EVALUATION OF AUTOMATED AUDITORY BRAINSTEM RESPONSE AND OTO ACOUSTIC EMISSIONS IN NEONATAL HEARING SCREENING IN NICU NEONATES VERSUS WELL BORN NEONATES

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Received: 4/7/2022
Accepted: 1/8/2022

Online ISSN: 2735-3540

ABSTRACT:

Background: *Universal neonatal hearing screening (UNHS) has been implemented in countries all over the world to detect neonates with congenital hearing loss early and provide appropriate intervention in time. Therefore, it is extremely important to find a convenient and effective screening protocol to identify precisely all newborns with hearing loss. This study mainly explored the effectiveness of ATEOAEs and AABR as first screening tool in risky and non-risky neonates.*

Aim of the work*: To compare performing time, referral rates, sensitivity and specificity of ATEOAEs and AABR as a screening tool in Neonatal Intensive Care Unit (NICU) and Well-Infant Nursery (WIN) and to identify obstacles against each screening tool.*

Patient and Methods:*510 neonates were recruited from Neonatal Intensive Care Unit (NICU) and Obstetrics & Gynecology maternity hospital in Ain Shams University Hospital. All neonates were screened by Automated Transient Evoked Oto-Acoustic Emissions (ATEOAEs) and Automated Auditory Brain stem Response (AABR) tests in first hearing screening, and those failed any test were scheduled for retest after one week. Failed neonates were assessed by diagnostic ABR. The results of ATEOAEs and AABR were compared among the NICU and Well Born Neonates (WBN) groups. The time spent on screening by each tool was recorded, validity and referral rates were calculated.*

Results: *AABR resulted in more pass and less refer outcome, with highly statistically significant difference in referral rates between ATEOAEs & AABR after first and second screening tests in both well born and NICU groups ($P<0.001$). As regards the total test time (including setting time plus the actual testing time), AABR test had significantly shorter total test time compared to ATEOAEs for both well born and NICU neonates. AABR was more valid than ATEOAEs in neonatal hearing screening in NICU neonates with higher sensitivity and specificity.*

Conclusions: *AABR is more sensitive and specific than ATEOAEs in diagnosis of hearing loss in NICU neonates, and with the newly developed technologies (BERAphone), screening test is cost effective than ATEOAEs due to significantly lower referral rate. So AABR is the screening test of choice for high risk NICU neonates.*

Key Words: *Neonatal hearing screening, NICU neonates, WBN, ATEOAEs, AABR.*

INTRODUCTION:

The incidence of significant bilateral hearing loss in neonates is 1-3 cases per 1000 live births and 2-4 per 100 infants surviving neonatal intensive care[(1)]. In the absence of early recognition and with resulting lack of access to language, a child who is deaf or hard of hearing in infancy, can experience delays in speech and language development, academic achievement, and social and emotional outcomes[(2)]. Early identification of hearing impairment improves prognosis, hence screening programs have been widely and strongly advocated[(3)].

Optimal Early Hearing Detection and Intervention (EHDI) programs have been defined as meeting the EHDI 1-3-6 goals. To provide appropriate access to language stimulation and intervention services as soon as possible, EHDI programs considered setting a new target of 1-2-3 months (screening completed by one month of age, audiologic diagnosis completed by two months of age, and early intervention initiated no later than three months of age)[(4)]. It may not be appropriate to apply this timeline to infants receiving care in the NICU, a recommendation is made that for preterm infants with prolonged hospitalization, a diagnostic audiologic evaluation prior to discharge from the NICU be completed. Infants identified as being deaf or hard of hearing could be referred directly for early intervention and audiological follow-up services at the time of discharge[(4)].

Studies have demonstrated that current screening technologies are effective in identifying hearing thresholds of approximately 35-40 dB HL and greater[(5)]. However, mildly elevated hearing thresholds are not identified using current screening technologies and even mildly elevated hearing thresholds that can impact speech and language development, accordingly, those children necessitate pre-school evaluation using more behavioral methods[(6)].

