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Factors Associated with the Severity of Perinatal Asphyxia Complicated by Hypoxic-Ischemic Encephalopathy in the Neonatal Unit of University Hospital Center Sourô SANOU of Bobo-Dioulasso

Bintou Sanogo[1,2*], Latifatou Tiendrébéogo[2], Fatimata Sahoura Nacro[1,3], Saga Alain Ouermi[4], Ahmed Cheick Ouattara[5], Nikiema Germain[1,6], Fatimata Zongo[2], Souleymane Konaté[2], Mariéta Sidanoma Tinto[1,2], Nakoulma Mahamadi[2], Ouoba Souanguimpari René[1,7], Ouattara Ad Bafa Ibrahim[4], Makoura Barro[1,7], Senkaye-Lagom Aimée Kissou[1,2]

[1]Higher Institute of Health Sciences (INSSA), Nazi BONI Univsersity (UNB), Bobo-Dioulasso, Burkina Faso
[2]Pediatrics Department, University Hospital Center Sourô SANOU (CHU-SS), Bobo-Dioulasso, Burkina Faso
[3]Regional University Hospital Center of Dédougou, Dédougou, Burkina Faso
[4]Pediatrics Department, Regional University Hospital Center of Ouahigouya, Ouahigouya, Burkina Faso
[5]Joseph Ki-ZERBO University, Ouagadougou, Burkina Faso
[6]Physical Medicine and Rehabilitation, University Hospital Center Sourô SANOU (CHU-SS), Bobo-Dioulasso, Burkina Faso
[7]Pediatrics Department, University Hospital of Pala, Bobo-Dioulasso, Burkina Faso
Email: *bintusan@yahoo.fr

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Abstract

Introduction: Perinatal asphyxia (PNA) is a major cause of neonatal morbidity and mortality. The objective of this study was to examine the perinatal characteristics and short-term clinical aspects of PNA and to determine factors associated with the severity of hypoxic-ischemic encephalopathy (HIE) in the neonatal unit of University Hospital Center Sourô Sanou, Bobo-Dioulasso. **Methods:** This was a cross-sectional study with descriptive and analytical objectives, focusing on eutrophic, full-term infants hospitalized for perinatal asphyxia complicated by hypoxic-ischemic encephalopathy (Apgar score < 7 at 5 minutes or the concept of resuscitation, with signs of encephalopathy according to the Sarnat classification) from January 2016 to December 2024. Sociodemographic data on the child and the mother, perinatal data, as well as in-hospital outcomes, were recorded. Multinomial analysis was performed to identify factors associated with severity of hypoxic-ischemic encephalopathy. **Results:** The frequency of perinatal asphyxia complicated by hypoxic-ischemic encephalopathy was 20.23%. Stages I, II, and III of AIE accounted for

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45.17%, 42.82%, and 12.01%, respectively. The average length of hospital stay was 5 days, and in-hospital mortality rate was 30.55%. Circular umbilical cord (OR = 2.81; CI = [1.29 - 6.12]; p = 0.010), maternal-fetal infection (OR = 3.29; CI = [1.22 - 8.87]; p = 0.019), Apgar score > 7 at fifth minute of life (OR = 0.47; CI = [0.28 - 0.78]; p = 0.004), and a resuscitation duration ≤ 10 minutes (OR = 0.25; CI = [0.11 - 0.55]; p = 0.001) were the main factors associated with the severity of hypoxic-ischemic encephalopathy. **Conclusion:** Improved prenatal care and neonatal resuscitation techniques could help reduce morbidity and mortality associated with perinatal asphyxia complicated by hypoxic-ischemic encephalopathy.

