ความหมายของการทดสอบ Side-lying ในการวินิจฉัยโรคเวียนศีรษะ

Benign Paroxysmal Positional Vertigo

นางเสาวรส อัศววิเชียรจินดา

สถาบันวิทยบริการจุฬาลงกรณ์มหาวิทยาลัย

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ลิขสิทธิ์ของจุฬาลงกรณ์มหาวิทยาลัย
DIAGNOSTIC ACCURACY OF SIDE- LYING TEST FOR DIAGNOSIS
BENIGN PAROXYSMAL POSITIONAL VERTIGO (BPPV)

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Thesis Title
Diagnostic Accuracy of Side-lying test for diagnosis
Benign Paroxysmal Positional Vertigo (BPPV)

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Health Development

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ปีการศึกษา 2548.

ลำนำชื่อ นิติกิตติ์

ลำนำชื่อ อาจารย์ที่ปรึกษา

ลำนำชื่อ อาจารย์ที่ปรึกษาร่วม
Objective: To determine sensitivity, specificity, likelihood ratio of side-lying test for diagnosis Benign paroxysmal positional vertigo when compare to Dix-Hallpike test.

Design: A diagnostic cross-sectional study.

Setting: Dizziness and hearing clinic, Department of Otolaryngology, Faculty of Medicine, Chulalongkorn University.

Method: Eighty-six dizzy patients, who experience vertigo not more than one month were assessed for having benign paroxysmal positional vertigo (BPPV). Both Dix-Hallpike maneuver and side-lying test were done under the computerized video electronystagmography. The diagnostic performance of side-lying test was analyzed using Dix-Hallpike test as the gold standard. During the procedure, the examiner recorded for the adverse events.

Result: There were 86 patients (60 females, 26 males) enrolled into the study with age range from 19 to 79 (mean 54.1 yrs) years. The prevalence of BPPV in this study was 49 (57%). Sensitivity was 89.8% (81.3-98.6), specificity was 89.2% (79.2 - 99.2), accuracy was 85.5%, positive predictive value, negative predictive value and likelihood ratio were 91.7%, 86.8% and 8.3 accordingly. There was no significant difference in adverse events. Subgroup analysis shows more prevalence rate in higher age. The sensitivity is also higher in older group, in contrast to specificity which was extremely high in younger age group.

Conclusion: Side-lying test had relatively high diagnostic performance for diagnosis benign paroxysmal positional vertigo when us Dix-Hallpike maneuver as a gold standard. Side-lying test may be an alternative for diagnosis BPPV.

Field of study Health Development
Academic year 2005
Advisor’s signature
Co-advisor’s signature
ACKNOWLEDGEMENTS

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CHAPTER I
INTRODUCTION

RATIONALE AND BACKGROUND

Positional vertigo is a common symptom that usually indicates a benign inner ear disorder. The most common variety, is benign paroxysmal positional vertigo (BPPV). BPPV is a clinical condition characterized by transient episodes of vertigo when the affected ear is in the dependent position. Although first described by Barany in 1921,[1] the specific characteristics of this disorder were defined in 1952 by Dix and Hallpike who advised a positioning maneuver to diagnose BPPV.

Among patients seen in a general internal medicine outpatient clinic[2] and in subspecialty dizziness clinics,[3,4] vertigo was the most frequent category of dizziness, and BPPV was the most common cause of vertigo. Symptoms of BPPV are triggered by head movement. Most of the episodes occur when the patient gets in and out of bed, leans back, bends over, or looks up.[5] The estimate incidence of BPPV is 160,000 new cases per year in the United States.[6]

BPPV has long been recognized, only recently has its underlying pathophysiology been clarified and substantiated.[7,8,9] Free-floating particulate matter with the posterior semicircular canal of the vestibular labyrinth has been observed in vivo in several patients with this disorder.[9,10] This finding led to the development of an innovation bedside treatment in which the free-floating particles are moved from the posterior semicircular canal to another location within the vestibular labyrinth.[6,11,12] This maneuver provide the patient with immediate, and long-lasting, relief from vertigo.[13,14]
BPPV has a significant impact on health-related quality of life and particle repositioning maneuver improves health-related quality[15] of life a lot. Therefore, the diagnosis of BPPV or differentiation BPPV from the other causes of dizziness is very important. BPPV is characterized by positional vertigo and by positional nystagmus elicited by head-hanging maneuver, usually called the Dix-Hallpike maneuver.[15,16,17] The Dix-Hallpike maneuver is widely used in the diagnosis of BPPV. The diagnosis is based on findings of typical positional rotatory nystagmus provoked by the head-hanging position and the observation of certain characteristic features including a brief latency (usually 1 to 5 sec), limited duration (usually < 60 sec), reversal on assuming an upright position and a fatiguing of the response on repeat testing. In the head-hanging left-ear down position, the nystagmus occurs in a clockwise direction, on the head-hanging right ear down position, the direction is counter clockwise.

Although Dix-Hallpike maneuver has several advantages, this maneuver also has some disadvantages. Many patients have difficulty relaxing enough to allow brisk passive movement of the head backward for fear of eliciting vertigo. The maneuver needs cervical range of motion. In a case of musculoskeletal limitation or obesity it is very difficult to perform and in some neck condition it may be contraindicated. Moreover, the biomechanics of the maneuver could strain the clinician’s back. An alternative test to use for diagnosis BPPV with comparable result will be beneficial for patients with limited range of neck motion or who are contraindicated for Dix-Hallpike maneuver.

To produce positioning nystagmus, one must understand the mechanism of how nystagmus is evoked. The lateral head-trunk tilt or side-lying maneuver is another way to stimulate the inner ear balance organ thus producing nystagmus. This maneuver stimulates the posterior semicircular canal by similar biomechanics. However, the validity and the usefulness of the maneuver have not been clearly demonstrated.
The purpose of this study is to assess the diagnostic performances i.e. sensitivity, specificity, likelihood ratio and other diagnostic property of side lying test regard to the gold standard Dix-Hallpike test for diagnosis BPPV.
CHAPTER II
REVIEW OF LITERATURES

Benign paroxysmal positional vertigo (BPPV) is the most common cause of vertigo, particularly in elderly. This condition is characterized by brief attacks of rotatory vertigo and concomitant positioning rotatory nystagmus which are elicited by rapid changes in head position relative to gravity.[18] It is common after colds, trauma, surgery, ear infections and is seen frequently in association with other inner ear disorders. However, many cases are idiopathic.

Epidemiology

BPPV had been said to be the most commonly recognized peripheral vestibular disorder. In one cohort study, the mean age at onset was 54 years, with a range of 11 to 84 years.[17] Froehling et al, estimated that the incidence is as high as 107 cases per 100,000 population per years.[2] Another study in Japan in which patients were considered to have benign paroxysmal positional vertigo only if had nystagmus during a Dix-Hallpike test found an incidence of 10.7 cases per 100,000 per year.[19] In another report by Katsarkas and Kirkham[15], the mean age of their 255 patients was 50 years, in the 240 patients described by Baloh and colleagues,[17] reported that the prevalence of BPPV in their dizziness clinic increased with advancing age.[20]

The prevalence of BPPV according to our previous study in Dizziness and Hearing clinic, Department of Otolaryngology, Faculty of Medicine, King Chulalongkorn Memorial Hospital was approximately 40 percent of all dizzy patients visited to clinic.[30]

There was some sex predominance in the study reported by Baloh and his colleagues. They found female outnumbered males by a ratio of 1.6:1 combining all diagnostic categories. This ratio was approximately 2:1 if one considers only the idiopathic and miscellaneous groups.
Cohort study, in Olmsted country, Minnesota, gender was not significantly associated with the incidence of BPPV. The age-adjusted incidence for women was 75 per 100,000 populations and that for men was 50 per 100,000.[6]

Pathophysiology

The mechanism creating the typical phenomena of nystagmus has long been a source of speculation. Dix and Hallpike described that in the majority of BPPV cases nystagmus occurred when the affected ear was placed undermost in the provocative position. This verified that the labyrinth is the origin of this mechanism.

There are two theories regarding to pathophysiology of BPPV. Cupulolithiasis and canalithiasis. Cupulolithiasis theory by Schuknecht who discovered basophilic particle or densities that were adherent to the cupula and postulated that the posterior semicircular canal (PSC) was rendered sensitive to gravity by these abnormal dense particle.[3,4] The posterior semicircular canal localization of this theory was verified in 1974 by the success of Gacek's singular neurectomy[21] but the heavy (adherent) copular has been brought into question for several reasons. Most important, physiologic principles dictate that gravity dependent defection of a cupular would continue as longe as the provocative orientation was maintained, thus evoking sustained nystagmus. This has been demonstrated by studies in which a density differential is created between the endolymph and the cupula by ingestion of alcohol or deuterium, resulting in nystagmus which is lasted for hours while the provocative head position is maintained.[22] In contrast, nystagmus in BPPV persists for only a few seconds and then abruptly ceases. So, this means that nystagmus of BPPV is not generated directly by the effect of gravity on a heavy cupula.

