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Laser peripheral iridotomy in patients with acute primary angle closure

Laserska periferna iridotomija kod bolesnika sa akutnim primarno zatvorenim komornim uglom

Svetlana Paunović*, Milan Paunović†‡, Sunčica Srečković*§, Nenad Petrović*§, Mihailo Jovanović §, Dušan Todorović*§, Tatjana Šarenac Vulović*§

University Clinical Center Kragujevac, *Clinic of Ophthalmology, †Pediatric Surgery Clinic, Kragujevac, Serbia; University of Kragujevac, Faculty of Medical Sciences, ‡Department of Surgery, §Department of Ophthalmology, Kragujevac, Serbia

Abstract

Background/Aim. Since glaucoma has a very high prevalence worldwide, it is important to examine additional treatment modalities, especially the prevention of its progression. The aim of the study was to determine the importance of laser peripheral iridotomy (LPI) in patients with acute primary angle closure (APAC) in preventing primary angle closure glaucoma progression and APAC in the fellow eye. **Methods.** The research included 40 patients and 80 eyes treated between 2017 and 2021, which was also the follow-up period in the study. In all patients, LPI was performed bilaterally on both the APAC-affected eye and the healthy fellow eye. The patients with an age range from 40 to 79 years who had the pupillary block in one eye were monitored. All patients underwent bilateral LPI, and the changes in angle width were monitored using gonioscopy. Intraocular pressure (IOP) measurements were made with an applanation tonometer and Vertical Cup/Disc ratio (Ver C/D rat) performing biomicroscopic examination with indirect ophthalmoscopy and +90 D lens. **Results.** All 40 patients underwent bilateral LPI. The angle width of the APAC-affected eye before treatment was 0.15 ± 0.36, and 1.20 ± 0.41 of the fellow eye. After 12 months, the measurements taken were 0.85 ± 0.36 for the affected eye and 1.90 ± 0.36 for the fellow eye (Wilcoxon rank test, $p < 0.01$ statistically significant difference). The mean value of IOP in the eye without progression of the disease before therapy was 53.6 ± 3.73 mmHg, while in the eye with progression, it was 60.10 ± 4.37 mmHg. After 12 months, it was 14.92 ± 1.22 mmHg in the eye without progression, while in the eye with disease progression, it was 23.40 ± 2.53 mmHg (independent samples *t*-test, $p < 0.01$). The change in the Ver C/D rat in the eye without progression was 0.40 ± 0.10, while in the eye with progression, it was 0.45 ± 0.05. After 12 months, it remained unchanged in the eye without progression, while in the eye with progression, it was 0.65 ± 0.06 (independent samples *t*-test, $p < 0.01$). **Conclusion.** Simultaneous LPI has been proven efficient in patients with APAC in both affected and fellow eyes.

Key words:
glaucoma, angle closure; laser therapy; ophthalmologic surgical procedures.

Apstrakt

Uvod/Cilj. Glaukom je veoma rasprostranjen širom sveta zbog čega je važno ispitati dodatne načine lečenja osoba sa glaukomom, a posebno prevenciju njegove progresije. Cilj rada bio je da se utvrdi značaj laserske periferne iridotomije (LPI) u lečenju bolesnika sa akutnim primarno zatvorenim komornim uglom (APZK) u prevenciji progresije u primarni glaukom zatvorenog ugla, kao i pojavi APZK na parnom oku. **Metode.** Istraživanjem je obuhvaćeno 40 bolesnika, 80 očiju, lečenih u periodu od 2017. do 2021. godine, što je ujedno bio i period praćenja u studiji. Kod svakog bolesnika rađena je LPI obostrano - i na oku sa APZK i na parnom zdravom oku. Praćeni su bolesnici starosti 40–79 godina, koji su imali blokadu zenice u jednom oku. Kod svih bolesnika urađena je LPI na oba oka i praćene su promene širine komornog ugla gonioskopijom. Intraokularni pritisak (IOP) je meren aplanacionom tonometrijom i *Vertical Cup/Disc ratio (Ver C/D rat)* indirektnom oftalmoskopijom na biomikroskopu, korišćenjem lupe od +90 D. **Rezultati.** Kod svih 40 bolesnika urađena je LPI na oba oka. Širina komornog ugla na oku sa APZK pre terapije iznosila je 0,15 ± 0,36, a na parnom oku 1,20 ± 0,41. Nakon 12 meseci na oku sa APZK izmerena širina komornog ugla je iznosila 0,85 ± 0,36, a na parnom oku 1,90 ± 0,36 (Wilcoxon test ranga, $p < 0,01$ statistički značajna razlika). Prosečna vrednost IOP na oku bez progresije bolesti pre terapije bila je 53,61 ± 3,73 mmHg, na oku sa progresijom bolesti 60,10

