

Brain computed tomography in centenarians presenting to the emergency department: is age an indication to CT scan?

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Abstract. – OBJECTIVE: This study aimed to explore the relationship between admission complaints and brain computed tomography (CT) examinations. Also, we evaluated the relationship between age and CT scan results in centenarians admitted to the emergency department for non-traumatic reasons.

PATIENTS AND METHODS: This study was a retrospective analysis of patients aged 100 years and older who presented to the tertiary hospital emergency department for non-traumatic reasons between 2012 and 2021. Demographic characteristics, admission complaints, and indications used for brain CT were evaluated. The Fazekas grade and Evans index were compared with a younger population aged 85-90 years.

RESULTS: Brain CT was ordered in 41.1% (n: 15/34) of the patients due to their atypical symptoms. While no acute pathology was found in the CT scans, 23.5% of the patients had an incidental intracranial mass and/or chronic ischemic areas. When the leukoencephalopathy findings of the centenarian patients were compared to the patients aged 85-90, it was determined that the Fazekas grade increased with age ($p = 0.002$). Concerning the ventricle diameter, there was a significant difference between the two groups ($p = 0.017$), with larger values detected in the 85-90 years group.

CONCLUSIONS: Although no acute pathology was found in the brain CT scans of the centenarian patients who presented to the emergency department for any reason other than trauma, CT plays a fundamental role in determining emergency diagnosis and management strategies in patients presenting with atypical symptoms. While the degree of leukoencephalopathy increased with age, the ventricle diameter was significantly larger in the younger age group than in the centenarian patients.

Key Words:

Brain, Centenarian, Computed tomography, Emergency.

Introduction

Computed tomography (CT) has become an indispensable tool for the management of patients admitted to the emergency department. It is frequently used to diagnose and treat patients presenting with neurological symptoms (dizziness, headache, altered consciousness, and motor and/or sensory loss)¹. However, radiation exposure is the most critical disadvantage of this imaging modality; therefore, it is essential to use it only in the presence of appropriate indications². In addition, the inappropriate request for imaging tests creates a significant and unnecessary economic burden on the health system and negatively affects its functioning³.

Changes in physiological and biological structure with increasing age, coupled with comorbidities, can lead to atypical symptoms and poor outcomes^{4,5}. This situation has revealed the concept of vulnerability, which is characterized by the increased vulnerability of the patient to stress factors in any acute or chronic event and is seen as a risk factor for the development of disability⁶. Changes in physiological and biological structure with increasing age are the most important reason for the atypical presentation of disease symptoms in the elderly population. This leads to the use of more diagnostic tests for diagnosis, increases emergency department length of stay, and increases the risk of functional decline⁷.

Neurological diseases are the most severe cause of disability and death in the elderly population. In a study conducted by Zhang et al⁸ with the participation of 985 people, moderate cognitive impairment was found to be significantly higher in patients over 80 years of age. The diagnosis and treatment of neurological diseases in these centenarians are more complex than in any older adult (65-100 years old). Neurological diseases in centenarians can present with many unrelated symptoms, such as fatigue, weakness, incontinence, decreased mobility, decreased eating, decreased fluid intake, etc., without any signs of neurological diseases. These atypical presentations can lead to the use of more imaging modalities to manage centenarian patients in the emergency department. This study aimed to explore the relationship between admission reasons and the use of brain CT and to determine whether age was an indication for the CT examination of centenarian patients who presented to the emergency department for non-traumatic reasons.

Patients And Methods

This study was conducted retrospectively by examining the data of patients aged 100 years and older who presented to the emergency department of a tertiary hospital for non-traumatic reasons between January 2012 and December 2021 and underwent brain CT. Approval for the study was obtained from the local ethics committee (date: March 27, 2023; decision number: 2023/73).

Study Design

The local digital hospital information management system (HIMS; AKGUN Software, Version hims-web-release_7.9.116 Ankara, Turkey), in which patient records are kept, was used to collect the clinical and neuroradiological data of the centenarian patients included in the study. Using HIMS, the patients' complaints, demographic characteristics, and indications used for brain CT were recorded. Hospital emergency department outcomes, discharge status, and final diagnoses were also noted. Patients younger than 100 years of age, those presenting with trauma, and those with missing data were excluded from the study group.

