# IMPROVING THE ORGANIZATION OF EARLY DIAGNOSIS OF MANIFESTATIONS OF MICROANGIOPATHY TO PREVENT THE RISK OF COMPLICATIONS

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*DOI: 10.35805/BSK2025III004*
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*recived: 21.07.2025*
*accepted: 16.08.2025*

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***Conflict of Interest:***
*The authors declare no conflict of interest related to this publication.*

**Abstract**

**Background.** Microangiopathy is a heterogeneous group of pathological conditions characterized by damage to small-caliber blood vessels, leading to impaired microcirculation and subsequent disruption of trophic, gas exchange, detoxification, and immune functions. It frequently develops in diabetes mellitus, arterial hypertension, systemic autoimmune, infectious, and neurodegenerative diseases. Untimely detection of microangiopathic changes significantly increases the risk of severe complications such as diabetic retinopathy, nephropathy, neuropathy, cognitive impairment, stroke, and dementia.

**Material and methods.** A retrospective analysis was conducted using brain magnetic resonance imaging data obtained on a 1.5 Tesla General Electric scanner at Clinical Hospital No. 5 in Almaty from 2022 to 2024. Patient records were evaluated for the presence and severity of microangiopathic changes according to the Fazekas scale.

**Results.** Among 1,814 patients who underwent brain magnetic resonance, pathological changes were detected in 58% of cases, of which 79% were of a microangiopathic nature. Early-stage changes (Fazekas 1) accounted for 57% of cases, suggesting that detection often occurs before severe structural damage develops. Advanced microangiopathy (Fazekas 2–3) was observed in the remaining cases, indicating the need for closer clinical monitoring and targeted intervention.

**Conclusion.** The findings demonstrate the high prevalence of microangiopathy among patients undergoing brain magnetic resonance in Almaty. Early detection through neuroimaging provides an opportunity for timely preventive and therapeutic measures, potentially reducing the risk of severe neurological complications and improving patient outcomes.

## Introduction

Microangiopathy is a group of heterogeneous pathological conditions characterized by damage to small-caliber blood vessels. This condition leads to a violation of microcirculation in the body and causes a violation of trophic, gas exchange, detoxifying and immunological functions of tissues and organs.[1] Microangiopathy most often develops against the background of diabetes mellitus, arterial hypertension, systemic autoimmune diseases (for example, systemic lupus erythematosus), infectious processes and neurodegenerative diseases.[2,3] The role of microangiopathic changes in the stage of complications of these pathologies is of decisive importance. For example, diabetic retinopathy, nephropathy and neuropathy are microangiopathic complications that are common in patients with diabetes mellitus and lead to disability.[4]

According to international data, 17.9 million people die annually in the world from diseases of the cardiovascular system, which ranks first in the structure of human mortality.[5] One of the main factors contributing to the high level of this indicator is the untimely detection

and insufficient assessment of microangiopathic changes.[6] In addition, in the data of the American Heart Association (2022), even in acute conditions such as stroke and myocardial infarction, the pathology of the microcirculatory channel is considered as one of the leading pathogenetic links.[7]

About 40% of patients with diabetes mellitus experience microangiopathic complications.[8] These pathologies not only reduce the quality of life of patients, but also lead to economic losses, disability and disruption of social adaptation.[9] In this regard, the development of modern approaches to the early detection and effective management of these diseases is one of the urgent tasks of medical science, including Public Health.[10]

At the same time, the problem of dementia is becoming more and more relevant at the global level. According to data from the World Health Organization, today more than 55 million people in the world live with dementia, and every year this number is replenished with 10 million new cases.[11] This means that one person receives a dementia diagnosis every three seconds. Microangiopathy and damage to small vessels in the brain lead to the development of subcortical infarction, periventricular leukoareosis and other structural changes, creating conditions for the appearance of cognitive disorders, including vascular dementia.[12] These data indicate the close relationship of pathology of small vessels with neurodegenerative processes and the need for timely investigation of this problem.

In the national project for the development of the healthcare sector of the Republic of Kazakhstan for 2021-2025 "healthy nation", early detection of complications of cardiovascular diseases and diabetes mellitus and the introduction of high-quality diagnostic methods are identified as priority areas (*Report on the implementation of the "Almaty Development Program - 2025" for 2021*). At the same time, identifying microangiopathy at the initial stage, assessing risk factors and combining Visualization, Laboratory and clinical data in clinical decision-making is one of the strategically important tasks for the domestic healthcare system.

