의학석사 학위논문

Role of Video Head-impulse Test in Lateralization of Vestibulopathy: Comparative Study with Caloric Test

비디오 두부충동검사의 전정기능이상 편측화에 대한 역할: 온도안진검사와의 비교연구

2016 년 02 월

서울대학교 대학원

임상의과학과

박 보 나

A thesis of the Degree of Master's

비디오 두부충동검사의 전정기능이상 편측화에 대한 역할: 온도안진검사와의 비교연구

지도교수 구 자 원

Role of Video Head-impulse Test in Lateralization of Vestibulopathy: Comparative Study with Caloric Test

Feb. 2016

The Department of Clinical Medical Sciences,
Seoul National University
College of Medicine
Pona Park

Role of Video Head-impulse Test in Lateralization of Vestibulopathy: Comparative Study with Caloric Test

by
Pona Park

A thesis submitted to the Department of Clinical Medical Sciences in partial fulfillment of the requirements for the Degree of Master's in Clinical Medical Sciences at Seoul National University College of Medicine

Feb. 2016

Approved by Thesis Committee:

Professor 김지수 Chairman
Professor 구자원 Vice chairman
Professor 김정훈

ABSTRACT

Introduction: Among diagnostic tests evaluating dizzy patients, caloric test and the head-impulse test (HIT) are important tools in evaluation of unilateral vestibular hypofunction. Since new video head-impulse test (vHIT) is introduced, various studies tried to evaluate the diagnostic value of this system. To evaluate the lateralization value of vHIT in unilateral vestibulopathy, we compared its variables with those of a caloric test.

Methods: In total, 19 healthy volunteers and 92 dizzy patients who underwent both a caloric test and a vHIT were enrolled. Patients were divided into two groups depending on their fluctuating pattern of vertigo. The vestibulo-ocular reflex (VOR) gain and gain asymmetry (GA) of a vHIT, and unilateral weakness (UW) and the sum of the slow-phase velocities (SPVs) of warm and cold irrigation of the same side were compared. A cutoff value of VOR gain of a vHIT was also calculated using a receiver-operating characteristic curve.

Results: A VOR gain in an affected ear and GA of a vHIT showed a statistically significant correlation with UW in a caloric response. There was a significant correlation between vHIT parameters and a caloric test in the patients with fluctuating vestibulopathy. Moreover, the cutoff value of a vHIT was determined to be 0.875, derived under the assumption that UW of a caloric test equal to or less than 25% is normal.

Conclusions: A VOR gain or GA of a vHIT may be a useful parameter in evaluating unilateral vestibulopathy. The vHIT can act as a complementary tool for lateralization of unilateral vestibular hypofunction.

Keywords: Head-impulse-test, Caloric irrigation, Vertigo, ROC curve

Student number: 2014-22204

CONTENTS

Abstract i
Contents iii
List of tables and figures iv
List of abbreviations vi

Introduction 1
Material and Methods 2
Results 5
Discussion 20
Conclusion 23
References 24
Abstract in Korean 27

LIST OF TABLES AND FIGURES

Tables

Table 1 Specific diagnoses within the entire study population 7

Table 2 Diagnostic rate of the video head-impulse test 8

Table 3 Comparison of unilateral caloric weakness depending on the response pattern of refixation saccade during the head-impulse test 9

Table 4 Dissociation between the results of video head impulse versus caloric testing (UW>25, VOR gain ≥ 0.88)…….. .... ………….10

Table 5. Dissociation between the results of video head impulse versus caloric testing (UW≤25, VOR gain < 0.88)…………..………..…...........11

Figures

Figure 1 Patterns of reflexive eye movement to impulse head rotation (mean VOR gain in parentheses).. 12
Figure 2 Comparison of ipsilateral VOR gain on video head-impulse test and sum of peak SPVs during warm and cold irrigation in all patients and healthy volunteers.. 13
Figure 3 Comparison between ipsilateral VOR gain on video head-impulse test and sum of peak SPVs during warm and cold irrigation in healthy volunteers.. 14
Figure 4 Comparison of ipsilateral VOR gain on video head-impulse test with the sum of peak SPVs during warm and cold irrigation in patients. . 15
Figure 5 Correlation analysis between UW on bithermal caloric tests and VOR gain of an affected ear (A), and GA (B) on video head-impulse test in patients.. 16
Figure 6 Correlation analysis between UW on bithermal caloric tests and VOR gain of an affected ear (A), and GA (B) on the video head-impulse test in patients with fluctuating vertigo... 17
Figure 7 Correlation analysis between UW on bithermal caloric test and VOR gain of an affected ear (A), and GA (B) on video head-impulse test in patients with non-fluctuation vertigo... 18
Figure 8 ROC curve. ROC curve of VOR gain is plotted against the reference value of UW. 19

LIST OF ABBREVIATION

HIT: head-impulse test

vHIT: video head-impulse test

VOR: vestibulo-ocular reflex

GA: gain asymmetry

UW: unilateral weakness

SPVs: sum of the slow-phase velocities

VN: vestibular neuritis

MD: Ménière's disease

RV: recurrent vestibulopathy

BVH: bilateral vestibular hypofunction

CPA: cerebellopontine angle

ITG: intratympanic gentamicin

ROC: receiver-operating characteristic

INTRODUCTION

Several laboratory diagnostic tests have been introduced to demonstrate unilateral vestibular hypofunction. Among them, the caloric test [1] and the head-impulse test (HIT) [2] are valuable tools with lateralization value by measuring the vestibulo-ocular reflex (VOR) in response to horizontal semicircular canal stimulation in the evaluation of dizzy patients. The caloric test is the gold standard method of demonstrating unilateral or bilateral vestibular hypofunction by measuring VOR response to ear specific irrigation with warm and cold water. In the HIT, the presence of delayed refixation saccades is a positive sign of inappropriate VOR when a patient is instructed to stare straight ahead during a brief, impulse head rotation to the lesion side [2]. Although the HIT is a simple bedside test, it has moderate sensitivity (35-45%) and high specificity (90%) compared with the caloric test [3]. To increase its sensitivity, a video system that can follow reflexive eyeball movement during impulse head rotation was introduced, because such a system can capture very early corrective saccades, so called covert saccades, during head rotation [4]. Moreover, HIT using a video system showed results comparable to those using sclera search coils [5].

