DIAGNOSTIC OUTCOME OF REFERRED NEONATAL HEARING SCREENING IN A SECONDARY HEALTHCARE CENTER AT EL MAHALLA, GHARBIA, EGYPT

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ABSTRACT:

Background: *An early detection of congenital hearing loss and appropriate hearing rehabilitation are mandatory for both individuals and societies.*

Aim of the Work: *To estimate incidence and identify type, degree, possible causes of congenital hearing loss among infants and identify difficulties encountered in diagnostic procedures.*

Patients and methods: *This cross-sectional study was conducted on 75 neonates who were referred from primary health care centers to Audiology unit, El Mahalla General Hospital to be diagnosed for possible hearing abnormalities. This work was done in the period from May 2022 to January 2023.*

Results: *Almost all examined neonates with type (A) tympanogram gave "Pass" results by otoacoustic emission (OAE) test & all neonates with type (B) tympanogram gave "Refer" results by otoacoustic emission (OAE) test. The results of click and tone burst ABR tests showed that a total of 33/72 ears (45.8%) had congenital hearing loss; 16 ears (48.5%) were conductive hearing loss, 15 ears (45.4%) were congenital permanent sensorineural hearing loss, and 2 ears (6.1%) were mixed hearing loss. 39 ears (54.2%) had normal hearing levels by ABR test.*

Conclusion: *Both conductive and sensorineural hearing loss were common in neonates with a slight high incidence of conductive hearing loss. Diagnosis of congenital hearing loss among neonates was by immittancemetry, otoacoustic emission (OAE) and auditory brainstem response (ABR) tests.*

Keywords: *Hearing loss, Transient Evoked Otoacouastic Emission, Diagnosis, Auditory Brainstem Response.*

INTRODUCTION:

Hearing is important for the development of language and communication skills. An early detection of hearing loss and appropriate hearing rehabilitation are mandatory for both individuals and societies (1).

Undiagnosed hearing impairment may have serious adverse effects on a child's language, social, emotional, cognitive, academic and vocational development. To minimize these consequences, early management with hearing aids or cochlear implants is recommended. Therefore, current health care standards recommend that neonatal HL must be confirmed before the age of 3 months and intervention must be performed before the age of 6 months. Achievement of this goal essentially relies on universal neonatal hearing screening (2).

According to the Joint Committee on Infant Hearing (JCIH 2007), high risk factors were defined.

Low birth weight baby, preterm baby, delivery by cesarean section, birth asphyxia, congenital anomalies, neonatal jaundice, newborn with a history of convulsions and infection were all categorized into high risk groups[3].

AIM OF THE WORK:

The aim of this study was to estimate incidence and identify type, degree and possible causes of hearing loss and also to identify difficulties encountered in diagnostic procedures for who were referred for diagnosis at El Mahalla General Hospital.

PATIENTS AND METHODS:

This cross-sectional study was conducted on 75 neonates who were referred from primary health care centers to Audiology unit, El Mahalla General Hospital to be diagnosed for hearing abnormalities in the period from May 2022 to January 2023.

Inclusion criteria:

All neonates referred from primary health care centers who got "Refer" result from the 1ry neonatal hearing screening which was done twice by Transient Evoked Otoacouastic Emissions “TEOAE" or Distortion Product of Otoacoustic Emissions" DPOAE" tests at primary health care centers.

Exclusion criteria:

Neonates who passed the screening at Primary Healthcare Centers were excluded.

Sample size:

sample size was calculated using PASS11 program and it was equal to 75 neonates.

Methods:

All neonates were subjected to:

Full history taking, general examination of the neonates including facial features to pick up congenital anomalies, then otological examination and the audiological assessment including the following;

Immittancemetry:

Both tympanometry & acoustic reflex tests were conducted to all neonates. Tympanometry was done with probe tone (226 Hz) as probe tone (1KHz) wasn't available. The test was carried out while the infant was naturally sleeping in the arms of the mother or caregiver to have the infant as calm as possible. When the tympanometric curve was not satisfactorily obtained, because of infant movement causing pressure escape, the test was repeated, removing the probe and re-inserting it in the same ear in order to obtain new reliable values.

