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Research Article

Causes and Short-Term Outcomes of Neonatal Seizures in the Neonatal Intensive Care Unit at Omdurman Maternity Hospital: A Prospective Study (March-August 2022)

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Abstract

Introduction: The aim of this study was to determine the causes of neonatal seizures and assess short-term outcomes in neonates admitted to the Neonatal Intensive Care Unit at Omdurman Maternity Hospital.

Methods: A prospective, cross-sectional, hospital-based study was conducted at Omdurman Maternity Hospital involving 103 inborn neonates with clinically observed or reported seizures. Data were collected using a structured questionnaire and analyzed with the Statistical Package for the Social Sciences version 26.0.

Results: Among the 103 neonates studied, 65 (63.1%) were male and 80 (77.7%) were full-term. Low birth weight (< 2.5 kg) was noted in 16 cases (15.5%). Seizures occurred within the first week of life in 98 of the neonates (95.1%). Subtle and clonic seizures were the most frequent types of seizures, each occurring in 35 cases (34%). The most common underlying causes were Hypoxic-Ischemic Encephalopathy (HIE), in 51 cases (49.5%) and sepsis, in 49 cases (47.6%). In terms of outcomes, 48 of the neonates (46.6%) were discharged after achieving seizure control, 31 (30.1%) developed neurological deficits and 24 (23.3%) died. Poor outcomes were significantly associated with low Apgar scores at 1 minute ($P = 0.001$) and 5 minutes ($P < 0.001$), the need for resuscitation at birth ($P < 0.001$), prematurity ($P = 0.019$) and seizures due to HIE ($P < 0.001$).

Conclusion: We found that neonatal seizures predominantly occurred in full-term males within the first week of life, with HIE and sepsis being the leading causes. Subtle and clonic seizures were the most common types of seizures. Efforts to address preventable causes and provide timely intervention can improve neonatal outcomes.

Keywords: Convulsions; Etiology; Etiology and Treatment; Neonatal; Neonatal Seizures; Outcomes; Seizures; Short-Term Outcomes; Sudan; Types of Seizure

Introduction

A seizure is characterized by a sudden disruption of normal neuronal activity that clinically presents as changes in motor function, behavior or autonomic responses [1]. Seizures in neonates have unique clinical features compared with those in older infants and children, for age-dependent properties of the immature brain enhance the initiation, maintenance and propagation of seizures. The clinical events consistently described as neonatal seizures include focal clonic and focal tonic seizures, certain types of myoclonic seizures and epileptic spasms. Neonatal seizures are now defined by their electroencephalographic signatures, whereas earlier classifications were based on motor manifestations such as focal clonic, multifocal clonic, generalized tonic, myoclonic and subtle seizures. "Subtle" seizures include events such as abnormal eye movements, lip smacking,

swimming or pedaling movements and apnea. Neonatal seizures remain a distinct entity according to the International League Against Epilepsy (ILAE) classification [2].

The most commonly adopted classification system is Volpe's, which categorizes neonatal seizures into five primary types: subtle seizures (50%), tonic seizures (5%), clonic seizures (25%), myoclonic seizures (20%) and non-paroxysmal repetitive behaviors [3].

From a pathophysiological perspective, the developing brain is highly prone to seizures due to increased excitability and reduced inhibition [4]. In neonates, gamma-aminobutyric acid functions as an excitatory neurotransmitter because of high intracellular chloride concentrations and inhibitory systems are not fully mature [4]. External factors such as birth injuries, infections and metabolic disturbances further increase the risk of seizures [4]. Although earlier studies suggested that the immature brain is relatively resistant to seizure-induced injury, more recent evidence indicates that early-life seizures can disrupt brain development by altering neural circuitry, resulting in learning and memory difficulties and increasing the risk of future epilepsy [5].

Hypoxic-Ischemic Encephalopathy (HIE) is the leading cause of neonatal seizures, accounting for approximately 50% of cases [6]. Other etiologies include brain malformations, intracranial hemorrhage, birth trauma, infections, drug withdrawal and metabolic disorders, while inborn errors of metabolism are less common [6]. Metabolic causes include hypomagnesemia, hypernatremia, hyponatremia, hypocalcemia and hypoglycemia. Although the precise mechanisms that trigger seizures in metabolic disturbances such as hypomagnesemia, hypoglycemia and hypocalcemia remain unclear, appropriate fluid and electrolyte management can minimize these imbalances and reduce the risk of seizures [6].

The global incidence of neonatal seizures varies by region and income level. In high-income countries such as the United States, the rates of seizures range from 1.0 to 4.4 per 1,000 live births, whereas, in upper-middle-income countries such as Iran, the rates are around 5.0 per 1,000 [7]. Data from low- and middle-income countries are limited, but a study in Kenya reported a much higher rate, of 39.5 per 1,000 live births [7]. The true incidence in Sudan remains unknown. Among preterm infants, the reported incidence varies widely depending on the diagnostic method, with clinical observation alone yielding rates of 3.9-57.5 per 1,000 live births [7]. Determining the true incidence remains challenging because clinical observations, which are often unreliable and underestimate the actual burden, are the source of most of the data [8].

Neonatal seizures are strongly associated with increased mortality and survivors are at risk of long-term complications, including epilepsy, neurological deficits and impaired growth [9]. Common long-term neurological outcomes include developmental delay (30%-50%), epilepsy (20%-35%) and cerebral palsy (15%-30%). Mortality rates range from 7% to 25% depending on the underlying etiology and are notably higher among preterm infants, reaching 30%-33% [7]. Among major causes, the highest mortality is observed in hypoxic-ischemic encephalopathy (26%), followed by intracranial hemorrhage (13%) and ischemic stroke (4%) [7]. Low birth weight and prematurity further increase the mortality risk in this population [7].

