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Neuroimaging utilization and clinical indications in geriatric patients presenting to the emergency department with dizziness

Handan ÖZEN OLCAY *MD*, Emine EMEKTAR *MD*, Seda DAĞAR *MD*, İzzettin ERTAŞ *MD*, Şeyma Nur ÇELİK *MD*, Yunsur ÇEVİK *MD*

Ataturk Sanatoryum Training and Research Hospital, Department of Emergency Medicine,

Abstract

Background & Objective: With the increasing prevalence of advanced technology, there has been a notable rise in the use of neuroimaging for patients presenting to the emergency department (ED) with dizziness in recent years. This study aims to investigate the frequency of neuroimaging, the clinical indications for its use, the findings, and the factors influencing these findings in geriatric patients presenting with dizziness to the ED. *Methods:* The study included patients aged 65 and older who presented to the ED with dizziness between January 1, 2018, and December 31, 2023, and who had undergone brain computed tomography (CT) and/or diffusion-weighted magnetic resonance imaging (DW-MRI), with complete data available. Intracranial masses, acute-subacute ischemic findings, intraparenchymal and subarachnoid hemorrhage, and brain edema detected on brain CT were classified as significant pathologies. Additionally, patients were compared based on the presence of ischemia on DW-MRI with other variables. *Results:* The study included 508 patients who underwent CT scan and/or DW-MRI. Significant pathology was detected in 6.3% of those who underwent CT scan. Among the patients who underwent DW-MRI, 9.1% were found to have acute-subacute ischemia. The incidence of significant pathology and ischemia was statistically higher in patients who underwent CT scan and DW-MRI due to indications such as aphasia, focal neurological deficits, vertical nystagmus, ataxia, and dysmetria/dysdiadochokinesia ($p<0.05$).
Conclusion: In geriatric patients, emergency neuroimaging should be performed considering clinical characteristics and risk factors. Limiting the use of CT scan to specific indications rather than routine use, and prioritizing DW-MRI in cases where ischemic events are suspected, may be more appropriate.

Keywords: Dizziness, elderly, geriatric, neuroimaging.

INTRODUCTION

Dizziness is one of the most common complaints encountered in emergency departments (ED) worldwide. The underlying pathologies causing this symptom range from benign conditions to life-threatening ones, involving the neurological, cerebrovascular, and vestibular systems.[1,2] In elderly patients, dizziness should be considered as a symptom rather than a standalone medical diagnosis. The patient's history is critical in determining the most likely cause of dizziness. A thorough history, clinical examination, laboratory tests, and neuroimaging methods can assist in reaching a diagnosis in patients presenting with dizziness.[3]

With the widespread use of technology, there has been a significant increase in the use of neuroimaging in patients presenting to the ED with dizziness in recent years.[1] Between 1995 and 2011, ED visits due to dizziness increased by 97%, reaching 3.9 million, while the use of neuroimaging rose from 10% to 40%, with brain computed tomography (CT) scans being the most commonly preferred method.[1,4]

Diffusion-weighted magnetic resonance imaging (DW-MRI) is of great importance, particularly in cases where ischemic stroke is suspected. The brain CT scans are useful in diagnosing serious clinical conditions such as masses, hemorrhage, and cerebral edema.[5] However, it is well known that the diagnostic

Address correspondence to: Handan ÖZEN OLCAY, MD, Ataturk Sanatoryum Training and Research Hospital, Department of Emergency Medicine, Ankara, TURKEY. Tel: +90 506 713 80 13, E-mail: hozen84@hotmail.com

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yield of CT scan in detecting significant structural causes in patients with dizziness is low.[4,6-8]

Physicians has keep the threshold for neuroimaging low in this age group although geriatric patients are at higher risk for neurovascular disease, have comorbidities, use anticoagulants, and are sometimes unable to express symptoms well.

Most neuroimaging studies related to patients with dizziness focus on the general adult population. However, factors such as increased life expectancy and the growing elderly population have led to the need to develop specific diagnostic and treatment algorithms for this population. Therefore, in this study focusing on the geriatric population, we aimed to investigate the frequency of brain CT and DW-MRI use, the indications for imaging, the findings from CT and DW-MRI, and the factors influencing these findings in patients presenting to the emergency department with dizziness.