In this study, parameters of a video-head-impulse test (vHIT) and a bithermal alternating caloric test were compared in dizzy patients and healthy volunteers to evaluate the role of vHIT in the lateralization of vestibular impairment.

MATERIALS AND METHODS

1. Study papulation

This study recruited 92 patients who underwent bithermal caloric tests and vHIT because of dizziness from May 2012 to June 2013 (47 males; age range, 9 to 87 years, mean age of 55 years). The study population included patients diagnosed with vestibular neuritis (VN), Ménière's disease (MD), recurrent vestibulopathy (RV), and bilateral vestibular hypofunction (BVH), and patients who underwent cerebellopontine angle (CPA) tumor surgery and vestibular hypofunction after intratympanic gentamicin (ITG) injection. Diagnoses of VN [6], MD [7], RV [8], and BVH [9] were made based on diagnostic criteria published previously. The patients who had spontaneous nystagmus were excluded to avoid calibration issue.

Patients with unilateral vestibular hypofunction were divided into two groups according to the characteristics of their vertigo: a fluctuating and a non-fluctuating group. The fluctuating group included patients with MD and RV, and the non-fluctuating group included patients with VN, CPA tumor removal, and ITG injection (Table 1).

Also, 19 healthy volunteers (6 males; age range, 20 to 43 years, mean age of 31.5 years) were enrolled in the same period. The vHIT and the bithermal caloric tests were performed on the same day. The study protocol was approved by the Seoul National University Bundang Hospital Internal Review Board (No. B-1305-202-106).

2. Bithermal caloric test

The bithermal caloric test was performed in the supine position with the upward head flexion of 30 degree [1]. Eye movements were recorded using a binocular video oculography system (I-Portal®, Neuro Kinetics Inc., Pittsburgh, USA) to track the horizontal eye movements. Caloric irrigation was performed using binaural alternate irrigation for 30s with 300 mL of cold (30°C) and warm (44°C) water (ICS NCI-480®, GN Otometrics, Taastrup, Denmark). There was an interval of at least 5min between individual irrigations. A unilateral weakness (UW) in the caloric irrigation was calculated using Jongkees' formula [1], and a response difference > 25%

between the ears was defined as abnormal [10]. The sum of a warm and a cold slow-phase velocity (SPV) in each ear was calculated and used for comparison with a VOR gain on vHIT.

3. Video-head-impulse test

The examinees were instructed to stair a stationary target at a distance of 1m in front of them while short lasting head rotations around an earth-vertical axis were randomly applied from behind the examinees. A video oculography system was used for acquisition and analysis of an eyeball and a head movement (ICS impulse®, GN Otometrics, Taastrup, Denmark). The test was repeated at least 10 times on each side in an unpredictable direction with 5°-10° and peak accelerations of 750°-6,000°/sec^2 [5, 11]. Only head rotations with a defined waveform were accepted within a predefined velocity and acceleration window. The vHIT was performed by one expert technician in our vestibular laboratory. The movements of the right eyeball and the head were recorded. The area under the velocity curves of those two movements was obtained from head-impulse onset to the back crossing of zero. A VOR gain on vHIT was defined the ratio of the area under the velocity curves of the right eye to head [12]. An another parameter, a gain asymmetry (GA) was defined as follows: GA= $|(R-L)/(R+L)|$, where R and L indicates the mean gain values for impulses to the right (R) and left (L) side [13]. The examinees who have contraindications for head impulses and who were unable to endure fast enough impulses were excluded in the study.

4. Parameters and statistical analysis

The parameters of each test were assessed for correlations with each other using Spearman's correlation analysis with statistical significance of $p < 0.05$. A receiver-operating characteristic (ROC) curve was plotted to determine the comparative diagnostic performance of vHIT, based on the results of the bithermal caloric test. The mean value of UW was also compared depending on the pattern of reflexive eye movement to impulse head rotation: overt saccades only, overt and covert saccades, covert saccades only, and intact VOR (Figure 1). Significant differences among the groups were evaluated by a *post hoc* ANOVA. All statistical analyses were conducted using the same software (SPSS® v22.0, IBM, New York, USA).

RESULTS

Comparison of VOR gain on vHIT with sum of peak SPVs in warm and cold irrigation

The results of all ears of the subjects in this study (222 ears of 111 subjects) were plotted (Figure 2). There was a statistically significant positive correlation between the two parameters with a correlation coefficient of 0.556 ($p < 0.0001$). However, the two parameters were not correlated with each other in healthy volunteers (38 ears of 19 subjects, *rho* = -0.250, $p = 0.130$; Figure 3). The VOR gain on vHIT ranged from 0.86 to 1.22 (mean = 1.064, SD = 0.092), while the sum of SPVs of warm and cold irrigation ranged from 17 to 83°/s (mean = 41.6, SD = 19.0). The lower normal value of VOR gain of vHIT was 0.88, which is derived from the mean minus 2 SD of the VOR gain in healthy volunteers. Correlation analyses between the two parameters were conducted separately in affected and unaffected ears in patients. There was a significant positive correlation between VOR gain and the sum of SPVs in the affected ears (*rho* = 0.743, $p < 0.0001$; Figure 4A), while the two parameters were not correlated in unaffected ears (*rho* = -0.002, $p = 0.978$; Figure 4B).

