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Review Article

Comparison of Intraocular Pressure after Phacoemulsification Compared to Laser Peripheral Iridotomy (LPI) in Acute Primary Angle Closure (APAC) Patients: A Systematic Review

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Abstract:

Aim: To compare IOP in APAC patients after phacoemulsification compared to LPI.

Background: Acute primary angle closure (APAC) is a type of PACG and an important cause of blindness in East Asia. In APAC patients, both LPI and phacoemulsification have been shown to be effective in controlling elevated IOP. Knowledge and information about changes in IOP after phacoemulsification and LPI in APAC patients, which is one of the criteria for successful APAC management, can be a reference as well as a consideration for choosing an effective treatment for APAC patients.

Results: Of the 15 articles reviewed, 84% of patients who received phacoemulsification intervention experienced >50% reduction and 24.3% of patients experienced <50% decrease in post-op IOP compared with the mean pre-op IOP. While patients who received LPI intervention, 80.5% of patients experienced >50% reduction in IOP and 19.4% of patients experienced <50% reduction in IOP post-op compared with the mean pre-op IOP.

Conclusion: There were decreases in IOP of APAC patients after phacoemulsification or LPI. In addition, there are differences in the decrease in IOP of APAC patients after phacoemulsification compared to LPI.

Clinical Significance: Phacoemulsification and LPI are effective for lowering IOP in the early stages of an acute attack. LPI is the preferred procedure according to most guidelines because it is relatively non-invasive, easy to administer on an outpatient basis, and has a lower risk of complications. Phacoemulsificatin has been shown to be a more effective treatment than LPI for IOP reduction in early and medium-term IOP controls.

Keywords: systematic review, acute primary angle closure, phacoemulsification, laser peripheral iridotomy.

Introduction:

Acute primary angle closure (APAC) is a bleeding symptomatic disease characterized by a sudden increase in intra-ocular pressure (IOP) which is often associated with severe eye pain and systemic symptoms.[1] Persistently high IOP values after APAC can cause irreversible glaucoma optic neuropathy and subsequent vision loss. It is estimated that up to 50% of eyes after an APAC episode develop PACG.[2] Acute primary angle closure (APAC) is a type of PACG and an important cause of blindness in East Asia.[3]

Table 1: Classification of Primary Angle Closure

Classification	Characteristics
PACS	≥180 degrees iridotrabecular contact (ITC), normal intraocular pressure (IOP), and no optic nerve damage
PAC	≥180 degrees ITC with peripheral anterior synechiae (PAS) or elevated IOP, but no optic neuropathy
PACG	≥180 degrees ITC with PAS, elevated IOP, and optic neuropathy
APAC or AACC	Occluded angle with symptomatic high IOP

Source: *American Academy of Ophthalmology's Primary Angle Closure Preferred Practice Pattern (PPP) Guidelines, 2015*

In 2013, the number of people (aged 40–80 years) with primary angle closure glaucoma was estimated at 15.47 million; 76.7% of these cases occurred in Asia. In addition, Asia is estimated to still have the largest number of PACG sufferers in 2040.[4] Asia also has a significantly higher incidence rate of APAC compared to Caucasian populations - with crude incidence rates of 12.2 and 10.4 per 100,000 people per year in Singaporean and Hong Kong populations over 30 years old, respectively.[5] This is higher than the average incidence rate of 3.9-4.1 cases per 100,000 people per year in the European regions.[6]

Acute primary angle closure (APAC) is a bleeding symptomatic disease characterized by a sudden increase in intra-ocular pressure (IOP) which is often associated with severe eye pain and systemic symptoms.[1] APAC is a subgroup of angle closure disease characterised by a sudden onset of headache, blurred vision, seeing halos around lights, corneal oedema, mid-dilated pupil, eye pain and redness.[7] The clinical signs and symptoms of AACC include pressure-induced corneal edema (experienced as blurred vision and occasionally as multicolored haloes around lights), a mid-dilated pupil, vascular (i.e., conjunctival and episcleral) congestion, eye pain, headache, nausea, and/or vomiting. (AAO, PAC PPP *Guidelines*, 2015). Persistently high IOP values after APAC can cause irreversible glaucoma optic neuropathy and subsequent vision loss. It is estimated that up to 50% of eyes after an APAC episode develop PACG.[2]