METHODS

Study design

This retrospective study was carried out in the ED of Ankara Atatürk Sanatoryum Training and Research Hospital (AASTRH), a tertiary care institution with 780 beds located in a busy provincial center, handling approximately 390,000 ED visits annually. The study received approval from the local ethics committee under protocol number 2024-BÇEK/14. Our research was conducted in alignment with the Standards for Reporting of Diagnostic Accuracy Studies (STARD) guidelines.

Data collection

Data were collected from electronic medical records and patient files. Two emergency medicine specialists, each with at least 5 years of experience, performed a retrospective review of the charts, which included clinical and demographic details of the patients, along with CT and DW-MRI scan results. Any disagreements between the two specialists were resolved by the lead investigator, who made the final decision. Interobserver agreement was not assessed, as the CT and DW-MRI scans were not re-evaluated; the review relied solely on the existing reports.

Study population

The study included patients aged 65 and older who presented to the ED with dizziness between January 1, 2018, and December 31, 2023, and who had undergone brain CT and/or DW-MRI with complete data available. Patients younger than 65, those with primary intracranial malignancy, those with altered consciousness, those with a history of trauma before or after presentation, those who were hemodynamically unstable, and patients with incomplete data were excluded from the study.

Patients were screened from the hospital database according to ICD-10 (International Statistical Classification of Diseases: R42, H81 and subcodes). The symptoms other than dizziness (nausea-vomiting, syncope/presyncope, amnesia, aphasia, headache), demographic information, comorbid diseases, medications, neurological examination findings, and imaging results were recorded. The indications for CT were classified as 'syncope/presyncope, aphasia, amnesia, nausea-vomiting, headache, focal deficit, visual disturbance, ataxia, dysmetria/dysdiadochokinesia, vertical nystagmus, and unresponsiveness to medical treatment.' It was observed that imaging was performed due to one or more of these defined indications. Systolic blood pressure above 140 mmHg at the time of presentation was considered hypertension. Additionally, treatments with dimenhydrinate and diazepam administered for medical purposes were recorded.

Patients with findings of intracranial mass, acute-subacute ischemia, intraparenchymal or subarachnoid hemorrhage, and cerebral edema on brain CT scan were considered as significant pathology. Other changes observed on CT scan, such as atrophy, encephalomalacia, arachnoid cysts, and calcifications, were not considered as significant pathology. Patients were divided into two groups: those whose acute management was altered based on the CT scan (those with significant pathology on CT scan) and those whose management was not altered. Additionally, patients were categorized based on whether or not they had diffusion restriction on DW-MRI. Management changes based on emergency neuroimaging were defined as deviations in the patient's emergency care plan driven by imaging results. These changes included neurosurgical interventions, specialized medical treatments (e.g., treatment for subarachnoid hemorrhage or central nervous system infections), or the need for hospital admission based on imaging findings.

Statistical analysis

All data collected and recorded on the study form were analyzed using the IBM SPSS 20.0 (Chicago,

IL, USA) statistical software. The distribution of discrete and continuous numerical variables was evaluated for normality using the Shapiro-Wilk test. Descriptive statistics for discrete and continuous numerical variables were presented as median (IQR 25-75), while categorical variables were displayed as frequencies and percentages. Categorical variables were analyzed using the Chi-square test, and continuous variables were assessed using either the Mann-Whitney U test. A critical alpha value of 5% was considered for all statistical analyses, and hypotheses were tested bidirectionally.

RESULTS

During the study period, 2754 patients presenting with dizziness were evaluated. A total of 567 patients underwent CT and/or DW-MRI. The study included 508 patients with complete data who had undergone CT and/or DW-MRI (Figure 1).

Of the patients, 60.6% were female, and the median age was 74 years (IQR 25-75, 68-79). Imaging was performed in 62.4% of the patients due to nausea and vomiting, and in 50.2% due to unresponsiveness to medical treatment. A total of 10.2% of the patients were admitted to the hospital for treatment. The demographic data, treatments, and outcomes of the patients are presented in Table 1.

