Original Article :

Prevalence and risk factors of hypoxic ischemic encephalopathy in neonates at Atbara hospital NICU, Sudan: A prospective study

Ashraf Abdelrhman Elbashir Elmdni[1]

Assistant professor, Department of Nursing, College of Nursing and Health Sciences, Jazan University, Saudi Arabia

Received on Apr 11, 2025, accepted for publication on Jul 08, 2025, dx.doi.org/10.5455/mjhs.2026.02.011

Corresponding author:
Ashraf Abdelrhman Elbashir Elmdni, Department of Nursing, College of Nursing and Health Sciences, Jazan University, Saudi Arabia. email: ashrafbarri1121435@gmail.com

OPEN ACCESS Distributed under Creative Commons CC BY-NC-ND 4.0

Abstract

Background and Aims:
Hypoxic ischemic encephalopathy (HIE) is a common cause of permanent neurological disability and mortality in neonatal across the globe. This study aims to evaluate the prevalence and identify the associated risk factors of HIE among neonates admitted to the Neonatal Intensive Care Unit (NICU) at Atbara Teaching Hospital.

Methods:
A prospective hospital-based study was conducted at Atbara Teaching Hospital from January to September 2022. The total sample included 1,674 live-born neonates, from which 68 cases were diagnosed with hypoxic ischemic encephalopathy (HIE). A purposive sampling method was used to include all neonates admitted to the Neonatal Intensive Care Unit (NICU) and clinically diagnosed with HIE during the study period. Data were collected using a structured, close-ended questionnaire filled by healthcare staff based on maternal and neonatal clinical records. The analysis aimed to measure the prevalence of HIE and identify associated maternal and neonatal risk factors. Data were analyzed using SPSS version 21, and statistical significance was considered at $p < 0.05$.

Results:
The results of this study indicated that out of 1,674 deliveries, 322 newborns were admitted to the NICU, and 68 of them (4.1%) were diagnosed with hypoxic ischemic encephalopathy (HIE). Among the maternal risk factors, 47.1% of mothers had meconium-stained amniotic fluid, and 61.8% experienced prolonged rupture of membranes. Regarding neonatal conditions, 77.9% of the affected neonates were diagnosed with sepsis, based on blood or umbilical cord culture results. Additionally, 56.5% of the neonates had a low APGAR score at five minutes. A statistically significant association was found between low APGAR score at five minutes and HIE outcomes (p-value = 0.000). The case fatality rate among neonates with HIE was 38.2%.

Conclusion:
The prevalence and case fatality rate of HIE were notably high. Several maternal and neonatal factors, such as meconium-stained liquor, prolonged rupture of membranes, neonatal sepsis, and low APGAR scores, were significantly associated with HIE. These findings highlight the need for early identification and monitoring of risk factors to reduce the burden of HIE in resource-limited settingss.

Keywords:
Hypoxic ischemic encephalopathy, Neonatal Intensive care Unit, Neonates, hypothermia, meconium, APGAR score

Introduction:

Hypoxic ischemic encephalopathy (HIE) is a known encephalic injury conditions in neonatal caused by reduced level of supply of oxygen to the brain in the perinatal duration[1]. It is among the most common causes of permanent fatal neurological conditions throughout the world [2, 3]. It is considered as the fifth most common cause of neonate's death or in children less than five years old[4]. HIE occurs approximately up to 2-3/1000 births in high-income countries, whereas, the ratio is 3-10 fold higher in low and in middle income countries[5]. The survival chance ranges between 20-50% in newborn infants which are affected by perinatal brain injury. However, in case of 25–60% of the survivors living with challenging life with permanent neurodevelopment handicaps which include seizures, learning disabilities, cerebral palsy and mental retardation[2].

Magnetic Resonance Imaging (MRI) is widely used to evaluate early brain injury after hypoxic-ischemic encephalopathy (HIE)[6]. Additionally, Electroencephalogram (EEG) helps detect clinical or electrographic seizures and monitor the progression of encephalopathy in neonates admitted to the neonatal intensive care unit (NICU)[7]. However, in this study, neither clinical evaluation nor imaging investigations such as MRI or EEG were performed to diagnose cerebral palsy (CP). Moreover, a defined post-delivery follow-up period is essential for confirming long-term neurological outcomes such as CP. In this study, the follow-up period was limited to the duration of the hospital stay, with no extended follow-up conducted after discharge.

