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ORIGINAL RESEARCH

Comparison of videonystagmography in subjects with vertigo between closed-loop and open-loop irrigation

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ABSTRACT

Background: Subjects with balance disorders are assessed using a series of vestibular function tests counting VNG (videonystagmography). However, performing the caloric test component of VNG is risky in subjects with ear infections. In such subjects, a closed-loop technique is utilized. **Aim:** The present study aimed to comparatively assess the efficacy of closed and open-loop techniques of caloric testing using videonystagmography in subjects with vertigo, and it was also applied to subjects with ear infections. **Methods:** The study assessed 166 subjects aged 20-60 who complained of giddiness utilizing videonystagmography with both open-loop and closed-loop methods. The data gathered were analyzed statistically for results formulation. **Results:** The study results showed that on comparison of outcomes of caloric responses in both the ears using the open-loop and closed-loop techniques, it was seen that the outcome was similar with both the techniques concerning the detection of the caloric response of the ear as there were no statistically significant differences in both the irrigation techniques. **Conclusions:** The present study concludes that the closed-loop irrigation technique has equal efficacy as the open-loop technique for the assessment of vertigo and can be used for the assessment of the vestibular system for subjects that are contraindicated for the use of the open-loop technique.

Keywords: caloric test, closed-loop irrigation, ear infection, vertigo, videonystagmography

INTRODUCTION

VNG (Videonystagmography) is a diagnostic test system utilized for reporting, analyzing, and recording the movement of the eyes using video imaging technology. The videonystagmography device provides a complete analysis of the nystagmus caused via a thermal gradient that accelerates the endolymph producing stimulus at the level of the canal. The result from this functional test is represented by labyrinth response, butterfly chart, and slow component based on time.[1]

The caloric response is also known as the thermal caloric test of Fitzgerald and Hallpike where cold and warm water are irrigated at 30°C and 44°C bilaterally. The cold and warm water transmits the temperature gradient into the middle ear air via an intact tympanic membrane and there is the generation of convection current in the endolymph of the horizontal semicircular canal.[2]

The butterfly chart is a pictorial representation of the caloric code and reactions are a symbolic representation of the caloric reactions in a subject. Subjects that have balance disorders are assessed using a series of vestibular function tests counting VNG (videonystagmography). However, it is risky to perform a caloric test component of VNG in subjects with ear infections. In such subjects, the closed-loop technique is utilized to perform the test. However, existing literature data is scarce in the Indian context.[3] Hence, the present study aimed to comparatively assess the efficacy of closed and open loop techniques of the caloric test using videonystagmography in subjects with vertigo that it can be applied in subjects with ear infections too.

MATERIALS AND METHODS

The present prospective clinical study was aimed to comparatively assess the efficacy of closed and open

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loop techniques of the caloric test using videonystagmography in subjects with vertigo that it can be applied in subjects with ear infections too. The study was done at F.H.Medical College Etmadpur AgraUttar Pradeshafter the clearance was given by the concerned Institutional Ethical committee. The study subjects were from the Department of ENT of the Institute. Verbal and written informed consent were taken from all the subjects before participation.

The study assessed 166 subjects of both genders and aged 20-60 years who presented to the Institute within the defined study period with complaints of giddiness. The exclusion criteria for the study were subjects who were not able to cooperate, subjects with acute symptoms of focal neurological deficits and/or vertigo, perforation of the tympanic membrane, and recent or ongoing ear discharge.

After final inclusion, detailed history was taken from all the subjects followed by comprehensive systemic and general examination, vestibular function tests, and ear examination. The subjects were then taken for closed-loop and open-loop technique of caloric test of VNG. VNG device was used for performing VNG.[14]

After placing subjects in a supine position with 30^{o} head raised above horizontal irrigation of the external auditory canal was done using 250ml water at 30- and 44-degrees following order as left cold, right cold, left warm, and right warm as per the steps. Each irrigation was done for 40 seconds and the capture button was pressed after starting irrigation. Test recording was automatically stopped and the video was kept. Between two ears, a 5-minute interval was kept and recordings were copied.