CT scans were normal in 20.9% of the patients, while significant pathology was detected in 6.3%, with the most common significant finding being acute-subacute ischemia (4.3%). The most frequently observed CT finding was atrophy (73%). It was noted that DW-MRI could not be performed in five patients with acute-subacute ischemia on brain CT due to contraindications. Among the patients who underwent DW-MRI, 9.1% were found to have acute-subacute ischemia. The imaging findings of the patients are presented in Table 2.

The comparison between patients with and without significant pathology on brain CT, as well as between those with and without ischemia on DW-MRI, is presented in Table 3. A history of cerebrovascular disease (CVD) and the use of anticoagulant medications were found to be statistically significant for the presence of significant pathology on CT ($p<0.05$ for all values). A history of hypertension, coronary artery disease, atrial fibrillation, and CVD in patients was found to be significant for ischemia on DW-MRI ($p<0.05$ for all values). Patients with elevated blood pressure at presentation had significantly higher rates of both significant pathology on CT and ischemia on DW-MRI ($p<0.001$). The rates of significant pathology and ischemia were statistically higher in patients who underwent CT

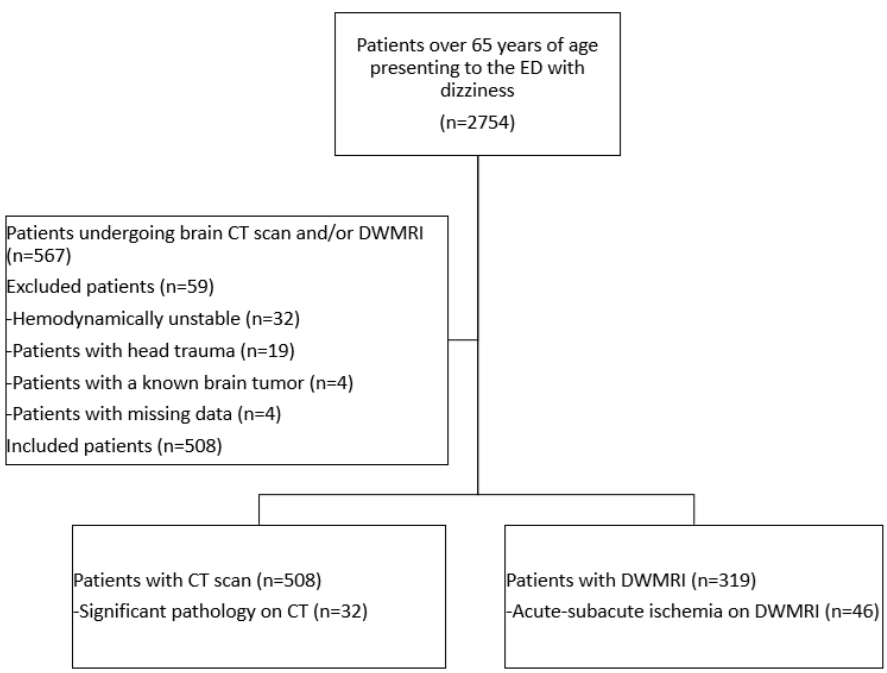

Figure 1. Flowchart showing number of patients of the study

Table 1: Demographic and clinical characteristics of the patients

Gender, *n(%)*	
Female	308 (60.6)
Age, *median (IQR[1] 25-75)*	74 (69-80)
Comorbidities, *n(%)*	
Hypertension	322 (63.4)
Diabetes mellitus	188 (37)
COPD[2]	62 (12.2)
CAD[3] /CHF[4]	132 (26)
AF[5]	44 (8.7)
CKD[6]	27 (5.3)
Malignancy	18 (3.5)
CVD[7]	42 (8.3)
BPV[8]	74 (14.6)
ASA[9] / Antiplatelet use	194 (38.2)
Anticoagulant use	31 (6.1)
Hypertensive patients, *n(%)*	198 (39)
Horizontal nystagmus	126 (24.8)
Duration of symptoms, *n(%)*	
0-8 hours	269 (53)
8-24 hours	157 (30.9)
Longer than 24 hours	82 (16.1)
Indications for imaging, *n(%)*	
Syncope/presyncope	61 (12)
Aphasia	28 (5.5)
Amnesia	4 (0.8)
Nausea/vomiting	317 (62.4)
Focal deficit	29 (5.7)
Headache	96 (18.9)
Visual disturbance	8 (1.6)
Vertical nystagmus	3 (0.6)
Ataxia	90 (17.7)
Dysmetria/dysdiadochokinesia	13 (2.6)
Unresponsiveness to medical treatment	255 (50.2)
Dimenhydrinate, *n(%)*	303 (59.6)
Diazepam	60 (11.8)
Patients Outcome, *n(%)*	
Discharge	456 (89.8)
Hospitalization	52 (10.2)
Length of hospital stay, days, *n(%)*	8 (5.25-10)

