

A Toolkit for Glaucoma Management in Sub-Saharan Africa



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Thanks to financial contribution from the Else Kröner Fresenius Stiftung (Germany), Light for the World launched its first multi-country Glaucoma programme called “Addressing Challenges of Glaucoma - the Silent Thief of Sight” aiming to improve glaucoma services in Burkina Faso, Mozambique and Ethiopia at the end of 2018. As one of the first interventions of this programme, in February 2019, a group of high-level glaucoma experts and general ophthalmologists came together for a workshop in Addis Ababa, Ethiopia, hosted by the Ethiopian Society of Ophthalmology (OSE) to develop a practical toolkit for glaucoma management in Sub-Saharan Africa (SSA). This work was supported by the International Council of Ophthalmology (ICO) and some sections of the ICO Guidelines for Glaucoma Eye Care were adapted for this toolkit.

Participants represented all SSA regions as well as global and regional eye health organisations such as the International Council of Ophthalmology (ICO), the International Agency for the Prevention of Blindness (IAPB), the College of Ophthalmology for Eastern, Central and Southern Africa (COECSA), the Francophone African Ophthalmic Society (SAFO), the West African College of Surgeons (WACS), the African Glaucoma Consortium, the Ethiopia, Ghana, Nigeria and South Africa Glaucoma and Ophthalmological Societies, as well as the scientific community and major international training institutions.

The group was able to develop the crucial outline for a practical toolkit on glaucoma management for SSA which will complement the important resources existing already, such as the ICO Glaucoma Guidelines. This unprecedented and dynamic toolkit, developed and owned by African eye care professionals and glaucoma specialists, is instrumental to guide ophthalmologists, glaucoma specialists and glaucoma care team members and programme planners to set up integrated glaucoma care services adequate to their very own context and to strengthen the health systems sustainably.

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GLOSSARY

5FU	5 Fluorouracil
AADI	Aurolab aqueous drainage implant
ACG	Angle closure glaucoma
ACG	Angle closure glaucoma
AGM	Anti-glaucoma medication
AI	Artificial intelligence
ALPI	Argon laser peripheral iridotomy
ALT	Argon laser trabeculoplasty
ATM	Anterior trabecular meshwork
AZOOOR	Acute zonal occult outer retinopathy
BL	Borderline
BMI	Body mass index
BP	Blood pressure
CAI	Carbonic anhydrase inhibitor
CCT	Central corneal thickness
CEHC	Commonwealth eye health consortium
CLASS	Carbon dioxide laser assisted sclerectomy
COECSA	College of Ophthalmology of Eastern, Central and Southern Africa
COPD	Chronic obstructive pulmonary disease
CT SCAN	Computerised tomography scan
CVF	Central visual field
CW-CPC	Continuous wave cyclophotocoagulation
D	Dioptre
dB	Decibel
DDLs	Disc damage likelihood score
ECG	Electro-cardiogram
EUA	Examination under anaesthesia
FDA	Food and drug administration
FDR	First degree relative
GAT	Goldmann applanation tonometry
GATT	Gonioscopy assisted transluminal trabeculectomy
GDD	Glaucoma drainage device
GPA	Glaucoma patient association
IAPB	International Agency for the Prevention of Blindness
ICEH	International Centre for Eye Health
ICO	International Council of Ophthalmology
IL-1	Interleukin 1
IOL	Intraocular lens
IOP	Intraocular pressure
ISEE	Integrated Sustainable Excellent Equitable