JCIH also recommended the use of physiological procedures for screening (EOAEs, evoked otoacoustic emissions, and AABR, automated auditory brainstem response). For neonates without risk factor for hearing loss (RFHL), any of the methods are considered appropriate. However, for neonates with RFHL and especially those who remained in the NICU, the use of AABR is indicated, considering the higher occurrence of retro cochlear losses, such as the auditory neuropathy spectrum disorder that cannot be identified when using EOAEs[(7)].

Although EOAEs are the most adequate hearing screening tests because they are accurate, economic, and of simple execution, the AABR provides information not only about the outer/middle ear and cochlea but also about the auditory pathway up to the brainstem. AABR has an agreement with conventional auditory brainstem response up to 98%. it can be used on the ward and during oxygen therapy without disturbance from ambient noise, and decreasing false positive cases[(8)].

As JCIH recommended that ABR screening accesses more central structures of the auditory system than OAEs screening, allowing for detection of neurologic involvement. It is the only currently available technique for detecting neural hearing loss (eg, auditory neuropathy/ dyssynchrony), and it is strongly recommended for infants who are admitted to the NICU[(4)].

In countries that have heavy economic loads, such as Egypt, there is still confusion regarding the cons & prons of each test, as

the preference is always given to the test with least functional cost, but this will not be useful in the case of high risk NICU neonates. So, the main objective of the current study was to explore the most suitable, practical and effective neonatal hearing screening tool especially for high risk neonates and to shed light on some controversial issues.

AIM OF THE WORK:

To compare test time, referral rates, sensitivity and specificity of ATEOAEs and AABR in neonatal hearing screening in Neonatal Intensive Care Unit (NICU) and Well-Infant Nursery (WIN) and to identify obstacles against each screening tool.

MATERIAL AND METHODS:

Study Population:510 neonates were included in this study. They were divided into 2 groups. **Group I** consisted of 100 well born neonates from maternity hospital with mean age of 2.51± 1.25 days, they were 49 males (49.0%) and 51 females (51.0%). **Group II** consisted of 410 neonates just after discharge from Neonatal Intensive Care Unit (NICU) with mean age of 21.88± 15.55 days. They were 229 males (55.9%) and 181 females (44.1%).

Methods: Screening by ATEOAEs and AABR was done in stage (1) for all included newborns. For Well born neonates screening was done 12-48 hours after birth, while for NICU neonates screening was done just after discharge from NICU or one week later in their first follow up visit. For neonates who gave "Refer" result in one or both screening tools weather unilateral or bilateral, they were scheduled for retest after one week. If "Refer" result was obtained in rescreening, a diagnostic ABR was conducted in stage (2). All neonates in this stage were submitted to detailed history taking, general examination, otological examination, and diagnostic Auditory Brainstem Response (ABR).

Ethical Considerations: Verbal consent obtained from parents of all neonates before testing after explaining the aim of the test and the procedure to be done. Also, approval from Ethical committee of Ain Shams University was obtained before start of this research.

RESULTS:

Demographic data: This research was conducted on a total number of 510 neonates: 100 of them were well being at birth (study group I) and 410 were admitted to Neonatal Intensive Care Unit (NICU) (study group II). The mean age at which the screening tests were performed was 2.51± 1.25 days & 21.88± 15.55 days for group I&II respectively in El-Demerdash hospital. Demographically there was highly statistically significant difference between the two groups in gestational age, birth weight and mode of delivery, while no statistically significant difference was detected in sex, twins, consanguinity and family history for hearing loss.