Another theory is canalithiasis. Hall et al. in 1979 proposed that those BPPV subjects that demonstrate response decline with repetitive provocation are due to free densities in the endolymph[7], In 1980 Epley indicated that the phenomena observed in patients with nystagmus were explainable by the presence of free floating particle in
the PSC created by gravity while the head is tilted backward, the particles are rotated up approximately 90 degree along the arm of the PSC. These cause the endolymph to flow away from the cupula and causes the cupula to be deflected and produces nystagmus.[8,9,10]

Pathophysiology of provocative position. When the head is moved to the tested position, the debris begin gravitating as a bolus. This well lead to an ampullofugal, thus depolarization occur. A few seconds are required for the drug to overcome the inertia and resistance of the endolymph within the canal and the elasticity of the cupula. This will lead to some latency before the rotatory nystagmus occurs. And when the canaliths stop gravitating or the drag on the endolymph ceases, elasticity returns the cupula to its neutral position, and the nystagmus and vertigo cease. So this call limited duration. During the simulation period the torsional nystagmus with its axis generally parallel to the axis of the PSC and its fast phase directed toward the undermost ear. (typical rotatory nystagmus) (fig 2.1)

Clinical Manifestation [11,12,22,13]

BPPV patients generally have two components of clinical symptom. The most initial symptoms at the onset is positionally induced vertigo without cochlear symptoms, such as tinnitus and hearing impairment. Positional vertigo was induced by moving the head. The classic scenario is an intense brief episode of spinning when getting up or lying down and also rolling over in bed. Vertigo also commonly occurs in a lesser degree when the patient is gazing upward or bending forward. The first attack of
Vertigo is often severe and associated with nausea, with or without vomiting. An unexpected intense vertigo at the initial onset may be frightening and may bring BPPV patient to an immediate visit at the emergency room. The duration of the vertigo is commonly short (no more than 60 seconds) but to many patients it feels like much longer. The interval between episodes many rang from hours to years.

The second component of symptoms is disequilibrium that is reported with movements. Some BPPV patients will present that they feel drunk when trying to walk with sensation they are going to fall to one side. They may sometimes say that they have noticed the phenomenon of adaptation and can make their dizziness to disappear by avoiding their head from provocative position.

One symptom of interest is of discomfort, and it may be of tenderness in the affected occipital region. However, this symptom is only presented in some cases.

**Differential Diagnosis**

The differential includes positional nystagmus of central origin, vestibular neuronitis, Meniere's disease, perilymphatic fistula and autoimmune inner ear disease.
The characteristic of other common vestibular disorder are shown in table 2.1

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Duration of Rotatory Vertigo</th>
<th>Rotation with Hearing Loss</th>
<th>Aural Fullness</th>
<th>Fluctuating Hearing</th>
<th>Tinnitus</th>
<th>Trauma</th>
</tr>
</thead>
<tbody>
<tr>
<td>BPPV</td>
<td>&lt;Minute</td>
<td>Position changes</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>Sometimes</td>
</tr>
<tr>
<td>Meniere's</td>
<td>Hours</td>
<td>No</td>
<td>Usually unilateral association</td>
<td>Usually</td>
<td>Usually</td>
<td>No</td>
</tr>
<tr>
<td>PLF</td>
<td>Minutes-hours</td>
<td>Physical straining unilateral</td>
<td>Sometimes</td>
<td>Sometimes</td>
<td>Sometimes</td>
<td>Usually</td>
</tr>
<tr>
<td>AIED</td>
<td>Hours</td>
<td>No</td>
<td>Progressive bilateral</td>
<td>Sometimes</td>
<td>Sometimes</td>
<td>None</td>
</tr>
</tbody>
</table>

Table 2.1 Characteristic of common fluctuating vestibular disorders

It is also important to consider whether the position vertigo and nystagmus is idiopathic or occurring in association with central nervous system.

From the report by Mohr[6], none of the 100 patients described by Dix-Hallpike test had central pathologic lesions.

**Etiologic Factors**

The major factors apparently predispose a person to have BPPV are: advanced age, trauma, inactivity and other ear diseases.

Most of the report in literatures review, noted that the average age of BPPV patient is above 50. This is probably related to the shedding of otoconia from the utricular macula that starts with middle age. This process can be accelerated by an untoward event such as trauma or infarction including ear surgery, severe head acceleration or deceleration such as whiplash injury or high-impact exercises.
BPPV had been reported after condition such major surgery, acute alcoholism and central nervous system disease, in which the common denominator is prolong inactivity of the head.

Last factor, 20 percent of BPPV is concomitant ear pathology, usually involving other manifestations of inner ear trauma.

**Clinical Evaluation and Diagnosis.**\[6,24,26,28\]

A diagnosis of benign paroxysmal positional vertigo can be established definitively by the Dix-Hallpike Maneuver. The physical exam in BPPV patients is generally normal with the exception of this test. The Dix-Hallpike test is performed by having the patient lie prone with the head turned approximately 45 degrees to the side being tested and slightly hanging over the edge of the examining table. During this, the eye are observed for nystagmus. A normal exam should demonstrate no evidence of nystagmus, and the patient should experience no vertigo. The diagnostic criteria includes the occurrence during the Dix-Hallpike test of a characteristic mixed torsional and vertical nystagmus with the upper pole of the eye beating toward the dependent ear and vertical nystagmus beating toward the forehead.

The presence of BPPV will elicit vertigo and nystagmus with five major characteristics:

1. latency of onset, usually 2-6 seconds
2. short duration, usually less than 30 seconds
3. reversibility
4. fatigability
5. direction (torsional)

Throughout the abnormal Dix-Hallpike test, BPPV patient will be fine at the beginning when getting to the prone position, but after a short latency period of 2-6 seconds, the nystagmus will occur. At the same time, the feeling of spinning will occur if nystagmus presented. The nystagmus and vertigo may last anywhere from a few
seconds to a minute. The nystagmus is rotatory movement of the eyes. For those BPPV of right ear will exhibit nystagmus with a fast phase in the counterclockwise direction (geotropic nystagmus, upper pole of the eye moving toward the ground). For those BPPV of left ear, the fast phase of the nystagmus is in the clockwise direction (geotropic nystagmus).

The reversal of nystagmus can be demonstrated when patient is brought back to the upright position, but usually in milder degree. This is called reversibility (ie. If patient has right side BPPV, the right Dix-Hallpike test would produce a counterclockwise nystagmus. When patient is brought back to the upright position, he will have clockwise nystagmus of lesser degree).

Repeated Dix-Hallpike test will result in progressively milder degree of both nystagmus and vertiginous symptom. This is called fatigability. If Dix-Hallpike test was repeated one can see less intense of nystagmus and less severe of vertigo. By the third or fourth repetition, the Dix-Hallpike test will demonstrate no evidence of nystagmus and patient will no longer note vertigo.

The steps for a correct diagnosis of BPPV is base on temporary history of positional rotatory vertigo, postural imbalance and also the presence of a reproducible vertigo and paroxysmal positioning nystagmus by Dix-Hallpike test which should be performed under Frenzel’s glasses or during electronystagmography. A precise diagnosis is very
important in view of specific treatment of this type of vertigo by rehabilitation therapy.[24]

Advantages of Dix-Hallpike maneuver

This maneuver has several advantages. One examiner can perform it easily. The eye movement can be recorded through electro-or video-oculography, or simple observed using Frenzel glasses.

Disadvantages of Dix-Hallpike maneuver

This maneuver also has some disadvantages. First, many patients have difficulty relaxing enough to allow brisk passive movement of the head backward for fear of eliciting vertigo. Secondly, the patient need cervical range of motion within functional limits and enough range in the trunk and hips to lie supine. Many patients are difficult to test as a result of musculoskeletal limitation or obesity. Lastly, the biomechanics of the maneuver could strain the clinician’s back.

Contraindication for Dix-Hallpike maneuver

Limitations in passive or active range of motion preclude testing some patients suspected of BPPV with Dix-Hallpike maneuver includes.[28,29]

a) Severe cervical spondylosis
b) Post cervical injury or operation
c) Cervical instability
d) Musculoskeletal limitations ie. rheumatoid arthritis, obesity
e) Relative contraindication in vertebrobasilar insufficiency
Analysis Data from Thai Physician [30]

Analysis of the survey data from Thai physicians during the contemporary management strategies for vertigo meeting, in 2004 revealed that most of physicians (including otolaryngologists, neurologists, and family doctors) felt uncomfortable with Dix-Hallpike test in those especially with severe cervical spondylosis or undergone cervical spine injury or operation. They also commended on the limitation of Dix-Hallpike test which need well trained physicians (42 percent). Ninety percent of physicians looked forward to another more comparable test. (test 2.2)

Table 2.2 the opinion of Thai Physicians regard to Dix-Hallpike test.

<table>
<thead>
<tr>
<th>Reason not doing Hallpike maneuver</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never be trained</td>
<td>1</td>
<td>3.85</td>
</tr>
<tr>
<td>Too difficult, take long time</td>
<td>21</td>
<td>80.77</td>
</tr>
<tr>
<td>Afraid of complication</td>
<td>4</td>
<td>15.38</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>26</strong></td>
<td><strong>100.00</strong></td>
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</table>

<table>
<thead>
<tr>
<th>Limitation of Dix-Hallpike test</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can be use only well trained ENT</td>
<td>21</td>
<td>42.00</td>
</tr>
<tr>
<td>Can be use generally</td>
<td>25</td>
<td>50.00</td>
</tr>
<tr>
<td>Too complicate, should have another test instead</td>
<td>4</td>
<td>8.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>50</strong></td>
<td><strong>100.00</strong></td>
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### Contraindication of Dix-Hallpike test

<table>
<thead>
<tr>
<th>Condition</th>
<th>Frequency</th>
<th>Percent</th>
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<tbody>
<tr>
<td>Severe cervical spondylosis</td>
<td>11</td>
<td>40.74</td>
</tr>
<tr>
<td>Vertebral-basilar insufficiency</td>
<td>1</td>
<td>3.70</td>
</tr>
<tr>
<td>Recent cervical injury or operation</td>
<td>15</td>
<td>55.56</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>27</strong></td>
<td><strong>100.00</strong></td>
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### If there is another test can be used instead of Dix-Hallpike test