ISGEO	International Society of Geographical and Epidemiological Ophthalmology
KDB	Kahook dual blade
LPI	Laser peripheral iridotomy
LPI	Laser peripheral iridotomy
MD	Mean deviation
MIGS	Minimally invasive glaucoma surgery
MLT	Micropulse laser therapy
MMC	Mitomycin C
MP TLT	Micropulse transcleral laser therapy
MRI	Magnetic resonance imaging
MSICS	Manual small incision cataract surgery
MTSCPC	Micropulse transcleral cyclophotocoagulation
Nd-YAG	neodymium-doped yttrium aluminum garnet
NF-1	Neurofibromatosis 1
NGO	Non-governmental organisation
NTG	Normal tension glaucoma
NVG	Neovascular glaucoma
OAG	Open angle glaucoma
OCT	Optical coherence tomography
OHT	Ocular hypertension
ONH	Optic nerve head
ONL	Outside normal limits
OSCARS	Ophthalmology surgical competency assessment rubrics
OSE	Ophthalmological Society of Ethiopia
PACD	Primary angle closure disease
PACG	Primary angle closure glaucoma
PAS	Peripheral anterior synechiae
PCG	Primary congenital glaucoma
PDG	Pigment dispersion glaucoma
PECI	Package of eye care interventions
PI	Peripheral iridectomy
POAG	Primary open angle glaucoma
PS-OCT	Posterior segment optical coherence tomography
PSD	Pattern standard deviation
PTM	Posterior trabecular meshwork
PXG	Pseudoexfoliation glaucoma
RAAB	Rapid assessment of avoidable blindness
RAPD	Relative afferent pupillary defect
RDI	Research, development, innovation
RNFL	Retinal nerve fibre layer
RTA	Road traffic accident
SAFO	Société Africaine Francophone d'Ophtalmologie
SD	Standard deviation

SICS	Small incision cataract surgery
SLT	Selective laser trabeculoplasty
SSA	Sub-Saharan Africa
TDM	Trabeculo-descemet's membrane
TEM	Traditional eye medication
TLT	Transcleral laser therapy
TM	trabecular meshwork
Trab-SICS	Trabeculectomy Small incision cataract surgery
TSCPC	Transcleral cyclophotocoagulation
TVT	Tube versus trabeculectomy
U&E	Urea and electrolytes
VA	Visual acuity
VCDR	Vertical cup:disc ratio
VFI	Visual field index
WACS	West African College of Surgeons
WHO	World Health Organization
WNL	Within normal limits
YAG	Yttrium Aluminum Garnet laser

LINKS FOR DOWNLOADS:

- Form 1:** [New patient glaucoma evaluation form](#)
Form 2: [Return patient glaucoma evaluation form](#)
Form 3: [Eye department local information form](#)

- Chart 1:** [Ocular Hypertension](#)
Chart 2: [Early and Moderate Glaucoma](#)
Chart 3: [Advanced and End-stage Primary Open Angle Glaucoma](#)
Chart 4: [Normal Tension Glaucoma](#)
Chart 5: [Acute Primary Angle Closure Glaucoma \(PACG\)](#)
Chart 6: [Chronic Angle Closure Glaucoma](#)
Chart 7: [Glaucoma and Co-existing Cataract](#)
Annex 1: [Adapting the Glaucoma care service in the times of the Covid-19 pandemic](#)

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INTRODUCTION

Glaucoma is a group of eye diseases characterised by progressive optic neuropathy with visual field loss. In Africa, it is a serious and irreversibly blinding eye condition of public health importance, with a prevalence of about 4% in people aged 40 years and above.¹ Glaucoma affects all ages, but the risk increases with increasing age, and genetics also play a role in its development. There is an interplay between raised intraocular pressure (IOP) and ocular anatomical structures such as corneal thickness, corneal hysteresis, optic nerve head size, and ocular blood flow dynamics and intracranial pressure.² In 85-95% of patients in Africa, glaucoma is open-angle glaucoma (OAG) where absence of distinct early symptoms makes the condition hard to be noticed by patients. As such, patients often present at the hospital with advanced disease, with about 90% already blind in one eye.³ Vision impairment in glaucoma cannot be cured but can be prevented if detected early and appropriate effective treatment instituted. These include medical treatment, surgical interventions and laser therapies. Glaucoma is a complex disease to manage and ophthalmologists face many constraints in managing it. Access to quality eye care is noted as a significant risk factor for glaucoma blindness, resulting from lack of treatment or poor treatment outcomes.⁴ It is essential that when eye care service providers make a timely diagnosis of glaucoma, they are resolute in their line of management.

The Toolkit for Glaucoma Management in Africa is intended to provide guidelines and information for developing protocols and models of care, towards improving services for glaucoma care in Africa. The toolkit contains practical steps towards diagnosis of glaucoma, risk assessment for progression and management decisions, as well as specific guidance for treatment and referral to key resources.

