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Combined phacoemulsification and nonpenetrating deep sclerectomy in the treatment of chronic angle-closure glaucoma with cataract

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PURPOSE. *To review the result of nonpenetrating deep sclerectomy (NPDS) combined with phacoemulsification in the treatment of chronic angle-closure glaucoma (CACG) with coexisting cataract.*

METHODS. *This is a retrospective review of 29 eyes of 26 patients who had undergone combined non-penetrating deep sclerectomy and phacoemulsification for cataract and chronic angle-closure glaucoma between January 2001 and June 2003. The visual acuity, intraocular pressure (IOP) and complications were analyzed.*

RESULTS. *The mean follow-up period was 33.8 months (range 23.3 to 54.0 months). Postoperative visual acuity improved in 21 eyes (72%) and remained the same in 6 eyes (21%). The IOP was reduced significantly from 20.3±3.9 mmHg (mean ± SD) preoperatively to 15.9±3.1 mmHg postoperatively at last follow-up visit ($p<0.001$). The number of antiglaucoma medications was also reduced significantly from 2.9±0.8 (mean ± SD) preoperatively to 1.0±1.2 at last follow-up ($p<0.001$). Fifteen eyes (52%) achieved complete success with IOP ≤ 21 mmHg without antiglaucoma medications and 25 eyes (86%) achieved qualified success with IOP ≤ 21 mmHg with or without medications at the last follow-up visit. Of the 25 eyes achieving qualified success, 24 (96%) had a reduction in the number of medications. There were 4 failures, defined as uncontrolled IOP requiring further filtering operation or oral drug treatment. Intraoperative complications included one accidental anterior chamber puncture and one iris plug intraoperatively. Postoperative complications included one choroidal effusion, three wound leaks requiring repair, and two punctate epithelial erosions. There was no shallowing of the anterior chamber, hyphema, hypotony, or infection encountered.*

CONCLUSIONS. *Combined NPDS and phacoemulsification could be a safe and effective surgical option for the management of CACG with cataract. (Eur J Ophthalmol 2007; 17: 208-15)*

KEY WORDS. *Nonpenetrating deep sclerectomy, Phacoemulsification, Angle-closure glaucoma, Cataract*

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INTRODUCTION

Chronic angle closure glaucoma (CACG) is a prevalent disease in Asians (1), and it is characterized by permanent closure of the angle as a result of peripheral anterior synechiae. The disease is more prevalent among the aged population, and a significant proportion are also affected by cataract. Hence, the management of coexisting cataract and glaucoma is now a commonly encountered clinical challenge in everyday practice. Management of CACG with coexisting cataract includes combined extracapsular cataract ex-

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traction (ECCE) and intraocular lens (IOL) implantation with trabeculectomy with or without adjunctive anti-metabolite, combined phacoemulsification and IOL with trabeculectomy (2), combined phacoemulsification and IOL with goniosynechialysis (3, 4), combined phacoemulsification and tube implant (5), and simple cataract extraction (6-8).

To date, there is no large-scale randomized controlled trial to indicate which is the best surgical treatment. Despite the fact that trabeculectomy has been the standard procedure in glaucoma surgery, this method is associated with a relatively high rate of hypotony (9, 10). It is also associated with complications such as iritis and cataract (9, 10). Nonpenetrating glaucoma filtering procedures have increasingly gained acceptance over the past few decades. This method of managing various types of glaucoma is well known for its safety and lower risk profile (11-13). It works by creating a very thin Descemet window and de-roofing of the Schlemm's canal to promote percolation of aqueous through this trabeculo-Descemet membrane (TDM) complex (14). Without entering the anterior chamber and/or removing the trabecular meshwork, the risk of complications such as hypotony and hyphema are avoided. Previous studies on nonpenetrating deep sclerectomy (NPDS) have been reported, and comparison with trabeculectomies has shown relatively lower complication rate (9, 15-18).

Fabrice Gianoli et al have reported the success of combined phacoemulsification, IOL implant, and NPDS in primary open angle glaucoma (POAG), and showed comparable success rate as combined phacotrabeculectomy (19). Thus far, there has been no reported case of combined NPDS and phacoemulsification for the treatment of CACG in the literature. We retrospectively reviewed a series of patients with CACG who had combined phacoemulsification, posterior chamber IOL (PCIOL) implantation, and NPDS by evaluating their visual acuity, IOP control, and postoperative complications.

