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Original article

Management and short-term outcomes of hypoxic-ischemic encephalopathy in neonates: A Study from the neonatal intensive care unit at Atbara Teaching Hospital, Sudan

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<p>CORRESPONDING AUTHOR</p> <p>Ashraf Elmdni Department of Nursing, College of Nursing and Health Sciences, Jazan University, Saudi Arabia Email: aelbashir@jazanu.edu.sa</p> <p> https://orcid.org/0000-0003-4208-5180</p> <hr/> <p>Received: 16 Feb 2025 Accepted: 23 March 2025 Published: 30 April 2025</p> <hr/> <p>DOI 10.37881/1.1011</p>	<p>ABSTRACT</p> <hr/> <p>Background: Hypoxic-ischemic encephalopathy (HIE) in newborns functions as a major reason for neonatal death and disability particularly in developing countries because they lack extensive neonatal treatment options. HIE develops from inadequate perinatal brain oxygen and blood supply that creates life-altering neurological development problems including cerebral palsy among other disabilities in infants.</p> <p>Aim: The study aimed to assess the general management approaches and early outcomes of neonates with HIE at Atbara Teaching Hospital Neonatal Intensive Care Unit (NICU) in Sudan.</p> <p>Methods: This cross-sectional study was conducted at Atbara Teaching Hospital NICU between January and September 2022 to evaluate the management approach and short-term outcomes of neonates with Hypoxic-ischemic encephalopathy (HIE). Neonates diagnosed with HIE were monitored from NICU admission through to either discharge or death.</p> <p>Results: The study revealed an overall case fatality rate of 38.2%, with mortality significantly associated with prolonged NICU stays, neonatal sepsis, and low Apgar scores at birth. The management of HIE was limited to basic interventions, including therapeutic hypothermia and mechanical ventilation, which may have contributed to suboptimal patient outcomes. The lack of advanced monitoring tools, such as blood gas analyzers and cerebral function monitoring, further limited early diagnosis and targeted interventions.</p> <p>Conclusion: Enhancing equipment availability, optimizing NICU protocols, and training healthcare providers are crucial steps in improving both survival rates and neurological outcomes in neonates affected by HIE. Addressing these challenges in resource-limited settings will contribute to better neonatal care and reduce long-term disability associated with HIE.</p> <p>Keywords: Neonatal hypoxic-ischemic encephalopathy, brain damage, neonates</p>
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INTRODUCTION

Hypoxic-ischemic encephalopathy (HIE) occurs when a neonate's brain lacks sufficient blood and oxygen, a common issue in low and middle-income countries, particularly Sudan, due to inadequate healthcare centers.^{1,2} Similar to most health facilities in Sudan, including the Atbara Teaching Hospital,

which is the only facility serving Atbara City and the surrounding areas, provided intervention for neonates with HIE is also limited to basic resuscitation. However, this strategy fails to consider the complex medical needs of such neonates.

Some therapies including therapeutic hypothermia, which involves cooling, are beneficial and reduce inflammation and apoptosis in the brain to enhance neurological outcomes.^{3,4} It is also essential to provide mechanical ventilation for the neonates to provide enough oxygen.⁵ However, the absence of those interventions increases the risks of death and prolonged brain damage at Atbara Teaching Hospital.^{1,2}

This study aims to assess HIE management and short-term outcomes in Atbara Teaching Hospital's NICU, comparing survival and complication rates between high-income and low-resource areas to highlight disparities and the need for improved training, technology, and capacity building.

METHODS

Study design

This cross-sectional study was conducted at Atbara Teaching Hospital NICU between January and September 2022 to evaluate the management approach and short-term outcomes of neonates with Hypoxic-ischemic encephalopathy (HIE). Neonates diagnosed with HIE were monitored from NICU admission through to either discharge or death. Data on management strategies and clinical outcomes were collected and analyzed to assess the effectiveness of current practices in the management of HIE in this setting.