Keywords

Perinatal Asphyxia, Anoxic-Ischemic Encephalopathy, Prognosis, CHU-SS, Burkina Faso

1. Introduction

Perinatal asphyxia (PNA) is a severe impairment of maternal-fetal gas exchange, compromising the newborn's cardiorespiratory adaptation at birth [1]-[3]. It leads to multiorgan failure and hypoxic-ischemic encephalopathy (HIE), the severity of which is classified according to Sarnat classification [3] [4]. PNA is one of the leading causes of neonatal mortality. In 2024, World Health Organization (WHO) ranked it as the second leading cause of neonatal mortality after prematurity in low-resource countries [5]. It is one of the most preventable causes of neonatal mortality [6]. In 2020, a study conducted at University Hospital Center Sourô SANOU (CHU-SS) of Bobo-Dioulasso reported a neonatal mortality rate of 29.8%, with PNA identified as a factor increasing the risk of mortality (HR = 1.64; 95% CI = 1.30 - 2.08) [7]. Despite these findings, few studies have examined the prevalence of PNA, its short-term prognosis, and its predictive factors at CHU-SS. The objective of this study was to examine the sociodemographic, perinatal, and short-term clinical outcomes of children hospitalized for PNA complicated by HIE in the neonatal unit at CHU-SS, and to describe the factors associated with the severity of hypoxic-ischemic encephalopathy (HIE). Updating these data would help improve intervention strategies to reduce mortality associated with this condition.

2. Methodology

This study is part of a larger project that had two objectives: 1) to examine the short, medium, and long-term outcomes of children hospitalized for perinatal asphyxia complicated by hypoxic-ischemic encephalopathy; 2) to examine factors associated with the severity of perinatal asphyxia complicated by hypoxic-ischemic encephalopathy (the present study).

The pediatric department (neonatal unit) of University Hospital Center Sourô

SANOU (CHU-SS) of Bobo-Dioulasso, Burkina Faso was our study center. It was a cross-sectional study with descriptive and analytical aims, carried out in two phases. The first phase was retrospective (covering the period of collecting records of eutrophic children, born at term, hospitalized from January 1, 2016, to December 31, 2024, for perinatal asphyxia complicated by hypoxic-ischemic encephalopathy in the department of pediatric of CHU-SS); followed by a prospective phase conducted from July 1 to October 31, 2025 (where surviving children were reviewed and examined, with interviews conducted with their parents). Population source was: all eutrophic children (birth weight between 2500 and 4000 g), born at term (37 weeks to 40 weeks 6 days) and hospitalized in the department of pediatric of CHU-SS for perinatal asphyxia complicated by hypoxic-ischemic encephalopathy from January 1, 2016, to December 31, 2024. The study was limited to full-term, and eutrophic children to reduce the influence of prematurity and underweight on the children's neurological outcomes.

Were excluded from the study newborns who had one or more congenital or chromosomal abnormalities at birth, or those who left alive without a reachable phone contact for one of the parents. A survey database was created using the unique identification numbers from patients' medical records. This survey database was made by reviewing hospital admission records from January 2016 to December 2024. A total of 4952 were hospitalized for PNA from 2016 to 2024.

So, 424 children were included in the study through simple random sampling, according to the sample size formula $n = [z^2 * p (1 - p)]/m^2$. Among these children, 41 had parents who couldn't be reached by phone, and others couldn't come to the hospital for the consultation. The analysis was therefore done on 383 children.

According to the American Academy of Pediatrics (AAP) and the American College of Obstetricians and Gynecologists (ACOG), the diagnosis of HIE is based on several clinical and/or biological criteria: clinically through cardio-respiratory and neurological depression (Apgar score < 7 at the 5th minute of life) and biologically by evidence of acute hypoxia determined by blood gas disturbances (acidosis with arterial blood pH < 7 and lactate levels > 12 mmol/l at the same time). It is recommended to simultaneously perform blood gas analysis from the umbilical artery and vein. In our context, marked by limited diagnostic resources, the diagnosis of PNA mainly relied on clinical criteria, notably an Apgar score < 7 at the 5th minute of life and/or the need for neonatal resuscitation at birth.

