

17TH INTERNATIONAL CONFERENCE OF THE
RESEARCH INSTITUTE OF OPHTHALMOLOGY

RIO 2025

*Anterior Segment Eye Diseases
Current Status & Future Directions*

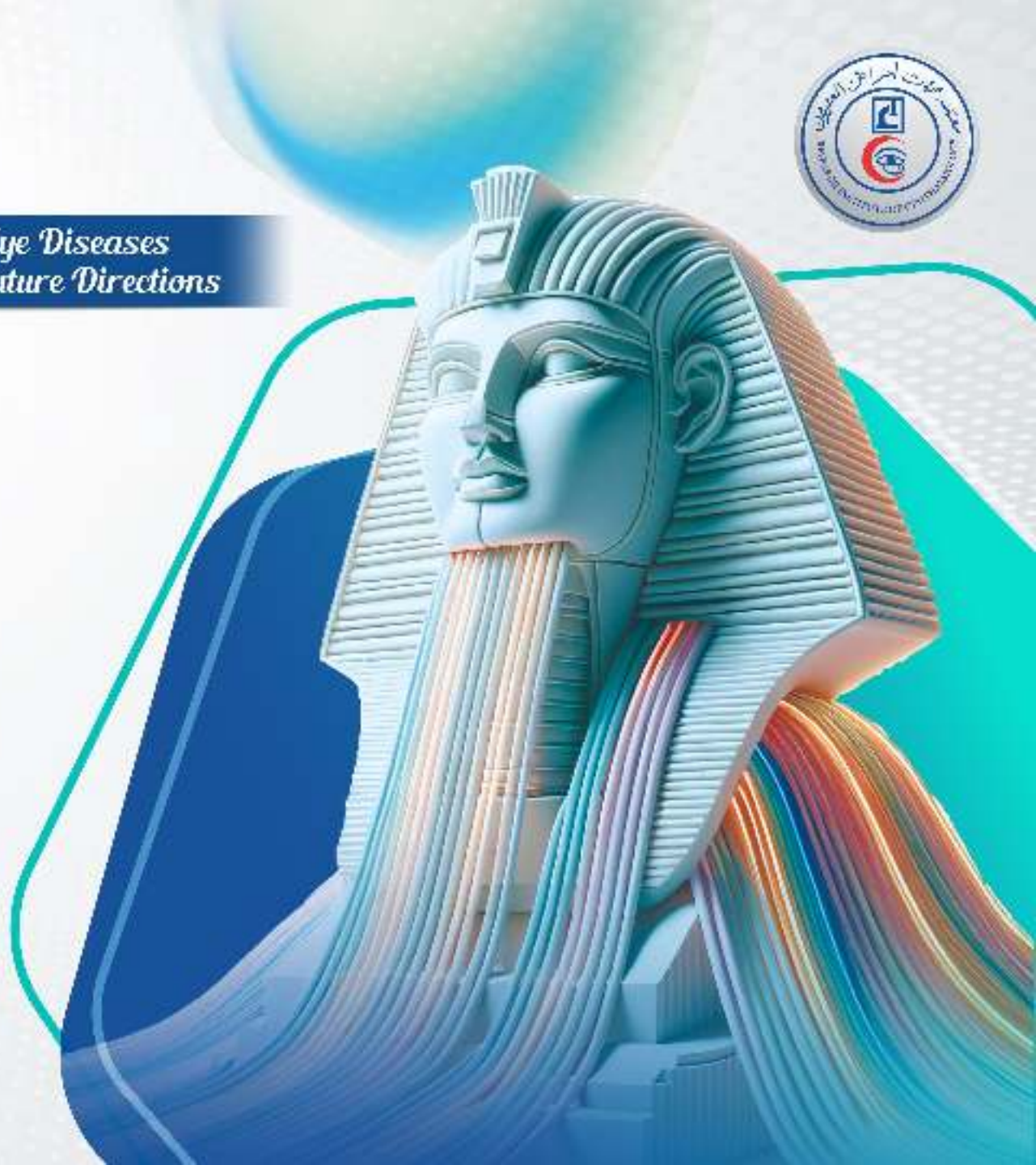


Aqueous Dynamics & Glaucoma

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**Kersley Eye
Clinic**



