Comparison of the Effectiveness of Computed Tomography and Magnetic Resonance Imaging Techniques in Patient Groups Aged under and over 65 Years and Diagnosed with Ischemic Stroke in the Emergency Department

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Journal of Bursa Faculty of Medicine
e-ISSN: 2980-0218

Original Article

Emergency Medicine

Received
May 10, 2024
Accepted
August 27, 2024
Published online
September 25, 2024

J Bursa Med 2024;2(3) 78-84

ABSTRACT

Objectives: Stroke is a condition with high morbidity and mortality. This study aims to investigate whether the effectiveness of Computed Tomography (CT) and diffusion-weighted Magnetic Resonance Imaging (MRI), the techniques that have a significant place in the diagnosis of ischemic stroke, the most common form of stroke, are affected by the physiological changes of advanced age.

Methods: A total of 436 patients were included in the study. The study population was divided into two groups depending on age: those above 65 and those under 65 years of age. Medical files, both the emergency department and clinical ward files, of the patients who were admitted to the emergency department in nine months and admitted to the neurology clinic with the diagnosis of ischemic stroke were retrospectively analyzed. The time from admission to imaging was determined depending on patient files and the Hospital Management Information System (HBYS). The CT and MRI reports interpreted by radiologists were also reviewed. While recording the data, the presence of a lesion, its direction, and localization were also noted.

Results: CT positivity was 21.3%, and the positivity of diffusion-weighted imaging was 82.1% in the study population. The time was shorter in the group of patients with positive CT results than in the group with negative CT results. In subjects under 65, the time between onset and imaging was shorter in the group with positive CT results than in the group with negative CT results. In subjects over 65, the time with positive CT results was not different from the group with negative CT results. It was determined that the mean time was shorter in the group with positive MRI results than in the group with negative results. In both the groups under the age of 65 and over the age of 65, the time interval was shorter in the patients with positive MRI results compared to those with negative MRI results.

Conclusions: Regardless of the positivity or negativity of CT and MRI results, the mean time from symptom onset to imaging was shorter in the group under 65 years of age compared to the group over 65 years. Aging prolongs the time to admission and the neuroradiological response of geriatric patients.

Keywords: Emergency department, stroke, geriatrics, penumbra

How to cite this article
Celik K., Uygun E., Elumar F. Comparison of the Effectiveness of Computed Tomography and Magnetic Resonance Imaging Techniques in Patient Groups Aged under and over 65 Years and Diagnosed with Ischemic Stroke in the Emergency Department. J Bursa Med 2024;2(3);78-84

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INTRODUCTION

According to the definition recommended by the World Health Organization (WHO) in 1970, "Stroke is a condition characterized by rapidly developed clinical signs of focal (or global) disturbance of cerebral function, lasting more than 24 hours or leading to death, with no apparent cause other than of vascular origin"[1]. According to the WHO, stroke is the second leading cause of mortality worldwide and the third leading cause of death in developing countries. Stroke is the major cause of disability worldwide. The prevalence of stroke in the United States increases with advancing age in both men and women. It was reported that an estimated 7.6 million Americans over the age of twenty had a stroke, and the overall prevalence of stroke was estimated to be 2.7% based on data from 2018 [2,3]. In the US, the annual incidence of new or recurrent stroke is approximately 795,000. Of those, 610,000 are first-time strokes, and 185,000 are recurrent strokes. Of all stroke cases, 87% are ischemic, 10% are intracerebral hemorrhage, and 3% are subarachnoid hemorrhage [3].