The data on Apgar scores and the idea of resuscitation were collected from neonatal records and/or children's booklets, while the Sarnat classification was determined from the clinical data recorded in medical files.

Sociodemographic data on newborns and their mothers, perinatal data (pregnancy care, maternal conditions, gestational age, anomalies predisposing to PNA, place of delivery, duration of labor, presentation, mode of delivery, appearance of amniotic fluid, birth weight, Apgar score, crying and resuscitation at birth, and severity of HIE according to the Sarnat classification), as well as follow-up data

(intra-hospital mortality) were collected. For descriptive statistics, quantitative variables were presented as mean and standard deviation, and qualitative variables as counts and percentages. Statistical tests were performed using Pearson's chi-square test.

To determine the factors associated with the severity of HIE (dependent variable) according to the Sarnat classification, a multinomial logistic regression analysis was carried out. The independent factors that could explain the severity of HIE were sociodemographic, maternal, and perinatal variables. Indeed, nine variables which are appearance of the amniotic fluid, presentation, duration of labor, duration of resuscitation, maternal age, premature rupture of membranes (PROM), circular umbilical cord, maternal-fetal infection, and Apgar score had p-values below 20% in the Chi-square and Fisher tests and were associated with the Sarnat classification. The variables amniotic fluid appearance, fetal presentation, PROM, and Apgar score were the only ones that had at least one group with fewer than the minimum of 5 patients, which is needed to ensure valid results for ordinal and multinomial logistic regression. As with the Apgar score, the smallest sample size is 4, and since the variable is particularly relevant, we kept it in the modeling. The dependent variable (Sarnat classification) is ordered (stage I < stage II < stage III), so it made sense to start with ordinal regression, which takes into account the order of the categories. However, the Brandt test (Omnibus: 0.011 < 5%) indicated that the proportional odds assumption was not met, so the ordinal model wasn't valid. Since the Brandt test invalidated the ordinal regression, we moved on to multinomial regression, which doesn't depend on the proportional odds assumption. A variable was considered associated with the severity of HIE if the odds ratio (OR) was >1, with a lower confidence interval (CI) limit > 1; or if the OR was <1, with an upper CI limit < 1.

3. Administrative Considerations

The study was carried out after obtaining permission from the Chief Executive Officer of CHU-SS and from the head of the pediatrics department. Data collection was done while respecting the anonymity of the children and the confidentiality of their information. To ensure this confidentiality during the study, only the children's initials were recorded, and no information that could identify a child was mentioned.

4. Results

4.1. Hospital Frequency

During the study period, of 24,480 hospitalized newborns, 4952 were hospitalized for PNA complicated by HIE, representing a hospitalization frequency of 20.23%. In this study, 383 infants were included.

4.2. Socio-Demographic Characteristics on Newborns and Their Mothers

The average age of the newborns at admission to the neonatal unit was 4 hours ±

15.6 of life. Males predominated, accounting for 67.62% (n = 259). The majority of the children's parents (82.25%, n = 315) lived in urban areas and had a medium socioeconomic status (47.52%, n = 182). The average age of the mothers was 26.75 years, ranging from 16 to 45 years. In 36.29% (n = 139) of cases, the mothers had no formal education, and in 29.77% (n = 114) of cases, they had completed primary school. Housewives accounted for 58.22%, 23.24% were shopkeepers, 7.57% were students, 6.27% were civil servants, and 4.7% worked in the informal sector. The average parity of the mothers was 2.4 ± 1.74; primiparity, pauciparity, multiparity, and grand multiparity were observed in 42.82%, 34.99%, 15.67%, and 6.53% of cases, respectively.