* A patient may have undergone a CT scan for multiple indications. IQR[1]: Interquartile Range COPD[2]: Chronic Obstructive Pulmonary Disease, CAD[3]: Coronary Artery Disease, CHF[4]: Congestive Heart Failure, AF[5]: Atrial Fibrillation, CKD[6]: Chronic Kidney Disease, CVD[7]: Cerebrovascular Disease, BPV[8]: Benign Paroxysmal Vertigo, ASA[9]: Acetylsalicylic Acid

and DW-MRI for indications such as aphasia, focal neurological deficit, vertical nystagmus, ataxia, and dysmetria/dysdiadochokinesia ($p<0.05$ for all values).

DISCUSSION

In this study, where we examined the frequency of neuroimaging performed in geriatric patients presenting to the ED with dizziness and the impact of neuroimaging results on the acute management of these patients, as well as the factors influencing neuroimaging findings, it was observed that 93.7% of brain CT scans and 90.9% of DW-MRIs did not reveal significant pathology that could affect the patient's emergency management. A history of CVD and the use of anticoagulant medications were found to be significant for the detection of significant pathology on CT scan, while hypertension, coronary artery disease, atrial fibrillation, and CVD were significant for the detection of ischemia on DW-MRI. Additionally, elevated blood pressure at presentation, aphasia, focal neurological deficits, vertical nystagmus, ataxia, and dysmetria/dysdiadochokinesia were found to be significant for the detection of significant pathology on both CT scan and DW-MRI. The results of our study emphasize that while a high proportion of unnecessary neuroimaging is performed in geriatric patients presenting to the ED with dizziness, the presence of significant findings, though infrequent, is important in patient diagnosis and management.

Dizziness is a common but difficult-to-define complaint in elderly individuals.[3] The underlying causes of dizziness are highly diverse, encompassing a wide range of etiologies, including neurological, metabolic, cardiovascular, and psychiatric factors.[3,10,11] Physicians often lower the threshold for neuroimaging in elderly patients with symptoms like dizziness due to concerns about missing a diagnosis or fear of malpractice lawsuits. While the excessive and almost routine use of neuroimaging in EDs can prevent the oversight of serious neurological conditions, it can also lead to several undesirable effects, such as unnecessary radiation exposure, prolonged patient stay in the ED, and increased healthcare system burden and costs.[13] In recent years, with increasing life expectancy and the growing elderly population, the need to tailor clinical decision-making rules based on age groups has become an essential aspect of physicians' daily practice.

The CT scan is the preferred neuroimaging method for ruling out pathologies such as acute

Table 2: Neuroimaging findings of the patients

Patients who underwent CT[1], *n(%)*	508 (100)
CT results, *n(%)*	
Normal	106 (20.9)
Atrophy	371 (73)
Encephalomalacia	200 (39.4)
Calcification	26 (5.1)
Acute-subacute ischemia	22 (4.3)
Mass	8 (1.6)
Cerebral edema	4 (0.8)
Intraparenchymal hemorrhage	2 (0.4)
Subarachnoid hemorrhage	2 (0.4)
Arachnoid cyst	2 (0.4)
Significant pathology on CT, *n(%)*	32 (6.3)
Patients who underwent DW-MRI[2], *n(%)*	319 (62.8)
Patients with acute-subacute ischemia on DW-MRI, *n(%)*	46 (9.1)