Early and effective treatment can reduce mortality and morbidity in strokes. Neuroimaging is the most helpful test for physicians after a comprehensive neurological examination in determining the strategy for treating strokes. Computed Tomography (CT) and diffusion-weighted Magnetic Resonance Imaging (MRI) are emergency neuro-imaging techniques used in ischemic stroke, which is more common and in which medical or invasive intervention is more valuable due to the race against the clock in this condition. For this reason, diffusion-weighted MRI has a significant place. A gold standard neuroimaging method has not been determined yet for acute ischemic stroke [4]. Computed tomography and MR angiography of the brain are used to detect vascular anatomy and intravascular thrombus. CT perfusion and MR perfusion help detect the penumbra. Diffusion-weighted MR imaging (DW-MRI) is used to measure the volume of the infarct area called the 'core' in ischemic stroke patients. In contrast, CT Perfusion and MR Perfusion sequences are used to measure the penumbra area that can be salvaged with reperfusion therapy [5]. Because advanced age is an independent risk factor for stroke, whether the success of CT and MRI is also affected by the physiological changes brought by advancing age can be a question that needs to be answered. We aimed to contribute to the diagnosis stage of ischemic stroke with this study, in which we tried to compare the effectiveness of CT and diffusion-weighted MRI in patient groups with ischemic stroke who were younger than and older than 65 years.

METHODS

The present study was conducted retrospectively on patients who presented to the emergency department of Bursa Yüksek İhtisas Training and Research Hospital and who were diagnosed with ischemic stroke. Medical files, both the emergency department and clinical ward files, of the patients who presented to the emergency department in nine months and were admitted to the neurology clinic with the diagnosis of ischemic stroke were reviewed. The time from admission to imaging was determined depending on the patient file and the Hospital Management Information System (HBYS). The CT and MRI reports interpreted by radiologists were examined. Obtained data were recorded in the study form. While recording the data, the presence of a lesion, its direction, and localization were also noted.

Patients aged over 18 years of age who underwent CT and MRI and were diagnosed with non-traumatic ischemic stroke were included in the study. Patients who were diagnosed with ischemic stroke but had contraindications for MRI (e.g., pacemaker, incompatible orthoses and prosthesis, permanent teeth) were excluded from the study. Moreover, patients detected to have artifacts or additional pathologies, such as mass or encephalitis, on imaging were excluded from the study. Ultimately, a total of 436 patients were included in the study. The local ethics committee approved the study (2011-KAEK-25 2015/18-08).

Statistical Analysis

We used the mean, standard deviation, median, minimum, maximum, frequency, and ratio values for descriptive statistics. The Kolmogorov-Smirnov test was used to measure the distribution of the variables. Quantitative data were analyzed using the Mann-Whitney U test. Qualitative data were analyzed using the Chi-square test. The Kappa Compatibility test was used for compatibility analysis. The SPSS 22.0 program was used for analysis.

RESULTS

Of the 436 patients included in the study, 48.6%

were female and 51.4% were male. Considering age distribution, 35.3% were under 65, while 64.7% were 65 and older. In general, the time from the onset of symptoms to imaging was 2.2 hours on average. In the CT imaging performed for 436 patients who presented to ED, 21.3% were positive (Table 1). In the MRI evaluation of 436 patients included in the study, 82.1% were positive (Table 2).

Table 1. Computerized Tomography (CT) findings of the patients admitted to the Emergency Department

		n	%
CT Findings	(+)	93	21.3
	(-)	343	78.7
CT-Cerebrum	(+)	55	12.6
	(-)	381	87.4
CT-Diencephalon	(+)	22	5.0
	(-)	414	95.0
CT-Brainstem	(+)	6	1.4
	(-)	430	98.6
CT-Cerebellum	(+)	19	4.4
	(-)	417	95.6

Table 2. Magnetic Resonance Imaging (MRI) findings of the patients admitted to the Emergency Department

		n	%
MR Finding	(+)	358	82.1
	(-)	78	17.9
MR-Cerebrum	(+)	219	50.2
	(-)	217	49.8
MR-Diencephalon	(+)	147	33.7
	(-)	289	66.3
MR-Brainstem	(+)	30	6.9
	(-)	406	93.1
MR-Cerebellum	(+)	49	11.2
	(-)	387	88.8
MR-Supratentorial	(+)	301	69.0
	(-)	135	31.0
MR-İnfratentorial	(+)	77	17.7
	(+)	359	82.3
Lesion Side	Bilateral	45	10.3
	Right	152	34.9
	Left	165	37.8
	Absent	74	17.0

There was no significant difference between the groups with positive CT results and negative CT results in terms of mean age and gender distribution, respectively [(p>0.05), (p>0.05)]. Nevertheless, the time was significantly shorter in patients with positive CT results than in the group with negative CT results (Table 3).