Procedure: probe was introduced in the external auditory canal of the infant by means of which a variable pressure of +200 daPa to -300 daPa was employed with a speed of 50 daPa/s. Response was analyzed as external ear volume, compliance, peak pressure and pressure gradient. Acoustic reflex thresholds were elicited ipsilaterally using pure tones of 500, 1000 Hz.

Transient Evoked Otoacouastic Emissions (TEOAEs):

TEOAEs test was conducted to all neonates. The TEOAEs was recorded in a soundproof room (single room double walled cabin). Testing was done while infants were naturally sleeping or were alert and calm in the lap of caregivers. If during the test infants were alert active or crying, the test couldn't be completed and retesting was performed on the next day.

Parameters: The TEOAEs were elicited using click stimuli with intensity 85dB SPL at 16 clicks/s of repetition rate. They were

analyzed during the 30 ms following stimulation onset averaging 260 responses in each recording session. Pass criteria were: Reproducibility > 50%. Signal-noise ratio >6 dB SPL in four of five frequency bands (1, 1.5, 2, 3 and 4KHz). The probe stability was kept at 90 % or higher.

Diagnostic Auditory Brainstem Response (ABR):

ABR test was conducted to the neonates who had abnormal findings by immittancemetry/ OAE tests or both (no= 36 neonates). Also neonates of normal findings for both tests but with one or more risk factors of hearing loss[4] (no= 17 neonates).

Preparation: The greasy materials were gently removed from the skin contact sites with electrodes using nuprep gel. A conductive electrode –gel was applied on the skin contact sites with electrodes. ABR testing was performed when the infant was naturally sleeping and was limited to the duration of the infant's nap. Caregivers were advised to keep infants awake and sleep-deprived the night before the procedure to maximize the time of sleep. In case the infant was awake, feeding was done to help more deep sleep.

Technique: Three surface electrodes were placed so that the active electrode was applied to the forehead, the reference and the ground electrodes to the ipsilateral and contralateral mastoid respectively. Starting with intensity of 70 dBnHL then decreased by 20 dB increments until threshold is obtained (down to 20/30 dBnHL). In case of absence wave V at 70 dBnHL, ascend to 90 dBnHl. In case of absence wave V at 90 dBnHL, cochlear microphonic protocol was conducted.

Parameters: Broadband click stimulus was used to estimate thresholds of hearing sensitivity between 2000 and 4000 Hz & tone burst was also used at 500 Hz with a window of 20 msec. Intensity of stimulation was variable at a rate of 37.7 p /sec with rarefaction polarity, band pass filter (100 - 3000 Hz) was used, 1000 sweeps were differentially amplified with a window of 14msec for click ABR, impedance was kept below 5Kohms & Interelectrode impedance was kept below 2 Kohms.

Response: The resulting waveforms were evaluated for repeatability, morphology (the subjective judgment on the shape & quality of the waveforms) and the absolute wave latencies (wave latency is defined by the time between the initial auditory stimulus and the peak of the waves I, III, V mainly) at maximum intensity.

Cochlear microphonic protocol:

By using insert earphones, polarity was reversed (starting with condensation then alternating polarity) and the stimulus tube was blocked (clibbing). This protocol was conducted for neonates with no ABR waves (no=7 ears).

Statistical Methods:

Statistical analysis was conducted using SPSS (version 21, Chicago, IL, USA). Qualitative data was presented as number and percentage; while quantitative parametric data (normally distributed) was presented as mean and standard deviation and quantitative non-parametric data (abnormally distributed) was presented as median (minimum, maximum).

Ethical consideration:

Informed written consent was taken from the parents of all neonates involved in this study and the study protocol has been approved by the Ain-Shams Institute's Ethical Committee of Human Research. Committee number is (MS 625/2022).

RESULTS:

Table 1: Demographic data among studied neonates (75 neonates)

		Total no. = 75
Gender	Male	38 (50.7%)
	Female	37 (49.3%)
Age of completion of diagnosis in months	Mean ± SD	1.55 month ± 0.8
	Range	1 – 5 months

This table shows that both males and females were nearly equally distributed with mean age of 1.55 months ± 0.8.

Table 2: Otoscopic examination among studied neonates (75 neonates).

