Neonatal Asphyxia as a Risk Factor for Sensorineural Hearing Loss in Indonesian Children

Ratna Anggraeni[1], Wijana[1], Pudyastuti Rachyanti[2]

[1]Associate Professor, [2]Resident, Department of Otorhinolangiology, Head and Neck Surgery, Faculty of Medicine, Universitas Padjadjaran – Dr. Hasan Sadikin General Hospital, Bandung, Indonesia

Abstract

Background: Neonatal Asphyxia is one of the risk factors for hearing loss in children. Neonatal Asphyxia causes cochlear damage due to lack of oxygenation and tissue perfusion which can lead to cell death. **Objective**: Determining the risk of Neonatal Asphyxia for the occurrence of sensorineural hearing loss in children. **Methods**: A case control study was done between July to September 2020. Children with sensorineural hearing loss are on study group and the control group is children with normal hearing. Participants were measured for previous labor history based on medical records that confirmed asphyxia. Participants were also examined for DPOAE and ABR / BERA. The measurement results were analyzed using the Chi-Square test, which was significant if $p < 0.05$. **Results**: Most participants aged 2-3 years experienced hearing loss (65.96%) and normal (68.08%; $p = 0.835$). Participants of sensorineural hearing loss with Neonatal Asphyxia (57.4%) were more than non- Neonatal Asphyxia (42.6%; OR = 1.82; 95% CI 0.81 - 4.13; $p = 0.149$). **Conclusion**: Neonatal Asphyxia increases the risk of sensorineural hearing loss by 1.82 times compared to children without Neonatal Asphyxia.

***Keywords**: Neonatal Asphyxia, children, sensorineural hearing loss*

Introduction

Hearing loss in children is a very serious problem, especially in the first three years of life which can affect the development and maturation of the hearing system and can cause speech and language development disorders that will limit the child's ability to communicate and carry out social activities[1, 2]. Hearing loss in children is could caused by genetic factors, but there are also other factors such as perinatal disease (e.i Neonatal Asphyxia) which gives a 10-times greater chance of suffering from hearing loss or more when accompanied by other factors[2, 3].

Corresponding author:
Ratna Anggraeni
Department of Otorhinolaryngology Head and Neck Surgery, Faculty of Medicine, Padjadjaran University - Hasan Sadikin General Hospital, Jl. Pasteur no 38, Bandung 40161, Indonesia
Mail: ratnaunpad@gmail.com
Orcid ID: 0000-0002-2528-6215

Neonatal Asphyxia is a condition when the neonate fails to breathe spontaneously and regularly at birth or particular times after birth. Many factors influence the occurrence of Neonatal Asphyxia, both from maternal, umbilical cord, and infant factors[4, 5]. Assessment of the severity of asphyxia uses the APGAR score and will then be classified into mild, moderate, and severe asphyxia[4, 6, 7]. The prevalence of perinatal asphyxia in Indonesia in 2005 was reported as 3,116 cases, of which there was still no hearing examination[8]. Neonatal Asphyxia is reported to be a risk factor for children to experience hearing loss, in which hearing loss interferes with children's growth and development, especially children's communication and behavior[4, 9].

Hearing loss in children needs to be detected as early as possible considering the important role of hearing function in speech development process. Delay in diagnosis also means that there is a delay in starting the intervention and will have a serious impact in its further development[2]. Based on the consideration of the number of incidences of Neonatal Asphyxia and the

importance of early hearing examination, the researchers were interested in conducting a study to determine the risk of Neonatal Asphyxia for the occurrence of sensorineural hearing loss in Dr. Hasan Sadikin General Hospital, Bandung, Indonesia.

Methods

Participants

Participants in this study were children with a history of Neonatal Asphyxia. The inclusion criteria included children ≥3 years of age with a history of asphyxia[4, 10, 11]. Exclusion criteria included conductive hearing loss, family history of congenital deafness, prenatal TORCHS infection (Toxoplasma, rubella, cytomegalovirus, herpes, syphilis), craniofacial anomalies, syndromes associated with congenital deafness, low birth weight (<1500 grams), positive postnatal infections associated with sensorineural hearing loss, hyperbilirubinemia, ototoxic drug exposure, history of preterm birth, NICU treatment >5 days, head trauma, and chemotherapy. Participants, represented by the caregiver, first read and filled out the informed consent form.

This study used a case control study which was carried out from January 2018 - January 2019. The sampling technique in this study used simple random sampling in which a total sample of 94 patients was obtained. This research was conducted first with Ethical Clearance (LB.02.01 / X.2.2.1 / 15389/2020). Participants were measured for the characteristics of the participants (age, gender, type of delivery, mother's education level, mother's occupation), history of asphyxia neonatorum, and hearing loss.

