VIA MEDICA

REVIEW ARTICLE

Acta Angiol
Vol. 29, No. 1, pp. 15–18
DOI: 10.5603/AA.2023.0001

ISSN 1234–950X
e-ISSN 1644–3276

Influence of endarterectomy on the structure and function of the retina and optic nerve

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Abstract

Carotid arteries are the main blood vessels supplying the brain, neck, and face as well as ophthalmic arteries. Internal carotid arteriosclerosis is strictly associated with ophthalmic symptoms caused by damage to the optic nerve. This condition can manifest as an ocular ischemic syndrome or anterior ischemic optic neuropathy. One of the surgical procedures that treat carotid arteriosclerosis is an endarterectomy. It has been proved that this surgical procedure can additionally reduce intraocular pressure and improve visual acuity, best corrected visual acuity (BCVA), visual field, a bioelectrical function of the optic nerve and retina, and perfusion of the optic nerve head. It has been also observed that the procedure does not affect retinal nerve fiber layer thickness and ganglion cell layer. The aim of this review was, to sum up information on the influence of endarterectomy on the function of the optic nerve based on the up-to-date internet database.

Key words: endarterectomy; internal carotid artery; optic nerve; perimetry; electrophysiology

Acta Angiol 2023; 29, 1: 15–18

Introduction

Carotid arteries are the main blood vessels supplying the brain, the neck, and the face as well as ophthalmic arteries [1]. Plaque forming in these arteries leads them to be hardened and narrower thus increasing the chances of carotid atherosclerotic diseases. Internal carotid arteriosclerosis is one of the main causes of stroke and transient ischemic attack worldwide. This condition has been strictly associated with ophthalmic symptoms and evidence shows that it may lead to ischemic lesions of the retina and optic nerve in 15–46% of involved patients [2]. As a matter of fact, when an embolus originating from the carotid artery reaches the ophthalmic artery, it may cause a wide variety of ocular problems that can be considered the first symptoms of carotid stenoses, such as transient monocular visual loss, central retinal artery occlusion and central retinal artery branch occlusion [3–5]. Ocular ischemic syndrome (OIS) and anterior ischemic optic neuropathy (AION) are also associated with significant carotid artery stenosis and may lead to ocular blood flow reduction and cause damage to the optic nerve. The main symptoms include permanent (AION) or transient (OIS) visual loss and ischemic ocular pain. Generally, it is important to observe ophthalmic symptoms as they may foreshadow possible future cerebrovascular complications [2, 6].

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Received: 09.11.2022 Accepted: 19.12.2022 Early publication date: 24.03.2023

Carotid arteriosclerosis can be treated with surgery — the atherosclerotic plaque can be removed by endarterectomy or angioplasty and stenting [1]. A broad range of research has highlighted that endarterectomy can improve multiple visual parameters in patients with severe ICA.

The aim of this review is to summarize the findings concerning the impact of endarterectomy on the function of the optic nerve, accumulated and published in the literature in the last five years.

Methodology

Two reviewers have independently searched electronic databases using search terms: "internal carotid endarterectomy and visual field", "influence of ICE on the optic nerve function", "atherosclerosis and optic nerve function", "ICE and vision", internal carotid endarterectomy and electrophysiology", "internal carotid endarterectomy and optical coherent tomography" to obtain information on the influence of internal carotid endarterectomy on the function of the optic nerve.

Background

Atherosclerotic cardiovascular diseases (CVD) are associated with the buildup of fats, cholesterol, and other substances in and around the arteries and form of plaque. These diseases are a leading cause of mortality worldwide [7]. In 2020, in people aged 30–79, the prevalence of increased carotid intima-media thickness was estimated to be 27.6%, the presence of plaque — 21.1% and of carotid stenosis — 1,5% [8].

Internal carotid arteriosclerosis (ICA) prevents proper blood flow in the brain and has been widely associated with ophthalmologic symptoms. This condition can be treated surgically by endarterectomy, angioplasty and stenting. However, treatment may differ depending on symptoms, as surgical intervention on asymptomatic patients is still disputed. Undergoing an operation is recommended for asymptomatic patients with high-grade stenosis (70–90%) or symptomatic ones with moderate (50–69%) or high-grade stenosis [1].

Carotid endarterectomy (CEA) restores the blood flow in the vessels and prevents the brain and eye from damage due to hypoperfusion. It has been documented that CEA can reduce intraocular pressure (IOP) as well as improve visual acuity, visual field, a bioelectrical function of the optic nerve and retina, and perfusion of the optic nerve head. It has been also observed that CEA doesn't affect retinal nerve fiber layer (RNFL) thickness and ganglion cell layer (GCL).

