·Basic Research·

Effect of CO_2 laser sclerectomy with iridectomy on ocular hypertension in rabbits

Zhi-Xiao Xue[1,3], Ying-Xin Li[2,3], Yan-Shan Xu[4], Jiu-Min Yang[1]

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[1] Laser Medicine Laboratory of Tianjin Medical University, Tianjin 300070, China

[2] Laser Medicine Laboratory, Biomedical Engineering Institute of Chinese Academy of Medical Sciences & Peking Union Medical College, Tianjin 300192, China

[3]Laser Medicine Technology Engineering Center of Tianjin, Tianjin 300192, China

[4] Eye Center of Tianjin Medical University, Tianjin 300384, China

Correspondence to: Ying-Xin Li. Laser Medicine Laboratory of Chinese Academy of Medical Sciences & Peking Union Medical College Institute of Biomedical Engineering, Tianjin 300192, China. yingxinli@yahoo.com

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Abstract

• AIM: To evaluate the efficiency and safety of an optimized CO_2 Laser glaucoma surgery system for laser sclerectomy with iridectomy.

• METHODS: Rabbit trials were performed to evaluate the efficiency and safety.

• RESULTS: IOP was significantly decreased in laser group compared with trabeculectomy group ($P<0.05$) from 7th postoperative day to 60th day. Compared with trabeculectomy group, histopathology studies confirmed fewer complications and better effects were found in laser group.

• CONCLUSION: CO_2 laser sclerectomy with iridectomy is effective and safe in terms of IOP lowering.

• KEYWORDS: CO_2 laser; glaucoma; sclerectomy with iridectomy; intraocular pressure; histopathological examination

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INTRODUCTION

Glaucoma is a common eye disease that can lead to irreversible blindness if left undiagnosed and untreated. The treatment of glaucoma mainly depends on intraocular pressure (IOP) lowering. There is evidence that vision is best preserved with IOP control in patients with glaucoma. Although elevated IOP is not always indicative of glaucoma, it is a major risk and causative factor in glaucomatous optic neuropathy, and therapy generally attempts to reduce IOP levels. It is well accepted by ophthalmologists that it is reasonable to treat glaucoma with ocular hypotensive drugs to achieve target IOP levels. In cases when such levels cannot be achieved, surgery is an option. Laser surgery added a new therapeutic modality. The hypotensive effect of this laser procedure was initially applied either for patients with uncontrolled IOP after maximum-tolerated drug therapy, or for patients at presurgical stages, to eliminate or at least postpone the need for surgery [1]. To facilitate a sclerectomy with iridectomy procedure, a new CO_2 laser glaucoma surgery system with self-feedback function was developed. To evaluate its efficacy and safety, rabbit eye trials were preformed.

MATERIALS AND METHODS

Materials Based on our pre-experiment, we postulated that CO_2 laser might be the most suitable one for this operation. CO_2 laser is highly effective in ablating tissues and is therefore widely applied in general and plastic surgery. We speculated that application of laser energy to the sclera tissue over the trabecular meshwork would cause localized ablation of the sclera until fluid started percolating through the thinned wall. Thus, a radio frequency CO_2 laser device was selected. The thermal damage extent and ablation rate in laser sclerectomy with iridectomy was evaluated. The different parameters, correlative models and applicable range of the pulsed laser were analyzed Then the optimum parameters were selected based on experimental data as Wavelength: 10.64 μm;Frequency:10Hz;Duty time:10 milliseconds; Interval time:90 milliseconds and Output power: 7W. To meet the needs of laser sclerectomy with iridectomy, the intelligent laser surgery system which can be operated in automatic feedback control mode was designed and developed. The main components are CO_2 laser device, image capture, ophthalmology operation microscope and central processing unit. After the beam leaves the tube, it passes through a set of optical components that straighten and expand the beam. This set of optics dramatically reduces

beam divergence and produces a beam whose direction can be changed freely. The optics system contains four switches which can adjust light spot size and is a general optical interface which can connect laser device with surgical microscope. In automatic feedback control mode the laser would be turned off automatically when the sudden change of color or brightness is observed by CCD camera. The images are transmitted through USB to PC. The software of self-controlled system is realized by Visual C++. The system was composed of the case database and the image processing. The case database has functions of case browsing, searching library (classified search and retrieval characters), case adding and deleting. The image processing functions were attached such as image division, image enhancement, image identify and signal feedback.

Methods Forty six-month-old male albino rabbits were used for this study, with mean body weight of 2.87±0.36kg. The rabbits were anesthetized with intramuscular ketamine (50mg/kg) and xylazine (10mg/kg) and received topical anesthesia with 4g/L benoxinate hydrochloride. CO_2 laser sclerectomy with iridectomy surgery was performed in right eye of all rabbits. After a half-thickness 5mm ×5mm sclerocorneal flap which is 1-2mm into the transparent cornea at the 12 o'clock position was finished, the sclera was pressed in order to be close to the iris. CO_2 laser irradiation was applied on the sclerocorneal bed to create a deep sclerectomy 3mm×2mm in size over the trabecular tissue. After penetrating the sclerocorneal bed, treatment is continued in super-short pulse mode until "red reflect" could be observed. The superficial scleral flap was irradiated in low-power pulse mode laser to prevent conglutination. After the above procedures, the wound was sewed up by two interrupted 10/0 nylon sutures. The traditional trabeculectomy surgery was performed in the other eye. The surgeon dissects a 5mm×5mm scleral flap, removes a piece of trabecular meshwork, then sutures the two flaps back to allow aqueous to percolate into subconjunctival spaces. IOP was examined on postoperative day 1, 2, 3, 5, 6, 7, 10, 14, 20, 25, 30 and 60. The rabbits were killed 3 (5 rabbits), 5 (5 rabbits), 7(5 rabbits), 14(5 rabbits), 30(5 rabbits) and 60(5 rabbits) days after the treatment. And all the eyes were then enucleated and subjected to histopathological examination every time.