Correlation analysis of vHIT parameters (VOR gain and GA) with unilateral caloric weakness in patients

VOR gain of the affected ear on vHIT showed a statistically significant negative correlation with unilateral weakness (*rho* = -0.699, $p < 0.0001$; Figure 5A), and GA on vHIT showed a significant positive correlation with unilateral weakness on the bithermal caloric test (*rho* = 0.603, $p < 0.0001$; Figure 5B). Patients with BVH were excluded from this analysis.

Correlation analysis of vHIT parameters (VOR gain and GA) with unilateral caloric weakness depending on the nature of vertigo

There was statistically significant negative correlation between the VOR gain of an affected ear, and UW in the caloric response (*rho* = -0.560, $p < 0.0001$; Figure 6A) and positive correlation between GA of a vHIT and UW in the caloric irrigation in the fluctuating vertigo group (*rho* = 0.483, $p < 0.0001$; Figure 6B). In the non-fluctuating vertigo group, there was similar correlation pattern between those parameters but it was not statistically significant (*rho* = -0.361, *p* =0.070; Figure 7A, *rho* = 0.331, *p* = 0.098; Figure 7B).

Diagnostic value of vHIT based on the bithermal caloric test

The diagnostic value of vHIT (lower normal value of VOR gain from the healthy volunteer = 0.88) was evaluated based on the bithermal caloric test result when UW > 25% is considered to be pathological in patients with unilateral vestibulopathy. The sensitivity, specificity, false positive rate, and false negative rate were 78.8%, 85.7%, 14.3%, and 21.2%, respectively (Table 2).

To determine a cutoff value of the VOR gain in a vHIT based on the caloric test, a ROC curve of VOR gain of vHIT was plotted under the assumption that UW equal to or less than 25% is considered as true. A cutoff value of 0.875 was determined, providing a sensitivity of 85.7% and a specificity of 79.2% versus caloric irrigation (Figure 8).

Comparison of UW depending on the pattern of reflexive eye movement on vHIT

UW was compared depending on the pattern of refixation saccade (overt saccade, covert saccade, normal VOR) in patients with unilateral vestibulopathy and healthy volunteers to assess whether covert saccade is present in patients with milder UW. The mean value of UW was higher in the overt saccade group than in the covert saccade group, or the covert and overt saccade group. However, there was no statistically significant difference among the groups by a *post hoc* ANOVA. The UW of the normal VOR group was significantly lower than that of the other three groups ($p < 0.0001$; Table 3).

Table 1. Specific diagnoses within the entire study population

Study group	Diagnosis	*N*
Non-fluctuating vestibulopathy (*n* = 26)	VN	15
	CPA tumor	7
	ITG injection	4
Fluctuating vestibulopathy (*n* = 57)	MD	31
	RV	26
Bilateral vestibular hypofunction (*n* = 9)	BVH	9

Abbreviations: N, number of patients, VN, vestibular neuritis, CPA, cerebellopontine angle, ITG, intratympanic gentamicin, MD, Ménière's disease, RV, recurrent vestibulopathy, BVH, bilateral vestibular hypofunction.

Table 2. Diagnostic rate of the video head-impulse test

vHIT	Bithermal caloric test	
	UW > 25%	UW ≤ 25%
VOR gain < 0.88*	41	7
VOR gain ≥ 0.88*	11	42

*0.88 is the mean minus 2 SD of the VOR gain in healthy volunteers. Abbreviations: vHIT, video head-impulse test, UW, unilateral weakness, VOR, vestibulo-ocular reflex.

Table 3. Comparison of unilateral caloric weakness depending on the response pattern of refixation saccade during the head-impulse test

VOR	Mean value of UW (range) (%)
Overt saccade only (*n* = 17)	65.5 (14-100)
Covert and overt saccades (*n* = 22)	56.8 (4-100)
Covert saccade only (*n* = 5)	52.6 (15-92)
Intact VOR (*n* = 58)	21 (1-88)

Abbreviations: VOR, vestibulo-ocular reflex, UW, unilateral weakness.

Table 4. Dissociation between the results of video head impulse versus caloric testing (UW>25, VOR gain ≥ 0.88)

Number	Age	Sex	UW (%)	VOR gain	Diagnosis	Onset	Last vertigo
1	32	M	37	1.34	RV	5MA	1MA
2	70	F	37	1.19	MD	13MA	2WA
3	35	M	45	1.18	RV	1MA	5DA
4	69	F	54	1.04	RV	9YA	?
5	39	F	41	1.03	MD	1MA	3DA
6	55	F	54	0.97	MD	6YA	25DA
7	41	F	26	0.97	MD	4MA	?
8	73	F	39	0.96	MD	2YA	1WA
9	76	M	59	0.95	RV	4YA	1MA
10	73	F	45	0.92	MD	3YA	10DA
11	42	F	44	0.92	RV	16YA	15DA

Abbreviations: VOR, vestibulo-ocular reflex, UW, unilateral weakness, RV, recurrent vestibulopathy, MD, Ménière’s disease, YA, years ago, MA, months ago, WA, weeks ago, DA, days ago.

Table 5. Dissociation between the results of video head impulse versus caloric testing (UW≤25, VOR gain < 0.88)

Number	Age	Sex	UW (%)	VOR gain	Diagnosis	Onset	Last vertigo
1	65	M	14	0.54	VN	6MA	
2	49	M	25	0.58	RV		1~2WA
3	63	F	4	0.66	RV	5YA	3YA
4	65	M	10	0.78	MD	3DA	
5	9	M	22	0.84	VN		5DA
6	34	F	10	0.86	Healthy volunteer		
7	43	M	10	0.86	MD	1YA	2MA

Abbreviations: VOR, vestibulo-ocular reflex, UW, unilateral weakness, VN, vestibular neuritis, RV, recurrent vestibulopathy, MD, Ménière’s disease, YA, years ago, MA, months ago, WA, weeks ago, DA, days ago.