**King's College
London &**



**St Thomas'
Hospital**

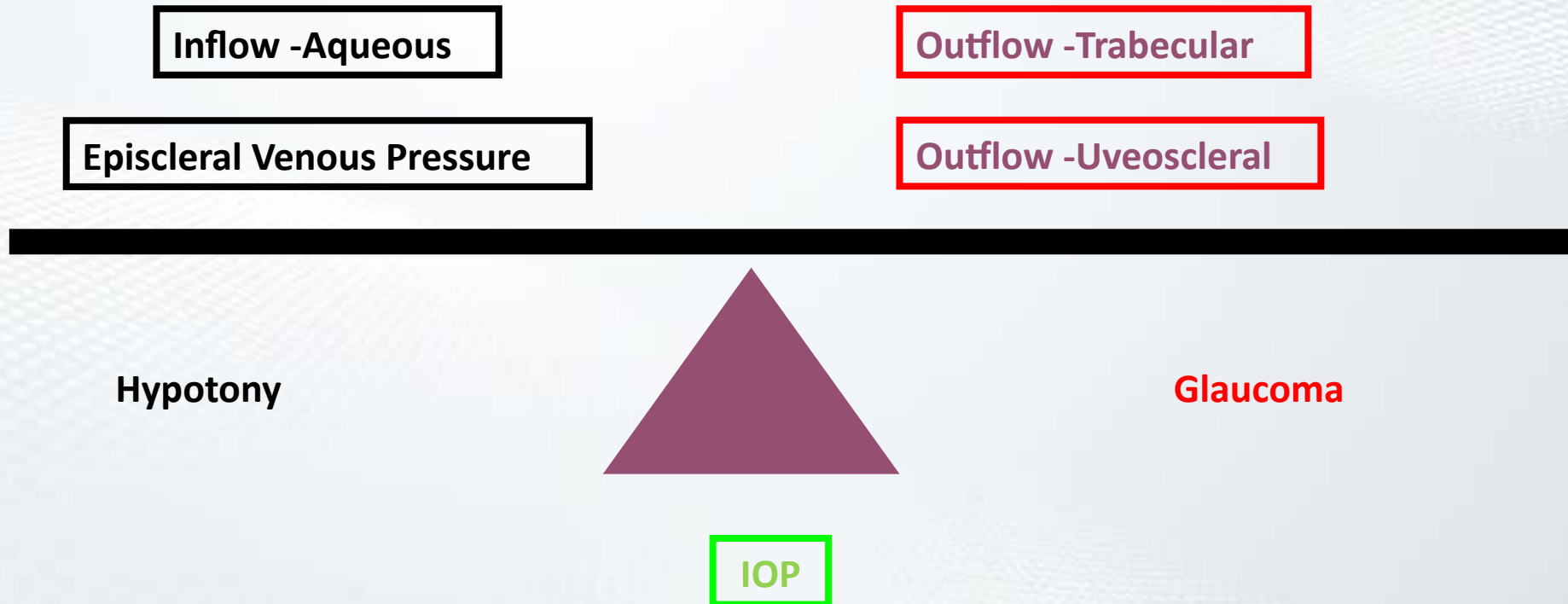


KCL Frost Eye Research Department

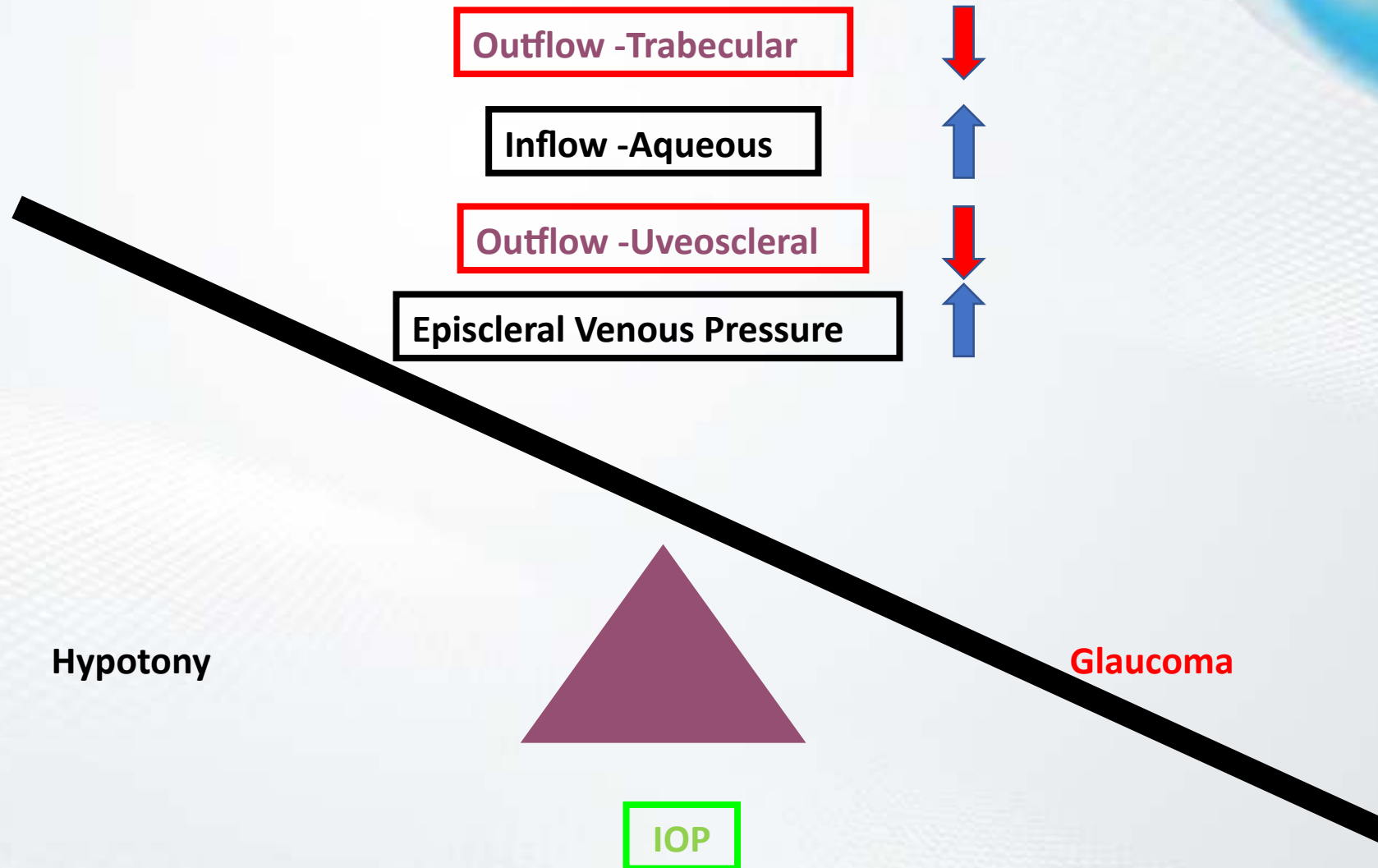
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 - Alan Duncan
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Aqueous Dynamics & Glaucoma



