



## Managing Primary Angle Closure

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Financial Disclosure:  
Consultant - Netra Systems Inc.,

1. You don't see it until you look for it
2. Who needs an iridotomy?
3. What is the efficacy of iridotomy?
4. It's (almost) all about the lens

## Terminology

Narrow angle

Occludable angle

AAO Preferred Practice Pattern  
**PRIMARY ANGLE CLOSURE**

## Definitions

- Based on AAO's Preferred Practice Guidelines
- Primary Angle Closure is characterized by Iridotrabecular contact for at least 180°
  - Iridotrabecular contact (ITC) is defined as PTM not visible by static gonioscopy

## Classification Primary Angle Closure

- Are there PAS?
- What is the IOP?
- What is the optic nerve status?

## Classification

<b>PACS</b>	Primary angle closure suspect	ITC 180 or more, Normal IOP, No PAS No optic neuropathy
<b>PAC</b>	Primary angle closure	ITC 180 or more with PAS or elevated IOP, No optic neuropathy
<b>PACG</b>	Primary angle closure glaucoma	ITC 180 or more with PAS or elevated IOP, and optic neuropathy
<b>APAC</b>	Acute primary angle closure	Closed angle with symptomatic high IOP

AAO PPP 2015

## Classification

- Eliminates symptom-based categorization
  - Most patients with PACG do not have a symptomatic phase
- Uniform system allows comparison across different study populations

## Detecting Angle Closure

- You don't see it until you look for it
- Gonioscopy
  - Perform in every patient
  - Perform periodically in phakic patients
    - even those with open angles

### Low Sensitivity of the Van Herick Method for Detecting Gonioscopic Angle Closure Independent of Observer Expertise

THOMAS V. JOHNSON, PRADEEP Y. RAMULU, HARRY A. QUIGLEY, AND ERIC L. SINGMAN

AMERICAN JOURNAL OF OPHTHALMOLOGY NOVEMBER 2018

Resident and Attending Assessments		
Van Herick Grade	pACD/pCT	Interpretation
1	< 1:4	Angle closure likely
2	= 1:4	Angle closure possible
3	> 1:4 and < 1:1	Angle closure unlikely
4	> 1:1	Angle wide open

### Definitions of angle closure

By Van Herick: Grade 1 or 2 = closed

By Gonioscopy: PTM not visible for at least 180°

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Observer	Sensitivity	Specificity
Technician	58%	89%
Resident	79%	88%
Attending	68%	88%

### Risk Factors Associated with Missed Diagnoses of Narrow Angles by the Van Herick Technique

Ophthalmology Glaucoma 2018;1:108-114

- Both VH and gonio by single glaucoma specialist
- 14% of eyes with ITC of at least 180° were classified as 'deep' on VH testing
- Risk of misdiagnosis higher in
  - PAC and PACG (versus PACS)
  - Males
  - Black or Asian race
  - Myopes

## ASOCT versus Gonioscopy for detection of Angle Closure

Sensitivity  
73 – 98%

Specificity  
12 – 87%

Definitions of angle closure not uniform across all studies

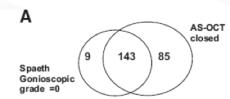
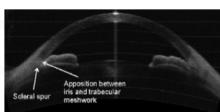
- Nolan et al. Ophthalmology, Jan 2007
- Lavanya et al. Ophthalmology, Oct 2008
- Nongpiur et al. Ophthalmology, Jan 2013; (98% Sensitivity, 78% specificity)
- Zhang et al. Ophthalmic Epidemiol, June 2014
- Dabasia et al. IOVS, June 2015; (87% Sensitivity, 87% specificity)
- Kochupurakal et al. J Clin Diag Res, Apr 2016

## Imaging devices for diagnosis of angle closure

- Detect more angle closure than gonioscopy
  - Varying definitions of angle closure
  - Different lighting conditions

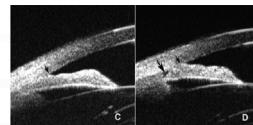
### Detection of Primary Angle Closure Using Anterior Segment Optical Coherence Tomography in Asian Eyes

Nolan et al. Ophthalmology 2005



### Appositional Closure Identified by Ultrasound Biomicroscopy in Population-Based Primary Angle-Closure Glaucoma Suspects: The Liwan Eye Study

