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Environmental exposure to tobacco smoke and condition of organ of vision

Narażenie na dym tytoniowy i jego wpływ na narząd wzroku

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Summary

According to the most recent epidemiological data, nicotine causes a greater number of addiction-related deaths than cocaine, heroin and alcohol combined. Its toxicity also significantly affects the organ of sight

Smoking exerts a severe influence on all structures of the eyeball, impairing physiological processes as well as stimulating pathological processes which result in eye diseases. Studies conducted within fundamental science allow for a deeper understanding of the mechanisms of nicotine influence on the organ of sight and its connection to the development and progression of ophthalmic diseases.

The authors comment the toxic effect of nicotine on several anatomical structures of the eye and the visual function and discuss the role of smoking and nicotine abuse in the pathogenesis of several ocular diseases.

Key words: tobacco, smoking, ocular involvement, eye

Streszczenie

Dostępne dane epidemiologiczne sugerują, że nikotyna jest odpowiedzialna za wyższy odsetek zejść śmiertelnych związanych z jej zażywaniem niż kokaina, nikotyna i alkohol łącznie.

Palenie czynne i bierne wywołuje istotny wpływ na struktury gałki ocznej, upośledza fizjologiczne procesy i stymuluje powstanie procesów patologicznych, które są odpowiedzialne za powstawanie chorób oczu. Badania przeprowadzone w obrębie nauk podstawowych umożliwiają głębsze zrozumienie mechanizmów wpływu nikotyny na narząd wzroku oraz ich związek z rozwojem i progresją schorzeń okulistycznych.

Autorzy omawiają toksyczny wpływ nikotyny na szereg struktur narządu wzroku i funkcję widzenia. Wyjaśniają rolę palenia i uzależnienia od nikotyny w patogenezie wielu chorób oczu.

Słowa kluczowe: tytoń, palenie, wpływ na narząd wzroku, gałka oczna

Nicotine was named after J. Nicot (1530-1600), a French ambassador in Lisbon who was sending tobacco leaves to France, thus making tobacco smoking popular. According to the most recent epidemiological data, nicotine causes a greater number of addiction-related deaths than cocaine, heroin and alcohol combined (1-3). Its toxicity also significantly affects the organ of sight (2, 3).

As an irritant, the tobacco smoke can cause conjunctival irritation and symptoms of the dry eye syndrome. This disease occurs frequently in industrialised countries. In the USA there are approximately 59 million patients suffering from this disease, and the number has doubled in the last 10 years (4). Demographic data show that approx. 25-40% of employees are exposed to tobacco smoke at work, due to both active

and second-hand smoking and 25% of them exhibit symptoms of the dry eye syndrome. Grus et al. conducted research into the chemical composition of tear film in smokers. In comparison to a control group of non-smokers, a significant increase of lower molecular weight protein content in tears was observed, as well as an overexpression of area of 25-40 kDa molecular weight in electrophoresis. According to the authors, these changes are a result of the toxic effect of tobacco smoke which causes oxidative damage to proteins and might potentially increase the concentration of smaller protein fragments present in the tear film. Smoking can also damage or change the blood flow in this area causing transudation of protein molecules. Moreover, there are indicators of damage caused through free radicals in these patients (4).

In histopathological studies, Satici et al. showed a metaplasia of conjunctival epithelium and its keratinization in persons exposed to tobacco smoke. According to the authors, these changes are caused by a change in the stability of tear film in smokers resulting from lipid layer deficiency, which may additionally intensify lacrimation and cause irritation to eye surface tissues. A decrease of lysozyme content in tears caused by its local binding by toxins present in tobacco smoke has also been described (5). Because smoking intensifies the symptoms of dry eye syndrome it can also cause contact lens intolerance (2, 3). Smoking can be also a risk factor for spinocellular carcinoma of the conjunctiva (6).

Smoking is also risk factor for lens opacification. In Reykjavik Eye Study, the influence of different risk factors for lens opacification in Reykjavik inhabitants was assessed. It was demonstrated that apart from ageing, smoking was the most important variable risk factor for opacifications of this type (not demonstrated in cortico-nuclear opacifications) (2, 3, 7).

Smoking is an acknowledged risk factor for the development of many systemic vessels diseases. Nicotine influences the increase of catecholamines level in blood, which manifests as tachycardia and arterial blood pressure increase. Tobacco smoke contains 2-6% of carbon monoxide among other components. Smoking leads to increased level of carboxyhemoglobin, up to 5-15% (0.5% in non-smokers). This increases the accessibility of oxyhaemoglobin, changes its dissociation curve and decreases the oxygen supply to tissues as a result. Oxygen deficit, through regulatory mechanisms, causes dilation of vessels and increase of blood flow velocity. The changes described also apply to eyeball and retrobulbar vessels. Kaiser et al. described that the increase of the blood flow velocity mostly concerns ophthalmic artery, middle artery, central retinal vein and lateral short posterior ciliary artery in comparison to the non-smoking group. The author also observed a lowered diastolic and systolic blood pressure as well as tachycardia in smokers (2, 3, 8).

