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Assessment of Brain Deep White Matter Hyperintensities in Smokers in Azerbaijan

Each year, more than six million of people worldwide die from smoking related diseases. The World Health Organization has also included nicotine dependence in its list of diseases [1,2]. Brain white matter hyperintensities (WMHs) increase the risk of stroke, causes geriatric(aging) syndrome such as depression, cognitive decline, urinary incontinence, functional disorders [3].

Every year, 15 million people worldwide suffer from stroke, from which 6 million die and 5 million sustain a permanent disability. It is estimated that 35.6 million people live with dementia, which is expected to triple by 2050. Stroke and dementia are among the primary health related problems of many governments, because the cause of the 20% of strokes and 40% of dementias secondary to small vessel diseases remains unclear [4,5]. When the cause is not clear, the results cannot be eliminated. White matter hyperintensities (WMHs) are among these causes. Therefore, it is important to investigate why WMH occurs, what is the pathophysiology behind it to eliminate the causes. It is known that there are no anastomoses or collaterals of terminal long penetrating arterioles in the brain. Hypoxia occurs when there is a decrease in blood flow. These changes cause neuronal atrophy and loss of myelin. However, hypoxia is not deep enough to damage the gray matter, only the white matter is damaged and white matter hyperintensities are formed [6]. Enlarged perivascular areas (which occur due to reduced interstitial fluid drainage), in more severe cases myelin and axonal tissue loss are the causes of formation white matter hyperintensities (WMH) [7].

Because research on the pathophysiology of white matter hyperintensities (WMH) is only possible postmortem, researchers face many challenges to study it. Histopathological analysis is performed only on certain small tissue samples. Changes may occur during sampling or sample fixation. It is easier for histopathologists to detect demyelination and axonal degeneration than to study changes in the extracellular fluid [4]. Magnetic resonance imaging (MRI) can detect white matter hyperintensity (WMH) at early stage. Before the use of

CT and MRI scans these T2 hyperintense foci (white matter hyperintensity) were missed on pathohistological examinations. Some studies suggest that the degree of damage in T2 hyperintense foci affects the «brightness» of foci in FLAIR sequence and understanding the term «dirty-appearing white matter»[4].

Wardlaw et al created a table to distinguish white matter hyperintensities (WMH) from other artifacts in FLAIR sequence during MRI. According to them, these artifacts may occur secondary to cerebrospinal fluid (CSF) and blood flow, magnetic field sensitivity, eye and head movement, the corticospinal tract, and combination of several of these factors [4,8]. Based on these artifacts, radiologist can identify hyperintense-appearing areas that do not really WMH.

Smoking also plays a role in the development of white matter hyperintensity. Smoking causes diseases of all organs of the human body. Actually, all smokers usually start smoking before the age of 18. More than 20 million deaths due to the preterm birth have been reported in the United States during a period, according to the report «The Health Consequences of Smoking — 50 Years of Progress». The main biomarker in smoking is the effect of nicotine and its metabolites on the body [9,10,11].

The primary purpose of this study is to examine the WMH in smokers in Azerbaijan using MRI and to identify differences in the number and size of WMH compared with healthy individuals.

Materials and methods

Total of 120 patients between 37 and 70 years were included in this study. The mean age was 50,2±0,8. People over the age of 70 were not included in the study because they had age-related WMH in their brains. Eighty (80) of the patients were smokers. All these patients have been smokers for at least 15 years-maximum 50 years. The average year of the smoking was 23,1±1. In addition, 40 healthy individuals were included in the study as a control group. All patients (100%) were men. Patients with oncological diseases, trauma, history of brain surgery, demyelinating disease, migraine were not included in the study, as the white matter hyperintensities developed secondary to these reasons can lead to false results in the study. Ethics committee approval was received for this study from the Azerbaijan Medical University Ethics Committee (protocol number 22). Informed consent form was received from all participants after a detailed explanation of the examination. We used 1.5-Tesla Magnetom Aera MRI equipment and images obtained with T2 turbo inversion recovery magnitude (TIRM) sequences. MRI images were obtained using TR-9200, TI-2450, TE-84 and 3.5 mm slice thickness, and 10% interslice gap. The number, size, location (according to the brain lobes) of the white matter hyperintensities were detected on brain MRI of the examined patients and average measurements were obtained. The results were compared with those in healthy individuals. Due to the thinness of slices, small gap between slices and high image quality, it was easier to differentiate white matter hyperintensities from small vessels, dilated perivascular spaces, and lacunes.