<table>
<thead>
<tr>
<th>Opinion</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agree</td>
<td>16</td>
<td>31.37</td>
</tr>
<tr>
<td>Agree if sensitivity and specificity have been tested</td>
<td>30</td>
<td>58.83</td>
</tr>
<tr>
<td>Disagree (Dix-Hallpike test is complete do not need another test)</td>
<td>5</td>
<td>9.80</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>51</strong></td>
<td><strong>100.00</strong></td>
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</table>

### Laboratory recordings

Rotatory eye movement during Dix Hallpike test cannot be directly identified by electronystagmography (ENG). Because ENG detects eye movement centering on the dipole through the pupil, the tracing pattern of the nystagmus varies with the gaze positional of the pupil. The horizontal channel tracing of nystagmus in the BPPV patient shows the fast phase directed toward the uppermost ear whenever the volitional pupillary position is inferior to the axis of rotation. However, the nystagmus of BPPV subject is more rotatory component that is very difficult to record by ENG. So the ENG is not recommend to be a standard laboratory recording. Infrared videoelectronystagmography is more useful for the test. The eyes can be recorded directly through this method.[24,26,27]
Side-lying test

Although Dix-Hallpike test is the gold standard test for BPPV. This maneuver has several disadvantages and there is some contraindication to perform this. The need for alternative test that is more simple to perform, adaptable for patients with limited range of motion or who has difficulty relaxing. The Side-lying test or Side-lying maneuver which also stimulates the posterior semicircular canal using different biomechanics is performed by briskly laying the patient on the side. (fig 2.3)

There is only one study that compare the side-lying test and Dix-Hallpike test.[29] In this study only 29 BPPV patients are reviewed from 61 study subjects. These was no mention why others were drop out. The technique used in this study was ENG (Electronystagmography) and the timing of each test (Side-lying and Dix-Hallpike was only 5 minutes). Also, There was no statistic report concerning the accuracy of the Side-lying test (ie. Sensitivity, specificity, likehood ration) as recommend by the STARD statement for reporting studies of diagnosis test.[31]

Therapy for Benign Paroxysmal Positional Vertigo [5,11,12,13,14]

Vestibular habituation exercise or the repositioning therapy are an effective treatment for patient with typical BPPV. Pharmacologic treatment with vestibular suppressant is generally ineffective.[32] Surgical interventions-singular neurectomy and posterior semicircular canal occlusion are effective, but are reserved for patient with intractable conditions who do not respond to conservative treatment.[33,34]
There are three basic repositioning therapy for BPPV, each with its own indications for use: canalith repositioning, Liberatory and Brandt-Daroff habituation exercise (Epley, 1992; Semon et al, 1988; Brandt and Daroff, 1980). Many studies on the efficacy of these treatment demonstrated that all three treatment facilitate recovery.

**Canalith repositioning Procedure (CRP)**

This therapy is based on the theory of canalithiasis that the transient nystagmus is exclusively caused by densities moving freely in the endolymph of a semicircular canal. CRP was instituted at the Portland Otologic clinic in 1979 as the treatment of choice for BPPV. The rational of CRP is depend on the moving of the debris (canaliths) particle to migrate by gravitation completely out of the PSC, by way of the common crus, to the utricle, where they no longer would affect the dynamics of the semicircular canals. The timing of CRP is based on ongoing observation of the induced nystagmus by Dix Hallpike test, which reflects the direction and rate of induced canalith migration. An oscillation device is applied throughout the procedure to minimize adherence of the canaliths and decrease their angle of repose relative to the side walls of the semicircular canal. The 5 position cycle for treatment of BPPV with classic nystagmus is illustrated in fig 2.4 This procedure is repeated until no nystagmus is observed during the last cycle, or until no progress is apparent in the last two cycles.

Epley's initial publication on the use of bedside treatment for BPPV reported an 80 percent success rate after a single treatment and a 100 percent success rate when there was more than one treatment session. Other following clinical trial reported success rate that rang from 44 percent to 88 percent.[5,11,14,35,36]
Semont maneuver

In 1988, Semont et al introduced a single libratory maneuver\cite{37} (fig 2.5). This maneuver require only a single sequence, making them preferable to the multiple repetitions over other repositioning maneuver. Fig 2.5 illustrates the semont maneuver in a patient with typical (posterior canal) left-side BPPV. The clot causes no deflection of the cupula in the upright position. When the patient quickly tilted toward the affected left ear with a 45° head rotation to the right (moving the left posterior canal to a plane corresponding to the plane of the head tilt), the clot gravitates toward the lower part of the canal, causing the cupula to deflect downward (ampulofugal), and triggering a typical BPPV attack. If the patient is swung toward the opposite right-side with the nose down, the clot will gravitate downward, causing stimulation of the posterior canal of the affected ear. The patient is then slowly moved to the upright position, the clot will gravitate downward through the common crus of the posterior and anterior canals and enter the utricular cavity, where it becomes harmless. Semon et al recommended having the patient maintain the upright position for 48 hours following the therapy.\cite{37}
Brandt-Daroff exercise

This exercise requires the BPPV patient to move repeatedly into the provoking position several times a day. Remission of vertigo occurs in 95 percent, however recovery is gradual and may take several weeks.[13]

The patient moves quickly into the side-lying position on the affected side and stays in that position until the vertigo stops and an additional 30 seconds. The patient
then sits up and wait for the vertigo to subside. The patient then repeats the movement to the opposite side, stay there for 30 seconds, and sit up. The entire treatment is repeated several times, usually three times a day until the patient has 2 days with no vertigo. (fig 2.6)

In conclusion, there are three highly effective therapy for BPPV. The Epley maneuver and Semont Liberatory maneuver are easily performed by a physician. The Brandt-Daroff exercises are simple for patient use.

Summary

BPPV is the most common cause of vertigo, particularly in elderly. By age 70, about 30% of all elderly subjects have experienced BPPV at least once. This condition is characterized by brief attacks of rotatory vertigo and concomitant positioning rotatory nystagmus which are elicited by rapid changes in head position relative to gravity.

There are two theory regarding to pathophysiology of BPPV. Cupulolithiasis and Canalithiasis. Cupulolithiasis theory by Schuknecht who discover basophilic particle or densities that were adherent to the cupula and postulated that the posterior semicircular canal (PSC) was rendered sensitive to gravity by these abnormal dense particles. [3,4] Another theory is Canalithiasis by Epley. This theory consist of free-moving densities in the PSC rather than fixed densities attacked to the cupula. While the head is tilted backward, the particles are rotated up approximately 90 degree along the arm of the posterior semicircular canal. These cause the endolymph to flow away from the cupula and causes the cupula to be deflected and produces nystagmus. [8,9]

The steps for a correct diagnosis of BPPV is based on typical history of positional rotatory vertigo, postural imbalance and also on the presence of a reproducible vertigo and paroxysmal positioning nystagmus by Dix-Hallpike test which should be performed under Frenzel’s glasses or during electronystagmography (ENG) recording. A precise diagnosis is very important in view of specific treatment of this type of vertigo by rehabilitation therapy.
The current gold standard of diagnosing BPPV is the Dix-Hallpike test.\cite{1,3} The maneuver is performed by rapidly placing the patient in the lateral supine position with the head hanging below the level of the horizontal plane. This position causes the endolymph to flow away from the ampulla and causes the cupula to be deflected and produce nystagmus. The result is considered positive if the position elicits rotatory nystagmus and vertigo that last for less than 1 minute, are fatigable and are associated with a several seconds latency. When the patient sits up, secondary nystagmus could occur. The special and temporal characteristics of the provoked nystagmus are crucial for diagnosis BPPV.\cite{24,28,29}

Although, the Dix-Hallpike maneuver is mandatory for diagnosis BPPV, there are many limitation to perform this test. Many patients who have cervical spine problem i.e. severe cervical spondylosis, post cervical spine injury or surgery, musculoskeletal limitations, obesity or in patient who have difficulty relaxing enough to allow brisk passive movement of the head backward for fear of eliciting severe vertigo.

Analysis of the survey data from Thai physicians during the Contemporary management strategies for vertigo meeting, in 2004, revealed that most of physicians felt uncomfortable with Dix-Hallpike test in some cases especially those with severe cervical spondylosis or undergone cervical spine injury or operation. They also commented on the limitation of Dix-Hallpike test which need well trained physicians. Ninety percents of physicians look for another more comparable test.\cite{30}

Lateral head trunk tilt or side-lying maneuver which have been introduced by Cohen is another method to examine BPPV patient. The procedure, adapted from Nylen, involve briskly laying the patient on the side which will stimulate posterior semicircular canal by different biomechanics.

There has been quite only one study regard to alternative test for Dix-Hallpike maneuver. In this study, the study design was prospective, within group in tertiary care diagnostic laboratory center. They planed to do prospective, but actually the records
were reviewed after the test. The data from 61 patients were available only 31 patients. The explanation of this problem was not clear and there could be some bias concerning this matter. Additionally, from 31 patients they calculated only 29 patients that had positive nystagmus. And, only 15 patients had classic response. Furthermore, eye movements were recorded with electrode (ENG) recording which was demonstrated in earlier clinical experiences that contribution of electrode ENG to the diagnosis of BPPV is rather poor, as only half of the cases showed a nystagmus by recording. Finally, the timing effect could not be excluded in methodology because the interval between Side-lying and Dix-Hallpike test maneuver was only 5 minutes. The fatigabilitity effect of nystagmus response when doing repeated testing maneuver had already mention in the literature. Inconclusion, the disadvantages of previous paper induced bias selecting the population, too small sample size, poor method of measurement and methodology and also lack of information on negative tests.

