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ARTICLE

Hatice Sema Başak¹
Özkan Doğan¹
Okay Başak²

¹Department of
Otorhinolaryngology, Adnan
Menderes University Medical
School, Aydın, Turkey
²Adnan Menderes University
Hospital Family Medicine
Clinic, Aydın, Turkey

Corresponding Author:
Okay Başak
Adnan Menderes University
Hospital Family Medicine Clinic,
Aydın, Turkey
Tel: +90 2564441256/2946
E-mail: okaybasak@yahoo.com

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konuralptipdergisi@gmail.com
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The Power of Diagnostic Tests for Benign Paroxysmal Positional Vertigo: A Syndromic Approach

ABSTRACT

Objective: To determine diagnostic power of the symptoms and findings of patients with complaints of dizziness/balance disorder and to identify the syndromic diagnostic components for the benign paroxysmal positional vertigo (BPPV).

Methods: A retrospective methodological study of 147 adult patients with dizziness/balance disorder visiting the Otorhinolaryngology Clinic between January and December 2014 was conducted. The symptoms, signs and laboratory test results of the patients in BPPV and non-BPPV groups were compared and analyzed through sensitivity, specificity, predictive values, likelihood ratios, post-test odds and probabilities, logistic regression analysis and ROC curve. The criterion indices having high post-test probability values were determined.

Results: The most common three diagnoses were psychogenic vertigo (34.0%), peripheral vertigo of unknown origin (22.4%), and BPPV (16.3%). Five complaints and findings were found to have statistically significant diagnostic power: characteristic dizziness complaint, dizziness attacks lasting less than two minutes, dizziness being present for less than one week, supine roll and Dix-Hallpike test positivity. The post-test probability increased to 95.4% in patients with attacks lasting less than two minutes and dizziness lasting less than one week, when the Dix-Hallpike test was positive (triple-index positivity). According to the logistic regression model, positive result of the Dix-Hallpike test increased the probability of BPPV by 65.6 times. Accuracy of the model was 92.5%, with the area under the ROC curve of 0.891.

Conclusions: Our study results have provided evidence basis for diagnostic power of the Dix Hallpike test and, to a lesser extent, of the supine roll test.

Keywords: Benign Paroxysmal Positional Vertigo, Diagnosis, Syndromic Approach.

Benign Paroksizmal Pozisyonel Vertigo İçin Tanısal Testlerin Gücü: Sendromik Yaklaşım

ÖZET

Amaç: Bu çalışmanın amacı baş dönmesi/denge bozukluğu yakınması olan hastaların semptom ve bulgularının benign paroksizmal pozisyonel vertigo (BPPV) için tanısal gücünü belirlemek ve sendromik tanısal bileşenleri tanımlamaktır.

Gereç ve Yöntem: Ocak-Aralık 2014 tarihleri arasında kulak burun boğaz polikliniğine başvuran ve baş dönmesi/denge bozukluğu olan 147 yetişkin hastayla retrospektif metodolojik bir çalışma yapıldı. BPPV olan ve olmayan hastaların semptom, belirti ve laboratuvar test sonuçları karşılaştırıldı ve duyarlılık, seçicilik, kestirim değerleri, olasılık oranları, test sonrası odds ve olasılıkları, lojistik regresyon analizi ve ROC eğrisi aracılığıyla değerlendirildi. Yüksek test sonrası olasılık değerleri olan kriter indeksleri belirlendi.

Bulgular: En sık konulan üç tanı psikojenik vertigo (%34,0), kökeni bilinmeyen periferik vertigo (%22,4) ve BPPV (%16,3) idi. Beş yakınma ve bulgunun istatistiksel olarak anlamlı tanısal gücü olduğu saptandı: Karakteristik baş dönmesi yakınması, iki dakikadan daha kısa süren baş dönmesi atakları, bir haftadan daha kısa süredir var olan baş dönmesi, supine roll ve Dix-Hallpike test pozitifliği. Atakları iki dakikadan kısa süren ve bir haftadan daha kısa süredir baş dönmesi olan hastalarda Dix-Hallpike testi pozitif çıktığında test sonrası olasılık %95,4'e çıkmaktaydı (üçlü-indeks pozitifliği). Lojistik regresyon modeline göre, pozitif Dix-Hallpike test sonucu BPPV olasılığını 65,6 kat artırmaktaydı. Modelin doğruluğu, 0,891'lik ROC eğrisi altında kalan alan değeriyle %92,5 olarak hesaplandı.