Smoking also causes changes in microcirculation. Steigerwalt et al. in turn described a 36% decrease in blood flow velocity in contraction and 52% in decontraction in ophthalmic artery, central retinal artery and posterior ciliary artery. According to the authors, this happens because of a contraction of minute vessels of the retinal and optic disc through sympathetic system excitation. This is why smoking may intensify the course of numerous ophthalmic diseases related to blood flow disorders e.g. diabetes, central retinal vein thrombosis, ischemic optic neuropathy and giant cell arteritis (Horton's disease) (2, 3, 9).

Apart from cardiovascular factors including arterial hypertension, smoking is an important risk factor for retinal vein thromboses. The most recent studies show that smoking plays an important role in the etiology of thromboses taking place in arteriovenous crossings – in a prospective analysis of 874 eyes such thromboses were the most frequently observed type (2, 3, 10).

What is interesting, the transmission of the toxic effect of nicotine can be intrauterine and it has been observed in the retinal vessels of newborns of smoking mothers. In a large group of 162 newborns of smoking mothers, thinning of retinal arteries was observed, accompanied by increased arterial blood pressure in 52 cases. The frequency of occurrence of these changes was 3 times higher in newborns with low birth weight, thus confirming the toxic effect of nicotine on intrauterine growth. Dilation and sinuosity of veins was observed in the eyes of 100 newborns of smoking mothers and presence of intraretinal haemorrhages was shown in 36. A statistically significant correlation between the intensity and extent of haemorrhage and the number of cigarettes smoked daily by the mother was proved. However, all of these changes yielded before 6th month of life (2, 3, 11).

Although the toxic effect of the exposition to nicotine in intrauterine life on retina and optic nerve functioning is well-known, it is not known exactly which layer of the retina is damaged the most. Studies in animals concerning fetal development of retina in rats exposed to tobacco smoke showed that the development of inner plexiform layer and retinal layer cells supplied by central retinal artery was disturbed the most. The overall retinal thickness was also lowered in animals exposed to tobacco smoke in comparison with the control group, indicating an ischemic background of the atrophic changes (2, 3, 12).

Smoking, along with age, hereditary factor and diet is an acknowledged risk factor for developing age-related macular degeneration (2, 3, 13). It is possible that the reason for this is the toxic effect of nicotine (releasing free radicals) and their ability to destroy carotenoids which can act protectively on the macula (2, 3, 14). It was also proved that smoking influences risk factors connected with pathogenesis of AMD e.g. immune activity, lowered level of antioxidants, decreased blood flow through retina and choroid, lowered level of lutein in macula, lower drug detoxication on the level of retinal pigment epithelium and intensifying angiogenesis by nicotine (15). Results of Beaver Dam Eye Study show that currently smoking people have a 45% higher risk of developing and progression of AMD than people who never smoked ([odds ratio] 1.43; 95% confidence interval 1.05-1.99; $P = 0.02$). After taking age and sex into account, smoking patients had a higher risk of early AMD occurring during 15 year observation period than people who never smoked ([odds ratio] 1.47; 95% [confidence interval] 1.08-1.99; $P = 0.01$) (15).

Blue Mountains Eye Study showed that mean intraocular pressure is higher in smokers (16.34 mmHg) than in the non-smoking control group (16.04 mmHg) (16). However, the role of smoking in the etiopathogenesis of primary open-angle glaucoma is yet to be determined unequivocally. This may be due to the fact that data available in literature usually concern relatively small groups of examined patients (less than 180 patients) (17). It is possible that nicotine

influences the vascular flow in the optic disc in two ways. It can induce a contraction of minute vessels and increase the blood viscosity, causing development and progression of glaucoma. Although, on the other hand, many studies show that nicotine causes an increase of the flow in cerebral vessels by increasing oxygen requirement. This influence also concerns the optic nerve (2, 3, 17).

Nicotine can cause eye movement disorders. Incidence of nystagmus has been described in smokers (27 [51%] of 53 patients which underwent a 3D eye movement analysis). Nicotine influences the synapses of vestibular or oculomotor system, although this process is not entirely recognized. In the system governing the eye movements, as in the peripheral and central vestibular system, a significant amount of cholinergic receptors (nicotinic and muscarinic) exists – they are located in medial and lateral nucleus, which have connections with cerebellum and medulla, in interstitial nucleus of Cajal (2, 3, 18).

There are reports of a confirmed negative influence of exposition to tobacco smoke on the course of thyroid

orbitopathy (19). Chain-smokers, similarly to alcoholics, can suffer from toxic amblyopia (amblyopia tabaco-alcoholica) resulting from protein and B vitamins. It is characterised by visual acuity deterioration in both eyes, colour vision disorders, centrocecal scotomas in the field of vision without any significant changes in the appearance of optic disc. The treatment is composed of diet complementation, multi-vitamin preparations, reducing or quitting the habit and hydroxocobalamin administered intramuscularly for 10 weeks in 1000 units dose each week. It should be noted that when administering the treatment proves difficult or there is no reaction to the treatment, the result might be a loss of vision (2, 3, 20).

As a summary, it is worth noting that smoking exerts a severe influence on all structures of the eyeball, impairing physiological processes as well as stimulating pathological processes which result in eye diseases. Studies conducted within fundamental science allow for a deeper understanding of the mechanisms of nicotine influence on the organ of sight and its connection to the development and progression of ophthalmic diseases.

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