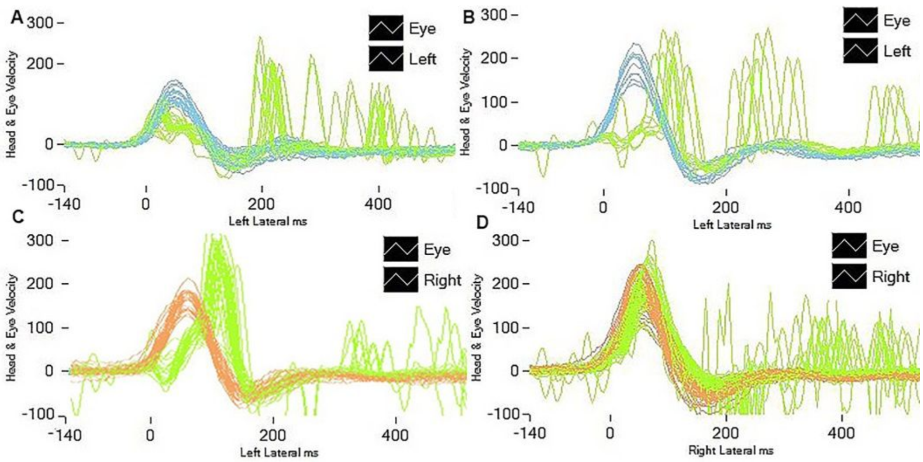

Figure 1. Patterns of reflexive eye movement to impulse head rotation (mean VOR gain in parentheses).

(A) Overt saccade only (0.56), (B) Overt and covert saccade (0.22), (C) Covert saccade only (0.46), (D) Intact VOR (0.96). VOR, vestibulo-ocular reflex.

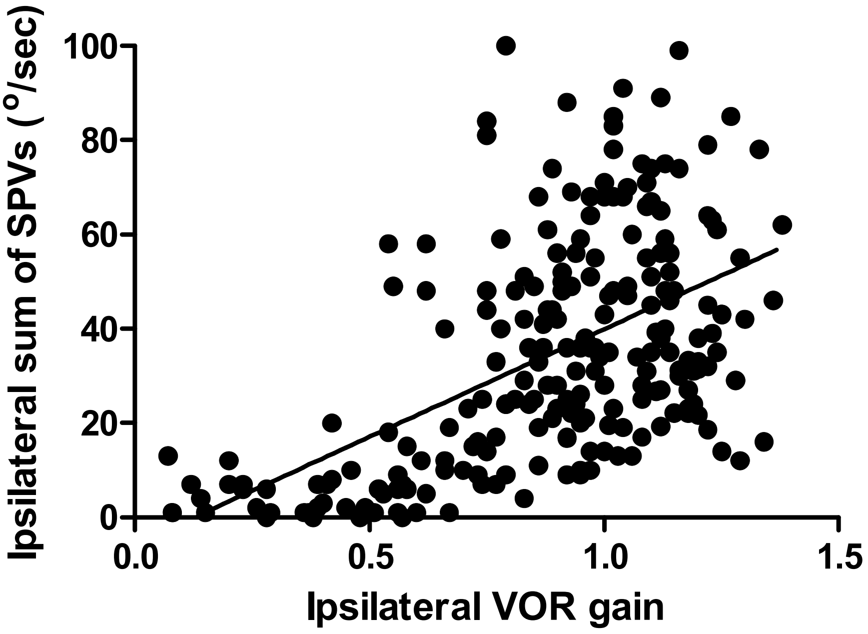

Figure 2. Comparison of ipsilateral VOR gain on video head-impulse test and sum of peak SPVs during warm and cold irrigation in all patients and healthy volunteers.

Scatter plot shows a significant positive correlation between two parameters (*rho* = 0.556, $p < 0.0001$). VOR, vestibulo-ocular reflex; SPVs, slow phase velocities.

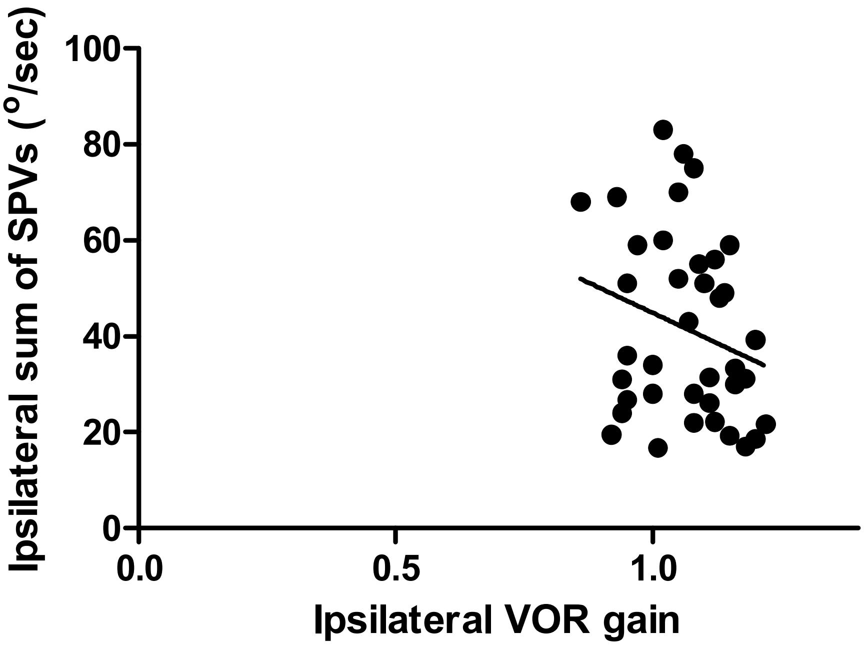

Figure 3. Comparison between ipsilateral VOR gain on video head-impulse test and sum of peak SPVs during warm and cold irrigation in healthy volunteers.