Sonuç: Çalışma sonuçlarımız supine roll testi için daha düşük olmak üzere Dix-Hallpike testinin tanısal gücü için kanıt temeli sağlamıştır.

Anahtar Kelimeler: Benign Paroksizmal Pozisyonel Vertigo, Tanı, Sendromik Yaklaşım

INTRODUCTION

Currently, diagnosing a patient with dizziness and balance disorder involves difficulties. Benign paroxysmal positional vertigo (BPPV) is one of the most commonly seen clinical conditions in these patients and the evidence regarding diagnosis and treatment of BPPV are insufficient (1). It is stated that the guidelines for diagnosis and treatment of dizziness/balance disorder do not contain data that are crucial for medical decision-making, such as sensitivity, specificity, and likelihood ratio and that consensus recommendations are mostly available in these guidelines (2).

The syndromic approach is making diagnosis by using various specific components of medical history and physical examination and has first been proposed for the diagnosis and treatment of genital system infections by the World Health Organization (3, 4). In a study conducted in Turkey, syndromic diagnostic components have been determined for the diagnosis of vulvovaginal candidiasis (5). It has also been suggested that data for as many clinical conditions as possible that can be used especially in primary care should be obtained and family physicians should make a habit of questioning the odds and predictive values of more diagnostic tests (3,4,6).

Studies related to determining the diagnostic power of symptoms and findings presented by patients and related to the syndromic approach are limited. The aim of this study is to determine to what extent symptoms and findings obtained in medical history, physical examination and laboratory investigations of patients with a complaint of dizziness/balance disorder contribute to the diagnosis of BPPV, and therefore, their diagnostic powers. From here, we aim to identify syndromic diagnostic components for the diagnosis of BPPV.

MATERIAL AND METHODS

Study design: This study had methodological design. Patient information was retrospectively obtained from the “Vertigo Polyclinic Patient Evaluation Forms” of the patients which contained demographic data, symptoms, signs, attack characteristics, ear nose and throat (ENT) and balance examination findings, audiological and laboratory test results in addition to videoelectronystagmography (VNG).

Study subjects: In this study, 147 adult patients with a complaint of dizziness or imbalance, visiting Adnan Menderes University Hospital Otorhinolaryngology Clinic were consecutively recruited between January and December 2014.

Test methods: “Recurrent and severe rotational sensation of the patient or the surrounding, manifested following sudden head movement” was regarded as characteristic dizziness (1). All other expressions were evaluated as balance disorder. Preliminary diagnosis of BPPV was made

by using positional tests and taking the data obtained from medical history and physical examination into consideration. Preliminary diagnoses of posterior canal BPPV (PC-BPPV), lateral canal BPPV (LC-BPPV) and anterior canal BPPV (AC-BPPV) were made using positional tests (Dix-Hallpike maneuver, supine roll test) in accordance with the descriptions in the BPPV Clinical Practice Guideline, American Academy of Otolaryngology – Head and Neck Surgery Foundation 2008 (1, 7). The definitive diagnosis of BPPV was made by observing characteristic nystagmus during the positional tests in VNG and VNG was accepted as the gold standard (8). In cases that positional tests were normal in VNG, other diagnoses (Meniere’s disease, vestibular neuritis, vertiginous migraine, central vertigo, psychogenic vertigo and peripheral vertigo of unknown origin) were also made in accordance with the related descriptions in the above mentioned guideline (1). Patients who described no complaint of dizziness/balance disorder as the chief complaint, those who did not adhere to recommendations for VNG test, those who were under the age of eighteen, and those who had a perforation of the tympanic membrane were excluded from the study.

Statistical analysis: The patients were divided into two groups as BPPV and non-BPPV according to the definitive diagnoses. The Statistical Package for Social Sciences version 21 was used for statistical analyses. Results with the $p < 0.05$ value were regarded as statistically significant. Descriptive statistics, Kolmogorov-Smirnov test, independent sample t-test, Mann-Whitney U test, Chi-square test, Fischer test were used for statistical evaluation of the study data. Sensitivity, specificity, predictive values, likelihood ratios (LR), post-test odds and probabilities for the variables having significant results in the univariate analysis were calculated. The variables with a positive LR in the range of between 1.2 and 1.9 were considered as low, between 2.0 and 4.9 as moderate, and above 5.0 as high increase in the probability of disease. Post-test probability values were calculated for different variables using the chain likelihood ratio method and criterion indices having high post-test probability values were determined (9). Positive LR was determined by using the formula “sensitivity of the test/1-specificity of the test”. Post-test odds was obtained by multiplying positive LR with pre-test odds. Pre-test odds was calculated as ‘pre-test probability/1-pre-test probability’. Post-test odds was converted to probability by dividing it to 1 plus itself (6). Multiple logistic regression analysis was performed to determine the effects of independent variables on the dependent variable. Receiver operating characteristic (ROC) curve was drawn according to the probability cut-off values obtained in regression

analysis and AUC (area under ROC curve) was calculated.