It is presented in three sections: firstly, on how to deliver good clinical care of a glaucoma patient in the Sub-Saharan African setting; secondly, on how to plan, set up and deliver glaucoma care services; and thirdly, a section on generating information and evidence, highlighting resources and glaucoma research priorities for SSA that will further support the development of glaucoma care services.

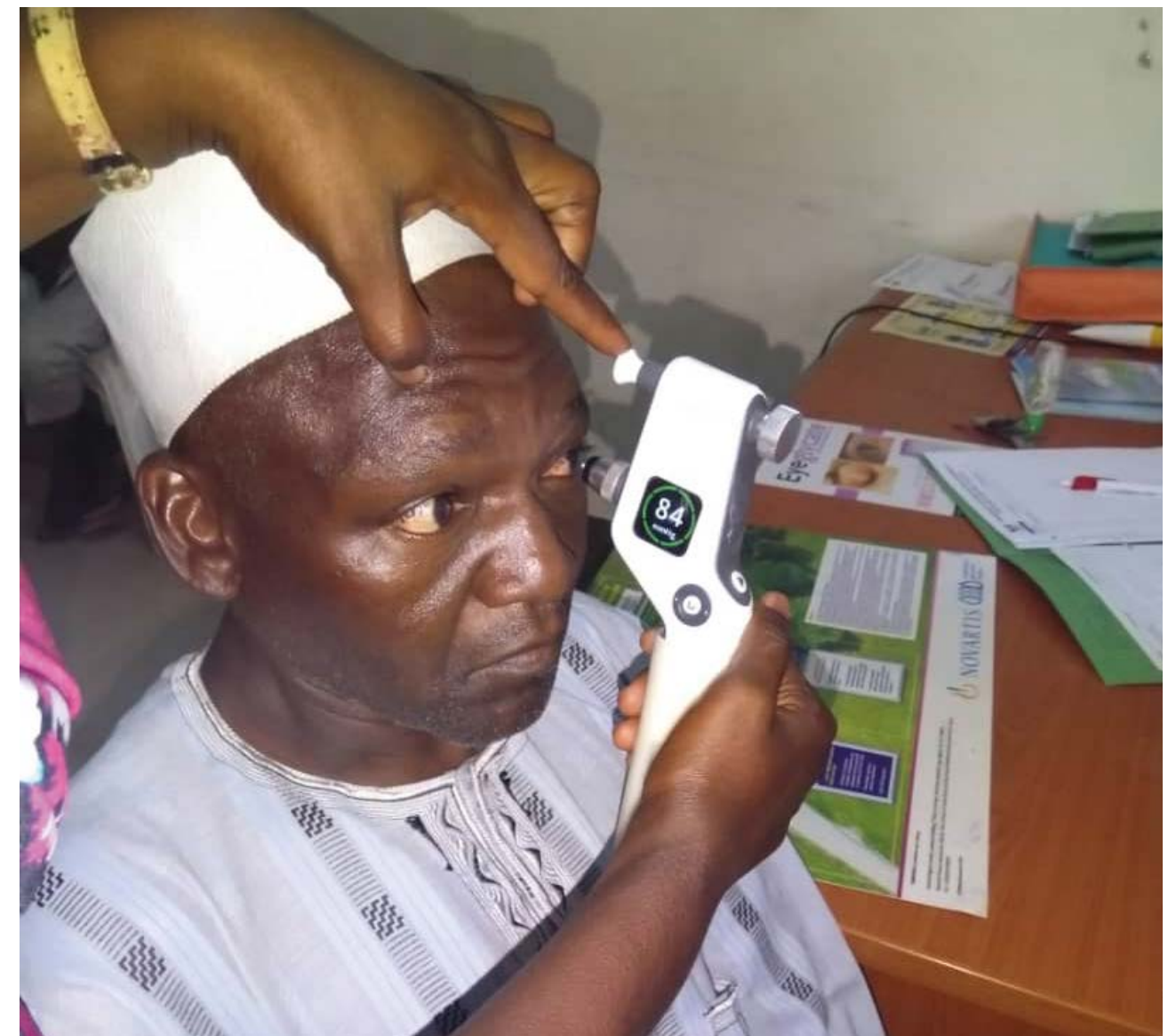
Partners and agencies have demonstrated good collaboration to implement the glaucoma guidelines and toolkit. They have also expressed interest to establish and demonstrate increased quality of glaucoma management through training and the use of guidelines/ toolkit. Some aspects of the toolkit will be piloted in Gondar, Ethiopia and Abuja, Nigeria.