Screening tests results*:*

Table (1): Comparison between OAEs & AABR time for pass response* in seconds in groups I&II :

	ATEOAEs				AABR				Student t test	P value
	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD		
Group I	40.00	190.00	123.19	42.38	60.00	320.00	149.19	65.91	47.415	<0.01 HS
Group II	25.00	260.00	95.84	40.84	35.00	340.00	149.50	62.34	69.956	
Student t test	1.35				1.87					
P value	0.19 NS				0.27 NS					

* Time for pass response is the time between well fitted probe insertion till the appearance of pass response.

Table (1) showed highly statistically significant difference between ATEOAEs & AABR pass response time in both study groups with shorter pass response time for ATEOAEs than for AABR, with no significant difference between two groups.

Table (2): Comparison between ATEOAEs & AABR total screening time* in seconds in groups I&II:

	ATEOAEs				AABR				Student t test	P value
	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD		
Group I	180.00	1020.00	548.00	182.39	185.00	1285.00	413.74	117.51	76.588	<0.001 HS
Group II	160.00	1080.00	530.00	171.32	175.00	1335.00	396.99	114.802	83.305	
Student t test	1.29				0.91					
P value	0.36 NS				0.20 NS					

*Total screening time includes preparation& administration till appearance of the result.

Table (2) showed highly statistically significant difference between ATEOAEs &AABR total test time in both study groups with shorter total test time for AABR than for ATEOAEs, with no significant difference between two groups.

Table (3): Number and Percentage of the results of the first screening test in group I with ATEOAEs & AABR:

	Bilateral Pass		Bilateral Fail		Unilateral Pass		Total	
	N	%	N	%	N	%	N	%
ATEOAEs	46	46.0%	53	53.0%	1	1.0%	100	100%
AABR	81	81.0%	19	19.0%	0	0%	100	100%
P value* <0.001 HS								

Table (3) showed highly statistically significant difference (P<0.001) between ATEOAEs & AABR for outcome of screening. AABR resulted in more pass and less refer outcome compared to ATEOAEs.

Table (4): Number and Percentage of the results of the first screening test in group II with ATEOAEs &AABR:

	Bilateral Pass		Bilateral Fail		Unilateral Pass		Total	
	N	%	N	%	N	%	N	%
ATEOAEs	163	39.8%	232	56.6%	15	3.7%	410	100%
AABR	330	80.5%	55	13.4%	25	6.1%	410	100%
P value* <0.001 HS								

Table (4) showed highly statistically significant difference (P<0.001) between ATEOAEs & AABR for outcome of screening. AABR resulted in more pass and less refer outcome.

Table (5): Referral rate after first and second screening for both screening tests in all screened neonates:

		N	%	ATEOAEs	AABR
Referral after first screening	Yes	331	64.9%	59 %	19.4 %
	No	179	35.1%		
	Total	510	100.0%		
Referral after second screening	Yes	72	21.8%	16.3 %	5.4 %
	No	259	78.2%		
	Total	331	100.0%		
P value		< 0.001			

*Yes: Refer No:Pass

Table (5) showed highly statistically significant difference in referral rate for both screening tests with less referral after second screening.

Table (6): Comparison between two groups as regards the referral rate:

		Group I		Group II		X^2	P value
		N	%	N	%		
Referral after first screening	Yes	73	73.0%	327	79.7%	0.46	0.50 NS
	No	27	27.0%	83	20.3%		
	Total	100	100.0%	410	100.0%		
Referral after second screening	Yes	0	0.0%	72	26.8%	21.21	<0.001 HS

*Yes: Refer No:Pass

Table (6) showed no statistically significant difference between both two groups in referral rate after first screening, while highly statistically significant difference is present between two groups as regards the referral rate after second screening test resulting in 72 NICU neonates (group II) were included in second stage (diagnostic hearing evaluation).

Diagnostic hearing evaluation:

Diagnostic hearing evaluation was done for neonates who failed second screening test with one or both screening tools. It was done with mean age of 34.86 days ± 10.5 days in Audiology unit in Ain Shams University Hospitals

Table (7) revealed that majority of tested neonates with diagnostic ABR test gave normal hearing thresholds.

