Original Article

Diagnostic Contribution of Magnetic Resonance Imaging and Computerized Tomography in Patients with Unidentified Vertigo and Normal Neurologic Examination in Emergency Medicine

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Abstract

Background: Vertigo and dizziness are common symptoms in patients presenting to emergency medicine (ED) clinics. Vertigo may be caused by peripheral or central origin. Routine imaging is not indicated; however, neuroimaging is increasing, and published studies have revealed a small number of positive findings on imaging modalities. **Aims:** The aim of this study was to investigate whether neurological imaging was necessary in patients classified as "unidentified vertigo," who were admitted to the emergency department with vertiginous complaints and not revealing typical peripheral vertigo findings and any neurological deficits. **Materials and Methods:** All patients with "dizzy symptoms" were included in the study. For patients who met the definition of "unidentified vertigo," experimental neurological imaging studies were done. Head computerized tomography (CT), magnetic resonance imaging (MRI) with gradient-echo sequences (GRE), and diffusion weighted images (DWI) were used for imaging. Patients who underwent neuroimaging in the ED were followed up for 6 months in Neurology and ENT clinics. **Results:** A total of 351 patients were included in the study. Experimental imaging was performed on 100 patients. CT detected a significant pathology associated with the vertigo complaint in only one patient. MRI results were similar to the CT results. MRI-GRE sequences showed some additional pathologies in 14 patients and 4 of them were thought to be related to vertiginous symptoms. None of the patients classified as "non-central causes of vertigo" in the neuroimaging group developed TIA or CVD during 6 months of follow-up. **Conclusion:** Head CT can be adequate to exclude life-threatening central pathology in "undifferentiated vertigo patients" and the addition of MRI did not add any diagnostic accuracy in ED management. Using the physical examination findings effectively to make a specific diagnosis may reduce misdiagnosis and improve resource utilization.

Keywords: *CT, dizziness, emergency medicine, MRI, neuroimaging, vertigo*

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Introduction

Vertigo is an illusion of self or environmental motion and is typically described as spinning or whirling by the patients. Vertigo is the third most common symptom in patients presenting to emergency medicine (ED) clinics and the most common symptom in patients over 75 years old.[1] Although the terms dizziness and vertigo are sometimes used interchangeably, vertigo describes a specific sensation, and distinguishing real vertigo and nonspecific dizziness is often difficult for the patient to describe. Various concepts have been used in the literature to describe and classify dizziness. These categories include vertigo, disequilibrium, presyncope

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or syncope, lightheadedness, and nonspecific dizziness. Vertigo may be caused by peripheral or central origin. Prospective studies found that peripheral vestibular dysfunction was the most frequent cause of persistent dizziness in ambulatory care settings.[2] A variety of other etiologies such as cerebrovascular disorders, cardiac abnormalities, and rarely brain tumors (<%1) are associated with dizziness and vertigo. In older adults, the stroke becomes more prominent for the central cause of vertigo. Routine imaging is not indicated for dizziness and vertigo; however, neuroimaging is increasing. Although the increase is sometimes due to patient's demand or pressure on the emergency physician, the most common reason is the fear of legal aspects due to not detecting potentially life-threatening disorders. This increased imaging burdens a significant financial load and also leads to the increased exposure to ionizing radiation in the population. So far, published studies have revealed a small number of positive findings on head computerized tomography (CT) of the patients with vertigo.[3]

The aim of this study was to investigate whether neurological imaging was necessary in patients classified as "unidentified vertigo," who were admitted to the emergency department with vertiginous complaints and not revealing typical peripheral vertigo findings and any neurological deficits.

Materials and Methods

Study design and setting

This prospective study was conducted in a tertiary care university hospital emergency department for 3 months between March and June, with an Institutional Ethics Committee approval (12.08.2015/26) in accordance with the Declaration of Helsinki. The study was funded using a short-term grant provided by the University Research Foundation. All study patients enrolled were given information and signed informed consent forms.