The initial evaluation should include a thorough review of pregnancy history, delivery events and any resuscitation measures. In neonates with encephalopathy, risk factors such as birth asphyxia and infection should be identified [9]. In clinically well infants, maternal and family histories of seizures or thrombosis should be explored [9]. A comprehensive physical examination, including the assessment of vital signs, cardiopulmonary status, organomegaly suggestive of metabolic disorders, fetal growth parameters, congenital anomalies and neurocutaneous markers, is essential [9]. Neurological examinations should assess mental status, cranial nerve function, motor activity and both primitive and deep tendon reflexes [9].

Conventional Electroencephalography (cEEG) and amplitude-integrated Electroencephalography (aEEG) are the primary modalities used to detect and monitor neonatal seizures. cEEG involves the use of multiple scalp electrodes placed according to a modified neonatal 10-20 system and trained technologists and neurologists are required to interpret the results. Though cEEG remains the gold standard for identifying electrographic seizures and assessing brain activity, continuous bedside monitoring may not be available in all settings [10]. Neuroimaging plays a crucial role in identifying structural abnormalities such as hemorrhage, infarction or cortical malformations. Head ultrasound is the preferred initial imaging modality in neonates because it is readily available and can be performed at the bedside of critically ill infants [11].

This study was conducted to assess the incidence, underlying causes and outcomes of neonatal seizures among inborn infants at Omdurman Maternity Hospital.

Materials and Methods

Study Design and Setting

This descriptive, prospective cross-sectional study was conducted at the Neonatal Intensive Care Unit (NICU) of Omdurman Maternity Hospital, a major referral center for high-risk pregnancies in Sudan, from March to August 2022.

Study Population

All of the inborn neonates admitted to the Omdurman Maternity Hospital NICU between March 1 and August 31, 2022, with observed or reported seizure events were prospectively and consecutively enrolled in the study. Consecutive sampling served to minimize selection bias and capture the full range of neonatal seizures presenting during the study period.

The inclusion criteria comprised inborn neonates with clinically observed or reported seizures during the neonatal period whose parents or legal guardians provided informed consent. We excluded from the study neonates who had dysmorphic features strongly suggestive of syndromic conditions, those who had received anticonvulsant therapy prior to admission, which prevented reliable baseline assessment and those for whom parental consent was not obtained.

Sample Size

The sample size was calculated using Cochran's formula:

$N = Z^2 \times p \times q / e^2$

where N represents the required sample size; Z is 1.96, corresponding to a 95% confidence level; p is the estimated prevalence of neonatal seizures (0.072); q equals 1 - p (0.928); and e is the margin of error (0.05). Based on this calculation, the minimum required sample size was 103 neonates.

Data Collection and Statistical Analysis

Data were analyzed using the Statistical Package for the Social Sciences version 26. The descriptive statistics that served to summarize the variables are presented as frequencies and percentages. Associations between categorical variables were assessed using the chi-square test or Fisher's exact test with Monte Carlo simulation–based correction, as appropriate. A multinomial logistic regression analysis was performed to evaluate the association between the seizure etiology and the outcomes, with adjustments for potential confounders, including Gestational Age (GA) and birth weight. A p-value of < 0.05 was considered statistically significant.

Seizure Diagnosis and Standardization

Based on bedside clinical observations, the attending neonatology team identified and classified seizures as either subtle, focal clonic, multifocal clonic, focal tonic, generalized tonic-clonic or myoclonic. This identification and classification followed the descriptions in Volpe's Neurology of the Newborn and the neonatal seizure guidance provided by the ILAE [2,3].

Before the study, the purpose of the research and the essential features of seizures were explained to the members of the NICU staff to ensure consistent observation. No formal training sessions, structured forms or pocket reference guides were used. The duration and semiology of each event were documented in the clinical record.

When the diagnosis was uncertain, the attending senior neonatologist was consulted for confirmation. Since neither video documentation nor electroencephalography (cEEG/aEEG) was available, seizures were diagnosed based solely on standardized clinical criteria. Recurrences of seizures were recorded as at least two distinct events separated by clinical recovery or at least 30 minutes between seizures when there was sufficient documentation. The threshold and definition used matched recent consensus statements on neonatal seizures [12].

Measurements and Measurement Protocol Gestational Age

GA was determined using a hierarchical approach involving (1) first-trimester ultrasound when available, (2) reliable Last Menstrual Period (LMP) when ultrasound was unavailable and the mother reported it consistently or (3) the New Ballard Score

within 48 hours of birth when neither early ultrasound nor reliable LMP was available.

Birth Weight:

Birth weight was measured using a calibrated digital infant scale (to the nearest 10 g). Scales were zeroed before each use and verified weekly using a standard test weight. The measurements were made within the first hour of life whenever possible. For delayed measurements, the time between delivery and weighing was documented to account for potential variability.

Apgar Scores:

Apgar scores at 1 minute and 5 minutes were assigned by a member of the delivery team (the medical officer or the registrar) according to the American Academy of Pediatrics/World Health Organization (WHO) definitions. The laboratory definitions for conditions such as hypoglycemia, hypocalcemia and elevated C-Reactive Protein (CRP) followed widely accepted neonatal reference thresholds, such as that of the WHO.