4.3. Perinatal Characteristics

The majority of pregnancies (78.59%, n = 301) received at least 4 prenatal care visits, with an average of 4.42 ± 1.21. The average gestational age was 38.84 weeks of amenorrhea (WA) ± 0.93, ranging from 38 to 40 WA. Nearly all deliveries (98.96%, n = 379) took place in a healthcare facility. Labor lasted more than 12 hours in 71.02% of cases. Cephalic presentation was the most common (94.78%, n = 363), followed by breech presentation (3.13%, n = 12) and transverse presentation (2.09%, n = 8). The mode of delivery was predominantly vaginal (73.89%), of which 65% (n = 249) were spontaneous and 8.88% (n = 34) involved the use of a vacuum extractor. The amniotic fluid (AF) was discolored in 46.21% (n = 177) of cases, clear in 36% (n = 138), meconium-stained in 7.31% (n = 28), and unspecified appearance in 10.44% (n = 40). The mean birth weight was 3113.16 g ± 368.48. Almost all (96.87%, n = 371) of the newborns did not cry within the first minute of life. At the fifth minute of life, 41% (n = 157) of the newborns had an Apgar score below 7. Nearly all (96.34%, n = 369) of newborns underwent resuscitation, of whom 21.68% (n = 80) were resuscitated for more than 10 minutes. The mean duration of resuscitation was 8.8 minutes ± 5.96, ranging from 1 to 35 minutes. According to Sarnat classification, HIE was classified stage I in 45.17% (n = 173) of cases, stage II in 42.82% (n = 164), and stage III in 12.01% (n = 46) of cases. No risk factors for PNA were identified in 40.44% of cases. The conditions predisposing to PNA were mostly primiparity (42.82%), circular umbilical cord (14.1%), maternal-fetal infection (9.7%), and preeclampsia/eclampsia (8.4%).

4.4. Short-Term Outcomes

The average length of hospital stay was 5.18 days ± 5.08, ranging from 0 to 35 days. In-hospital neonatal mortality was 30.55% (n = 117).

4.5. Factors Associated with the Severity of Hypoxic-Ischemic Encephalopathy (HIE)

- **HIE classified as stage II Sarnat**

At multinomial analysis, 4 variables are associated with HIE stage II. The results are presented in Table 1.

Table 1. Factors associated with HIE classified as stage II (multinomial analysis).

Predictors	*Odds Ratios*	*CI*	p	*HIE Stage*
Circular umbilical cord	2.81	1.29 - 6.12	**0.010**	Stade II
Apgar score ≥ 7 at fifth minute	0.47	0.28 - 0.78	**0.004**	Stade II
Maternal-fetal infection	3.29	1.22 - 8.87	**0.019**	Stade II
Maternal age ≤ 30 ans	1.12	0.62 - 2.02	0.717	Stade II
Resuscitation duration ≤ 10 minutes	0.25	0.11 - 0.55	**0.001**	Stade II
Labor duration ≥ 12 hours	1.41	0.83 - 2.42	0.206	Stade II

CI: confidence interval; HIE: Hypoxic-iscgemic-encephalopathy.

- **HIE classified as stage III Sarnat**

At multinomial analysis, 5 variables are associated with HIE classified stage III. The results are presented in Table 2.

Table 2. factors associated with HIE classified as stage III (multinomial analysis).

Predictors	*Odds Ratios*	*CI*	p	*HIE Stage*
Circular umbilical cord	3.84	1.32 - 11.14	**0.014**	Stade III
Apgar score ≥ 7 at fifth minute	0.06	0.02 - 0.18	**<0.001**	Stade III
Maternal-fetal infection	4.17	1.09 - 16.03	**0.037**	Stade III
Maternal age ≤ 30 ans	0.38	0.16 - 0.91	**0.030**	Stade III
Resuscitation duration ≤ 10 minutes	0.13	0.05 - 0.36	**<0.001**	Stade III
Labor duration ≥ 12 hours	1.19	0.49 - 2.92	0.700	Stade III

CI: confidence interval; HIE: Hypoxic-iscgemic-encephalopathy

5. Discussion

Our study had some limits, especially the lack of certain clinical data in the hospitalization records. Also, the results of our study concerned full-term, eutrophic newborns, so they can't be generalized to preemies or underweight babies, for example. Moreover, a selection bias can be observed because the study was conducted in a university hospital, which is a referral center and therefore receives more severe cases. There's also the issue of insufficient data for certain variables in stages II or III of HIE, such as the appearance of amniotic fluid, fetal presentation, and premature rupture of membranes, which were not specified for some children, forcing us to remove them before performing the multinomial regression.