Correspondence to: Svetlana Paunović, Clinic of Ophthalmology, University Clinical Center, Zmaj Jovina 30, 34 000 Kragujevac, Serbia. E-mail: cecaana.paunovic@gmail.com

± 4,37 mmHg. Nakon 12 meseci na oku bez progresije izmerena vrednost bila je 14,92 ± 1,22 mmHg, a na oku sa progresijom 23,40 ± 2,53 mmHg (*t*-test za nezavisne uzorke, $p < 0,01$). Promena *Ver C/D rat* na oku bez progresije bila je 0,40 ± 0,10, na oku sa progresijom 0,45 ± 0,05, a nakon 12 meseci na oku bez progresije ostala je nepromenjena, dok je na oku sa progresijom bila 0,65 ± 0,06 (*t*-test za nezavisne uzorke, $p < 0,01$). **Zaključak.** Istovremena primena LPI bila je efikasna u lečenju bolesnika sa APZK i na bolesnom i na parnom oku.

Ključne reči:
glaukom, zatvorenog ugla; lečenje laserom; hirurgija, oftalmološka, procedure.

Introduction

Glaucoma is the most common neurodegenerative disease leading to structural and functional changes in the optic nerve. It affects 80 million people worldwide. It is the second cause of blindness [1, 2]. Considering eyesight, primary angle-closure glaucoma (PACG) is far more destructive than open-angle glaucoma and affects 20 million people worldwide [3]. Acute primary angle closure (APAC) is defined as the presence of contact between the iris and trabecular meshwork as well as the possible presence of peripheral anterior synechiae (PAS), which leads to elevated intraocular pressure (IOP) without changes in the optic nerve head [4]. The incidence of acute angle closure is the highest in Singapore, occurring annually at 12.2 per 100,000 people over 30 years of age [5]. The risk of its occurrence is a narrow angle (≤ 20°) [4]. In 75% of cases, the pupillary block is the reason for its occurrence [6]. Initial medication treatment is administered to prepare patients for LPI, which should be performed as soon as possible in all patients with APAC to remove the pupillary block and as a preventive measure for the fellow eye [7, 8]. If IOP cannot be controlled, additional surgical treatment such as lens extraction or trabeculectomy (TTR) is indicated [9]. LPI is the standard treatment of PACG, as well as the preventive treatment of APAC [10–12]. Moreover, it reduces the risk of acute attack in the fellow eye [13–16].

The aim of the study was to present the importance of LPI in patients with APAC preventing its progression to PACG and the occurrence of APAC in the fellow eyes.

Methods

The research was conducted as a retrospective cohort interventional study, with the participants being both the study subjects and controls. The research included 40 patients who suffered unilateral APAC due to pupillary block aged 40 to 79 years, admitted to the Clinic of Ophthalmology, University Clinical Center in Kragujevac, Serbia. The patients did not have glaucoma or glaucomatous optic neuropathy (GON) before APAC. All patients were monitored over 12 months after LPI, as presented in the research. The research was performed from 2017 to 2021, and it was approved by the Research Ethics Committee of the University Clinical Center in Kragujevac (No. 01-8678 from September 27, 2010). After hospital admission, all patients were first treated with systemic and local drugs to achieve a reduction in IOP and improve corneal transparency, after which LPI was performed in the affected eye, and then a few days after, during hospitalization, the patients underwent prophylactic LPI in the healthy fellow eye. In all patients, the LPI procedure was performed using Nd:YAG laser (Carl Zeiss, Germany). The laser energy used during LPI ranged from 1.8 to 4.1 mJ. The laser application of 1.8 mJ was insufficient, so the iridotomy opening was closed 7 days after the intervention, and we had to repeat LPI with a higher energy level. That happened to another patient treated with 2.8 mJ, so there were 2 patients in whom LPI had to be repeated after 7 days due to iridotomy closure caused by lower laser energy used.

To reduce iris thickness so that it can be perforated more easily, we applied Pilocarpine 2% (Pharmacy Zaječar, Serbia) and tetracaine hydrochloride 0.5% (Pharmacy Zaječar, Serbia) as the local anesthetic agent. Then, the Abraham lens (66-dioptre, 10 mm in diameter) was located with suitable hydroxypropyl-methylcellulose 2% gel (Galena, Belgrade). The site of iridotomy was chosen where the iris appeared thinnest, at a non-perpendicular angle directed toward the peripheral retina, to avoid possible macular laser coagulation.