Kong, He et al. IOVS 2011



'High' Iridotrabecular contact

	PACS	Controls
Superior	55%	21%
Nasal	30%	11%
Inferior	46%	11%
Temporal	17%	12%

## Imaging

- Both ASOCT and UBM detect more ITC than gonioscopy
- What is the clinical significance?
  - Angle closure on imaging cannot be solely used to recommend treatment since most patients with even gonioscopic angle closure do not develop disease

### Anterior Segment Imaging Predicts Incident Gonioscopic Angle Closure

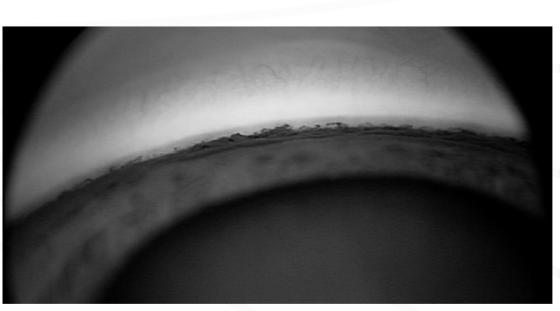
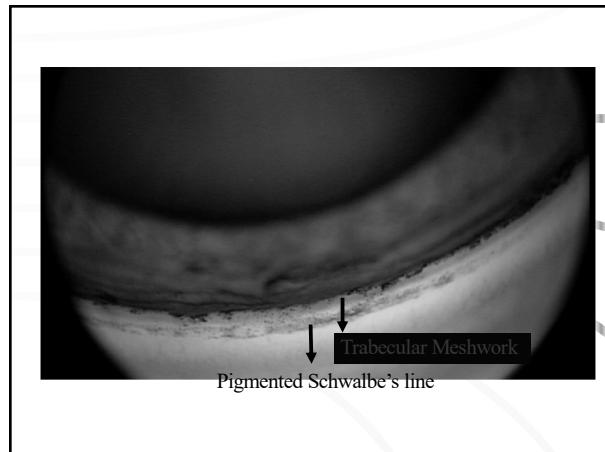
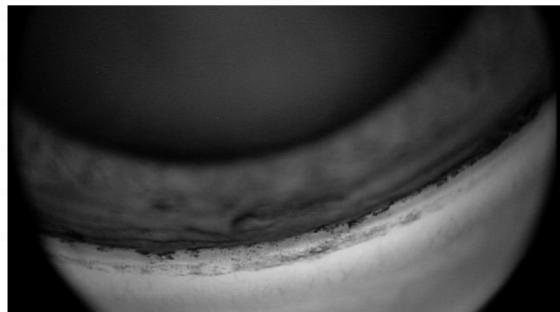
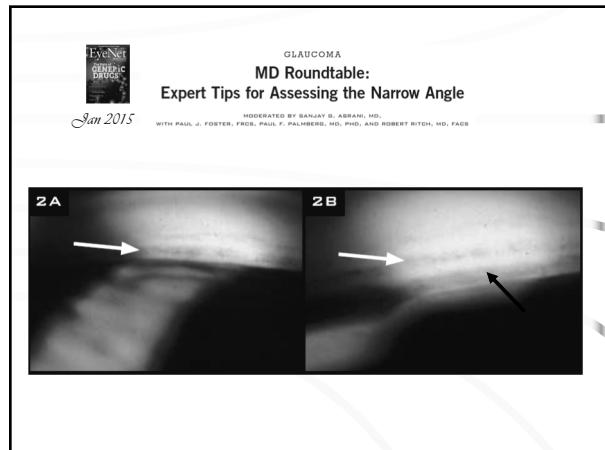
Mari Banerjee, DNB,<sup>1,2,3</sup> Jayant V. Jyer, MBBS, MMed,<sup>1</sup> Anus K. Narayanaswamy, DNB, MMed,<sup>1</sup> Yingfei He, BSc(Hons),<sup>1</sup> Leandro M. Sakata, MD, PhD,<sup>1,2</sup> Renyi Wu, MD, PhD,<sup>1,2,3</sup> Daenna Liu, MD,<sup>1,2</sup> Monisha E. Nongpiur, MD,<sup>1,2,3,4</sup> David S. Friedman, MD, PhD,<sup>1,2,3,4</sup> Tin Aung, FRCS(Ed), PhD,<sup>1,2,3,4,5</sup>

