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Assessment of Alterations in Cerebrospinal Fluid in Acute and Chronic Infarcts Utilizing Computed Tomography

Akut ve Kronik Enfarktüslerde Beyin Omurilik Sıvısındaki Değişikliklerin Bilgisayarlı Tomografi Kullanılarak Değerlendirilmesi

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ABSTRACT

Objective: This study aims to examine the differences in cerebrospinal fluid among patients with acute infarcts, chronic infarcts, and healthy controls by evaluating the density of cerebrospinal fluid via computed tomography (CT) scans of the brain.
Materials and Methods: In this study, density measurements of cerebrospinal fluid (CSF) were retrospectively conducted from the lateral ventricle in a sample of 128 patients. The analysis incorporated diffusion-weighted magnetic resonance imaging (DWI) alongside CT scans of the brain. A circular region of interest (ROI) with an area of 0.25 cm^2 was consistently applied for the density measurements in each case.
Results: The analysis of mean intraventricular density values in relation to infarct status revealed that individuals with acute infarction exhibited a mean density of 5.79 HU, which was the lowest recorded, while those without infarction had a mean density of 6.36 HU, representing the highest value.
Conclusions: The analysis of changes in CSF using CT in acute and chronic stroke conditions plays a vital role in understanding the extent of neurological injury and in the development of appropriate therapeutic interventions. Evaluation of changes in CSF in acute and chronic infarctions plays a critical role in understanding the course of the disease.
Keywords: Computed tomography; CSF; density; infarct

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ÖZET

Amaç: Bu araştırma, akut enfarktüslü, kronik enfarktüslü ve normal sağlıklı kontroller arasında beyin omurilik sıvısı yoğunluğunu beyin bilgisayarlı tomografi (BT) taramaları ile değerlendirerek beyin omurilik sıvısındaki farklılıkları incelemeyi amaçlamaktadır.
Materyal ve Metot: Bu araştırmada, 128 hastadan oluşan bir örneklemde lateral ventrikülden beyin omurilik sıvısının yoğunluk ölçümleri retrospektif olarak gerçekleştirilmiştir. Analiz, beyin BT taramalarının yanı sıra difüzyon ağırlıklı manyetik rezonans görüntüleme (DAG) yöntemlerini de içermektedir. Her bir olguda yoğunluk ölçümleri için 0,25 cm^2 alana sahip dairesel bir ilgi alanı (ROI) uygulanmıştır.
Bulgular: Ortalama intraventriküler yoğunluk değerlerinin enfarktüs durumuna göre analizi, akut enfarktüsü olan bireylerin ortalama yoğunluğunun 5,79 HU olduğunu ve bunun kaydedilen en düşük değer olduğunu, enfarktüsü olmayan bireylerin ise ortalama yoğunluğunun 6,36 HU olduğunu ve bunun en yüksek değer olduğunu ortaya koymuştur.
Sonuç: Akut ve kronik inme durumlarında bilgisayarlı tomografi (BT) kullanılarak beyin omurilik sıvısındaki (BOS) değişikliklerin analizi, nörolojik hasarın boyutunun anlaşılmasında ve uygun terapötik müdahalelerin geliştirilmesinde hayati bir rol oynar. Akut ve kronik enfarktüslerde beyin omurilik sıvısındaki değişikliklerin değerlendirilmesi, hastalığın seyrinin anlaşılmasında kritik bir rol oynar.
Anahtar Kelimeler: Bilgisayarlı tomografi; BOS; yoğunluk; enfarktüs

INTRODUCTION

TCerebrovascular diseases persist as a leading cause of both morbidity and mortality worldwide. Ischemic strokes, distinguished by acute or chronic infarcts, notably affect neurological function (1). Investigating the pathophysiological modifications in cerebrospinal fluid (CSF) during these events is essential for enhancing our understanding of disease progression, improving diagnostic methods, and exploring potential therapeutic interventions (2).