CT Analysis

Patients who underwent brain CT (16-slice CT scanner, Alexion TSX-034A, Toshiba, Shimoishigomi, Otawara-Shi, Toschigi-Ken, Japan) without

intravenous contrast agent administration were included in the study. In our emergency department, every CT scan taken is interpreted by a radiologist on duty *via* remote access. After the initial evaluation, the CT images of the patients were re-evaluated by a neuroradiologist with 20 years of experience. In addition, the degree of leukoencephalopathy was assessed using the Fazekas scale⁹, while ventricular system volume was assessed using the Evans index¹⁰ on CT. The Fazekas scale was used to rate changes in periventricular and deep white matter areas on magnetic resonance imaging and CT. Using this scale, we classified leukoencephalopathy as mild (I), moderate (II), or severe (III) according to the hypodense lesions detected in brain CT images without intravenous contrast agent administration. The findings obtained from the centenarians were compared to a population of 34 randomly selected patients aged 85-90 years who were consecutively admitted to the hospital's emergency department for non-traumatic reasons and underwent brain CT.

Statistical Analysis

All statistical analyses were performed using IBM SPSS Statistics for Windows Version 22.0 (IBM Corp., Armonk, NY, USA) and Jamovi 1.6 Statistics (The Jamovi Project (2021) Computer Software, Version 1.6. Sydney, Australia) package programs. *p*-value was accepted as 5% for all comparisons. The Kolmogorov-Smirnov test was used to determine whether the data were normally distributed. Of the continuous variables, those with a normal distribution were expressed as mean and standard deviation, and those without a normal distribution were expressed as interquartile ranges (IQRs). Frequency values were used to define the categorical variables. In the comparison of continuous variables, the *t*-test was used for groups with a normal distribution, while the Mann-Whitney U test was used for those without a normal distribution. The Chi-squared test was used to compare categorical variables between the groups. Statistical significance was accepted as *p*-value < 0.05.

Results

Of the 34 patients aged 100-106 years (median: 102; IQR: 100-103) included in the study group, 33 (97.1%) were female. The most common reason for admission was headache (*n* = 8, 23.5%), followed

by dizziness (11.8%) and fainting (11.8%). In 27 patients (79.4%), brain CT was performed for the first time in a calendar year. When the reasons for brain CT examinations were evaluated, 15 (41.1%) centenarians had atypical symptoms, such as nausea, vomiting, loss of strength, fatigue, and oral food intake problems. While no acute pathology was observed on the CT scans, there were incidentally detected intracranial masses and/or chronic ischemic areas in eight patients (23.5%). The final diagnoses at the emergency department were headache in eight patients (20.6%) and ischemic stroke in five (14.7%) (Table I).

The degree of leukoencephalopathy of the centenarian patients was greater (Grade III) compared to the population aged 85-90 years. A statistically significant difference was found between the two groups according to the Fazekas scale (p -value = 0.002). However, there was no statistically

significant difference between the subgroups formed based on the presence of symptoms such as headache, dizziness, acute neurological deficit, and nausea-vomiting (Table II) (Figure 1).

The mean Evans index was 0.284 ± 0.0451 in the centenarian group and 0.310 ± 0.0428 in the 85-90 years group. The difference between the two groups was statistically significant (p -value = 0.017). No significant difference was detected between the ventricle volumes of the subgroups formed based on presentation complaints (Table II) (Figure 2).

Discussion

In this study, although no acute pathology was found in the brain CT scans of centenarian patients who presented to the emergency department for any reason other than trauma, brain CT was

Table I. Demographic characteristics of the centenarian patients.

Variable	n (%)
Gender, female	33 (97.1%)
Age, median (IQR) (years)	102 (100-103)
Presentation complaint	
Headache	8 (23.5%)
Dizziness	4 (11.8%)
Fainting	4 (11.8%)
Shortness of breath	4 (11.8%)
Poor general condition	3 (8.8%)
Loss of strength	3 (8.8%)
Altered mental state	2 (5.9%)
Palpitations	2 (5.9%)
Nausea, vomiting	2 (5.9%)
Speech disorder	1 (2.9%)
Abdominal pain	1 (2.9%)
Atypical symptoms (nausea, vomiting, weakness, fatigue, oral food intake problems, etc.)	15 (44.1%)
Number of CT scans taken in a calendar year	
1	27 (79.4%)
2	5 (14.7%)
3	1 (2.9%)
8	1 (2.9%)
Incidentally detected findings on brain CT	
Parenchymal chronic ischemic change	7 (20.6%)
Intracranial mass	1 (2.9%)
Final diagnosis at the emergency department	
Headache	7 (20.6%)
Ischemic stroke	5 (14.7%)
Dizziness	4 (11.8%)
Syncope	3 (8.8%)
Acute renal failure	3 (8.8%)
Pneumonia	3 (8.8%)
Urinary tract infection	2 (5.9%)
Congestive heart failure	2 (5.9%)
Other (atrial fibrillation, ventricular fibrillation, myocardial infarction, acute gastroenteritis, and chronic renal failure)	5 (14.7%)

IQR: interquartile range; CT: computed tomography.