Table (7): Results of diagnostic ABR test:

ABR result	Number of neonates	Percent
Normal	55	13.4 %
Moderate HL	4	0.9 %
Moderately severe HL	2	0.4 %
Severe to profound HL	3	0.7 %
ANSD	8	1.9 %

Table (8): Relation between diagnostic ABR results and risk factors for neonates underwent diagnostic ABR:

		ABR				**t***	**P value**
		HL		**Normal**			
		Mean	**SD**	**Mean**	**SD**		
NICU admission (days)		31.76	21.59	18.07	15.34	2.43	0.02 S
Gestational age (weeks)		34.71	3.16	35.44	3.01	0.86	0.39 NS
Birth weight (gram)		2025.00	767.12	1822.38	428.04	0.78	0.45 NS
		N	%	N	%	X^{2**}	P value
Twins	No	15	88.2%	52	94.5%	0.80 FE	0.59 NS
	Yes	2	11.8%	3	5.5%		
Mode of delivery	Vaginal	7	41.2%	16	29.1%	0.87	0.35 NS
	CS	10	58.8%	39	70.9%		
Consanguinity	No	13	76.5%	46	83.6%	0.45	0.50 NS
	Yes	4	23.5%	9	16.4%		
FH	Negative	15	88.2%	52	94.5%	0.80 FE	0.59 NS
	Positive	2	11.8%	3	5.5%		
Respiratory distress	No	6	35.3%	14	25.5%	0.63	0.43 NS
	Yes	11	64.7%	41	74.5%		
LBW	No	11	64.7%	38	69.1%	0.12	0.74 NS

	Yes	6	35.3%	17	30.9%		
Preterm labor	No	11	64.7%	35	63.6%	0.01	0.94 NS
	Yes	6	35.3%	20	36.4%		
Neonatal sepsis	No	11	64.7%	45	81.8%	2.20	0.14 NS
	Yes	6	35.3%	10	18.2%		
IUGR	No	17	100%	53	96.4%	0.64 FE	1.00 NS
	Yes	0	.0%	2	3.6%		
Neonatal jaundice	No	11	64.7%	39	70.9%	0.24	0.63 NS
	Yes	6	35.3%	16	29.1%		

**t: Student t test **X^2: Chi Square test (FE: Fisher Exact)*

Table (8) revealed that the only significant risk factor on ABR test results was number of days of admission in NICU.

Table (9): Validity of ATEOAEs in comparison to ABR results:

		Diagnostic ABR		
		HL	Normal	Total
ATEOAEs	Fail	10	45	55
	Pass	7	10	17
	Total	17	55	72

Sensitivity: 58.8%, Specificity: 18.2%, Positive Predictive Value: 18.2%, Negative Predictive Value: 58.8%

Table (10): Validity of AABR in comparison to ABR results:

		Diagnostic ABR		
		HL	Normal	Total
AABR	Fail	17	10	27
	Pass	0	45	45
	Total	17	55	72

Sensitivity: 100%, Specificity: 81.8%, Positive Predictive Value: 62.9%, Negative Predictive Value: 100%

DISCUSSION:

The main objective of the current study was to explore the most suitable, practical and effective neonatal hearing screening tool, especially for high risk neonates. Meanwhile, other objectives were included in this study to shed light on some controversial issues regarding different tools of neonatal hearing screening. The best place to perform the test, testing time, referral rates, sensitivity and specificity for each screening tool were analyzed. The obstacles found in each screening tool were discussed. The study consisted of two stages; the screening part using Automated Transient Evoked Oto -Acoustic Emissions (ATEOAEs) and Automated Auditory Brainstem Response (AABR) and the diagnostic part using Auditory Brainstem Response (ABR) to confirm the diagnosis for those who did not pass the screening tests.