Ophthalmology 2015;122:2380-2384

- Prospective study
- 277 eyes with open angles on gonio but closed angles (1-4 quadrants) on ASOCT
  - Closed angle on OCT = visible ITC beyond scleral spur
- After 4 years (62% of original sample),
  - 17% developed gonioscopic angle closure in 2 or more quadrants
  - 10% in 3 or more quadrants

## ASOCT for population based screening for angle closure

- Individual OCT parameters have inadequate specificity and sensitivity
- Scleral spur is not visible in 25-30% of images
  - Still useful for qualitative analysis
- Captures only a few meridians at a time



## Who needs an LPI?

- |                       |                    |
|-----------------------|--------------------|
| • PAC:                | Yes                |
| • PACG:               | Yes                |
| • Acute PAC:          | Yes                |
| • Fellow eye of APAC: | Yes                |
| • PACS:               | "Maybe considered" |

From: AAO Preferred Practice Pattern, Primary Angle Closure, 2016

PACS	Primary angle closure suspect	ITC 180 degrees Normal IOP No PAS
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- Little data on natural history of PACS
  - At least 3 prospective studies in which bilateral PACS subjects were treated with unilateral LPI but no data available on disease progression

## PACS – LPI or not?

- Prospective study in South India (2003): PACS subjects identified and re-examined 5 years later
  - 22% progressed to PAC. **No Acute attack**, No PACG
  - Only 42% of original sample were re-examined
- Older studies
  - 1993, Chicago: Of 129 eyes with “narrow angle” or CACD < 2mm, **6% developed acute attack**, 13% developed appositional or synechial closure
  - 1992, Greenland Eskimos: Of 20 eyes with “occludable angles”, **10% developed acute attack**, 35% developed some form of angle closure

### AAO Preferred Practice Patterns, Primary Angle Closure, 2016

- LPI “may be considered” in PACS
- Factors that may influence the decision to perform LPI
  - Use of medication that may provoke pupillary block
  - Presence of symptoms suggestive of prior acute angle closure
  - Difficulty in immediately accessing eye care in case of an acute attack

PACS	Primary angle closure suspect	ITC 180 degrees Normal IOP No PAS
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- Other factors
  - Extent of angle closure
  - Refractive error
  - AC depth/Lens position
  - Family history of angle closure
  - Status of fellow eye
  - Need for frequent dilation
  - Patient concerns

## PACS - Other considerations

- Most PACS will not develop Acute PAC
- No way to predict which PACS patient will develop acute attack or gradual angle/disc damage
- Acute PAC can be visually devastating
- Relative risk of laser iridotomy is low

**Patient involvement in the treatment decision is key**

## PACS

- If iridotomy not done:
  - Discuss APAC symptoms
  - Avoid meds such as decongestants and antihistamines

PAC Primary angle closure ITC 180 degrees  
High IOP or PAS

- LPI is indicated
- Some have advocated monitoring PACS until they develop PAC and then perform LPI

## Acute Primary Angle Closure

- Ophthalmic emergency that can cause irreversible visual loss if not treated promptly
- Goals of treatment:
  - to lower IOP as soon as possible in order to relieve pain and nausea and to clear corneal edema
  - to prevent permanent damage to the anterior segment structures and optic nerve
  - to avoid recurrent attacks, and
  - to minimize progression to glaucoma

## Conventional treatment of APAC

Initiate IOP lowering treatment – topical and systemic



Once IOP is lowered – pilocarpine to induce miosis and pull iris away from angle



Definitive treatment to relieve pupillary block: LPI

## Alternate treatments

Initial medical treatment	—	AC tap
		Iridoplasty
Pilocarpine		
Laser iridotomy	—	Phacoemulsification

## Fellow eye in APAC

- Approximately 50% will develop acute PAC in 5 years if untreated
- Acute PAC in fellow eye can occur within days of presentation
- **Management of acute attack includes LPI in the fellow eye as soon as possible**

## Primary Angle Closure Glaucoma

- LPI if extensive synechial angle closure has not occurred
- IOP spike after LPI may be a concern if there is advanced optic nerve damage