Table II. Evaluation of leukoencephalopathy (Fazekas scale) and ventricular volume (Evans index) according to age groups.

	85-90 years group	Centenarian group	p-value
Fazekas grade, overall			
I	12 (35.3%)	2 (5.9%)	0.002 ^a
II	10 (29.4%)	8 (23.5%)	
III	12 (35.3%)	24 (70.9%)	
Fazekas grade, headache subgroup	(n = 2)	(n = 8)	
I	1 (2.9%)	1 (2.9%)	0.131 ^a
II	1 (2.9%)	0 (0.0%)	
III	0 (0.0%)	7 (20.6%)	
Fazekas grade, dizziness subgroup	(n = 2)	(n = 4)	
I	2 (5.9%)	1 (2.9%)	0.223 ^a
II	0 (0.0%)	2 (5.9%)	
III	0 (0.0%)	1 (2.9%)	
Fazekas grade, acute neurological deficit subgroup	(n = 5)	(n = 4)	
I	2 (5.9%)	0 (0.0%)	0.329 ^a
II	2 (5.9%)	2 (5.9%)	
III	1(2.9%)	2 (5.9%)	
Evans index	0.0310 ± 0.0451	0.284 ± 0.0451	0.017 ^b
Headache subgroup			0.690 ^b
Dizziness subgroup			0.012 ^b
Acute neurological deficit subgroup			0.055 ^b

^a: Pearson's Chi-square test. ^b: Independent samples *t*-test.

shown to play a fundamental role in determining emergency diagnoses and management strategies in patients presenting with atypical symptoms.

Neurological diseases are among the conditions that require medical care in the emergency department^{11,12}. Age-related physiological, psychological and cognitive changes, comorbid conditions and polypharmacy make the acute illness clinic atypica¹⁷. This leads to the use of more imaging

methods in the therapeutic diagnosis process, especially in the patient population aged 80 and over. In the current study, a brain CT was ordered for 44.1% of the patients due to non-specific atypical symptoms, such as nausea, vomiting, weakness, fatigue, and oral food intake problems.

Imaging modalities effectively determine neurodegenerative conditions that may occur with aging or many comorbid diseases. Brain CT has

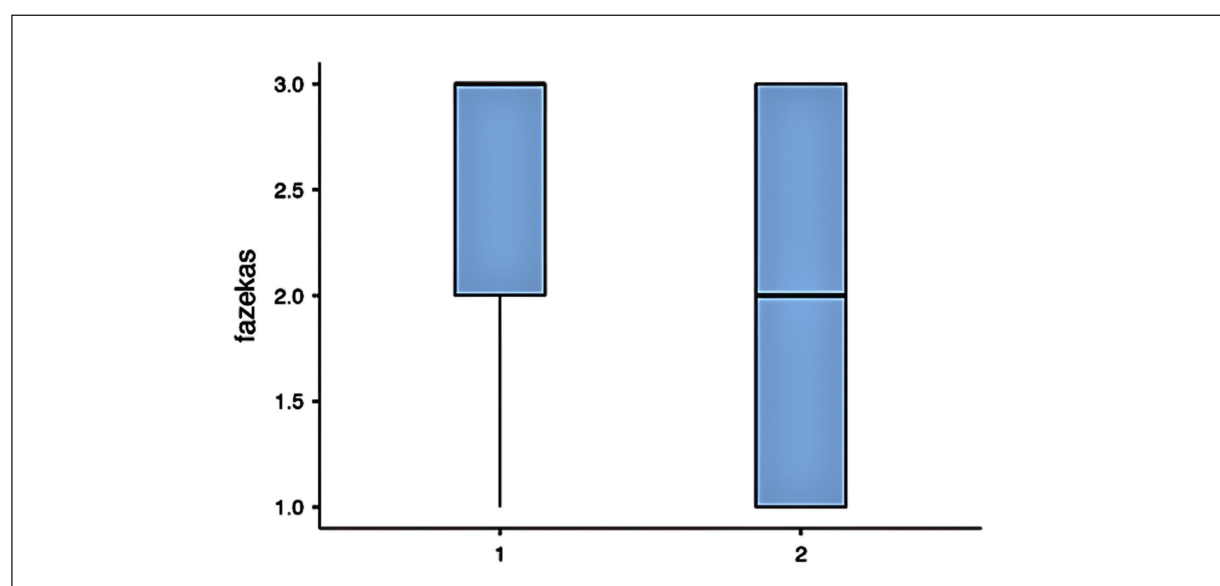


Figure 1. Distribution of Fazekas grades by age group. (1: centenarian group, 2: 85-90 years group).