Statistical analysis was performed using SPSS-26 package program. Descriptive data were expressed as mean ± Standard Error of Mean, minimum and maximum. The distribution of variables was checked with the t-Student Bonferroni and U Mann-Whitney test. Frequencies between the groups of patients were compared on the basis of the Pearson chi-square test. The relationship between the indicators was studied by Rho-Spearman correlation analysis. For all statistical analysis, $P < 0.05$ was considered statistically significant.

Results

The mean age of the smokers was 50,7±1,0 (37-70) years. In addition, the mean age of the healthy individuals was 49±1,1(39-62) (Pu=0,556). Our study indicated that, the number of WMH increases with age, regardless of whether the patient smokes or not (ρ=0,271; P=0,003) (Figure1).

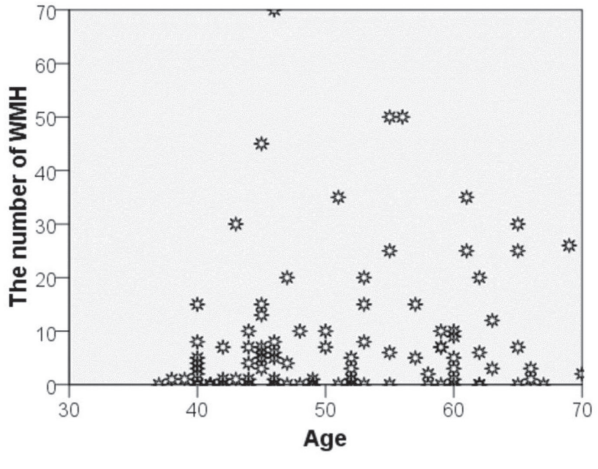

Figure 1. The number of white matter hyperintensities (WMH) increases with age

We found that, there was no significant difference in the statistically correct correlation (in the number and size of the WMH) between those who had smoked for longer years-50 years and those who had smoked the least-15 years (ρ=0,050; P=0,659).

In this study WMH was not found in 21(52,5%) patient from 40 healthy individuals (Figure 2). The average number of WMH detected in 47.5% (19) of patients was 3.2±0,8 (min0-max20) and the average size was 1.9±0,1 mm (min1.5-max 2.5).

According to the measurements and numbers performed on 80 smokers included in the study, the average number of WMHs was 8.8±1,5(min0-max70) and the average size was 2.3±1,0 mm(min1.5-max6) (Figure 3).

At the same time, WMHs were not observed in 28 (35,0%) smokers. The parameters about the number and average size of WMHs are shown in Table 1.

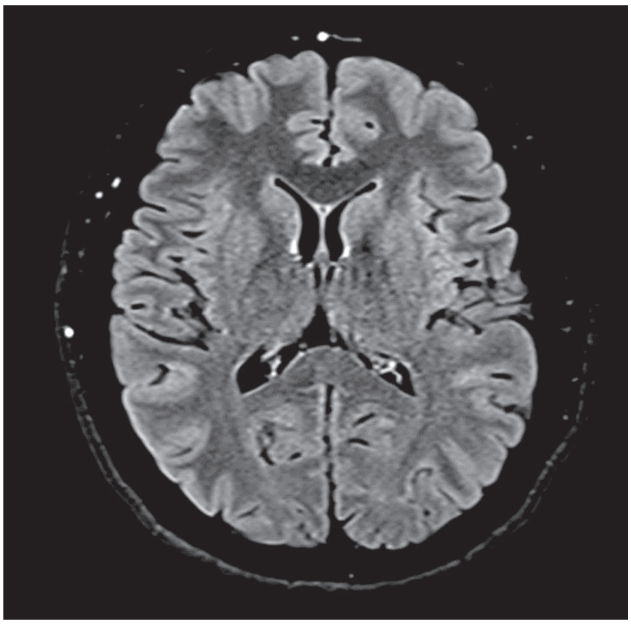

Figure 2. Axial T2 TIRM image in a healthy man demonstrates absence of white matter hyperintensity