In this study, 510 newborns were screened, 100 of them were well born neonates and were recruited from El-Demerdash maternity hospital, the remaining 410 were recruited from NICU after incubation for a period that ranged from 2 to 90 days. Well born neonates were screened 12 to 48 hours after delivery, whereas NICU neonates were screened in the day of discharge from NICU or one week after discharge in their first follow up visit to NICU with mean age of 21.88±15.55 days.

At the beginning of the study, hearing screening was performed for all neonates whether well born babies or NICU graduates in the maternity hospital and NICU

respectively. Interestingly, after screening 150 newborns using both ATEOAEs and AABR, 80 % of them did not pass one or both tests in the first screening, while most of them passed the test when rescreened in a quiet room in the Audiology unit. The unfavorable acoustical and electrical environments in the maternity hospital and the NICU are most likely the cause of such high referral rate beside other local causes in the ear.

Accordingly, relatively continuing screening tests in the Audiology unit seemed to be a right decision. This arrangement was feasible only for NICU neonates as they were scheduled to be tested on the day of discharge or in the first follow up visit to NICU. On the other hand, for well born neonates, it was difficult for the mother on the delivery day to go to another place relatively far from the maternity hospital. Taking this into consideration, the first screening test for well babies was planned to be done in the maternity hospital. Neonates who failed screening were scheduled to continue testing in the Audiology unit.

ATEOAEs versus AABR test results:

a) Time consumption:

In the current study the average time to complete ATEOAEs first screening test in both ears for well born neonates was two minutes (± 42 seconds), while AABR screening time was longer with an average time of two and half minutes (± 66 seconds). Meanwhile, NICU neonates consume slightly shorter time for ATEOAEs test 1.5 minutes (± 40.8 seconds) and nearly the same time for AABR test 2.5 minutes (± 62 seconds) (table 1). This time included period from the start of the test till the appearance of pass response. These results agree with previous studies[9,10&11]. However, when calculating the total required screening time including settling time (comforting and calming the baby), test preparation, obtaining good probe fit and repetition of trials in case of movement or crying plus the actual testing time, AABR test had significantly shorter total test time compared to ATEOAEs for both well born and NICU neonates (table 2).

There are three factors influence the time taken to complete each of the screening measures: the first factor is the state of the newborn, the second is the signal to noise ratio for ATEOAEs test and the third factor is the (EEG) for the AABR.

Although OAEs is faster and take shorter time, the total test time was longer than expected because ATEOAEs test probe irritates the sleeping baby and awakens him. Consequently, more trials were needed to complete the test consuming longer total test time. On the other hand, AABR (using BERAphone) consumed relatively longer response time, so only another trial was performed if the test was interrupted by the baby movement resulting in electrodes margination and stop of the test.

Ambient noise levels influenced ATEOAEs screening outcomes which, not only influence the efficiency of the NHS program, but also have higher cost implications. In the present study, for the well babies, ATEOAEs test was conducted in the ward at the maternal bedside, during peak hours, which severely affected the SNR and delayed the initiation of the test resulting in longer total test time. It is worth mentioning that the ward is relatively quiet only four hours after mid night, during which it was not feasible to conduct the test. This agrees with **Salina et al. (2010)** who reported that refer findings were highest during peak hours when screening was conducted at the maternal bedside. The surrounding environment in which the NHS program is conducted has important implications on the choice of the tool for hearing screening. It indicates both the time required and the possible influencing factors (such as SNR & EEG interference) which if managed, would lead to the success of a screening program specially in a resource restricted community[12].

b) Referral Rate:

Referral rate after first screening in well born neonates (group I) was 54 % (54 neonates) and 19 % (19 neonates) for ATEOAEs and AABR respectively (table 3). Meanwhile, for NICU neonates (group II), referral rate was 60.2 % (247 neonates) and 19.5 % (80 neonates) for ATEOAEs and AABR respectively (table 4).

