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Original Research Article

Effect of pregnancy on the auditory and visual reaction time

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ABSTRACT

Background: The auditory and visual pathways are complex multi-synaptic neuronal circuits prone to alteration in conductivity under the influence of various neuro-hormonal modulators. The female sex steroids have shown significant effect on these circuits during different phases on menstrual cycle and pregnancy.
Methods: The present study was designed with an aim to find out the auditory and visual reaction time variations during different trimesters of pregnancy. The healthy non pregnant women, in premenstrual phase were grouped as controls (Group NP; n=30) whereas the cases were further divided into 3 groups depending on the duration of pregnancy as Groups T1,T2and T3 with 30 volunteers in each.
Results: The ART and VRT were measured using RTM-608 (Medicaid) in the Obstetrics and Gynaecology department of our hospital. The observations were recorded and analysed using one way ANOVA and post hoc Tukey test. A significant increase ($p<0.001$) in reaction time of both the auditory and visual pathways has been observed in Group T1 as compared to Group non-pregnant. Whereas Group T2 and T3 had shown not much difference of ART and non-significant increase of VRT when compared to Group NP. The increased reaction time could be attributed to the raised HCG levels during 1st trimester, modulating the neuronal conductivity during that period.
Conclusions: However, the non-significantly increased or similar reaction time in Group T2and T3could be attributed to increased levels of estrogen and progesterone. Hence, these hormones have neuromodulatory effect on the neuronal excitability, plasticity and excitability, though the direct effect of HCG needs further exploration.

Keywords: ART, Audio-visual reaction time, Estrogen, HCG, Progesterone, VRT

INTRODUCTION

Human body responds to number of external environmental stimuli of different modalities by giving a desired and purposeful voluntary response to stimulus. Stimulus is an event that evokes a specific functional reaction in an organ or tissue viz. visual and auditory stimulus, taste, smell, touch etc.

The response to any stimulus is called as the reaction. The reaction time is the elapsed time between the presentation of a stimulus and the subsequent behavioural response i.e. time required for an observer to react to a stimulus. Hence, it measures the ability of an individual to process information and judges its ability to concentrate and coordinate for a visible reaction. Hence, auditory and visual reaction time is the time taken by an individual to respond to the auditory or visual stimuli which have been found out to be 0.17s and 0.25s respectively in healthy individuals.[1] For ART, the stimulus is sound perceived by the auditory hair cells. This information is processed in the temporal cortex and communicated to the motor area through temporo-frontal association fibers.

Whereas for VRT, the stimulus is light this is perceived by the photoreceptors. This information is processed in the occipital cortex and communicated to the motor area through occipital frontal association fibers. The motor neurons arising from the motor area supply the skeletal muscles and exhibit the desired response for both auditory and visual reaction.

Hence, the reaction to any stimulus can be divided into 3 phases

- The time for the nerve impulses to pass from the receptor to the cerebral cortex
- The time needed to process the signal in CNS and resultant stimulation of the motor area.
- The time taken by the impulse to travel from motor cortex to the motor activity.

The reaction time depends on the modality of the stimulus; i.e., type of signal stimulus; the intensity, the degree of conditioning, the attunement to perception of signal, age, sex and the complexity of reaction. Several studies have shown the significant prolongation of auditory and visual reaction time during premenstrual/ lutealphase; due to high progesterone levels.[2,3] Hence, the female sex hormones appear to have a definitive effect on the neurons affecting the reaction time. Further, the lengthened VRT, during 1st trimester of pregnancy has also pointed towards evidence of neuro-modulatory role of these hormones.[4]

Hence, the present study was designed to assess the effect of pregnancy on auditory and visual reaction time; a reliable index of central nervous system processing, and to assess the effect of duration of pregnancy on auditory and visual reaction time i.e. 1st, 2nd and 3rd trimester.

METHODS

The present study was designed as a comparative study, which was started after obtaining ethical clearance from institutional ethical committee on 26th November 2015. The pregnant volunteers were recruited from the ante-natal clinic visiting our tertiary care hospital and non-pregnant volunteers were recruited from normal healthy population.

