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Original Article

The Usefulness of Magnetic Resonance Imaging for Acute Isolated Vertigo Patients in the Emergency Department

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OBJECTIVE: The aims of study were to determine how many patients require magnetic resonance imaging (MRI) for a diagnosis of central vertigo among all patients with acute isolated vertigo in the emergency department (ED).

MATERIALS and METHODS: We retrospectively analyzed 2671 patients. Diffusion-weighted and T2 MR imaging was performed in all patients with the exception of those with trauma and benign paroxysmal positional vertigo. Patients were divided into three groups according to age (young adult, adult, old). Final diagnosis, MRI findings, and risk factors for central vertigo were evaluated.

RESULTS: Among 2671 patients, 23.4% (626) needed MRI to diagnose vertigo of central origin. Of these, 4.6% (122/2671) of patients had confirmed vertigo of central origin, such as cerebral infarction (2.4%, 63/2671) or cerebral vascular accident (0.7%, 19). For the diagnosis of a central cause of acute isolated vertigo in patients in the ED, the sensitivity of MRI was 89.3%, and the specificity was 100%. In both young adult and adult patients, the frequency of central vertigo increased in patients with underlying diseases.

CONCLUSION: The utility of MRI may not be high in patients with acute isolated vertigo in the ED under age 65 years unless they have signs or risk factors of cerebral vascular accident.

KEY WORDS: Vertigo, stroke, magnetic resonance imaging, risk factor

INTRODUCTION

Dizziness is one of the most common reasons for visiting the emergency department (ED) and is estimated to account for 4% of ED visits [1, 2]. Although the large majority of patients with dizziness has benign processes that are not life-threatening, a small percentage has serious central nervous system pathologies, including infarction, space-occupying lesions, or other processes. Misdiagnosis of central nervous system pathology may result in significant morbidity and mortality [3, 4].

Trained otologists or neurologists can order appropriate neuroimaging tests to diagnose the central cause of acute isolated vertigo based on only a thorough history and physical examination [5]. However, it is not easy to determine which patients require magnetic resonance imaging (MRI) for diagnosis of acute isolated vertigo, especially among ED physicians, if the patient does not show warning symptoms and signs of stroke or other central origin pathologies. In addition, there is significant overlap in the presentation of patients with peripheral and central causes of vertigo, and screening and diagnostic tests, such as neuroimaging studies, are frequently ordered for patients who present to the ED due to dizziness [6]. Although computed tomography (CT) is widely available in the ED setting, it has limited sensitivity for detecting brain ischemia or infarction, especially in the posterior fossa [6]. On the other hand, MRI has greater sensitivity for detection of cerebral infarction and posterior fossa lesions [7]. However, MRI carries higher initial costs. Despite the relative lack of research on the comparative effectiveness of the application and yield of these neuroimaging methods in the ED, many such imaging studies are performed worldwide to evaluate patients with dizziness in the ED. However, these neuroimaging studies do not improve the diagnosis of stroke, which is one of the most critical causes of acute isolated vertigo [8, 9].

The aim of this study was to determine the usefulness of MRI for evaluating the central causes of acute isolated vertigo and determine which patients require MRI in the ED. For this purpose, we investigated the ratio of central causes of acute isolated vertigo in the ED, the usefulness of MRI in determination of a central cause, and the various risk factors for central causes (e.g., age, underlying disease) in patients with acute isolated vertigo who visit the ED.

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MATERIALS and METHODS

Study Design

Patients were identified via an electronic chart of the patient database for the term "vertigo" at the ED of our medical center from March 2010 to February 2012. We retrospectively reviewed charts of consecutive patients who had acute isolated vertigo and underwent brain MRI in the ED. Study subjects included all patients who presented to the ED with acute isolated vertigo and who had an MRI within 24 h. Acute isolated vertigo was defined as the commencement of vertigo within 24 h and no central neurologic signs except vertigo. Vertigo was defined as illusion of movement, either of the external world revolving around the individual or of the individual revolving in space [10]. Patients were excluded if the cause of vertigo was trauma or drugs or if they showed central neurologic signs. Central neurologic signs included ataxia and important warning signs of stroke according to the National Institute of Neurological Disorders and Stroke (sudden numbness or weakness of the face, arm, or leg, especially on one side of the body; sudden confusion; trouble talking or understanding speech; or sudden trouble seeing in one or both eyes) [11]. In addition, central neurologic signs were evaluated with a nystagmus test (spontaneous, gaze, positioning, and evoked), cerebellar function test, gait test, cranial nerve function test, and peripheral motor function test. All patients with vertigo were evaluated by a senior resident in otolaryngology or neurology within 1 h after arrival. Brain MRI was performed for all vertigo patients except those with trauma or those with benign paroxysmal vertigo who experienced immediate relief of their symptoms after a repositioning maneuver. MRI included diffusion-weighted images and T2 images without enhancement. Two radiologists confirmed abnormal MRI findings. All vertigo patients who were discharged from the emergency room were instructed to visit our clinic within 24 h to follow up if their vertigo did not subside or other neurologic symptoms developed. After 1 day, severe events experienced by all patients with vertigo (visit or admission to another hospital) were evaluated using phone calls made by a nurse.