PATIENTS AND METHODS

The records of consecutive CACG patients with visually significant cataract who had combined NPDS, phacoemulsification, and PCIOL implantation between January 2001 and June 2003 at the Department of Ophthalmology, Tung Wah Eastern Hospital, were reviewed. CACG was defined as the presence of glaucomatous optic neuropathy with compatible visual field loss, in association with a closed angle on gonioscopy for at least 180 degrees of angle in which the trabecular meshwork was not visible, and with evidence of peripheral anterior synechiae (PAS) in any part of the angle. The indications for combined surgery included patients with visually significant cataract and either controlled glaucoma with multiple eye drops or progression of disease on the visual fields or uncontrolled glaucoma despite maximal tolerable topical and systemic antiglaucoma therapy. All patients undergoing surgery were examined with detailed gonioscopy ensuring that the areas of planned NPDS had accessible trabeculum and were free from obstruction by peripheral anterior synechiae before operation. All angle-closure from secondary ocular pathologies were excluded.

Surgical technique

All operations were performed by a single experienced glaucoma surgeon (S.P.H.) under local anesthesia or monitored anesthetic care. A superior rectus traction suture was placed to enhance exposure. A fornix based conjunctival flap was created and hemostasis was achieved with minimal wet-field electrocoagulation cautery. A superficial scleral flap, 1/3 of the estimated total scleral thickness (300 μm), measuring 4 to 5 mm was created with a 15 degree slit knife (Alcon, Fort Worth, TX) and a 55 degree crescent knife (Beaver, Becton Dickinson Surgical Systems, Franklin Lakes). The flap was dissected forward into clear cornea for at least 1 to 1.5 mm.

Depending on the tenon status, antimetabolite of either 5-fluorouracil (5-FU) or mitomycin C (MMC) was used. Both 5-FU and MMC were applied with a cellulose sponge placed both below the scleral flap as well as in the subconjunctival space on top of the scleral flap. The exposure was for a specific period of time (3 to 5 min) followed by irrigation with balanced salt solution.

Phacoemulsification was performed using a separate 3.5 mm clear corneal wound. Sodium chondroitin sulfate-sodium hyaluronate (Viscoat) was injected to fill the anterior chamber and a capsulorhexis forceps was used to create a 5.0 mm continuous curvilinear cap-

sulorhexis. In eyes with poor mydriasis, the pupil was enlarged by separation of the posterior synechiae and subsequent stretching of the iris sphincter with iris hook (Krugen, Katena) or with the use of iris retractors (Alcon).

Phacoemulsification was performed using the stop and chop technique with the Legacy 20000 machine (Alcon). Cortical remnants were then aspirated, the capsular bag filled with sodium hyaluronate (Provisc), followed by the implantation of a foldable IOL via a 3.5 mm corneal wound. IOL model used included MA30BA (Alcon acrylic foldable lens), SA30AL (Alcon acrylic foldable lens), and AR40e (AMO acrylic foldable lens). Viscoelastic was then evacuated and replaced with balanced salt solution. The phacoemulsification wound was then closed with one 10-0 nylon stitch. 1% acetylcholine chloride (Miochol®, CIBA Vision) was injected intracamerally to constrict the pupil. The surgery was followed by the dissection of the deep scleral flap up to 90% of the total scleral thickness and was continued towards the limbus to expose the sclerocorneal trabecular meshwork. The dissection was extended at least 1 mm into clear cornea. Special care was taken to create a large enough TDM complex without microperforation. The juxtacanalicular trabecular membrane was removed together with the inner wall of Schlemm's canal with the aid of the trabecular forceps (Huco, Switzerland). At this stage, aqueous humor was seen percolating through the thin TDM. If percolation was inadequate, further stripping of the membrane was performed. The deeper flap was excised with the Vannas scissors flushed to the dissection made into the cornea taking care not to apply excessive traction on this deep flap to avoid breaking the very fragile TDM complex. SK-gel (Cornéal, France), an absorbable hyaluronic acid implant, was implanted underneath the scleral flap as to the surgeon's discretion to enhance the filtration of deep sclerectomy. The superficial scleral flap was closed loosely with 10-0 nylon and the conjunctiva was closed with 8-0 polyglactin 910 (Vicryl).