However, today in Kazakhstan at the level of primary health care (PHC), this issue has not been sufficiently resolved. For example, limited availability of visualization methods (MRI, CT, ultrasound), insufficient human resources, as well as incomplete implementation of diagnostic standards prevent early detection of microangiopathy. In megacities, where there is a high rate of urbanization, this problem is clearly manifested.

For example, according to expert data conducted from 2021 to 2025 using a GE MRI machine with a capacity of 1.5 Tesla in Almaty, pathological changes were detected in 58% of patients with MRI of the brain, of which more than 79% were microangiopathic.[13] This indicator clearly proves the prevalence of microcirculatory disorders and the importance of early diagnosis.

In modern clinical practice, the combination of visualization methods (MRI, CT) with laboratory biomarker indicators (HbA1c, creatinine, microalbuminuria, C-reactive protein, etc.) makes it possible to improve diagnosis and prognosis.[14] This integrative approach contributes to making a clear and evidence-based clinical decision, improving the quality of treatment, and reducing the risk of complications.

In addition, large-scale research is being carried out in the international scientific community in the direction of assessing risk factors for microangiopathy, early diagnosis and building prognostic models. However, in Kazakhstan, the number of comprehensive scientific works on this topic is limited, and there is no close connection with domestic clinical practice. In order to fill these gaps, our research will focus on providing solutions to current problems.

As a result of survey studies conducted by the author, 100% of medical workers noted the need to improve their knowledge of early detection of microangiopathy. At the same time, the polarity of opinions on clinical protocols (50% – effective, 50% – ineffective) and the fact

that most of the proposed solutions (40% – strengthening training programs, 30% – information measures, 20% – state support, 10% – other recommendations) are focused on knowledge and practice – further increase the relevance of the study.

Thus, the scientific and practical significance of the dissertation work is directly related to the need to identify manifestations of microangiopathy at the initial stage, systematically assess risk factors, improve the diagnostic process at the level of the domestic PHC and improve the quality of clinical decision – making. The results of this study can not only characterize the features of the spread of microangiopathic pathologies in Kazakhstan, but also make a significant contribution to the development of the public health system through specific recommendations and solutions.

Purpose of the study. Evaluation and optimization of the organization of early diagnosis of manifestations of microangiopathy in order to prevent the risk of complications.

**Materials and methods**

This retrospective study was conducted at Clinical Hospital No. 5 in Almaty, Kazakhstan, and included analysis of brain magnetic resonance imaging (MRI) data obtained between January 2022 and December 2024. Imaging was performed using a 1.5 Tesla GE Signa Explorer scanner with standard brain MRI protocols, including T1-weighted, T2-weighted, fluid-attenuated inversion recovery (FLAIR), and diffusion-weighted imaging (DWI) sequences. Microangiopathic changes were assessed on FLAIR images using the Fazekas scale (grades 0–3).

Sample size and study groups A total of 1,814 patients were included in the analysis. Patients were stratified into groups according to the severity of white matter changes (Fazekas 0, 1, 2, or 3).

*Inclusion criteria:*

Patients aged ⩾18 years;

Underwent complete brain MRI examination on a 1.5 T GE scanner;

Availability of complete MRI images and clinical records;

No significant artifacts in MRI scans.

*Exclusion criteria:*

History of acute traumatic brain injury within the past 6 months;

Presence of brain tumors or demyelinating diseases;

Severe motion artifacts on MRI preventing accurate evaluation;

Incomplete MRI or missing clinical data.

*Methods of analysis.* All MRI studies were reviewed independently by two experienced radiologists. Discrepancies in Fazekas scoring were resolved by consensus. Demographic data (age, sex) and comorbid conditions (diabetes mellitus, hypertension, cerebrovascular disease) were extracted from electronic medical records.

**Ethical approval.** The study protocol was approved by the Local Ethics Committee of Clinical Hospital No. 5, Almaty. All patient data were anonymized in accordance with the Declaration of Helsinki (2013). Extract from Protocol No. 7 dated 29.01.2025 y.