Ethical Considerations

This study was approved by the Sudan Medical Specialization Board in collaboration with the Omdurman Maternity Hospital Research Department (Research No. 621, dated April 7, 2022). Written informed consent to participate was obtained from the parents or legal guardians of all of the enrolled neonates prior to their inclusion in the study. The confidentiality of the data was maintained throughout the study. A scanned, officially translated copy of the Institutional Review Board's approval letter is available under the human subject option.

Results

This study included 103 neonates who presented with seizures, of whom 65 (63.1%, 95% CI: 53.8-72.4) were male and 38 (36.9%, 95% CI: 27.6-46.2) were female, resulting in a male-to-female ratio of 1.7:1. Most of the neonates (n = 80; 77.7%, 95% CI: 69.7-85.7) were full-term and most (n = 86; 83.5%; 95% CI: 76.3-90.7). Most of the seizures (n = 98; 95.1%, 95% CI: 90.9-99.3) occurred within the first week of life (Table 1).

Variable (N = 103)	N	%
Gender		
Male	65	63.1
Female	38	36.9
Gestational age		
Full term (37-42 weeks)	80	77.7
Post-term (≥ 42 weeks)	19	18.4
Pre-term (< 37 weeks)	4	3.9
Birth weight (Kg)		
< 2.5 (LBW)	16	15.5
2.5-3.0 (NBW)	53	51.5
3.0-3.5 (NBW)	33	32
> 3.5 (NBW)	1	1
Age at onset of convulsions		
0-7 days	98	95.1
8-15 days	4	3.9
16-21 days 1 1.0		
Kg = Kilogram; LBW = low birth weight; NBW = normal birth weight		

Table 1: The characteristics of neonates presenting with seizures.

Table 1 presents detailed characteristics of the neonates presenting with seizures. Low Apgar scores were frequently observed, with 55 of the neonates (53.4%, 95% CI: 43.8-63.0) showing abnormal scores at 1 minute and 54 (52.4%, 95% CI: 42.8-62.0) showing abnormal scores at 5 minutes (Fig. 1).

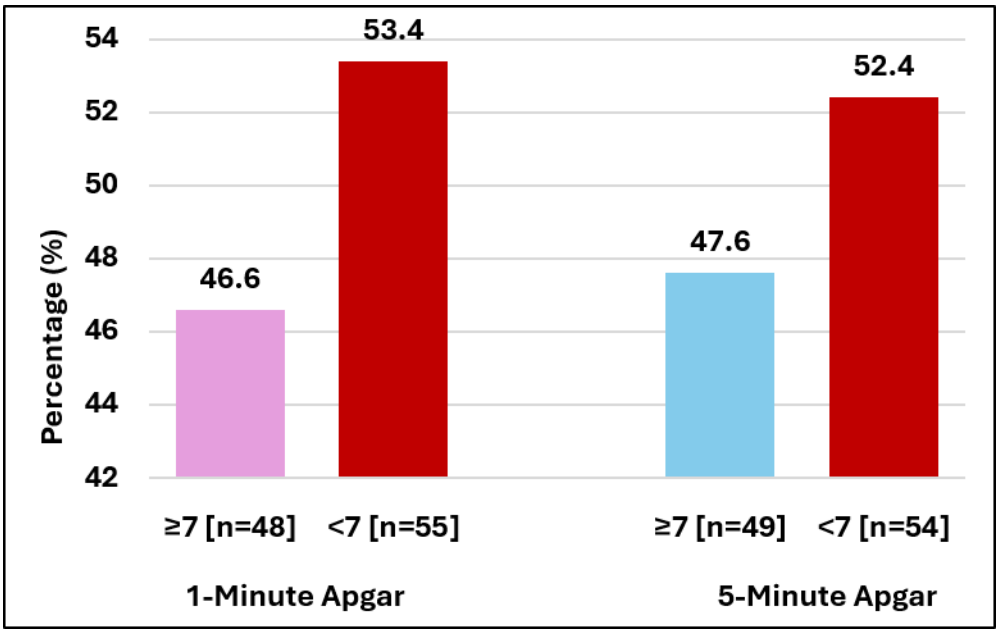

Figure 1: The 1-minute and 5-minute Apgar scores of the neonates with seizures.

Regarding maternal characteristics, most of the mothers (n = 54; 52.4%) belonged to the youngest age group (18-25 years), while 3 (2.9%) were over the age of 35 years. Most of the mothers lived in urban areas (n = 88; 85.4%). Primigravida mothers accounted for 44 (42.7%) of the cases, followed by those with parity ranging from 2 to 4 (n = 37; 35.9%). Regular antenatal care follow-up was reported by 81 (78.6%) of the mothers. Most of the deliveries occurred in hospitals (n = 96; 93.2%), with spontaneous vaginal delivery being the most common mode of delivery (n = 67; 65%). Medical officers or registrars attended the deliveries in 57 (55.3%) of the cases; in 49 (47.6%) cases, they reported the need for resuscitation after delivery. The detailed maternal and labor characteristics are shown in Table 2.