The inclusion criteria were patients aged 40–79 years diagnosed with APAC with the pupillary block in one eye, ocular and periocular pain, nausea, vomiting, blurred vision with a halo effect surrounding a light source, IOP > 30 mmHg, corneal edema, ciliary injection, a medium-wide unreactive pupil, shallow anterior chamber leading to a forward shift of the peripheral iris, gonioscopically confirmed iridotrabecular contact in ≥ 3 quadrants, without glaucomatous change of the optic nerve head. The exclusion criteria were patients with APAC with GON, chronic angular glaucoma, secondary angle-closure glaucoma, previous intraocular surgery, corneal disease, macular degeneration, diabetic retinopathy, uveitis, patients on long-term anti-inflammatory therapy, and patients with cataract. All patients underwent a detailed ophthalmological examination – determination of the best-corrected visual acuity (VA), biomicroscopic examination, measuring IOP with the Goldmann applanation tonometer Digital Vision (Italy), fundus biomicroscopic examination with indirect ophthalmoscopy and +90 D lens, gonioscopy using a Goldmann 3 mirror lens, and automated static perimetry using the Humphrey Visual Field Analyzer, program 30–2 threshold. In this research, we presented changes in the angle width, IOP values, and Cup/Disc ratio during the follow-up monitoring of both eyes.

IOP values are easily measurable using the Goldmann applanation tonometer (GAT), mounted on a biomicroscope. IOP results are expressed in mmHg with the range from 10 to 21 mmHg in healthy individuals. IOP measurements were taken after 7 days, 1 month, and then every 3 months during the follow-up period.

To perceive the anatomy of the angle, we performed a gonioscopy using a biomicroscope with the Goldmann contact lens. The entire chamber angle was examined by 360-degree rotation, and the contact lens was placed on the corneal surface with the 1% methylcellulose solution. Gonioscopic angle width was graded in five categories from 0 mean closed to 4 mean wide open based on the Shaffer grading system.

The Vertical Cup/Disc value (Ver C/D rat) is useful in detecting glaucomatous damage. We determined it by examining the fundus by indirect ophthalmoscopy and the biomicroscope with a +90 D lens. The Ver C/D rat difference between both eyes and Ver C/D rat > 0.65 indicated glaucomatous damage. The closer the values are to 1.0, the more severe the damage.

We performed automated static perimetry using the threshold 30-2 test on the Humphrey Visual Field Analyzer based on the mean defect (MD) indices and Glaucoma Hemifield Test (GHT) results outside normal limits. The visual half-field test evaluated by Humphrey perimetry was used to compare groups of corresponding points above and below the horizontal meridian and showed visual field results denoted as "within normal limits", "outside normal limits", and "threshold values". When the values were "outside normal limits", it was a sign of disease progression.

Statistical data processing was carried out with the SPSS program, version 20.0. The results of $p < 0.05$ were considered statistically significant. Wilcoxon signed-rank test, contingency-table test, *t*-test for independent samples, and multivariate regression analysis were employed in the data processing.

Results

The research included 40 patients, 28 females and 12 males, with a mean age of 65.8 ± 11.8 years. At the time of contacting a doctor, based on the Shaffer grading system, the width of the angle in the APAC-affected eye was 0.15 ± 0.36 and 1.2 ± 0.41 in the fellow eye, and after 12 months, it was 0.85 ± 0.36 in the affected eye and 1.9 ± 0.36 in the fellow eye (Z = -5.91, $p < 0.01$) (Table 1).

The rates of MD progression and GHT results outside normal limits were found in 15 APAC-affected eyes (37.5%) of 9 females and 6 males. Disease progression was similar in both sexes ($\chi^2 = 0.51$, df = 1, $p > 0.05$), and they were all patients with moderate glaucoma defects MD < 12 dB. From the moment of detection until the end of the follow-up period, the average MD values were at the level of moderate glaucomatous defects. GHT results outside normal limits were not found in any healthy fellow eyes until the end of the follow-up period covering the research.

In 3 patients, there was a rise in IOP > 21 mmHg 7 days after LPI; after 6 months, IOP rose in other 4 patients, and after 12 months of follow-up, it rose in 7 additional patients, thus additional drug therapy was introduced, and in 3 of these patients, TTR was performed. There was no occurrence of cataracts during the follow-up period.