Accordingly, the first screening pass rate of AABR was significantly higher than that of ATEOAEs, with a difference of 35% and 40.7% in well born and NICU neonates groups respectively (tables 3&4). This means that around 350 to 400 more babies per 1,000 newborns will not pass the first screening with ATEOAEs compared to AABR with subsequent requirement for a second screening which is translated to extra cost. Similarly, lower AABR referral rates than ATEOAEs were reported in several studies[9,13&14]**.** Overall referral rates for ATEOAEs and AABR screening in hospital-based one stage screening in South Africa on well babies were 37.9% in TEOAE and 16.7% in AABR[9]**.** On the other hand, a comparative study in Egypt between ATEOAEs and AABR using BERAphone on well born neonates in primary health care center reported a referral rate after first stage screening of 8.18% and 16.73% respectively. Such lower referral rate for OAEs may be due to the mean age of tested neonates 5.2 days.

The marked high referral rate of ATEOAEs after first screening in the current study 59% (331 neonates out of 510) (table 5) compared to referral rates in other reports could be due to several factors, first, the age at first screening. Well born babies had to be screened early during the first 12-48 hours before discharge from maternity hospital while the debris in the canal, liquid and mesenchyme in the middle ear is expected to resolve later in the first few hours or days of life, making it likely that more newborns will pass the OAEs test at later times. This agrees with several reports [9,15&16].

The second reason is the ambient noise in the test environment. **Norton et al. (2000)** highlighted that the internal noise of the infant affected the signal to noise ratio particularly in the low frequency bands. Additionally, the frequencies used for screening influence the outcome[5]. Hearing screening involving higher frequencies (e.g. 2-4 or 2-5KHz) has demonstrated lower referral rates than screening involving lower frequencies such as 1KHz[17]. These findings are of clinical significance when setting pass/refer criteria for NHS programs with possible exclusion of 1KHz within OAEs protocol reducing the effect of ambient noise which would in turn influence the overall pass/refer outcome[18].

The third reason to be highlighted in the present study is the probability of OME in NICU neonates who were fed lying flat in their incubators resulting in absent OAEs. Unfortunately, 1 KHz tympanometry was not available at time of examination to confirm or exclude such condition.

In comparison to the first hearing screening, the referral rate significantly decreased in the second screening for both screening tests (table 5). Referral rates after second screening significantly decreased for NICU neonates to be 16.3 % for ATEOAEs and 5.4 % for AABR , while for well born neonates, referral rate was 0% for both screening tests (tables 5&6). This highlights the value of a two-stage screening protocol in reducing the referral rates. Similar findings have been reported by several studies[19&20].

The Egyptian national program for newborn hearing screening implies performing the test on the 7th day of delivery, this seems a good time for screening as it will lead to less referral rates, hence less cost for ensuring the coverage of the largest number of newborns in screening.

Diagnostic test was mandatory for statistical calculation of screening test validity. Seventy two neonates who failed the second screening test in one or both tests whether unilateral or bilateral were referred to the Audiology unit in Ain Shams University Hospital for diagnostic hearing evaluation. The mean age at testing was 34.86 days ± 10.5 with no statistical differences between males and females.

In the current study, based on the final ABR test result, 17 cases (4.1 %) had abnormal diagnostic ABR test result, eight neonates diagnosed with ANSD and nine neonates had different degrees of hearing loss. The hearing loss ranges from moderate to severe to profound hearing loss: four neonates (0.9 %) were diagnosed with moderate hearing loss (wave V could be traced down to 60 dBnHL), two neonates (0.4 %) were diagnosed with moderately severe hearing loss (wave V traced down to 70 dBnHL) and three neonates (0.7 %) were diagnosed with severe to profound hearing loss with no ABR waves at 90 dBnHL (table 7), 8 neonates (1.9 %) had auditory findings characteristic of ANSD, absent or abnormal ABR but normal TEOAEs, and/ or preserved cochlear microphonics, only one neonate from the eight had fail response with ATEOAEs. The percentage of hearing loss is close to **Kamal et al. (2020)** who reported hearing loss in 5.09 % out of 530 neonates with risk factors[21].