Despite these limitations, the study was able to be carried out and allowed us to obtain results that we analyzed and compared with data from the available literature.

We conducted a descriptive and analytical cross-sectional study with the aim of describing the sociodemographic, perinatal, short-term outcomes of newborns hospitalized for perinatal asphyxia in the neonatal unit at CHU-SS, and of identi-

fying the factors associated with the severity of hypoxic-ischemic encephalopathy.

Despite efforts to improve maternal and child health care, perinatal asphyxia remains a public health problem in low-resource countries. This study helped clarify the extent of neonatal morbidity and mortality associated with PNA complicated by HIE. Indeed, the hospital frequency of PNA was high (20.23%), as well in-hospital mortality (30.55%). Similar trends in incidence [1] [6] [8]-[12] and mortality [2] [10] [12] [13] have been described in other low-resource African countries.

These results contrast with data from developed countries [14], where improvements in the quality of prenatal care, assisted deliveries, and the availability of therapeutic interventions (particularly controlled hypothermia) have led to a significant reduction in morbidity and mortality of PNA [12]. The lack of diagnostic tools, neuroprotective strategies, and limited resuscitation and monitoring resources in low-resource countries underscore the importance of measures to prevent PNA.

The mean age of newborns at enrollment in our study was 4 hours ± 15.6; same data were reported by Hanssens-Gilbert [15] in France and by Okoko in Congo-Brazzaville [2], who reported mean ages at admission of 2.03 hours ± 1.13 and 2.7 hours, respectively. Coulibaly [16] in Burkina Faso, on the other hand, found a higher mean age at admission (1.7 days ± 2.6 days). These differences could be explained by variations in the organization of patient referral and evacuation systems, as well as by the geographic accessibility of specialized healthcare facilities.

In accordance with data from the literature [9] [10] [17]-[19], male predominance was observed in our study. This could be explained by the male sex's greater biological vulnerability to neonatal hypoxia-ischemia, linked in particular to neurobiological differences [12].

The high proportion of mothers with no formal education and from low- and middle-income socioeconomic backgrounds is a key factor, as it is associated with poor adherence to prenatal care and delays in seeking specialized care, thereby increasing the risk of PNA [19].

Obstetric events associated with a risk of outcome of PNA were mostly primiparity, circular umbilical cord, and maternal-fetal infection. The same conclusion was reported by other authors [12] [20]-[22]. Primiparity is recognized as increasing the risk of PNA [12].

Majority of pregnancies had received at least four prenatal care visits. These results are similar to those found in Cameroon [23], Ivory coast [12], Mali [22], and Benin [13]. This high proportion of pregnancies that received at least four prenatal care visits is encouraging, but it underscores that the number of prenatal visits does not guarantee effective prevention of PNA in the absence of optimal-quality care. WHO recommends eight prenatal care visits. This would allow for better monitoring, early detection, and prompt management of any complications, thereby reducing maternal and neonatal mortality.

In this study, labor was prolonged in 71% of cases. Sames conclusions have been observed by other authors [12] [13] [22] [23]. Prolonged labor can lead to depletion of oxygen reserves in the chorionic villi with reduction in fetal oxygen supply, which is a cause of PNA [12].