IOP was statistically significantly higher in patients with disease progression from the beginning, before the start of treatment, measuring 60.1 ± 4.37 mmHg compared to 53.6 ± 3.73 mmHg in patients without progression (t = -5.03, df = 38, $p < 0.01$) and over the time of monitoring. After 7 days, it was 20.67 ± 3.89 mmHg in the eye with progression compared to 17.52 ± 1.9 mmHg in the eye without progression (t = -2.93, df = 18.1, $p < 0.05$); after one month, the value was 19.87 ± 3.2mmHg in the eye with progression compared to 17.12 ± 2.26 in the eye without progression (t = -3.18, df = 38, $p < 0.05$); after 3 months, it was 21.73 ± 3.45 mmHg in the eye with progression compared to 16.88 ± 1.83 mmHg in the eye without progression (t = -5.04, df = 38, $p < 0.01$); after 6 months, the value was 22.53 ± 2.75 mmHg in the eye with progression compared to 16.08 ± 1.5 mmHg in the eye without progression (t = -8.38, df = 19.1, $p < 0.01$); after 9 months the value was 22.53 ± 2.59 mmHg in the eye with progression compared to 15.84 ± 1.57 mmHg in the eye without progression (t = -10.21, df = 38, $p < 0.01$); after 12 months the value measured was 23.4 ± 2.53 mmHg in the eye with progression compared to 14.92 ± 1.22 mmHg in the eye without progression (t = -14.29, df = 38, $p < 0.01$) (Table 2).

After 3 months from the beginning of treatment, the Ver C/D rat was significantly higher in the eye with disease progression (t = -4, df = 14, $p < 0.05$). It increased over time, and it showed a statistically highly significant difference in relation to the eye without disease progression after 6 months (t = -8.26, df = 14, $p < 0.01$), after 9 months (t = -14.7, df = 14, $p < 0.01$), and after 12 months of treatment (t = -19, df = 14, $p < 0.01$) (Table 3).

The largest number of patients, half of them (n = 20, 50%), contacted doctors within 12 hrs of the onset of symptoms, while the smallest number of patients (n = 3, 7.5%) consulted doctors between 12 and 24 hrs. Between 24 and 72 hrs of the onset of symptoms, 11 people contacted doc-

Table 1

Changes in angle width in the acute primary angle closure affected and fellow eyes

Period	Affected eye n = 40	Fellow eye n = 40	*p*-value
Before treatment	0.15 ± 0.36	1.2 ± 0.41	< 0.01
After 1 month	0.53 ± 0.36	1.51 ± 0.34	< 0.01
After 4 months	0.83 ± 0.39	1.88 ± 0.34	< 0.01
After 8 months	0.85 ± 0.36	1.9 ± 0.36	< 0.01
After 12 months	0.85 ± 0.36	1.9 ± 0.36	< 0.01

All values are expressed as mean ± standard deviation; Paired sample *t*-test, Wilcoxon rank test.

Table 2

Changes in intraocular pressure (IOP) in the eyes without (A) and with (B) disease progression

Period	IOP (mmHg)		*p*-value
	A (n = 25)	B (n = 15)	
Before treatment	53.6 ± 3.73	60.1 ± 4.37	< 0.01
After 7 days	17.52 ± 1.9	20.67 ± 3.89	< 0.05
After 1 month	17.12 ± 2.26	19.87 ± 3.2	< 0.05
After 3 months	16.88 ± 1.83	21.73 ± 3.45	< 0.01
After 6 months	16.08 ± 1.5	22.53 ± 2.75	< 0.01
After 9 months	15.84 ± 1.57	22.53 ± 2.59	< 0.01
After 12 months	14.92 ± 1.22	23.4 ± 2.53	< 0.01

All values are expressed as mean ± standard deviation; Independent samples *t*-test.

Table 3

Changes in the excavation of the optic nerve papilla in the eyes without (A) and with (B) disease progression

Period	Vertical Cup/Disc ratio		*p*-value
	A (n = 25)	B (n = 15)	
After 3 months	0.4 ± 0.1	0.45 ± 0.05	< 0.05
After 6 months	0.4 ± 0.1	0.53 ± 0.06	< 0.01
After 9 months	0.4 ± 0.1	0.57 ± 0.05	< 0.01
After 12 months	0.4 ± 0.1	0.65 ± 0.06	< 0.01

Independent samples *t*-test; All values are expressed as mean ± standard deviation.

tors (n = 11, 27.5%), and 6 of them waited for more than 72 hrs (n = 6, 15%), of which 3 patients (n = 3, 7.5%) underwent TTR. Multivariate regression analysis showed that the length of time before consulting a doctor is the most important factor in the progression of the disease, along with the IOP values in the second place.