It would be helpful if diagnostic test was all backed by sound date comparing its accuracy to an appropriate standard.[31,38] In this case, Side-lying test should be compare with Dix-Hallpike test in disease populations as well as non-disease population. In study of diagnostic accuracy, the outcomes from test under evaluation are compared with outcome form the reference standard in this case the Dix-Hallpike maneuver. The goal of all clinical studies describing the value of diagnostic test should be obtain data for all possibility (include disease, non disease) without all these data, it is not possible to answer important questions concerning the performance of the tests.[38,39,40,41]
CHAPTER III
RESEARCH DESIGN

Research Questions

• Primary research question
  What is the diagnostic accuracy of Side lying test for diagnosis Benign Paroxysmal Positional Vertigo as compare to Dix-Hallpike test?

• Secondary research question
  - Are there any difference in the adverse events during and after performing these two test?

Research Objectives

• Primary objective

• Secondary objective
  - To compare the adverse events of Dix-Hallpike and Side-lying test
CONCEPTUAL FRAMEWORK

Benign Paroxysmal Positional Vertigo
BPPV.

Pathophysiology
“Cupulolithiasis”
“Canalolithiasis”

Dix-Hallpike test
Side-lying test

Positional nystagmus
Classic positional nystagmus for BPPV
- brief latency (1-5 second)
- limited duration (< 60 second)
- geotropic rotatory nystagmus
- accompany with rotatory vertigo

Diagnosis of BPPV.
OPERATION DEFINITION

BPPV benign paroxymal positional vertigo is a disease of semicircular canal which occurs as an degeneration process. The typical characteristic of disease is positional vertigo last for seconds.

Dix-Hallpike maneuver (test) is the standard clinical test for BPPV. It is performed by having the patient lie prone with the head turned approximately 45 degrees to the side being tested and slightly hanging over the edge of the examining table. During this, the eyes are examined for nystagmus. The findings of classic rotatory nystagmus with latency and limited duration is concerned pathognomonic. (Figure 2.2)

Side-lying maneuver (test) The patient sits on the bed with the legs over the side and the head is rotated 45 degrees horizontally away from the labyrinth to be tested. The patient then quickly lies down on the side opposite to the direction the head is turned. The patients is asked to report any vertigo and is observed for nystagmus. (figure 2.3)

Positive test result. criteria for positive test result includes
1. nystagmus that occur in brief latency (1-5 second)
2. nystagmus has limited duration (<60 second)
3. the characteristic of nystagmus has to be geotropic rotatory pattern
4. accompany with rotatory vertigo

Nystagmus in defined as involuntary eye movements usually trigger by inner ear stimulation. It usually begins as a slow pursuit eye movement followed by a fast, rapid resetting phase.
**Adverse events** of the test is the symptom presenting during or after the test which includes.

- **Severity of vertigo**
  - no: no serious vertigo
  - grade I: vertigo with nausea
  - grade II: vertigo with nausea and vomiting

- **Neck pain define as**
  - no: no neck pain or root pain
  - grade I: neck pain alone
  - grade II: neck pain and root pain

**Infrared Video Electronystagmography**

Infrared Video electronystagmography is a method of recording eye movement which use infrared laser to record the eye movement during many procedure of testing and calculate the result by computerized machine.

**RESEARCH DESIGN**

Descriptive, cross-sectional study, diagnostic test
CHAPTER IV  
RESEARCH METHODOLOGY  

POPULATION AND SAMPLE

Target population
Dizzy patients

Study population
Dizzy patients with history of positional vertigo who attended the Dizziness and Hearing clinic, Department of Otolaryngology, King Chulalongkorn Memorial Hospital, and met all the eligible criteria.

Eligible criteria
- Inclusion criteria
  - Dizzy patients age from 18 to 80 years old.
  - Patients who have the dizzy spell onset not more than one month.
  - Agree to participate in the study and sign the informed consent.

- Exclusion criteria
  - Patients with neck problem, in whom the hyperneck extension is contraindicated such as severe neck pain, severe cervical spondylosis, prolapsed intervertebral disc, severe rheumatoid arthritis with cervical instability
  - Dizzy patients who are undertaken antivertigo medication or central nervous system suppressive drug.

Sample size [38,39]

To determine how many subjects should be recruited in order to meet the purpose of the study, the sample size calculations are required. Sample size
calculations require some arbitrary assumptions such as the level of statistical confidence.

Since BPPV has a significant impact on health-related quality of life and diagnosis can lead to improve health-related quality of life a lot by effective repositioning physical therapy. It is expected that sensitivity of the test (side-lying) to identity BPPV is about 90% with 10% allowable error. In a prevalence study confined to one population, the formula for calculating sample size using 95% confidence interval is:[52]

\[
n = \frac{Z^2 \cdot PQ}{d^2}
\]

\(n = \) number of BPPV patients  
\(p = \) expected sensitivity of test \(= 0.90\)  
\(Q = 1 - p\)  
\(d = \) accepted error of sensitivity \(=0.10\)  
Where \(\alpha = \) type I error \(= 0.05\)  
\(Z_{0.025} = 1.96\)

Thus \(n = \frac{(1.96)^2 \cdot (0.90 \times 0.1)}{(0.1)^2}\)  
\(n = 34.5744\)

According to our previous study, the data from statistic records of dizzy patients in Dizziness and Hearing clinic[42], Department of Otolarygology, Faculty of Medicine, King Chulalongkorn Memorial Hospital, the prevalence rate of BPPV was about 0.4. Therefore, the required sample size would the be approximately.

\[
\text{Sample size} = \frac{n}{\text{Prevalence}} = \frac{34.5744}{0.4} = 86.43
\]
Therefore, the required sample size would be approximately = 86 subjects

PROCEDURE

Dizzy patients who come to the Dizziness and Hearing clinic at Department of Otolaryngology, King Chulalongkorn Memorial hospital, were underwent a complete examination and bedside vestibular test including ear, nose and throat examination, oculomotor test, Romberg’s test and tandem gait test.

Patients who met the inclusion criteria were randomly allocated into two groups by simple randomization. Gr.I, Subjects were first given standard Dix-Hallpike maneuver, and then were tested with Side-lying maneuver. In group II, subjects were tested with side-lying maneuver and then Dix-Hallpike maneuvers. In order to eliminate the timing effect the interval between Side-lying and Dix-Hallpike maneuver was 60 minutes.

Dix-Hallpike maneuvers was performed in standard manner. Each subject head was turned with the nose pointing 45° toward the side being tested. The subject was moved briskly into supine-lying, with the neck hyperextended approximately 20° under ENG eye goggle video-recording. The onset and duration of nystagmus were recorded, as well as the severity of vertigo and any adverse events of the maneuver. Then, the patient was asked to sit up and recording of nystagmus and vertigo was done again. (Fig 3.2)

For Side-lying test, the patient sat on the bed with the legs over the side and the head was rotated 45 degrees horizontally away from the labyrinth to be tested. The patient then quickly lied down on the side opposite to the direction the head was turned. The patient was asked to report any vertigo and was observed for nystagmus. The onset and duration of nystagmus as well as the symptom of vertigo were recorded under ENG eye goggle video-recording. Then, the subject was assisted to sit up. (Fig 3.3)
RESEARCH ADMINISTRATION SCHEME

Dizzy patients

- Patient baseline
- Age, gender
- Systemic disease
- Onset of vertigo

Randomly allocated

Gr I Dix-Hallpike test

(60 min)
Rest

Pattern of nystagmus
Onset and duration of nystagmus
Severity of vertigo
Severity of Neck pain

Side-lying test

Dix-Hallpike Test

Gr II Side-lying test

(60 min)
Rest

Figure 4.1 research administration scheme
OUTCOME MEASUREMENT

**Main outcomes**: proportions of positive and negative test result of Dix-Hallpike test and Side-lying test

- Test results of Side-lying test (primary outcome)
- Test results of Dix-Hallpike test (primary outcome)
- Adverse events of Side-lying test (secondary outcome)
- Adverse events of Dix-Hallpike test (secondary outcome)

**Primary outcome variable**

- The presence or absence of nystagmus (onset and duration of nystagmus are recorded under infrared video electronystagmography goggles)
- Positive test result defined as typical (Classic) positional nystagmus response which includes
  1. brief latency (1-5 second)
  2. limited duration (< 60 sec)
  3. nystagmus characteristic of geotropic rotatory nystagmus
  4. accompany with rotatory vertigo

**Secondary outcome variable**

- Severity vertigo define as the symptom of dizziness sensation during or immediate after the two test
  - no: no serious vertigo
  - grade I: vertigo with nausea
  - grade II: vertigo with nausea and vomiting
- Neck pain is define as
  - no: no neck pain or root pain
  - grade I: neck pain alone
  - grade II: neck pain and root pain
DATA COLLECTION

Case record form was generated for each subject and recorded by research assistant. All the data included:

1. Demographic data, baseline characteristics:
   - Age (yrs)
   - Gender
   - Last vertigo attack
   - History regard to etiology
   - Severity of vertigo

2. Main outcomes:
   The outcome variables were recorded as
   Intra testing findings:
   - Positive test result was judged as the presence of geotropic rotatory or horizonto-rotatory nystagmus accompany with vertigo during the test, paroxysmal positional nystagmus had four characteristic:
     1. It was usually delayed in onset (1-5 seconds)
     2. It was always transient (duration < 60 seconds)
     3. Nystagmus characteristic of geotropic rotatory nystagmus
     4. It was always accompanied by vertigo (rotatory vertigo)

The presence of nystagmus including slow phase velocity and latency were calculated by electronystagmography computerized machine.