Variable (N = 103)	N	%
Maternal age (Years)		
18-25	54	52.4
26-35	46	44.7
> 35	3	2.9
Residence		
Urban	88	85.4
Rural	15	14.6
Parity		
Primigravida	44	42.7
Para 1	13	12.6
Para 2-4	37	35.9
Para 5 or more	9	8.7
ANC during pregnancy		

Yes	81	78.6
No	22	21.4
Site of delivery		
Hospital	96	93.2
Home	7	6.8
Mode of delivery		
SVD	67	65.0
Emergency C/S	23	22.3
Elective C/S	8	7.8
Instrumental vaginal delivery	5	4.9
Attendance of delivery by medical officer/registrar		
Yes	57	55.3
No	46	44.7
Need for resuscitation after delivery		
Yes	49	47.6
No	54	52.4
ANC = Antenatal Care, SVD = Spontaneous Vaginal Delivery, C/S = Cesarean Section		

Table 2: Maternal and labor characteristics of the neonates with seizures.

Fifty-five (53.4%) of the mothers experienced medical complications during pregnancy. The most common medical problems were preterm premature rupture of membranes (n = 20; 19.4%) and prolonged second stage of labor (n =19; 18.4%) (Fig. 2).

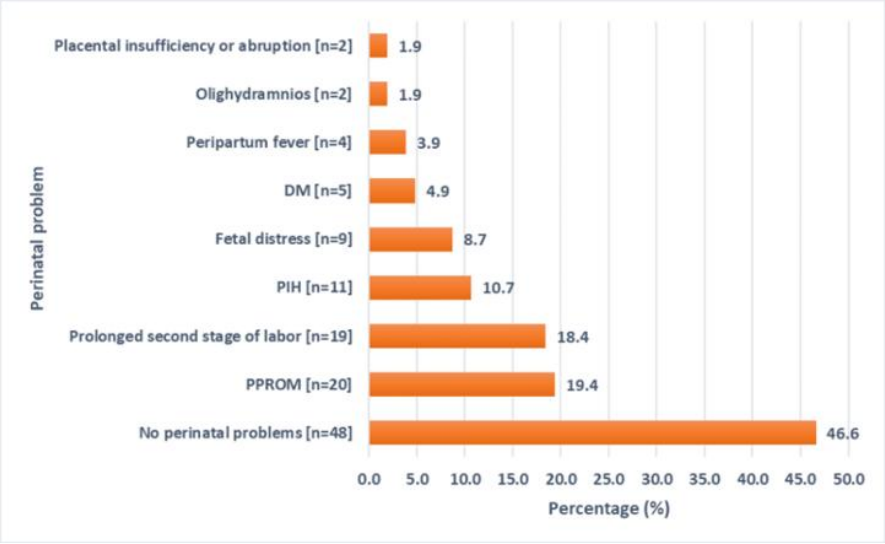

Figure 2: The distribution of perinatal problems among the mothers of neonates with seizures. DM = Diabetes Mellitus, PIH = Pregnancy-Induced Hypertension, PPROM = Preterm Premature Rupture of Membrane.

During admission, 31 (30.1%) of the neonates presented with fever. Most of the neonates (n = 98; 95.1%) had a normal head circumference. Forty-five of them (43.7%) were hypotonic, 30 (29.1%) were hypertonic and 28 (27.2%) were normotonic. Primitive reflexes were sluggish or absent in 74 (74.8%) of cases.

Laboratory investigations during admission showed that hypoglycemia was detected in 32 (31.1%) of the neonates, hyperglycemia in 4 (3.9%), hypocalcemia in 15 (14.5%) and hypernatremia in 14 (13.6%). Low hemoglobin levels were found in 7 (6.8%) of the neonates, while high CRP levels (> 10 mg/dl) were recorded in 31 of the cases (30.1%). Table 3 presents the physical examination findings and lab results of the neonates.

Variable (N = 103)	N	%
Fever		
Yes	31	30.1
No	72	69.9
Head circumference		
Normal	98	95.1
Microcephaly	3	2.9
Macrocephaly	2	1.9
Muscle tone		
Hypotonic	45	43.7
Hypertonic	30	29.1
Normotonic	28	27.2
Primitive reflexes		
Present	29	28.2
Sluggish	51	49.5
Absent	23	22.3
Hemoglobin		
Normal	96	93.2
Low 7 6.8		
Blood glucose level		
Normal	67	65
Hypoglycemia	32	31.1
Hyperglycemia	4	3.9
Calcium		
Normal	88	85.5
Low	15	14.5
Magnesium		
Normal	102	99
Low	1	1
Sodium		
Normal	88	85.4
Hypernatremia	14	13.6
Hyponatremia	1	1

Urea		
Normal	82	79.6
High	21	20.4
Creatinine		
Normal	76	73.8
High	27	26.2
Bilirubin		
Normal	92	89.3
High	11	10.7
CRP		
Normal	72	69.9
High	31	30.1
CRP: C-Reactive Protein		

Table 3: Findings from physical examination and laboratory investigations of neonates with seizures.

The most common seizure etiologies among neonates were HIE, which occurred in 51 cases (49.5%) and sepsis, which occurred in 49 cases (47.6%). The other etiologies are presented in Fig. 3.