Glaucoma



Clinical Aqueous Dynamics

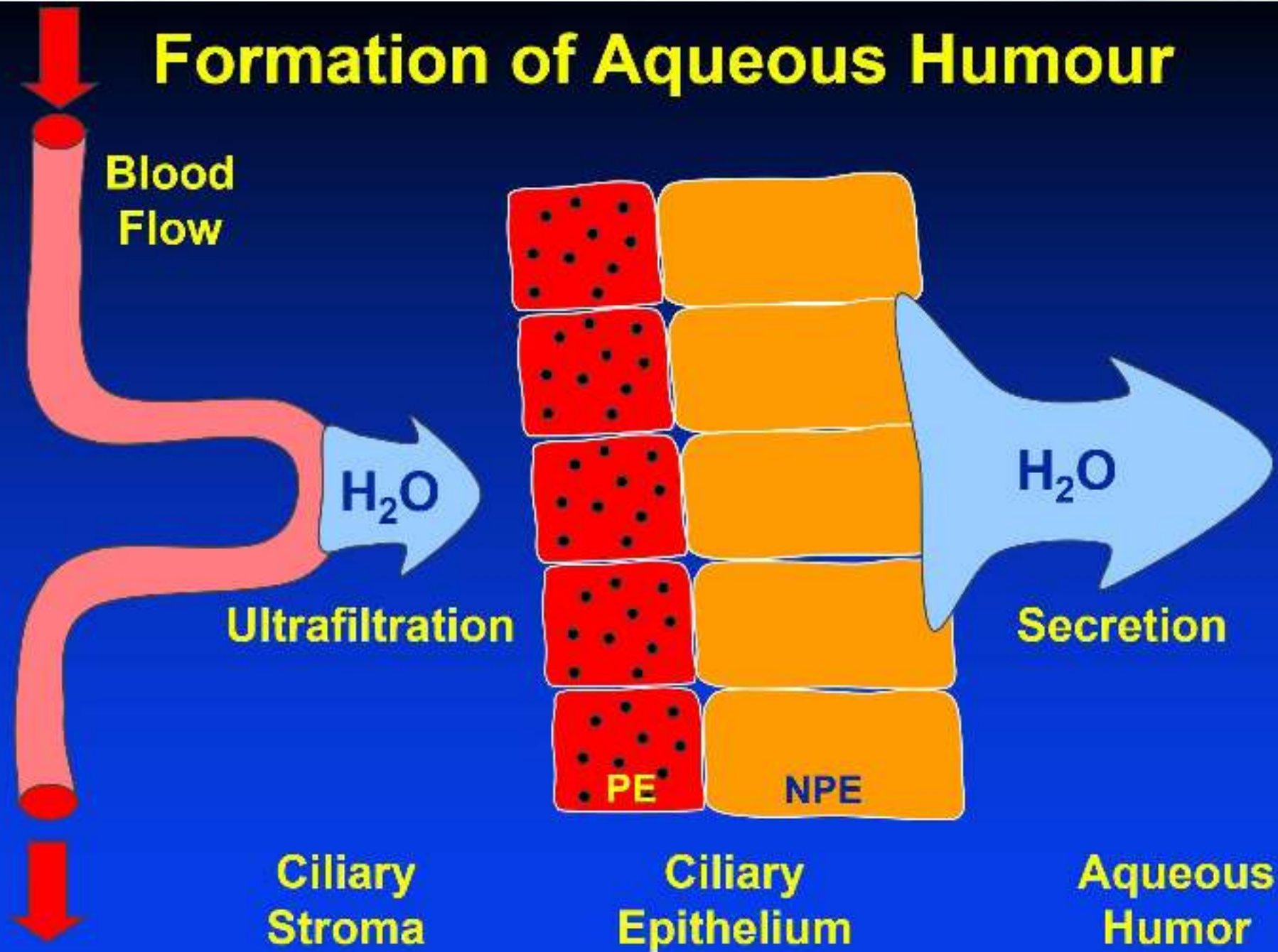
- Measurement of Aqueous Dynamics
- Disease & Race
- Treatment Effect

