Neonatal hearing screening in newborns of pregnant women diagnosed with syphilis

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ABSTRACT

Introduction: Congenital Syphilis is considered a Risk Indicator for Hearing Impairment (RIHI) by the Joint Committee on Infant Hearing (JCIH), making neonates exposed to this indicator more susceptible to this problem. Objective: To analyze the results of Neonatal Hearing Screening (NHS) in neonates whose mothers were diagnosed with syphilis during pregnancy. Methods: Cross-sectional and retrospective study. The following tests were performed: Transient Evoked Otoacoustic Emissions (TOAE) and/or Automatic Brainstem Auditory Evoked Potential (AABR). Results: A total of 169 medical records of newborns were analyzed, divided into two groups: syphilis (neonates of adequately treated mothers) and syphilis requiring intermediate hospitalization (inadequately treated mothers). The mean age at the first test was 2 days, with a predominance of males. In the comparative analysis between the right and left ears, there was no significant difference between the pass/fail results, and the pass result prevailed in both ears. The AABR was the most used in the test and retest in both groups. Of the 169 neonates, 37 failed the hearing screening and 29 were retested. In the retest, three individuals in the sample remained with the altered test and only one continued the diagnostic process, initially identifying conductive hearing loss and later results considered normal in the auditory evoked potential. Conclusion: The results of the study indicate that, in the sample studied, there was no association between the maternal diagnosis of syphilis and neonatal hearing loss, although syphilis is an important indicator of risk for hearing loss.

Keywords: Syphilis, Congenital Syphilis, Neonatal Hearing Screening.

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INTRODUCTION

Syphilis is a Sexually Transmitted Infection (STI) caused by the bacterium *Treponema Pallidum* (T. Pallidum) that is curable and exclusive to humans, which spreads through contact with infectious lesions or body fluids.(1) According to the Ministry of Health, sexually transmitted infections (STIs) are caused by viruses, bacteria, and other organisms.(2) They are transmitted mainly through sexual contact (acquired syphilis), without the use of male or female condoms, with a person who is infected and who, when not treated early, can progress to a chronic disease with irreversible long-term sequelae.(3)

The transmission of an STI can also occur through vertical transmission (congenital syphilis) to the child during pregnancy, childbirth or breastfeeding, when prevention measures are not carried out.(1) There is no vaccine against syphilis, and infection with the causative bacterium does not confer protective immunity. This means that people can be infected as many times as they are exposed to *T. pallidum.* The natural history of the disease shows an evolution that alternates periods of activity with distinct clinical, immunological, and histopathological characteristics (primary, secondary, and tertiary syphilis) and periods of latency (latent syphilis).(9)

Congenital syphilis is the result of hematogenous spread of *T. pallidum* from the infected, untreated or inadequately treated pregnant woman to the conceptus transplacentally.(4) According to the Brazilian Ministry of Health,(3) every pregnant woman should be tested twice for syphilis during prenatal care. One in the first trimester of pregnancy and the second in the third trimester. Sexual partnership should also be tested. Vertical transmission of *T. pallidum* can occur at any gestational stage or clinical stage of maternal disease and the main factors determining the likelihood of vertical transmission of *T. pallidum* are the stage of syphilis in the mother and the duration of exposure of the fetus in utero.(2) For classification purposes, congenital syphilis has two stages: early, diagnosed up to two years of age, and late, after this period.(2)

The clinical syndrome of early congenital syphilis appears up to the 2nd year of life and should be diagnosed through a careful epidemiological evaluation of the maternal situation and clinical and laboratory evaluations and imaging studies in the child.[2]The clinical syndrome of late congenital syphilis appears after the 2nd year of life. As with early congenital syphilis, the diagnosis should be established through the association of epidemiological, clinical, and laboratory criteria.[2]

According to the Ministry of Health,6 from 1998 to June 2021, 260,596 cases of congenital syphilis in children under one year of age were reported in the Notifiable Diseases Information System (SINAN), of which 115,806 (44.4%) were residents in the Southeast region, 77,686 (29.8%) in the Northeast, 30,442 (11.7%) in the South, 22,155 (8.5%) in the North, and 14,507 (5.6%) in the Midwest. Congenital syphilis is preventable when the pregnant woman infected with syphilis is treated properly.[5]

Congenital syphilis, even if asymptomatic, can cause early or late sensorineural hearing loss in neonates.[7] Sensorineural loss can compromise the structures of the inner ear, due to injuries to hair cells or the auditory nerve, reducing the efficiency of sound transmission.[8]Congenital syphilis is considered a risk indicator for hearing impairment (RIHI) by the *Joint Committee on Infant Hearing* (JCIH)[11], which makes neonates more susceptible to this problem.

