The Effects of Multi Canal Stimulation on Vestibulo-Occular Reflex

Khatua SS*, Agarwal A+

Abstract

The vestibular system sits in the inner part of petrous temporal bone. The location makes access difficult, which in turn results in a difficulty in assessing the functional and anatomical integrity of the vestibular system. The easy accessibility and easy stimulation of the horizontal semicircular canal (SCC) makes it the focus forthe assessment and research. The other canals remain less studied, although they also play an important role in orientation, balance and vestibulo-occular reflex (VOR). This study was aimed at stimulating all the SCCs simultaneously and assessing the VOR response. 20 healthy male volunteers subjected to coriolis illusion at 10 RPM (Rotations per minute) and nystagmus was recorded by Electronystagmograph (ENG) recrording of Nexus-10 Physiological monitoring system. All the participants did not get nystagmus. The nystagmus recorded was torsional rather than purely horizontal or vertical in direction. The various characteristics of nystagmus showed a wide range of variation. There were no correlation between various characteristics in a single head movement and various head movements except amplitude and slow phase velocity (SPV) of nystagmus. The stimulus given was inadequate to induce nystagmus in all the participants in all the head movements. Future studies with a larger stimulus are required to be conducted, in order to elicit a more uniform response. The nystagmus recorded was torsional and properties of torsional nystagmus can be better studied with Videonystagmograph (VNG).

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Key words: Vestibiular system, Petrous temporal bone, Vestibulo-occular reflex, Semicircular canals.

Introduction

Vestibular system plays an important role in orientation, balance and VOR (1). Its importance in orientation creates an interest amongst the Aerospace Medicine Specialists. Any insult to the vestibular system or the connecting pathway causes an imbalance in these vital functions. Thus there is a need to assess functions and pathologies involving the vestibular system. However, the difficulty in accessing the vestibular system has been a challenge for researchers for a long time. Due to its easy accessibility, the horizontal SCC has been the center of assessment for researchers and clinicians (2). Another problem after accessing or stimulating the canals is to interpret the output of the canals. The connections of the vestibular system with the eyes are an indirect and reliable way of assessing vestibular function . Though the anterior and posterior canals play an equally important role in all the functions mentioned above, studies involving all three SCCs are less in number. Another complicating factor in vestibular research is that whenever the body is subjected to stimulation due to motion or otherwise, the input for orientation comes from all three canals and the otolith organs simultaneously, compounded by the fact that the canals are not placed exactly in the body axes (1). The higher centers sort out the signals and provide information regarding orientation, balance and VOR (1). Thus studies involving a single canal will give a limited input about the real time stimulation as well as less knowledge about the simultaneously stimulated canals. Considering this fact, this study was aimed at stimulating all the canals together and studying the VOR. One method for stimulating all the SSCs together is to subject the participants to Coriolis illusion (1,3). In this study, the participants were subjected to Coriolis illusion in Air Fox DISO

* MO (AV Med) IAM, IAF

+ Senior Advisor (AV Med) & SMO 2 Wg AF

simulator, resluting in stimulation of all three SCCs together. The results have been brought out.

Material and Methods

The study was approved by ethical committee at IAM,IAF, Bangalore. 20 healthy male volunteers participated in the study and were screened for any ENT related diseases by history and clinical examination. Air-Fox DISO simulator (4) was used for the study, which had the facility of continuously rotating in the yaw axis and had a completely dark environment inside, as requiredfor the study. ENG ports of Nexus-10 physiological monitoring system (5) was used for recording the eye movements. Initial calibration of eye movement was done using 5 fluorescent markers (center, right 30°, left 30°, up 30° and down 30°) in a dark room as the final recording was done in the DISO simulator to avoid errors in recording due to the effects of light on corneo-retinal potential. After the calibration the participants closed their eyes and were guided to the DISO simulator.This was to prevent any variation in corneo-retinal potential during the transition stage (6). The participants were demonstrated the head movements and were instructed to move their head according to the counts of the instructor (1-2-3) to ensure that all participants move their head within a period of 2-3 s. Following this, the participants were rotated at a constant speed of 10 RPM, where the sensation of rotation died down gradually. As per the instructions, the participants reported after cessation of rotation sensation. They were instructed to move their head in 8 directions (head forward HF, forward to neutral FN, head right HR, right to neutralRN, head left HL, left to neutral LN, head back HB, back to neutral BN) one by one, as per the instructions. A 30 s gap was given in between all the head movements for the fluid movement in the SCCs to settle down. Nystagmus was recorded in horizontal and vertical directions for both the eyes simultaneously. The ENG was restricted to a two channel recording, assuming that the nystagmus will be conjugate. Two electrodes were put 1 cm below and 1cm above the right eye and two electrodes were put at the outer canthus of both the eyes.The ground electrode was connected to the right arm of all the participants. Various properties of nystagmus ie time period, latency, direction, amplitude and SPV of nystagmus were analysed.The time period of nystagmus was calculated as the longest possible nystagmus whether it is vertical or horizontal. The latency of nystagmus was defined as the time gap from the starting of the stimuli to the starting of the nystagmus. Considering the fact that the nystagmus was torsional and the amplitude was quite variable in a single head movement, the sum of the amplitude of horizontal and vertical nystagmus were taken for the assessment in the present study. The slow phase velocity was calculated from the maximum amplitude and the time period of the slow phase.