Selection of the participants

The data were recorded in a standard form created for the study. All patients who presented to the emergency department triage area on an outpatient basis or brought by ambulance and whose complaint was "vertigo and dizziness" were evaluated by the triage nurses and the demographic data part of the study form was filled out. Afterward, the patients were re-evaluated by ED residents under the supervision of a specialist in the care areas within the ED. The dizzy complaints are first classified as "true vertigo" or "other ED diagnosis" based on symptoms described by the patients (onset, duration, type, frequency, aggravating, or relieving factors). The "true vertigo" was defined as the illusion of self or environmental motion in a rotational form like whirling. Other dizzy symptoms were classified in the study form as; nonspecific dizziness symptoms rather than vertigo, lightheadedness, disequilibrium, and vertiginous migraine. These patients were not undergone experimental neuroimaging. The true vertigo patients were then examined for detecting peripheral and central causes. Detailed neurological examination findings (truncal ataxia in gait test; sudden numbness or weakness especially on one side of the body; trouble talking or understanding speech; or sudden confusion and altered mental status) and test results predicting positional peripheral vertigo (Fast-phase alternating nystagmus induced by Dix-Hallpike test, nystagmus and/or triggered vertiginous symptoms by Supine Roll test, abnormal Head Thrust test,) were recorded to the study form. Among the patients evaluated as true vertigo, patients without findings consisting of peripheral vertigo and without clear neurological deficit signs met the definition of "unidentified vertigo." Experimental neurological imaging studies were done in these selected "unidentified vertigo" groups. Non-contrast CT of the brain, T1 and T2 weighted magnetic resonance imaging (MRI) and gradient-echo sequences (GRE) and diffusion weighted images (DWI) were used for imaging. Both CT and MRI were used for all patients in the experimental imaging group. All imaging studies were done within 6 hours after the ED presentation. CT imaging studies were done with Toshiba Activion 16 (Toshiba Medical Systems Corporation, Tochigi, Japan) and MAGNETOM Aera (Siemens Healthcare, Erlangen, Germany) was used for MRI imaging.

Inclusion criteria for experimental imaging

Selected "Unidentified vertigo" patients with ongoing symptoms who did not have findings compatible with BPPV in posterior, lateral, or anterior semicircular canal tests, and without any neurological examination sign.

Exclusion criteria for experimental imaging

- Patients with dizzy complaints incompatible with true vertigo.
- Presence of ongoing or temporary neurological deficits highly suggesting a central cause other than nystagmus.
- Presence of positive test results (nystagmus and/or vertigo triggered with tests) compatible with BPPV.
- Patients with head and neck trauma.

Outcome measures

All patients included in the study (both with or without neuroimaging) were discharged with the clinical decision of the physicians who followed them in the ED after the evaluation and treatment, or hospitalization was planned if necessary. The follow-up of the patients who

underwent neuroimaging continued in the "Ear, Nose, Throat (ENT)" and "Neurology" outpatient clinics. All readings of neuroimaging studies were done by a single radiologist. The follow-up examinations in the outpatient clinics were also done by a single neurologist and ENT specialist. The decision of these specialists about the study patients' final diagnosis in course of follow-up was accepted as a gold standard. Re-hospital admissions, treatment responses, and other prognostic data of the patients in the first, third, and sixth months were followed up by telephone and outpatient clinic information data. These data abstractions and evaluations were done by the same researcher in a constructed form. Hospital Information Management System (MIAMED) program was used to reach the examination results, follow-up, and prognosis of the patients.

Statistical analysis

Data were analyzed with the IBM Statistical Package for the Social Sciences (Version 20.0, IBM Corp, Armonk, NY) statistical package program. Continuous data are presented as mean ± standard deviation, and categorical data as frequencies and percentiles.

Results

A total of 351 patients who presented to the emergency department with the complaint of "vertigo and dizziness" were included in the study. Experimental imaging was performed in 100 of these patients. The patient flow chart is shown in Figure 1.