VNG system automatically assesses readings and gives SPV (slow phase velocity) and Claussen's butterfly chart. Also, the same procedure was repeated using a closed loop technique after 2 2-hour time gap to allow the effect of the previous irrigation with an open loop to subside. Closed-loop technique utilized a latex barrier of good thermal conductivity of 4-8 mil thickness layered on walls of the tympanic membrane and external and external auditory canal to prevent water contact with tissues. Subjects with known latex allergy were excluded. Hand latex examination gloves were used as finger gloves that were placed in the external auditory canal and warm and hot water was irrigated through the finger glove to the external auditory canal and water contact to tissues was avoided.

Various nystagmus parameters assessed to quantify caloric responses included amplitude, frequency, and duration. Presently, the most practical measure of intensity is nystagmus SPV.[2,3,5,6] Hence, the studyutilized SPV values (°/s). To assess nystagmus SPV, knowing eye movement axes and scales of time is vital. The scale for the time axis is assessed by settings on the equipment and the scale for the eye movement axis is assessed by the calibration. To assess caloric responses, it is vital to assess total responses from the left ear (TotLE) and right ear (TotRE) where TotRE = PeakRC – PeakRW and TotLE = PeakLW – PeakRC.

In subjects where total responses from both left and right ears were very small, the caloric test indicates the presence of bilateral caloric weakness. In cases where bilateral weakness exists, the equations for the remaining response parameters do not produce valid results because the denominator approaches zero. Hence, in very small responses from both ears, further calculations must not be performed.

Traditionally, criteria for bilateral weakness were based on combined caloric responses from both ears whereas in a few cases, adequate response from one ear and minimal response from the other ear can be misunderstood as bilateral weakness. Another criterion considering the British standard needs all four irrigation responses as very small as <8°/s for bilateral weakness as BSA 2010. To overcome these concerns in the study, the criteria of TotRE <12°/s and TotLE <12°/s for bilateral caloric weakness were used. A threshold value of 12°/s is a composite of the thresholds used by Barber and Stockwell (1980) and Jacobson and Newman (1993).

RESULTS

The present prospective clinical study was aimed to comparatively assess the efficacy of closed and open loop techniques of the caloric test using videonystagmography in subjects with vertigo that it can be applied in subjects with ear infections too. The study assessed 166 subjects aged 20-60 years and had complaints of giddiness that were assessed utilizing videonystagmography with both open-loop and closed-loop methods. The highest incidence was seen in the 4th decade in 33.7% (n=56) subjects followed by 30.1% (n=50) 3rd decade cases. By comparison of the outcomes of caloric responses in the right ear using closed-loop and open-loop irrigation techniques in vertigo subjects from different age groups, it was seen that outcomes were similar in both the techniques concerning detection of the caloric response of the ear. The difference was statistically non-significant in both irrigation techniques with p=0.991.

The study results showed that on comparison of outcomes for caloric responses in the left ear utilizing the closed-loop and open-loop irrigation techniques, it was seen that in subjects with vertigo at different age groups, outcomes were similar in both the techniques for detection of caloric response of the ear with statistically non-significant difference in two irrigation techniques with p=0.989 (Table 1).

It was also seen that there was a higher number of males affected compared to females with 55.4% (n=92) males and 44.6% (n=74) female subjects. Among 56 subjects with vertigo in the age range of 41-50 years, 32 subjects got hyporesponse with <12 to caloric stimulation in the right ear using an open-loop irrigation technique. In 32 subjects, hyporesponsive was seen to caloric stimulation in the right ear with a

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closed-loop irrigation technique., 24 subjects depicted a good normal response of >12 to caloric stimulation in the right ear with an open-loop irrigation technique, and 24 subjects depicted a normal response as >12 to caloric stimulation in the right ear with closed-loop irrigation technique.

The study results also showed that in 56 subjects with vertigo in the age range of 41-50 years, 28 subjects had hyporesponse <12 to caloric stimulation in the left ear with an open-loop irrigation technique. Also, 34 subjects depicted hyporesponse to caloric stimulation in the left ear using a closed-loop irrigation technique from 56 subjects with vertigo in the age range of 41-50 years. 28 subjects got a normal response of>12 to caloric stimulation in the left ear while using the open-loop irrigation technique. In 22 subjects with a normal response of >12 was seen to caloric stimulation in the left ear using a closed-loop irrigation technique.