Study area and population

Atbara Teaching Hospital is located in Atbara City in Sudan and is the reference hospital for other regions. The hospital's neonatal care unit began in 2016 with simple amenities such as incubators, oxygen concentrators, and phototherapy equipment. However, it fails to provide complex equipment such as mechanical ventilators, hypothermia treatment devices, and blood gas analysis tools. The participants consisted of 68 neonates diagnosed with HIE, and data collection sources consisted of the mothers, healthcare providers, and the NICU team.

Inclusion and exclusion criteria

The study protocol includes the inclusion criteria for neonates diagnosed with HIE during the study period and exclusion criteria for neonates with major congenital malformations or chromosomal anomalies.

Sample size

A total of 68 neonates diagnosed with HIE were included in the study.

Data collection

Structured questionnaires were employed during face-to-face interviews with mothers and healthcare providers. The questionnaires were administered by trained interviewers during scheduled sessions within the NICU to ensure consistency, confidentiality, and reliability of responses. In addition, the level of spending as well as the real-life experience regarding neonatal resuscitation and management were as well documented. The survey obtained data regarding maternal characteristics, risk of HIE, resuscitation process and treatment procedures, and neonatal outcomes, including survival, recovery, and adverse effects.

Outcome measures

The outcome measures utilized in the study included mortality rate, neurological improvement reflected by clinical signs and Apgar scores, length of NICU stay, and respiratory needs including mechanical ventilation or Continuous Positive Airway Pressure (CPAP).

RESULTS

The study revealed that all neonates requiring resuscitation received management at NICU while no resuscitation was performed in the delivery room. This implies that there is a delay in management during the critical periods within the initial hours after birth that may result in poor outcomes for neonates with HIE. Basic measures targeting life-sustaining interventions in the NICU included warmth, oxygen, suction, and bag-mask ventilation. Only 36.8% of the neonates received mechanical ventilation due to insufficient availability of appropriate ventilatory support systems. These findings reveal gaps in neonatal care, which include the lack of adequate availability of advanced neonatal Resuscitation or the ability to provide necessary ventilatory care to neonates, which may have affected the outcomes of these neonates.

Short-term outcomes

The statistics presented a mortality rate of 38.2%, which demonstrated that approximately 40% of the neonates who developed HIE did not survive during hospitalization. This is an emerging issue suggesting that HIE remains fatal to neonatal survival, particularly in regions where advanced therapeutic methods are inaccessible. 48.5% of all the neonates required a NICU stay for more than 10 days, proving the seriousness and long severity of the HIE. While 70% of the neonates experienced some clinical improvement, most were at high risk for further neurological problems, including cerebral palsy, seizures, and developmental delay. These outcomes support the importance of early and proper management to eliminate long-term effects, even if short-term recovery involves challenges.

Complications

Sepsis was common at 77.9% among the neonates, which underscores susceptibility to infections among infants. The high rate of sepsis is evident in neonates with HIE as they have compromised immune systems due to more extended hospital stays and invasive interventions. Another serious complication encountered was a low Apgar score, which was observed in 56.5% of the neonates. Low Apgar scores are an indicator of adverse outcomes, such as higher mortality rates and adverse neurodevelopmental disorders. In this study, a low Apgar score was associated with an increased case fatality rate, underlining the importance of neonate resuscitation and monitoring.

Table 1: Neonatal outcomes in Atbara NICU (January to September 2022)

Outcome Measure	Frequency (%)
Mortality rate	38.2
Duration of NICU stay > 10 days	48.5
Sepsis present	77.9
Low apgar score (5 mins)	56.5
Neurological recovery	The majority improved but at risk for long-term

Table 1 presents outcomes for neonates with HIE at Atbara NICU from January to September 2022, with a 38.2% mortality rate, 48.5% of infants experiencing NICU stays exceeding 10 days, 77.9% developing sepsis, and 56.5% recording low Apgar scores at 5 minutes. These results suggest that severe initial hypoxic injury and suboptimal resuscitation, as well as high infection rates, are likely to lead to increased mortality and longer hospital stays. While most survivors presented neurological improvement, the long-term risk of complications indicates the need for enhanced neuroprotective measures and improved infection control measures in this setting.