- 1 Kyari F, Abdull MM, Bastawrous A, Gilbert CE, Faal H. Epidemiology of glaucoma in sub-saharan Africa: prevalence, incidence and risk factors. Middle East Afr J Ophthalmol. 2013 Apr-Jun;20(2):111-25. doi: 10.4103/0974-9233.110605. Review. PubMed PMID: 23741130; PubMed Central PMCID: PMC3669488.
- 2 Jonas JB. Role of cerebrospinal fluid pressure in the pathogenesis of glaucoma. Acta Ophthalmol. 2011 Sep;89(6):505-14.
- 3 Kyari F, Entekume G, Rabi M, Spry P, Wormald R, Nolan W, et al. A Population-based survey of the prevalence and types of glaucoma in Nigeria: results from the Nigeria National Blindness and Visual Impairment Survey. BMC Ophthalmol 2015;15(1):176. <http://bmcophthalmol.biomedcentral.com/articles/10.1186/s12886-015-0160-6>
- 4 Kyari F, Wormald R, Murthy GVS, Evans JE, Gilbert CE, on behalf of the Nigeria National Blindness and Visual Impairment Study Group. Ethnicity and deprivation are associated with blindness among adults with primary glaucoma in Nigeria. Results from the Nigeria National Blindness and Visual Impairment Survey. Journal of Glaucoma. 2016;25(10):e861-872

PART 1: Clinical Guidelines and Toolkit

The clinical guidelines sections consist of the following:

1. A **checklist** which can be used in clinic, to facilitate good **clinical diagnosis**, risk assessment and management of a glaucoma patient.
2. Guidance on **staging and risk assessment** in order to determine how aggressive treatment should be.
3. Specific **decision algorithms** for treatment of different types of glaucoma.
4. A **resource / reference section of recipes** of how to conduct clinical procedures mentioned in the checklist.
5. A **current opinion** section for areas of glaucoma care which don't have enough evidence to be included in the algorithms or may be areas of controversy.



CHAPTER 1 - DIAGNOSTICS AND CHECKLIST





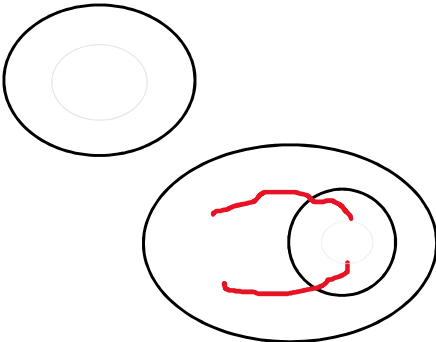
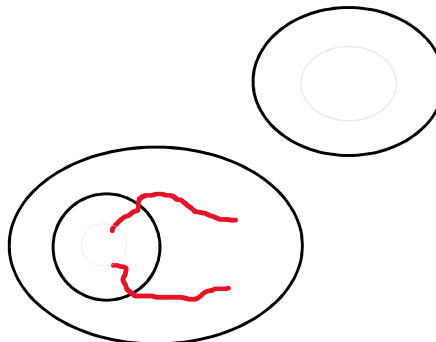
The diagnostics and checklist forms are template forms for users to capture patient information and local evidence of the current situation.

1.1 New Patient Glaucoma Evaluation



The **New Patient glaucoma evaluation** form (**Form 1**) is designed to be user friendly. It includes the key components of the clinical examination to be used with tick boxes for describing the findings. The relevant examination procedures and investigations for making a diagnosis of glaucoma are indicated and represented or graded on the form. Although the actual form is colour-coded, it is also in grey scale for easy reprinting. It is designed in such a way that it can easily be completed by print or electronically. On how to perform some of the specific examinations, see section 1.4.