Table 1: Comparison of age groups in study subjects to left, right closed and open loop technique

Age (years)	Open loop				Closed loop			
	Right ear SPV		Left ear SPV		Right ear SPV		Left ear SPV	
	$<12^0$/s	$>12^0$/s	$<12^0$/s	$>12^0$/s	$<12^0$/s	$>12^0$/s	$<12^0$/s	$>12^0$/s
<30	0	4 (5.4)	4 (4.2)	0	2 (2.3)	2 (2.6)	4 (3.9)	0
31-40	24 (26.1)	26 (35.1)	24 (25)	26 (37.1)	24 (27.3)	26 (33.3)	26 (25.5)	24 (37.5)
41-50	32 (34.6)	24 (32.4)	28 (29.2)	28 (40)	32 (36.4)	24 (30.8)	34 (33.3)	22 (34.4)
51-60	30 (32.6)	16 (21.6)	34 (35.4)	12 (17.1)	24 (27.3)	22 (28.2)	32 (31.4)	14 (21.9)
61-70	6 (6.5)	4 (5.4)	6 (6.3)	4 (5.7)	6 (6.8)	4 (5.1)	6 (5.9)	4 (6.3)

DISCUSSION

The present study assessed 166 subjects aged 20-60 years and had complaints of giddiness that were assessed utilizing videonystagmography with both open-loop and closed-loop methods. The highest incidence was seen in the 4th decade in 33.7% (n=56) subjects followed by 30.1% (n=50) 3rd decade cases. By comparison of the outcomes of caloric responses in the right ear using closed-loop and open-loop irrigation techniques in vertigo subjects from different age groups, it was seen that outcomes were similar in both the techniques concerning detection of caloric response of the ear. The difference was statistically non-significant in both irrigation techniques with p=0.991. These data were comparable to the previous studies of Jałocha-Kaczka A et al[7] in 2014 and Burman D et al[8] in 2002 where authors reported similar findings of videonystagmography in their study subjects as seen in the results of the present study.

It was seen that on comparison of outcomes for caloric responses in the left ear utilizing the closed-loop and open-loop irrigation techniques, it was seen that in subjects with vertigo at different age groups, outcomes were similar in both the techniques for detection of caloric response of the ear with statistically non-significant difference in two irrigation techniques with p=0.989. These results were consistent with the findings of Dell'Osso LF[9] in 2002 and Zuniga SA et al[10] in 2021 where results for comparison of outcomes for caloric responses in the left ear utilizing the closed-loop and open-loop irrigation techniques similar to the present study were also reported by the authors in their respective studies.

The study results showed that there were a higher number of males affected compared to females with 55.4% (n=92) males and 44.6% (n=74) female subjects. Among 56 subjects with vertigo in the age range of 41-50 years, 32 subjects got hyporesponse with <12 to caloric stimulation in the right ear using an open-loop irrigation technique. In 32 subjects, hyporesponsive was seen to caloric stimulation in the right ear with a closed-loop irrigation technique., 24 subjects depicted a good normal response of >12 to caloric stimulation in the right ear with an open-loop irrigation technique, and 24 subjects depicted a normal response as >12 to caloric stimulation in the right ear with closed-loop irrigation technique. These findings were in agreement with the results of Sorathia S et al[11] in 2018 and Priesol A. et al[12] in 2015 where authors also reported a higher number of males affected compared to females in their studies as seen in the present study.

It was also seen that in 56 subjects with vertigo in the age range of 41-50 years, 28 subjects had hyporesponse <12 to caloric stimulation in the left ear with an open-loop irrigation technique. Also, 34 subjects depicted hyporesponse to caloric stimulation in the left ear using a closed-loop irrigation technique from 56 subjects with vertigo in the age range of 41-50 years. 28 subjects got a normal response of>12 to caloric stimulation in the left ear while using the open-loop irrigation technique. In 22 subjects with a normal response of >12 was seen to caloric stimulation in the left ear using a closed-loop irrigation technique. These results were in line with the findings of Piker EG et al[13] in 2014 and Mahringer A et al[14] in 2016 where results comparable to the present study were also reported by the authors in their respective studies.

CONCLUSIONS

The present study, considering its limitations, concludes that the closed-loop irrigation technique has equal efficacy as the open-loop technique for the assessment of vertigo and can be used for the assessment of vestibular system for subjects that are contraindicated for the use of the open-loop

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technique. However, the study has a few limitations a smaller sample size and short monitoring. Hence, further longitudinal studies with larger sample sizes and longer monitoring are needed to reach a definitive conclusion.

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