Characteristics of vertigo (onset, duration, type, frequency, and aggravating or relieving factors), medical history (hypertension, diabetes, arrhythmia, coronary artery disease, previous stroke, cancer, other history of major surgery, and medications), and accompanying symptoms (hearing impairment, ear fullness, tinnitus, nausea, vomiting, fever, headache, and visual disturbance) were documented. The findings were recorded on the vertigo patient recording form of our hospital.

Statistical Analysis

Data were recorded onto a standardized data collection form. Data were then entered into an electronic database (Access 2007, Microsoft Corporation) and imported into Statistical Package for the Social Sciences (SPSS) version 13 (Chicago, IL, USA) for data analysis. Our patients were divided into three groups according to age: young adult (<45 years old); adult (45-64 years old); and old (>65 years old). Types of vertigo were classified as peripheral, central, psychogenic, and others according to the origin of vertigo after the final diagnosis was confirmed. The peripheral type included benign paroxysmal positional vertigo, vestibular neuronitis, Meniere's disease, recurrent vestibulopathy, and other peripheral diseases, such as migrainous vertigo or labyrinthitis. Meniere's disease was diagnosed according to the guidelines of the AAO-HNS Committee of Hearing and Equilibrium [12]. The central type included cerebral infarction, hemorrhage, transient ischemic attack, vertebrobasilar insufficiency, and tumors, such as acoustic tumors or cerebropontine angle tumors. The final diagnosis of cerebral stroke was achieved by a neurologist through follow-up medical and imaging examinations. The psychogenic type included anxiety disorder, somatoform disorder, and phobic postural vertigo. Others included drugs; cardiogenic or pulmonary, endocrine, or hematologic origin; and others. Common risk factors for cerebrovascular accident (hypertension, diabetes, and smoking) and history of cerebrovascular accident were considered risk factors for central vertigo [13].

Our results are given as the mean ± standard deviation or as a percentage. Logistic regression analysis was performed to predict the outcomes of clinical variables and findings of MRI. $p<0.05$ was accepted as a statistically significant difference. This study was approved by the Institutional Review Board and Ethics committee at Korea university guro hospital.

RESULTS

A total of 2671 patients visited the ED for acute isolated vertigo in this period. Benign paroxysmal positional vertigo (1166), trauma (467), and known Meniere's attack or other causes (412) were diagnosed without MRI. During follow-up, 698 patients were lost. Thus, 23.4% (626/2671) patients received MRIs and completed follow-up.

The mean age of the subjects was 58.2 years, with a range from 12-93 years. The male-to-female ratio was 1:1.1. Demographic data according to age are shown in Table 1. Only 4.6% of patients (122/2671) who visited the ED for acute isolated vertigo had a central cause of vertigo. Among the 626 patients who underwent MRI, a total of 19.5% had a central cause of vertigo, including cerebral infarction (10.1%), TIA (3.0%), and tumors (6.4%). Approximately 44% of the total analyzed patients did not receive confirmation of their cause of acute isolated vertigo. The next most frequent cause was the peripheral type. Central origin, other origin, and psychogenic origin followed in that order. Among patients with a known cause, when these diseases were analyzed based on age, the most common disease in the young adult and adult groups was the peripheral type. However, in the old group, a central origin accounted for the largest proportion. In the group under 45 years of age, only one patient had a cerebral infarction on MRI. Furthermore, only 4.4% of the group was diagnosed with central vertigo. In the group aged 45 years or older, a considerable number of patients had abnormal findings on MRI when patients had underlying diseases. In particular, in men aged 65 or older, one-fourth of the patients who underwent MRI due to dizziness had a central cause of vertigo.

The sensitivity of MRI was 89.3% and the specificity was 100% (Table 2). Of central vertigo patients, 89.3% (109 patients) showed abnormal findings on MRI. However, 10.7% of central vertigo patients (13 patients) did not show abnormal findings on MRI. The cause of these included TIA and VBI.