The two parameters showed no correlation in healthy volunteers (*rho* = -0.250, *p* = 0.130). VOR, vestibulo-ocular reflex; SPVs, slow phase velocities.

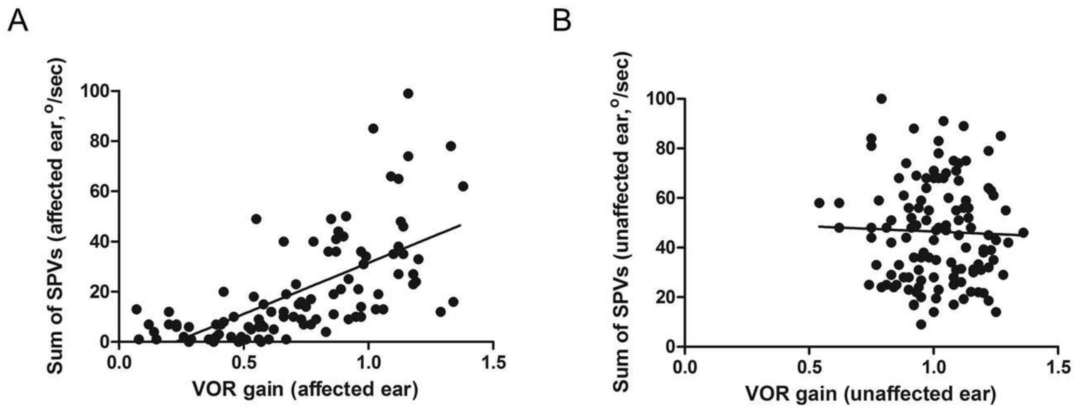

Figure 4. Comparison of ipsilateral VOR gain on video head-impulse test with the sum of peak SPVs during warm and cold irrigation in patients.

Affected ears and unaffected ears are analyzed separately. Scatter plot shows significant positive correlation between the two parameters in affected ears (*rho* = 0.743, $p < 0.0001$) (A), while there was no correlation in unaffected ears (*rho* = -0.002, $p = 0.978$) (B). VOR, vestibulo-ocular reflex; SPVs, slow phase velocities.

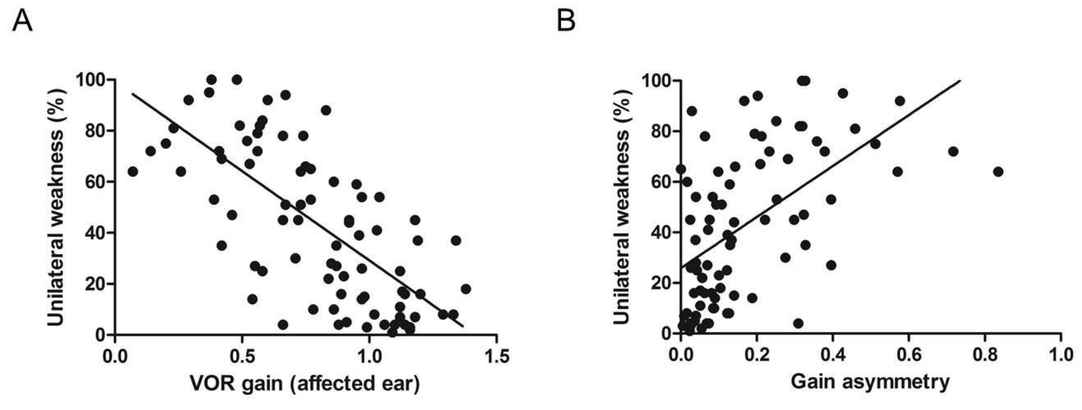

Figure 5. Correlation analysis between UW on bithermal caloric tests and VOR gain of an affected ear (A), and GA (B) on video head-impulse test in patients.

Scatter plots show a significant negative correlation between UW and VOR gain (*rho* = -0.699, $p < 0.0001$) (A) and significant positive correlation between UW and GA (*rho* = 0.603, $p < 0.0001$) (B). UW, unilateral weakness; VOR, vestibulo-ocular reflex; GA, gain asymmetry.

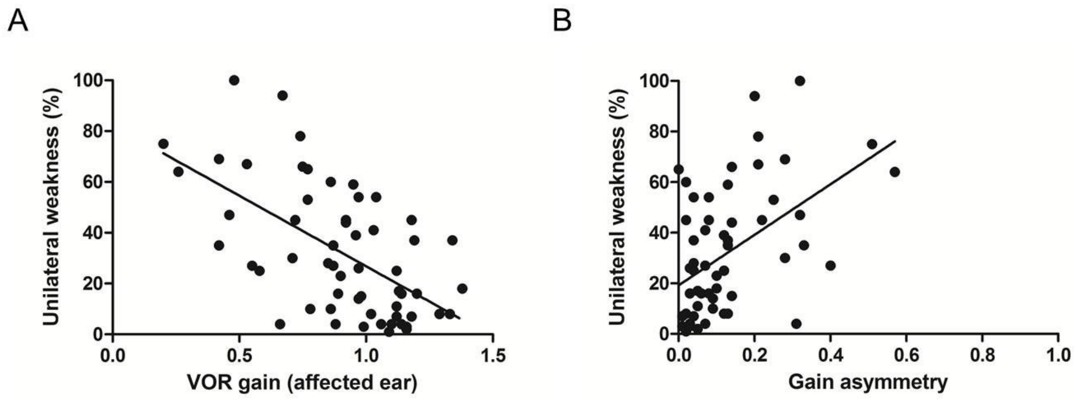

Figure 6. Correlation analysis between UW on bithermal caloric tests and VOR gain of an affected ear (A), and GA (B) on the video head-impulse test in patients with fluctuating vertigo.