Material and Methods:

This study uses a systematic review approach, where data is collected from published journals. Data was collected from PubMed, Science Direct and Google Scholar databases. The article search method used the PICO Characteristics (Population, Intervention, Comparison, Outcome), then compiled using the PRISMA method (Preferred Reporting Items for Systematic Review and Meta-Analysis).

Theory/Calculation:

The pathogenesis of angle closure has been evolving as the imaging devices for the anterior segment of the eye developed in recent years.

Aside from pupillary block and plateau iris, multiple mechanisms are recognized as more common contributors for the closure of the angle. More and more studies confirmed that the configuration and dynamic behavior of the iris, ciliary body, and choroid may be responsible for the presenting features of primary angle-closure glaucoma (PACG).[8,9,10,11,12,] The dynamic behavior of the uvea (including iris, ciliary body, and choroid) may also have something to do with sympathetic-parasympathetic nerve activity, especially in APAC, because IOP can be affected by the emotional state.[13,14] Notably, the crucial role of the lens in the pathogenesis of angle-closure disease was largely revealed. It was believed that either an increase in its thickness or a more anterior position resulted in angle crowding and a greater predisposition to pupillary block.[10,15]

According to all the new findings in pathogenesis, the classification of PACG can further be divided into five types: pupillary block[7], plateau iris[16], anteriorly rotated ciliary body[17,18], changes in lens position[17] and choroidal expansion.[19] It was reported that 54.8% PACG in Chinese patients was caused by multiple mechanisms, 38.1% was caused by pure pupillary block and less than 7.1% was caused by pure non-pupillary block mechanisms. Therefore, non-pupillary block factors should still be evaluated and handled after the relief of the pupillary block.

Moreover, APAC had different ocular anatomies compared with chronic primary angle-closure glaucoma (PACG) cases, such as a less deep anterior chamber, thicker lens, shorter axis, and more narrow entrance of chamber angle. Meanwhile, acute cases are more common for females, while chronic cases are more common for males.[20]

In clinical practice, APAC can be further divided into preclinical, attack (including acute, sub-acute, or intermediate attacks), intermittent, chronic progression, and absolute stages according to the symptom and signs.[21,22] Therefore, timely control of IOP is crucial not only for preventing visual loss but also for preventing progression to chronic angle-closure glaucoma (CACG). As an important cause of blindness in East Asian people, it was reported that 18% of eyes had become blind, 48% of eyes had developed glaucomatous optic neuropathy, and 58% of eyes had vision worse than 20/40 in the 4–10 years following an acute attack.[23]

Phacoemulsification / IOL deepens the anterior chamber and eliminates pupil block.[24,] Phacoemulsification was performed by an experienced surgeon under topical anesthesia with a clear 3.2 mm corneal incision. 4.5 mm capsulorhexis, centered on the dilated pupil, is performed with the help of capsulorhexis forceps. The right eye incision is on the temporal side while the left eye is on the paranasal side. The remaining viscoelastic is completely absorbed. Phacoemulsification offers the advantages of a small self-sealing incision, better maintenance of the anterior chamber intraoperatively, less risk of iris prolapse, and less iris manipulation. Phacoemulsification through a 3.0- to 4.0-mm self-sealing corneal incision significantly deepens the anterior chamber and widens the angle. In one study, the chamber was 1.37 times deeper and the angle 1.57 times wider after cataract surgery.[25] The shallower the preoperative anterior chamber, the greater the postoperative change in the chamber depth. The more narrow the preoperative angle, the greater the postoperative change in the angle. These findings suggest that cataract extraction with IOL implantation is an effective therapeutic treatment for patients with PACG or for eyes with a narrow angle.[26]