Results

All the participants did not get nystagmus in all the head movements. The no of participants getting nystagmus in different head movements are 6, 8, 10, 8, 10, 9, 12, 11 in HF, FN, HR, RN, HL, LN, HB and BN head movements respectively. The nystagmus was found to be torsional rather than only horizontal or vertical. The direction of nystagmus was down & left, up & right, up & right, down & left, up & left, down & right, up & right, down & left in HF, FN, HR, RN, HL, LN, HB, BN head movements respectively.The duration of nystagmus varied from a minimum of 0.307 s to a maximum of 9.325 s. The latency of the nystagmus varied from zero to a maximum of 33.37 s. The amplitude varied from a minimum of 0.21° to a maximum of 37.25° for vertical nystagmus. The mean amplitude was found to be 11.8±9.4°

(Mean±SD) for the vertical nystagmus.The minimum and maximum amplitude was found to be 0.3° and 32.47° in the horizontal direction. The mean amplitude is 9.1±6.7°. The mean amplitude in various head movements are given in Table1. The SPV varied from a minimum of 0.47°/ s to a maximum of 121.72°/ s for vertical nystagmus. The mean SPV was 40.1±35.1°/ s for the vertical nystagmus. The minimum and maximum SPV were found to be 1.05°/ s and 84.09°/ s in the horizontal direction. The mean SPV was found to be 17.8±16.9°/s in the horizontal direction. The mean SPV in different head movements are given in Table 2. Statistical analysis was done to find out any correlation between all the parameters. There was no correlation found in between all these characteristics in a single head movement and various head movements except the amplitude and the slow phase velocity of nystagmus with a correlation coefficient of 0.8. SPV is a derivative of amplitude and correlation is expected.

Table 1: Mean horizontal and vertical amplitude in various head movements

Head movement	Mean horizontal amplitude	Mean vertical amplitude
HF	6.3±1.4	19.2±18.7
FN	19.7±7.7	5.1±2.3
HR	13.6±13	8.9±6.1
RN	9.4±9	9.3±9.1
HL	5.9±3.6	8.3±7.5
LN	11.2±5.1	6.04±3.9
HB	18.7±18.4	9.3±4.4
BN	12.9±12.1	12.9±7.2

Table 2: Mean horizontal and vertical SPV in various head movements

Head movement	Mean horizontal SPV	Mean vertical SPV
HF	23.6±15.5	43.15±38.6
FN	78.4±38	9.27±6.1
HR	39.1±42.5	21.04±19.3
RN	34.7±49.6	12.7±17.1
HL	18.02±14.7	18.1±10.6
LN	28.6±9.6	9.2±5.5
HB	84.09±16.05	25.6±20.6
BN	48.3±44.1	19.1±8.2

Discussion

In the present study 2 participants did not get nystagmus in any of the head movements. Amongst remaining 18 participants, all the participants did not get nystagmus in all the head movements. The inequality of response can be explained as the threshold for the vestibular stimulation varies between individuals.The threshold for the Coriolis illusion is 5 RPM (7) and the present study was conducted at 10 RPM (8,9), slightly higher RPM than the threshold. Studies have documented absence or nil significant nystagmus at a lower RPM (10,11) and presence of nystagmus in all the head movements at a higher RPM (12,13,14,15). Thus, the stimulation of all the SSCs should be studied at a higher RPM to get a uniform response in all the head movements. The initial thought before conducting the study was that, nystagmus would develop either in vertical or horizontal direction. However, nystagmus was recorded in both the horizontal and vertical directions. Finally, it was concluded that, nystagmus was torsional (15,16) which has been recorded by the ENG instrument in both horizontal and vertical directions. The movement of the fluid in all the 3 SSCs produce a torsional nystagmus, that can be better studied by Videonystagmograph (VNG) (6), which gives better recordings for torsional nystagmus. The amplitude and SPV showed a wider variation in various head movements with large SD. Similar findings were observed by Guedry [10]. He subjected participants to Coriolis illusion at various rotation speeds and recorded nystagmus. He found that, the amplitude was different for different subjects at the same rotational speed. The amplitude showed an increase as the rotation speed increased. The amplitude varied from 75° to 200° at 10 rpm in different subjects (10).There was no correlation found between the various characteristics of nystagmus except the amplitude and the slow phase velocity of nystagmus in a single head movement. The slow phase velocity being a derivative of amplitude the correlation is expected. All the characteristics were compared between various head movements. No correlation were found between the same characteristics in between various head movements. It was postulated that, this may be due to different quantum of stimuli in different head movements. To verify, the head movements were measured by goniometry in various directions in the DISO cockpit. There was a 20° restriction to backward head movement due to the head rest. The movement in the head forward direction was larger than the right and left head movements. This causes the head forward movement to result in the strongest stimulus, while the head back movement provides the weakest stimulus. However the time period, amplitude and slow phase velocity did not show any such trend in the head movements. So the hypothesis of difference of various characteristic of nystagmus due to varied quantum of stimuli was rejected. Other possibility is that, the higher centers respond differently to different head movements and makes necessary modifications requiered for the eyes to focus. However evidence pertaining to this possibility is not persisting. Thus the complex interaction occuring due to movement of fluid in all the canals needs to be be studied further of fluid in all the canals needs to be be studied further.

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