Assessment of Neonatal Asphyxia was based on the medical records of the participants who delivered in the hospital. Measurement of Neonatal Asphyxiais divided into 2 groups, namely without Neonatal Asphyxia and with Neonatal Asphyxia[10]. Assessment of hearing loss in children is suggested by examining otoacoustic emissions (OAE) and Auditory Brainstem Response (ABR) or Brainstem Evoked Response Audiometry (BERA). OAE assessment used distortion product otoacoustic emissions (AuDX Biologic, Pleasanton CA, USA), where the measurement results were "pass" and "refer". Meanwhile, ABR / BERA measurements used Biologic System AEP Version 1.3.0 (years 2004-2014) (Bio-Logic Systems Corp., Mundelein, Chicago, IL, USA), where the results of the measurement were the intensity of the V wave appeared ≤25 dB and > 26 dB. Interpretation of examination results confirmed no hearing loss if the OAE result was "Pass" and the ABR / BERA result was the V wave appeared at intensity ≤25 dB[12, 13].

Statistical analysis in this study used IBM SPSS Statistics software version 23.0 (IBM Corp., Armonk, NY, USA). The statistical test used the Chi square test to see the relationship between Neonatal Asphyxia and sensorineural hearing loss (significant if $p < 0.05$), followed by determining the odds ratio to determine the risk of Neonatal Asphyxia to the occurrence of sensorineural hearing loss.

Results

Characteristics of Participants

Most participants aged 2-3 years (67.02%), of which 65.96% had hearing loss and 68.08% did not experience hearing loss ($p = 0.835$). Most of the participants were male (71.28%), of which 61.70% had hearing loss and 80.85% did not experience hearing loss ($p = 0.040$). Most participants had a history of spontaneous labor (81.92%), of which 78.72% had hearing loss and 87.23% had no hearing loss for participants with history of induction labor ($p = 0.272$). Meanwhile, most participant's mothers had high school education (51.04%), of which 53.19% experienced hearing loss and 48.94% did not experience hearing loss ($p = 0.704$). Most participant's mothers did not work (73.40%), of which 65.96% had hearing loss and 80.85% did not experience hearing loss ($p = 0.102$; table 1).

Correlation Between Neonatal Asphyxia with Sensorineural Hearing Loss

Participants of sensorineural hearing loss with Neonatal Asphyxia (57.4%) were more than non-Neonatal Asphyxia (42.6%), but statistically not significant as indicated by $p = 0.149$ (Table 2). The sensorineural hearing loss's odds ratio was 1.82 with a 95% confidence interval of 0.81 - 4.13 indicated that the risk of hearing loss in Neonatal Asphyxia infants was

1.82 times higher than in non-Neonatal Asphyxia infants.

Table 1. Correlation between Characteristics of Participants and Sensorineural Hearing Loss

Variable	Total n = 94	Hearing Loss		p
		Yes (%) n = 47	No (%) n = 47	
Age				
<1 year	14 (14.89)	8 (17.02)	6 (12.77)	
1- <2 year	17 (18.08)	8 (17.02)	9 (19.15)	0.835
2-3 year	63 (67.02)	31 (65.96)	32 (68.08)	
Sex				
Male	67 (71.28)	29 (61.70)	38 (80.85)	0.040*
Female	27 (28.72)	18 (38.30)	9 (19.15)	
Types of Birth				
Spontaneous	16 (17.02)	37 (78.72)	6 (12.77)	0.272
Induction	78 (82.98)	10 (21.28)	41 (87.23)	
Education level				
Primary	10 (10.64)	5 (10.64)	5 (10.64)	
Secondary	14 (14.89)	5 (10.64)	9 (19.15)	0.704
High	48 (51.04)	25 (53.19)	23 (48.94)	
College	22 (23.40)	12 (25.53)	10 (21.28)	
Mother's occupation				
Working	25 (26.60)	16 (34.04)	9 (19.15)	0.102
Unemployed	69 (73.40)	31 (65.96)	38 (80.85)	

Note: *significant $p < 0.05$

Table 2. Correlation Between Neonatal Asphyxiawith Sensorineural Hearing Loss

Asphyxia neonatorum	Hearing Loss		OR	95% CI	p
	Yes (%) n = 47	No (%) n = 47			
+	27 (57.54)	20 (42.55)	1.82	0.81 – 4.13	0.149
-	20 (42.55)	27 (57.54)			

Discussion

In this study, it was found that participants and sufferers of sensorineural hearing loss were more common in males than females. Previous studies stated that sensorineural hearing loss tends to be greater in male[14, 15]. Another study also found a statistically significant association between sex and hearing loss[16]. Sensorineural hearing loss, which is more common in males, is caused by a shorter cochlear length in females, so that acoustic stimulation reaches the outer hair cells more quickly thus the exposure to the cochlea in males is greater than in females[17].

Most participants were 2-3 years old, which was in accordance with previous studies[18]. Hearing examination and detection of sensorineural hearing loss at the age of 2-3 years, which was the highest age group in this study, indicate that the knowledge and awareness of parents about hearing loss in children is still low, thus parents only realize and carry out hearing examination when the child's language and hearing abnormalities become clearer at a quite old age. In addition, hearing screening in newborns may not have been carried out properly. In accordance with Carlijn's study, this study statistically did not find a significant relationship between age and sensorineural hearing loss[19].