ANSD could be related to various etiological factors in infants and children[22]. In the current study eight neonates were diagnosed with ANSD, with neonatal jaundice reported in seven of them. Blood exchange transfusion was necessary in three neonates, while phototherapy was sufficient to decrease bilirubin levels in the other four. This agrees with several recent reports suggested that neonatal jaundice is one of the most common causes of ANSD among late preterm and term neonates[23,24,25].

The only risk factor in the study group affecting ABR test result was the duration of NICU admission (table 8). This agrees with **Bielecki et al. (2011)** who concluded that hospitalization in NICU in excess of seven days was a risk factor for hearing loss due to increasing the number of risk factors to which the infant is exposed and their synergistic effect increasing the probability of developing hearing loss[26].

c) Sensitivity and specificity:

In the selection of neonatal hearing screening program, the sensitivity and accuracy of screening tool, as well as its feasibility should be considered. The ideal program should have high sensitivity and high specificity [27].

Tables (9 & 10) showed the sensitivity of screening by ATEOAEs and AABR relative to diagnostic ABR test, results was 58.8 % and 100% respectively. This reflects that AABR screening test permits the identification of all newborns as possible who do have a hearing loss. The specificity of screening by ATEOAEs and AABR was 18.2 % and 81.8 % respectively reflecting that AABR screening test can exclude as many newborns as possible who do not have a hearing loss.

ATEOAEs had positive predictive value (PPV) of 16.6 % while AABR PPV was 62.9%. The probability of hearing loss when test result is fail in AABR is more than in ATEOAEs, while Negative predictive value (NPV) of ATEOAEs and AABR were 58.8% and 100 % respectively making the probability of absence of hearing loss when test result is pass is higher in AABR than in ATEOAEs. (tables 9&10).

Data of the current study agree with **Rajkumar et al. (2016)** who reported sensitivity of 92.86%, a specificity of 50%, a PPV of 30.23%, and a NPV of 96.77% for the diagnosis of hearing loss in two stage screening with the MAICO MB11 BERAphone on well born neonates[8]. The results also agree with the manufacturer reports and most of other studies. The manufacturer reports stated that the AABR

has a sensitivity of more than 99% and test specificity of 87% for a onetime test.

A study done by AABR in sound treated room showed sensitivity of 100% and specificity of 96.8% , PPV of 88.2% and NPV of 100% for diagnosis of hearing loss in well born and NICU neonates[28]. **Konukseven et al. (2010)** reported in the initial and second stage screening with AABR in well born neonates, sensitivity was 98% and 100 % respectively[29]. In previous studies, the AABR specificity ranged from 93% to 99.7% [30,31&32].

Meanwhile, results of the present work disagree with a study conducted in Egypt in primary health care center on well infant babies. Indeed, **Kamal et al. (2017)** reported validity of ATEOAEs of 100% sensitivity and 85.41% specificity, while AABR sensitivity was 90% and specificity was 59.57%[11]. Different studies had revealed that the sensitivity of the newborn ATEOAEs test is between 55 and 100% and the specificity is between 71 and 91% (33)(34)(35)**.** Also specificity ranged from 91.8% to 99.7% was reported by several studies[29,30&36]. The difference in OAEs results may be due to more suitable conditions with less ambient background noise and more stability of screened neonates during testing with ATEOAEs. The extreme low specificity of ATEOAEs is explained by the high referral rate of the screening test and its previous mentioned possible factors.