Due to these and other indicators, as well as the possibility that children without risk indicators (RI) may have hearing impairment, Neonatal Hearing Screening (NHS) programs are necessary, which aim at early identification and intervention.[9]

NHS became mandatory in 2010 with Federal Law No. 12,303 and should be performed, preferably, in the first days of life (24 to 48 hours) in the maternity ward, and, at most, during the first month of life, except in cases when the child's health does not allow the exams to be performed.[10-22]

Based on these premises, this study aims to analyze the results of NHS in neonates whose mothers were diagnosed with syphilis during pregnancy.

METHOD

This cross-sectional and retrospective study resulted in the analysis of the results found in the Neonatal Hearing Screening of live newborns from a maternity hospital in a University Hospital whose mothers were diagnosed with syphilis during pregnancy. The present study was approved by the Research Ethics Committee of the institution under number 2020-0299 and CAAE: 32690820.5.00005327.

The study sample consisted of a sample of newborns of both sexes, with the presence of a risk indicator for hearing loss of maternal syphilis. The hearing screening was performed by the Speech Therapists who perform the exam at the hospital. The inclusion criteria for the study were:

- Newborn hearing screening at the hospital where the study was developed;
- Complete registration of information in the electronic medical record;
- Positive serology for syphilis in the current pregnancy.

The exclusion criteria for the study were:

- Data prior to January 2018 and after April 2020;
- Presence of other risk indicators for hearing impairment besides syphilis in pregnancy

The sample of the present study was divided into two groups of newborns, determined by syphilis and syphilis with intermediate hospitalization. The syphilis group consisted of mothers who had syphilis diagnosed during pregnancy, underwent the correct treatment recommended14 and who, at the time of admission, had their tests negative or a drop in the titers of the *Venereal Disease Research Laboratory* (VDRL) laboratory test, which identifies whether the patient has syphilis.

The group determined by syphilis requiring intermediate hospitalization consisted of mothers who had syphilis diagnosed during pregnancy, underwent incomplete treatment or did not undergo treatment at all, and whose newborns had their tests positive for syphilis and who required prophylaxis for the disease.

The neonatal hearing screening protocol at the hospital where the research was carried out includes the group with and absence of a risk indicator for hearing loss. In order to choose the appropriate protocol for performing the test (Transient Evoked Otoacoustic Emissions - TOAE and/or Automatic Brainstem Auditory Evoked Potential - BAEP-A), the presence of RIHI is first verified, according to the JCIH[11] criteria and adapted to the routine of the institution where the tests were performed.

To start the NHS process, a list of newborns eligible for the exam is checked in the system, that is, those who are already between 24-48 hours after birth. The request for the exam must be included in the hospital's electronic system. Next, a medical record search is carried out in order to search for clinical information and the presence of risk indicators in the maternal and/or newborn history. After validating this information, the speech therapist goes to the bedside of the puerperal woman to confirm the NB's data. Some questions are asked, referring to family history, prenatal progress, childbirth and puerperium.

The exams can be performed both in a specific room and in the bed itself, taking into account the environmental noise and the clinical conditions of the neonate. For NHS, in the study, the Transient Evoked Otoacoustic Emissions (TOAE) and the Automatic Brainstem Auditory Evoked Potential (AABR) were used.

TOAE is a fast, simple, non-invasive test with high sensitivity and specificity, capable of identifying most cochlear hearing loss. A probe, together with the olive, is positioned in the ear canal of the NB where the emissions were researched using the *Madsen® AccuScreen equipment of the* Otometrics *brand*, where the response is detected through the analysis of valid peaks in the frequency range of 1Hz – 4Hz. The test must register a total of at least 8 valid peaks in alternating directions (counted both above and below the midline) to result in pass, which indicates that the patient has normal functioning of the outer hair cells in the area corresponding to the test signal.[13]

If the result passes in both ears, the newborn is released, with the normal exam and recorded in his Child Health Handbook, in the hospital's database spreadsheet and released in the report of the institution's electronic system by the hired speech therapist. The result of failure in this test, soon after the TOAE is performed, the BAEP-a search is performed for such confirmation.