After the initial treatment, the acute attack could be aborted in most cases. However, the rate of recurrence of another acute attack is high unless definitive treatment is performed. Once the IOP has been lower sufficiently to allow corneal edema to clear, LPI will be introduced. LPI has been established as a safe and effective treatment for APAC to relieve pupil block and has superseded surgical peripheral iridectomy due to its non-invasive nature, ease of performing the pro- cedure on an outpatient basis, and the low risk of complications.[27] LPI was performed in the

superior iris area (from 10 hours to 2 hours) with argon laser and neodymium-yttrium-aluminum-garnet sequentially after pretreatment with 2% pilocarpine implanted into the eye one hour before LPI. The power settings used were 500-1000 mW with a spot size of 50 μm for a duration of 0.05 seconds with an argon laser and 2-5 mJ with a yttrium-aluminum-garnet laser. Topical drugs that can affect angle measurement are not prescribed in post-LPI.

The treatment outcomes of APAC are quite different between Asian (more pigmented iris) and Caucasian eyes (usually less pigmented iris). Laser peripheral iridotomy (LPI) tend to be less effective in controlling the IOP in Asian eyes with APAC. (Chan In APAC, both LPI and primary lens extraction by phacoemulsification and intraocular lens implant (phaco/ IOL) were demonstrated to be effective to control IOP elevation. The latter has been shown to be the more effective treatment than LPI for IOP reduction at the early and mid-term IOP control. Together with the advancement of phaco/IOL technique, primary lens extraction is the more popular choice of treatment nowadays. However, operating on an eye with early aborted APAC is technically challenging and may increase the risk of complications because of the presence of corneal oedema, inflammation, shallow anterior chamber, floppy iris and unstable lens. Furthermore, "the best time window" for performing lens extraction after an APAC attack remains uncertain.[28] The long-term results (e.g. more than 5 years) of early lens extraction compared to the conventional LPI are also unknown.

Knowledge and information about changes in IOP (intraocular pressure) after phacoemulsification and LPI (laser peripheral iridotomy) in APAC patients, which is one of the criteria for successful APAC management, can be a reference as well as a consideration for choosing an effective treatment for APAC patients.

Results:

Table 2. Characteristic of Data Study

No	Author	Year	Study design	Mean age (year)	Diagnosis	Intervention
1	Hou et al [29]	2015	*Retrospective study*	62.32 ± 8.48 (47–79)	APAC	Phacoemulsification
2	Moghimi et al [30]	2016	*Nonrandomized comparative prospective study*	61.1 ± 6.9 60.0 ± 8.9	APAC	Phacoemulsification/IOL LPI
3	Su et al[31]	2016	*Case report*	59	APAC	LPI
4	Moghimi et al[32]	2016	*Prospective interventional study*	60.7 ± 9.2	APAC	LPI
5	Sakai et al[33]	2017	*Case report*	59	APAC	LPI
6	Lee et al[34]	2017	*Prospective EDI-OCT study*	65.6 ± 7.7	APAC	LPI
7	Patthanathamrongkasem et al[35]	2017	*Retrospective study*	60.1 ± 6.03	APAC	LPI-Phacoemulsification
8	Romkens et al[36]	2018	*Retrospective analysis*	71 ± 10	APAC	Phacoemulsification/IOL

9	Enkhzul et al[37]	2018	*Retrospective study*		APAC	Phacoemulsification/IOL
10	Su et al[38]	2018	*Case report*	64	APAC	Phacoemulsification/IOL
11	Moghimi et al[39]	2018	*Prospective, fellow eye–matched case series*	60.4 ± 9.6	APAC	LPI
12	Fang et al[40]	2018	*Retrospective study*	56.86 ± 12.90	AAC	Phacoemulsification-peripheral iridectomy
13	Baek, Kim, Lee dan Lee[41]	2018	*Retrospective study*	67.32 ± 8.4	APAC	Phacoemulsification
14	Tian et al[42]	2019	*Retrospective cohort study*	65.00 ± 9.54	APAC	Phacoemulsification-GSL
15	Lin et al[43]	2020	*Retrospective nonrandomized study*	Group A: 70,58 Group B: 72,19 Group C: 68.14	APAC	Group A: *Primary phaco*/IOL Group B: LPI followed by phacoemulsification/IOL Group C: LPI