The ratio of underlying diseases in cases of MRI was significantly more common compared to the other origins in the young adult and adult groups ($p<0.001$) (Table 3). More underlying disease was

Table 1. Demographic data and etiology of acute isolated vertigo patients who underwent MRI in the emergency department

Characteristic	Young adult (<45)	Adult (45-64)	Old (>65)	Total
Patients (n)	113	304	209	626
Age (years)	37.5±7.3	55.8±6.3	72.6±7.3	58.2±16.5
Sex, n (%)				
Male	56 (49.6)	144 (47.4)	78 (37.3)	279 (44.6)
Female	57 (50.4)	160 (52.6)	131 (62.7)	347 (55.5)
Etiology, n (%)	**Not confirmed**	**Not confirmed**	**Not confirmed**	**Not confirmed**
	57 (50.4)	136 (44.7)	85 (40.7)	278 (44.4)
	Peripheral 35 (31)	**Peripheral 87(28.6)**	**Central 62 (29.7)**	**Peripheral 159 (25.4)**
	BPPV 14 (12.4)	BPP V 47 (15.5)	CI 35 (16.7)	BPPV 88 (14.1)
	VN 13 (11.5)	VN 24 (7.9)	TIA&VBI 9 (4.3)	VN 43 (6.9)
	MD 5 (4.4)	MV 6 (2.0)	Tumor 18 (8.6)	MV 9 (1.4)
	RV 1.8 (2)	MD 6 (2.0)	**Peripheral 37 (17.7)**	RV 8 (1.3)
	MV 1 (0.9)	RV 4 (1.3)	BPPV 27 (12.9)	MD 11 (1.8)
	Psychogenic 10 (8.8)	**Central 55 (18.1)**	VN 6 (2.9)	**Central 122 (19.5)**
	Others 6 (5.3)	CI 27 (8.9)	MV 2 (1.0)	CI 63 (10.1)
	CA&PU 3 (2.7)	TIA&VBI 10 (3.3)	RV 2 (1.0)	TIA&VBI 19 (3.0)
	Drug 2 (1.8)	Tumor 18 (5.9)	**Others 22 (10.5)**	Tumor 40 (6.4)
	EC&HE 1 (0.9)	**Others 22 (7.2)**	CA&PU 12 (5.7)	**Psychogenic 17 (2.7)**
	Central 5 (4.4)	CA&PU 14 (4.6)	EC&HE 6 (2.9)	**Others 50 (8.0)**
	CI 1 (0.9)	EC&HE 6 (2.0)	Drug 4 (1.9)	CA&PU 29 (4.6)
	Tumor 4 (3.5)	Drug 2 (0.7)	**Psychogenic 3(1.4)**	EC&HE 13 (2.1)
		Psychogenic 4 (1.3)		Drug 8 (1.3)

BPPV: benign paroxysmal positional vertigo; VN: vestibular neuronitis; RV: recurrent vestibulopathy; MV: migrainous vertigo; CA: cardiogenic disease; PU: pulmonologic disease; EC: endocrinologic disease HE: hematologic disease; CI: cerebral infarction; TIA&VBI: transient ischemic attack and vertebrobasilar insufficiency; ON: other neurologic disease including acoustic tumor

Table 2. Usefulness of magnetic resonance imaging for identification of a central cause of vertigo in acute isolated vertigo patients

	MRI (+)	MRI (-)
Central vertigo (+)	109	13
Central vertigo (-)	0	504

MRI: magnetic resonance imaging

present with increasing age (p=0.007). With the increase in age, cases of both abnormal findings on an MRI scan and central vertigo were significantly increased (p<0.001). A review of the charts of patients with central vertigo showed that most patients (81%) complained of headache. However, ~20% (17 patients) complained of dizziness only, without other clinical manifestations, such as abnormal neurologic findings or severe headache, and were diagnosed with infarction based on an MRI scan.

DISCUSSION

The aim of this study was to determine the usefulness of MRI in the evaluation of central causes of acute isolated vertigo and to determine which patients require MRI in the ED. Our results showed that the utility of MRI for acute isolated vertigo in the ED may not be very high in patients under 65 years of age unless they have warning signs of stroke, underlying disease, or headache.

Vertigo is a common cause of ED visits [14]. Several methods of distinguishing between peripheral and central vertigo have been introduced, including the head impulse test, caloric test, visual fixation, and pattern of nystagmus. The pattern of nystagmus includes down-beating nystagmus and bidirectional gaze-evoked nystagmus, which indicate a central lesion, or whether nystagmus follows Alexander's law [2, 15]. However, learning and performing this examination is not easy for physicians in the ED, with the exception of neurologists and neurotologists. Although a central origin of vertigo can not be ruled out by means of only warning signs of stroke, age, and history of underlying disease, we believe that the usefulness of MRI is increased with the consideration of these factors.