There was no significant difference between the groups with positive MRI results and negative MRI results in terms of mean age and gender distribution, respectively [(p>0.05), (p>0.05)]. On the other hand, in patients with positive MRI results, the time was significantly shorter compared to the group with negative MRI results (Table 4).

In the group under 65, the time was significantly shorter in patients with positive CT results than in those with negative CT results. In the group over the age of 65 years, however, the time was not significantly (p>0.05) different between patients with positive CT results compared to those with negative CT results (Table 5).

In the group under age 65, the time interval was significantly shorter in patients with positive MRI results compared to those with negative MRI results (p<0.05). In the group over the age of 65, the time was significantly (p>0.05) shorter in patients with positive CT results than in patients with negative CT results (Table 6).

There was significant (36.9%) consistency between MRI and CT. There was a significant (59.2%) consistency between MRI and CT regarding cerebrum localization. There was a significant (68.6%) consistency between MRI and CT regarding the localization of the Diencephalon. There was a significant (68.6%) consistency between MRI and CT regarding the localization of the brain stem. There was a significant (68.6%) (p<0.05) consistency between MRI and CT in terms of the localization of the cerebellum (Table 7).

DISCUSSION

Previous studies on strokes of ischemic origin, which constitute the majority of stroke cases, investigated the importance of gender differences between subjects. Petty et al. reported that large vessel occlusions and related stroke cases were more common in men than in women [6]. Similarly, in a study conducted by İnal et al., stroke was more common in the male population compared to women [7]. In our study, the number of male subjects was higher, and our results were consistent with the literature.

Kıyan et al. stated in the study they conducted with 124 patients with acute ischemic stroke and published in 2009 that the complaints of patients who applied to the emergency department started at 13±18.5 hours before admission [8]. In Schroeder et al., the mean time from the onset of symptoms to admission to the hospital was reported as 2.85 hours in stroke patients

Table 3. Evaluation of the demographics between positive and negative Computerized Tomography (CT) findings groups

		CT Finding (+)		CT Finding (-)		
		Mean±SD n (%)	Median (Min-Max)	Mean±SD n (%)	Median (Min-Max)	p
Age		67.6±13.2	70 (42-95)	70.0±12.2	72 (29-95)	0.078
Age	**< 65**	40 (43.0)		114 (33.2)		0.080
	≥ 65	53 (57.0]		229 (66.8)		
Gender	**Female**	39 (41.9)		173 (50.4)		0.146
	Male	54 (58.1)		170 (49.6)		
Time (hour)		1.8±1.5	1 (1-9)	2.3±1.9	2(1-12)	***0.005***

Table 4. Evaluation of the demographics between positive and negative Magnetic Resonance Imaging (MRI) findings groups

		MRI Finding (+)		MRI Finding (-)		
		Mean±SD n (%)	Median (Min-Max)	Mean±SD n (%)	Median (Min-Max)	p
Age		69.7±12.2	71 (30-95)	68.4±13.7	71 (29-93)	0.547
Age	**< 65**	123 (34.4)		31 (39.7)		0.367
	≥ 65	235 (65.6)		47 (60.3)		
Gender	**Female**	177 (49.4)		35 (44.9)		0.464
	Male	181 (50.6)		43 (55.1)		
Time (hour)		2.1±1.7	2(1-12)	2.6±1.9	2 (1-10)	***0.000***