Computed tomography (CT) has proven to be a crucial method for the non-invasive evaluation of these changes. This article explores the assessment of CSF changes in acute and chronic infarcts using CT imaging, drawing attention to key findings and their significance in clinical contexts.

MATERIALS AND METHODS

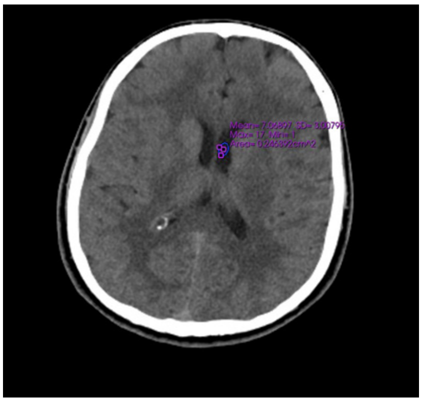
We included patients with both CT and brain magnetic resonance diffusion MRI images who applied to the emergency clinic between 2020 and 2022. The patients with both acute and chronic infarct areas were excluded from the analysis. We confirmed acute and chronic infarct cases with diffusion MRI.

All CT scans were performed without contrast media, using the 128 Slice GE Revolution EVO CT Scan multidetector device (General Healthcare, Chicago, Illinois, USA). Images were evaluated on the workstation through the brain parenchymal CT window, and density measurements were obtained as Hounsfield Unit.

Since our study is retrospective, consent was not required. A total of 128 patients in our hospital archive were scanned and divided into three groups: patients with acute infarction, patients with chronic infarction and healthy controls. The ANOVA test was used to statistically compare the groups.

Measurements of the CSF density in the lateral ventricle were performed on brain CT images from 31 patients suffering from acute infarcts, 33 patients with chronic infarcts, and 64 control patients, who were matched for both age and sex and did not exhibit infarcts, regardless of the infarct's size and location (Figure 1).

Figure 1. Intraventricular density measurement.



RESULTS

The study comprised 31 patients with acute infarcts, 33 patients with chronic infarcts, and 64 patients from a control group matched for age and sex, who did not have infarcts. In total, 128 patients were assessed. Among these participants, 72 (56.3%) were male and 56 (43.8%) were female. The ages of the patients ranged from 28 to 93 years, with an average age of 69.6 ± 12.9 years.

A comparison of mean intraventricular density values based on infarct status revealed that individuals with acute infarction exhibited a mean density of 5.79, the lowest recorded, while those without infarction had a mean density of 6.36, the highest. A statistically significant difference in mean intraventricular densities was observed between the two groups (p<0.001) (Table 1), attributed primarily to the patients who did not experience infarction.

In Table 1, the mean intraventricular density values are detailed according to the presence of infarcts. The findings indicate that the mean density for acute infarcts (n=31) is 5.79 ± 0.84, with a significant p-value of <0.001. The mean for chronic infarcts (n=33) is recorded at 5.35 ± 0.74, while those without infarcts (n=64) show a mean of 6.36 ± 1.07. The overall mean across all participants (n=128) is 5.96 ± 1.03. In our study, CSF density was found to be lower in the chronic infarct group than in the acute infarct group.

Table 1. Mean intraventricular density values according to infarct status

Infarct	Mean intraventricular density ± SD	P value
Acute infarct (n=31)	**5,79 ± 0,84**	**<0,001**
Chronic infarct (n=33)	**5,35 ± 0,74**	
Absence of infarct (n=64)	**6,36 ± 1,07**	
All (n=128)	**5,96 ± 1,03**	

n: number of patients

The Evans index averages were analyzed in relation to the infarct status of the patients. This index is determined by dividing the maximum width between the lateral edges of the frontal horns of the lateral ventricles by the maximum distance between the two inner tables. A diagnosis of hydrocephalus is indicated when the Evans index exceeds 0.3. Among the groups studied, patients with chronic infarction exhibited the highest mean Evans index, while those without infarction had the lowest mean. However, no statistically significant difference was observed between these groups (p=0.203) as shown in Table 2.