- Adverse events
  1. Intractable vertigo (No, grade I, grade II)
  2. Neck pain, root pain (No, grade I, grade II)
All of the measured variable including administrate variables, baseline variable, test results and adverse events are tabulated in table 4.1

**Table 4.1 summary of measured variable**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Scale</th>
<th>Description statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administrative variables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Name</td>
<td>Nominal</td>
<td></td>
</tr>
<tr>
<td>• Identification no</td>
<td>Nominal</td>
<td></td>
</tr>
<tr>
<td>• Address</td>
<td>Nominal</td>
<td></td>
</tr>
<tr>
<td>Baseline variables/covariates</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Age (yr)</td>
<td>Continuous numerical</td>
<td>Mean ± SD</td>
</tr>
<tr>
<td>• Sex</td>
<td>Two categorical</td>
<td>N (%)</td>
</tr>
<tr>
<td>• Last vertigo attack</td>
<td>Ordinal categorical</td>
<td>N (%)</td>
</tr>
<tr>
<td>• Severity of vertigo</td>
<td>Ordinal categorical</td>
<td>N (%)</td>
</tr>
<tr>
<td>• History regard to etiology</td>
<td>Dichotomous categorical</td>
<td>N (%)</td>
</tr>
<tr>
<td>Outcome variables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Result of the test</td>
<td>Dichotomus categorical</td>
<td></td>
</tr>
<tr>
<td>• Severity of vertigo</td>
<td>Ordinal categorical</td>
<td>N (%)</td>
</tr>
<tr>
<td>• Neck pain</td>
<td>Ordinal categorical</td>
<td>N (%)</td>
</tr>
</tbody>
</table>
DATA ANALYSIS

General Considerations

The statistical analysis was focused on the accuracy of the new test (Side lying test) as compare to gold standard test (Dix Hallpike maneuver).

The statistical analysis was performed using SPSS for windows, release 11.0.1 (SPSS, Inc).

Plan for statistical data Analysis

Baseline characteristic

Baseline characteristic (age, gender, when was the last vertigo attack, occurrence of vertigo) will be performed by descriptive statistics.

Primary objective

- Diagnostic performance[40,41,43,44,45]

Statistical analysis was performed to compare the result (whether test positive or not) of the test between Dix Hallpike test and side lying test and were reported in terms of sensitivity, specificity, positive prediction value, negative predictive value, accuracy and likelihood ratio.

<table>
<thead>
<tr>
<th>Gold Standard (Dix-Hallpike test)</th>
<th>positive</th>
<th>negative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Side lying test</td>
<td>a</td>
<td>b</td>
</tr>
<tr>
<td>positive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>negative</td>
<td>c</td>
<td>d</td>
</tr>
</tbody>
</table>

Sensitivity is the proportion of positives that are correctly identified by the test.

Sensitivity = \( \frac{a}{a+c} \)
**Specificity** is the proportion of negatives that are correctly identified by the test.

Specificity  =  \[ \frac{d}{d+b} \]

95% CI for sensitivity  =  \[ \left( \frac{a}{a+c} \right) \pm 1.96 \sqrt{\frac{(a/a+c)(c/a+c)}{a+c}} \]

95% CI for specificity  =  \[ \left( \frac{d}{b+d} \right) \pm 1.96 \sqrt{\frac{(d/b+d)(b/b+d)}{b+d}} \]

**Positive predictive value** is the proportion of patients with positive test results who are correctly diagnosed.

positive predictive value  =  \[ \frac{a}{a+b} \]

**Negative predictive value** is the proportion of patients with negative test results who are correctly diagnosed.

negative predictive value  =  \[ \frac{d}{d+c} \]

**Accuracy**  =  \[ \frac{a+d}{a+b+c+d} \]

**Likelihood ratio** = \[ \frac{\text{Prob (positive test / disease)}}{\text{Prob (positive test / no disease)}} = \frac{\text{Sensitivity}}{1-\text{Specificity}} \]

= \[ \frac{a}{(a+c)/b+(b+d)} \]

Secondary objective

- Adverse events of the test

The adverse events of the test including severe vertigo and neck pain will be reported and compared as percentage of cases.
ETHICAL CONSIDERATION

This study was conducted in accordance with the ethical principles and was approved by the ethical committee of Faculty of Medicine, Chulalongkorn University. All the subjects were thoroughly informed prior to recruitment into the study concerning the following items:

- Purposes and method of the study
- Outcome and benefits of the study
- Any possible side effects
- Patients’ right to refuse to participate in the study or withdraw from the study at anytime, without affecting their proper medical care.

The informed consent document containing a statement defining that the consent was freely given and had to be sign for every subject. (Appendix II)
CHAPTER V
RESULT OF THE STUDY

Baseline and Demographic data

From eighty-two dizzy patients who met the eligible criteria, only 86 were enrolled into the study during April 2005-February 2006 at Department of Otolaryngology, Faculty of Medicine, Chulalongkorn University. Six patients were dropped because four of them could not wait for long process, other two developed other significant and unrelated health condition a. Among 86 patients in the final sample, 60 were female and 26 were male. The range of age was 19-79 years old with mean of 54.1 years (table 5.1). Other baseline characteristics included the last vertigo attack, occurrence of vertigo and any history regard to etiology were shown in table 5.1 in form of percentage in each group.

Table 5.1 Baseline characteristics and demographic data

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Number of subject</th>
<th>Age in years (mean ± SD)</th>
<th>Sex</th>
<th>Side</th>
<th>When was the last vertigo attack</th>
<th>Occurrence of vertigo</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>86</td>
<td>54.1 ± 13.9</td>
<td>male (number (%))</td>
<td>right (number (%))</td>
<td>&lt;3 days</td>
<td>25 (29.1%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>female (number (%))</td>
<td>left (number (%))</td>
<td>3-7 days</td>
<td>19 (22.1%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>female : male</td>
<td></td>
<td>1-2 weeks</td>
<td>33 (38.4%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&gt;2 weeks</td>
<td>9 (10.5%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>17 (19.8%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>many times 58 (67.4%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>just come only once 11 (12.8%)</td>
</tr>
</tbody>
</table>
Table 5.1 Baseline characteristics and demographic data (cont.)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Any history regard to etiology</td>
<td></td>
</tr>
<tr>
<td>no</td>
<td>83 (96.5%)</td>
</tr>
<tr>
<td>previous head trauma</td>
<td>3 (3.5%)</td>
</tr>
</tbody>
</table>

Table 5.2 age distribution of patients

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>Number of cases</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 20</td>
<td>1</td>
<td>1.2</td>
</tr>
<tr>
<td>20-29</td>
<td>4</td>
<td>4.7</td>
</tr>
<tr>
<td>30-39</td>
<td>5</td>
<td>5.8</td>
</tr>
<tr>
<td>40-49</td>
<td>23</td>
<td>26.7</td>
</tr>
<tr>
<td>50-59</td>
<td>23</td>
<td>26.7</td>
</tr>
<tr>
<td>60-69</td>
<td>18</td>
<td>20.9</td>
</tr>
<tr>
<td>70-79</td>
<td>12</td>
<td>14.0</td>
</tr>
<tr>
<td>Total</td>
<td>86</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Table 5.2 Shows age distribution in the study group. Predominant age range are 40-49 (26.7%), 50-59 (26.7%) and 60-69 (20.9%). The distribution of age can also be seen by histogram 5.1
Outcomes Analysis

Primary objective analysis

Outcomes performance

86 study subjects were tested by using Dix Hallpike test as a gold standard and by side-lying test as a new diagnostic test. Dizzy subjects with present nystagmus were classed as positive cases, and those found absent nystagmus were classed as negative cases.

The number of dizzy patients and BPPV patients diagnosed by Dix Hallpike test were shown in table 5.3

There were 44 cases who had positive test result both Dix-Hallpike and Side-lying test. As well as those 33 negative cases in both tests. The 4 cases of negative Dix Hallpike test but positive Side lying test result includes 2 cases of lateral canal BPPV, one cases of Meniere’s disease and one case of vestibular neuritis.
Table 5.3 Result of the tests

<table>
<thead>
<tr>
<th>Side lying test</th>
<th>Dix Hallpike (gold standard)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Positive disease</td>
<td>Negative disease</td>
</tr>
<tr>
<td>Positive result</td>
<td>(a) 44</td>
<td>(b) 4</td>
</tr>
<tr>
<td>Negative result</td>
<td>(c) 5</td>
<td>(a) 33</td>
</tr>
<tr>
<td>Total</td>
<td>49</td>
<td>37</td>
</tr>
</tbody>
</table>

The diagnostic performance

The sensitivity is the proportion of positive that are correctly identified by the test

Sensitivity = a/(a+c) = 44/(44+5) = 0.898 = 89.8 percent

The specificity is the proportion of negative that are correctly identified by the test

Specificity = a/(a+b) = 33/(4+33) = 0.892 = 89.2 percent

Other diagnostic performance are shown in table 5.4

Table 5.4 Diagnostic performance

<table>
<thead>
<tr>
<th>Diagnostic characteristics</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>a/(a+c)</td>
</tr>
<tr>
<td></td>
<td>89.8 (81.3 to 98.6)</td>
</tr>
<tr>
<td>Specificity</td>
<td>d/(b+d)</td>
</tr>
<tr>
<td></td>
<td>89.2 (79.2 to 99.2)</td>
</tr>
<tr>
<td>Accuracy</td>
<td>(a+d)/(a+b+c+d)</td>
</tr>
<tr>
<td></td>
<td>89.5</td>
</tr>
<tr>
<td>Positive predictive value (PPV)</td>
<td>a/(a+b)</td>
</tr>
<tr>
<td></td>
<td>91.7</td>
</tr>
<tr>
<td>Negative predictive value (NPV)</td>
<td>d/(c+d)</td>
</tr>
<tr>
<td></td>
<td>86.8</td>
</tr>
<tr>
<td>Likelihood ratio</td>
<td>a/(c+a) / b/(b+d)</td>
</tr>
<tr>
<td></td>
<td>8.3</td>
</tr>
</tbody>
</table>

The sensitivity of Side-lying test using Dix-Hallpike test as the gold standard was relatively high (89.8%) as well as the specificity (89.2%). The probability that the subjects with a positive test result would have benign paroxysmal positional vertigo (positive predictive value) was 91.7% and the probability that an individual with a negative test result would not have benign paroxysmal positional vertigo (negative predictive value) was 86.8%. The chance of test positive if the subject has disease (likelihood ratio) is 8 times to the chance of a positive result of the subject does not
have disease. A high likelihood ratio for a positive result reveals that this test provides beneficial information.