		Total ears	Right ear	Left ear
		No. =150	No. =75	No. = 75
Otoscopic examination findings	Normal T.M	128(85.3%)	64(85.3%)	64(85.3%)
	Abnormal T.M	18 (12.0%)	9 (12.0%)	9(12.0%)
	CNT	4 (2.7%) *	2(2.7%) *	2(2.7%) *

This table shows that most of neonates had normal tympanic membranes.

***N.B:** Tympanic membrane (TM) couldn't be examined in 2 neonates due to external canal atresia, external canal stenosis & auricle deformity (1neonate of Treacher Collins syndrome (syndromic bilateral atresia) & 1 neonate of non-syndromic bilateral atresia).

Table 3: Tympanometry (226Hz) parameters results among studied neonates (75 neonates).

Tympanometry(226Hz)		Total ears	Right ear	Left ear
		No. = 150	No. = 75	No. = 75
Peak pressure	Type A	128(85.3%)	64(85.3%)	64(85.3%)
	Type B	16(10.7%)	8 (10.7%)	8(10.7%)
	Type C	2(1.3%)	1 (1.3%)	1(1.3%)

This table shows that most of neonates had type (A) tympanograms.

N.B: Tympanometry (226 Hz) couldn't be done in the previously mentioned 2 neonates (1neonate of Treacher Collins syndrome &1 neonate of non-syndromic bilateral atresia).

Table 4: Relation of (OAE) test results in both ears with tympanometry (226 Hz) pressure (73 neonates).

		OAE test results	
		Pass	Refer
		No. = 111 ears	No. = 35 ears
Pressure	Type (A)	109(98.2%)	19(54.3%)
	Type (B)	0(0.0%)	16(45.7%)
	Type (C)	2(1.8%)	0 (0.0%)

This table shows that almost all neonates with type (A) tympanogram gave "Pass" results by OAE test & all neonates with type (B) tympanogram gave "Refer" results by OAE test.

Table 5: Numbers & percentages of neonates with normal and abnormal click & T.B (500Hz) ABR thresholds (72 ears).

	Total ears	Right ear	Left ear
	No. = 72	No. = 36	No. = 36
Normal click & T.B ABR threshold	39 (54.2%)	19 (52.8%)	20 (55.6%)
Abnormal click & T. BABR threshold	33 (45.8%)	17 (47.2%) ●	16(44.4%)

N.B: ● One neonate had right unilateral hearing loss by click & T.B ABR (absent wave (V) at 90 dBnHL).

Table 6: Relation of presence of hearing loss in both ears according to ABR threshold with results of OAE test (36 neonates (72 ears)).

Results of OAE test	ABR results	
	Normal hearing	Hearing loss
	No. = 39 ears	No. = 33 ears
Pass with risk factors of HL	33 (84.6%)	0 (0.0%)
Refer	6(15.4%)	29(87.9%)

This table shows that most of neonates with risk factors and passed OAE test had normal hearing by ABR test, only 15.4% had false negative response by OAE test.

Table 7: Types of hearing loss among studied neonates who undergone ABR test (click & T.B (500Hz)) (17 neonates).

		Total ears	Right ear	Left ear
		No. = 33	No. = 17	No. =16
Types of hearing loss	Conductive hearing loss	16 (48.5%)	8 (47.1%)	8(50.0%)
	Sensorineural hearing loss	15 (45.4%)	8 (47.0%)●	7(43.8%)
	Mixed hearing loss	2(6.1%)	1(5.9%)	1(6.2%)

N.B: ● 1 neonate had right unilateral hearing loss by click& T.B ABR (absent wave (V) at 90 dBnHL).

Table 8: Possible etiology of permanent congenital sensorineural hearing loss (SNHL) among studied neonates (15 ears).

		Total ears
		No. = 15
Possible etiology of SNHL	Idiopathic	2(13.3%)
	NICU admission (>5 days)	4(26.7%)
	Low birth weight (<1500 gm)	3(20.0%)
	Heredofamilial	4(26.7%)
	Treacher Collins syndrome	2(13.3%)

N.B Permanent congenital sensorineural hearing loss (SNHL) was present only in 15/150 ears (10%) of studied neonates.

Table 9: Degree of permanent congenital (SNHL) among studied neonates who undergone ABR test (click & T.B(500 Hz)) (15 ears).