Table 5. Comparison of the time between positive and negative Computerized Tomography (CT) findings

	CT Finding (+)		CT Finding (-)		
	Mean±SD n (%)	Median (Min-Max)	Mean±SD n (%)	Median (Min-Max)	p
Age< 65					
Time (Hours)	1.2±0.5	1(1-4)	1.5±1.6	1(1-12)	***0.042***
Age ≥ 65					
Time (Hours)	2.4±1.8	2(1-9)	2.7±1.8	2(1-12)	0.129

Table 6. Comparison of the time between positive and negative Magnetic Resonance Imaging (MRI) findings

	MR Finding (+)		MR Finding (-)		
	Mean±SD n (%)	Median (Min-Max)	Mean±SD n (%)	Median (Min-Max)	p
Age < 65					
Time (hour)	1.4±1.5	1 (1-12)	1.5±0.8	1 (1-4)	***0.034***
Age≥ 65					
Time(hour)	2.5±1.7	2 (1-12)	3.4±2.1	3 (1-10)	***0.000***

Table 7. The evaluation of the consistency between Computerized Tomography (CT) and Magnetic Resonance Imaging (MRI) findings

		MRI (+)	MRI (-)	Consistency	Non-consistence	Kappa	p
CT ***Findings***	(+)	88	5	36.9%	63.1%	0.078	***0.000***
	(-)	270	73				
CT ***Cerebrum***	(+)	48	7	59.2%	40.8%	0.186	0.000
	(-)	171	210				
CT ***Diencephalon***	(+)	16	6	68.6%	31.4%	0.111	***0.000***
	(-)	131	283				
CT ***Brainstem***	(+)	3	3	93.1%	6.9%	0.147	***0.000***
	(-)	27	403				
CT ***Cerebellum***	(+)	17	2	92.2%	7.8%	0.466	***0.000***
	(-)	32	385				

included in the study [9]. In our study, the interval from the onset of symptoms to imaging was 2.2±1.8 hours on average.

Imaging methods developed in the last 30 years guide not only the diagnosis process but also the medical attention and intervention to be applied in acute ischemic stroke. Brain CT continues to be the primary screening method at the first post-stroke admission as it is faster, cheaper, non-invasive, and easily accessible for all patients. In a study conducted by Taşdemir et al. based on 64 patients, 44% negative and 56% positive were found in CT results obtained within the first 8 to 12 hours [10]. The longer the time passes after the onset of ischemic stroke, the greater the possibility of seeing a lesion in CT. Decreased contrast between cerebral gray matter and white matter, in other words, the anatomical boundaries between gray matter and white matter becoming invisible, is the first sign of ischemia on CT and can be detected in the first 3 hours after stroke onset. It was stated in another reference that signs gradually emerge in ischemic stroke, and no pathology was detected in 60% of cases in the first few hours [11]. In general, our CT results are consistent with the literature.

Considering the time from symptom onset to imaging, the mean time interval in the group with positive CT results was 1.8±1.5 hours. The mean time interval was 2.3±1.9 hours in the group with negative CT results. In short, the mean time from symptom onset to imaging was statistically significantly shorter in the group with positive CT results than in negative CT results. Considering these facts, it can be concluded that patients with a more severe clinical course and more obvious symptoms seek medical attention earlier. In other words, it can be said that the prognosis is worse in patients who show positive CT results early. Taşdemir et al. [10] compared various demographic, clinical, and examination results between patients who showed CT findings in the early period (within the first 8-12 hours) and those who did not and demonstrated that there was no variable causing a significant difference between the groups. In our study, however, we identified that the patients with positive CT results had presented to the hospital earlier than those with negative CT results.