Scatter plots show a significant negative correlation between UW and VOR gain (*rho* = -0.560, $p < 0.0001$) (A) and a significant positive correlation between UW and GA (*rho* = 0.483, $p < 0.0001$) (B). UW, unilateral weakness; VOR, vestibulo-ocular reflex; GA, gain asymmetry.

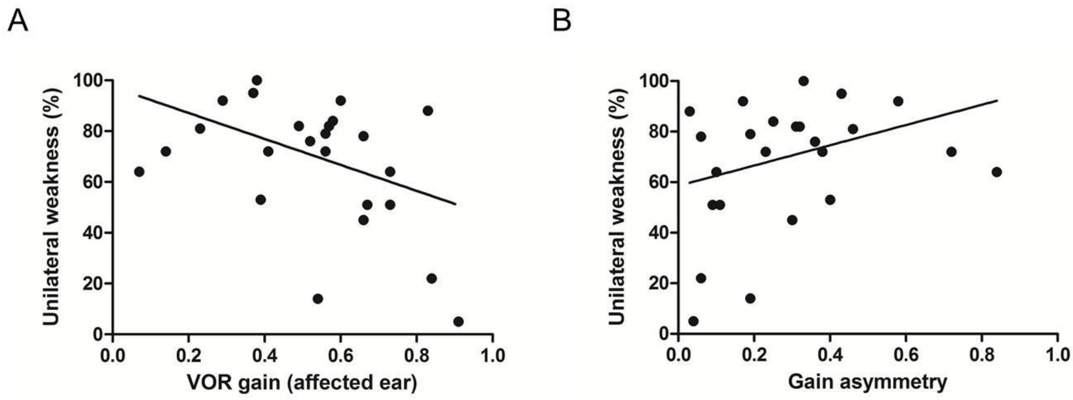

Figure 7. Correlation analysis between UW on bithermal caloric test and VOR gain of an affected ear (A), and GA (B) on video head-impulse test in patients with non-fluctuating vertigo.

Scatter plots show a negative correlation tendency between VOR gain and UW (*rho* = -0.361, *p* = 0.070) (A) and a positive correlation tendency between GA and UW (*rho* = 0.331, *p* = 0.098) (B), which were not statistically significant. UW, unilateral weakness; VOR, vestibulo-ocular reflex; GA, gain asymmetry.

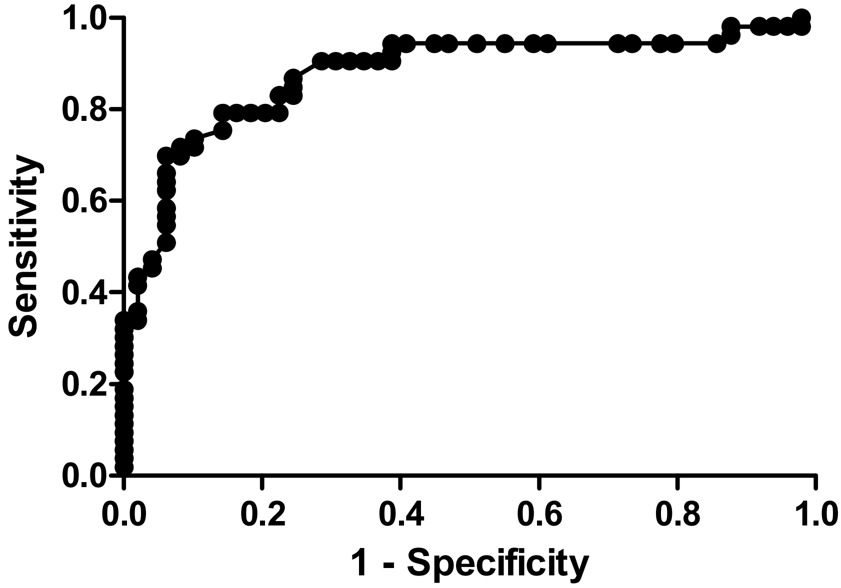

Figure 8. ROC curve. ROC curve of VOR gain is plotted against the reference value of UW.

The area under the curve is 0.8783. The cutoff value of 0.875 provided a sensitivity of 85.7% and a specificity of 79.2%. ROC, Receiver-operating characteristic; VOR, vestibulo-ocular reflex; UW, unilateral weakness.

DISCUSSION

A vHIT is more sensitive and specific than bedside HIT in detecting unilateral vestibulopathy [14]. Moreover, vHIT can be a quantitative method for measuring unilateral vestibular weakness in that a VOR gain for each ear can be an important indicator of vestibular impairment. However, there is a validation issue using a VOR gain of a vHIT as a specific indicator of vestibulopathy, like unilateral weakness in a caloric test. Unilateral vestibular hypofunction has been evaluated using a caloric test although it uses non-physiological vestibular stimulation [15].

Studies comparing vHIT parameters and the caloric test have been performed. Mahringer and Rambold [13] reported that the frequency of vHIT increases with increasing UW although a pathological HIT might depend on disease duration (acute vs. non-acute), the amount of UW in caloric irrigation or a differences in the test itself. Rambold et al. [16] analyzed the relationship between a vHIT and a caloric test in unilateral vestibular neuritis according to the time course. They concluded that there are different parallel recovery processes for vestibular function showing that no linear correlation between the time course of GA or VOR gain of the vHIT with that of the UW of caloric irrigation. In another report, patients with early MD showed a higher gain in rotation toward the affected ear during attack while they displayed a moderate canal paresis on the affected side although they used rotating chair of acceleration of $100°/sec^2$ instead of vHIT [17].

Clinical correlation

Overall, there was a statistically significant correlation between ipsilateral VOR gain of a vHIT and ipsilateral SPV in a caloric irrigation test. However, there was no linear correlation in healthy volunteers. Theoretically, the VOR gain of vHIT in healthy volunteer may be around 1, and it ranged from 0.86 to 1.22 in this study (mean = 1.064, SD = 0.092). However, SPVs in caloric test have much wider range in healthy volunteer. It seems reasonable that there is no linear correlation between the two variables in healthy volunteers.