The Prevalence of BPPV

Prevalence = \( \frac{(44+5)}{(44+4+5+33)} = 0.57 = 57 \text{ percent} \)

False positive rate = \( \frac{4}{(4+33)} = 0.108 \)

False negative rate = \( \frac{5}{(44+5)} = 0.102 \)

By using Dix-Hallpike test as the gold standard, the prevalence of benign paroxysmal positional vertigo in this study was 57 percent, False positive rate is 10.8 percent and false negative rate is 10.2 percent.

Sub-group analysis

When we divided the patients into two groups according to their age whether they are younger than 50 years old (<50) or equal and older than 50 year old (50-80 years old). The diagnostic performance was analyzed in 33 dizzy patients in gr I. and 53 patients in group II.

The test result of gr I and gr II were shown in table 5.5

Table 5.5 outcome findings in gr I (age < 50 years old)

<table>
<thead>
<tr>
<th>Side lying test</th>
<th>Dix Hallpike (gold standard)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Positive disease</td>
<td>Negative disease</td>
</tr>
<tr>
<td>Positive result</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>Negative result</td>
<td>3</td>
<td>19</td>
</tr>
<tr>
<td>Total</td>
<td>14</td>
<td>19</td>
</tr>
</tbody>
</table>
Table 5.6 outcome findings in gr II (age ≥50 years old)

<table>
<thead>
<tr>
<th>Side lying test</th>
<th>Dix Hallpike (gold standard)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Positive disease</td>
<td>Negative disease</td>
</tr>
<tr>
<td>Positive result</td>
<td>33</td>
<td>4</td>
</tr>
<tr>
<td>Negative result</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td>35</td>
<td>18</td>
</tr>
</tbody>
</table>

Table 5.7 Diagnostic performances of two groups.

<table>
<thead>
<tr>
<th>Characteristic of test</th>
<th>Age &lt; 50 (percent)</th>
<th>Age ≥ 50 (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>78.6</td>
<td>94.3</td>
</tr>
<tr>
<td>Specificity</td>
<td>100.0</td>
<td>77.8</td>
</tr>
<tr>
<td>False positive rate</td>
<td>0.0</td>
<td>22.2</td>
</tr>
<tr>
<td>False negative rate</td>
<td>21.4</td>
<td>5.7</td>
</tr>
<tr>
<td>Accuracy</td>
<td>90.9</td>
<td>88.7</td>
</tr>
<tr>
<td>Positive predictive value (PPV)</td>
<td>100.0</td>
<td>89.2</td>
</tr>
<tr>
<td>Negative predictive value (NPV)</td>
<td>86.4</td>
<td>87.5</td>
</tr>
<tr>
<td>Prevalence</td>
<td>42.4</td>
<td>66.0</td>
</tr>
</tbody>
</table>

The diagnostic performance of patients in group I (age <50) demonstrated that the specificity of the side-lying test is very high (100 percent) and the false positive rate was zero. Also the positive predictive value was 100 percent.

In group II (age > 50), the sensitivity of the test is higher than gr I, but the specificity is lower. There is still high false positive rate (22.2 percent) in this group.

The prevalence rate of disease (BPPV) was 42.4 percent in group I and slightly higher in group II (66 percent).

Secondary objective analysis

The secondary objective is to compare adverse events of Dix-Hallpike test and Side-lying test.
Table 5.8 shows the adverse event as define by severity of vertigo during the test and neck pain and root pain.

Table 5.8 Summary of adverse events

<table>
<thead>
<tr>
<th>Adverse events</th>
<th>Dix-Hallpike test</th>
<th>Side-lying test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severity of vertigo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• No (number (%))</td>
<td>74 (86.1%)</td>
<td>76 (88.4%)</td>
</tr>
<tr>
<td>• grade I</td>
<td>12 (13.9%)</td>
<td>10 (11.6%)</td>
</tr>
<tr>
<td>• grade II</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>neck pain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• no (number (%))</td>
<td>85 (98.8%)</td>
<td>86 (100%)</td>
</tr>
<tr>
<td>• grade I</td>
<td>1 (1.2%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>• grade II</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
</tr>
</tbody>
</table>

Severity of vertigo during the test is slightly higher during Dix-Hallpike test (13.9%) as compare to side-lying test (11.6%).

Another side effect of the test is neck pain. During the Dix-Hallpike test, one patient complaint of neck pain (1.2%). There is no adverse event regarding to neck pain during the Side-lying test.
CHAPTER VI
DISCUSSION

Baseline and Demographic data

Similar to other studies[4,6,17,19] in the literature, the average age of BPPV in this study was 54.1 yrs and more BPPV patients in advance age group.

The characteristic epidemiologic features of BPPV as shown in table 5.1. The age distribution is range from 19 year old to 79 years old. The predominant age distribution was 40 to 50 and 50 to 60 and the trend was more parentage of BPPV in older age than in younger age.

According to gender distribution, The female preponderance of BPPV was previously observed by Katsarkas and Kirkham [15] of their 255 cases, 175 were females and only 80 were males. In this study, female outnumbered male 2.3 to 1. Possibly, hormonal factor are important in the cause of idiopathic BPPV. Assuming that Schuknecht’s cupulolithiasis theory is correct, metabolic changes in the calcium carbonate crystals of the otolithic membrane in females could be important in the pathophysiology of BPPV. There was no side predominance.

Of our 86 patients, three (3.5 percent) reported having head trauma before the onset of symptoms and the diagnosis of BPPV. Similarly, 17 percent of the patients described by Katsarkas and Kirmah [15] and 18 percent of those in Baloh and associated study [17] had prior head trauma. From this study design, however did not allow as to address the relative risk of BPPV associated with prior head trauma.

Discussion of outcome analysis [48,49,50,51]

The purpose of this study is to determine the diagnostic accuracy of side-lying test for diagnosis BPPV using the Dix-Hallpike as a gold standard.
To determine how good of diagnostic test depends on the ability of the test to differentiating disease from non-diseased subjects. The fundamental way to consider is that where patients can be classified into two groups according to the result of Dix-Hallpike test, as the positive or negative of disease. Table 5.3, which shows the relation between test of interest here is how good is the side-lying test at diagnosis of benign paroxysmal positional vertigo.

Firstly, to compute the proposition of patients with presence and absence disease diagnosed by Dix-Hallpike maneuver. There are 49 positives and 37 negative. The proportions of there two groups that have correct diagnosis on side-lying test are $44/49 = 0.898$ (sensitivity) and $33/37 = 0.892$ (specificity) respectively. The accuracy of side-lying test is 89.5 percent. Therefore, we can say that from this study, one would expect nearly 90% of patients with benign paroxysmal positional vertigo to have positive side-lying test, as well as nearly 90% of those with no disease would have negative side-lying test. There range of 95% CI for the sensitivity (81.3-98.6) and specificity (79.2 to 99.2) are relatively wide. These could be due to the sample population. If the number of sample is increased, one can expect to see the 95% CI of sensitivity and specificity more narrow.

However, the main point of a diagnostic tool is to use it to help making a diagnosis, so we need to know what is the chance of the test giving the correct result, whether it is positive or negative. The sensitive and specialty do not give this information. So one should approach the data from the direction of the test result.[46,47,48]

Of the 48 subjects with positive side-lying test, 44 had benign paroxysmal positional vertigo. Therefore the positive predictive value or the proportion of subjects with positive test result who are correctly diagnosed is $44/48 = 0.917$ Likewise, among the 38 subjects with negative side-lying test the proposition of correct diagnose was $33/38 = 0.868$. 
From this study, side-lying test give a rather high positive predictive value and negative predictive value. This mean that it is useful in clinical practice. Nevertheless, the predictive value are depend on the prevalence. The prevalence of benign paroxysmal positional vertigo in this study was relatively high (57 percent). Thus, making the predictive value are very high value. In other clinical setting where the prevalence of BPPV is not as high as this sitting, the predictive values might be deferent.

At last, the likelihood ratio which defined as the likelihood of that test result in the diseased group divided by likelihood of the same test result in the non-diseased group. Likelihood expresses how many times more (or less) likely a test result is to be found in disease, compared with non diseased population.[48]

The positive likelihood ratio in this study is 8.3 which verified that an individual with BPPV is 8.3 times more likely to have test positive than in normal population. This high likelihood ratio for a positive result has verified that side-lying test provides useful information.

Subgroup analysis

Benign proxysenal positional vertigo are the most common vestibular disorder. In one cohort study, the mean age at onset was 54 years, with a range of 11 to 84 years[4,6]. Many other study found that BPPV associated with old age or caused by degeneration. In this study, we found the mean age was approximately 54.1 years like other study and the age range was between 19-79 years.

Considering the age effect, we had divided dizzy subjects into two group according to their age. Group I age range from 19 to 50 years old, and group II age is equal or above 50 years. We decided the age cut off point is 50 years old because when we consider that BPPV is more affected middle to old age group and it is more likely to effect female. So it could be related to hormonal deficiency in menopausal group.
The diagnostic performances in group I were high specificity, zero false positive rate and very high positive predicative value. These means that if one whose age below 50 years had a positive side lying test, one probable had a high chance to has BPPV. However if this test is used as the screening test for diagnosis BPPV in dizzy population. It is suitable for people age above 50 (higher sensitivity).