Ethical approval for the study was obtained from Adnan Menderes University Medical Faculty, Ethics Committee for Non-interventional Research (Protocol no:2014/510, 13.03.2014).

RESULTS

The mean age of 147 patients included in the study was 48.6 ± 15.1 , and the female/male distribution was 75/72. The most common three diagnoses were psychogenic vertigo (34.0%), peripheral vertigo of unknown origin (22.4%), and BPPV (16.3%). All diagnoses are shown in Table 1.

Table 1. The diagnoses of all patients included in the study, n=147

Diagnoses	Number	%
Psychogenic vertigo	50	34.0
Peripheral vertigo with unknown origin	33	22.4
Benign Paroxysmal Positional Vertigo	24	16.3
Central vertigo	16	10.8
Meniere disease	14	9.5
Vestibular neuritis	6	4.0
Vertiginous migraine	4	2.7

All preliminary diagnoses of BPPV made by the ENT clinician were confirmed following VNG; there were no other patients diagnosed through VNG but had no preliminary diagnosis of BPPV. In 24 patients diagnosed with BPPV, the most common type was PC-BPPV with 79.1% (n=19), followed by LC-BPPV (16.6%; n=4) and AC-BPPV (4.1%; n=1).

The patients with and without BPPV did not show any differences regarding age and gender ($p > 0.05$). The main complaint of characteristic dizziness, the onset of complaints within the last week, the dizziness lasting less than 2 minutes, and positive results for the Dix-Hallpike maneuver and the supine roll test were significantly higher in the group with BPPV when compared to the group without BPPV ($p < 0.05$). No significant differences were found between two groups regarding other symptoms, attack features, triggering conditions, additional disorders, use of any drugs, and ENT examination and other laboratory test results ($p > 0.05$). The diagnostic test results that are found to be statistically significant comparing to the definitive diagnosis of BPPV are shown in Table 2.

Table 2. The diagnostic test (history and physical examination) features that were found to be statistically significant comparing to the definitive diagnosis of BPPV

Complaints and findings	Diagnosis of BPPV			Sensitivity and specificity	Predictive values	Statistics
	Yes, n	No, n	Total, n			
Characteristic dizziness	Present	24	105	129	Sen: %100 Spe: %14.6	PPV: %18.6 NPV: %100 $\chi^2=4.002$ p=0.045
	Absent	0	18	18		
	Total	24	123	147		
The supine roll test*	+	3	0	3	Sen: %12.5 Spe: %100	PPV: %100 NPV: %85.4 $\chi^2=15.695$ p=0.004
	-	21	123	144		
	Total	24	123	147		
The Dix-Hallpike test	+	12	2	14	Sen: %50.0 Spe: %98.4	PPV: %85.7 NPV: %91.0 $\chi^2=54.535$ p<0.001
	-	12	121	133		
	Total	24	123	147		
Complaint duration	≤ 1wk	9	23	32	Sen: %37.5 Spe: %81.3	PPV: %28.1 NPV: %87.1 $\chi^2=4.168$ p=0.041
	> 1wk	15	100	115		
	Total	24	123	147		
Attack duration	≤ 2 min	12	36	48	Sen: %50.0 Spe: %70.7	PPV: %25.0 NPV: %87.9 $\chi^2=3.925$ p=0.048
	> 2 min	12	87	99		
	Total	24	123	147		

* Fisher's Exact test

BPPV: Benign Paroxysmal Positional Vertigo; Sen: Sensitivity; Spe: Specificity; PPV: Positive Predictive Value; NPV: Negative Predictive Value; wk: week; min: minute

Five complaints and findings were found to have statistically significant diagnostic power. Sensitivity of the characteristic dizziness complaint and specificity of the supine roll test for the diagnosis of BPPV were 100%. Three criteria were identified for the diagnosis of BPPV, one weakly, one moderately, and one strongly positive. Dizziness attacks lasting less than two minutes increased the BPPV probability to 25.0%, with dizziness being present for less than one week to 28.1%, and positive Dix-Hallpike test result up to