In dizzy patients, a VOR gain of the affected ear and GA have a statistically significant linear relationship with UW in a caloric response. This may support our hypothesis that when vestibular function decreases, a VOR gain of the affected ear decreases and the GA of a vHIT increases. Moreover, a VOR gain of a vHIT and sum of SPVs showed a statistically significant correlation. This is also consistent with our hypothesis. However, there was no significant correlation between the VOR gain of an unaffected ear and sum of SPVs. This may be for the same reason as in healthy volunteers.

We assumed that there would be a difference in the correlation of the variables of vHIT and the caloric test according to the episodic pattern of vertigo. There was a significant correlation between the parameters of vHIT and the caloric test in patients with fluctuating vestibulopathy but not in patients with non-fluctuating vestibulopathy, which are opposite results to our expectation. But, there was linear correlation tendency although there was no significant correlation between the parameters of vHIT and the caloric test in non-fluctuating vestibulopathy group. If number of the patients in non-fluctuating group were larger, there might be a statistically significant correlation between the parameters of vHIT and the caloric test.

What explains dissociation between a vHIT and a caloric test?

We divided the VOR gain of a vHIT according to 0.88, a value derived from the healthy volunteers. The false negative rate of a VOR gain in a vHIT compared with the caloric test was 21.2%. For a reference, the amount of unilateral caloric weakness needed to ensure a pathological result has been determined to be 40-57% [18-20]. What caused this dissociation? We suggest several possible reasons, as follows.

A vHIT and a caloric test can measure the UW of horizontal semicircular canal function using VOR. However, HIT is examined under a fast head impulse with high frequency [21] whereas a caloric test is measured under bithermal irrigation with much lower frequency, 0.003Hz [22]. All patients showing positive caloric test and negative vHIT are patients diagnosed with RV and MD (Table 4). McGarvie et al. [23] proposed one of possible explanations of dissociated results of vHIT and caloric test in MD. They insisted that there can be endolymphatic circulation within the duct itself, which can reduce effect of thermally induced endolymphatic flow of caloric test.

This hypothesis can apply to our study in that widely known pathophysiology of RV and MD is hydrops of semicircular canals. On the other hand, Park et al. [24] suggested that selective loss of type II hair cells in MD might lead to less sensitive response to caloric tests than HIT. Thus, careful interpretation is needed when it comes to RV and MD patients.

On the other side, there were 6 patients and 1 healthy volunteer showing positive results of a vHIT and negative caloric test results (Table 5). How can we explain in these cases?

There may be a technical issue that the goggles for the vHIT seem to slip on Asian because of the lower dorsum of nose. Moreover, the video system we used in this study can detect only right eyeball movement. To minimize the effect of slippage, we conducted the test 10 times with the goggles fixed as tightly as possible with an additional sponge on the nose. However, those two technical problems were solved in other video oculography devices.

Cutoff value of VOR gain of vHIT

A range of cutoff values of VOR gain of a vHIT has been reported in previous studies, from 0.6 to 0.8 [13, 25, 26]. We determined a cut-off value of 0.875, somewhat higher than in previous reports. This may be because the value was derived under the assumption that a UW in the caloric test equal to or less than 25% is true. However, it can be used as a guide, and provided acceptable sensitivity and specificity versus the caloric response.

Covert saccade of vHIT

A vHIT has higher sensitivity and specificity than bedside HIT in that the test can capture covert saccades. When we analyzed the average score of UW of a caloric test according to the presence of overt or covert saccades, there was an elevated tendency for UW of a caloric test as overt saccade is definite. It can be meaningful although it is a qualitative rather than quantitative analysis.

CONCLUSION

There was a statistically significant correlation between variables of the vHIT and the caloric irrigation tests. A VOR gain of vHIT might be considered as a valuable objective parameter having a lateralization value in evaluating unilateral vestibulopathy. However, considering some dissociation between a vHIT and a caloric test, these tests can be complementary tools for the lateralization of vestibular impairment.

REFERENCES

1. Bhansali SA, Honrubia V. Current status of electronystagmography testing. Otolaryngol Head Neck Surg. 1999 120(3):419-26.

2. Halmagyi GM, Curthoys IS. A clinical sign of canal paresis. Arch Neurol. 1988 45(7):737-9.

3. Beynon GJ, Jani P, Baguley DM. A clinical evaluation of head impulse testing. Clin Otolaryngol Allied Sci. 1998 23(2):117-22.

4. Weber KP, MacDougall HG, Halmagyi GM, Curthoys IS. Impulsive testing of semicircular-canal function using videooculography. Ann N Y Acad Sci. 2009 1164:486-91.

5. MacDougall HG, Weber KP, McGarvie LA, Halmagyi GM, Curthoys IS. The video head impulse test: diagnostic accuracy in peripheral vestibulopathy. Neurology. 2009 73(14):1134-41.

6. Brandt T. Vertigo: its multisensory syndromes. 2nd Ed. London/Berlin/Heidellberg: Springer; 2003.

7. Monsell EM, Balkany TA, Gates GA et al. Committee on hearing and equilibrium guidelines for the diagnosis and evaluation of therapy in Ménière's disease. Otolaryngol Head Neck Surg. 1995 113(3):181-5.

8. Leliever WC, Barber HO. Recurrent vestibulopathy. Laryngoscope. 1981 91(1):1-6.

9. Kim S, Oh YM, Koo JW, Kim JS. Bilateral vestibulopathy: clinical characteristics and diagnostic criteria. Otol Neurotol. 2011 32(5):812-7.