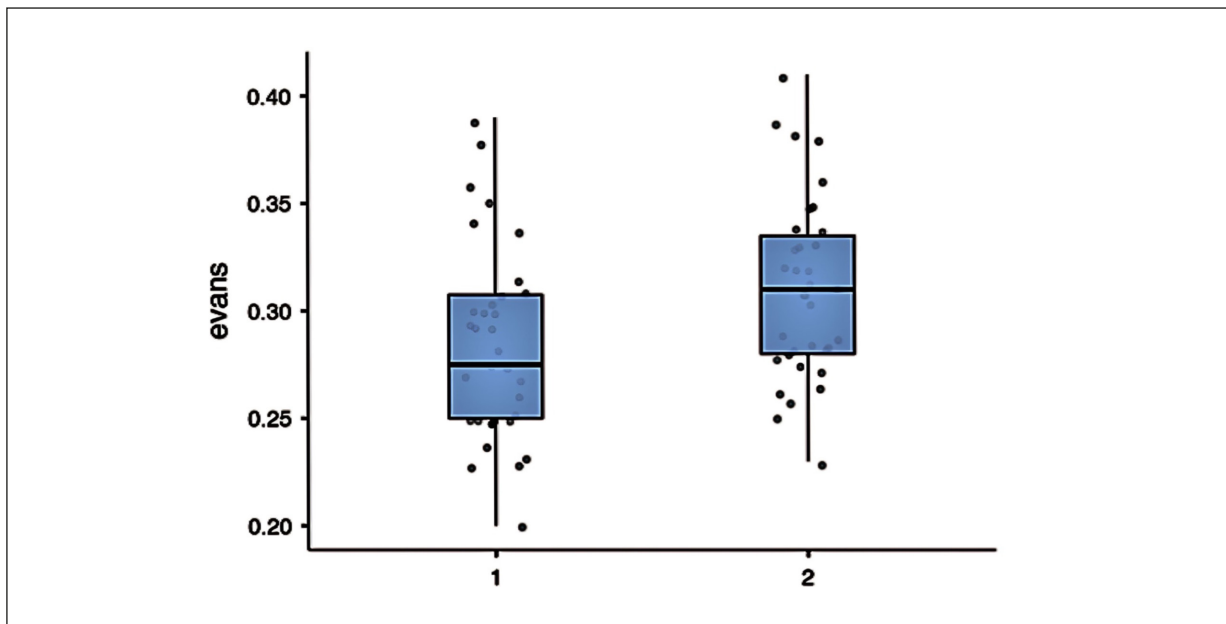


Figure 2. Distribution of Evans index scores by age group. (1: centenarian group, 2: 85-90 years group).

become the primary diagnostic tool in the rapid recognition and assessment of the severity of intracranial diseases in the elderly patient population¹³. In recent years, increasing patient density in emergency departments and legal responsibilities have led to more brain CT scans. The absence of acute intracranial pathologies in the CT scans included in the current study is an indicator of the excessive use of brain CT examinations in the emergency department. On the other hand, it should be kept in mind that atypical symptoms observed in this patient population – who are frail and use multiple drugs to treat comorbid diseases – may occur due to drug reactions, and necessary evaluations should be made against these risks¹⁴. Therefore, patients should be subjected to a multi-dimensional geriatric evaluation, which must not be limited to the acute symptoms that bring them to the emergency department⁷.