The gender distribution of all patients included in the study is 40% male and 60% female. The mean age was 44.4 ± 16.9 in patients without experimental neuroimaging, and 54.5 ± 16.2 in patients with experimental neuroimaging.

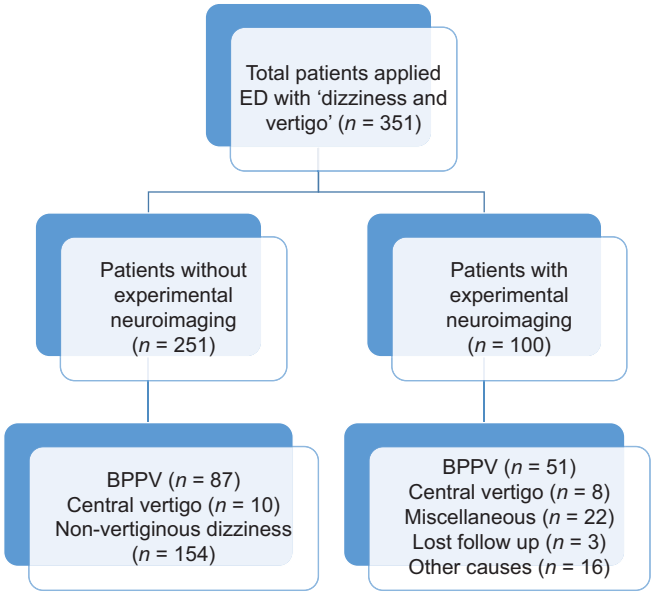

Figure 1: Patient Flow Chart

Patients without experimental neuroimaging

Experimental neuroimaging was not performed on 251 patients in the study population. Among these, 154 patients were accepted as non-vertiginous dizziness by the physician who evaluated them. In 87 of the patients, peripheral causes of vertigo were considered with physical examination findings and referred to the ENT clinic after treatment and relieving the symptoms. Neurological central vertigo was considered in ten patients and consulted with neurologists in ED. The distribution of patients without neuroimaging were shown in Table 1.

Results of experimental neuroimaging

Patients classified as "unidentified vertigo" undergo neuroimaging. CT detected a significant pathology associated with the vertigo complaint in only one patient (Right cerebellar mass and hydrocephalus). T1 and T2 weighted MRI results were similar to the CT results. DWI results were normal in all patients. GRE sequences showed some additional pathologies in 14 patients and 4 of them were thought to be related to vertiginous symptoms. Results of head CT and MRI are shown in Figures 2 and 3.

Table 1: The distribution of patients without neuroimaging

Patients without neuroimaging	*n* (%)
Gender	
Female	148 (59)
Male	103 (41)
Accepted as non-vertiginous dizziness by evaluating physician	154 (61)
Nonspecific dizziness	43
Lightheadedness	36
Disequilibrium	22
Vertiginous migraine	14
Dizziness symptoms secondary to flu-like infections	4
Miscellaneous/missing data	34
Peripheral vertigo	87 (35)
BPPV with nystagmus (horizontal, rotator, or mix)	81
Other causes	6
Central vertigo	10 (4)
Hospitalized at a neurology clinic with the diagnosis of CVD	4
Developed additional neurological deficits and diagnosed as CVD	2
Lung cancer-related brain metastasis	1
Peripheral vertigo (final diagnosis was changed after reevaluation)	3

