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Main Articles

Audiological findings in pregnancy

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Abstract
This investigation was carried out in the Audiology and Speech Pathology Section of the Department of Otorhinolaryngology of Hacettepe University. The pregnant group comprised of 20 women followed by the Department of Gynaecology and Obstetrics of the same university; 18 non-pregnant women comprised the control group. The aim of this investigation was to study the relationship between hormonal changes in pregnancy and cochlear functions. All subjects underwent ENT examination, audiologic and acoustic immitance measurements and auditory brain stem response (ABR) tests. Results from each trimester and post-partum period of the pregnant group were compared. These results demonstrated that there was a decrease in hearing levels for 125 Hz, beginning in the first trimester and increasing in the second and third trimesters. Hearing returned to normal in the post-partum period. Similar findings were also obtained for 250 and 500 Hz; however, frequencies higher than 500 Hz demonstrated no significant correlation. Uncomfortable loudness was statistically significant between the third trimester and post-partum period. ABR tests did not reveal any differences. In conclusion, there is a low-frequency hearing loss and tolerance problem in pregnancy mimicking cochlear pathology. However, this hearing loss did not reach pathologic levels in any case and returned to normal in the post-partum period.

Key words: Pregnancy; Hearing loss, Sensorineural; Audiometry

Introduction

Gender effects on the hearing system have received considerable attention in the literature.[1] The hormonal systems of women are unique because of the cyclical changes observed during pregnancy, menstrual cycle and menopause. During these periods there are physiological changes in the body due to the changing levels of oestrogen and progesterone hormones. Sex hormones exert regulatory influences on the central nervous system. Baker and Weiler[2] showed that the circulating levels of sex hormones, particularly female sex hormomes, affect the functioning of the sensory nervous system. As a result, there are changes in hearing levels as well as in other systems.

There are contradictory findings concerning the impact of the menstrual cycle on hearing levels. Fagan and Church[3] found gender differences in auditory brain stem response (ABR) latency, peak amplitude and behavioural threshold of the ABR stimuli, without any variations during the menstrual cycle. Elkind-Hirsch *et al.*,[4] however, demonstrated a significant increase in the peak latencies of wave III and V in the mid-cycle phase. On the other hand, Dehan and Jerger[5] demonstrated a shortening of wave V latency during the luteal phase. It is thus evident that there are conflicting results about the influence of the hormonal changes during the menstrual cycle.

Oestrogen and progesterone production rates for non-pregnant women (oestrogen 0.02–0.1 mg/24 hr and progesterone 0.1–40 mg/24 hr, respectively) show considerable increases in the near-term pregnant women (oestrogen 50–100 mg/24 hr and progesterone 250–600 mg/24 hr). While creating the optimal conditions for pregnancy, these hormonal changes cause an increase of 6.5 l in extracellular fluids, and 1.2 l in intracellular fluids.[6] As a result of osmotic changes in the body, water and sodium retention takes place. As we know from previous investigations that circulating sex hormones affect the sensorineural hearing system, one may expect changes in hearing levels with so much fluid retention during pregnancy.

Uchide *et al.*[7] reported a case of Meniere's disease in which symptoms worsened during pregnancy: the

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patient experienced 10 times more attacks during early pregnancy. Uchide *et al.* correlated the increase in vertigo attacks with the decline in serum osmolality during pregnancy. Therefore, changes in fluid osmolality may affect inner ear during pregnancy.

There are very few reports in the literature about the effect of pregnancy on hearing levels. Tsunoda *et al.*[8] investigated ear problems in a group of pregnant women and found that pure-tone audiometry and impedance audiometry showed normal hearing in all cases. However, they did not take into account the different stages of pregnancy. Only one article was found which investigated the relationship of pregnancy and ABR. Tandon *et al.*[9] found that absolute peak latencies of waves I–V were similar in both groups; however, interpeak latencies I–III, III–V were higher in the pregnant women. Therefore, we planned to investigate the effect of pregnancy on hearing levels and ABR.