For this study, as the neonates had RIHI, it was recommended that testing be performed with the AABR. This indication is due to the fact that in neonates and infants with RIHI there is a higher prevalence of retrocochlear hearing loss, which is not identifiable through TOAE recording [12].

To perform the AABR, disposable electrodes are connected to the device's electrode cable; Cleaning the newborn's skin is performed with abrasive paste or chlorhexidine aqueous solution soaked in gauze or cotton. These electrodes are positioned on the upper part of the forehead, malar region and on the nape of the newborn's neck. For better stimulus conduction, a drop of conductive gel is used on the electrodes.

After placing electrodes, the probe with olive is positioned in the ear canal of the newborn. In order to avoid irritation on the newborn's skin, a medium-chain triglyceride solution is used, made available by the institution, soon after the removal of the electrodes.

The AABR is performed with the same equipment used for the investigation of otoacoustic emissions, with the result being indicated by **"✓"** and the result by **"X".**

The newborn who fails the hearing screening (TOAE and AABR) is referred for retesting at the Speech-Language Pathology and Audiology sector, at the outpatient level, located in the same institution. A retest date is provided in 15 days and/or according to the available schedule and parents are advised of the importance of performing a new exam to rule out (or not) a hearing loss. In case of non-attendance on the stipulated date, an active search is carried out by the speech-language pathology team, according to the telephone contact previously informed at the time of scheduling the retest, in order to clarify the non-attendance at the exam. If the non-attendance persists, a telegram is sent to the residence, informing of the legal terms in relation to the realization of the TAN and scheduling a new time for the retest. If the guardians still do not show up with the child for the retest, the exam is canceled in the system, and the non-attendance is recorded.

The newborn who undergoes the retest and who still persists in the failure is referred to the diagnostic stage. A complete audiological evaluation is performed, again including the AABR, clinical BAEP (neural and airway and bone auditory threshold). The neonate with a risk indicator who passes this evaluation is released and returns after three months for a new stage of electrophysiological examinations; the newborn who persists in failing is regulated by the Municipality's own Health Department. When hearing loss is diagnosed, the newborn is included in the auditory rehabilitation program, with the selection and adaptation of hearing aids, hearing speech therapy and, if necessary, referrals and evaluations for the use of cochlear implants (CI) are made.

All the data necessary for this research work were obtained after consulting the electronic medical records of the patients, and a database was developed.

For data analysis, quantitative variables were described as mean and standard deviation or median and interquartile range. Categorical variables were described as absolute and relative frequencies. After collecting the data, they were arranged in a spreadsheet in Microsoft Excel, based on the protocols used, and were later analyzed in the Statistical Package for Social Science (SPSS) software.

To compare medians between the groups, the Mann-Whitney test was applied. The association between categorical variables was analyzed using Pearson's chi-square test or Fisher's exact test. The level of significance was set at 5% ($p<0.05$) and the analyses were performed using the SPSS software, version 28.0.

RESULTS

During the period selected for the development of the study, 5,579 neonates were screened at the hospital. As the objective of the research was to evaluate only neonates whose mothers were diagnosed with syphilis during pregnancy, 203 medical records of newborns with the presence of this indicator were selected. Of these, 34 were excluded due to the presence of other risk indicators associated with syphilis.

Thus, 169 medical records of newborns were analyzed, which were divided into two groups: syphilis and syphilis requiring intermediate hospitalization (those who required low-risk intermediate hospitalization for Benzilpenicillin for the treatment and prophylaxis of the disease). The mean age at the first test was 2 days, with a predominance of males. There was no statistically significant association between the results of the tests (1st and retest) with the baby's gender ($p>0.50$). (Table 1)

Regarding neonatal hearing screening, BAEP-A prevailed as the first choice in the examination protocol to be performed on the newborn. In the comparative analysis between the right and left ears, there was no significant difference between the pass/fail results, and the pass result prevailed in both ears. (Table 2)

It was found that 37 neonates failed the NHS (Table 2), but only 29 neonates underwent the retest (Table 3). It is observed that the time between the 1st neonatal hearing screening test and the necessary retest was longer in the Syphilis group (17.5 days). The AABR was the most used in the retest in both groups.