The use of neuroimaging studies to diagnose vertigo in the ED has increased [7, 8]. Recently, the importance of MRI for acute vertigo in the ED has been reported; a small stroke within the posterior fossa can present as acute severe dizziness, mimicking vestibular neuritis [2, 16]. Although CT is used more often than MRI in the ED for acute vertigo, MRI is more useful than CT for diagnosis of central vertigo [2]. However, the use of MRI has many limitations in terms of cost and equipment. In addition, there have been some reports that use of MRI does not increase the detection rate of acute infarction, which is one of the most common reasons for the central origin of acute vertigo [8, 9].

In our study, abnormal findings on MRI were present in 4.6% (122/2671) of patients with acute isolated vertigo in the ED and in 19.5% (122/626) of patients with acute isolated vertigo who underwent MRI in the ED. In addition, a cerebral vascular accident requiring urgent intervention was present in 3.0% (82/2671) of patients with acute isolated vertigo and in 13.1% (82/626) of patients who underwent MRI. Therefore, we think that most acute isolated vertigo patients do not need MRI. However, abnormal findings on MRI were as high as 29.7% in the oldest group, and the presence of cerebral vascular accident was also high, at 21.1%. In addition, about 80% of patients with a central origin had

Table 3. Proportions of acute isolated vertigo patients with underlying disease (hypertension, diabetes mellitus, history of smoking, previous stroke history)

Group	Young adult (<45)	Adult (45-64)	Old (>65)	Total % (ratio)
Central vertigo	40.0 (2/5)	50.9 (28/55)	77.4 (48/62)	63.9 (78/122)
Cerebral infarction	100.0 (1/1)	59.3 (16/27)	82.9 (29/35)	73.0 (46/63)
Other origins	14.8 (16/108)	38.2 (95/249)	62.6 (92/147)	40.3 (203/504)
Not confirmed	15.8 (9/57)	33.1 (45/136)	61.2 (52/85)	38.1 (106/278)
Peripheral vertigo	14.3 (5/35)	40.2 (35/87)	62.2 (23/37)	39.6 (63/159)
Psychogenic origin	20.2 (2/10)	100.0 (4/4)	33.3 (1/3)	41.2 (7/17)
Other disease	0.0	50.0 (11/22)	72.7 (16/22)	63.6 (28/44)
p value	0.001	0.001		

Ratio: patients with underlying disease to acute isolated vertigo patients of each group

a headache. In particular, patients who had underlying disease had more abnormal findings on MRI. Thus, we recommend the use of MRI in patients aged 65 or older and that MRI should be considered if patients have underlying disease or headache. In patients younger than the age of 65, we recommend the use of MRI only when the patient has underlying disease or severe headache.

The results of the present study correspond with those of earlier studies, which reported that the rate of serious neurologic findings in dizziness was not high [14, 15]. Previous studies showed that the incidence of central vertigo was 3% to 6% in patients with vertigo in the ED, and the most common cause of central vertigo is cerebral infarction [14, 17, 18]. Predictors of a central origin of vertigo included advanced age, gait instability, or neurological examination abnormality [18, 19].

We only used MR diffusion-weighted and T2-weighted imaging in the ED, because a full MRI series requires more time and greater cost. Unfortunately, MR diffusion-weighted imaging is associated with some degree of false-negative results. In our study, the false-negative rate of MRI was about 10.7%. Other studies also reported that the rate of false negatives in diffusion-weighted MRI was from 5% to 25% [20, 21]. Therefore, physicians should consider a central origin of vertigo even if the findings of diffusion-weighted MRI are not specific in patients aged 65 or older.

In this study, the most common etiology of acute isolated vertigo was not confirmed. Although all patients were instructed to visit our clinic for follow-up, many patients did not come back to the clinic. After diagnosis of acute vertigo and relief of symptoms in the emergency room, they did not want to visit the clinic due to cost and inconvenience. If they had another vertigo attack or other neurologic symptoms, they may have visited our hospital or clinic. Therefore, we believe that most unconfirmed cases were of the peripheral type and not the central type. In addition, to correctly diagnose the etiology of all patients with vertigo is very difficult, even if all patients are tested [1, 4, 22]. Navi et al. [18] reported that about one-fourth of dizziness remains uncharacterized, even after extensive evaluations.

Headache often accompanies stroke and dizziness [5]. Headache is observed in about 15% to 40% of patients with acute ischemic stroke and is seen more often in patients with posterior circulation stroke (59%) [23] compared with other areas [24]. In this study, we found that headache can be an important sign of central vertigo.

In conclusion, the use of MRI can be decreased through careful neurologic examination and risk factor analysis. The use of MRI to diagnose acute isolated vertigo can be recommended when patients have underlying risk factors, are older than 65 years, or have acute-onset headache. When vertigo does not resolve, a central origin should be considered in elderly patients, even if MRI findings are not specific.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Korea University Guro Hospital.

Informed Consent: Written informed consent was not received due to the retrospective nature of this study.

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