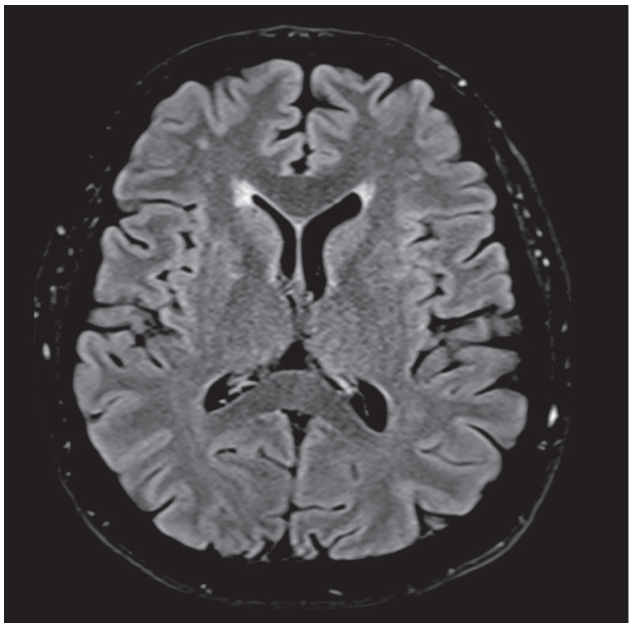

Figure 3. Axial T2 TIRM image in smoker demonstrates several white matter hyperintensities in both frontal lobes

Table 1. Parameters about the number and the size of WMH in healthy individuals and smokers

WMH parameters		Healthy individuals (n=40)	Smokers (n=80)	Pt-value	Pu-value
Number	M ± m	3,2±0,8	8,8±1,5	0,016	0,025
	Minimum	0,0	0,0		
	Maximum	20,0	70,0		
Size	M ± m	1,9±0,1	2,3±0,1	>0,05	0,459
	Minimum	1,5	1,5		
	Maximum	2,5	6,0		

WMH-white matter hyperintensity. M-mean, m-Standard Error of Mean.
Statistical correctness of the difference between the indicators of the groups: Pt – by the criterion Student-Bonferroni, Pu – by the criterion Mann-Whitney

It was found that the number of WMH in smokers was higher than in control group-healthy individuals (Pu=0,025) (Figure 4). But the size of WMH in smokers was not differ so much than in healthy individuals (Pu=0,459).

We found WMHs mainly in the frontal lobe in smokers 51(63,7%) (Pu=0.051). Secondly WMHs were in the parietal lobe 23(28,7 %) (Pu=0.182) and the least number of the WMHs was in temporal lobe 2(2.5%) (Pu=0.315) in smokers. Besides, WMHs in control group was mostly in frontal lobe 18(45,0%), secondly in parietal lobe 7(17,5%) too. WMHs was not found in the temporal lobe in the control group (Table 2).

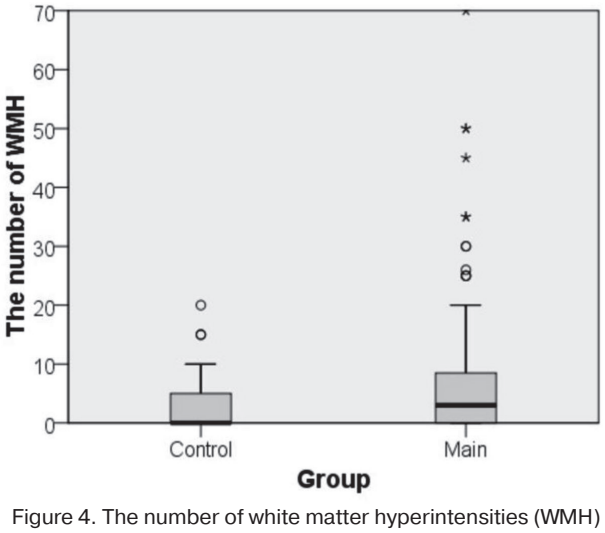

Figure 4. The number of white matter hyperintensities (WMH) was higher in smokers than in control(healthy) group

Table 2. Distribution of the WMH in brain lobes in smokers and control (healthy) group

Lobes	WMH	Control (n=40)	Smokers (n=80)	Pχ2-value	P_U-value
Frontal	no	22 (55,0%)	29 (36,3%)	0,050	0,051
	yes	18 (45,0%)	51 (63,7%)		
Parietal	no	33 (82,5%)	57 (71,3%)	0,180	0,182
	yes	7 (17,5%)	23 (28,7%)		
Temporal	no	40 (100,0%)	78 (97,5%)	0,313	0,315
	yes	0 (0,0%)	2 (2,5%)		

WMH-white matter hyperintensity.
Statistical correctness of the difference between the indicators of the groups: pχ2 - by the criterion Pearson, P_u – by the criterion Mann-Whitney

Discussion

Tissue level changes were studied due to the expanded capabilities of magnetic resonance imaging (MRI) [12,13]. Regardless of the form in which nicotine is taken (including even chewing), it is rapidly absorbed into the bloodstream and reaches its plasma peak level within minutes. The lipophilic structure of nicotine allows it to quickly cross the blood-brain barrier. Further elimination of nicotine from the brain and body depends on changes in the blood [12,14].