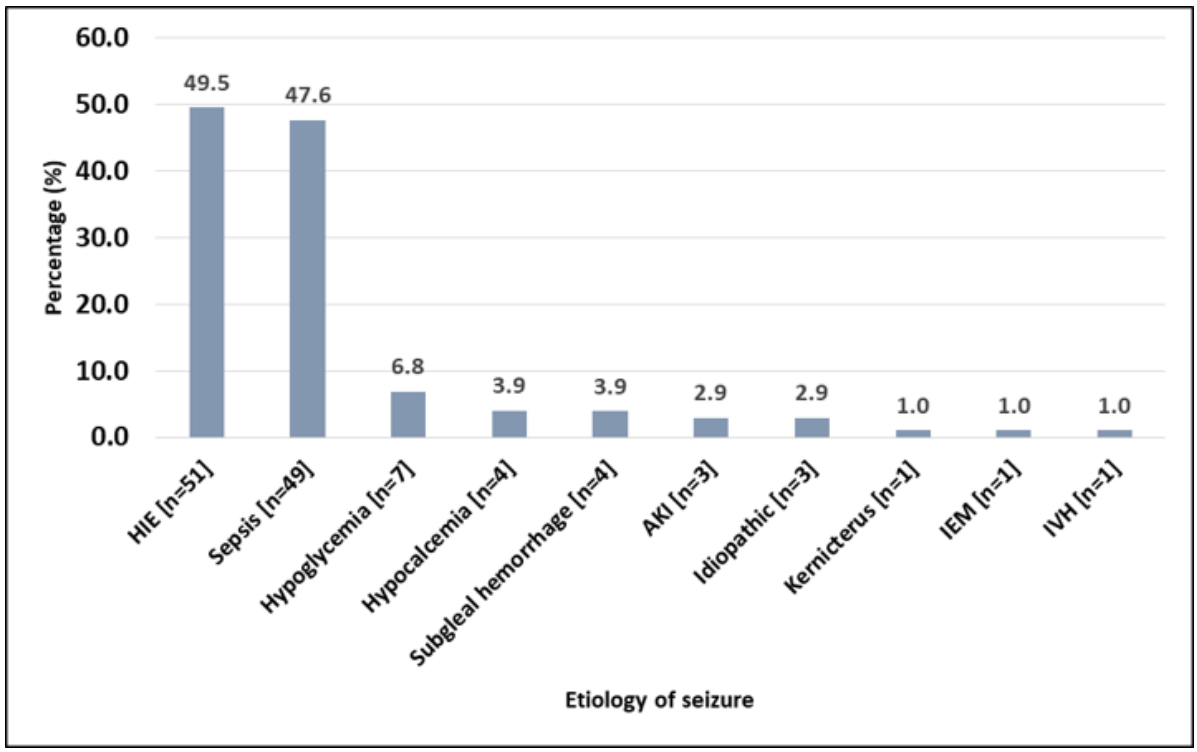

Figure 3: The distribution of seizure etiology among neonates. HIE = Hypoxic Ischemic Encephalopathy, AKI = Acute Kidney Injury, IEM = Inborn Error of Metabolism, IVH = Intraventricular Hemorrhage.

The predominant seizure types were subtle (n = 35; 34.0%, 95% CI: 24.8-43.1) and clonic (n = 35; 34.0%, 95% CI: 24.8-43.1), followed by generalized tonic-clonic seizures (n = 30; 29.1%, 95% CI: 20.6-37.6). Focal tonic seizures were the least common (n = 3; 2.9%, 95% CI: 0.0-6.1) (Fig. 4).

Regarding the outcomes, of the 103 neonates, 48 (46.6%, 95% CI: 37.0-56.2) were discharged after their seizures were controlled, 31 (30.1%, 95% CI: 21.3-38.9) were discharged with neurological deficits and 24 (23.3%, 95% CI: 15.1-31.5) died (Fig. 5).

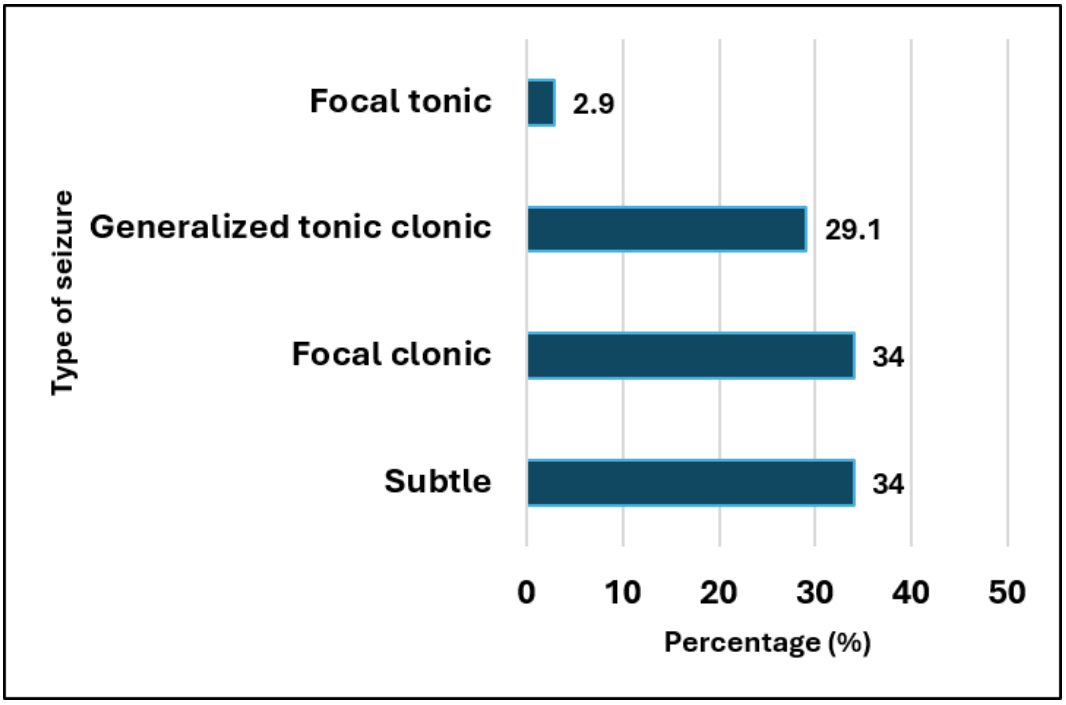

Figure 4: Distribution of seizure types among neonates (N = 103).