The pathogenesis of HIE includes the failure of cerebral perfusion to the fetus triggered by the prior or during birth comprise in uterine, placental, or umbilical cord[8]. The severity of HIE determines the therapeutic strategy in different stages. For instance, in stages 2 and 3 require long-term medical treatment due to compromising capability of organ however the mild type quickly recovers neurologically[9]. Therapeutic hypothermia is the standard treatment in neonatal HIE by inhibiting inflammatory cascades, decreasing the synthesis of reactive oxygen species (ROS), further inhibiting site specific apoptosis, providing endogenous neuroprotective effect, and lowering the concentration of radicals and neurotransmitters like glutamate and glutamine [10]. If not treated well, the severity leads to death. It is reported that the fatalities due to cerebral palsy or impairment in cognitive sites were 47% at 3 years and older [11]. In early childhood it is reported that 10-12% will have post-neonatal epilepsy, 9% hearing loss, and 26%

impaired vision [11].

Primary Objective to determine the prevalence and identify the risk factors of hypoxic ischemic encephalopathy (HIE) in neonates admitted to the neonatal intensive care unit (NICU) at Atbara Teaching Hospital, Sudan. The secondary objectives to assess maternal and neonatal characteristics associated with HIE, to evaluate medical management and nursing care of HIE in NICU, to determine short-term outcome of HIE, to correlate APGAR (Appearance, Pulse, Grimace, Activity, and Respiration) score at five minutes to HIE outcome and to correlate time to resuscitate to outcome.

Several studies have explored the prevalence and risk factors of hypoxic-ischemic encephalopathy (HIE) among neonates in different settings. A multicenter study involving 2,849 newborns across 33 units in six countries reported a prevalence rate of 5.1% for HIE. The severity distribution was 19% mild, 25% moderate, 29% severe, and 27% unknown. Despite the severity, therapeutic hypothermia was performed in only 13% of cases, and the mortality rate due to encephalopathy was 42% [12].

Another study evaluating 1,752 newborns using the Sarnat and Sarnat classification found that 11.5% had birth asphyxia. Among these, 39.0% had moderate and 10.2% had severe HIE. Common neurological signs included lethargy, hypotonia, and absent or weak reflexes. The overall mortality rate from HIE was 9.1%, with a significantly higher mortality of 84.2% among those with severe HIE [13].

In Uganda, Hellen Namusoke et al. investigated the incidence and early consequences of HIE. Their results showed an incidence rate of 30.6 per 1,000 live births. The majority of cases were mild (43.5%), followed by moderate (34.8%) and severe (21.7%) HIE. Identified complications included poor suckling reflex, reduced Moro response, and need for respiratory support[14].

Anima Ferdous et al. in Bangladesh assessed clinical features and EEG patterns in neonates with HIE. Their findings highlighted significant associations between HIE and risk factors such as meconium-stained amniotic fluid, prolonged labor, premature rupture of membranes (PROM), neonatal hypothermia, hypotonia, lethargy, weak primitive reflexes, and seizures [15].

A study conducted in Abha city reported the prevalence of HIE and identified several associated risk factors. These risk factors included late preterm birth, meconium-stained amniotic fluid, abnormal cardiotocographic tracings, prolonged second stage of labor requiring assisted delivery, sentinel events, and low 1-minute

APGAR scores[16].

In Japan, Masahiro Hayakawa et al. investigated prognostic risk factors for poor outcomes in neonates with HIE. The study identified outborn delivery, low 5-minute APGAR score, use of epinephrine, and low cord blood pH as significant intrapartum risk factors. Additionally, abnormal brain MRI findings and elevated serum biomarkers were associated with adverse neurodevelopmental outcomes and mortality at 18 months [17].