Aqueous Dynamics Papers

Published

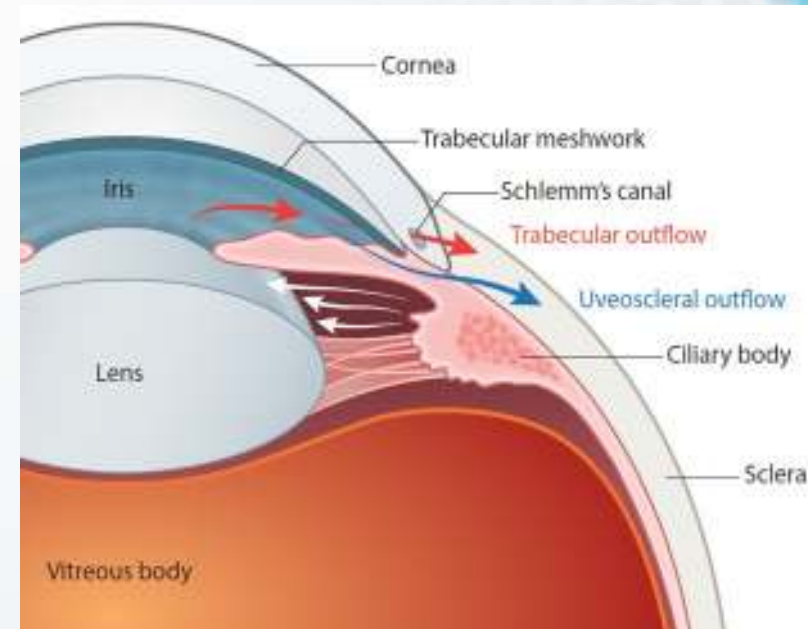
- Effect of High-Intensity Focused Ultrasound (HiFU) treatment on intraocular pressure and aqueous humour dynamics: 12 months results. Kin Sheng Lim, Anindyt Nagar, Lina Danieliute, Cynthia Yu-Wai-Man, Arij Daas, Elizabeth Galvis, and Pouya Alaghband. Eye. 2020 Nov 6.
- The effect of high intensity focused ultrasound on aqueous humor dynamics in glaucoma patients. P. Alaghband, E. Galvis, A. Ramirez, M. Madekurozwa, B. Chu, D. Overby, KS Lim. *Ophthalmology Glaucoma*. 2020 Mar-Apr;3(2):122-129.
- Aqueous dynamic in Uveitic. P. Alaghband, KS Lim et al. American Journal of Ophthalmology. December 2019 Volume 208, Pages 347–355
- The effect of phacoemulsification on outflow facility. P. Alaghband, E. Galvis, Overby D & KS Lim. British Journal of Ophthalmology 2018
- Aqueous outflow facility after phacoemulsification with or without goniosynechialysis in primary angle closure: a randomised controlled study. Rodrigues, P. Alaghband, E. Galvis, S. Jones, L. Beltran-Agullo, R. Hussain, KS Lim. British Journal of Ophthalmology. 2017
- The Effect of Selective Laser Trabeculoplasty on Aqueous Humor Dynamics in Patients with Ocular Hypertension and Primary Open Angle Glaucoma. Beltran-Agullo L, Alaghband P, Obi A, Hussain R, Lim KS. Journal of Glaucoma. December 2013
- Comparative human aqueous dynamics study between black and white subjects with glaucoma. Beltran-Agullo L, Alaghband P, Rashid S, Gosselin J, Obi A, Husain R, Lim KS. Invest Ophthalmol Vis Sci. 2011
- Effect of primary selective laser trabeculoplasty on tonographic outflow facility: a randomised clinical trial. Goyal S, Beltran-Agullo L, Rashid S, Shah SP, Nath R, Obi A, Lim KS. Br J Ophthalmol. 2010
- Comparative study on the mechanism of action of bimatoprost, latanoprost and travoprost in healthy subjects. A double-masked, placebo-controlled, randomized, paired comparison, 4-session crossover study. Lim KS, Nau C, O'Byrne M, Hodge D, Toris C, McLaren J, Johnson DH. Ophthalmology 2008

Formation of Aqueous Humour



Aqueous Outflow Pathways

- Trabecular outflow (conventional)
 - Pressure dependent
- Uveo-scleral outflow (unconventional)
 - ciliary body → supra-choroidal → sclera
 - Pressure independent
 - 5-20% of aqueous outflow



Goldmann's Equation

$$F = (P_i - P_e) \times C + U$$

F = Aqueous Flow

P_i = Intraocular Pressure

P_e = Episcleral Venous Pressure

C = Outflow Facility

U = Uveoscleral Outflow

Goldmann's Equation

	Methods	Assumptions	Accuracy
F	Fluorophotometry	many	
P_i	Goldmann Tonometry		
P_e	Venomanometry		
C	Pneumatography		
	Schiotz		
	Fluorophotometry		
U	calculation		

Fluorophotometric – Aqueous Flow Rate

Patients put fluorescein 2% drops the night before



Goldmann's Equation

	Methods	Assumptions	Accuracy
F	Fluorophotometry	many	Yes
P_i			
P_e			
C			
Fluorophotometric study of the effect of iStent on Aqueous Humor Dynamics. <i>Fernández-Barrientos et al. IOVS July 2010</i>			

Goldmann's Equation

	Methods	Assumptions	Accuracy
F			
P_i	Goldmann Tonometry	some	
P_e			
C			
U			



Goldmann's Equation

	Methods	Assumptions	Accuracy
P_e	Venomanometry		

Episcleral venous pressure

Venomanometer Zeimer Arch Ophthalmol 1983



Sit et al. A novel method for computerized measurement of EVP in humans. Exp Eye Res 2011

Brubaker RF. Measurement of uveoscleral outflow in humans. J Glaucoma. 2001

Trabecular Outflow Facility Measurement

	Methods	Assumptions	Accuracy
F			
P_i			
P_e			
C	Pneumatography	some	?
	Schiotz	some	Yes
	Fluorophotometry	some	?
U			

Mechanism of Action of Bimatoprost, Latanoprost, and Travoprost in Healthy Subjects A Crossover Study.
Lim, Nau, Johnson, McLaren et al. Ophthalmology 2007

- The main aim of this study was to compare the different trabecular outflow measurement techniques in the same subjects

Trabecular Outflow Facility Measurement Techniques

- Schiotz (Grant 1950)
- Pneumatography (Langham 1976)
- Fluorophotometry (Yablonski 1988)

Mechanism of Action of Bimatoprost, Latanoprost, and
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Comparison of Techniques

Pneumatography - variable

Fluorophotometry – variable

Schiotz* - similar to previous studies

Schiotz had lowest variability over time ($p < 0.03$)