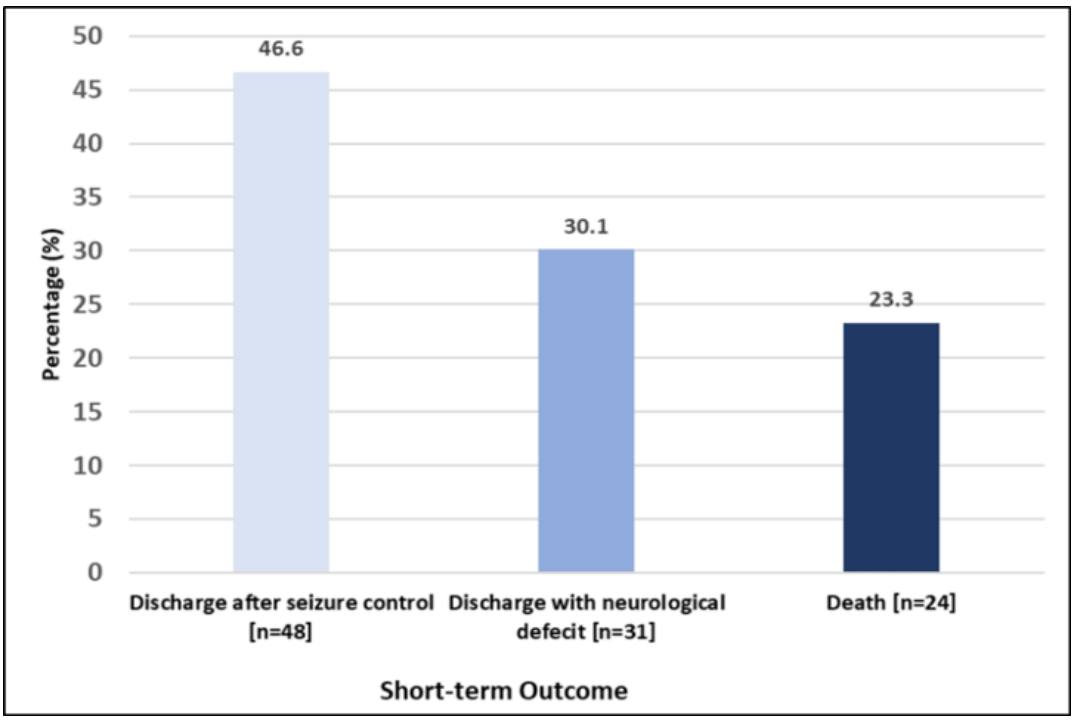

Figure 5: Short-term outcomes among neonates presented with seizures.

HIE, as the primary etiology, was strongly associated with poor outcomes. Thus, 17 (47.2%) of the neonates with HIE died and 13 (36.1%) were discharged with neurological deficits. Most neonates with sepsis or metabolic causes were discharged after seizure control; among those discharged, 24 (70.6%) had hypoglycemia and 8 (72.7%) had hypocalcemia. This association between the etiology of the seizures and the short-term outcomes was statistically significant (Fisher's exact test with Monte Carlo simulation = 32.09, $P < 0.001$; Table 4).

	Discharge after seizure control (%)	Discharge with neurological deficit (%)	Death (%)	Total	P
HIE	6 (16.7)	13 (36.1)	17 (47.2)	36	
Sepsis	24 (70.6)	8 (23.5)	2 (5.9)	34	
HIE and Sepsis	7 (46.7)	7 (46.7)	1 (6.7)	15	< 0.001
Metabolic	8 (72.7)	1 (9.1)	2 (18.2)	11	
Others	3 (42.9)	2 (28.6)	2 (28.6)	7	
HIE = Hypoxic Ischemic Encephalopathy					

Table 4: Association between short-term outcomes and causes of seizures.

A multinomial logistic regression was performed to examine the association between the etiology and outcomes of the seizures after adjusting for the potential confounders of GA and birthweight. The reference outcome was "discharge after seizure control," and the reference etiology was "hypoxic ischemic encephalopathy." The etiology remained a significant predictor of the outcomes ($P < 0.05$). Compared with those with HIE, the neonates with metabolic causes had significantly lower odds of death (Adjusted Odds Ratio [AOR] = 0.04, 95% CI: 0.003-0.59, P = 0.019) and discharge with neurological deficit (AOR = 0.06, 95% CI: 0.006-0.64, P = 0.019). Similarly, sepsis was associated with reduced odds of death (AOR = 0.02, 95% CI: 0.003-0.15, P < 0.001) and neurological deficit (AOR = 0.16, 95% CI: 0.04-0.55, P = 0.004) compared with HIE.

GA was significantly associated with mortality. Preterm infants had about 5.8-fold higher odds of death (AOR = 5.79, 95% CI: 1.11-30.33, P = 0.038) and post-term infants had 55-fold higher odds (AOR = 55.31, 95% CI: 2.12-1444.23, P = 0.016) compared with full-term infants. By contrast, birth weight was not a significant predictor of either mortality or neurological deficit. The neonates with abnormal 1-minute and 5-minute Apgar scores had significantly higher mortality rates, respectively ($\chi^2(2) = 14.83$, P =0.001, $\chi^2(2) = 16.45$, P <0.001), than those with normal scores, as Table 5 shows. The mortality rates were significantly higher among the neonates who required resuscitation after birth ($\chi^2(2) = 19.38$, P <0.001) than those who did not. The preterm neonates exhibited a significantly higher mortality rate (75% died; P = 0.019) than the other neonates, as shown in Table 5.