The operated eyes were patched with neomycin and polymyxin sulfates and dexamethasone ointment (Maxitrol®) overnight. All patients were reviewed on the first postoperative day and then as clinically indicated. Visual acuity, IOP, and complications were monitored.

Outcome criteria

The surgical outcome was assessed in terms of IOP, visual acuity, and the incidence of complications. Complete success was defined as IOP ≤ 21 mmHg without additional glaucoma medication, qualified success as IOP ≤ 21 mmHg with additional glaucoma medication, and failure as IOP > 21 mmHg requiring oral glaucoma treatment or surgery for IOP control. Eyes with no light perception or that were phthisical were also classified as failures.

RESULTS

Twenty-nine eyes of 26 patients with coexisting CACG and cataract were included. All patients had previous laser iridotomies performed. Demographic data of the patients are shown in Table I. The mean age at time of surgery was 75.0 years (range 45 to 86). All were Chinese, with 6 male and 20 female patients. The mean follow-up duration was 33.8 months (range 23.3 to 54.0 months). The most commonly used IOL was the MA30BA acrylic foldable IOL (Alcon) in 21of 29 eyes (72.4%); others included 6 SA30AL (Alcon) and 1 with AR40e (Sensar Acrylic IOL, AMO, Santa Ana, USA). Fifteen eyes received intraoperative MMC (concentration ranging from 0.3 mg/mL to 0.4 mg/mL for 2 to 4 minutes), and 4 eyes received intraoperative 5-FU (50 mg/mL for 5 minutes). SK-gel was implanted in 4 eyes. The mean preoperative IOP was 20.3±3.9 mmHg (range 13 to 30 mmHg), and mean postoperative IOP was 15.9±3.1 mmHg (range 10 to 23 mmHg), with a mean follow-up of 33.8±8.9 months (range 18.8 to 54.0 months) ($p<0.001$). The number of medications decreased from 2.9±0.8 preoperatively to 1.0±1.2 postoperatively. Fifteen eyes (52%) required no glaucoma medications at the last follow-up, 3 re-

TABLE I - DEMOGRAPHIC CHARACTERISTICS

Characteristic	Value
Age, yr, mean ± SD	75±10
Female	20
Male	6
Chinese race, n (%)	26 (100)
Right eye	13
Left eye	16

quired one eye drop, 6 required two eye drops, and 1 required three eye drops for IOP control. The qualified success was 86.2% (25 eyes). Among the qualified success eyes, 14 showed 20% reduction in IOP and in the remaining 11 eyes, all showed reduction in number of postoperative medications. Laser goniopuncture was performed in four eyes and the flow was increased after the laser procedure. Four cases failed and required oral therapy or further surgical treatment for IOP control.

The preoperative visual acuity ranged from hand movement to 0.3 and the postoperative visual acuity ranged from no light perception to 0.7 at the last follow-up. Eighteen eyes (62%) had a significant postoperative improvement in visual acuity, achieving a visual acuity of 0.3 or better, and 17 eyes (59%) had an improvement of 2 or more Snellen lines (Tab. II, Fig. 1). Six patients failed to show an improvement in visual acuity. One eye had pre-existing central retinal vein occlusion and subsequent development of neovascularization of iris resulting in no light perception (NLP). The remaining eyes were in patients with advanced glaucoma with visual fields loss encroaching fixation preoperatively.

Intraoperative complications included one inadvertent anterior chamber perforation without iris plugging, and one with small iris plug, managed accordingly without the need of conversion to trabeculectomy.

Early postoperative complications included three leakage requiring supplementary suturing, one choroidal effusion which resolved spontaneously by the third day post operation, and two punctate epithelial erosions. There was no shallow anterior chamber, hyphema, hypotony, or infection in the postoperative period. Insufficient drainage of aqueous was noted in four eyes requiring laser goniopuncture with YAG laser using the YAG Trokel single mirror lens (Ocular Instruments, Bellevue, WA). The time of laser ranged from 6 days to 25 months after the initial surgery. No late complication was noted.