[illegible]

19	Intraocular pressure, IOP	IOP Time of measurement Tonometry used Diurnal phasing Consider dilated IOP in selected situations	IOP Peak IOP Mean IOP Fluctuation	<table border="1"><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr></table> mmHg													IOP Peak IOP Mean IOP Fluctuation	<table border="1"><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr></table> mmHg																											
20	Target pressure (or range)		Low Mid Late teens	Low Mid Late teens																																									
21	Gonioscopy: width/structures seen Note iris insertion, synechiae, pigment clumps, areas of iris recession, new vessels, flakes, etc. A - dark room gonioscopy B - indentation gonioscopy	<table border="1"><tr><td>1</td><td>Open (1)</td><td>2</td><td>Other (2)</td></tr></table>  A  B	1	Open (1)	2	Other (2)	<table border="1"><tr><td>1</td><td>Open (1)</td><td>2</td><td>Other (2)</td></tr></table>  A  B	1	Open (1)	2	Other (2)																																		
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22	Dilated fundus exam ONH vertical disc diameter category 1 small 2 med 3 large Vertical cup:disc ratio, VCDR ONH: specify excavation, notch, neuroretinal rim thinning (focal/diffuse), disc haemorrhage, peripapillary atrophy, etc RNFL - Normal or focal/ diffuse loss Macula Vessels Periphery Disc damage likelihood scale (DDLS) score	<table border="1"><tr><td></td><td></td><td></td><td>mm</td></tr></table> <table border="1"><tr><td></td><td></td><td></td></tr></table>  <table border="1"><tr><td></td><td></td></tr></table>				mm						<table border="1"><tr><td></td><td></td><td></td><td>mm</td></tr></table> <table border="1"><tr><td></td><td></td><td></td></tr></table>  <table border="1"><tr><td></td><td></td></tr></table>				mm																													
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24	PS-OCT (attach print-out) RNFL analysis (quadrants) Average RNFL thickness Rim area/Rim:Disc ratio Macula Ganglion Cell IPL+	Device used, Test quality, Date <table border="1"><tr><td></td><td>WNL</td><td></td><td>BL</td><td></td><td>ONL</td></tr></table> <table border="1"><tr><td></td><td></td><td></td><td></td><td></td><td></td><td>µm</td></tr></table>		WNL		BL		ONL							µm	<table border="1"><tr><td></td><td>WNL</td><td></td><td>BL</td><td></td><td>ONL</td></tr></table> <table border="1"><tr><td></td><td></td><td></td><td></td><td></td><td></td><td>µm</td></tr></table>		WNL		BL		ONL							µm																
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27	Glaucoma stage	<table border="1"><tr><td>0</td><td>Not glaucoma (0)</td><td>1</td><td>Early (1)</td><td>2</td><td>Moderate (2)</td><td>3</td><td>Advanced (3)</td></tr></table>	0	Not glaucoma (0)	1	Early (1)	2	Moderate (2)	3	Advanced (3)																																			
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1.2 Return Patient Glaucoma Evaluation

The **Return Patient glaucoma evaluation** form (**Form 2**) include a review of findings and evidence of progression in the relevant parameters.

These two patient forms are being piloted and will be amended as necessary.



1	Hospital no./ project code																
2	First Name, Last Name																
3	Date of Birth (dd/mm/yyyy)												Age (years)				
4	Glaucoma diagnosis	Right eye															
		Left eye															
5	Significant interim medical/ocular history																
6	Past glaucoma treatments	1 Medical (1)				2 Surgery (2)				3 Laser (specify) (3)							
7	Glaucoma surgery details & dates																
8	Current ocular medications	Names															
	duration of use																
	frequency of application																
	time of last application																
9	Visual acuity	Right Eye							Left Eye								
		<div></div>							<div></div>								
	Correction status	1 Uncorrected (1) 2 Corrected with current glasses (2) 3 Best-corrected (refracted) (3)							1 Uncorrected (1) 2 Corrected with current glasses (2) 3 Best-corrected (refracted) (3)								
	Current power of glasses, or refraction, as applicable																
10	Pupil: Round & reactive to light?	1 Yes (1)				2 No (2)				1 Yes (1)				2 No (2)			
	If yes,	Brisk (1) 1 Sluggish (2) 2								Brisk (1) 1 Sluggish (2) 2							
	Afferent defect (or RAPD)?	1 Yes (1)				2 No (2)				1 Yes				2 No			
11	Confrontation visual field	1 Full (1) 2 Defect (2)							1 Full (1) 2 Defect (2)								
		<div></div>							<div></div>								
12	Anterior segment																
	Lids/lashes																
	Conjunctiva																
	For Bleb review, note:																
	1. Width of bleb	Clock hours 1-2 3-4 >4							Clock hours 1-2 3-4 >4								
	2. Height of bleb	Low Medium High							Low Medium High								
	3. Bleb vascularity compared to surrounding conjunctiva	Avascular Mild Normal Moderate Severe							Avascular Mild Normal Moderate Severe								
	4. Presence of corkscrew vessels	If yes, number							If yes, number								
	5. Conjunctival microcysts	Absent Moderate Few Abundant							Absent Moderate Few Abundant								
	6. Other bleb features	Thinning Sweat/Leak							Thinning Sweat/Leak								
		Tenon's cyst Overhanging							Tenon's cyst Overhanging								