Table 2. Mean Evans index values according to infarct status

Infarct	Mean Evans Index ± SD	P value
Acute infarct (n=31)	**0,269 ± 0,05**	**0,203**
Chronic infarct (n=33)	**0,279 ± 0,04**	
Absence of infarct (n=64)	**0,262 ± 0,04**	
All (n=128)	**0,268 ±0,05**	

n: number of patients

In Table 2, the mean values of the Evans index are detailed according to the infarct status of the patients. The mean Evans index for the acute infarct group (n=31) is recorded as 0.269 ± 0.05, while the chronic infarct group (n=33) shows a mean of 0.279 ± 0.04. For those with no infarct (n=64), the mean value is 0.262 ± 0.04. The overall mean Evans index for all participants (n=128) is 0.268 ± 0.05. It was evaluated whether there was a difference in ventriculomegaly between patients with acute infarction, patients with chronic infarction and healthy individuals using the Evans index measurement. An analysis of the ventricular enlargement status of patients based on the Evans index revealed that the prevalence of normal ventricular enlargement was greatest among those without infarction, while it was least among patients with chronic infarction. Conversely, the occurrence of definite ventriculomegaly was most pronounced in patients with chronic infarction and least prevalent in those without infarction. Nevertheless, the differences observed between the groups were not statistically significant (p=0.154) (Table 3).

Table 3. Ventricular Enlargement Status of Patients According to Evans Index Ranges

VM Status	Acute Infarct n (%)	Chronic Infarct n (%)	Absence of Infarct n (%)	All n (%)	P value
Normal	**7 (22,6)**	**6 (18,2)**	**22 (34,4)**	**35 (27,3)**	**0,154**
Early VM	**19 (61,3)**	**17 (51,5)**	**34 (53,1)**	**70 (54,7)**	
Definite VM	**5 (16,1)**	**10 (30,3)**	**8 (12,5)**	**23 (18,0)**	
Total	**31 (100,0)**	**33 (100,0)**	**64 (100,0)**	**128 (100,0)**	

n: number of patients, VM: Ventriculomegaly

DISCUSSION

CSF is a transparent, colorless substance that flows through the ventricular system and the subarachnoid space surrounding the brain and spinal cord. It serves essential functions such as providing cushioning for the brain, eliminating metabolic waste, and regulating intracranial pressure. Alterations in its composition, circulation, or volume may signal the presence of neurological disorders, including stroke. (3)

In the context of ischemic infarcts, modifications in CSF can be attributed to direct neuronal injury, inflammatory reactions, disruption of the blood-brain barrier, or secondary effects such as edema or hydrocephalus (4). The application of advanced imaging techniques, particularly CT, can significantly assist in differentiating between acute and chronic infarcts (5).

Acute infarcts are defined by an abrupt cessation of blood supply to a particular area of the brain, resulting in swift neuronal injury. During the initial phases of an acute infarct, CT scans may show minor alterations in CSF dynamics, attributed to cytotoxic edema and elevated intracranial pressure (6). Key indicators of acute ischemia on CT include the effacement of sulci, a hyperdense middle cerebral artery, loss of gray-white matter differentiation, and the presence of hydrocephalus (7-10).

Chronic infarcts are the long-term consequences of ischemic damage, frequently characterized by gliosis, atrophy, and adaptive modifications in CSF spaces. In contrast to acute infarcts, chronic infarcts generally display more significant changes in brain tissue and CSF Dynamics (11). Enlargement of the ventricles and sulci, the occurrence of cystic cavitation, calcifications, and enduring asymmetry are characteristics that may be observed in brain tissue impacted by chronic infarction (12-15). In our study, we likewise discovered an elevated Evans index in individuals with chronic infarction.