* A patient may have more than one CT finding. CT[1]: Computed Tomography, DW-MRI[2]: Diffusion-weighted Magnetic Resonance Imaging

hemorrhage. However, CT scan typically yields normal results in the early hours of acute ischemic events. DW-MRI is significantly more sensitive than CT scan in diagnosing acute ischemic stroke, with a sensitivity of approximately 80-95% within the first 24 hours.[14,15] Nevertheless, certain limitations in the use of DW-MRI, such as contraindications (e.g., pacemakers, prostheses) and the need for patient cooperation, can restrict the application of this method.

Studies in adult patients report that the detection rate of significant pathology on brain CT scans performed for dizziness is 5-7%, while the rate of acute subacute ischemia on DW-MRI is reported to be 10-20%.[1,5,8,16-19] In our study, which focused on the geriatric population, similar rates of significant pathology were identified on both CT and DW-MRI, consistent with rates reported in the literature. These findings suggest that the diagnostic value of neuroimaging in the geriatric population is comparable to that in the younger adult population. The physiological brain atrophy that occurs with aging can lead to symptoms such as postural instability and dizziness.[20] The high prevalence of brain atrophy (73%) in our study suggests that age-related neurodegenerative processes may be an important underlying factor in symptoms such as dizziness.

In one study, approximately 38% of early DW-MRI scans detected acute pathology, and age, cardiovascular risk factors, short symptom duration, and the presence of neurological deficits on physical examination were reported to be significant for the detection of acute pathology on imaging.[5] Similarly, other studies have reported higher rates of acute pathology in patients with hypertension, focal neurological findings, ataxia, and central oculomotor signs.[16,17] In our study, a history of CVD, the use of anticoagulant medications, elevated blood pressure at presentation, aphasia, focal neurological deficits, vertical nystagmus, ataxia, and dysmetria/dysdiadochokinesia were found to be predictors of significant pathology on CT. Hypertension, coronary artery disease, atrial fibrillation, CVD, elevated blood pressure at presentation, aphasia, focal neurological deficits, vertical nystagmus, ataxia, and dysmetria/dysdiadochokinesia were also found to be significant for the detection of ischemia on DW-MRI. Although the risk of central pathology is high in the geriatric patient population, routine neuroimaging in EDs is not an appropriate approach. It is clear that imaging decisions should be made by considering patients' existing chronic diseases, medications, and especially neurological examination findings. In patients with suspected ischemia, the cost of CT can be reduced by using DW-MRI alone. However, in cases where hemorrhage or mass lesions are suspected, clinical decision-making rules are needed to determine whether MRI alone or CT followed by DW-MRI is required. Such strategic decisions can improve diagnostic accuracy and enable more efficient use of resources.

The limitations of this study is first, the study is single-center and retrospective. Some patients underwent CT scans for multiple indications, which may have influenced the results. The sample