There were four failures with uncontrolled IOP despite maximal topical medications. Three required oral Diamox for IOP control and one required revision of the operative site 1 month after the combined phacoemulsification and NPDS operation. Three of the failures were caused by iris plugging to the inner TDM complex during the postoperative course not responsive to laser goniosynechialysis treatment. One of the three

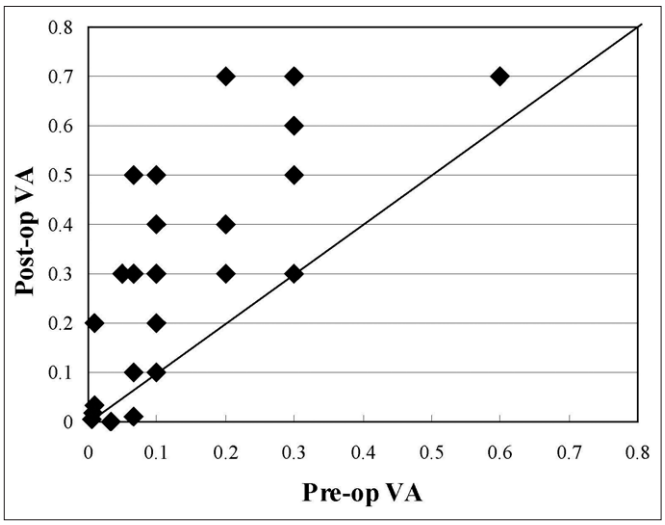

Fig. 1 - *Visual acuity (VA) changes.*

TABLE II - VISUAL ACUITY OUTCOME

Visual acuity	Preoperative (%)	Postoperative (%)
6/6 to 6/12	1/29 (3.4)	10/29 (34.5)
Less than 6/12 to 6/36	9/29 (31.0)	11/29 (37.9)
Less than 6/36	19/29 (65.5)	8/29 (27.6)

patients noticed to have iris plugging volunteered a history of eye rubbing postoperatively. He underwent revision of the operated site to convert to trabeculectomy 1 month after the initial operation. On last follow-up, all of them showed improved visual acuities postoperatively and IOP stabilized at around 14 mmHg with medication including oral acetazolamide.

One patient had operation done in July 2001 with initial wound leak requiring supplementary suturing, drainage of aqueous slowly decreased with scarring, and decrease in size of the external bleb noted and required oral acetazolamide for IOP control 1.5 years after the operation. This patient's best-corrected visual acuity increased from 0.6 to 0.7 at his latest visit in September 2005, and his IOP was 18 mm Hg with treatment.

DISCUSSION

Combined phacoemulsification and glaucoma surgery has become increasingly performed in treating glaucoma with cataract. There are a number of