Table 3. Changes in IOP after intervention with phacoemulsification and LPI

No	Author	Subject (n)	Intervention	Mean IOP pre-OP (mmHg)	Mean Follow-up Time	Mean IOP post-OP (mmHg)	Mean IOP reduction (mmHg)
1	Hou et al[29]	25	Phacoemulsification	52.60 ± 8.15	1 year	16.64 ± 3.08	35.96 (68.3%)
2	Moghimi et al[30]	20 15	Phacoemulsification/IOL LPI	54.0 ± 9.4 57.1 ± 10.2	1 year	13.90 ± 2.17 17.80 ± 4.16	40.1 (74.2%) 39.3 (68.8%)
3	Su et al[31]	1	LPI	40 (RE) & 19 (LE)	2 year	Antara 16.00-20.00	24 (RE) (60%) & 3 (RE) (15.7%)
4	Moghimi et al[32]	52	LPI	45.0 ± 12.1	6 weeks	11.87 ± 5.15	33.13 (73.6%)
5	Sakai et al[33]	1	LPI	70.0 (RE) & 14.0 (LE)	11 days	12.00	58 (RE) (82.8%) & 2 (LE) (14.2%)
6	Lee et al[34]	30	LPI	48.1 ± 10.5	11-12 months	13.6 ± 5.6	34.5 (71.7%)
7	Patthanat hamrong kasem et	19	LPI-phacoemulsification	46.10 ± 17.00	6 months	14.00 ± 5.50	32.1 (69.6%)

	al[35]						
8	Römkens et al[36]	35	Phacoemulsification/IOL	17 ± 8.2	3 months	13.2 ± 3.9	3.8 (22.3%)
9	Enkhzul et al[37]	9	Phacoemulsification/IOL	37.9 ± 13.0	3 months	11.3 ± 1.4	26.6 (70.1%)
10	Su et al[38]	1	Phacoemulsification/IOL	64	2 months	13.00	51 (79.6%)
11	Moghimi et al[39]	52	LPI	45.0 ± 12.1	6 weeks	11.87 ± 5.15	33.13 (73.6%)
12	Fang et al[40]	22	Phacoemulsification-IOL peripheral iridectomy	50.81 ± 6. 0	18.77 ± 9.72 months	12.95 ± 3.36	32.04 (63%)
13	Baek, Kim, Lee dan Lee[41]	62	Phacoemulsification/IOL	45.46 ± 9.56	1 year	13.56 ± 3.02	32 (70.2%)
14	Tian et al[42]	13	Phacoemulsification-GSL	29.77 ± 11.55	3 months	14.92 ± 1.66	14.85 (49.8%)
15	Lin et al[43]	Group A (n=24) Group B (n=23) Group C (n=34)	*Primary phaco*/IOL LPI, followed by phaco/IOL in 6 months LPI	25.58 17.92 15.86	1 year	12.60 11.42 15.59	12.98 (50.7%) 6.48 (36.1%) 0.27(1.7%)

Discussion:

The treatment principles for APAC aim at (1) initial rapid reduction of IOP to limit optic nerve damage, followed by (2) elimination of pupil block, which reduces the risk of recurrent seizures and the risk of progression to the chronic form of primary angle closure glaucoma (PACG). Rapid reduction of IOP is an important first step in treating APAC because it prevents further glaucoma optic nerve damage. It will also reduce corneal pain and edema, allowing more definite treatment to be applied; namely LPI and lens extraction. Several medications may be needed to abort an APAC episode. However, many of these patients are elderly patients and some may have various medical conditions. They may not tolerate the potential side effects of this drug, especially in situations where systemic drugs are needed. Most APAC patients do not respond adequately to medical care alone. In this case, other interventions might be considered to achieve rapid IOP reduction.[44] In this study, the intervention carried out was divided into 2 types, namely phacoemulsification and LPI (laser peripheral iridotomy).