Despite being close to the limit value ($p=0.068$), in the comparative results of pass and failure between the ears, no statistically significant difference was found in the retest result ($p>0.50$). Regarding the retest, three individuals in the sample remained with the altered test, but only one newborn in the syphilis group requiring hospitalization (Table 3) attended the diagnostic tests, which was diagnosed with conductive hearing loss, in a first clinical evaluation. In a second examination, carried out later, however, clinical BAEP was found to be within normal standards, both in terms of the absolute and relative latencies of waves I, III and V and the minimum level of response for the visualization of wave V (20dB in both ears).

Tabela 1 – Caracterização da amostra

Variáveis	n=169
Idade no 1º teste (dias) – mediana (P25 – P75)	2 (2 – 3)
Sexo – n(%)1[1]	
Feminino	81 (47,9)
Masculino	88 (52,1)
Indicador de risco –n(%)	
Sífilis sem internação	150 (88,8)
Sífilis com internação intermediária	19 (11,2)

Legenda: n= número; [1]Não houve associação estatisticamente significativa dos resultados dos testes (1º e reteste) com o sexo do bebê (p>0,50).

Tabela 2 – Triagem Auditiva Neonatal

Variáveis	Amostra total (n=169)	Sífilis (n=150)	Sífilis com internação intermediária (n=19)	p
Tipo de exame – n(%)				0,710
EOAT/PEATE-a	6 (3,6)	5 (3,3)	1 (5,3)	
PEATE -a	159 (94,1)	141 (94,0)	18 (94,7)	
EOAT	4 (2,4)	4 (2,7)	0 (0,0)	
Resultado Orelha Direita – n(%)				0,499
Passa	143 (84,6)	128 (85,3)	15 (78,9)	
Falha	26 (15,4)	22 (14,7)	4 (21,1)	
Resultado Orelha Esquerda – n(%)				1,000
Passa	150 (88,8)	133 (88,7)	17 (89,5)	
Falha	19 (11,2)	17 (11,3)	2 (10,5)	
Resultado Final (Ambas as orelhas)– n(%)				1,000
Passa	133 (78,7)	118 (78,7)	15 (78,9)	
Falha	36 (21,3)	32 (21,3)	4 (21,1)	
Precisou retestar – n(%)	37 (21,9)[1]	32 (21,3)	5 (26,3)	0,569

Legenda: n= número; EOAT= Emissões Otoacústicas Evocadas Transientes; PEATE-a= Potencial Evocado Auditivo de Tronco Encefálico Automático; [1]No resultado final, 01 neonato com resultado passa realizou reteste por indicação da Fonoaudióloga do serviço *Fisher Exact Test

Tabela 3 – Resultados do reteste

Variáveis	Amostra total (n=29)	Sífilis (n=24)	Sífilis com internação intermediária (n=5)	p
Tempo do 1º teste até o reteste (dias) – mediana (P25 – P75)	17 (9 – 24)	17,5 (10 – 23)	10 (6 – 44)	0,845
Tipo de exame – n(%)				0,071
EOAT/PEATE-a	1 (3,4)	0 (0,0)	1 (20,0)	
PEATE-a	26 (89,7)	22 (91,7)	4 (80,0)	
EOAT	2 (6,9)	2 (8,3)	0 (0,0)	
Resultado Orelha Direita – n(%)				0,172
Passa	28 (96,6)	24 (100)	4 (80,0)	
Falha	1 (3,4)	0 (0,0)	1 (20,0)	
Resultado Orelha Esquerda – n(%)				0,068
Passa	26 (89,7)	23 (95,8)	3 (60,0)	
Falha	3 (10,3)	1 (4,2)	2 (40,0)	
Resultado Final (Ambas as orelhas) – n(%)				0,068
Passa	26 (89,7)	23 (95,8)	3 (60,0)	
Falha	3 (10,3)	1 (4,2)	2 (40,0)	
Realizou exames complementares – n(%)	1 (3,4)	0 (0,0)	1 (20,0)	0,172

Legenda: n= número; EOAT= Emissões Otoacústicas Evocadas Transientes; PEATE-a= Potencial Evocado Auditivo de Tronco Encefálico *Fisher Exact Test