Materials and methods

Subjects

The study was carried out in the Audiology Section of the Department of Otolaryngology of Hacettepe University. Thirty-eight healthy individuals were evaluated. The pregnant group consisted of 20 females diagnosed and followed in the Department of Gynaecology and Obstetrics of the same university. Their ages ranged between 25 and 35 years (mean 29). The control group consisted of non-pregnant individuals with normal β-HCG values, whose ages ranged between 18 and 38 years (mean 27) and who were not using contraceptives. The subjects were selected according to the following criteria: 1. No systemic disease; 2. Normal ENT examination; 3. No ear complaint before pregnancy; 4. No use of medication during pregnancy; 5. No toxaemia during pregnancy; 6. Normal blood pressure and electrolytes.

After ENT examination, all subjects underwent pure-tone audiometry, impedance measurements and ABR testing. The pregnant subjects were investigated periodically in each of the four stages according to the classification.

(i) Group I, – 14 weeks (first trimester); (ii) Group II, 15–28 weeks (second trimester); (iii) Group III 29–42 weeks (third timester); (iv) Group IV postpartum period (3–6 months after delivery); Group V is the control group comprised of non-pregnant women.

Clinical protocol

Audiometric assessment

Pure-tone thresholds were measured on all subjects between 125 and 18000 Hz for air conduction and between 500 and 4000 Hz for bone conduction. For the octave frequencies, 125–6000 Hz were measured as a HL and 8000–18000 Hz as a SPL according to standards. Thresholds were measured using an Interacoustic AC 5 audiometer with TDH 39 earphones and MX/41 AR cushions. High frequency thresholds were measured using an Interacoustic AS 10 HF audiometer with Koss HV-IA earphones. Speech discrimination scores and uncomfortable loudness level were also evaluated. Uncomfortable loudness level (UCL) was determined by starting at the most comfortable loudness (MCL) and gradually increasing the intensity level and noting the level when sound became uncomfortably loud to the subject. Speech testing was performed using Turkish spondee words for SRT and phonetically balanced Turkish monosyllable word lists for speech discrimination. Speech materials were delivered via earphones with live voice at MCL. All tests were conducted with subjects comfortably seated in an IAC sound isolated room, where the background sound level was below the accepted level (less than 35 dB SPL for 125 Hz).

Acoustic admittance assessment

Tympanometric and acoustic reflex testing was carried out with an Interacoustic model AZ-7 electroacoustic impedance bridge.

ABR measurements

Each subject was comfortably resting in reclining position while measurements were obtained. Click stimuli of rarefaction polarity were given independently to each ear through headphones (TDH-49) at a level of 100 dB SPL and a rate of 11/s. Two channel recordings were obtained from scalp electrodes placed on the vertex (active), each mastoid (reference) and the forehead (ground). A total of 2000 sweeps was averaged. ABR waveforms were analysed separately for each ear. Absolute peak latencies of component waves I, III and V were measured, and interpeak intervals were calculated. ABR was recorded using an Ampliad mk 15 auditory-evoked potential system.

First, the test of homogeneity of variances was applied to all data. If the material was normally distributed, comparisons of baseline measurements between groups were performed using one-way analysis of variance (ANOVA). According to the results of this test, if the difference was significant, Tukey Honestly Significance Test was used for comparison. Only in Table III for wave III was the material not distributed normally, and first the

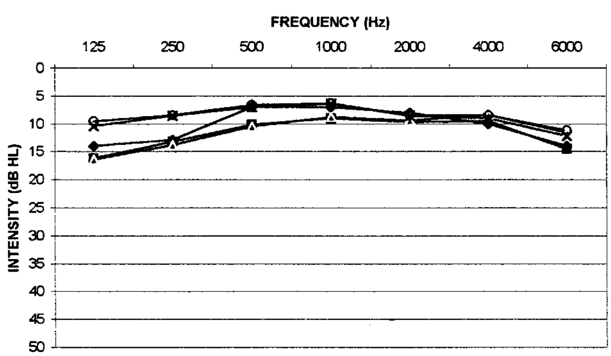

FIG. 1

Mean pure tone thresholds for pregnant and non-pregnant subjects. —◆— Group I; —■— Group II; —▲— Group III; —★— Group IV; —⊖— Group V.