Yan et. al performed a study on 15 patients with severe internal carotid stenosis (> 70%) but who did not suffer from ocular symptoms [9]. They underwent carotid endarterectomy (CEA) and complex ophthalmic examination before and after surgery. Upon surgery, the number of patients with low visual acuity (20/200 – 20/60) decreased while the number of patients with middle level of visual acuity (20/50–20/28) increased presenting partial improvement. Additionally, results showed that IOP levels decreased after surgery and the mean value of IOP was reduced from 17.41 ± 2.59 to 15.95 ± 2.50 mm Hg [9]. However, previous studies obtained controversial results, one found IOP to be significantly decreased after CEA [10], while Guclu et al. drew opposite conclusions [11]. Overall, although the mechanisms underlying these dynamics are not well understood, it was suggested that CEA might cause ophthalmic hemodynamic changes to IOP.

Another research showed that CEA can significantly improve the parameters of both static and dynamic visual fields. Konstantiniuk et. al. conducted a cohort study on 29 patients suffering from carotid artery stenosis [12]. Of 11 of the presented preoperative impairment of visual field parameters, 18 had those parameters preoperatively normal. The subjects had a full ophthalmic examination of both eyes before and after endarterectomy comprising the assessment of dynamic visual field (Goldmann perimetry). In a group of 11 patients, 8 experienced postoperative improvements in the visual field parameters. In the group of 18 patients, 3 experienced minor impairments; in two cases there were respectively, focal and temporal impairments in the contralateral eyes. In the third case there were both focal improvements and impairments. In the rest 15 patients, the vision remained unchanged, after the ICA [12].

Furthermore, other studies support the idea that CEA is associated with the subjective improvement of different visual symptoms after CEA, such as blurred vision, amaurosis fugax, and visual acuity [13, 14]. A study conducted by Yan et al., aiming at the analysis of changes in the visual field, highlighted how both kinetic and static visual field parameters significantly improved after CEA [9]. Researchers also showed that eyesight appeared to be enhanced after CEA was performed on patients suffering from anterior ischemic optic neuropathy or ocular ischemic syndrome [2, 6, 15]. Different studies underlined improvements in visual acuity or perimetric parameters after the surgery [16, 17].

Moreover, CEA may have a positive effect on the bioelectrical function of the retina and optic nerve in patients with significant ICA. In their research Yan et. al. assessed flash visual evoked potentials (FVEPs), pattern visual evoked potentials (PVEPs), and electroretinogram (ERG) before and after CEA. The outcome of FVEPs and PVEPs showed that the latency of the P2 wave was significantly shortened in both eyes and that the P100 latency was only slightly reduced, while its amplitude increased. However, differences in P100 were not statistically significant. The results of ERG showed that the oscillatory potential amplitudes statistically significantly increased [9]. Supporting these results, a previous study reported latency diminution and amplitude increase, reinforcing eyesight improvements and the recovery of visual function upon CEA [10]. Finally, another study analyzed different electrophysiological parameters of the optic nerve function in patients with the acute ocular ischemic disorder. Both the threshold of electrical sensitivity and the level of liability of the optic nerve appeared to be improved after the surgery [2].

Perfusion of the retina and optic nerve head is further ophthalmic parameters enhanced after CEA. Lahme et al. investigated optic nerve head (ONH) perfusion in patients with severe asymptomatic carotid artery stenosis [18]. The study analyzed 25 eyes of 25 participants suffering from this condition and compared them to 25 eyes of 25 healthy individuals. Optical coherence tomography angiography (OCT-A) was performed before and after the carotid surgery. The results showed that, in patients with ICA, the flow density of the radial peripapillary capillary (RPC) layer of the ONH was significantly lower than in healthy controls. Additionally, the flow density in the RPC of ONH was improved after CEA in both ipsilateral and contralateral eyes [18].

Finally, retinal nerve fiber layer (RNFL) and ganglion cell layer (GCL) parameters are generally considered to be unchanged before and after CEA. Pierro et al. enrolled 30 patients with unilateral carotid artery stenosis and 30 healthy patients as controls [19]. All participants underwent complex ophthalmic examination including OCT and OCT-A scans, and RNFL, ganglion cell layer (GCL) as well as choroidal (CT) thicknesses were assessed. RNFL and GCL were similar between the study group and controls and remained unchanged after the surgery [19]. Other studies confirmed that RNFL thickness remained unchanged before and after CEA and specifically no connection between retinal blood flow and RNFL thickness in glaucoma patients was found [9, 20]. Overall, researchers speculated that these results suggest that blood flow velocity does not affect the caliber of the retinal blood vessels.

Conclusions

Improved artery blood flow following endarterectomy demonstrated a positive effect on the function of the optic nerve and it can, to some degree, enhance and restore visual functions in patients with severe carotid artery stenosis. Multiple results of studies proved that the surgery can reduce IOP and improve different ophthalmic parameters such as visual acuity, BCVA, visual field, the bioelectrical function of the optic nerve and retina, and perfusion of the optic nerve head. It has been also observed that the procedure does not affect RNFL and GCL thickness.

Conflict of interest

None.

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