In Pakistan, Ghzanfar Nadeem et al. found that most term newborns with birth asphyxia were born to primiparous mothers. The key risk factors included prolonged labor, fetal distress, and meconium-stained amniotic fluid [18]. Lastly, a study by Gabkika BM et al. reported that maternal factors such as primiparity, young maternal age, obstructed labor, spontaneous PROM, oxytocin use, and hypertensive disorders (e.g., preeclampsia/eclampsia) were major contributors to birth asphyxia, a key precursor to HIE [19].

Methods:

Study design and setting:

A prospective hospital-based study included 1,674 newborns immediately after delivery. It was conducted from January to September 2022 at Atbara Teaching Hospital. The follow-up period for neonates post-delivery was up to 7 days. The Neonatal Intensive Care Unit (NICU) is not fully equipped; advanced respiratory support such as intubation, Continuous Positive Airway Pressure (CPAP), and mechanical ventilation (MV) is not available. Resuscitation was limited to bag-mask ventilation (Ambu bag) only.

Inclusion criteria:

It includes all newborn babies diagnosed with HIE in NICU from January 2022 to September 2022

Exclusion criteria:

Newborns with major congenital abnormalities, including central nervous system (CNS) malformations such as neural tube defects, hydrocephalus, and other structural brain anomalies, as well as chromosomal abnormalities.

Sampling and Sample size:

A purposive sampling technique was used to include all 68 newborns diagnosed with hypoxic ischemic encephalopathy (HIE) during the study period.

Study variable:

Dependent variable: Hypoxic Ischemic Encephalopathy (HIE)

Independent variable: maternal characteristic is age, and neonatal characteristics are age, weight

Data collection method:

Data were collected using a structured, close-ended questionnaire that was developed specifically for this study based

on a review of relevant literature and expert consultation. The questionnaire was composed of four parts:

- **Part One:** Designed to collect data on maternal characteristics (3 questions, items 1–3).
- **Part Two:** Focused on identifying potential risk factors (10 questions, items 4–13).
- **Part Three:** Collected data on characteristics and resuscitation of newborns with HIE (9 questions, items 14–22).
- **Part Four:** Addressed the management practices for neonates with HIE (7 questions, items 23–29).
- The validity of the questionnaire was established through review by a panel of clinical experts in neonatology and nursing. To ensure reliability, a pilot test was conducted on a sample of 10% of the population before the main data collection, and necessary modifications were made based on the results. The internal consistency was assessed using Cronbach's alpha, which yielded a value of 0.82, indicating good reliability.

Data collection technique:

The data of the patient was consistently collected within three shifts (morning – afternoon –night). The questionnaire was completed by interviewing with mothers by researcher to answer questions related to antenatal and perinatal event. Details about delivery, condition of the baby and post-natal event were taken from personnel who attended delivery (doctors and midwives). Resuscitation details information was taken from attending personnel in labor room or NICU.

Data analysis:

Statistic package for social science (SPSS; Version 21) was used to analyze the data and resented in forms of tables and figures. Crosstabs (chi-square) were used to find out the correlation between time to admission to NICU and outcome of HIE.

Ethical consideration:

An official approval letter was obtained from the Graduate Studies Board at Al Neelain University and subsequently approved by the Atbara State Ministry of Health to conduct the study. The approval letter was then forwarded to the medical director of Atbara Teaching Hospital. Additionally, ethical clearance was obtained from the Institutional Review Board (IRB) of Al Neelain University under reference number (IRB No: HAPO-10-Z-001).

Participation in the study was completely voluntary, and written informed consent was obtained from each participant or the legal

guardian when appropriate. No coercion or pressure was applied. To maintain confidentiality, serial numbers were used instead of identifiable personal information. Participants retained the right to accept, refuse, or withdraw from the study at any time without any consequences.

Informed Consent:

Informed consent was obtained from the mothers of the neonates before participating in the study. All participants were informed about the purpose of the study, their right to withdraw at any time, and that the information collected would be kept confidential and used for research purposes only.

Results:

A total of n=1674 newborns were delivered at Atbara Teaching Hospital, in which n=322 newborns were admitted to NICU during a period of the study (January 2022- September 2022). Further, n=68 was diagnosed with HIE (4.1%) and case fatality (38.2%).

