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Clinical implication of cervical vestibular evoked myogenic potentials in benign paroxysmal positional vertigo

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HIGHLIGHTS

- Multivariable analysis was performed to determine relation of cVEMP parameters to prognosis of benign paroxysmal positional vertigo (BPPV).
- Decreased cVEMP interaural amplitude difference (IAD) ratio on the affected side was related to resistance of BPPV to the repositioning maneuver.
- Affection of the posterior semicircular canal is also related to resistance of BPPV to the repositioning maneuver.

ABSTRACT

Objectives: To evaluate the value of cervical vestibular evoked myogenic potential (cVEMP) as a prognostic factor for benign paroxysmal positional vertigo (BPPV).

Methods: We reviewed 65 patients with BPPV who underwent cVEMP. Patients were divided into two groups according to resistance to the repositioning maneuver. Univariable and multivariable analyses were performed with age, gender, affected semicircular canal, affected side and cVEMP parameters to find the associated factors for resistance to the repositioning maneuver.

Results: From univariable analysis, cVEMP interaural amplitude difference (IAD) ratio, the affected semicircular canal and the affected side showed a better association ($p < 0.10$) with resistance to the repositioning maneuver. With multivariable analysis, decreased cVEMP IAD ratio at the affected side ($\leqslant -25\%$) ($p = 0.043$, OR = 4.934) and the posterior semicircular canal ($p = 0.049$, OR = 3.780) remained as associated factors.

Conclusions: Decreased cVEMP IAD ratio at the affected side is associated with resistance to the repositioning maneuver. BPPV patients with decreased cVEMP IAD ratio at the affected side have a higher likelihood of their BPPV persisting after a single repositioning maneuver.

Significance: cVEMP test may provide a prognosis of BPPV. A decreased cVEMP IAD ratio at the affected side may be prognostic of BPPV not resolving after a single repositioning maneuver.

1. Introduction

Vestibular evoked myogenic potentials (VEMPs) are electromyographic responses originating from the vestibule by sound or vibration stimulation (Colebatch and Halmagyi, 1992). There are two types of VEMP, namely the cervical VEMP (cVEMP) and ocular VEMP (oVEMP) (Murofushi et al., 2011). cVEMPs and oVEMPs are supposed to reflect the otolith-colic reflex (Colebatch and Halmagyi, 1992; Colebatch et al., 1994) and the otolith-ocular reflex, (Rosengren et al., 2005; Chihara et al., 2007) respectively. oVEMP was relatively recently proposed as a potential test of vestibular function (Chihara et al., 2007; Iwasaki et al., 2007; Todd et al., 2007). Several studies are still ongoing to discover the physiology and clinical applications for oVEMPs (Rosengren et al., 2013; Rosengren and Kingma, 2013; Dennis et al., 2016). In comparison, cVEMPs were first described in 1992 (Colebatch and Halmagyi, 1992) and they are part of a basic neuro-otological test (Rosengren and Kingma, 2013).

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The reflex pathway of cVEMP includes the saccule, inferior vestibular nerve, vestibular nucleus and vestibulospinal tract (Murofushi, 2016), and cVEMP has been used to evaluate the various diseases related to these organs. The two representative diseases are the Meniere's disease and vestibular neuritis, which respectively include the saccule and inferior vestibular nerve in their pathogenesis. In addition, cVEMP can also be used to evaluate benign paroxysmal positional vertigo (BPPV), which is one of the most common peripheral vestibular disorders (Nedzelski et al., 1986; Strupp and Brandt, 2013). BPPV is caused by the entrance of otoconia into the semicircular canals (Zappia, 2013), and otoconia are supposed to originate from a degenerating saccule or utricle (Welling et al., 1997; Gacek, 2003; Korres et al., 2011; Hoseinabadi et al., 2016; Singh and Apeksha, 2016). The state of saccule or utricle can be evaluated with cVEMP and oVEMP, respectively. Several studies have consequently been performed to evaluate the clinical implication of cVEMP in BPPV (Akkuzu et al., 2006; Hong et al., 2008; Korres et al., 2011; Longo et al., 2012; Lee et al., 2013; Sreenivasan et al., 2015; Hoseinabadi et al., 2016; Singh and Apeksha, 2016; Xu et al., 2016). Most of these studies reported the BPPV patients showing abnormal cVEMPs more frequently than normal subjects. Some studies have also looked into whether cVEMPs are associated with prognosis of BPPV (Longo et al., 2012; Lee et al., 2013; Xu et al., 2016). However, there is still a debate on the value of cVEMP as a prognostic factor for BPPV.

Although BPPV has a benign nature, dizziness experienced by a patient during BPPV can lead to a catastrophic situation. This experience could be a risk factor for development of anxiety disorders, which leads to persistent psychogenic dizziness (Eagger et al., 1992; Pollak et al., 2003). To prevent this, psychological support including a comprehensive explanation about the disorder should be offered to the patients (Heinrichs et al., 2007). However, there is no definite test or parameter that can predict the disease course of BPPV. Therefore, if a test or parameter that can predict the prognosis of BPPV is developed, it can contribute to patient care. In the present study, we aimed to evaluate the value of cVEMP as a prognostic factor for BPPV.