Schiøtz (Mueller) Electronic Tonography



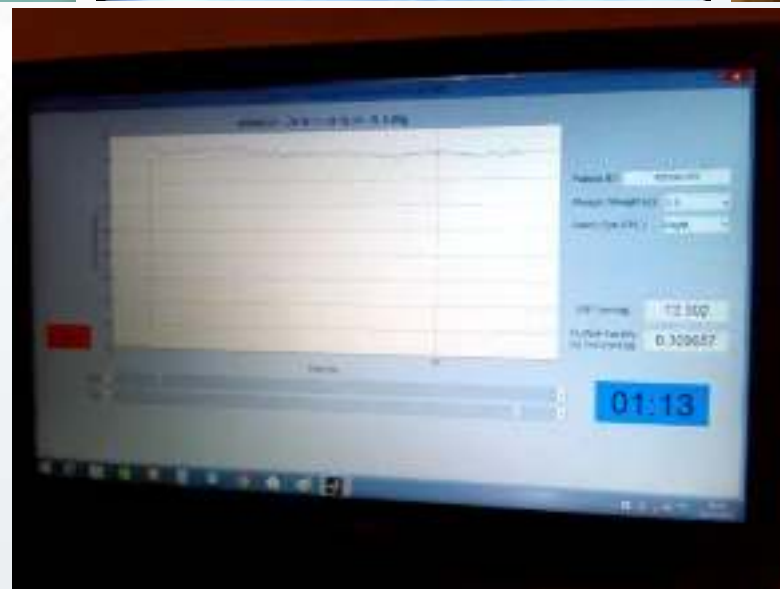
French Hospital Store Room (2007)



eBay (2014)

Digital Schiötz Tonography

Chu, Madekurozwa & Overby. Imperial College



Goldmann's Equation

	Methods	Assumptions	Accuracy
F	Fluorophotometry	many	Yes
P_i	Goldmann Tonometry	some	Yes
P_e	Venomanometry	many	Assumed
C			
	Schiotz	some	Yes
U	calculation	many	depends

Goldmann's Equation

$$F = (P_i - P_e) \times C + U$$

F = Aqueous Flow

P_i = Intraocular Pressure

P_e = Episcleral Venous Pressure

C = Outflow Facility

U = Uveoscleral Outflow

Disease Status & Aqueous Dynamic Effect

- POAG
- Racial difference
- Uveitis

Glaucoma

Comparative Human Aqueous Dynamics Study between Black and White Subjects with Glaucoma

Laura Beltran-Agullo, Pouya Alagbband, Safina Rashid, Josee Gosselin, Adanna Obi, Rabat Husain, and Kin Sheng Lim

POAG/OHT Versus Normals. Black & White patients

Aqueous Dynamic Effects - POAG & Race

POAG/OHT Versus Normals. Black & White patients

	Methods	Median Facility $\mu\text{l}/\text{min}/\text{mmHg}$
White	Normal	
	POAG/OHT	
Black	Normal	
	POAG/OHT	

Comparative human aqueous dynamics study between black & white subjects with glaucoma.
Beltran-Agullo L, Lim KS. IOVS. 2011