	7. Bleb photograph taken?		Yes		No		Yes		No	
	Cornea Anterior chamber Iris: note pupillary ruff, flakes Lens (opacity, deposits, etc)/ IOL									
13	Intraocular pressure, IOP Time of measurement Tonometer used Target IOP (or range)	<div>mmHg</div> <div>Low Mid Late teens</div>				<div>mmHg</div> <div>Low Mid Late teens</div>				
14	Gonioscopy: structures seen A - dark room gonioscopy B - indentation gonioscopy	1 Open (1) 2 Other (2) <div>A B</div>				1 Open (1) 2 Other (2) <div>A B</div>				
15	Dilated fundus exam ONH vertical disc diameter	<div>mm</div>				<div>mm</div>				
	category	1small 2 med 3 large				1small 2 med 3 large				
	Vertical cup:disc ratio, VCDR	<div></div>				<div></div>				
	ONH: specify excavation, notch, neuroretinal rim thinning (focal/diffuse), disc haemorrhage, peripapillary atrophy, etc	<div></div>				<div></div>				
	RNFL - Normal or focal/ diffuse loss									
	Macula									
	Vessels									
	Periphery									
	Disc damage likelihood scale (DDLS) score	<div></div>				<div></div>				
	16	Visual field (attach print-out)	Machine used & date							
		Test strategy & Test quality								
		Mean deviation, MD	<div>dB</div>				<div>dB</div>			
Pattern standard deviation, PSD		<div>dB</div>				<div>dB</div>				
17	PS-OCT (attach print-out)									
	Device used & Test quality & Date	<div>WNL ONL BL Mixed (specify)</div>				<div>WNL ONL BL Mixed (specify)</div>				
	Average RNFL thickness	<div>µm</div>				<div>µm</div>				
	Change from previous?									
18	Additional information									
19	Other diagnosis									
20	Glaucoma stage	1 Early (1) 2 Moderate (2) 3 Advanced (1)								

NOTES

1.3 Eye Department Local Information

The third form is for the Eye Department (**Form 3**) to capture local information about the glaucoma situation in the area/clinics; and baseline information on how glaucoma is being managed in the unit/clinic. These include local epidemiology, glaucoma statistics in the clinic, clinical eye examination practice, clinical treatment – surgery numbers, quality of management – for example assess 60 consecutive patients in treatment for at least 3 to 6 months.



Form 3 – Eye department local information form

Date:

	Parameter	Information
1	Name of eye clinic and location - city, state, region, country	
Local Epidemiology		
2	Prevalence of glaucoma (RAAB or survey) – local or national results with dates	
3	Estimated number of people with glaucoma in the catchment area (extrapolate per million population)	
4	Potential number/proportion of undiagnosed glaucoma patients (%)	
5	Is there a local name for glaucoma? Mention	
Glaucoma patients information/statistics in the clinic		
6	Number of glaucoma patients registered in the clinic in the last 3 months (specify dates)	
7	Types of glaucoma and proportions (OAG, ACG, secondary glaucoma, etc)	
Clinical eye examination protocol and pattern of practice in the clinic		
8	Is there a written outlined clinical protocol for glaucoma diagnosis and care?	
9	In the last 3 months, of all new patients aged 40 years and above, how many had the following eye examination? 1. VA test 2. Pupillary reaction assessment 3. VCDR 4. IOP 5. Gonioscopy	Total number assessed – Total number diagnosed with glaucoma - Number who had: 1. VA test 2. Pupillary reaction assessment 3. VCDR 4. IOP 5. Gonioscopy
Basic information on treatment for glaucoma patients in the clinic		
10	Number of glaucoma surgeries done in the last 3 months (specify dates)	