BPPV=Benign paroxysmal positional vertigo; CVD= Cerebrovascular disease

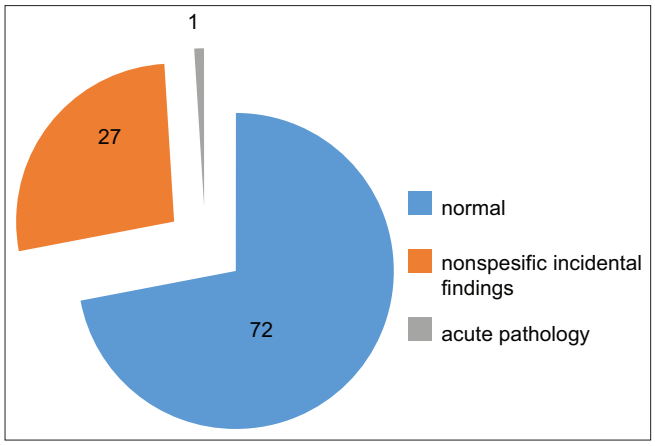

Figure 2: Results of head CT. Acute pathology: Right cerebellar mass and hydrocephalus. Nonspecific incidental findings: Senile cerebral atrophy, old cerebral infarcts, encephalomalacia, chronic ischemic changes, meningioma

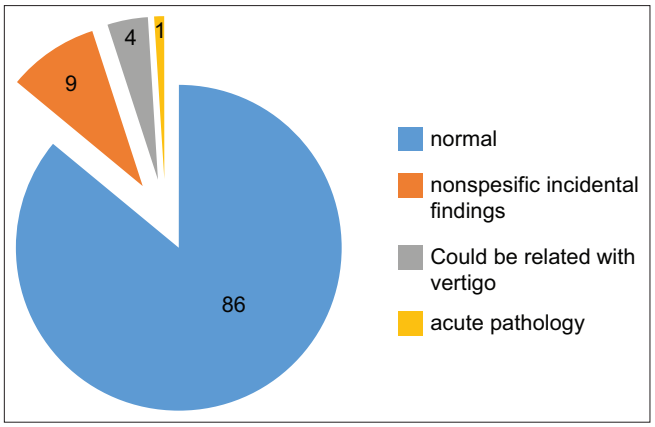

Figure 3: Results of GRE—MRI. Acute pathology: Right cerebellar mass and hydrocephalus. Nonspecific incidental findings: Nonspecific gliotic foci. GRE sequences findings could be related with vertiginous symptoms: Occipital cavernoma, vertebrobasilar telangiectasias, left posterior pons cavernoma, left temporal cavernoma

Table 2: The distribution of the final diagnosis of patients with neuroimaging

Patients with experimental neuroimaging	*n*=100
Gender	
Female	61
Male	39
Peripheral vertigo	52
BPPV	51
Meniere disease	1
Central vertigo	8
TIA	3
Vestibuler migraine	3
Epileptic seizure	1
Cerebellar mass	1
Miscellaneous–Nonspecific dizziness (no clear central or peripheral pathology, patients were all symptom free at follow-up)	22
Other causes	15
Drug adverse reactions	4
Symptoms due to hypertension	3
Alzheimer disease	2
Psychogenic causes of dizziness	6
Lost follow up	3

BPPV=Benign paroxysmal positional vertigo; TIA=Transient ischemic attack

Prognosis of the patients with experimental neuroimaging

Patients who underwent neuroimaging in the ED were followed up for 6 months in Neurology and ENT clinics. Central vertigo was considered in eight patients and consulted with neurologists in ED. In 51 patients out of the total 100, peripheral causes of vertigo were considered as the final diagnosis by the ENT specialist who evaluated them in the outpatient clinic after discharge from the ED, and their symptoms were relieved by treatment. The distribution of the final diagnosis of the patients with neuroimaging was shown in Table 2. None of the patients classified as "non-central causes of vertigo" in the neuroimaging group developed (TIA) Transient ischemic attack or (CVD) Cerebrovascular disease during 6 months follow-up.

Discussion

It is important to differentiate peripheral and central causes in patients presenting to the ED with dizziness and vertigo. While peripheral vestibular dysfunction-related vertigo is usually benign, less common central vertigo can be life-threatening. Although patient history and physical examination findings are guiding in peripheral etiologies, there are also patients who cannot be diagnosed clearly despite advanced neuroimaging or vestibular tests. In the present study, experimental neuroimaging both with head CT and MRI was performed in ED, in undifferentiated vertigo patients without deficits on neurological examination and with normal vestibular tests. A significant pathology that could explain the symptoms was found in only 1 out of 100 patients who underwent imaging. MRI did not make any additional contribution to brain CT imaging in terms of the acute diagnostic process.