Table 3: Comparison of patients with and without significant pathology on CT

	Patients with significant pathology on CT[10] (n=32)	Patients without significant pathology on CT (n=476)	p	Patients with ischemia on DW-MRI[11] (n=46)	Patients without ischemia on DW-MRI (n=273)	p
Age, *median (IQR[1] 25-75%)*	75 (71-78)	74 (69-80)	0.458	75 (70.75-81.25)	74 (69-81)	0.597
Gender, *n(%)*						
Female	22 (68.8)	286 (60.1)	0.331	29 (63)	156 (57.1)	0.453
Comorbidities, *n(%)*						
Hypertension	22 (68.8)	300 (63)	0.515	38 (82.6)	162 (59.3)	0.003
Diabetes mellitus	11 (34.4)	177 (37.2)	0.750	22 (47.8)	104 (38.1)	0.212
COPD[2]	3 (9.4)	59 (12.4)	0.435	9 (19.6)	40 (14.7)	0.399
CAD[3] /CHF[4]	5 (15.6)	127 (26.7)	0.167	21 (45.7)	62 (22.7)	0.001
AF[5]	5 (15.6)	39 (8.2)	0.148	10 (21.7)	12 (4.4)	<0.001
CKD[6]	1 (3.1)	26 (5.5)	0.480	1 (2.2)	16 (5.9)	0.266
Malignancy	3 (9.4)	15 (3.2)	0.097	2 (4.3)	6 (2.2)	0.324
CVD[7]	6 (18.8)	36 (7.6)	0.039	11 (23.9)	17 (6.2)	<0.001
BPV[8]	2 (6.3)	72 (15.1)	0.127	2 (4.3)	29 (10.6)	0.142
ASA[9] / antiplatelet use	5 (15.6)	189 (39.7)	0.007	24 (52.2)	92 (33.7)	0.016
Anticoagulant use	6 (18.8)	25 (5.3)	0.009	5 (10.9)	14 (5.1)	0.121
Hypertensive Patients, *n(%)*	24 (75)	174 (36.6)	<0.001	37 (80.4)	96 (35.2)	<0.001
Horizontal Nystagmus	0 (0)	126 (26.5)	<0.001	0 (0)	83 (30.4)	<0.001
Duration of symptoms, *n(%)*						
0-8 hours	11 (34.4)	258 (54.4)	<0.001	27 (58.7)	153 (56)	0.093
8-24 hours	8 (25)	149 (31.3)		9 (19.6)	87 (31.9)	
Longer than 24 hours	13 (40.6)	69 (14.5)		10 (21.7)	33 (12.1)	
Indications for imaging, *n(%)*						
Syncope/presyncope	0 (0)	61 (12.8)	0.015	0 (0)	30 (11)	0.007
Aphasia	5 (15.6)	23 (4.8)	0.025	12 (26.1)	15 (5.5)	<0.001
Amnesia	1 (3.1)	3 (0.6)	0.230	1 (2.2)	2 (0.7)	0.374
Nausea/vomiting	11 (34.4)	306 (64.3)	0.001	13 (28.3)	183 (67)	<0.001
Focal deficit	13 (40.6)	16 (3.4)	<0.001	26 (56.5)	1 (0.4)	<0.001
Headache	6 (18.8)	90 (18.9)	0.982	2 (4.3)	34 (12.5)	0.079
Visual disturbance	2 (6.3)	6 (1.3)	0.085	2 (4.3)	4 (1.5)	0.209
Vertical nystagmus	3 (9.4)	0 (0)	<0.001	3 (6.5)	0 (0)	0.003
Ataxia	18 (56.3)	72 (15.1)	<0.001	28 (60.9)	43 (15.8)	<0.001
Dysmetria/dysdiadochokinesia	5 (15.6)	8 (1.7)	0.001	12 (26.1)	0 (0)	<0.001
Unresponsiveness to medical treatment	4 (12.5)	251 (52.7)	<0.001	4 (8.7)	165 (60.4)	<0.001

IQR[1]: Interquartile Range COPD[2]: Chronic Obstructive Pulmonary Disease, CAD[3]: Coronary Artery Disease, CHF[4]: Congestive Heart Failure, AF[5]: Atrial Fibrillation, CKD[6]: Chronic Kidney Disease, CVD[7]: Cerebrovascular Disease, BPV[8]: Benign Paroxysmal Vertigo, ASA[9]: Acetylsalicylic Acid, CT[10]: Computed Tomography, DW-MRI[11]: Diffusion-weighted Magnetic Resonance Imaging

size of our study is limited. The lack of evaluation of inter-observer agreement for the interpretation of CT and DW-MRI findings may have affected the consistency of the reported results. Additionally, the study does not assess the long-term outcomes of patients, nor does it consider the incidence of significant pathology in patients presenting with dizziness who did not undergo neuroimaging, which are further limitations.

In conclusion, given the low diagnostic yield of CT in detecting significant pathology in geriatric patients presenting with dizziness, it may be more appropriate to use imaging not as a routine diagnostic tool but in patients with specific clinical

indications or risk factors. In patients with a history of hypertension, coronary artery disease, atrial fibrillation, and LVH, and in patients with suspected ischemia who have focal neurological findings on physical examination, DW-MRI may be the first choice for emergency neuroimaging.

DISCLOSURE

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