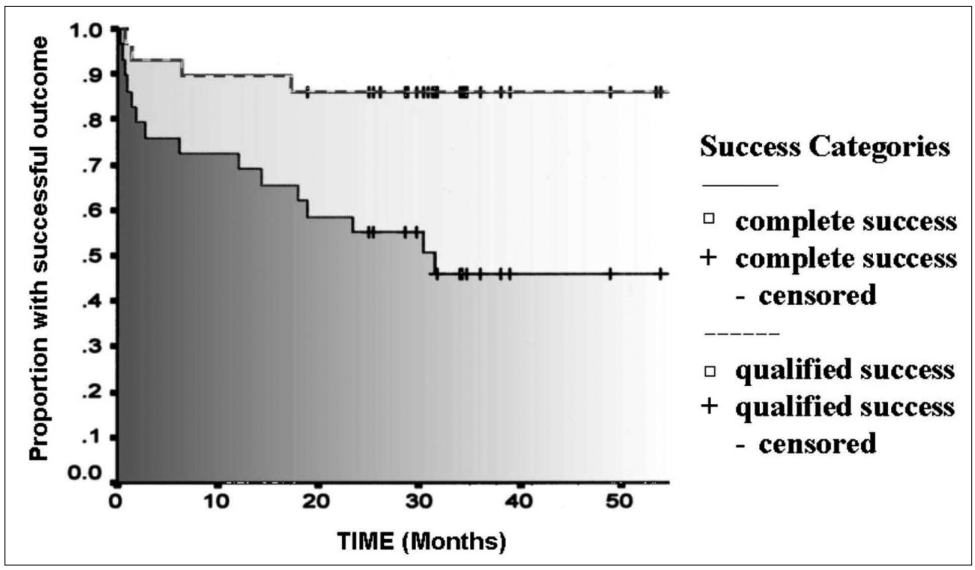

Fig. 2 - *Kaplan Meier survival curve.*

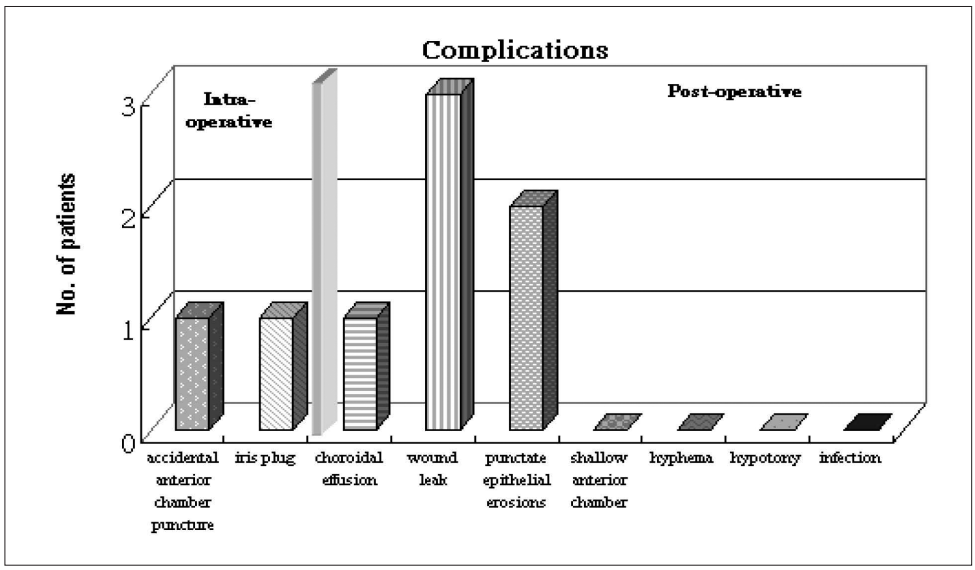

Fig. 3 - *Complications.*

studies reporting their success and complication rates on open-angle glaucoma and heterogeneous types of glaucoma (20-24).

For CACG patients with cataract, combined operation for managing these patients may include ECCE with trabeculectomies, phacoemulsification with goniosynechialysis (reported 90.4% complete success rate) (3), combined phacoemulsification IOL and limited goniosynechialysis followed by diode laser peripheral iridoplasty (success of 100% with a mean follow-up of 8.9 months) (4), simple cataract extraction (6-8), and the most commonly performed operation of phacoemulsification with trabeculectomies with or without antimetabolites (reported success of 81% complete success and 98% qualified success with a mean follow-up of 22 months) (2).

The use of NPDS in treating various types of glaucoma has been reported with comparable success rate to trabeculectomies with much lower complications reported so far (9, 15-18). The use of NPDS combined with phacoemulsification on treating open angle glaucoma has been widely studied and compared with the most commonly performed phacoemulsification and trabeculectomies and has shown comparable results with very low risk profile especially on postoperative shallow anterior chamber, choroidal effusions,

hypotony, and hyphema (19). In our study, the results of combined NPDS and phacoemulsification for CACG were reviewed.

The complete success rate was 15 in 29 eyes (52%) after a mean follow-up of 33.8 months. The qualified success rate reached 25 in 29 eyes (86%) at last follow-up (Fig. 2).

There was postoperative visual acuity improvement in 25 eyes and 17 eyes (59%) achieved an improvement of two or more Snellen lines. Postoperative complications included one choroidal effusion, three wound leak requiring suturing, and two with punctate epithelial erosions. There was no shallowing of the anterior chamber, hyphema, hypotony, or infection (Fig. 3).