Table 1 shows the distribution of newborns' mothers according to maternal medical conditions during pregnancy. The results showed that 22 (32.4%) of newborns' mothers had maternal infection, 16(23.5%) had Antepartum hemorrhage, 17(25%) had hypertension and 5 (7.4%) had placenta previa shown in table (1).

Table 1: Distribution of newborns' mothers according to maternal medical conditions during pregnancy (N=68).

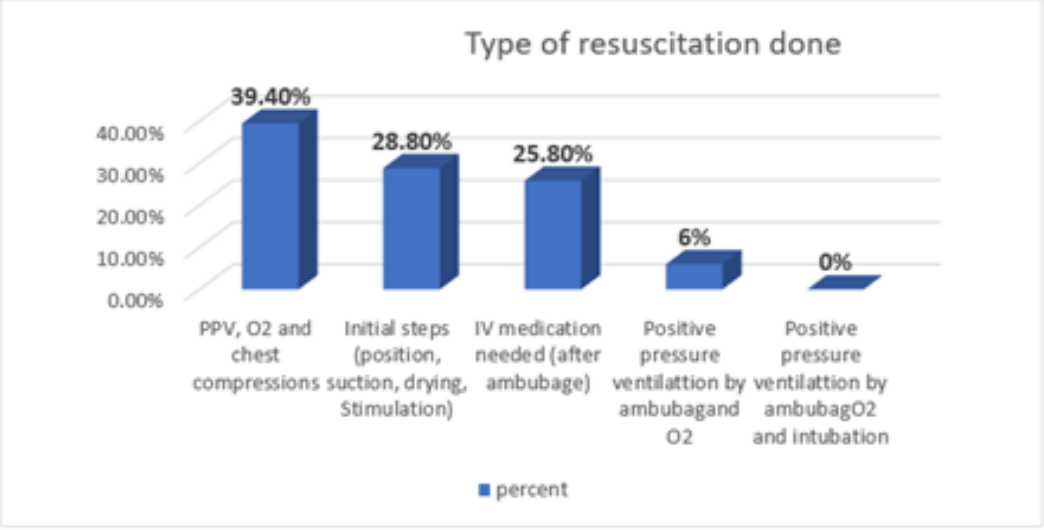
Maternal medical condition during Pregnancy	Frequency	Percent
Maternal infection	22	32.4%
Antepartum hemorrhage	16	23.5%
Pregnancy-induced hypertension	17	25%
Placenta Previa	5	7.4%
Malaria	2	2.9%
Ante partum eclampsia	2	2.9%
Oligohydminus	2	2.9%
DM	1	1.5%
Preeclampsia	1	1.5%
Total	68	100%

Table 2 shown illustrates the distribution of the study group according to APGAR score at (one, five, ten) minutes. The results showed that 32 (51.6%) of study group had low APGAR score at one minute, while 35 (56.5%) had Moderate low score at 5 minutes. Only 22(35.5%) of them had normal score at 10 minutes.

Table 2: Distribution of the study group according to APGAR score at (one, five, ten) minute (N=68).

APGAR score	Frequency	Percent
Score at one minute		
Normal (7-10)	0	0%
Moderate low (4-6)	30	48.4%
Low (0-3)	32	51.6%
Total	62	100%
Score at 5 minutes		
Normal (7-10)	5	8.1%
Moderate low	35	56.5%
Low	22	35.4%
Total	62	100%
Score at 10minute		
Normal (7-10)	22	35.5%
Moderate low	33	53.2%
Low	7	11.3%
Total	62	100%

Figure 1 shown illustrates the distribution of study group according to type of resuscitation done. The results showed that 26 (39.4%) of the study group required (PPV, O2, and chest compressions), whereas in 19(28.8%) only initial steps were performed.



Figer1: Distribution of study group according to type of resuscitation done (N=68).

Table 3 shown describes the distribution of study group according to management in NICU. The results showed that 40 (58.8%) of study group were treated with (Oxygen+ PPV (Ambubag) + Cardiopulmonary support+ Maintaining normal electrolyte and glucose levels).

Table 3: Distribution of study group according to management in NICU(N=68).