The study was conducted on 120 healthy women who were divided into four groups (NP, T1, T2 and T3) by stratified random sampling; where GroupsT1, T2 and T3had 30 pregnant volunteers each in 1st, 2nd, and 3rd trimester respectively; group NP however, comprised of 30 age matched non-pregnant women, serving as control population. It was ensured that the non-pregnant volunteers were in pre-menstrual phase to standardize the phase of menstrual cycle and to avoid the effect of hormonal fluctuations on reaction time. Pre-menstrual phase was specifically choosen, as it is the progesterone dominated phase of cycle. The volunteers found with any systemic disease, pregnancy induced hypertension and abnormality / deformity of upper limb; hindering the limb movement were excluded from the study.

The audio-visual reaction time was measured in a quiet room of OBG department. It was measured using audio-visual reaction time machine (RTM-608, supplied by Medicaid, Chandigarh) which has a sensitive quartz clock that measures upto 1/10th of a msec with an accuracy of +1 and -1 digit. The test was performed with subject sitting comfortably in a chair and to alleviate any fear or apprehension, each subject was made familiar with the apparatus and procedure.[5,6] Each subject was instructed to use her dominant hand to press the switch of apparatus on perceiving the stimulus. Before, measuring visual reaction time, the subject was sensitised to the flashing of red, green and yellow light respectively and then, she was instructed to switch off the light by as soon as she perceives the respective light. This process was randomly repeated several times to record the 3 readings per stimulus.

For measuring auditory reaction time, the subject was asked to concentrate on the sound signal produced and to switch off the sound immediately by pressing the respective sound. Three sound signals were used as stimuli and given as a continuous beep at 250HZ, 500HZ and 750HZ. These stimuli were randomly presented to the subject several times to record 3 readings of reaction time per stimulus.

All reading for ART-VRT were recorded as per the appropriate groups. The averages of all these stimuli were recorded as mean ART/VRT ± SD. The data collected was analysed using one way ANOVA and Post hoc Tukey test. The value of $p<0.01$ was considered as significant.

RESULTS

The statistical analysis, using one way ANOVA and Post hoc Tukey test had shown a significant effect of pregnancy on auditory and visual reaction time (Table 1). Asignificant effect of pregnancy on the ART at the $P<0.05$ level was seen in Group T1 [$F(3,116)=4.262$, $p=0.007$].

Table 1: Mean ART and VRT in all the groups.

GROUPS	ART MEAN ± SD (milliseconds)	VRT MEAN ± SD (milliseconds)
NP (n=30)	1.299±0.44	0.8236±0.03
T1 (n=30)	1.747±0.5*	1.038±0.04**
T2 (n=30)	1.575±0.48	0.896±0.03
T3 (n=30)	1.611±0.55	0.864±0.03

*p=0.004, **p= 0.001

Post hoc comparison using the Tukey HSD test indicated that the mean ART for group NP (mean=1.299s; SD=0.44) to be significantly different (p=0.004) from

group T1 (mean=1.747ms; SD=0.50). However, no significant finding in ART was observed on comparing other groups.

Similarly, a significant effect of pregnancy was seen on VRT at the P <0.05 [F (3116) =5.862; P=0.001]. Post-hoc Tukey HSD test shows that there was significant difference (P=0.001) between the mean VRT for non-pregnant women (mean=0.8236; SD=0.2100) and those in 1st trimester of pregnancy (mean=1.038; SD=0.248). VRT in group NP significantly differs (P <0.01) from mean VRT in group T3 (mean=0.864ms; SD=0.172). However, there were no significant findings on comparing VRT of other groups.

Table 2: Mean age, heart rate and blood pressure shows a non-significant difference in the vital statistics of the groups.

Groups	Age Mean± SD (years)	H.R. Mean± SD (beats/min)	SBP Mean± SD (mm of Hg)	DBP Mean± SD (mm of Hg)
NP (n=30)	22.1±4.9	70.8±4.1	115.3±8.3	75.3±6.7
T1 (n=30)	26.3±2.6	77.5±3.9	109.2±12.4	70.8±7.9
T2 (n=30)	27.2±3.7	75.7±4.7	107.4±9.0	68.1±7.8
T3 (n=30)	26.8±3.2	73.2±5.2	110.2±11.6	71.9±10.7

The vital statistics viz. age, systolic blood pressure (SBP), diastolic blood pressure (DBP) and Heart Rate (HR) were recorded in Groups NP, T1, T2 and T3 (Table 2) and were found to be in the normal range almost similar in all the groups.