		Total ears	Right ear	Left ear
		No. = 15	No. = 8	No. =7
Degree of SNHL	Mild SNHL	2(13.3%)	1(12.5%)	1(14.3%)
	Moderate SNHL	4(26.7%)	2(25.0%)	2(28.6%)
	Moderatly severe SNHL	4(26.7%)	2(25.0%)	2(28.6%)
	Severe SNHL	2(13.3%)	1(12.5%)	1(14.3%)
	Severe to profound SNHL	3(20.0%)	2(25.0%)●	1(14.3%)

DISCUSSION:

Both early diagnosis of hearing loss (HL) in newborns and the identification of risk factors for late–onset HL are of fundamental importance to assess a therapeutic program to reach adequate linguistic competences [(5)].

In the current study, the mean age of the examined neonates was 1.55 month ± 0.8 with nearly equal gender distribution (M= 50.7%, F= 49.3%) table 1. Otological examination of examined neonates revealed that most of neonates had normal tympanic membranes (85.3%) table 2. Tympanic membrane couldn't be examined in 2 neonates due to external canal atresia, external canal stenosis & auricle deformity (1neonate with Treacher Collins syndrome & 1 neonate with bilateral atresia). Abnormal tympanic membranes were seen in (12.0%) of examined ears in the form of retracted & congested tympanic membrane. All neonates were without vernix caseosa in

the external auditory canal as they were examined within one month after birth.

The otoscopic examinations in the study of *Bezuidenhout et al.* [6] revealed a large majority, (71%) neonates have normal tympanic membrane except for vernix caseosa in their external auditory canals, and (32%) were subjectively considered to have narrow ear canals. Other otoscopic findings were presence of congestion in the ear (n = 1), a preauricular skin tag (n = 1) and an ear canal that collapsed during testing (n = 1).

Tympanometric (226 Hz) data showed that most of examined ears had type (A) tympanogram 128/150 ears (85.3%), 16/150 ears (10.7%) were type B and only 2/150 ears (1.3%) were type C table 3.

Refer results by OAE test in the current study with type (A) tympanogram were seen in [19/35(54.3%)] ears table 4. It's worth to be mentioned that not all of them appeared to have SNHL by ABR test &6 ears had normal ABR (false positive)**.**

Diagnostic auditory brainstem response was done for the neonates in the current study using click ABR test at (2-4 KHz) and T.B ABR at (500 Hz) by headphone TDH-49P. The results of click and T.B ABR tests showed that a total of 33/72 ears (45.8%), had hearing loss table 5. Among them, 39 /72ears (54.2%) with normal hearing by ABR test, 6 ears (15.4%) had "Refer" (with RFs& without RFs of HL) results by OAE test table 6. According to many studies, the main reason for false-positive outcomes with OAE testing are transient conditions in the external auditory canal (e.g., collapse of the ear canal and the presence of debris) and middle ear (e.g., presence of amniotic fluid and mucus), as well as high ambient noise level. These problems usually resolve within the first few hours or days of life [7]. Regarding types of hearing loss; 16 ears (48.5%) were conductive hearing loss, 15 ears (45.4%) were congenital permanent sensorineural hearing loss, and 2 ears (6.1%) were mixed hearing loss table 7.

Sensorineural hearing loss was related to NICU admission > 5 days in 2 neonates [4 (26.7%) ears], history of heredofamilial hearing loss in 2 neonates [4 ears (26.7%), 1 neonate with (low birth weight <1500 gm, 1 neonate of Treacher Collins syndrome [2 (13.3%) ears], and 1 neonate of idiopathic HL [2 (13.3%) ears] table 8. Recent study by *Acke et al.* [8] about the audiological and etiological results of neonatal hearing screening reported that the main causes of hearing loss included middle ear diseases mostly otitis media with effusion, genetic disorders (12%), congenital cytomegalovirus infection cCMV, (5%) and atresia/stenosis of the external ear canal (5%).

As regards the degree of SNHL, mild & severe HL affected 1 neonate while moderate & moderately severe affected 2 neonates each. Severe to profound HL affected 1 neonate with bilateral SNHL and 1 neonate with unilateral SNHL table 9.