The results indicated that combined phacoemulsification and nonpenetrating deep sclerectomy may be a promising surgical option for this group of patients. The mechanism of IOP lowering after combined phacoemulsification-NPDS operation may include the following:

- Removal of the large cataractous lens helps to deepen the anterior chamber and widen the angle. This is especially true in this group of patients who are having crowded anterior chamber before operation. However, solely opening up the angle and deepening the anterior chamber cannot account for the amount of decrease of IOP in this group of patients.
- The drainage of aqueous via the NPDS must be contributing to the success of IOP control postoperatively. Since NPDS involved deroofing of the Schlemm canal and the removal of the inner wall of the Schlemm canal together with the juxtacanalicular trabeculum which is the main part of resistance in outflow of aqueous. Percolation of aqueous thus achieved via the deroofed Schlemm canal and the thin TDM complex is important. A common intraoperative complication in NPDS was perforation of the thin TDM during deep sclerectomy dissection. Achieving an intact TDM entails a steep learning curve, and it is crucial to the proper drainage of aqueous. The area of planned NPDS should have accessible trabeculum, free from obstruction by peripheral anterior synechiae preoperatively. We recommend a detailed examination of the angle status preoperatively, in order to properly plan the operative site. Adequate percolation of aqueous was further confirmed intraoperatively, achieved with the dissection of a large enough TDM and deroofing of the Schlemm canal.
- NPDS are reported to have low risk profile especially in relation to overdrainage of aqueous, e.g., flat anterior chamber, choroidal effusion, persistent hypotony, and also those related to the entry to the eyeball and creation of peripheral iridectomy, e.g., hyphema and excessive inflammation. By avoiding all these complications, the postoperative course would be less stormy. This allows the eyes to quiet down earlier and hence a better chance of establishing the flow of aqueous to the intrascleral lake and the subconjunctival filtering bleb.

There were four failures in our series. These are mainly due to the development of peripheral anterior synechiae (PAS) to the inner window of the NPDS site and hence defeat the mechanism for drainage of aqueous. The development of PAS is especially likely in cases with small pupil, where intraoperative stretching of the pupil sphincter prior to phacoemulsification was performed. In these cases, the iris may also be more floppy and hence more likely to adhere to the inner window of the NPDS operation site. However, as newer medications are being used more readily nowadays, miotics such as pilocarpine drops are less commonly used, especially in patients with significant amount of cataract. Therefore, the likelihood of this complication may be reduced in the future. Our four patients resulted in controlled IOP with oral medication or after operation. The one patient with loss of vision on last follow-up was a patient with pre-existing central retinal vein occlusion and subsequently developed neovascularization.

Our series has limitations. This is a retrospective review with variable follow-up periods. The outcome chosen to assess success of surgical intervention for glaucoma treatment including IOP, visual acuity, and complications was not ideal. Other parameters to determine glaucoma damage, e.g., optic nerve head morphology and visual field loss, would add on more information. Yet the criteria analyzed in our study allowed comparison with previous reported series of surgical options for management of CACG patients with cataract. There are variations in the technique used especially on the part of NPDS. This is essential as though NPDS works by percolation of aqueous to the intrascleral lake, drainage of aqueous to the subconjunctival space to form a draining bleb also accounts for the augmented outflow of aqueous

in the mechanisms of IOP control offered by this operation. Hence the use of antimetabolites was employed in cases when dissection revealed thick tenon or in young patients. SK-gel was implanted in cases when we wanted to augment the intrascleral lake further in patients requiring lower long term IOP, e.g., advanced glaucoma cases. There are well known potential difficulties in performing phacoemulsification in this group of patients. First, the crowded and shallow anterior chamber give us less space to work with during phacoemulsification; second, small pupil that cannot be dilated pharmacologically, be it due to posterior synechiae binding down the sphincter or chronic pilocarpine use, has to be dealt with by means of pupil stretching or with iris retractors. These maneuvers help to improve the exposure for phacoemulsification and yet also induce floppy iris and are technically demanding. In our series, all cases were performed by a single glaucoma surgeon with experience dealing with small pupil phacoemulsification and similar operative techniques eliminated the problem of surgical variations.

At present, there is no consensus as to the best approach to this group of CACG patients with cataract. Combined NPDS and phacoemulsification seems to offer a promising option for management. To our knowledge, this is the first report of the surgical outcomes of combined NPDS and phacoemulsification for the treatment of CACG. Further study with randomized controlled trial is needed to discover the best surgical treatment for this group of patients.

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