study conducted by Rahman F et al. [15] and Adebami OJ et al. [16]. Few of the related studies were reported [17-19]. Higher mortality was observed, which was because outborn babies were more than inborn, had low birth weight, and suffered from respiratory distress, apnoea, cyanosis, feed intolerance.

5. CONCLUSION

Apgar scored at 1min. Has a strong positive correlation with serum sodium and calcium levels at <12 and 24-48 hours. It was observed that as the severity of HIE increases sodium, calcium levels decrease and potassium levels increase.

DISCLAIMER

The products used for this research are commonly and predominantly used in our research area and country. There is no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for litigation but the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

CONSENT

Written informed consent was obtained from the parents of these neonates.

ETHICAL APPROVAL

As per international standard or university standard ethical approval has been collected and preserved by the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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