**Statistical analysis.** Statistical processing was performed using IBM SPSS Statistics, version 26.0. Continuous variables were expressed as mean ± standard deviation (SD) or median with interquartile range (IQR), depending on the data distribution. Categorical variables were presented as absolute numbers and percentages. Statistical significance was set at $p < 0.05$.

**Results**

Baseline characteristics of the study population The analysis included 1,814 patients (57.2% women, 42.8% men) with a mean age of 58.4 ± 12.7 years (range: 19–88). Hypertension was present in 63.1% of patients, diabetes mellitus in 21.4%, and both conditions in 15.8%.

Distribution of microangiopathy severity:

Fazekas 0 (no lesions): 765 patients (42.2%);

Fazekas 1 (mild lesions): 1,033 patients (56.9%);

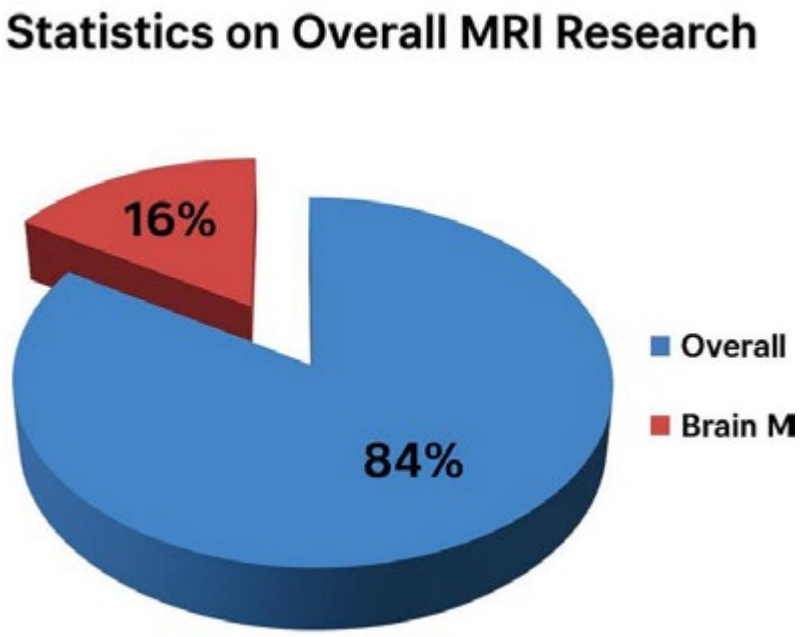
Fazekas 2 (moderate lesions): 258 patients (14.2%);

Fazekas 3 (severe lesions): 98 patients (5.4%).

Among patients with any microangiopathic changes (Fazekas 1–3), 79% had isolated mild white matter hyperintensities, while 21% had moderate-to-severe lesions requiring follow-up and targeted management.

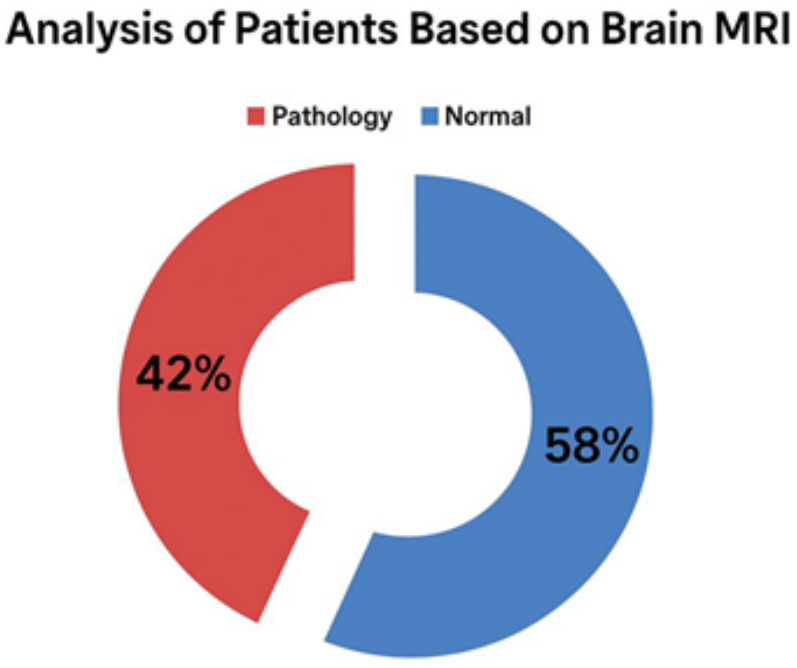
*Correlation with comorbidities*. The prevalence of microangiopathy (Fazekas ≥ 1) was significantly higher in patients with hypertension ($p < 0.001$) and diabetes mellitus ($p = 0.004$) compared to those without these conditions.