DISCUSSION

The present study documents an increased VRT during all the trimesters of pregnancy, which was significant only during 1st trimester (p<0.001). The study also reports significant increase of ART during 1st trimester (p<0.01) when compared to non-pregnant women. The increased reaction time (ART and VRT) during pregnancy could be attributed to the rising levels of hormones during pregnancy. In present study, we identified the changes in audio-visual reaction time during pregnancy; which is a physiological state altering the functions of most endocrine glands related with increase in concentration of sex steroids viz. estrogen, progesterone, human chorionic gonadotropin, leutenising hormone and certain other hormones (Figure 1).

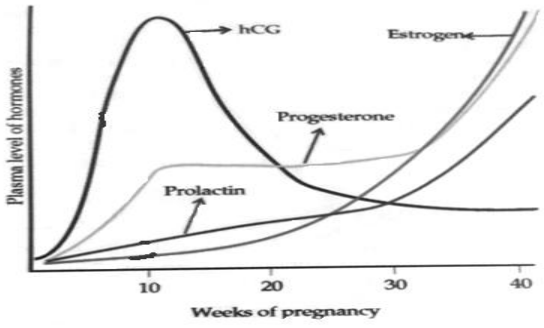

Figure 1: Level of various hormones in maternal plasma during pregnancy.

Ovarian steroids have widespread neuronal effects on various regions of brain which are involved in spatial and declarative memory and signify the altered effects of ovarian steroids on various affective and cognitive states of brain.[7,8]

Human chorionic gonadotropin (HCG), a glycoprotein containing hexosamine and galactose, is the prime hormone secreted during 1st trimester which peaks around 12th week of pregnancy and plays a critical role in placental steroidogenesis. It stimulates vomiting centre and other areas of brain like hippocampus, hypothalamus, brain stem.[9] It has been seen that reaction to any stimuli has physiological as well as psychological effects on brains like irritability, mood, depression, decreased concentration, poor judgement, tension etc. which alters the reaction time duringmenstrual cycle and pregnancy.[3,4,10]

Apart from this, an increased production of HCG by trophoblasts gives signal to corpus luteum to secrete progesterone causing amenorrhea during pregnancy.[11] Levels of progesterone and estrogen continue to rise with advancement in pregnancy and reach its peak in 3rd trimester during parturition. These hormones through their genomic actions produce, metabolise and release many neurotransmitters like nor-adrenaline, dopamine, gamma amino butyric acid (GABA), acetylcholine etc. regulating the electrical excitability, synaptic functioning and cerebral functioning.[10] Studies have shown that the neurotransmitter GABA-A, has receptors for many agonists on brain tissues like allopregnanolone, pregnanolone, androstenediol and tetrahydrodeoxy-corticosterone which alters memory changes, cognitive changes, mood changes during pregnancy.[12] Further, the direct effects of estrogen and progesterone on the nervous tissue have been well established. Estrogen acts by increasing the neuronal excitability and increased

synaptic transmission whereas progesterone exerts a neuroprotective role by decreasing neuronal excitability.[13] Due to the fluctuating excitatory and inhibitory effects of hormones, the visual reaction time in 2nd and 3rd trimester has decreased in comparison to 1st trimester but remains higher than non-pregnant state.

It has been reported in earlier findings that estrogen secretion influences hearing sensitivity by affecting the role of acetylcholine, a neurotransmitter in auditory pathway whereas others have documented that there is a participation of multiple neuroendocrinal modalities like estrogen, HCG and progesterone which describes the working of female sex hormones in regulating auditory and visual reaction time.[2,3,10] These hormones have a profound influence on various neurological and behavioural symptoms.

Further, the sudden increase of HCG in 1st trimester might be affecting the homeostasis and altered neuronal activity during this period. The slow rise of estrogen and progesterone throughout the pregnancy, reaching their peak in T3 could allow the maternal body to adapt to the changing hormonal profile resulting in a non-significant variation of reaction time of both auditory and visual stimuli.

Though the direct effect of HCG on CNS is not well documented in literature, but some references are available where HCG, in high doses, has been shown to stimulate neurite overgrowth through MAP Kinase and ERK receptors.[14] Hence, from this study we can hypothesize a definitive neuromodulatory role of HCG during pregnancy especially during 1st trimester.

CONCLUSION

The present study hypothesises that the rapid increase of HCG during first trimester could affect the neuronal excitability, which needs to be explored further. Whereas the slow and persistent increase of estrogen and progesterone could have some effect on reaction directly or indirectly, not affecting the reaction time significantly.

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