DISCUSSION

In this study, 169 medical records were analyzed, which were divided into two groups: syphilis and syphilis with intermediate hospitalization. This amount is compatible with the number of children investigated in another study.[19]Syphilis is an RIHI described by JCIH11. Some early detection programs select newborns with a higher probability of some hearing impairment, where the objective is to select only neonates with RIHI, directing them to specific protocols for NHS.[21]In the present study, we specifically analyzed the RIHI syphilis, and these findings are similar to previous studies where this indicator is one of the most prevalent.18-19-20-21

Regarding the sample evaluated, the mean age in days of NHS was 2 days, that is, within the minimum period of 24 to 48 hours of life and up to a maximum of 30 days as recommended by the Neonatal Hearing Screening Guidelines.[10-22]This data may reflect on the active search and the importance of early identification of a hearing impairment, where the professionals involved in this process, speech therapists, physicians, nurses, who work directly or indirectly in the NHS, are committed and attentive to signal probable risk indicators and their early intervention, in order to refer the hearing impairment as soon as possible when the hearing impairment is effectively diagnosed.

Of the newborns participating in the study, 52.1% were male and 47.9% female. In other studies, the authors show that the percentage of NHS was higher in males.[15-16]In the study by

RODRIGUES et al.(2016)[17], the percentage of NHS performed in males was 53.85% and females were 46.15%, contrary to the study by POZZI et al. (2021).[19]The findings of the present study reveal that there was no statistically significant association between the results of the tests (test and retest) and the baby's gender (p>0.50).

In the present study, it was evidenced that the AABR test was the test chosen in most cases as the first to be performed in NHS, due to the standard protocol used in the institution, which makes it possible to identify retrocochlear alterations. Although syphilis is treated appropriately during pregnancy, the protocols recommend that these neonates undergo more specific tests.[21]The findings of the present study show the prevalence of the results passed in both ears in both groups.

These findings are similar to those found in the scientific literature, since in studies carried out in neonates with the same RIHI the results are that both ears are passing, however, contrary to this study, the protocol used in NHS was TOAE in a group with RIHI but also in control groups for comparison purposes.[20]

It is important to emphasize that the result passed the test means that at the time it was carried out, the results were compatible with the expected responses in the AABR, that is, at the level of the brainstem and in the TOAE compatible with the integrity of the outer hair cells.[16]The literature shows that NHS, including TOAE and AABR tests, is essential both for early detection of hearing impairment and for subsequent referral for rehabilitation.[16]

The retest stage must take place within 30 days after the test.[11]The retest should be performed in both ears, even if the test failed unilaterally, a criterion that was evidenced in this study, where the time in days of the retest in relation to the first test performed was within the expected time: 17.5 days. The findings of the present study are in line with other studies regarding the flaw result, where 21.9% of neonates in the normal sample were evidenced in this study, a slight increase in relation to the 11.5% found by some researchers.19

Findings related to NHS and retesting are worrisome, considering the purpose of screening, to monitor the child's auditory development.[19]Even with an active search for newborns who failed the NHS retest for the time being, in this study it was noted that only 3.4% of the total sample continued treatment and had their referral for diagnosis.

The data from this study corroborate the quality indicators for screening established by the JICH, where a maximum of 4% of referrals for complete hearing evaluation after NHS is suggested.[18]If the newborn does not attend the retest, the child's hearing health is compromised.[20] From the audiological point of view, all newborns exposed to maternal syphilis, regardless of whether or not there has been adequate treatment, should undergo evaluation and monitoring every six months until the age of two, as well as perform treponemal tests after 18 months.[6-20]

In the sample analyzed, 37 patients were identified who failed the NHS and 29 underwent the retest; where only three persisted with the failure. After an active search via telephone contact and telegram, only one patient returned for further evaluations and was referred for diagnosis, in which conductive hearing loss was identified. The first BAEP-diagnosis performed on the newborn presented a result indicative of conductive alteration. In the second BAEP-diagnosis, the result was the presence of waves I, III and V, with normal absolute and interpeak latencies and with a minimum response of 20dB. These data differ from those reported in the specialized literature, which states that neonates whose mothers have been diagnosed with syphilis have a greater chance of presenting sensorineural hearing loss18-20

CONCLUSION

The results of this study indicate that there was no association between the maternal diagnosis of syphilis and the presence of hearing loss in the screened neonates.

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