The studies reviewed in this systematic review showed that there was a significant reduction in IOP in APAC patients who received both phacoemulsification intervention and LPI (laser

peripheral iridotomy) which could be assessed by comparing the IOP of pre-op and post-op.

The criteria for long-term surgical outcome, complete success (complete success) were defined as IOP <22 mmHg without anti-glaucoma drugs; qualified success was defined as IOP <22 mmHg with one or more anti-glaucoma drugs; and failure was defined as IOP between 22 and 24 mmHg measured on two occasions or IOP ≥24 mmHg on one occasion during the follow-up period.[43]

The studies reviewed in this systematic review showed that there was a significant reduction in IOP in APAC patients who received both phacoemulsification intervention and LPI (laser peripheral iridotomy) which could be assessed by comparing the IOP of pre-OP and post-OP.

From the results of this systematic review, it can be seen that APAC patients who received phacoemulsification intervention were in the "complete success" category because the average post-OP IOP <22 mmHg without anti-glaucoma drugs was 121/144 or 84% of patients experienced a> 50% decrease. The post-OP IOP was compared with the mean pre-OP IOP and 35/144 or 24.3% of patients had a <50% decrease in post-OP IOP compared with the mean pre-OP IOP.

In APAC patients who received LPI (laser peripheral iridotomy) intervention, based on post-OP IOP, it can be categorized as "complete success" because the mean post-OP IOP <22 mmHg without anti-glaucoma drugs is 141/175 or 80.5%. patients had> 50% reduction in post-OP IOP compared with mean pre-OP IOP and 34/175 or 19.4% of patients had a <50% decrease in post-OP IOP compared with mean pre-OP IOP.

After that, another study in APAC patients who received a combined intervention such as that conducted by Lin et al., 2020, namely LPI, followed by phacoemulsification / IOL within 6 months experienced a decrease in IOP by 36.1%, research by Tian et al., 2019 which received intervention Phacoemulsification-GSL experienced a decrease in IOP by 49.8%, a study conducted by Moghimi et al., 2016 proved that phacoemulsification-LPI decreased by 74.2%, Fang et al., 2018 with peripheral iridectomy phacoemulsification-IOL intervention experienced a decrease in IOL post-OP by 63 %, and the last one is research from Patthanathamrongkasem et al., 2017, namely that LPI-phacoemulsification succeeded in reducing post-OP IOP by 69.6%.

Conclusion:

1. There is a decrease in the intra-ocular pressure (IOP) of the acute primary angle-closure (APAC) patient after phacoemulsification.

2. There is a decrease in the intra-ocular pressure (IOP) of the acute primary angle-closure (APAC) patient after LPI (laser peripheral iridotomy).

3. There is a difference in the decrease in intra-ocular pressure (IOP) of patients with acute primary angle-closure (APAC) after phacoemulsification compared to LPI (laser peripheral iridotomy).

Clinical Significance:

Phacoemulsification and laser peripheral iridotomy (LPI) are effective means of lowering IOP in the early stages of an acute attack. LPI (laser peripheral iridotomy), the current standard first-line treatment for acute PAC, is the preferred procedure according to most guidelines.[45] LPI is now preferred because it is relatively non-invasive, easy to administer on an outpatient basis, and has a lower risk of complications.[46]

In patients diagnosed with APAC, LPI and primary lens extraction by phacoemulsification and intraocular lens implants (phacoemulsification / IOL) have been shown to be effective in controlling elevated IOP. The latter has been shown to be a more effective treatment than LPI for IOP reduction in early and medium-term IOP controls. Together with advances in phacoemulsification / IOL techniques, primary lens extraction is a more popular treatment option today. However, surgery on an eye with APAC that has an early abortion is technically challenging and can increase the risk of complications due to corneal edema, inflammation, superficial anterior chamber, drooping iris and unstable lens.[28]

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