Acute cerebral ischemia can result in changes to the composition of CSF. In the course of an ischemic episode, there may be an elevation in the levels of specific proteins and enzymes, including lactate dehydrogenase and neuron-specific enolase. These biomarkers serve as indicators of neuronal damage and offer critical insights into the severity and advancement of the ischemic condition (16). Acute cerebral ischemia may compromise the blood-brain barrier (BBB), an essential protective structure that regulates the transfer of substances between the bloodstream and the central nervous system (CNS). When the BBB is disrupted, it can lead to increased permeability, allowing proteins, ions, and other materials to pass from the blood into the CSF. This disruption can cause modifications in the osmolarity and composition of the CSF, which may reflect ischemic damage (17).

Ischemic episodes may result in modifications to the CSF's composition, including variations in protein concentrations, glucose levels, and other biochemical indicators, which may signify neuronal injury or inflammation (18). Diminished blood flow can provoke a compensatory rise in CSF production or a decrease in its absorption, leading to heightened intracranial pressure (19). Ischemia can instigate an inflammatory reaction, resulting in the accumulation of inflammatory cells and cytokines within the CSF (20). Prolonged ischemia may contribute to neurodegenerative processes, which can be reflected in alterations of specific biomarkers in the CSF, such as tau proteins and beta-amyloid levels, commonly linked to disorders like Alzheimer's disease (21).

The ability to identify acute versus chronic infarcts through CSF changes is crucial for customizing effective treatment strategies. Moreover, a thorough understanding of CSF variations may facilitate the differentiation of ischemic strokes from other neurological conditions, including infections, tumors, or hemorrhages.

The current investigation revealed that patients with infarction exhibited reduced CSF density on CT scans when compared to those without infarction. A comparison of the mean intraventricular CSF density values indicated that the lowest mean density was observed in patients experiencing acute infarction, while the highest mean density was recorded in patients without any infarction.

LIMITATIONS AND FUTURE DİRECTIONS

While CT is a prevalent imaging modality, it has inherent limitations in the detection of subtle CSF changes when juxtaposed with advanced techniques such as magnetic resonance imaging (MRI). MRI is particularly advantageous due to its superior resolution, which facilitates the assessment of periventricular white matter changes and diminutive cystic lesions.

Acute and chronic infarcts frequently present in our daily practice. It is not uncommon to observe both types of infarcts in a single patient on the same imaging study. By utilizing larger datasets and leveraging artificial intelligence, we can determine cut-off values for cerebrospinal fluid density associated with acute and chronic infarcts. We believe that this advancement will facilitate quicker diagnoses, reducing the necessity for additional investigations.

Future studies should concentrate on the amalgamation of CT findings with biomarkers associated with cerebrospinal fluid composition to elevate diagnostic accuracy. Moreover, advancements in machine learning and artificial intelligence could play a crucial role in enhancing the analysis of sophisticated imaging information.

CONCLUSİONS

The assessment of alterations in CSF through CT provides significant understanding of the pathophysiological mechanisms underlying both acute and chronic infarcts. In our study, it was revealed that the CSF density of the chronic infarct patient group was lower than both the acute infarct patient group and the healthy group. On going improvements in imaging technology are expected to enhance our capacity to evaluate these changes, ultimately leading to better outcomes for individuals suffering from cerebrovascular diseases.

Ethics Committee Approval: Ethical approval was obtained from the Local Non-Interventional Clinical Research Ethics Committee (06.02.2022 Decision No: 2022/25 Malatya Turgut Özal University)

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Conflict of Interest: The authors declare that there is no personal or financial conflict of interest within the scope of the study.

Author Contributions: Idea/Concept: Serkan Ünlü; Design: Serkan Ünlü, Bülent Petik Supervision/Consulting: Serkan Ünlü,Mehtap Ilgar; Data Collection and/or Processing: Serkan Ünlü,Mehmet Akçiçek; Analysis and/or Interpretation Serkan Ünlü; Literature Review: Serkan Ünlü, Bülent Petik; Writing of the Article: Serkan Ünlü, Bülent Petik; Critical Review: Serkan Ünlü, Mehtap Ilgar. Resources and Funding:No financial support was received for this study

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