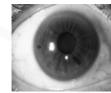
## Iridotomy

- Technique
  - Topical anesthesia
  - Pilocarpine prior to laser
  - Abraham lens
  - Yag laser
  - Temporal location



## LPI

- Dark eyes may require more than one session to complete
- Short course of steroid post laser
- Elimination of pupillary block results in a flat iris profile



## LPI – Short-term complications

- Bleeding: 30 to 41%
  - Usually minor, no difference if on antithrombotic treatment or not
- IOP spike: 2 to 64%
  - Defined as specified increase from baseline or IOP > 21, studies mostly included PACS eyes
  - 2-10% in 3 studies that used Brimonidine before LPI
  - 10%, 64% in 2 studies that did not use Brimonidine before LPI
- Need for repeat LPI: 1% to 20%
  - within 2 weeks to 6 months after initial LPI

## LPI – Short-term Complications

### Dysphotopsia: 2-11%

	11%	2.4%
	2.7%	3.6%
	4%	
Retrospective study – mostly <u>temporal</u> ; Mostly (77%) PACS		2%

No follow-up data on patients who developed dysphotopsia

## LPI – Longer term complications

- Cataract progression: 23-39% over 1-6 yrs in 3 studies
- Only 1 study included a control group
  - Chennai Eye Disease Study: 190 PACS subjects 6 years after LPI compared to 3015 subjects who did not undergo LPI. Cataract progression defined as change of ≥ 2 units on LOCS grading OR cataract surgery in the interval between baseline and f/u
  - LPI increased risk of cataract progression (OR 1.7)
  - Cataract progression in 39% of eyes with LPI versus 23% in controls

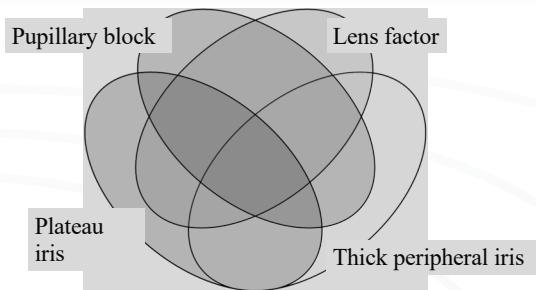
## Primary angle closure Goals of Treatment

- Reverse Iridotrabecular Contact
- Control IOP
- Prevent or reduce damage to the optic nerve

## Primary Angle Closure

- Laser iridotomy is an integral part of the treatment
- Efficacy depends on
  - Mechanism of angle closure
  - LPI only eliminates pupillary block
  - Stage of disease

## Mechanisms of primary angle closure



### Primary angle closure glaucoma in Chinese and Western populations

WANG Ningli 王宁利, WU Heping 吴河坪 and FAN Zhiqiang 范志刚

*Chin Med J* 2002; 115 (11): 1706-1715

- Mechanisms of angle closure in Chinese
  - Pupillary block – 38.1%
  - Non pupillary block
    - Anterior ciliary body (Plateau iris) – 3.9%
    - Thick peripheral iris that crowds into angle with mydriasis – 3.9%
  - Multi-mechanism = Pupillary block + plateau and/or thick iris – 54.8%

AMERICAN ACADEMY  
OF OPHTHALMOLOGY®  
Ophthalmic Technology Assessment

### Laser Peripheral Iridotomy in Primary Angle Closure

A Report by the American Academy of Ophthalmology

Sunjay Raghavendra, MD,<sup>1</sup> Philip P. Chen, MD,<sup>2</sup> Anni K. Jank, MD,<sup>3</sup> Koura Nnam-Makani, MD, MS,<sup>4</sup>  
Teresa C. Chen, MD<sup>5</sup>  
*Ophthalmology* 2018;125:1110-1120 | July 2018

This OTA addressed the following questions:

1. What is the efficacy of LPI in primary angle closure? Specifically, what is its effect on:
  - Angle width
  - IOP control
  - Disease progression
2. What are the clinically relevant short- and long-term complications of LPI?