In previous studies, it was determined that the patients who presented to the ED with dizziness were mostly women.[4-6] In our study, it was seen that 60% of the patients were women. While the mean age of all patients included in the study was 47, it was slightly lower in the non-imaging group and higher in the imaging group. In younger age groups, vertigo is mainly caused by peripheral origin such as BPPV, whereas central pathologies increase in older patients. Therefore, even when symptoms are nonspecific, more imaging may be requested for fear of missing serious pathologies.

In the study conducted by Ahsan *et al*.[7] in which the imaging utility was evaluated in dizzy patients, it was found that the patients who underwent CT imaging were statistically significantly older than the total patient group. More than 50% of the final diagnoses were BPPV in the present study as it was shown in the previous studies.[2,8]

In the present study, clinically compatible significant pathology was detected in only one patient from a total of 100 patients who were chosen for experimental imaging. In studies published in previous years, the rate of detection of acute pathology in tomography was found to be higher.[7,9,10] All of these studies were designed as retrospective chart review, in which the records of all patients who presented to the ED with symptoms of dizzy or vertigo were evaluated. Therefore, patients with neurological deficits on examination were also included in the population of the studies. Thus, pathologies such as intracranial hemorrhage, acute infarction, hydrocephalus, and intracranial mass were detected in the imaging results. In our study, only undifferentiated vertigo patients were screened in a prospective design, so patients with neurological deficits were excluded from the experimental imaging group. This may explain the low rate of detection of acute significant pathology in imaging.

It is also controversial which imaging method should be chosen in the emergency department. T1 and T2 weighted MRI and DWI results obtained in our study did not show significant pathologies; however, GRE-MRI enabled the detection of vertigo-related pathology in four of the patients. We recognized that MRI would give additional information rather than CT if specific sequences such as GRE were used. These four patients were all followed as outpatient without the need for hospitalization in the neurology clinic. Findings detected by GRE-MRI did not make a significant difference in terms of early medication and discharge from the ED. However, in the follow-up of these patients, due to the risk of bleeding from the cavernous areas in the future, initiating antiplatelet therapy should be discussed cautiously in the outpatient setting with the diagnosis of TIA. In previous studies, it was mentioned that CT detects sufficient findings in the differential diagnosis of intracranial pathologies in many patients in the early period.[11-13] DWI with higher sensitivity may be preferred to detect acute cerebellar, brain stem, and posterior fossa infarcts where CT may be insufficient to recognize. However, despite serious central pathology concerns, according to large cross-sectional studies, the stroke rate of patients presenting with acute vertigo is low (approximately 3%), and the risk of stroke is much lower (approximately 0.7%) if there are no central nervous system (CNS) symptoms and signs.[14,15] In previous studies, it was observed that imaging methods in the emergency department did not significantly change the diagnosis of CVD or TIA in patients with dizziness.[7,16] Kerber *et al*.[6] evaluated dizziness presentations in U.S. emergency departments and found that the utilization of CT and/or MRI increased 169% from 1995 to 2004, which was more than any other test. However, the rate of CNS diagnoses (e.g., cerebrovascular disease or brain tumor) did not increase over time. Another cost-utility study found similar results and concluded that, in more than 90% of cases, radiological findings are not shown in relation to vertigo.[17]

In our present study, none of the patients in the experimental neuroimaging group with a final diagnosis of "non-central vertigo" developed CVD or TIA during the 6 months follow-up period. Other studies determining the risk of short- and long-term stroke, in patients discharged from an emergency department who were given a diagnosis of a peripheral vestibular disorder concluded that the frequency of early stroke was extremely low after discharge from an ED with the diagnosis of peripheral vertigo.[18-20]