85.9%. The post-test probability increased to 40.1% in patients with dizziness present for less than one week and attacks lasting less than two minutes (double-index positivity); to 91.2% in patients with attacks shorter than two minutes and positive Dix-Hallpike test (double-index positivity); to 92.4% in patients with dizziness for a period less than one week and positive Dix-Hallpike test (double-index positivity), and to 95.4% in patients with attacks lasting less than two minutes and dizziness lasting less than one week, when the Dix-Hallpike test was

positive (triple-index positivity). Pre-test and post-test diagnostic features of the significantly positive

variables and criteria for the diagnosis of BPPV are shown in Table 3.

Table 3. The pre-test and post-test diagnostic features of the significantly positive variables and criteria for the diagnosis of benign paroxysmal positional vertigo

Variables and indices	Pre-test probability	Pre-test odds	+ Likelihood ratio	Post-test odds	Post -test probability
Attack duration	0.1632	0.1950	1.71	0.333	0.2501
Complaints duration	0.1632	0.1950	2.01	0.390	0.2805
Dix-Hallpike test	0.1632	0.1950	31.25	6.093	0.8590
2-index*	0.2501	0.3335	2.01	0.670	0.4012
2-index**	0.2501	0.3335	31.25	10.422	0.9124
2-index***	0.2805	0.3898	31.25	12.181	0.9241
3-index****	0.4012	0.6700	31.25	20.938	0.9544

* Double-index positivity: Dizziness present for less than one week and attacks lasting less than 2 minutes

** Double-index positivity: Attacks shorter than two minutes, when the Dix-Hallpike maneuver is positive

*** Double-index positivity: Dizziness for a period less than one week, when the Dix-Hallpike test is positive

**** Triple-index positivity: Attack lasting for less than two minutes and dizziness lasting for less than one week, when the Dix Hallpike test is positive

Additionally, logistic regression analysis was performed to verify diagnostic contribution of five variables significantly positive for the diagnosis of BPPV. A model with one variable was constituted in logistic regression analysis (Table 4). According to this model, positive result of the Dix-Hallpike test increased the probability of BPPV by 65.610 fold (95% CI: 11.988-359.069; $p=0.000$).

The ROC curve, drawn according to the probability estimates obtained through the regression analysis has been shown in Figure 1. With ROC analysis, accuracy rate of the one-variable model was 92.5%, and area under the curve was found as 0.891 (0.813-0.969). The optimum sensitivity threshold was 0.833 (Figure 1).

Table 4. Logistic regression model with one variable, performed for determining the contributions of the independent variables to the diagnosis of BPPV

Dependent variable: Presence of benign paroxysmal positional vertigo						
Independent variable	Beta	SE	Wald	p	Odds ratio	95% CI
Dix-Hallpike test positive	4.184	0.867	23.272	0.000	65.610	11.988 – 359.069
Constant	- 32.744	23646.528	0.000	0.999	0.000	

BPPV: Benign paroxysmal positional vertigo; SE: Standard Error; CI: Confidence interval

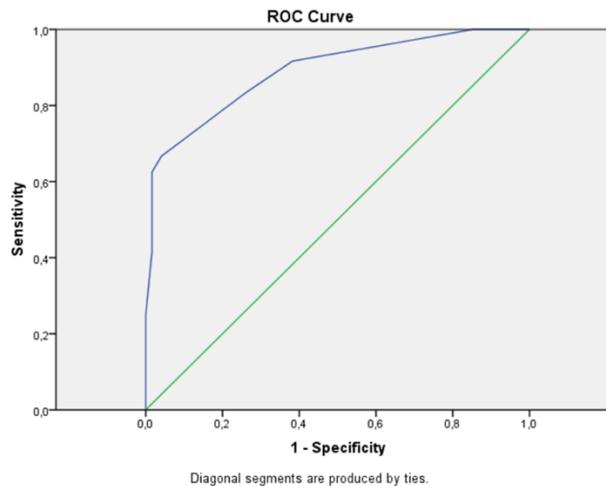


Figure 1. The ROC (Receiver Operating Characteristic) curve drawn according to the probability estimates obtained through logistic regression analysis

DISCUSSION

The BPPV Clinical Practice Guideline published by American Academy of Otolaryngology–Head and Neck Surgery Foundation in 2008 emphasizes the importance of developing definitive and sufficient methods for the diagnosis (1). We think that our study results provide the evidence basis for the diagnostic value of some symptoms and signs in medical history and physical examination used by family physicians and ENT practitioners in BPPV diagnosis.