## OTA methodology

- Review of studies that met the following inclusion criteria:
  1. The study reported on outcomes or complications of LPI in patients with primary angle closure
  2. Definition of primary angle closure was in accordance with the AAO PPP guidelines and if not, there was sufficient detail in the Methods section to reclassify patients. Studies on fellow eyes of APAC were included regardless of classification used.

## Inclusion criteria

3. Minimum number and follow-up
  - a. At least 50 eyes if reporting on short-term outcomes or complications
  - b. At least 30 eyes with a minimum of 1-year follow-up (or 6 months for APAC) if reporting on intermediate to long-term outcomes or complications

## Methodology

- Literature search yielded 300 citations
- 36 articles met the inclusion criteria
  - Level I: 6
  - Level II: 11
  - Level III: 19

## Published results

- Effect of LPI on:
  - Angle width
  - IOP
  - Disease progression
- Complications of LPI
  - Short-term
  - Long-term

## LPI – Effect on angle width Short term (1-8 weeks)

- Increases angle width in all stages of angle closure

	Pooled N	Mean Shaffer grade	
		Pre-LPI	Post-LPI
PACS (no PAS)	1105 (4 studies)	0.7	2.4
Other (PAS present) (PAC, PACG, APAC, fellow eyes)	506 (5 studies)	0.7	1.1

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## Persistent angle closure after LPI

Defined as ITC of at least 180° or 270 °

	Pooled N	Persistent ITC
All stages	1621 (8 studies)	2 to 57%
PACS	1086 (3 studies)	11 to 25%

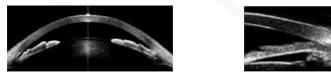
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## Baseline factors associated with persistent angle closure after LPI

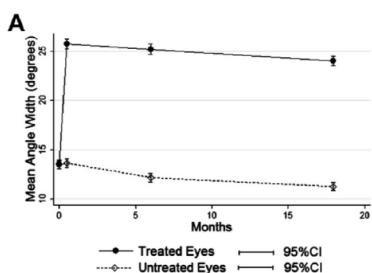
- Narrower angle at baseline
  - Presence of PAS <sub>Gonioscopy</sub>
  - Shallower angle width <sub>UBM</sub>
- Increased IOP
- Non pupillary block mechanisms
  - Increased lens vault <sub>OCT</sub>
  - Thicker iris <sub>OCT and UBM</sub>
  - Anteriorly positioned ciliary body <sub>UBM</sub>



## LPI – Effect on angle width Long term (12-18 months)

- 2 studies (Level I and II)
  - Significant decrease in angle width in the duration between 2 weeks and 18 months after LPI
  - Level I study – Zhongshan Angle Closure Prevention Study (ZAP study)
    - 1 randomly selected eye of 775 Chinese PACS subjects was treated with LPI and the fellow eye acted as the control
    - Longitudinal decrease in angle width over 18 months was more rapid in untreated eyes versus eyes treated using LPI

## ZAP study



## Published results

- Effect of LPI on:
  - Angle width
  - IOP
  - Disease progression
- Complications of LPI
  - Short-term
  - Long-term

## LPI: Effect on IOP

- Most commonly reported outcomes related to IOP were:
  - IOP elevation above 21mm Hg
  - Need for further treatment of any type (medications, laser, or surgery) after LPI
  - Need for further glaucoma surgery after LPI

## Additional treatment after LPI

	Any treatment	Glaucoma surgery
PACS 4 studies, 392 eyes, f/u 1-12 yrs	0 – 7%	0 – 0.4%
PAC 3 studies, 158 eyes, f/u 4-12 yrs	42 – 67%	0 – 13%
APAC 4 studies, 156 eyes, f/u 1-2 yrs	21 – 47% IOP rise occurred within 6 months in most subjects	0 – 38%
PACG 3 studies, 219 eyes, f/u 4-12 yrs	83 – 100%	20 – 43%

## Factors associated with the need for additional treatment after LPI

- Higher IOP
- C:D ratio  $\geq 0.8$
- Greater extent of PAS at presentation
- History of APAC

## Published results

- Effect of LPI on:
  - Angle width
  - IOP
  - Disease progression
- Complications of LPI
  - Short-term
  - Long-term