Management in NICU	Frequency	Percent
Oxygen+PPV(Ambubag)+Cardiopulmonary support+ Maintaining normal electrolyte and glucose levels	40	58.8%
Oxygen+PPV(Ambubag)+Maintaining normal electrolyte and glucose levels	20	29.4 %
Oxygen+Cardiopulmonary support+Maintaining normal electrolyte and glucose levels	8	11.8 %
Cooling	0	0%
CPAP	0	0%
Mechanical ventilation	0	0%
Total	68	100%

Table 4 describes the correlation between neonatal outcomes and APGAR scores at 5 minutes. Among the 35 neonates who were discharged in good condition with follow-up arranged, 14 (40%) had a moderate APGAR score, representing 82.4% of those in the moderate category. Similarly, percentages for normal and low APGAR score groups were calculated in relation to their outcomes. A statistically significant association was observed between the APGAR score at 5 minutes and the clinical outcome of neonates diagnosed with HIE, with a p-value of 0.000, indicating a strong correlation.

Table 4: Correlation between outcome & APGAR score at 5 min.

Score5Min Discharge in good condition follow uparranged		Outcome				Total
		Diagnosed as CP	Developed other complication during stay	Died		
Normal (7- 10)	Count	2	2	0	1	5
	%	11.8%	10.0%	0.0%	4.2%	8.1%
Moderatelow	Count	14	12	1	8	35
	%	82.4%	60.0%	100.0%	33.3%	56.5%
Low	Count	1	6	0	15	22
	%	5.9%	30.0%	0.0%	62.5%	35.5%
Total	Count	17	20	1	24	62
	%	100.0%	100.0%	100.0%	100.0%	100.0%
P-value	0.000					

A diagnosis of cerebral palsy was reported in 10% of cases with normal APGAR score, 60% with moderate, and 30% with low. However, the diagnosis was not based on clinical neurological assessment or confirmatory investigations such as MRI or EEG, and no standardized criteria for cerebral palsy diagnosis were applied in the study. Therefore, the reported rates should be interpreted with caution.

Discussion:

The current study showed that HIE was prevailed in 4.1% among all delivered babies during the period of the study. This result was comparable to the study conducted in Latin America which revealed prevalence of 5.1% [12]. In contrast, other studies showed higher prevalence in Tanzania (9.1%) [13], (7.1%) Nigeria [20] and (20%)north Ethiopia [21]. The possible reason in this variation could be explained by the difference in health of wife, facilities and recourses in neonatal units and pre-term diet.

The similarity of occurrence in primiparous mother could be attributed to inadequate uterine contraction resulted in delayed lobar. Delayed labor may cause maternal tiredness and an unsettling fetal heart rate, resulting in delivery hypoxia and HIE. Labour difficulties increase the likelihood of umbilical blood flow stoppage during labour. The results showed the majority (82.4 %) of newborns' mothers had prolonged second stage of labor. However, Gumus et al showed prolonged second stage of labouring (42.4 %) [22].

On the other hand, the study showed that only (2.9%) of the newborn babies were admitted to NICU in 1-5 minutes, whereas half (50%) were admitted at 6-10 minute, (32.4%) at 11-15 minutes and (14.7%) after more than 15 minutes. There was significant association between time to admission to NICU and the outcome of HIE with P value 0. 000.This was attributed to delay to start initial steps of resuscitation. The percentage of neonatal resuscitation in delivery room is 0% and all neonates (100%) were resuscitated in NICU, which is minutes away from delivery rooms and theatre. They were resuscitated by initial steps and oxygen therapy. Ideally management should include effective resuscitation at the delivery room followed by supportive care under frequent monitoring in NICU. Room air resuscitation for infants with prenatal asphyxia is as effective as resuscitation with 100% oxygen. In addition, neonates resuscitated with room air have a lower level of circulating markers of oxidative stress [23].