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TABLE I
PURE TONE THRESHOLDS (dB HL)

Frequency (Hz)	Group I	Group II	Group III	Group IV	Group V	F	p
125	14.00±5.52	16.25±7.41	16.40±5.86	10.40±6.44	9.60±3.08	4.715	0.004*
250	12.90±5.02	13.20±6.78	13.80±5.05	8.60±5.30	8.50±3.08	4.708	0.004*
500	7.00±4.70	10.20±5.35	10.50±4.20	7.00±3.22	6.66±3.16	4.390	0.006*
1000	7.00±4.70	9.00±4.75	8.80±4.39	6.40±4.89	6.34±3.47	1.960	0.126
2000	8.00±4.70	9.75±5.49	9.40±4.85	8.60±4.45	8.50±4.46	0.830	0.481
4000	10.00±5.61	9.50±6.04	8.40±4.26	9.00±5.00	8.50±5.02	0.387	0.762
6000	14.00±5.98	14.50±5.47	11.60±5.90	12.20±6.60	11.20±4.95	0.523	0.663

TABLE II
HIGH FREQUENCY PURE-TONE THRESHOLDS (dB SPL)

Frequency (Hz)	Group I	Group II	Group III	Group IV	Group V	F	p
8000	30.00±10.00	33.00±18.87	29.31± 6.41	31.25± 9.69	30.00± 8.55	0.373	0.773
10000	33.88± 9.93	39.50±20.64	39.59±12.28	37.29±14.36	33.82± 9.92	0.459	0.712
12000	45.55±20.78	48.00±25.15	46.59±21.62	44.16±19.76	42.61±21.60	0.747	0.527
14000	61.66±21.82	63.00±25.36	63.18±25.47	60.41±24.22	62.28±16.80	0.119	0.949
16000	83.00±24.00	87.50±25.93	90.45±20.75	88.95±20.58	86.00±19.09	0.833	0.480
18000	102.22± 4.91	102.5 ±11.97	105.90± 4.26	104.16± 7.61	102.90± 7.60	0.988	0.403

Kruskal–Wallis and later the Mann–Whitney *U*-test was applied. A difference was considered to be statistically significant when the probability (p) was <0.05.

Results

Pure-tone thresholds

The pure-tone and high frequency pure-tone thresholds are shown in Tables I and II. As there was no air bone gap, only air conduction thresholds were given. For 125 Hz, post-partum (group IV) and control groups (group V) showed a statistically significant difference from the first, second and third trimesters (Groups I, II and III respectively) (p<.05). For 250 and 500 Hz, the differences between Groups III and IV, and Groups III and V were both significant (p<0.05). For 1000 Hz and higher frequencies, there were no significant differences between the trimesters, post-partum period and the control groups (p>0.05).

Uncomfortable loudness level

UCL showed significant differences between groups III and IV, and groups III and V (p<0.05).

Speech audiometry

Speech discrimination scores were within normal limits in all groups and therefore were not evaluated further.

Acoustic admittance measurements

Middle ear pressure findings were found to be within the normal limits (± 50 mm HO) and did not show any significant difference among the trimesters and the control group. None of the women showed severe negative middle ear pressure and a low frequency hearing loss. Acoustic reflex measurements were obtained in all groups.

Auditory brain stem response

ABR results showed no significant differences between the groups. Mean and standard deviations of ABR peak latencies and interpeak latencies are shown in Tables III and IV.

Discussion

The main outcome of this investigation was the gradual decrease in the pure-tone averages at 125, 250 and 500 Hz from first trimester to third trimester.

TABLE III
MEAN ABR PEAK LATENCIES (MSEC)

	Group I	Gorup II	Group III	Group IV	Group V		p
I	1.70±0.09	1.72±0.12	1.70±0.15	1.70±0.12	1.63±0.10	F = 0.273	0.845
III	3.74±0.14	3.75±0.16	3.79±0.19	3.75±0.22	3.69±0.15	X^2 = 0.732	0.866
V	5.56±0.22	5.62±0.21	5.59±0.19	5.61±0.19	5.54±0.18	F = 0.328	0.805

TABLE IV
MEAN ABR INTERPEAK LATENCIES (MSEC)

	Group I	Group II	Group III	Group IV	Group V	F	p
I–III	2.05±0.17	2.02±0.13	2.08±0.15	2.01±0.15	2.04±0.15	0.902	0.444
III–V	1.80±0.14	1.86±0.12	1.79±0.13	1.86±0.12	1.85±0.14	1.613	0.192
I–V	3.86±0.26	3.89±0.21	3.87±0.19	3.88±0.14	3.89±0.18	0.055	0.983

This decrease returned to normal in the post-partum period. Although there was a statistically significant difference between the groups, this cannot be regarded as a hearing loss according to ANSI standards.[10] The results of this investigation also demonstrated that there was no change in the hearing sensitivity between 1000 and 18 000 Hz. This shows that pregnancy does not affect the high frequency hearing level. Tsunoda *et al*.[8] investigated ear problems in a group of pregnant women and found that pure-tone audiometry and impedance audiometry showed normal hearing in all cases. However, they did not mention the findings in different frequencies and also did not take into account the different stages of pregnancy. Therefore, it is difficult to compare our results with theirs.