The white matter hyperintensity is the main manifestation of small vessel disease on brain MRI. Increased incidence of white matter hyperintensities (WMH) on MRI was observed in smokers without other known risk factors [12]. In our study, 89% of patients had no co-morbidities (11% had mild arterial hypertension). And there was an increase in the number and size of foci in these patients too, when compared to healthy individuals.

Some studies show there is a parallel correlation between the increase in the dose of nicotine and the increase in the number of WMH [12]. However, we did not find such a correlation in our study. They say not all smokers had white matter changes. In this study we did not evaluate WMH in all smokers as well.

Smoking or intravenous administration of nicotine increases cerebral blood flow. Although cerebral blood flow increases during smoking, it decreases at the same rate when you stop smoking. This increase occurs in the frontal lobes and cerebellum [12,15]. In our study WMH was mostly found in frontal lobes, maybe it`s associated with changing (increasing and decreasing) of blood flow in these areas.

Researchers performed baseline brain magnetic resonance imaging (MRI) on a group of patients. They did second MRI scan of the brain in these patients after 6 years to examine the changes in the brain caused by smoking. Smoking has been reported to be associated with white matter hyperintensities which reflect subclinical small vessel disease [16,17]. Researchers reveal that white matter hyperintensity is higher in those who smokes 50 packs/year. And increase in the amount of the packs correlates with the increase in linear white matter hyperintensities. Researchers did not find a link between the age of onset of smoking and the increase in white matter hyperintensities [16,18]. In this study we also didn`t find such a correlation.

Smoking is associated with some psychiatric conditions, such as major depression and alcohol use. Smoking is also associated with conditions such as decreased overall cognition, impaired decision-making, and decreased speed of cognitive processing. A meta-analysis of 761 individuals found that smoking reduced volume in the left insula, right cerebellum, left parahippocampal gyrus, mediodorsal thalamus, and numerous prefrontal cortical areas. The relationship between smoking and white and gray matter volume was investigated [19,20].

Studies show that exposure to tobacco smoke increases the risk of attention deficit and development of hyperactivity disorders. Nicotine dependence at younger age develops faster compared to older age. Intrauterine tobacco exposure increases the body's ability to store fat and reduces the size of the amygdala in the brain [9,21]. Therefore, number of actions is taken to limit smoking. In Azerbaijan almost all women don`t smoke, that's why we could not do research on this.

Smoking weakens the structural integrity of the corpus callosum, but it can be restored slowly, over the years after smoking cessation [1,22]. However, we did not reveal any macroscopic changes in the corpus callosum of patients in our study.

We have some limitations, so that we could not obtain the information about the number of packs of cigarette smoked per year by patients, that's why we couldn't learn its effect on WMH. The lesion characterization was difficult in elderly patient groups who had chronic hypertensive vascular disease. And couldn't analyze the

relationship between smoking and brain volume in our patients either.

Conclusion

Smoking is one of the most harmful habits in modern life. Therefore, there is a growing interest to study the damage to the body caused by smoking. The brain is one of the main organs that control the body. One of our missions is to try to protect our future by identifying white matter hyperintensities, revealing their linkages to smoking and informing young people about it.

Transparency of the study. The study was not funded by sponsors. The authors are solely responsible for submitting the final manuscript to print.

Declaration of Financial and Other Relationships. All authors participated in the conception and design of the study and in the writing of the manuscript. The final version of the manuscript was approved by all authors. The authors did not receive payment for the study.

Abbreviations

MRI — Magnetic resonance tomography
WMH — White matter hyperintensity
pχ^2 — by the criterion Pearson,
pu — by the criterion Mann-Whitney
pt — by the criterion Student-Bonferroni

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Оцінка гіперінтенсивності глибокої білої речовини головного мозку у курців в Азербайджані

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Анотація. Обґрунтування: гіперінтенсивні вогнища Т2 (гіперінтенсивність білої речовини) спостерігаються в білій речовині мозку на магнітно-резонансній томографії (МРТ) у курців. Мета дослідження полягає в тому, щоб виявити зв'язок, кількість і розмір гіперінтенсивності білої речовини з курінням у чоловіків, що палять в Азербайджані, і порівняти їх з контрольною групою.