The study showed that (58.8%) of the study group received oxygen, PPV (Ambubag), cardiopulmonary support and electrolyte

and glucose levels maintenance. This result was not compatible with previous studies conducted in Chad showed (68.2%) of their study group received suction, oxygen or bag and mask [19]. Also, the percentage of receiving ventilation, continuous positive air way pressure (CPAP) and therapeutic hypothermia (0%) and all neonates needed CPAP or mechanical ventilation were transferred, because these facilities were not available in the respective facilities. In contrast, a study done in India showed that (17%) of their study group were received mechanical ventilation and around (60%) were received therapeutic hypothermia[24]. The current study reflected that about one third (32.4%) of the study group developed other complication during stay in NICU including CP and seizure. For example, Glass et al showed that (25%) of infants with HIE experience severe and lasting cognitive sequelae such as mental retardation, cerebral palsy, and epilepsy related to delayed resuscitation because half of the study group were resuscitated after five minutes [25]. The possible explanations for this difference are variation in guideline on child birth and delivery, training and availability of resources and modern tools.

Conclusion:

The finding of the present study concluded that the prevalence of HIE in our study was high, and the case fatality rate was high as well. Prolonged second stage of labor, meconium stain, primiparous mother, low APGR score at five and ten minutes, post maturity, delayed of initial resuscitation and prolonged rapture of membrane were main risk factors associated with HIE prevalence. Almost half of the study group received oxygen, PPV (Ambu bag), cardiopulmonary support and electrolyte and glucose levels maintenance. Initial neonatal resuscitation was not started at delivery room or theatre. It was done at NICU located at a distance delayed to admission and low APGAR score at 5and 10 minutes adding a negative effect on the outcome. Moreover, limited resources at the NICU contributed to the high mortality and morbidity.

Recommendations:

The study recommends improvement of monitoring of labor. Capacity building regarding neonatal resuscitation is needed for doctors, midwives and nursing. Initial steps of resuscitation must be done immediately after delivery in labor room or theatre, with provision of proper equipment for advanced neonatal resuscitation in labor room and theatre, in addition to improving NICU facilities for management of HIE.

Limitations:

This study has several limitations. Firstly, it was conducted in a single hospital, which may limit the generalizability of the

findings to other settings. Secondly, the diagnosis of HIE was based on clinical assessment only, without confirmatory investigations such as MRI or EEG. Thirdly, there was no defined follow-up period to assess long-term outcomes such as the development of cerebral palsy. Lastly, the lack of certain facilities such as CPAP and mechanical ventilation may have influenced both management options and neonatal outcomes.

References:

1. Abeyaratne C, Nhu T, Malone D. Self-assessment of therapeutic decision-making skills in pharmacy students. American journal of pharmaceutical education. 2022;86(4):8696.
2. Arnaez J, García-Alix A, Arca G, Caserío S, Valverde E, Moral MT, et al. Population-based study of the national implementation of therapeutic hypothermia in infants with hypoxic-ischemic encephalopathy. Therapeutic Hypothermia and Temperature Management. 2018;8(1):24-9.
3. Aakanksha M, Seeli MA, Parmar MD, Ali MNI, Gupta MS. Nursing Foundation Procedure: Xoffencerpublication; 2023.
4. Ehlting A, Zweyer M, Maes E, Schleehuber Y, Doshi H, Sabir H, et al. Impact of hypoxia-ischemia on neurogenesis and structural and functional outcomes in a mild–moderate neonatal hypoxia-ischemia brain injury model. Life. 2022;12(8):1164.
5. Chen A, Chen X, Deng J, Zheng X. Research advances in the role of endogenous neurogenesis on neonatal hypoxic-ischemic brain damage. Frontiers in Pediatrics. 2022;10:986452.
6. Negro S, Benders MJ, Tataranno ML, Coviello C, de Vries LS, van Bel F, et al. Early prediction of hypoxic-ischemic brain injury by a new panel of biomarkers in a population of term newborns. Oxidative medicine and cellular longevity. 2018;2018(1):7608108.
7. Glass HC, Rowitch DH. The role of the neurointensive care nursery for neonatal encephalopathy. Clinics in perinatology. 2016;43(3):547-57.
8. Ristovska S, Stomnaroska O, Danilovski D. Hypoxic ischemic encephalopathy (HIE) in term and preterm infants. prilozi. 2022;43(1):77-84.
9. Doandes FM, Manea A-M, Lungu N, Cioboata D, Brandibur T, Costescu O, et al. Clinical, biological and electroencephalographic monitoring of newborns with neurological risk

in the Neonatal Intensive Care Unit. Experimental and therapeutic medicine. 2021;22(1):760.