2. Materials and methods

2.1. Patients

The patients were part of a retrospective analysis; they were diagnosed with canalithiasis type of BPPV between April, 2011 and March, 2016 and underwent a cVEMP test within 7 days after diagnosis at our tertiary care center. Those who were diagnosed with secondary or bilateral BPPV or had treatments prior to being tested were not included. This study was approved by the institutional review board (IRB) of our medical center (C2016060-1803). The diagnosis of BPPV for the affected side was determined based on the typical nystagmus seen during the positioning maneuver. The patients were treated with repositioning maneuvers that moved the otoconia out of the affected semicircular canal and into the vestibule. The patients with posterior semicircular canal BPPV (PSC-BPPV) or lateral semicircular canal BPPV (LSC-BPPV) were treated with Epley's maneuver or barbecue roll maneuver, respectively. A Total of 65 patients with canalithiasis type of BPPV were included in this study. The patients were comprised of 17 men and 48 women, with a mean age of 53.1 years (range, 17–79 years). Forty-seven patients were diagnosed with PSC-BPPV and 18 patients were diagnosed with LSC-BPPV. Thirty-three patients were affected at right side and 32 patients were affected at left side (Table 1).

We assessed resistance to the repositioning maneuver as a prognostic factor for BPPV. The results of repositioning maneuvers defined two groups: group 1 and 2. The patients whose BPPV was resolved after a single repositioning maneuver belonged to group 1. The patients whose BPPV was not resolved after a single repositioning maneuver belonged to group 2. The repositioning maneuver was performed on the day when the patient was diagnosed with BPPV. A recovery from BPPV was determined by checking the nystagmus during the positioning maneuver at the following outpatient clinic. In case BPPV was not resolved after the repositioning maneuver, the proper repositioning maneuver was performed again.

Table 1
Clinical characteristics of patients.

Characteristic	All patients ($n = 65$)	Group 1 ($n = 17$)	Group 2 ($n = 48$)
Age	53.1 (14.0)	57.0 (9.6)	51.7 (15.1)
Gender			
Male	17	5	12
Female	48	12	36
cVEMP			
p13 latency (ms)	16.5 (2.2)	16.5 (2.4)	16.3 (1.9)
n23 latency (ms)	24.1 (2.3)	24.3 (2.3)	24.1 (2.2)
Interpeak latency (ms)	7.6 (1.6)	7.8 (1.7)	7.8 (1.7)
p13–n23 amplitude (μV)	74.3 (56.2)	67.7 (31.8)	76.7 (62.9)
IAD ratio			
−25% < IAD ratio < 25%	32	12	20
IAD ratio ⩽ −25%	22	3	19
IAD ratio ⩾ 25%	11	2	9
Affected SCC			
Lateral canal	18	8	10
Posterior canal	47	9	38
Affected side			
Right	33	5	28
Left	32	12	20

All values are either mean (standard deviation) or number of patients. Group 1 was composed of patients whose BPPV was resolved after a single repositioning maneuver. Group 2 was composed of patients whose BPPV was not resolved after a single repositioning maneuver. One patient in group 1 and 4 patients in group 2 showed no cVEMP response. Measurement of p13 latency, n23 latency, interpeak latency and p13–n23 amplitude was excluded in those patients. IAD ratio was defined as follows: (affected side ear amplitude − unaffected side ear amplitude) ÷ (affected side ear amplitude + unaffected side ear amplitude).
cVEMP = cervical vestibular evoked myogenic potential; IAD = interaural amplitude difference; SCC = semicircular canal.

2.2. Vestibular evoked myogenic potential

cVEMP was performed following the internationally suggested guidelines (Papathanasiou et al., 2014). Surface electromyographic (EMG) activity was recorded using Navigator Pro (Bio-logic Systems, Mundelein, IL, USA). The subjects were tested at sitting position with their head in rotation. The amount of sternocleidomastoid muscle (SCM) contraction (30 mmHg) was monitored with a self-monitored feedback method using a blood pressure manometer with inflatable cuff (Vanspauwen et al., 2006a,b; Suh et al., 2009). The active, reference, and ground electrodes were placed on the upper third of the SCM, the upper border of the sternum, and the glabella, respectively. Acoustic stimuli (short tone bursts; 500 Hz, 95 dB HL, 5.1 times/s) were delivered through inserted earphones. The rise-plateau-fall times were 1–2–1 ms. The EMG signal from each side was amplified and band-pass filtered between 10 and 1500 Hz. Typically, 200 responses in each ear were averaged. The latencies of each peak (p13 and n23), interpeak latencies (ms) and p13–n23 amplitudes (μV) were measured. To estimate the relative response of the affected side of the ear, we modified the IAD ratio. The "original" IAD ratio was defined as follows: (right side ear amplitude − left side ear ampli-