Table 2 outlines several key maternal and neonatal risk factors associated with HIE. Prolonged rupture of membranes (61.8%) can increase the risk of intrauterine infection, compromising fetal oxygenation.

Meconium-stained liquor (47.1%) is indicative of fetal distress, often resulting from hypoxia before or during labor. Maternal infections (32.4%) further heighten the risk by potentially inducing systemic inflammation and sepsis, which can adversely affect placental function and fetal oxygen supply. Prolonged labour (82.4%) heightens fetal stress and the risk of hypoxic events by extending uterine contractions that can impair blood flow, highlighting the need for improved prenatal care and monitoring to reduce HIE severity.

Table 2: Maternal and neonatal risk factors

Risk Factor	Frequency (%)
Prolonged rupture of membranes	61.8
Meconium stained liquor	47.1
Maternal infection	32.4
Prolonged labour	82.4

DISCUSSION

This study evaluated the management and early outcomes of neonates admitted at Atbara Teaching Hospital NICU with HIE. Hence, this study aimed to assess the current management practices, the efficacy of available interventions, and short-term outcomes of neonates with HIE in Atbara, a resource-constrained facility. HIE is one of the leading causes of neonatal morbidity and mortality, and it is characterized by long-term neurological deficits.⁶ HIE results from insufficient blood and oxygen supply to the brain of neonates, mainly due to complications during labour and delivery.⁷ The condition can range from mild to severe, causing serious neurological complications and death. HIE impacts the developing neonatal brain by causing neuronal injury and, if not addressed, can lead to developmental problems and learning disorders, and they may lead to seizures.^{8,9} Improving survival rates for these neonates significantly depends on early identification and management.

Early intervention improves neonatal survival and prevents developmental impairments. One study highlights that neonatal resuscitation, ventilation support, and neuroprotective measures improve outcomes in moderate to severe HIE neonates.¹⁰ These interventions are most effective if administered after birth because this is the time when the brain is most susceptible to the effects of hypoxia. However, Training, equipment, and early intervention policies are key areas for investment so that neonates with this condition have increased survival rates and better neurological outcomes.

Some of the challenges facing the management of HIE include the absence of advanced interventional procedures. Therapeutic hypothermia, when instituted within the first six hours of life, delays the progression of brain injury and improves the neurologic outcome of neonates with moderate to severe Encephalopathy.¹¹ Mechanical ventilation should also be employed in neonates with respiratory failure or encephalopathy.¹² This indicates that the current management of severe HIE cases in Atbara teaching hospital has not been effective due to the reduced implementation of these interventions.

Basic measures such as oxygenation supplementation, suctioning, and warming are adequate; however, these interventions fail to adequately address the needs of neonates with moderate to severe HIE. When therapeutic hypothermia and ventilatory support are not used, there may be continuous ongoing brain injury and respiratory failure, which may cause clinical deterioration, complications, and an increased rate of mortality.¹³ These findings imply many neonates who needed resuscitation were admitted to the NICU; however, only a few of these neonates received mechanical ventilation. This shows the lack of equipment required for ventilating neonates experiencing severe respiratory-related complications. The

mortality rate of 38.2% shows that patients did not receive advanced interventions which may be attributed to the observed poor outcomes.

These challenges are not unique to Atbara Teaching Hospital as they are currently observed in other hospitals in developing countries. There are significant limitations to neonatal health in many LMICs because of inadequate physical equipment, human resources, and technology. Neonatal health is also compromised and infant mortality is high due to a lack of equipment as well as specialized care from other developing countries, along with the absence of neuroprotective measures and ventilatory support.¹⁴ Compared to developed countries, the management in Atbara is diverse; hence, there is a need for the application of evidence-based practices for therapeutic hypothermia for neonates with moderate to severe HIE within the first 6 hours of life.¹⁵ One study found therapeutic hypothermia improves survival and reduces complications; however, its absence in Atbara worsened outcomes in severe HIE cases.¹⁶

HIE was aggravated by the lack of mechanical ventilation to help manage HIE amongst this patient population. In neonates experiencing respiratory inability to adequately oxygenate blood, mechanical ventilation assists in maintaining the supply of blood to the brain and other vital organs.¹⁵ The study showed limited ventilator availability in Atbara, with only 36.8% of HIE neonates receiving adequate ventilation, highlighting a gap between international standards and the resource-constrained environment that must be addressed to improve early prognosis.