However, it is worth to be mentioned that ATEOAEs is not a sufficient screening tool in infants at risk of neural hearing loss such as Auditory Neuropathy Spectrum Disorder (ANSD)[37]. The low sensitivity of ATEOAEs of the current study is attributed to the presence of ANSD cases. This was confirmed by the fact that when sensitivity of ATEOAEs was recalculated after exclusion of ANSD cases it turned to be 100%. According to the **JCIH (2007, 2019)** any infant graduated from NICU or having risk factors should undergo screening with AABR not to miss ANSD cases[4&27].

From the current study, it can be concluded that AABR using BERAphone is a more sensitive and specific tool compared to TEOAEs in neonatal hearing screening in NICU neonates in Egypt. The use of BERAphone, screening test is no longer time consuming and cost effective relative to TEOAEs due to the significantly lower referral rate. So AABR is recommended for use in neonatal hearing screening in high risk neonates in NICU in a quiet place away from electric and acoustic interference of NICU and for well born neonates if NHS program is planned to be done in the same day of delivery.

Conclusion:

In summary, this study concludes that the electric and acoustic interference are considered major obstacles in performing neonatal hearing screening whether by OAEs or BERAphone in NICU, the overall time needed for hearing screening using BERAphone is significantly shorter compared to OAEs in NICU and well born neonates, the first referral rate is significantly lower for BERAphone than OAEs in NICU and well born neonates, BERAphone has better sensitivity and specificity than OAEs in neonatal hearing screening in NICU neonates, and two stage hearing screening is mandatory to decrease the referral rate.

Conflicts of Interest: The authors state that the publishing of this paper is free of any conflicts of interest.

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تقييم البيرافون والانبعاث الصوتي في المسح السمعي لحديثي الولادة الطبيعيين واطفال ا لحضانات

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المقدمه والهدف من البحث:مقارنة الوقت المستخدم لجهاز البيرافون و الانبعاث الصوتي في المسح السمعي لحديثي الولادة في المستشفيات، معرفة معدل تحويل الحالات لكلا الجهازين، معرفة الصعوبات التي تعوق استخدام الجهازين في المسح السمعي في المستشفيات.

المرضى والطرق: سوف تتم الدراسة علي ٥٠٠ طفل من حديثي الولادة (من مستشفي النساء التوليد و من محضن الأطفال لمستشفي الدمرداش) و لا يتم استبعاد اي طفل مولود من المسح السمعي.تتم الدراسة علي مرحلتين:المرحلة الاولي:مرحلة المسح السمعي:وهي التي تتم لكل الاطفال باستخدام جهازي المسح السمعي لحديثي الولادة تتم لاطفال مستشفي النساء و التوليد بعد ٢٤ ساعة من الولادة و لاطفال المحضن في اقرب وقت بعد خروجهم مباشرة من المحضنوبالنسبة للطفل الذي يعطي نتيجة سالبة لاي من الاختبارين يتم اعادة الاختبار مرة اخري بعد اسبوع واذا ظلت النتيجة سالبة ينتقل الطفل للمرحلة التالية لعمل الاختبار التشخيصي و هو قياس السمع عن طريق جذع المخ المثار.المرحلة الثانية:قياس السمع التشخيصي :و تتم هذه المرحلة للاطفال الذين يعطوا نتيجة سالبة لاي من اختباري المسح السمعي و يتم فيها الاتي لكل طفل :أخذ تاريخ مرضي كامل للطفل و تاريخ عائلي ,فحص شامل للطفل ,فحص الاذن باستخدام منظار الاذن ,قياس ضغط الاذن و قياس السمع عن طريق جذع المخ المثار.

النتائج :هناك اختلاف احصائي كبير في الوقت الكلي لاختبار المسح السمعي بالجهازين حيث وجد ان وقت الاختبار الكلي لجهاز البيرافون اقل من وقت الاختبار الكلي لجهاز الانبعاث الصوتي ووجد ان معدل التحويل للاختبار التشخيصي اعلي لجهاز الانبعاث الصوتي عن جهاز البيرافون.

الخاتمه : جهاز البيرافون هو الانسب للمسح السمعي لاطفال المحضن .