The results of clinical ABR in the study of Di *Stadio et al.* [9] showed that 12/25 (48%) neonates had moderate and profound SNHL; 11/25 (44%) were false positives after newborn screening by OAE test and had normal hearing. Among neonates with hearing loss, 4 neonates (33.4%) had unilateral profound SNHL, 3neonates (25%) had bilateral profound SNHL, 3 neonates (25%) had unilateral moderate SNHL, 1neonate (8.3%) had bilateral moderate SNHL and1 neonate (8.3%) received a diagnosis of auditory neuropathy. *Gáborján et al.* [10] in their study about neonatal hearing screening in Hungary, using ABR in diagnosis stage they found that regarding the severity of the hearing loss (from 102 children) mild, moderate, severe and profound hearing loss were diagnosed in 12%, 31%, 9% and 48% respectively).

Sabbagh et al.[11] in their study about the neonatal hearing screening revealed that of

24 hearing-impaired newborns, (62.5%) had bilateral hearing loss and (37.5%) had unilateral HL where mild hearing loss (20-39 dB) was (12.5%) , moderate hearing loss (40-55 dB) in (20.8%) neonates, severe hearing loss (70-90 dB) in (37.5%), and profound hearing loss (>90 dB)in (29.2%) neonates.

Conclusion:

The absence of risk factors of hearing loss in neonates doesn't guarantee normal hearing and the presence of risk factors of HL isn't main factor for presence of HL.

Both conductive and sensorineural hearing loss were reported in neonates with a slight higher incidence of conductive hearing loss.

Moderate to moderately severe degrees were the commonest degree encountered.

The most common risk factor of HL was NICU admission > 5 days followed by craniofacial / ear anomalies.

Diagnosis of hearing loss among neonates was by otoacoustic emission (OAE), immittancemetry and auditory brainstem response (ABR) tests.

Recommendations:

Further studies should be performed on a larger sample size with multicentric analysis to confirm the results of the current study.

Long-term follow up of neonates who developed hearing loss is recommended after introduction of the appropriate management plan.

Conflicts of interest:

No conflicts of interest

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نتيجه تشخيص المسح السمعي لحديثي الولاده المحالين في مركز رعايه صحيه ثانويه بالمحله - الغربيه - مصر

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المقدمة: يعد الاكتشاف المبكر لفقدان السمع وإعادة التأهيل المناسب لفقدان السمع أمرًا إلزاميًا لكل من الأفراد والمجتمعات.

الهدف من العمل: تقدير نسبه حدوث فقدان السمع منذ الولاده ،التعرف علي نوع فقدان السمع ،التعرف علي الاسباب الممكنه لفقدان السمع،التعرف علي الصعوبات المواجهه في اجراءات التشخيص.

المرضي وطريقة البحث: اجريت هذه الدراسة المستعرضة على ٧٥ من الأطفال حديثي الولادة الذين أحيلوا من الرعاية الصحية الأولية إلى وحدة علم السمع، مستشفى المحلة العام ليتم تشخيصها بسبب اضطرابات السمع في الفترة من مايو٢٠٢٢ الي يناير٢٠٢٣.

تقريبا جميع الأطفال حديثي الولادة الذين لديهم مخطط طبلة الاذن من النوع (أ) اعطوا نتائج "نجاح" (النتائج عن طريق اختبار الانبعاثات الصوتيه) وجميع الأطفال حديثي الولادة الذين لديهم مخطط طبلة من النوع (ب) اعطوا نتائج "احاله".

أظهرت نتائج اختبارات رسم السمع عن طريق جزع المخ(النقر وانفجار النغمه) أن من مجموع ٣٣/٧٢أذنا (45.8%) تعاني من فقدان السمع. كانت ١٦ أذنا (48.5%)تعاني من فقدان السمع التوصيلي و١٦ اذنا(45.4 %) من فقدان السمع الحسي العصبي الدائم الخلقي، وكانت أذنان (6.1%) من فقدان السمع المختلط. وكان ٣٩ أذنا لديهم سمع طبيعي بواسطه اختبار السمع عن طريق جزع المخ.

الخلاصه: كان كل من فقدان السمع التوصيلي والحسي العصبي شائعا في الأطفال حديثي الولادة مع ارتفاع طفيف في معدل فقدان السمع التوصيلي في هذه الدراسه.