Variable (N = 103)		Discharge with Neurological Deficit	Death	Total	P
1-minute Apgar					
≥ 7	32	10	6	48	0.001
< 7	16	21	18	55	
5-minute Apgar					
≥ 7	33	10	6	49	< 0.001
< 7	15	21	18	54	
Resuscitation					
Yes	12	19	18	49	< 0.001
No	36	12	6	54	
Gestational age					
Term	41	26	13	80	
Preterm	1	0	3	4	0.019
Post term	6	5	8	19	
Note: Pearson's chi-square was used for the variables with sufficient expected counts. Fisher's exact test with Monte Carlo simulation (10,000 samples) was used for gestational age because of sparse cells (44.4% of cells with an expected count of < 5, minimum = 0.93).					

Table 5: Association between the short-term outcomes among neonates with seizures and Apgar scores, gestational age and the need for resuscitation.

Seizures within the first week of life were more common among the neonates who were delivered in hospitals (n = 93; 94.9%), while two (50.0%) of the seizures that occurred in the second week were in neonates delivered at home. This association was statistically significant based on Fisher's exact test with Monte Carlo simulation (P = 0.034, Table 6).

Age at Convulsions Onset	Site of Delivery		Total	
	Home (%)	Hospital (%)		P
0-7 days		5 (5.1)		
8-15 days	2 (50.0)	93 (94.9)	98	
16-21 days	0 (0.0)	2 (50.0)	4	0.034
Total	7	1 (100.0)	1	

Table 6: Association between age at seizure onset and site of delivery.

Repeated seizures occurred in 72 (70.3%) of the neonates. In most of the cases (n = 82; 79.6%), seizures were observed by medical staff in the NICU, while caregivers or parents observed the remaining cases (20.4%), as shown in Fig. 6.

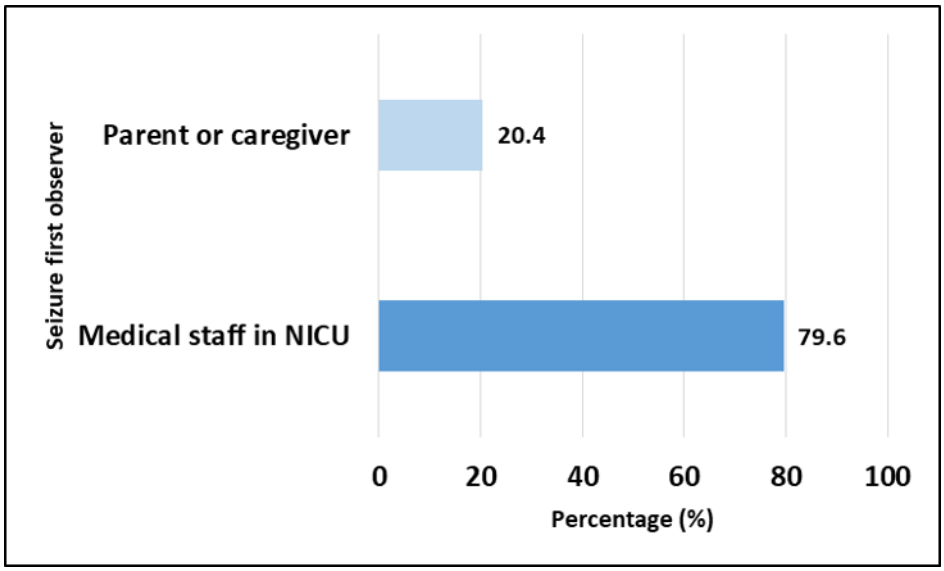

Figure 6: First person to observe seizure among neonates (%) (N = 103). NICU = Neonatal Intensive Care Unit.

Discussion

Neonatal seizures are a common pediatric emergency. They are associated with high morbidity and mortality. Identification of the underlying etiology is crucial for guiding therapeutic strategies, determining the prognosis and influencing the outcomes [13,14].

In the present study, most of the neonates (n = 65; 63.1%) were male (male-to-female ratio = 1.7:1). This predominance is consistent with previous studies conducted in Sudan, Libya, Ethiopia and India, which also reported a higher incidence of seizures among male neonates [15-19].

Most of the affected neonates in our cohort were born at term (n = 80; 77.7%), while 4 (3.9%) were preterm and 19 (18.4%) were post-term. These findings are consistent with reports by Weldegerima, et al., Hamid, et al., and Kuldeep, et al., which similarly demonstrated a predominance of term neonates among seizure cases [16-21]. The poor outcomes in our study were significantly associated with preterm gestation (P = 0.019) and these findings are also consistent with prior reports [7,16]. Although advances in neonatal care have reduced mortality, morbidity remains high among preterm infants [23].

Regarding birth weight, 86 (83.5%) of the neonates had normal birth weight (> 2.5 kg), while 16 (15.5%) had low birth weight. Comparable findings were reported by Kancherla, et al., Mohamed, et al., and Agarwal, et al. [24-26]. Most of the seizures (n =

98; 95.1%) occurred within the first week of life, demonstrating an early-onset pattern. Similar early presentation has been reported by Dinesh, et al., and others [23-27].