**Figure 1.**
The indicator of general studies conducted in Clinical Hospital No. 5 of Almaty in 1.5 Tesla GE magnetic resonance imaging, (%).




A total of 11,342 patients underwent MRI studies during the said period. 84% of these studies (9,518 patients) were conducted on various organs and systems, and 16% (1,814 patients) were focused on magnetic resonance imaging of the actual brain. That is, on average, every sixth patient was referred for an MRI with headaches or other neurological complaints. This indicator testifies to the fact that neurological symptoms are often recorded in modern medical practice and its diagnostic significance.

**Figure 2.**
Brain studies conducted in Clinical Hospital No. 5 of Almaty at 1.5 Tesla GE magnetic resonance imaging, %.



Of the 1,814 patients who underwent an MRI examination of the brain:

✓ In 761 patients (42%), no pathological changes in the structure of the brain were detected, that is, the result of the study was within the norm.

✓ In the remaining 1053 patients (58%), various pathologies were recorded.

This means that more than one in every two brain studies reveals abnormalities to a certain extent. This result indicates the effectiveness of neuroimaging in diagnostics and the ability to identify pathological changes at an early stage with its help.

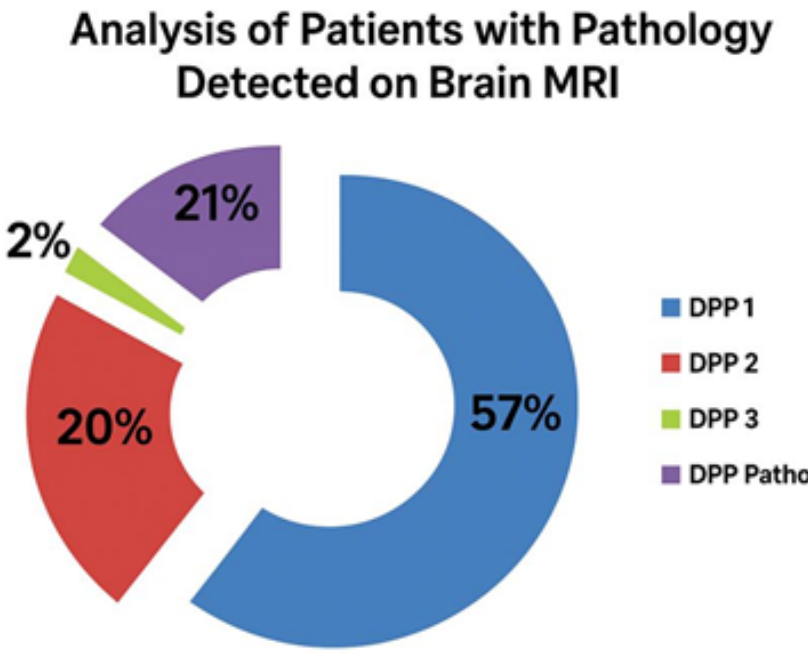



**Figure 3.**
Brain studies conducted in Clinical Hospital No. 5 of Almaty at 1.5 Tesla GE magnetic resonance imaging, %.

Among the 1053 patients with pathology, special attention is paid to microangiopathic changes. Of these patients, the following diagnoses are made:

✓ 599 patients (57%) were diagnosed with Phasecas Level 1 microangiopathy Diffusion/Perfusion Project (DPP 1). In this case, small hyperintensive foci are usually observed in the subcortical white matter of the Cerebral Hemispheres. Such changes are often seen as a sign of primary-stage chronic circulatory disorders.

✓ 210 patients (20%) had phasecas Level 2 microangiopathy (DPP 2). In this stage pathology, many hyperintensive foci are detected in the subcortical and deep white matter, among which there may be fused foci.

✓ 21 patients (2%) were diagnosed with Phasecas Level 3 microangiopathy (DPP 3). At this stage, changes are very clearly observed, and the involvement of many large foci and drainage zones is recorded in the subcortical and deep white matter. Such a manifestation usually develops as a result of prolonged cerebral circulation disorders.