The positivity of diffusion-weighted imaging was 82.1% of our study population. The most significant and common use of diffusion-weighted MRI is ischemic stroke imaging. It is reported that the sensitivity of DW-MRI is close to 100% 2 hours after the onset of ischemia. In human studies, diffusion-weighted MRI is defined as a technique that has nearly 100% sensitivity and specificity and does not require invasive procedures [12]. Simonsen et al. [13] reported that diffusion-weighted MRI combined with perfusion-weighted imaging had a sensitivity of 97.5% in acute ischemic stroke. Considering the data in the literature, the sensitivity of DW-MRI was found to be a bit lower in our study.

When evaluated in terms of time, the mean time was 2.1±1.7 in patients with positive results and 2.6±1.9 in those with negative results. The time was statistically significantly shorter in the group with positive MRI results than those with negative MRI results. We believe that this might be because, as the patient's clinical conditions and initial symptoms were more severe, they presented to the hospital earlier. In other words, patients' clinical symptoms with early positive MRI findings are more apparent. The localizations with the highest involvement in patients with positive MRI findings were the cerebrum, diencephalon, cerebellum, and brain stem.

In the group under age 65, the mean time was 1.2±0.5 hours in the CT-positive group and 1.5±1.6 hours in the CT-negative group. In the group under the age of 65, the time was statistically significantly ($p<0.05$) shorter in patients with positive CT results compared to those with negative CT results. In the group over 65, the mean time was 2.4±1.8 hours in the CT-positive group and 2.7±1.8 hours in the CT-negative group. However, in the group over the age of 65, the time was not significantly ($p>0.05$) different between patients with positive and negative CT results. If we need to address the reasons underlying the difference here, the clinical course and symptoms of CT-positive patients under the age of 65 are more obvious than the group with negative symptoms. Also, small changes in an individual with full physical and cognitive capacities can be noticed early. This shortens the time it takes for patients to present. In patients aged 65 years or older, on the other hand, pathologies cannot be noticed unless there is a significant change in the physical and cognitive functions of the patients due to age-related limitations or co-morbidities. Due to these facts, there was no statistically significant difference between the groups with negative and positive results regarding the time interval.

In the group aged under 65 years, the mean time was 1.4±1.5 hours in the group with positive MRI results and 1.5±0.8 hours in the group with negative MRI results. In the group under age 65, the time was significantly shorter in patients with positive MRI

results compared to those with negative MRI results ($p<0.05$). In the group aged over 65 years, the mean time was 2.5±1.7 hours in the group with positive MRI results and 3.4±2.1 hours in the group with negative MRI results. In the group aged over 65 years of age, the time was significantly ($p>0.05$) shorter in patients with positive MRI results than in patients with negative MRI results. In both the group under the age of 65 years and the group over the age of 65, the time from symptom onset to imaging was shorter in the patients with positive MRI results than in the group with negative MRI results.

The mean time of CT-positive patients under 65 years of age is similar to that of MRI-positive patients under 65. Additionally, the mean time of CT-positive patients over the age of 65 is similar to the meantime of MRI-positive patients over the age of 65. Nevertheless, when we compare the groups under 65 years of age and over 65 years of age, it will be seen that there is a serious difference between the groups regarding the mean time from symptom onset to imaging. It is necessary to address the reasons leading to this difference. Neurological deficits are noticed later in the patient group over 65 due to physical and cognitive limitations in this age group. This may be the primary reason for the difference. Compensation for edema occurring in the ischemic region due to atrophy in the brain resulting from aging may cause a late onset of the obvious clinical course in patients with limited cognitive and physical capacity. On the other hand, there will inevitably be a decrease in blood flow to the brain due to the contribution of both advanced age and diseases such as hypertension, diabetes mellitus, and hyperlipidemia to atherosclerosis. The clinical reaction and neuroradiological manifestation time will differ in ischemic stroke developing after a decrease in chronic cerebral flow and ischemic stroke developing in individuals with the ideal cerebral flow. As a different hypothesis, when we look at stroke at the cellular level, it is predicted that the need for cells for oxygen and glucose will decrease due to the reduction in neuronal activity resulting from aging. Even if an ischemic stroke develops, the cell can live on the remaining blood in the region for a while, so the activation of cellular destruction mechanisms may be delayed.