10. Dumbuya JS, Chen L, Wu J-Y, Wang B. The role of G-CSF neuroprotective effects in neonatal hypoxic-ischemic encephalopathy (HIE): current status. Journal of Neuroinflammation. 2021;18:1-15.
11. Debillon T, Bednarek N, Ego A, Saliba LWGP-YAOBM-LCCDCFPGGKSMJPLSE. LyTONEPAL: long term outcome of neonatal hypoxic encephalopathy in the era of neuroprotective treatment with hypothermia: a French population-based cohort. BMC pediatrics. 2018;18:1-8.
12. Domínguez-Dieppa F, Cardetti M, Rodríguez S, García-Alix A, Sola A. Hypoxic ischemic encephalopathy in units reporting to the Ibero-American Society of Neonatology Network: prevalence and mortality. MEDICC review. 2021;23(1):30-4.
13. Simiyu IN, Mchaile DN, Katsongeri K, Philemon RN, Msuya SE. Prevalence, severity and early outcomes of hypoxic ischemic encephalopathy among newborns at a tertiary hospital, in northern Tanzania. BMC pediatrics. 2017;17:1-6.
14. Namusoke H, Nannyonga MM, Ssebunya R, Nakibuuka VK, Mworozi E. Incidence and short term outcomes of neonates with hypoxic ischemic encephalopathy in a Peri Urban teaching hospital, Uganda: a prospective cohort study. Maternal health, neonatology and perinatology. 2018;4:1-6.
15. Ferdous A, Mollah AH, Das SK, Kulsum U, Efa TK. Correlation of Clinical Profile and Electroencephalographic Finding in Hypoxic-Ischemic Encephalopathy in a Tertiary Care Hospital: A Single-Center Experience from Bangladesh. 2022.
16. Thigha RM, Alzoani AA, Almazkary MH, Khormi AA, Albar RH. Magnitude, short-term outcomes and risk factors for hypoxic ischemic encephalopathy at abha maternity and children hospital, Abha City, Saudi Arabia and literature review. Journal of clinical neonatology. 2020;9(2):98-110.
17. Hayakawa M, Ito Y, Saito S, Mitsuda N, Hosono S, Yoda H, et al. Incidence and prediction of outcome in hypoxic–ischemic encephalopathy in J apan. Pediatrics International. 2014;56(2):215-21.
18. Nadeem G, Rehman A, Bashir H.

Risk factors associated with birth asphyxia in term newborns at a tertiary care hospital of Multan, Pakistan. Cureus. 2021;13(10).

19. Gabkika B, Souam N, Adrienne N, Yannick A. Birth asphyxia in full-term neonates in N'djamena mother and child hospital (Chad). The Journal of Medical Research. 2018;4(3):151-3.
20. Bongomin F, Kwizera R, Mande E, Aloyo SM, Achan B, Namusobya M, et al. Aspergillus-specific IgM/IgG antibody serostatus of patients hospitalized with moderate-critical COVID-19 in Uganda. African Health Sciences. 2022;22(3):506-11.
21. Neil Abdurashid Ibrahim NAI, Ahmed Muhye AM, Selah Abdulie SA. Prevalence of birth asphyxia and associated factors among neonates delivered in Dilchora referral hospital, in Dire Dawa, eastern Ethiopia. 2017.
22. Gumus H, Demir A. An evaluation of risk factors in cases of perinatal asphyxia. J Clin Exp Invest. 2021;12(1):343-51.
23. Rasmussen LA, Bell E, Racine E. A qualitative study of physician perspectives on prognostication in neonatal hypoxic ischemic encephalopathy. Journal of Child Neurology. 2016;31(11):1312-9.
24. Kumar C, Peruri G, Plakkal N, Oleti TP, Aradhya AS, Tandur B, et al. Short-term outcome and predictors of survival among neonates with moderate or severe hypoxic ischemic encephalopathy: data from the Indian Neonatal Collaborative. Indian Pediatrics. 2022;59(1):21-4.
25. Glass HC. Hypoxic-ischemic encephalopathy and other neonatal encephalopathies. CONTINUUM: Lifelong Learning in Neurology. 2018;24(1):57-71.