As other authors [12] [13] [21], the appearance of the amniotic fluid was predominantly pathological (meconium-stained and discolored) in this study. Clear amniotic fluid was most commonly observed in Lembet's study in Gabon [10]. Hypoxia leads to increased intestinal peristalsis, relaxation of the anal sphincter due to sympathetic stimulation, resulting in the passage of meconium [12]. However, as meconium can be detected in 20% of normal pregnancies, it is not a 100% predictive factor for the occurrence of PNA. Stained amniotic fluid generally indicates a maternal-fetal infection; its high prevalence in this study could be explained by the presence of factors associated with infectious found in several parturient.

Vaginal deliveries were the most common, with vacuum extraction used in 8.88% of cases. Instrumental delivery is known to increase the risk of PNA.

Nearly all (96.87%) of the newborns did not cry at birth and required resuscitation (96.34%). At 5 minutes of life, 41% of newborns had an Apgar score < 7, indicating PNA. Resuscitation of an asphyxiated newborn is a critical intervention that can improve the prognosis and must be initiated within the first minute of life: is it the "golden minute" [24].

HIE classified as stage I according to Sarnat classification was the most common, followed by stage II, with a significant proportion of stage III cases. The same trend was observed in Burkina Faso [6] and Ivory Coast [12]. The severity of HIE appears in the literature to be the primary determinant of vital and functional prognosis [25] [26].

In the multinomial analysis, factors associated with an increase risk in the occurrence of HIE classified as stage II and stage III were circular umbilical cord, materno-fetal infection. However, the occurrence of HIE classified stage II and III was lower in cases of Apgar score ≥ 7 at fifth minute, resuscitation duration ≤ 10 minutes. Any compression of the umbilical cord, especially when tight, contributes to a decrease in maternal-fetal gas exchange, which can lead to PNA. Maternal-fetal infection promotes the onset of PNA through chorioamniotitis, which causes inflammation and impaired maternal-fetal gas exchange; or through fetal hypermetabolism, which increases oxygen demand. Apgar score of ≥7 at 5 minutes is not part of the definition of neonatal asphyxia. However, 75% of newborns classified as having HIE stage I had an Apgar score ≥ 7 at 5 minutes. This highlights the subjectivity involved in Apgar scoring, underscoring the importance of raising awareness among obstetricians and midwives to ensure more accurate assessment of this parameter, which helps to evaluate the newborn's adaptation to extrauterine life [12]. HIE classified stage II and III are moderate and severe form of HIE with a guarded or catastrophic prognosis, most often can requiring prolonged resuscitation.

6. Conclusion

Perinatal asphyxia complicated by hypoxic-ischemic encephalopathy is one of the most common neonatal conditions encountered in hospital practice, as evidenced by its incidence in this study. It is a serious condition associated with high mortality. The factors associated with the severity of hypoxic-ischemic encephalopathy identified in this study are largely predictable. Improvements in the prevention of perinatal asphyxia through high-quality prenatal care (eight prenatal visits, systematic screening for maternal infection, obstetric ultrasound) and assisted deliveries; improved methods for diagnosing PNA (Apgar score classification, lactate levels, blood gas analysis), and improved management of PNA (proper neonatal resuscitation techniques, controlled hypothermia) could help reduce the morbidity and mortality associated with this condition in University Hospital Center Sourô Sanou of Bobo-Dioulasso.

Author Contributions

Bintou Sanogo: Design, Literature Review, data collection, Writing, Revision, validation of the manuscript; Latifatou Tiendrébéogo: Literature Review, data collection, Writing; Fatimata Sahoura Nacro: data collection, literature review; Saga Alain Ouermi: Literature Review, data collection; Ahmed Cheick Ouattara: conception and statistical analysis of the manuscript; Nikiema Germain: data collection; Fatimata Zongo: data collection; Souleymane Konaté: data collection; Mariéta Sidanoma Tinto: data collection; Nakoulma Mahamadi: data collection; Ouoba Souanguimpari René: data collection; Ouattara Ad Bafa Ibrahim: literature review; Makoura Barro: supervision of the study; Senkaye-Lagom Aimée Kissou: conception and supervision of the study, revision and validation of the manuscript.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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