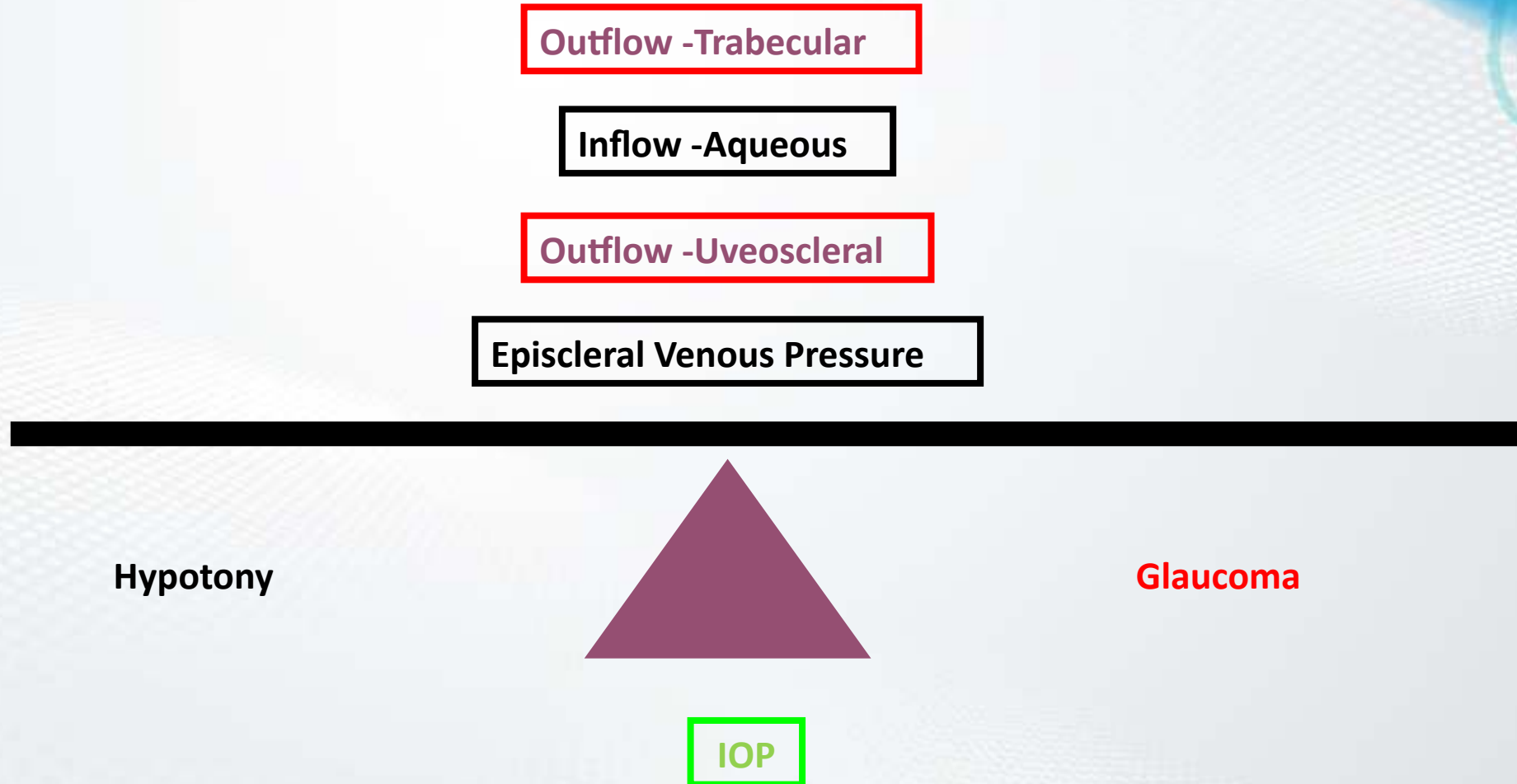
Aqueous Dynamic Effects - POAG & Race

POAG/OHT Versus Normals. Black & White patients

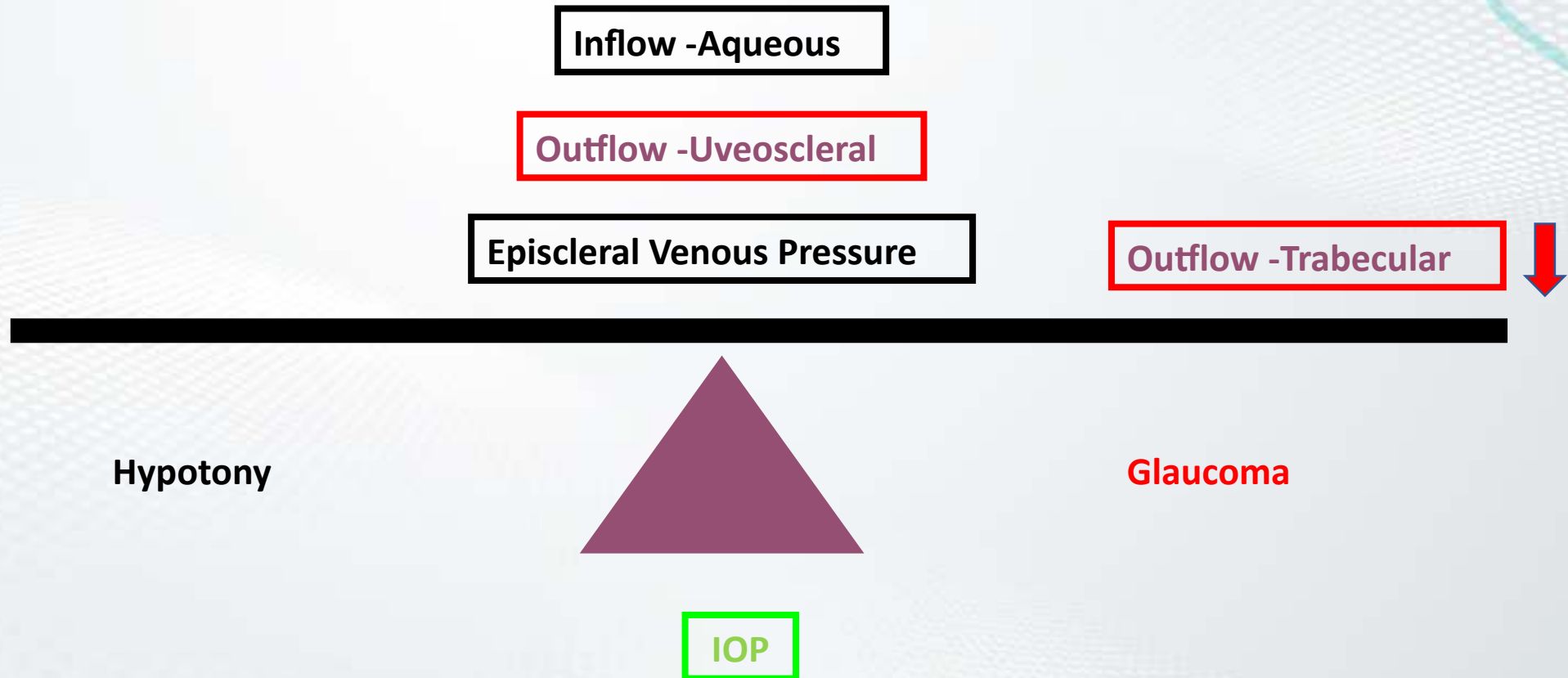
	Methods	Median Facility μl/min/mmHg
White	Normal	0.21
	POAG/OHT	0.11
Black	Normal	0.18
	POAG/OHT	0.12