10. Koo JW, Kim JS, Hong SK. Vibration-induced nystagmus after acute peripheral vestibular loss: comparative study with other vestibule-ocular reflex tests in the yaw plane. Otol Neurotol. 2011 32(3):466-71.

11. Lehnen N, Aw ST, Todd MJ, Halmagyi GM. Head impulse test reveals residual semicircular canal function after vestibular neurectomy. Neurology. 2004 62(12):2294-6.

12. MacDougal HG, McGarvie LA, Halmagyi GM, Gurthoys IS, Weber KP. The video head impulse test (vHIT) detects vertical semicircular canal dysfuction. PLoS One 2013 8(4):e61488.

13. Mahringer A, Rambold HA. Caloric test and video-head-impulse: a study of vertigo/dizziness patients in a community hospital. Eur Arch Otorhinolaryngol. 2014 271(3):463-72.

14. Weber KP, MacDougall HG, Halmagyi GM, Curthoys IS. Impulsive testing of semicircular-canal function using video-oculography. Ann N Y Acad Sci. 2009 1164(1):486-91.

15. Shepard NT, Telian SA, Smith-Wheelock M. Habituation and balance retraining therapy: a retrospective review. Neurol Clin. 1990 8(2):459-75.

16. Zellhuber S, Mahringer A, Rambold HA. Relation of video-head-impulse test and caloric irrigation: a study on the recovery in unilateral vestibular neuritis. Eur Arch Otorhinolaryngol. 2014 271(9):2375-83.

17. Maire R, van Melle G. Vestibulo-ocular reflex characteristics in patients with unilateral Meniere's disease. Otol Neurotol. 2008 29(5):693–8.

18. Shepard NT. Caloric weakness needed to achieve a positive head thrust test. In: Transactions of the XXth regular meeting of the Barany society. Amsterdam: Elsevier; 2000.

19. Magnusson M, Karlberg K, Halmagyi M, Hafström A. The video-impulse test enhances the possibility of detecting vestibular lesions. J Vestib Res. 2002 11:231.

20. Perez N, Rama-Lopez J. Head-impulse and caloric tests in patients with dizziness. Otol Neurotol. 2003 24(6):913-7.

21. Jorns-Haderli M, Straumann D, Palla A. Accuracy of the bedside head impulse test in detecting vestibular hypofunction. J Neurol Neurosurg Psychiatry. 2007 78(10):1113-8.

22. Halmagyi GM, Curthoys IS, Cremer PD, et al. The human horizontal vestibulo-ocular reflex in response to high-acceleration stimulation before and after unilateral vestibular neurectomy. Exp Brain Res. 1990 81(3):479-90.

23. McGarvie LA, Curthoys IS, MacDougall HG & Halmagyi GM. What does the dissociation between the results of video head impulse versus caloric testing reveal about the vestibular dysfunction in Ménière's disease? Acta Otolaryngol. 2015 135(9):859-65.

24. Park HJ, Migliaccio AA, Della santina CC, Minor LB & Carey JP. Search-coil head-thrust and caloric tests in Ménière's disease. Acta Otolaryngol. 2005 125(8):852-7.

25. Pérez-Fernández N, Gallegos-Constantino V, Barona-L, leo L, Manrique-Huarte R. Clinical and video-assisted examination of the vestibulo-ocular Reflex: a comparative study. Acta Otorrinolaringol Esp. 2012 63(6):429-35.

26. Blödow A, Pannasch S, Walther LE. Detection of isolated covert saccades with the video head impulse test in peripheral vestibular disorders. Auris Nasus Larynx. 2013 40(4):348-51.

국문 초록

서론: 온도안진검사와 두부충동검사는 어지럼증 환자의 편측 전정기능저하 방향을 진단하는데 있어 중요한 역할을 한다. 비디오 두부충동검사가 도입된 이래로 연구자들은 이 검사의 진단적 가치를 증명하기 위해 노력해왔다. 이에 본 연구에서는 비디오 충동검사의 변수들과 온도안진검사의 변수들을 비교함으로써 비디오 충동검사가 전정기능이상 환자에서 갖는 편측화 가치에 대해 밝히고자 한다.

방법: 19 명의 건강한 자원자와 온도안진검사와 비디오 두부충동검사를 함께 시행한 92 명의 어지럼증 환자를 대상으로 하였다. 환자들은 어지럼증 양상에 따라 두 그룹으로 나뉘었다. 본 연구에서는 비디오 두부충동검사의 전정안구반사 이득 그리고 이득의 편차와, 온도안진검사의 편측 전정기능약화 정도(unilateral weakness) 그리고 냉온수 각각에서의 안진의 느린 성분 속도 (slow-phase velocities)의 합을 비교하였다. 또한 수신기작동특성곡선을 이용하여 비디오 두부충동검사에서 전정안구반사 이득의 분계값(cutoff value)을 구해 보았다.

결과: 비디오 두부충동검사의 이환된 쪽에서의 전정안구반사 이득과 이득의 편차는 온도안진검사의 편측 전정기능약화 정도와 통계적으로 유의한 연관성을 보였다. 또한 비디오 두부충동검사의 변수들은 온도안진검사의 변수들과 어지럼증의 양상이 변동하는 군에서 통계적으로 의미 있는 상관관계를 보였다. 온도안진검사의 편측 전정기능약화정도를 25% 이하가 정상이라고 가정했을 때, 비디오 두부충동검사의 분계값은 0.875 로 정하여졌다.

결론: 비디오 두부충동검사의 전정안구반사 이득 또는 이득의 편차는 편측 전정기능이상 환자를 평가하는데 있어 유용한 변수로 생각된다. 또한 비디오 두부충동검

사는 편측 전정기능저하의 방향을 결정하는 데에 상호보완적인 정보를 제공하리라 기대된다.

주요어 : 두부충동검사, 온도안진검사, 현훈, 수신기작동특성곡선

학 번 : 2014-22204