Today, CT remains in first place in the treatment and management of acute ischemic stroke in the emergency setting. However, based on strong evidence from some guidelines, MRI has an equivalent success rate to CT in detecting intraparenchymal hemorrhages in the first 6 hours [14]. Diffusion-weighted MRI is more specific and sensitive than non-contrast CT in ischemic stroke in both patients under 65 years of age and patients above 65 years of age [15].

The incidence of stroke and ischemic stroke, the most common subtype, will increase in the future due to the increased life expectancy. Furthermore, with the increase in unhealthy eating habits and the effect of genetic factors, stroke will be seen in younger populations, leading to a significant increase in disability and health expenditures in society. Early diagnosis is essential for the effective treatment of ischemic stroke. Most of these patients present to the hospital using 112 emergency health services or hastily by their means. Emergency medicine physicians have a crucial role at this point. The sooner they make a diagnosis and guide the treatment process, the higher they contribute to reducing the mortality and morbidity rates. The first step of the diagnosis is a good anamnesis and physical examination, which are essential in medicine. Especially in patient groups over 65 years, a physical examination may be insufficient. Therefore, the information that the physician receives from the patient's relatives in the anamnesis is valuable. Deterioration in the patient's nutrition, sleep, or mood may be a precursor of a stroke. Currently, CT is the easiest imaging method to access in most places for a physician diagnosing ischemic stroke. The clinician manages the ischemic stroke treatment process in the absence of hemorrhage on CT. With the advancements of the day, clinicians have found the opportunity to evaluate the patient group without CT results with diffusion-weighted MRI. Its higher sensitivity and specificity in ischemic stroke make diffusion-weighted MRI superior to CT. Therefore, the clinician should be able to interpret and evaluate the examinations ordered effectively. In this study, we tried to compare and examine the effectiveness of CT and diffusion-weighted MRI in ischemic stroke in the patient groups over and under 65. We want to present our achievements respectively.

CONCLUSION

First, as stated in the literature, our study also proved that diffusion-weighted MRI is superior to CT in imaging ischemic stroke. Our achievements are the outcomes we've identified that, based on our literature review, have not been previously documented. The time from symptom onset to imaging was significantly shorter in the patient group with positive CT results

than in the group with negative CT results. In the group under 65, the time was significantly shorter in those with positive CT results than in those with negative CT results. In the group over 65 years of age, the time with positive CT results was not significantly ($p>0.05$) different from the group with negative CT results. There was no statistically significant difference between the groups with positive and negative MRI results regarding mean age and gender distribution. It was determined that the mean time was significantly shorter in the patient group with positive diffusion-weighted MRI results than in the group with negative DW-MRI results. In both the groups under the age of 65 and over the age of 65, the time from symptom onset to imaging was shorter in the patients with positive MRI results compared to the group with negative MRI results. Regardless of the positivity or negativity of CT and MRI results, the mean time from symptom onset to imaging was shorter in the group under 65 years of age compared to the group over 65 years. In the present study, we tried to explain what may cause this situation based on the factors related to pathophysiology and aging. However, to provide a better explanation of the issue, there is a need for additional studies examining other various factors, such as the potential effect of comorbidities and whether the quality of the imaging devices affects results or not. There is a need for further studies to indicate the factors that affect the results more precisely.

Conflict of Interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical Approval

The protocol of the study was approved by the Medical Ethics Committee of Bursa Yüksek Ihtisas Training & Research Hospital, Bursa, Türkiye. (Decision number: 2011-KAEK-25 2015/18-08).

Authors' Contribution

Study Conception: KÇ; Study Design: KÇ, EU; Literature Review: KÇ, EU; Critical Review: KÇ, FE; Data Collection and/or Processing: KÇ, FE,; Analysis and/or Data Interpretation: KÇ; Manuscript preparing: KÇ.

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