Ordering imaging tests for the right patient at the right time is essential in reducing radiation exposure and the economic burden on the health system. In particular, the concern of misdiagnosis and mistreatment of emergency physicians has led to an increase in the use of CT over the years, due to its easy accessibility^{15,1}. Although neurological diseases have a significant impact on mortality and morbidity, the clinical outcomes they cause also significantly affect the quality of life, depending on the severity of the neurological condition, as well as existing comorbidities and

the presence of emerging complications¹⁶. The initial evaluation of elderly patients and their correct management are important in emergency departments. Although there are no clear criteria for patients presenting for non-traumatic reasons, the literature supports the use of CT scans to detect the presence of abnormal findings in conditions such as increased age, focal neurological findings, altered mental status, nausea-vomiting, or headache accompanied by nausea and vomiting^{17,18}. In our study, the advanced age of the patients and the presence of admission complaints, such as headache, dizziness, syncope, and altered mental status, are consistent with the criteria specified in the literature as indications for brain CT scans. However, although 14.7% of the included patients had admission complaints and physical examination findings supporting ischemic stroke, and 11.8% of them were hospitalized and received medical care at the neurology clinic, there were no findings that supported acute ischemia on the brain CT scans. Therefore, it should be noted that brain CT is limited in evaluating acute ischemic stroke¹⁹.

Changes that occur due to chronic or transient recurrent hypoperfusion in the brain white matter are among the incidental findings in elderly individuals. However, publications suggest this is associated with cognitive impairment and a high risk of death after stroke^{20,21}. In the current study, 70.9% of our centenarian patients had grade III

leukoencephalopathy findings, classified as severe. There was a significant difference when the centenarian group was compared to the 85-90 years group. While this result supports age-related leukoencephalopathy, it contradicts the study conducted by Romano et al²². In the evaluation we performed, according to presentation complaints and the presence of neurological deficits, we did not find a significant difference between the two age groups in terms of leukoencephalopathy. This may be attributed to the small number of patients in the subgroups.

Aging causes progressive enlargement of the cerebral ventricle system²³. The Evans index is used to determine this enlargement, and 0.30 is considered the threshold value for detecting an underlying neurological condition, regardless of age²⁴. In the presence of an Evans index above 0.30, care should be taken regarding the possibility of dementia and degenerative or vascular cognitive diseases. In this study, the difference between the Evans indexes of the two age groups was statistically significant. However, despite their higher degree of leukoencephalopathy, the centenarians had a lower Evans index than the 85-90 years group, suggesting that they had good neurological health, which could be attributed to hereditary factors and living conditions. This is parallel to the results reported by Romano et al²² and Chrzan et al²⁵.

Many factors that determine cognitive impairment and dementia risk in elderly patients, such as age, depression, diabetes, ischemic heart disease, and polypharmacy, have been described in the literature. In particular, polypharmacy and the properties of the drugs used are important²⁶. For example, it has been determined that inappropriately prescribed proton pump inhibitors without any signs of the gastrointestinal tract may affect cognitive functions by causing the accumulation of certain proteins, such as amyloid, in the brain²⁷. For this reason, the evaluation of cognitive function regression defined by the relatives or caregivers of the patients should be managed with a multidisciplinary approach. However, although the diseases that cause comorbidity were included in our study, polypharmacy and the drugs used were not discussed. We think that considering this situation in future studies can shed light on the care of centenarian patients.

The most important limitation of this study is that it only represents part of the population aged 100 years and over since it was designed

retrospectively with data obtained from a single center and a specific geographical region. The study also included only a limited number of patients. The number of female patients was considerably higher than male patients. In addition, the relationship between the medications used due to the medical history of the individuals and cognitive status was not evaluated, and the effects of polypharmacy were not determined.

Conclusions

In conclusion, although we did not identify any pathology that could be related to the clinical presentation in the neuroimaging of centenarian patients who presented to the emergency department for non-traumatic reasons, brain CT remains an essential tool for emergency diagnoses and patient management. However, the excessive use of CT causes radiation exposure and burdens the health system economically. Therefore, in emergency departments, imaging tests should be ordered following a good physical examination and anamnesis taken from the patient and/or their relatives, and age alone should not be considered an indication for this examination.

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Authors' Contributions

Initials of the contributing authors were listed in brackets after the relevant parts of the research: Literature search (MMY, İA), study design (MMY, ÖB), legislative applications (MMY, GE), data collection (MMY, İA), supervision and quality control (ÖB, GE, MMY), statistical data analysis (MMY), data interpretation (MMY, İA, GE), drafting the manuscript (MMY, İA). All authors were involved in the writing and critical revision of the manuscript and approved the final version. MMY and İA take the whole responsibility for the paper.

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Availability of Data and Materials

The authors agree to the conditions of publication, including the availability of data and materials in our manuscript.

Conflicts of Interest

None declared.

Informed Consent

Patients' informed consent was obtained before starting the study.

Ethics Approval

This study was approved by the institutional review board and ethics committee (Date: March 27, 2023, decision number: 2023/73). The principles outlined in the Declaration of Helsinki have been followed.

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