In our selected "unidentified vertigo" patient group, the final diagnosis was a peripheral etiology in 50%. This differentiation of final diagnosis is neither solely a basic selection bias nor an inadequate patient evaluation of ED physicians. The most common reason for misdiagnosis which factored in 70% of misdiagnoses was an evolution of the clinical course over time, since what is obvious the next day, or even a few hours later, is not always clear on initial presentation.[21] In a Swiss study of 951 patients referred (not all from an ED) to a multidisciplinary dizziness clinic, there was a significant change in the final diagnoses of dizzy patients.[22] These findings questioned the existing paradigm of vertigo evaluation and diagnosis which is based on symptom quality (asking the patient "what do you mean dizzy?"), as well as the difficulty in doing the standard physical examination for all. The patient variability in describing their symptoms would make the diagnosis questionable, also if the stimulation tests and neurological examination were not correctly interpreted in a standardized fashion, then the diagnosis would change. In a study, ED patients with dizziness were asked a series of questions aimed at determining the reliability and consistency of eliciting "symptom quality." When the main question was re-asked an average of 6 min later, half of the patients changed their primary dizziness type. Rather than symptom quality, the responses to timing and triggers of dizziness were more consistent and reliable

for diagnosing vestibular syndromes.[23] Fortunately, the physical examination can make the distinction between vestibular neuritis and posterior circulation stroke with greater sensitivity than early MRI.[24] Performing head impulse, nystagmus, test of skew (HINTS) along with a targeted neurologic examination and gait testing can decrease both neuroimaging and hospitalization.[25] Our study results revealed that our ED evaluation of dizzy patient was insufficient and demanded a new diagnostic paradigm based on timing, triggers, and associated symptoms.

The evaluation of dizziness contributes significantly to the cost of health care. Of the 3-year study's total charges of $1.2 million for CT and MRI for ER patients with dizziness and vertigo, only 1.49% of scans demonstrated significant pathology.[7] Total U.S. national costs for patients presenting with dizziness to the ED are estimated to exceed $4 billion per year (about 4% of total ED costs).[26] Increased cost savings are possible by developing appropriate guidelines for ordering imaging studies in patients presenting with dizziness without neurological symptoms. Reasonable use of neuroimaging in patients presenting with dizziness plus neurological or ophthalmological complaints may be helpful.

Limitations

Relatively small number of patients in the experimental imaging group may reduce our results reliability. There was only one patient with a significant pathology in the neuroimaging group and this would be insufficient to make a clear statement about MRI usefulness.

The presence of more than one emergency physician who decides that the patients' complaints of dizziness are due to central or peripheral causes or unidentified vertigo may have led to different interpretations/results in the inclusion of the study patients into the groups. However, we think that this possibility is negligible since all physicians receive the same training in the same clinic in a standard fashion.

Also asking for symptom quality and patient definition of vertigo as an inclusion criterion, rather than timing, triggers, and aggravating factors of dizzy symptoms weaken our results, because all these make our grouping prone to errors. The failure of each patient to describe the definition of motion-related vertigo may have led to different interpretations/results.

The lack of demographics in the study form like the history of atrial fibrillation, hypertension, diabetes, or other stroke risk factors, and medications used by the patients was a limitation. However, our study population was younger with a mean age of 50s, so we think that these risk factors predicting stroke risk, especially in patients older than 65 would not affect our results significantly.

Conclusion

In undifferentiated vertigo patients without neurological deficits and with normal vestibular tests, head CT can be adequate to exclude life-threatening central causes and the addition of routine MRI did not add any diagnostic accuracy in ED management. Using standardized examination methods and vestibular tests effectively to make a specific diagnosis in patients with vertiginous symptoms may reduce misdiagnosis of serious central pathologies, including posterior fossa problems, and improve resource utilization.

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Conflicts of interest

There are no conflicts of interest.

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