Most participants were born with medical assistance. There was no significant relationship between the type of delivery and sensorineural hearing loss. Previous studies stated that the type of delivery did not have a significant relationship with sensorineural hearing loss, although at the first OAE examination it was said that subjects with high referral results were obtained in both types of labor. This may be due to the mobility of the tympanic membrane or the accumulation of amniotic fluid and debris in the outer ear which is usually found at the beginning of birth, leading to false positives in the results of the study. Meanwhile, on the second OAE examination, the number of subjects with referral results decreased significantly because the fluid had been absorbed over time[20, 21].

A mother with higher education and spending most of the time with her child is expected to notice earlier if there is hearing loss in the child[22]. In this study, there was no significant relationship between education, mother's occupation and sensorineural hearing loss. It could be inferred that without a sufficient level of knowledge from a mother, even though she has had enough time to care for her child, it does not improve the level of awareness of hearing loss in children[23].

It is known that 50% of sensorineural hearing loss in children has no risk factors, even in other studies it has been shown that 82.23% of sensorineural hearing loss patients have no risk factors[18, 24]. This study found that 42.6% of participants with sensorineural hearing loss had no risk factors, thus demonstrating the importance of hearing screening in newborns[25].

Neonatal Asphyxia is often cited as a major cause of sensorineural hearing loss because it can lead to a lack of oxygenation resulting in cell death[4, 5]. Tissue hypoxia in newborns at a pressure of O_2 <50 mmHg causes greater injury to spiral cells and vestibular ganglion cells which are primary ganglion cells, in severe hypoxia it can cause irreversible damage to the cochlea, especially outer hair cells and vascular stria. In this situation, there is a decrease in oxygen levels in the blood and decreased perfusion to various organs including the ear[26]. Lack of oxygen supply to the stria vascularis inhibits potassium and sodium pumps resulting in failure of active sodium pumps, intracellular sodium accumulation, diffusion of extravasation of potassium and inhibits endocochlear electrical potential, which causes cell damage resulting in increased hearing threshold[26, 27].

Previous studies stated that asphyxia is a risk factor for sensorineural hearing loss, in which asphyxia and low APGAR scores are the cause of temporary hearing loss, with the results of research stating that the APGAR score at 5 minutes did not have a significant relationship with sensorineural hearing loss. The study also said that the various factors influencing sensorineural hearing loss are not fully identified, such as a history of labor with complications that are difficult to determine the etiology of sensorineural hearing loss because there are too many risk factors involved[5].

Hair cell damage in asphyxia is partly reversible, which can occur due to improved oxygenation and perfusion in the cochlea to brain tissue. Maturity and

plasticity of the auditory pathway starting from the cochlea in the form of changes in the size and shape of the hair cells to the maturity of synapses function and the central temporal auditory process of the brain as indicated by the development of thalamic-cortical function also results in improved examination results. Plasticity is also influenced by chronic and complex stimulation that results in hearing system repair process[27]. After 3 days of hypoxia-ischemic damage to the central auditory system, there tends to be recovery and the hearing system will experience a significant improvement after 1 week[5]. In some cases, the effects of Neonatal Asphyxia are worsened or manifest only a few days after resuscitation. Thus, it is known that early intervention in the incidence of asphyxia during the first hours after birth can prevent or reduce the occurrence of hearing nerve damage. Tabuchi suggested that when the ischemic circulation is improved, cochlear function is fully restored if the ischemic period is less than 10 minutes. When cochlear function is followed for a long time after the onset of recirculation, ischemia of 15 to 30 minutes induces hair cell loss and permanent cochlear dysfunction[27, 28].

Hearing loss in Neonatal Asphyxia is thought to be due to hypoxia and ischemia conditions that cause brain cell damage so that the distribution of oxygen to various tissues decreases. The initial stage of hypoxia and ischemia is the occurrence of a compensatory mechanism in the form of an increase in blood flow to the brain which is triggered by a decrease in cerebrovascular resistance and systemic hypertension. In severe asphyxia, cerebrovascular resistance increases so that blood flow to the brain decreases. In the late phase, there is a failure of the homeostatic mechanism in which cardiac output decreases and systemic hypotension occurs with a consequent decrease in blood flow to the brain[27]. The level of cell damage is strongly influenced by the duration and degree of asphyxia, the longer and the higher the degree of asphyxia, the more severe the damage occurs, including damage to the inner ear[16, 27].

In this study, it was found that Neonatal Asphyxia increased the risk of sensorineural hearing loss by 1.82 times compared to infants without Neonatal Asphyxia. There were 42.6% sensorineural hearing loss without risk factors, and there was a relationship between gender and sensorineural hearing loss.

Conclusion

Infants with a history of Neonatal Asphyxia were identified as having a risk of sensorineural hearing loss by 1.82 compared to infants without a history of asphyxia.

Conflict of Interest: None.

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Ethical Approval: This research was conducted first with Ethical Approval base on Declaration of Helsinki (LB.02.01 / X.2.2.1 / 15389/2020).

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