These findings highlight the need for a cohesive plan to improve neonatal care for HIE, emphasizing the importance of therapeutic hypothermia and ventilation to increase survival and reduce post-HIE neurological complications. Based on the findings of this study, certain recommendations should be considered to enhance care for neonates with HIE in Atbara Teaching Hospital and other health facilities. A key recommendation is to improve access to critical care resources, like ventilators and therapeutic hypothermia, ensuring their availability and maintenance to enhance outcomes and reduce neurological injury.¹⁰

Training of healthcare providers needs to be improved, particularly in neonatal resuscitation, ventilatory support, and neuroprotective care. Lack of proper training has been identified as a barrier to effective care for neonates with severe HIE.¹⁷ Adopting best practices, as recommended by Kariuki, will help improve the handling of such critical cases.¹⁸ Refresher courses, simulation-based exercises, initiatives for mentorship programs, and maintaining close associations with faculties and learning institutions will assist in closing this knowledge gap, especially in low-resource settings; platforms such as e-learning and telemedicine will expand accessibility to the most up-to-date, effective protocols. Another crucial factor that needs to be addressed in managing HIE is the implementation of enhanced infection prevention and control protocols. Since sepsis prevalence is high among neonates (77.9%) in this study, proper hygiene is essential to reduce infection risks.¹⁹ This encompasses hand hygiene, protective gear use, effective surfaces, and instrument cleaning. In addition, practical measures such as implementing antibiotic stewardship and isolation areas in the NICU will protect these patients from severe infections.

Another important recommendation involves improving the physical conditions of the NICU. The expansion of facilities to avoid overcrowding can have a positive impact on spatial organization and contribute to the improvement of patient care. Modern incubators, multi-parameter monitors, and other life-support tools help monitor the condition of neonates and effectively manage complications. As discussed in the findings, having an optimized NICU positively impacts neonates and the staff as it lowers the adverse effects and enhances the delivery of healthcare services.²⁰

To address these recommendations, efforts from the hospital administration, local and national governments, and global entities are needed. It is crucial to allocate resources and efficiently implement

these interventions in practice; thus, there is a need for evidence-based policies, dedicated funding, and active monitoring. Therefore, consultation of all stakeholders, including community leaders and practitioners in the healthcare field, will aid in developing effective, sustainable, and culturally acceptable change proposals. Addressing these areas, such as equipment supply, provider training, infection control, NICU reinforcement, follow-up, and research that involve facilities such as Atbara Teaching Hospital, can significantly improve the survival rates of neonates with HIE. This approach provides enhanced guidance on the application of HIC interventions with consideration to high-income countries to reduce causes of neonatal illness and deaths, as well as the achievement of improvements in maternal and child health.

CONCLUSION

This study demonstrated that HIE continues to be a leading cause of neonatal mortality and neurologic damage in the Atbara Teaching Hospital NICU. The high case fatality rate, long NICU stays, cases of sepsis, and low Apgar scores indicate that current existing facility strategies are insufficient. These adverse results are attributed to inadequate therapeutic hypothermia and mechanical ventilation measures. This study shows that urgent intervention in equipment and training in neonatal care is crucial in increasing the survival rate for neonates with HIE in Atbara. Training in neonatal care combined with equipment such as ventilatory support and therapeutic hypothermia can help eliminate disparities in care for neonates, especially in encephalopathy. Further studies need to evaluate the long-term outcomes of HIE survivors to develop appropriate interventions better and improve neonatal care systems, increasing survival and neurological outcomes.

Conflict of Interest

The author declares no conflicts of interest relevant to this article.

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