No difference in Aqueous Production Rates

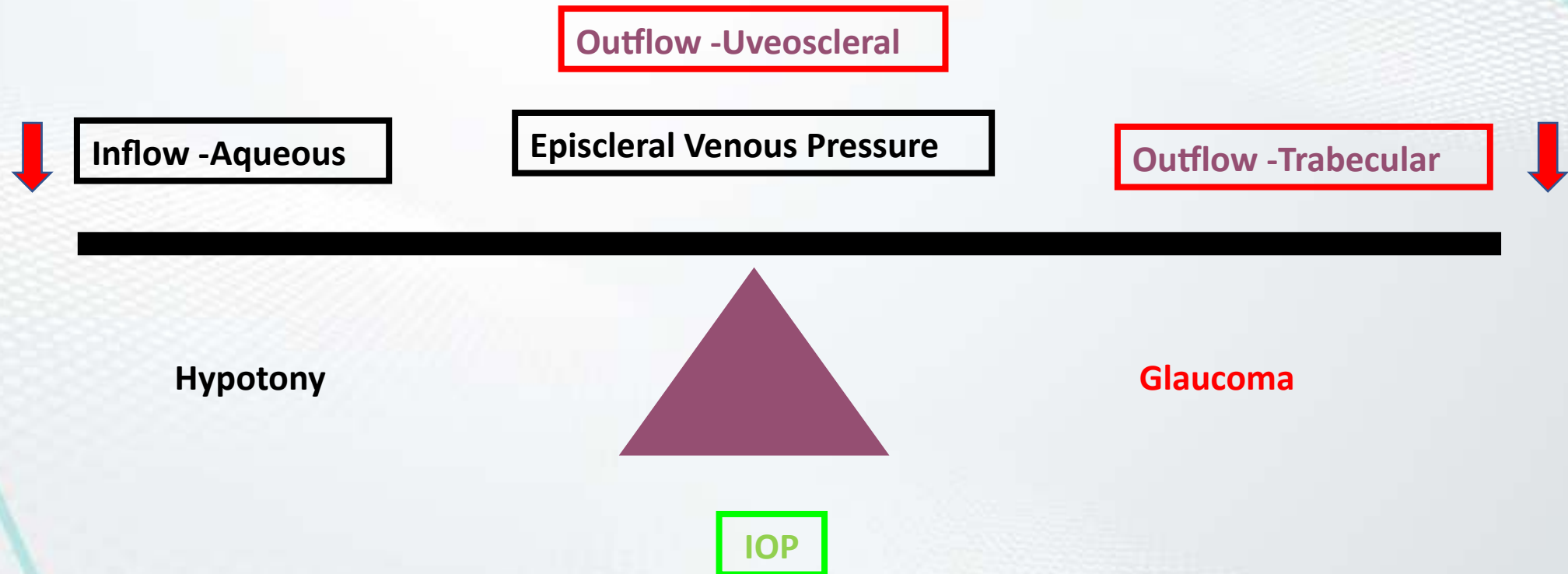
Uveitic Glaucoma



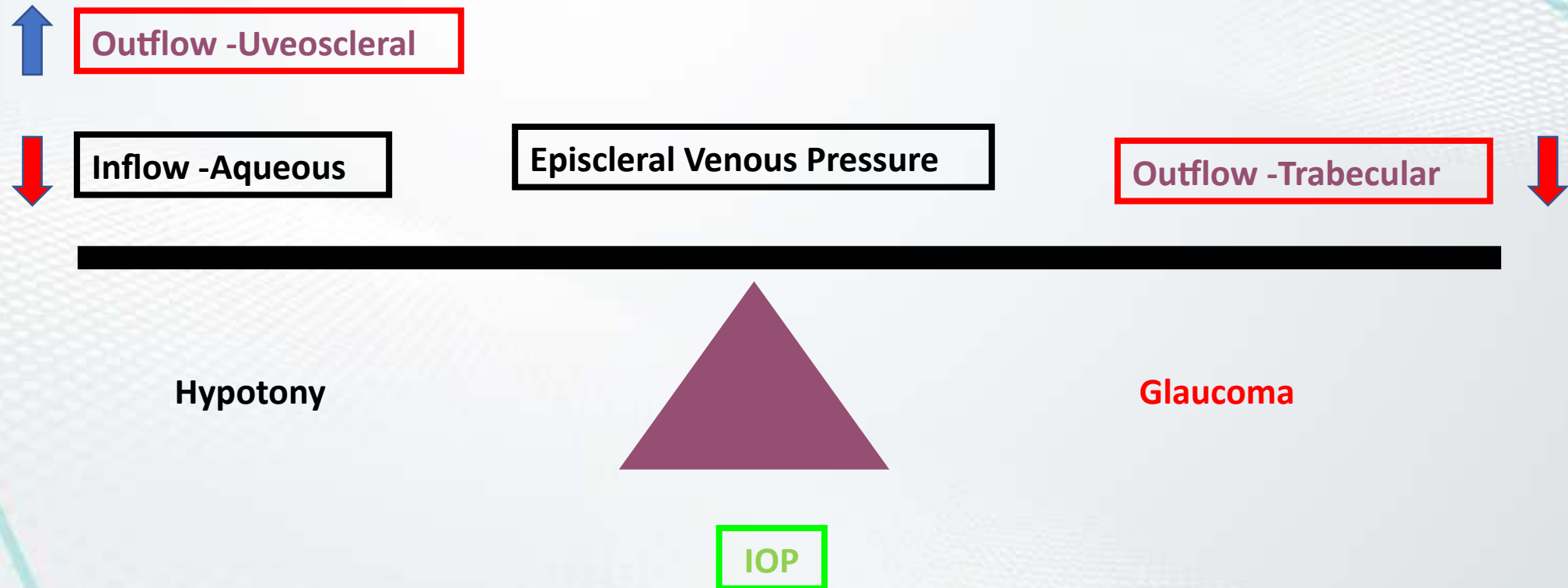
Uveitic Glaucoma



Uveitic Glaucoma



Uveitic Glaucoma



Aqueous Humor Dynamics in Uveitic Eyes



POUYA ALAGHBAND, ALEXANDER JAN BANEKE, ELIZABETH GALVIS, MICHAEL MADEKUROZWA,
BRIAN CHU, MILES STANFORD, DARRYL OVERBY, AND KIN SHENG LIM

American Journal of Ophthalmology 2019

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Three Types of Uveitis:

1. Acute inflammation
2. Previous mild to moderate uveitis (< 5 attacks)
3. Previous severe multiple uveitis (>5 attacks)

Uveitic Aqueous Dynamic Study

Funding:

IGA/RCOphth

St Thomas Charity

EyeHope

Pouya Alaghband
Alex Baneke
Elizabeth Galvis

1. Why do some uveitic eyes develop glaucoma but not others?
2. What is the effect of repeated iritis on trabecular outflow?
3. What is the effect of repeated iritis on aqueous production rate?