## Disease progression to PACG After LPI

PACS 4 studies, 392 eyes, f/u 1-12 yrs No untreated control group	0 – 0.3% per year
PAC 4 studies, 225 eyes, f/u 4-12 yrs	0 – 4% per year
APAC 2 studies, 132 eyes, f/u 2-6yrs	19% 48%
Fellow eyes of APAC 1 study, 70 eyes, f/u 6 yrs	7%

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PACS	0 – 0.3% per year
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PAC	0 – 4% per year
4 studies, 225 eyes, f/u 4-12 yrs	
APAC	19% 48%
2 studies, 132 eyes, f/u 2-6yrs	
Fellow eyes of APAC	7%
1 study, 70 eyes, f/u 6 yrs	

## Progression to PACG after APAC

- 2 studies showed very different outcomes after APAC
- In the study with lower (19% vs. 48%) frequency of progression:
  - Duration of attack was shorter (28 hours versus 3 days)
  - More subjects underwent cataract surgery during follow-up (50% versus 43%)
  - None had glaucomatous optic neuropathy at presentation

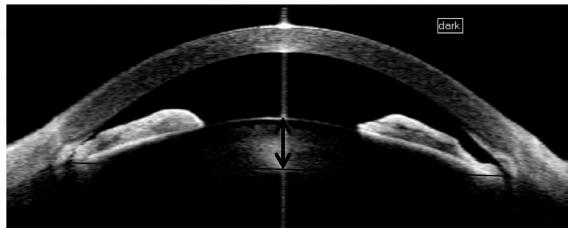
## Factors associated with disease progression after LPI

- For PACS to PAC
  - Decreased angle width was associated with progression
  - Cataract surgery was protective
- PAC to PACG OR worsening of PACG
  - More than 2 quadrants of angle closure
  - Family history of glaucoma
- APAC to PACG
  - Longer duration of attack

## PAC/PACG – Additional treatment besides LPI

- Medications
- Laser trabeculoplasty
- Iridoplasty
- Clear lens extraction
- Cataract surgery
- Glaucoma surgery
- Combined cataract and glaucoma surgery

## The LENS in Angle Closure



## Surgical treatment

FILTERING SURGERY  
± CATARACT EXTRACTION



CATARACT EXTRACTION  
± FILTERING SURGERY

CrossMark Ophthalmic Technology Assessment

**The Effect of Phacoemulsification on Intraocular Pressure in Glaucoma Patients**

A Report by the American Academy of Ophthalmology

Philip P. Chen, MD,<sup>1</sup> Shan C. Lin, MD,<sup>2</sup> Anna K. Jank, MD,<sup>3</sup> Srinivas Raghavachari, MD,<sup>4</sup> Kader Singh, MD, MPH,<sup>5</sup> Terri C. Chen, MD<sup>6</sup>

	IOP reduction	Medication reduction
<b>POAG</b>	13%	12%
<b>XFG</b>	20%	35%
<b>PACG</b>	30%	58%

**AcutePAC** | 71% IOP reduction | Meds rarely required

**Randomized Trial of Early Phacoemulsification versus Peripheral Iridotomy to Prevent Intraocular Pressure Rise after Acute Primary Angle Closure**

Donna S. C. Lam, MD, FRCOphth,<sup>1</sup> Dexter Y. L. Leung, FRCS, DRCOphth,<sup>1</sup> Clement C. Y. Tham, FRCS,<sup>1</sup> Felix C. H. Li, MRCS,<sup>2</sup> Yuklina Y. Y. Kwong, MRCS,<sup>3</sup> Thomas Y. H. Chia, FRCS,<sup>4</sup> Dorothy S. P. Fan, FRCS<sup>5</sup>

- At 18 months, IOP > 21 occurred in 47% of LPI group and 3% of phaco group

Lam DS et al, Ophthalmology 2008;115:1134-40

Lam et al · Early Phacoemulsification to Prevent IOP Rise after APAC

**Survival Functions**

Cumulative Survival

Time after attack of Acute Primary Angle-closure (Weeks)

Phaco Group + indicates censored

LPI Group + indicates censored

Figure 1. Kaplan-Meier survival curve for intraocular pressure (IOP) rise in the phacoemulsification (phaco) and laser peripheral iridotomy (LPI) groups. A test of equality of survival distributions with Mantel-Cox log rank ( $P<0.0001$ ), Breslow ( $P<0.0001$ ), and Tarone-Ware ( $P<0.0001$ ) statistics showed a significant difference in survival between the two groups.