More than half of the neonates had abnormal Apgar scores at 1 minute (n = 55; 53.4%) and 5 minutes (n = 54; 52.4%). These rates are higher than those reported by Weldegerima, et al., and Hamid, et al., [16,21]. These findings may reflect higher rates of perinatal distress, suboptimal resuscitation practices or inadequate intrapartum monitoring.

Most of the mothers of the neonates were aged 18-25 years (n = 54; 52.4%) and primiparous (n = 44; 42.7%). Amare and Amare similarly reported a high proportion of primiparas, though the maternal age distribution differed from that in the present study [15]. Pregnancy-related complications were present in 55 (53.4%) of the mothers, most commonly preterm premature rupture of membranes and prolonged labor. This rate is higher than the rates reported in other regional studies [17,23]. Though most of the mothers (n = 81; 78.6%) received antenatal care, improved antenatal and perinatal management remains essential.

Normal vaginal delivery accounted for 67 (65.0%) of the births, consistent with other studies that have reported a predominance of vaginal delivery among neonates who later developed seizures [18,25,26,29]. However, Hamid, et al., reported higher rates of cesarean delivery among neonates who later developed seizures [22].

Hospital-delivered neonates accounted for most of the first-week seizure presentations (n = 93; 94.9%), whereas two (50%) of the second-week seizures occurred among home-delivered infants. Since most of the seizures were observed by healthcare providers (n = 82; 79.6%), home delivery may contribute to delayed recognition and management.

Fever was observed in 31 of the cases, accounting for 30.1%, whereas Weldegerima, et al., reported 19% [17]. Most of the neonates had normal head circumference (n = 98; 95.1%), similar to the findings of Mohanad, et al. [18]. Abnormal muscle tone was common, with 45 (43.7%) of the neonates being hypotonic and 30 (29.1%) hypertonic. These findings are comparable to those reported by Weldegerima, et al. [17].

The metabolic disturbances included hypoglycemia (n = 32; 31.1%), hypocalcemia (n = 15; 14.5%), hypernatremia (n = 14; 13.6%), hyponatremia (n = 1; 1.0%) and hypomagnesemia (n = 1; 1.0%). Similar metabolic patterns have been reported in other regional studies [23,28,29]. These findings emphasize the importance of early metabolic screening and correction.

Subtle and clonic seizures were the most common types (n = 35; 34% each), consistent with previous studies reporting that subtle seizures were predominant [15,16,17,29]. In other studies, focal clonic or generalized tonic-clonic seizures were the most common types [21,23]. Seizures recurred in 72 (70.3%) of the neonates, a rate higher than the rates reported in some regional studies [21,29]. The high rate of recurrence underscores the importance of early etiological identification and management.

HIE was the leading cause of the seizures (n =51; 49.5%), followed by sepsis (n = 49; 47.6%). These results are consistent with global and regional data [13,15,23,29]. The prominence of HIE likely reflects gaps in perinatal care and resuscitation services in resource-limited settings. The major role of sepsis highlights ongoing infection control challenges [28,29].

Twenty-four (23.3%) of the neonates died, a mortality rate comparable to that reported in Ethiopia and similar settings but higher than that reported in some regional studies [15-17,21]. Mortality was particularly high among the neonates who required resuscitation, consistent with findings linking the need for resuscitation to perinatal asphyxia and adverse outcomes.

Among the survivors, 48 (46.6%) were discharged after their seizures were controlled, while 31 (30.1%) had neurological deficits at discharge. Similar outcomes have been reported elsewhere [15]. Poor outcomes were significantly associated with low Apgar scores and HIE etiology, consistent with previous studies [9,15,17,21].

A major strength of this study is its focus on neonatal seizures among Sudanese newborns, a population that has been the subject of limited prior research. Standardized definitions and consistent NICU observations strengthened the reliability of the findings. The limitations of the study include the single-center design, potential information bias from parental reports, the reliance on

clinical diagnosis without routine EEG, the limited availability of neuroimaging and the lack of long-term follow-up. These factors may affect the generalizability of the findings and assessment of the outcomes.

To address these gaps, it is necessary to strengthen neonatal resuscitation capacity, improve perinatal care, expand access to EEGs and neuroimaging and implement multidisciplinary management strategies. Larger multicenter studies with long-term neurodevelopmental follow-up are needed in Sudan to better define the outcomes and guide national policy.

Conclusion

Neonatal seizures in this setting were most commonly caused by HIE and sepsis. Subtle and clonic seizures were the predominant clinical types. Most of the cases presented within the first week of life. Adverse short-term outcomes were significantly associated with low Apgar scores, the need for resuscitation, prematurity and the presence of HIE. Despite these risk factors, the overall short-term outcomes were relatively favorable, though the mortality rate of 23.3% is notable.

These findings highlight the need to strengthen perinatal and neonatal care by improving delivery practices, enhancing resuscitation capacity and improving antenatal risk identification. The early recognition and management of neonatal seizures should be supported by standardized protocols, timely metabolic and infectious evaluation and expanded access to EEG monitoring. A multidisciplinary approach, improved diagnostic resources and better data systems are essential for the optimization of outcomes, while larger multicenter studies with long-term follow-up are needed to guide national strategies.

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

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Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Ethical Statement

The project did not meet the definition of human subject research under the purview of the IRB according to federal regulations and therefore was exempt.

Informed Consent Statement

Informed consent was obtained from all participants included in the study.

Authors' Contributions

All of the authors reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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