Methods

- H/O recurrent (≥ 3 attacks) anterior uveitis and being treated for 2° glaucoma or OHT (group 1), recurrent anterior uveitis (≥ 3 attacks) (group 2), and normal control group (group 3)
- one-off aqueous humor dynamic measurements. Patients from group 1 who were on topical anti-hypertensive medications were washed out for 4-weeks
- **Main outcome measure:** Trabecular outflow (measured by digital Schiøtz tonometry), Aqueous flow rate (measured by fluorophotometry) and Uveoscleral outflow (calculated from the Goldmann's equation)

Results

- 14 eyes in group 1 (treated OHT/Glaucoma) had normal IOP post-washout
- None of the eligible patients recruited had more than 5 previous attacks of uveitis

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Severe uveitis tend to need intraocular surgery

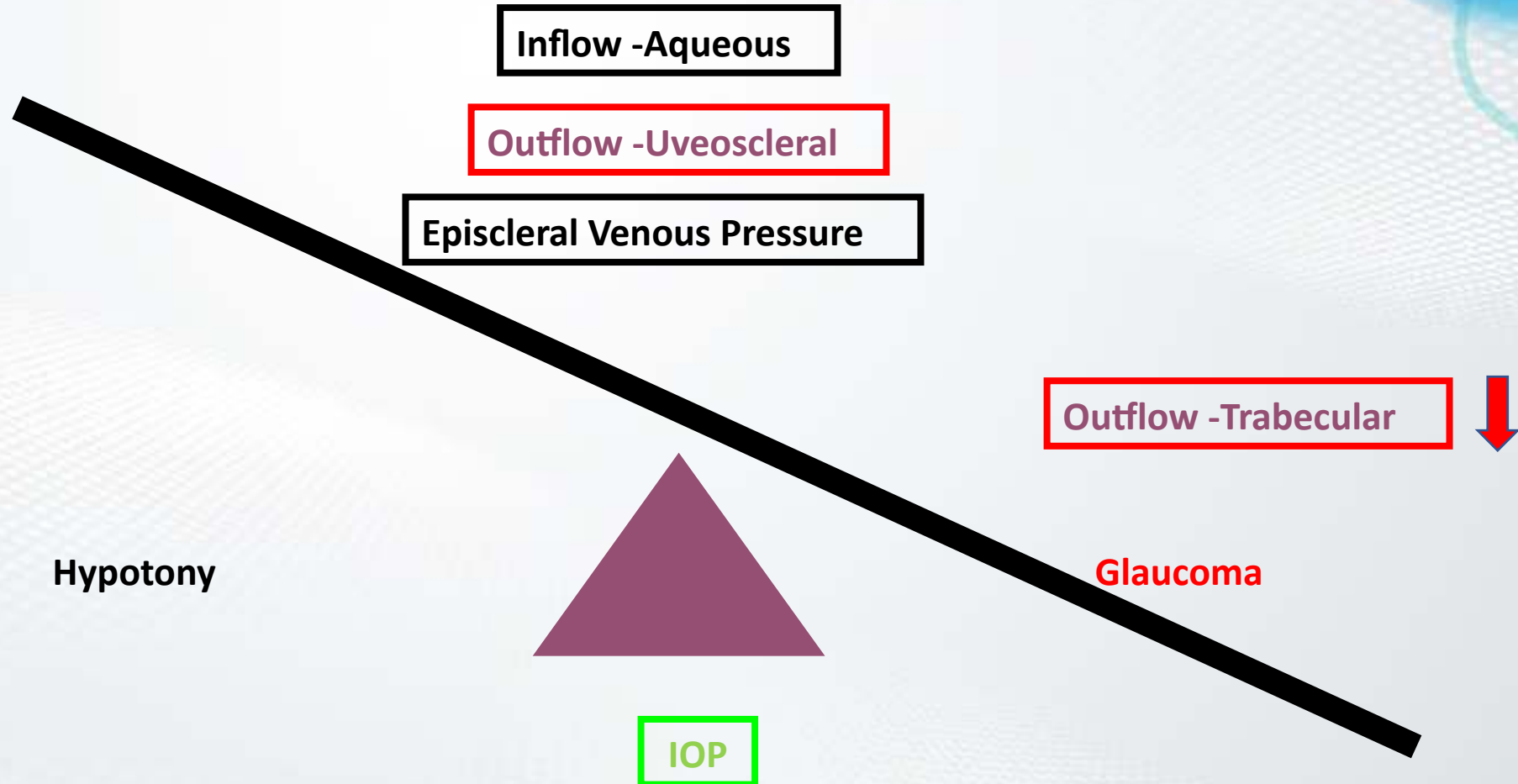
Results

	Group 1 (n=30) uveitic glaucoma/OHT	Group 2 (n=32) Uveitis	Group 3 (n=30) Normal
IOP, mmHg	25±10.2* (10-52)	16±2.7† (10-22)	16±2.2 (11-19)
Aqueous flow rate(Ft), µl/min	2.46±0.9	2.13±0.9	2.25±0.7
Trabecular outflow facility, µl/min/mmHg	0.18±0.1*	0.26±0.1†	0.25±0.1
Uveoscleral outflow µl/min (EVP 10 mmHg)	0.48±1.8 (-3.9 - 3.3)	0.41±1.4	0.77±1.3

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Moderate Uveitic Glaucoma



Conclusion

- After **fewer than 5** uveitis attacks:
- elevated IOP in the uveitic glaucoma/OHT eyes was due to **reduced trabecular outflow** facility
- Aqueous humor flow rate was **not** significantly different among the groups
- No difference in the calculated uveoscleral outflow
- Consider wash-out for low risk 'uveitic glaucoma'
- Surgical technique rather than aqueous shut-down, more likely the cause of hypotony after trabeculectomy in moderate uveitis

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Summary

- Clinical aqueous dynamic are essential for:
 - Understanding disease process
 - Studying treatment effects (glaucoma)
 - Help us in formulating better treatment strategies in glaucoma patients

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Thank You

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