The prevalence of disease was different in two groups. The higher incidence was found in those whose age is equal or above 50 years similar to other study that BPPV is usually occurred in middle to old age population. However, the subgroup analysis was not planned before study, all the result and interpretation of the analysis should be considered carefully.

Secondary objective analysis

When compare the adverse events between Dix-Hallpike test and side-lying test, there is slightly difference regarded to the severity of vertigo. During Dix-Hallpike maneuver, some subjective experienced feeling of severe vertigo (13.9%), slightly lighter than during the side-lying test (11.6%).

As the neck pain during the test was concerned, there is only one case reported during Dix-Hallpike maneuver (1.2%).

The adverse events during the two tests is not statistically significant. This could be due to the small number of the subjects or because of the exclusion criteria that we excluded the dizzy subjects who had cervical spondylosis or neck problem.

Limitation

This study may have limitation on generalizability. Firstly, because the study was performed at the Dizzy clinic, department of Otolaryngology, Faculty of Medicine, Chulalongkorn University which is the tertiary care center. The prevalence rate of BPPV is relatively high compare to general outpatient clinic. Secondly, to study diagnostic
performance of a test the tester or who interpret the result should be blind. In our study, even the result is computerized by electronystagmography machine, still needed interpreter decide whether the test is positive or negative. Moreover, we could not blind the examiner who performed the test.

All of these have some power on the result of the diagnostic performance of the test.

CONCLUSION

The sensitivity, specificity, accuracy as well as other diagnostic performance of Side-lying test is relatively high for diagnosis benign paroxysmal positional vertigo use Dix Hallpike as a gold standard.

The information obtained from this study yields Side-lying can be alternative choice for diagnosis BPPV if Dix Hallpike is contraindicate. The adverse events during these two test procedure were not much different including the neck pain. However, all the subjects in this study had no history of neck problem (ie. cervical spondylosis, neck injury or surgery, limitation of neck movement).

Further study which aims to demonstrate the usefulness of Side-lying test in those who have neck problem is recommended to evaluate whether Side-lying test is an perfect alternative to Dix Hallpike test in that situation or not.
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สถาบันวิทยบริการ
จุฬาลงกรณ์มหาวิทยาลัย
โครงการการศึกษาความแม่นยำของการทดสอบ Side-lying ในการวินิจฉัยโรค Bênign Paroxysmal Positional Vertigo (BPPV)

โรค Bênign paroxysmal positional vertigo (BPPV) หรือโรคหินปูนในหูชั้นในเคลื่อนเป็นโรคที่มีสาเหตุของอาการเวียนศีรษะที่พบได้บ่อยที่สุด โรคนี้มักเกิดจากอาการเวียนศีรษะ เมื่อมีการเคลื่อนไหวศีรษะ เช่น ล้มตัวลงนอน ลุกจากที่นอน ก้ม เล่น อาการเวียนศีรษะจะมีการเวียนศีรษะแบบหมุน ตามทิศทางการเคลื่อนไหว อาการ อาการเวียนศีรษะจะมีอาการเวียนศีรษะแน่นอน เมื่อมีการเคลื่อนไหวศีรษะในท่าเดิม

โรคเวียนศีรษะชนิดหินปูนในหูชั้นในเคลื่อนนี้ในทางพยาธิวิทยาจะพบความผิดปกติในอวัยวะการทรงตัวของหูชั้นใน โดยพบตะกอนหินปูนที่เป็นแสดงชีเม.ctx (Calcium Carbonate) อยู่บริเวณ หรือหลุดออกจากที่เดิม ซึ่งจะทำให้เกิดอาการเวียนศีรษะ

ในการรักษาโรคนี้ ปัจจุบันทำให้การรักษาโดยวิธีกายภาพเพื่อเคลื่อนตะกอนหินปูนให้เข้าสู่การปกติ (Repositioning maneuver) เป็นการรักษาที่ได้ผลดีมาก ซึ่งการกระทบให้การรักษาต่างกล้าวได้ขึ้นอยู่กับการทดสอบได้อย่างถูกต้องก่อน

สำหรับการวินิจฉัยโรคนี้ ปัจจุบันใช้วิธีทดสอบ Dix-Hallpike test โดยให้ผู้ป่วยหนมั่นคงนอนท่าหน้าอย่างรวดเร็ว และหันศีรษะไปทิศทางข้างหรือขวา โดยที่เที่ยงวัน แพทย์จะตรวจดูการกระตุกของลูกตา ซึ่งถ้าพบว่าเป็นโรคนี้ จะได้การทดสอบผลวิจัย คือจะพบการกระตุกของลูกตาแบบหมุนร่วมกับอาการเวียนศีรษะ

การทดสอบ Dix-Hallpike test มีข้อจำกัดหลายอย่าง อาทิเช่น ไม่สามารถทำได้ในรายผู้ป่วยที่มีปัญหาเรื่องกระดูกแบบที่เป็นโรคกระดูกคอเลือด (Cervical spondylosis) กระดูกคอติดแข็ง (Cervical stiffness) หรือพิษผิดกระดูกคอมา
การทดสอบ Side lying test เป็นการทดสอบใหม่ จุดประสงค์เพื่อมาทดแทนการทดสอบ Dix-Hallpike test เพื่อสามารถใช้ได้ในผู้ป่วยที่มีปัญหาคอดังกล่าวแล้ว แต่ในปัจจุบันยังไม่มีการวัดมาตรฐานของการทดสอบนี้ชัดเจน

โครงการการศึกษา จุดประสงค์เพื่อนำการทดสอบนี้มาทดแทน Dix Hallpike test ถ้าพบว่ามาตรฐานใกลเคียงกัน

ผู้ร่วมการศึกษาจะได้รับการทดสอบทั้ง Dix-Hallpike test (แบบดั้งเดิม) และ Side-lying test ภายใต้การดูแลของแพทย์ ณ คลินิกเวียนศีรษะและการได้ยิน ใน ภปร.10 แผนก หู คอ จมูก โดยจะบันทึกผลการทดสอบ เพื่อนำข้อมูลไปใช้ภายในด้านการศึกษาเท่านั้น

สำหรับอาการไม่พึงประสงค์ที่อาจเกิดได้ขณะได้รับการศึกษา ได้แก่
1. อาการเวียนศีรษะ
2. อาการปวดบริเวณคอจากการทดสอบแบบดั้งเดิม คือ Dix Hallpike test

ประโยชน์ของการศึกษา
1. อาจทำให้พบการทดสอบใหม่ สำหรับวินิจฉัยโรคเวียนศีรษะชนิด BPPV อย่างง่ายดายมากกว่า ช่วยให้ได้สะดวกมากขึ้น
2. สามารถนำมาทดสอบนี้ไปใช้ในผู้ป่วยที่มีปัญหาเรื่องคอ

สถาบันวิทยบริการ
จุฬาลงกรณ์มหาวิทยาลัย
หนังสือยินยอมเข้าร่วมการศึกษาวิจัย (Consent form)

ข้าพเจ้า………………………………………………………………………………ได้รับทราบจากแพทย์ผู้รักษา ซึ่งได้ลงนามในหน้าท้ายของหนังสือนี้ถึงวัตถุประสงค์และแนวทางการศึกษาโครงการ การศึกษาความแม่นยำของการทดสอบ Side-lying ในการวินิจฉัยโรค benign paroxysmal positional vertigo (BPPV) โดยวิธีทดสอบ Side-lying test เปรียบเทียบกับ Dix Hallpike test รวมทั้งทราบถึงผลที่จะได้รับ ผลข้างเคียง และความเสี่ยงที่อาจเกิดขึ้น ข้าพเจ้าได้เข้า>Lorem ipsum dolor sit amet, consectetur adipiscing elit. Sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum.

ข้าพเจ้าได้เข้าร่วมการศึกษาวิจัยนี้โดยสมัครใจ และจากตอนที่จากการเข้าร่วมการศึกษาตั้งแต่การศึกษาจะไม่มีผลกระทบใดๆ และมีผลดีที่จะได้รับความเสี่ยงที่อาจเกิดขึ้น

ข้าพเจ้ายินดีให้ข้อมูลของข้าพเจาแก่แพทย์ผู้รักษา เพื่อประโยชน์ในการศึกษาวิจัยครั้งนี้

ข้าพเจาได้อ่านข้อความข้างต้นแล้วและมีความเข้าใจถึงวัตถุประสงค์ และได้ลงนามในใบยินยอมนี้ด้วยความเต็มใจ

วันที่…………………………………… พ.ศ.…………
ลงชื่อ………………………………………………………ผู้เข้าร่วมการวิจัย
(……………………………………………………………………………………………………)
ลงชื่อ………………………………………………………แพทย์ผู้ดำเนินการวิจัย
(แพทย์หญิงเสาวรส อัศววิเชียรจินดา)
ลงชื่อ………………………………………………………พยาบาล
(……………………………………………………………………………………………………)
ลงชื่อ………………………………………………………พยาบาล
(……………………………………………………………………………………………………)
Diagnostic accuracy of Side-lying test for diagnosis Benign Paroxysmal Positional Vertigo (BPPV)

Principal investigator

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Address : Department of Otolaryngology
           Chulalongkorn University
           Bangkok, Thailand
Telephone : +662 2564103
Fax : +662 2527787
Eligibility criteria

Inclusion criteria
- Written informed consent [ ] [ ]
- Age 18-80 years [ ] [ ]
- Last dizzy spell onset not more than one month [ ] [ ]
- Agree to participate in the study and sign the informed consent. [ ] [ ]