Матеріали та методи. У дослідження було включено 120 пацієнтів віком від 37 до 70 років. Середній вік становив 50,2±0,8 років. Вісімдесят (80) пацієнтів були курцями і 40 з них були здоровими людьми. У нашому дослідженні ми вивчаємо локалізацію (відповідно до часток мозку), розмір і частоту гіперінтенсивних вогнищ Т2 на МРТ. Ми використовували обладнання для магнітно-резонансної томографії Magnetom Aera 1,5 Тесла та зображення, отримані за допомогою послідовностей Т2 турбоінверсії відновлення величини (TIRM). Зображення МРТ були отримані з використанням TR-9200, TI 2450, TE 84 і товщиною зрізу 3,5 мм і міжзрізовим проміжком 10%.

Результати. Середній вік курців становив 50,7±1,0 (37-70) років. Середній вік здорових осіб становив 49±1,1(39-62) (Pu=0,556).

У 21(52,5%) пацієнта з 40 здорових осіб WMH не виявлено. Середня кількість WMH, виявлених у 47,5% (19) пацієнтів, становила 3,2±0,8 (min0-max20), а середній розмір становив 1,9±0,1 мм (min1,5-max 2,5).

Згідно з вимірюваннями та цифрами, проведеними на 80 курцях, включених у дослідження, середня кількість WMH становила 8,8±1,5 (min0-max70), а середній розмір становив 2,3±1,0 мм (min1,5-max6). Водночас у 28 (35,0%) курців WMH не спостерігалися.

Встановлено, що кількість WMH у курців була вищою, ніж у здорових осіб контрольної групи (Pu=0,025). Але розмір WMH у курців відрізнявся не так сильно, як у здорових осіб (Pu=0,459).

Висновок: у чоловіків, що палять в Азербайджані, було виявлено збільшення кількості гіперінтенсивності білої речовини в мозку порівняно зі здоровими людьми. Не було суттєвої різниці в статистично правильному співвідношенні (кількості та розміру WMH) між тими, хто курив довше (50 років), і тими, хто курив найменше (15 років). Кількість WMH збільшується з віком, незалежно від того, курить пацієнт чи ні.

Ключові слова: МРТ, гіперінтенсивність білої речовини, паління .

Assessment of Brain Deep White Matter Hyperintensities in Smokers in Azerbaijan

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Abstract. Bacground: T2 hyperintense foci (white matter hyperintensities) are seen in the white matter of the brain on magnetic resonance imaging (MRI) in smokers. The aim of the study is to reveal the relationship, number and size of these white matter hyperintensities with smoking in Azerbaijani smoking men and to compare them with the control group.

Materials and Methods: Total of 120 patients between 37 and 70 years were included in this study. The mean age was 50,2±0,8. Eighty(80) of the patients were smokers and 40 of them was healthy individuals. In our study we exam the location(according to the brain lobes), size and frequency of T2 hyperintense foci on MRI. We used 1.5-Tesla Magnetom Aera MRI equipment and images obtained with T2 turbo inversion recovery magnitude (TIRM) sequences. MRI images were obtained using TR-9200, TI 2450, TE 84 and 3.5 mm slice thickness, and 10% interslice gap.

Results: The mean age of the smokers was 50,7±1,0 (37-70) years. The mean age of the healthy individuals was 49±1,1(39-62) (Pu=0,556).

WMH was not found in 21(52,5%) patient from 40 healthy individuals. The average number of WMH detected in 47.5%(19) of patients was 3.2±0,8 (min0-max20) and the average size was 1.9±0,1 mm (min1.5-max 2.5).

According to the measurements and numbers performed on 80 smokers included in the study, the average number of WMHs was 8.8±1,5(min0-max70) and the average size was 2.3±1,0 mm(min1.5-max6). At the same time, WMHs were not observed in 28 (35,0%) smokers.

It was found that the number of WMH in smokers was higher than in control group-healthy individuals(Pu=0,025). But the size of WMH in smokers was not differ so much than in healthy individuals(Pu=0,459).

Conclusion: An increase in the number of white matter hyperintensities in the brain was found in smoking men in Azerbaijan compared to the healthy individuals. There was no significant difference in the statistically correct correlation (in the number and size of the WMH) between those who had smoked for longer years-50 years and those who had smoked the least-15 years. The number of WMH increases with age, regardless of whether the patient smokes or not.

Key words: MRI, white matter hyperintensities, smoking

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