✓ In the remaining 220 patients (21%), other pathological changes were detected, which were not microangiopathic in nature. In this category of patients, the brain has different etiologies (from birth, * inflammatory, tumor-like, etc.) other pathologies may be registered.

The statistical data obtained by MRI examination of the brain prove that microangiopathic changes are more common among patients. The fact that changes in the early stage (Fazecas 1) are often recorded indicates that this condition is being diagnosed at an early stage and there is a possibility of timely application of preventive or therapeutic measures.

The results of the study will help doctors classify patients and develop personalized treatment and control strategies for them. In addition, these data are an important basis for predicting the

prevalence and severity of neurological diseases in the public health field.

**Discussion**

The present study demonstrated a high prevalence of microangiopathic changes in patients undergoing brain MRI in Almaty, with pathological findings in 58% of cases, 79% of which were consistent with microangiopathy. Early-stage lesions (Fazekas 1) predominated, accounting for 57% of cases, which is consistent with data indicating that white matter hyperintensities are common in middle-aged and elderly populations and are often detected incidentally through neuroimaging.[1,12]

Our findings align with international reports emphasizing the role of small vessel pathology in the development of stroke, vascular dementia, and cognitive decline.[4,6] For example, WHO estimates that 17.9 million people die annually from cardiovascular diseases, in which microvascular pathology contributes significantly to adverse outcomes.[4] In diabetes mellitus, up to 40% of patients develop microangiopathic complications such as retinopathy, nephropathy, and neuropathy,[2,8] while microangiopathy is also a key link in the pathogenesis of neurodegenerative disorders.[1]

In our cohort, hypertension and diabetes mellitus were strongly associated with higher Fazekas scores, which is consistent with previous studies identifying these conditions as major risk factors for cerebral small vessel disease.[9,14] Importantly, the high proportion of Fazekas 1 lesions suggests that opportunities for preventive measures exist before irreversible damage occurs, which is in line with recommendations from the American Heart Association (2022) for early identification and management of microvascular disease.[15]

The public health implications of our findings are substantial. *The "Healthy Nation" national project in Kazakhstan (2021–2025)* prioritizes early detection of chronic diseases, including vascular complications. The integration of MRI-based Fazekas scoring into primary health care could improve risk stratification, guide timely interventions, and reduce the burden of disability associated with stroke and dementia.

**To summarize the above, we recommend:**

- Incorporate early MRI-based screening for microangiopathy into clinical protocols;
- Use the Fazekas scale for standardized reporting and risk stratification;
- Enhance preventive programs targeting vascular risk factors;
- Strengthen collaboration between neurologists, radiologists, and primary care physicians for timely intervention.

Limitations. This study was conducted at a single center, which may limit the generalizability of the findings. The retrospective design relied on existing MRI and medical records, which could introduce selection bias. Clinical follow-up data on patient outcomes were not available, limiting correlation between imaging findings and long-term prognosis. Additionally, the absence of advanced MRI techniques (e.g., diffusion tensor imaging, perfusion studies) restricted assessment to conventional structural markers.

What's Known? Microangiopathy is a key factor in the development of cognitive impairment, stroke, and diabetic complications, and MRI is an effective tool for its detection.

What's New? This study provides quantitative data on the prevalence and severity of microangiopathy using the Fazekas scale in a Kazakh cohort.

**Conclusion**

The study revealed a high prevalence of microangiopathy in patients undergoing brain MRI in Almaty. Pathological changes were detected in 58% of cases, with 79% being microangiopathic in nature and 57% at the early Fazekas 1 stage. These findings support the need for integrating early MRI-based diagnosis into national screening and preventive programs. Routine application of the Fazekas scale in clinical practice, coupled with targeted management of hypertension and diabetes, could significantly reduce the burden of stroke,

dementia, and related complications in Kazakhstan.

**Acknowledgments.** The authors thank the radiology department staff of Clinical Hospital No. 5 for providing access to imaging data, and the medical records department for assistance in retrieving clinical information.

**Author Contributions:** U.I. – study conception and design, data analysis, manuscript drafting; S.A. – MRI data review, interpretation of imaging findings; T.P.– statistical analysis, literature review. All authors approved the final manuscript.

**Funding:** no external funding was received for this study.

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