Laboratory facilities such as vestibular evoked myogenic potentials, VNG, and posturography, which can be used for evaluation of a patient with dizziness/balance disorder, are not available in most of the health centers. Performing these tests is time-consuming, and their interpretation needs experience (1, 8). Diagnostic criteria obtained by syndromic approach help us to make our clinical decision by separating the possibility of a disease (e.g., BPPV) into low, intermediate and high categories. The intermediate category includes doubtful conditions, and in this category, additional investigations may be required for verification of the diagnosis. In low and high categories, additional investigations will not be helpful for making a diagnosis (6).

The syndromic approach to the diagnosis of BPPV that we have developed has been shown in Figure 2. Sensitivity of the characteristic dizziness complaint regarding the diagnosis of BPPV is 100%. Since there are no false negatives, we can be confident that the diagnosis is not BPPV in the absence of characteristic dizziness. So, starting with questioning the characteristic dizziness complaint in the diagnostic process for BPPV would be appropriate. However, due to the multitude of false positives, the presence of characteristic dizziness in a person is not diagnostic (18.6% positive predictive value with 100% sensitivity and 14.6% specificity, at 16.3% prior probability).

Since there are no false positives, we can be confident that the diagnosis is BPPV when the supine roll test is positive in a patient with complaint of characteristic dizziness. However, the test is able to capture very few of the real BPPV patients. Due to the presence of false negatives, negative supine roll test is not detracting from BPPV diagnosis (85.4% negative predictive value with 12.5% sensitivity, and 100% specificity, at 16.3% prior probability) and when the test is negative, other diagnostic tests should be continued for identifying the remaining BPPV cases. When the Dix-Hallpike test is not positive, particularly in a patient with a medical history of recurrent dizziness following head movements, performing the supine roll test is definitely recommended for the diagnosis of lateral canal BPPV (1). However, we suggest the supine roll test evaluation be made prior to the Dix-Hallpike test during the diagnostic

process. When the test turns out to be positive, we are able to diagnose lateral canal BPPV. When the result is negative, we should continue our investigation towards diagnosing other BPPV types with the Dix-Hallpike test. This approach could be a way of solving the problem of “canal switch” being thought to occur following performance of the repositioning maneuvers for an initial diagnosis of posterior canal BPPV (10).

Our study results have revealed three criteria with diagnostic power in patients with a complaint of characteristic dizziness, but having negative supine roll test result. We suggest performing the Dix-Hallpike test as the third step for these patients. The positive result of this test leads to a serious increase in the probability of BPPV diagnosis. When an attack duration less than 2-minute and dizziness present less than 2-week are added to the Dix-Hallpike test positivity, the likelihood of BPPV diagnosis increases more, although limited. When all of these three tests are positive (triple-index positivity), the probability of BPPV diagnosis nearly approaches 100% (Table 3). As seen in the diagram, we can make the diagnosis of BPPV in all situations that the Dix-Hallpike test is positive, with no need for further tests and investigations like VNG (Figure 2). Hanley and O’Dowd have reported a positive predictive value of 83% and a negative predictive value of 52% for the Dix Hallpike test in diagnosing BPPV (11). The authors have suggested that when the test is negative the diagnosis should not be excluded and the test should be repeated in a new encounter to confirm the diagnosis and avoid false negative results. Predictive values are, of course, one of the criteria showing the power of diagnostic tests. However, for this, the clinician should foresee the prior risk before the test in every patient. The likelihood ratios, calculated through sensitivity and selectivity, are not affected by prior probability. The clinician is able to use the predetermined likelihood ratios in every situation.

The power of the Dix-Hallpike test in diagnosing BPPV has been supported by logistic regression and ROC analyses. While the limited powers of the supine roll test and other three history indexes for diagnosing BPPV, defined with the likelihood ratios, cannot be shown in regression analysis, the Dix-Hallpike test itself has constituted a powerful model. It can be said that the results obtained for the Dix-Hallpike test, the values of the odds ratio obtained by logistic regression analysis and AUC are consistent.

When Dix-Hallpike test is negative, the likelihood of BPPV diagnosis is reduced. In cases that dizziness has been present for less than two weeks, with attacks lasting less than two minutes or both, the likelihood of BPPV diagnosis is over 25% but remains below 65%. In this case, further

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