Due to the scarcity of literature on this aspect of pregnancy, the findings are discussed according to the menstrual cycle. In spite of the cyclic fluctuations of oestrogen and progesterone levels during menstruation, Cox[11] demonstrated that there was no change in hearing levels during this menstruation period in the pure-tone averages at 500, 1000 and 2000 Hz. Swanson and Dengerink,[12] on the other hand, found fluctuations in auditory sensitivity, displaying poorer thresholds at 4 kHz during the menstrual phase than at ovulation or the luteal phase.

The low tone decrease in hearing level may be due to the excessive water and salt retention. This hearing loss pattern resembles Meniere's disease. None of the pregnant group, however, had any of the characteristic Meniere's symptoms. Decrease in the hearing level was not a hearing loss according to ANSI. Therefore, these findings show that, although there is a hearing decrease mimicking Meniere's disease, the findings are always within physiological limits.

UCL level was found to be significantly lower in the third trimester when compared with the post-partum period and the control group. When the normal audiologic findings are also taken into account, the results indicate that most probably UCL findings are due to fluid retention in the inner ear; but this is not large enough to produce hearing loss, or other inner ear disorders.

This study showed that speech audiometry findings are within normal limits during pregnancy. Abnormal speech findings are usually characteristic of moderate to severe hearing loss and especially retrocochlear pathologies. As neither of them is present in pregnant women, and low tone decrease is within physiologic limits, one should not expect changes in speech audiometry findings.

Cox[11] found negative middle ear pressure during the third and fourth days of the menstrual cycle. The author attributed this finding to the increase in the interstitial fluids during the pre-menstrual period and the resultant eustachian tube blockage. In pregnancy, however, although there is a much higher fluid retention, the findings suggest that eustachian tube function remains normal. Tsunoda *et al*.[8] also found normal impedance audiometry findings in pregnancy. One possible explanation is that, during menstruation, fluid retention takes place in a short time, within a matter of few days, whereas, in pregnancy these changes take place over a long period with resulting adaptation. Therefore, while Cox[11] observed negative pressure during pre-menstrual period, no changes in impedance audiometry were found during pregnancy.

Our results indicate no statistical difference in the ABR between the trimesters, post-partum period and the control individuals; this has also been investigated in the menstrual cycle. Fagan and Church[3] found no change in the absolute latencies and the amplitudes during the cycle. Elkind-Hirsch *et al*.,[4] on the other hand, found an increase in the absolute latency of wave V and I–V interpeak level during the mid-cycle oestrogen peak. Dehan and Jerger[5] showed a decrease in the absolute latency of wave V.

As can be easily seen, there is no consensus on the effects of hormones on the auditory pathway. According to Elkind-Hirsch *et al*.,[13] who worked on patients receiving oestrogen and progesterone replacement treatment, sex hormones demonstrate their effects through gamma amino butyric acid (GABA). GABA is an inhibitory product for the hearing pathways. They stated that oestrogen increased the synthesis of GABA, whereas progesterone reduced it. GABA is the mediator at the brain stem and these hormones act at this location.

No change in the absolute and interpeak latencies was shown in our investigation. As no medication was used during pregnancy, Elkind-Hirsch *et al*.'s[13] findings can be due to oral contraceptives. The only investigation during pregnancy was an ABR research by Tandon *et al*.,[9] who found an increase in the absolute latency of wave V and the I–V interpeak latencies. They thought that it was due to the increased oestrogen and progesterone levels, and acetyl choline and fluid-salt retention also played a role here.

In conclusion, it may be claimed that there is a decrease in the low frequency hearing level during pregnancy, and a tolerance problem with normal ABR findings. This shows us that these findings, mimicking cochlear pathology, can be present in the third trimester of pregnancy. These findings always remain within physiologic limits and return to their initial state in the post-partum period.

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