Exclusion criteria
- Neck problem: severe cervical spondylosis, prolapsed intervertebral disc, severe rheumatoid arthritis with cervical instability [ ] [ ]
- Undertaken antivertigo medication [ ] [ ]
- Undertaken CNS suppressive drug [ ] [ ]

Conclusion
- Patient fulfills all inclusion criteria and none of the exclusion criteria [ ] [ ]

 Стахьи вятибригкак  
 олпохогнмомахвятиллай
<table>
<thead>
<tr>
<th><strong>Patient description</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Date of birth</td>
<td><em><strong>/</strong></em>/___ dd mm yy</td>
</tr>
<tr>
<td>Day, Month and year at last vertigo attack</td>
<td><em><strong>/</strong></em>/___ dd mm yy</td>
</tr>
<tr>
<td>Sex (M,F)</td>
<td><em><strong>/</strong></em></td>
</tr>
<tr>
<td>Age</td>
<td>____Yrs.</td>
</tr>
<tr>
<td>When was the last vertigo attack</td>
<td>[] &lt; 3 days</td>
</tr>
<tr>
<td></td>
<td>[] 3-7 days</td>
</tr>
<tr>
<td></td>
<td>[] 1-2 weeks</td>
</tr>
<tr>
<td></td>
<td>[] &gt; 2 weeks</td>
</tr>
<tr>
<td>Occurrence of vertigo</td>
<td></td>
</tr>
<tr>
<td>[] once a day</td>
<td></td>
</tr>
<tr>
<td>[] many times a day depend on head position</td>
<td></td>
</tr>
<tr>
<td>[] just come only once</td>
<td></td>
</tr>
<tr>
<td>Any history regard to etiology</td>
<td></td>
</tr>
<tr>
<td>[] previous head trauma, when</td>
<td></td>
</tr>
<tr>
<td>[] previous ear surgery, when</td>
<td></td>
</tr>
<tr>
<td>[] previous ear disease, what</td>
<td>when</td>
</tr>
</tbody>
</table>
Physical examination

Dix Hallpike’s maneuver

**Primary outcome**

1) When Lt ear down: nystagmus
   - [ ] present    [ ] absent
   - character of nystagmus
     - [ ] horizontal
     - [ ] rotatory
     - [ ] horizontal-rotatory
     - [ ] other_________
   if nystagmus present
     - [ ] beating to gravity
     - [ ] beating opposite to gravity
   - onset______(sec)  latency______(sec)
   - slow phase eye velocity_____________
   - Conclusion of test result  [ ] positive    [ ] negative

2) When Rt ear down: nystagmus
   - [ ] present    [ ] absent
   - character of nystagmus
     - [ ] horizontal
     - [ ] rotatory
     - [ ] horizontal-rotatory
     - [ ] other_________
   if nystagmus present
     - [ ] beating to gravity
     - [ ] beating opposite to gravity
   - onset______(sec)  latency______(sec)
   - slow phase eye velocity_____________
   - Conclusion of test result  [ ] positive    [ ] negative

**Secondary outcome**

- **Severity of vertigo**
  - [ ] No (no serious vertigo)
  - [ ] grade I (vertigo with nausea)
  - [ ] grade II (vertigo with vomiting)

- **Neck pain**
  - [ ] No (no neck pain and root pain)
  - [ ] grade I (neck pain alone)
  - [ ] grade II (neck pain and root pain)
Side-lying test

**Primary outcome**

1) When Lt ear down: nystagmus [ ] present [ ] absent
   character of nystagmus [ ] horizontal
   [ ] rotatory
   [ ] horizontal rotatory
   [ ] other___________

   if nystagmus present [ ] beating to gravity
   [ ] beating opposite to gravity

   onset__________ (sec) latency__________ (sec)

   slow phase eye velocity___________

   Conclusion of test result [ ] positive [ ] negative

2) When Rt ear down: nystagmus [ ] present [ ] absent
   character of nystagmus [ ] horizontal
   [ ] rotatory
   [ ] horizontal rotatory
   [ ] other___________

   if nystagmus present [ ] beating to gravity
   [ ] beating opposite to gravity

   onset__________ (sec) latency__________ (sec)

   slow phase eye velocity___________

   Conclusion of test result [ ] positive [ ] negative

**Secondary outcome**

- Severity of vertigo
  [ ] No (no serious vertigo)
  [ ] grade I (vertigo with nausea)
  [ ] grade II (vertigo with vomiting)

- Neck pain
  [ ] No (no neck pain and root pain)
  [ ] grade I (neck pain alone)
  [ ] grade II (neck pain and root pain)
APPENDIX D

The START statement checklist

Checklist

Table 1. START checklist of items to the reporting of studies on diagnostic accuracy.

*Test version, November 2001. For evaluation purposes only.*

<table>
<thead>
<tr>
<th>Section and Topic</th>
<th>Item #</th>
<th>Describe</th>
<th>Reported On page #</th>
</tr>
</thead>
<tbody>
<tr>
<td>TITLE/ABSTRACT/KEYWORDS</td>
<td>1</td>
<td>The article as a study on diagnostic accuracy (recommend MeSH heading ‘sensitivity and specificity’)</td>
<td></td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>2</td>
<td>The research question(s) such as estimating diagnostic accuracy or comparing accuracy between tests or across participant groups</td>
<td></td>
</tr>
<tr>
<td>METHODS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participants</td>
<td>3</td>
<td>The study population: the inclusion and exclusion criteria, setting(s) and location(s) where the data were collected</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Participant recruitment: was this based on presenting symptoms, result from previous tests, or the fact that the participants had received the index test(s) or the reference standard?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Participant sampling: was this a consecutive series of patients defined by selection criteria in (3) and (4)? If not specify how patients were further selected.</td>
<td></td>
</tr>
<tr>
<td>Section and Topic</td>
<td>Item #</td>
<td>Describe</td>
<td>Reported On page #</td>
</tr>
<tr>
<td>-------------------</td>
<td>--------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Data collection: were the participants identified and data collected before the index test(s) and reference standards were performed (prospective study) or after (retrospective study)?</td>
<td></td>
</tr>
<tr>
<td>Reference standard</td>
<td>7</td>
<td>The reference standard and its rationale</td>
<td></td>
</tr>
<tr>
<td>Test methods</td>
<td>8</td>
<td>Technical specification of material and methods involved including how and when measurements were taken, and/or cite reference for index test(s) and reference standard</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Definition and rationale for the inits, cutoffs and/or categories of the results of the index test(s) and the reference standard</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>The number, training and expertise of the persons (a) executing and (b) reading the index test(s) and the reference standard</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>Whether or not the reader(s) of the index test(s) and reference standard were blind (masked) to the results of the other test(s) and describe any information available to them</td>
<td></td>
</tr>
<tr>
<td>Statistical methods</td>
<td>12</td>
<td>Methods for calculating measures of diagnostic accuracy or making comparisons, and the statistical methods used to quantify uncertainty (e.g. 95% confidence intervals)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>Methods for calculating test reproducibility, if done</td>
<td></td>
</tr>
</tbody>
</table>

RESULTS
<table>
<thead>
<tr>
<th>Section and Topic</th>
<th>Item #</th>
<th>Describe</th>
<th>Reported On page #</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Participants</strong></td>
<td>14</td>
<td>When study was done, including beginning and ending dates of recruitment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>Clinical and demographic characteristics (e.g. age, sex, spectrum of presenting symptom(s), comorbidity, current treatment(s), recruitment center)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>How many participants satisfying the criteria for inclusion did or did not undergo the index test and/or the reference standard; describe why participants failed to receive either test (a flow diagram is strongly recommended)</td>
<td></td>
</tr>
<tr>
<td><strong>Reference standard</strong></td>
<td>17</td>
<td>Time interval and any treatment administered between index and reference standard</td>
<td></td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>Distribution of severity of disease (define criteria) in those with the target condition; describe other diagnoses in participants without the target condition</td>
<td></td>
</tr>
<tr>
<td><strong>Test results</strong></td>
<td>19</td>
<td>Across tabulation of the results of the index test(s) by the result of the reference standard; for continuous results, the distribution of the test results by the results of the reference standard</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>Indeterminate results, missing responses and outliers of index test(s) stratified by reference standard result and how they were handled</td>
<td></td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>Adverse events of index test(s) and reference standard</td>
<td></td>
</tr>
<tr>
<td>Section and Topic</td>
<td>Item #</td>
<td>Describe</td>
<td>Reported On page #</td>
</tr>
<tr>
<td>-------------------</td>
<td>-------</td>
<td>----------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Estimation</td>
<td>22</td>
<td>Estimates of diagnostic accuracy and measures of statistical uncertainty (e.g. 95% confidence intervals)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>23</td>
<td>Estimates of variability of diagnostic accuracy between subgroups of participants, readers or centers, if done</td>
<td></td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>Measures of test reproducibility, if done</td>
<td></td>
</tr>
<tr>
<td>DISCUSSION</td>
<td>25</td>
<td>The clinical applicability of the study findings</td>
<td></td>
</tr>
</tbody>
</table>
Dr. Saowaros Asawavichianginda was born on November 19, 1960 in Bangkok. She was graduated with M.D degree from Faculty of Medicine Siriraj Hospital, Mahidol University, Thailand. In 1991, she received Thai Board in Otolaryngology, Faculty of Medicine, Chulalongkorn University. From 1993 to 1994 she studied abroad at the Toronto General Hospital and obtained a certificate of fellowship in Neuro-Otology from University of Toronto, Canada.

Her present position is Associate Professor, Director of Neuro-Otologic Unit, Department of Otolaryngology, Faculty of Medicine, Chulalongkorn University, Thailand.