**Surgical treatment**

TRABECULECTOMY

↓

CATARACT EXTRACTION

↓ ?

CLEAR LENS EXTRACTION

**Effectiveness of early lens extraction for the treatment of primary angle-closure glaucoma (EAGLE): a randomised controlled trial**

Augusto Azuara-Blanco, Jeniffer Bur, Craig Ramsay, David Cooper, Paul J Foster, David S Friedman, Graham Scotland, Mehdi Javanbakht, Claire Cochrane, John Norrie, for the EAGLE study group

*Lancet* 2016; 388: 1389-97

**EAGLE trial**

- Multicenter RCT, 22 in UK and 8 in East Asia
- Eyes with PACG (not advanced) or PAC with IOP > 30 mm HG
- Randomized to clear lens extraction or standard therapy (LPI and topical therapy)

## EAGLE trial – baseline data

	Clear-lens extraction (n=208)	Laser peripheral iridotomy (n=211)	Missing data
Diagnosis in study eye			
PAC	80 (38%)	75 (36%)	0
PACG	127 (61%)	136 (64%)	0
Goniscopy (angle closure °)			
Closure without indentation	300.0 (270.0 to 360.0)	360.0 (270.0 to 360.0)	23
Synechial closure	90.0 (20.0 to 180.0)	90.0 (10.0 to 180.0)	247
IOP (mm Hg)	30.0 (24.0 to 33.0)	30.0 (26.0 to 33.0)	0
Axial length (mm)	22.5 (22.0 to 23.1)	22.7 (22.1 to 23.2)	7
Visual field mean deviation (dB)	-3.0 (-7.0 to -0.8)	-3.5 (-7.2 to -1.3)	42

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	Clear-lens extraction (n=208)	Laser peripheral iridotomy (n=211)
Medications (any) at 36 months*		
0	126 (60.6%)	45 (21.3%)
1	33 (15.9%)	67 (31.8%)
2	15 (7.2%)	46 (21.8%)
3	3 (1.4%)	19 (9.0%)
4	1 (0.5%)	4 (1.9%)
Missing	30 (14.4%)	30 (14.2%)
Additional glaucoma surgery†		
Lens extraction	0	16 (67%) of 24
Trabeculectomy	1 (100%) of 1	6 (25%) of 24
i-Stent	0	1 (4%) of 24
Ahmed tube	0	1 (4%) of 24

	Clear-lens extraction (n=208)	Laser peripheral iridotomy (n=211)
Medications (any) at 36 months*		
0	126 (60.6%)	45 (21.3%)
1	33 (15.9%)	67 (31.8%)
2	15 (7.2%)	46 (21.8%)
3	3 (1.4%)	19 (9.0%)
4	1 (0.5%)	4 (1.9%)
Missing	30 (14.4%)	30 (14.2%)
Additional glaucoma surgery†		
Lens extraction	0	16 (67%) of 24
Trabeculectomy	1 (100%) of 1	6 (25%) of 24
i-Stent	0	1 (4%) of 24
Ahmed tube	0	1 (4%) of 24

## Complications – EAGLE study

	Clear lens extraction N=208	LPI + Medication N=211
PC rupture	2 (1%)	
Malignant glaucoma	1 (0.5%)	2 (1%)
Flat AC	2 (1%)	1 (0.5%)
Corneal edema	1 (0.5%)	0
Macular edema	5 (2.4%)	3 (1.4%)
Dysphotopsia	0	1 (0.5%)
Intraocular surgery for complications	3 (1.4%)	1 (0.5%)
Irreversible loss of vision >10 ETDRS letters	1 (0.5%)	2 (1%)

## Lens extraction - Cautions

- Poor reserve in subjects with advanced optic nerve damage and on MTMT
- Risks of operating in small eyes

### Surgery for primary angle closure

- Filtering surgery
- Aqueous drainage devices
- Goniosynechiolysis
- Endocyclophotocoagulation
- Transscleral cyclophotocoagulation

### Take home points

1. Gonioscopy is key for diagnosis
2. Iridotomy alone may not be sufficient
3. Lens extraction can have a profoundly beneficial effect in eyes with primary angle closure