There was neither increase above IOP normal values greater than 8 mmHg within 7 days after LPI nor the occurrence of later cataracts and other more serious complications during the follow-up period.

Discussion

APAC is one of the most urgent conditions in ophthalmology. Our research topic is particularly important in clinical work because it could save a lot of valuable time that is lost through diagnosing procedures. The research emphasizes the need for the reduction of high IOP values as soon as possible so that the cornea is transparent for timely LPI. Thus, well-maintained IOP values eliminate pupillary block and prevent APAC recurrence in the same eye as well as prophylactic LPI to prevent the occurrence of APAC in the fellow eye. The importance of timely care in terms of LPI performed in both eyes enables the prevention of disease progression to PACG. If LPI is not performed timely, irreversible vision loss occurs as a result, so it should be done as soon as possible, as the cornea is sufficiently clear because PACG is one of the leading causes of bilateral blindness in the world.

Many studies evaluate the effects of LPI in patients with APAC. Some studies show its effect on the angle width in these patients, such as the study by Lim et al. [17], where the average angle width was 0.7 before and 1.1 after LPI. The values of 0.25 before and 1.22 after LPI were reported by Moghimi et al. [18] and 0.82 before and 0.95 after LPI by Ahmadi et al. [11]. In studies dealing with follow-up after LPI, a rise in IOP was reported in 21–47% of eyes within a window of 6 to 18 months according to Rao et al. [19]. In two retrospective studies, additional treatment after LPI was necessary for 56% of eyes after 50 months as reported by Rao et al. [19] and for 67% after 46 months in the study by Pandav et al. [20], primarily drug therapy, while glaucoma surgery was performed in only 0–13% of patients, as Rao et al. [19] reported. This additional treatment has been discussed in many studies, including cataract surgery [20–24]. Drug treatment alone is not sufficient in the cases of angular glaucoma. All patients must undergo LPI as soon as possible to remove the pupillary block. If IOP control cannot be maintained following LPI and drug treatment, additional surgical treatment such as lens extraction and/or TTR is required. TTR proved to be effective but has a higher risk for postoperative development of cataracts and the shallower anterior chambers. Lens extraction can deepen the anterior chamber and open the chamber angle, thus preventing angle closure and disease progression to PACG [25]. Post-LPI eyes appeared to have a 47% lower risk of developing an acute attack or PAGG [13]. Progression to PACG occurred in 28.5% of subjects with APAC, according to the study by He et al. [26], which resulted from higher IOP values before the treatment, as reported by Rao et al. [19]. Our research demonstrated the efficacy of LPI in most patients with APAC, while in 15 patients (37.5%) the disease progressed to PACG. Our results are similar to Lai et al. [27]

and show the disease progression to PACG in patients with higher IOP values at the beginning of the disease. In our research, there was neither increase above IOP normal values greater than 8 mmHg within 7 days after LPI [16] nor the later occurrence and surgery of cataracts, which is another therapeutic option for patients with APAC [28], or other more serious complications during the follow-up period. The progression of the disease was mostly influenced by the duration of symptoms before consulting a doctor. Therefore, the longer the symptoms lasted, the worse the prognosis would get. Thus, trepano-trabeculectomy was performed in 3 patients who saw the doctor 72 hrs after the onset of symptoms, which is shorter than in the study by Aung et al. [29], where 26.1% of patients had symptoms more than a week before seeing a doctor. The results in our research were similar to those in the study by Tan et al. [30], where the average duration of symptoms before presentation was 28.2 hrs, and 75% of patients consulted the doctor on the first day. Our retrospective interventional cohort study demonstrated the efficacy of LPI in patients with unilateral APAC in preventing progression to PACG, as well as the prophylactic role of LPI in the fellow eye. A study published by Singh and Rijal [9] showed the efficacy of LPI in 78% of eyes in which IOP was well maintained after LPI. The great importance of prophylactic treatment of LPI has also been pointed out in the studies by Weinreb and Moghimi [31] and Koh et al. [32].

Conclusion

LPI is of great importance in preventing the progression from APAC-affected eye to PACG and also the occurrence of APAC in the fellow eye. Its effectiveness is mostly affected by the duration of symptoms before visiting a doctor and the level of IOP before starting treatment. In addition to its efficacy, it proved to be safe since no serious complications followed the treatment throughout the period of monitoring.

Conflict of interest

The authors declare no conflict of interest.

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