RESULTS

The mean pretreatment IOP was 16.27±1.19mmHg in the laser group and 16.16±1.35mmHg in the control group. There was no statistical significance in IOP between the laser group and the trabeculectomy group (P>0.05). On the first day, the mean post-treatment IOP was 6.83±0.14mmHg and 7.39±0.14mmHg in the laser and control groups, and statistical significance was found between the laser group and the traditional group (P<0.05). From the 2nd to 6th day, there was no statistical significance between the laser group and the control group (P>0.05). From the 7th to 60th day, the mean IOP increased gradually, there was statistical significance between the laser group and the traditional group (P<0.05, Figure 1).

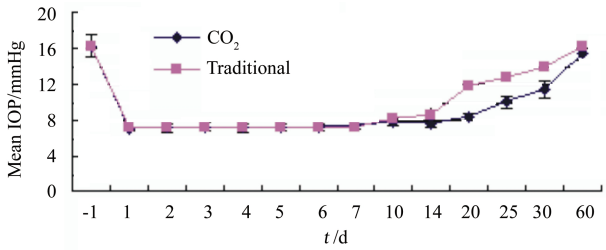

Figure 1 Intraocular pressure of rabbit eyes in laser and traditional surgery

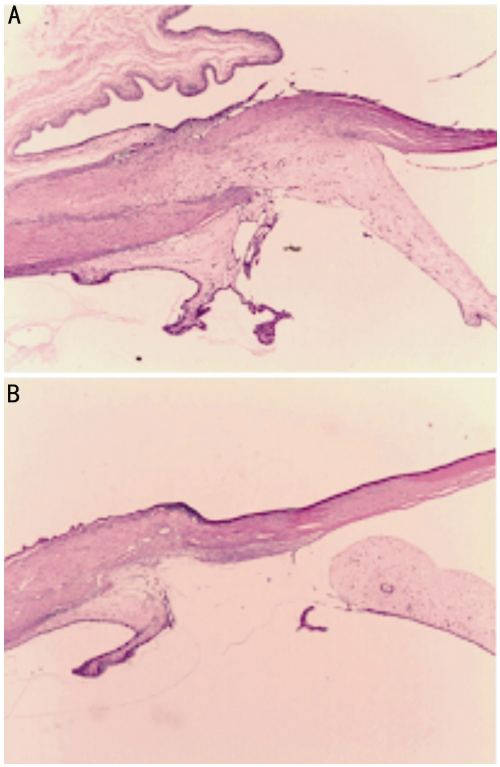

Figure 2 Laser intervention on subconjunctival inflammatory exudation(HE) A: Control; B: Laser

Histopathological Examination Hemorrhage and subconjunctival inflammatory exudation in the anterior chamber were less in the laser group than those in the control group. Lateral tissue damage was limited to the close vicinity of the ablated area and no remote tissue damage was observed in the ciliary body and adjacent corneoscleral tissue in the laser group. No obvious fibrinous reaction was observed in the anterior chamber and the iris root and no cellular damage was seen beneath the fibrin clot in the laser group (Figure 2).

DISCUSSION

CO_2 laser is the most commonly used laser in surgery. It is relatively inexpensive and widely available[2]. While working

at rapid super short pulsed mode, it can be only used for sclera and iris ablation in filtration procedures and is also effective in avoiding damage to surrounding tissues. Another advantage of CO_2 laser is its hemostatic effect, which finishes sclerectomy in a blood-free surgical field[3]. Rabbits have been widely used for evaluating glaucoma surgery, because its trabecular meshwork morphology is similar to that of human eye and costs are relatively low [6]. In our study, rabbit eyes were used to observe the change in IOP and complications after pulse CO_2 laser application. Various types of laser procedures have been applied to improve glaucoma drainage surgery. Argon laser trabeculoplasty (ALT) lowered intraocular pressure. Many studies [5] showed that SLT delivered far less energy to the trabecular meshwork than ALT and offered the theoretical advantages of repeat treatment and a better safety profile. Efficacy of IOP lowering appears to be at least equal to ALT [6]. Lima *et al* [7] prospectively assigned 68 eyes with refractory glaucoma to either Ahmed tube shunt or endoscopic cyclophotocoagulation (ECP). ECP was performed with an 810nm diode laser, using a superior temporal pars plana approach. ECP offers the advantage of more precise ablation of the ciliary body and potentially fewer complications than transscleral cyclophotocoagulation (TCP) or glaucoma drainage devices. Klink *et al* [8] published that after excimer, erbium: YAG and CO_2 lasers performing deep sclerectomy, the excimer and CO_2 lasers achieve a more regular and smoother tissue surface. The excimer laser has the advantage to dissect without thermal tissue damage. In conclusion, CO_2 laser sclerectomy with iridectomy seems to be a safe, easily performed, and effective procedure to the rabbit eye. Although the human glaucomatous eyes differ from the normal rabbit eyes, favorable results prompt us to continue our study. Further clinical trials are about to been carried out.

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