11	Indicate reasons for low surgical output e.g. cost, willingness of surgeon to offer surgery, acceptance by patient, etc	
12	Types of glaucoma medication available in the clinic/hospital. Is the latanoprost heat stable? Is it available? How is it usually obtained?	
Information of quality of glaucoma care in the clinic		
13	Retrospective review of 60 consecutive glaucoma patients who have been in treatment for at least 6 months – to assess if there is a methodical way of monitoring glaucoma patients: Re-examination for: 1. Visual acuity 2. IOP at regular intervals/visits 3. Visual fields Is there a set target IOP?	
Community glaucoma care and support		
14	Is there a local eye care support system such as glaucoma ambassadors or glaucoma patients association?	
15	Identify glaucoma service centres (existing or potential) at the primary, secondary and tertiary level in relation to the eye unit/clinic Are they linked to work together and can develop a model of glaucoma care continuum?	

CHAPTER 2 - STAGING AND RISK ASSESSMENT



The staging and risk assessment tool indicates the criteria for assessing the patient's stage at presentation, viz. early glaucoma, moderate glaucoma, or advanced glaucoma. This creates a risk calculator (scoring system) in a sub-Saharan African setting to identify the patient characteristics which are likely to predict the patient's risk of sight loss in their lifetime; indicating whether low risk, medium risk, or high risk. A combined table of stage and risk is to identify the urgency of treatment and referral; and what level of care will optimally suit the patients after initial diagnosis and management. For example, low risk and early stage can be followed up in primary care but advanced glaucoma at high risk should be managed in higher levels of care setting. This may have to be adapted for Africa from current staging and risk assessment scores at first, but further research ideas could be suggested too.

2.1 Staging the severity of glaucoma

On staging, criteria for both optic nerve head (ONH) and visual fields (VF) are included. Staging should be based on the worst eye, taking into account the disc appearance and visual fields, where possible. However, we also want to get an idea of severity even from primary eye care workers in the community who may not have visual fields or even ability to see the disc. In which case, the primary eye care worker might be able to indicate advanced nature of glaucoma based on the navigating ability of the patient in his/ her surroundings.

At the primary level the emphasis will be on case finding (or screening) for glaucoma. At this level of care, visual acuity (VA), IOP assessment (by Shiotz, Tonopen or Non-contact tonometers), recognition of non-reactive pupils ("black pupils" associated with loss of vision) and presence of family history are key screening tools.

At the secondary level, we should consider the following, at the least:

- ▶ **Early glaucoma** - No pupil abnormality, VF to confrontation essentially full
- ▶ **Moderate glaucoma** - Pupillary reaction may still be brisk, VF to confrontation missing in either superior or inferior hemifield
- ▶ **Advanced glaucoma** - Mid-dilated or sluggish pupils* with loss of most or all peripheral vision, small central vision remaining.

*Note that pupils are often sluggish in advanced glaucoma. RAPD is uncommon or subtle as glaucoma is often bilateral. A fixed pupil may be seen in acute angle closure attack or in no light perception stage. Moreover, pupil examination needs a specified light source and considerable skill. The role of pupil examination is limited in glaucoma.

At the secondary level we would recommend that both scores for the ONH and VF are done but the worst is used for final severity scoring. Where there is a mismatch between structure and function, probably safest to score according to the disc damage likelihood scale (DDLS) score, if the optic disc is visible.

However, be cautious with taking the worse of the two as the final stage, as VF can be bad due to poor test effort or coincident eye disease and it would be inappropriate to stage someone as severe who has a small focal ONH notch and a terrible field due to cataract or poor test quality. For this reason, perhaps the ophthalmologist should, at discretion, take the staging as the better of the two scores. If the nerve looks cupped but the field is minimally impacted, perhaps that is a large nerve with some degree of physiologic cupping. Conversely, an eye may have modest cupping but severe VF loss due to cataract or poor test effort. In such cases, selecting the better of ONH or VF is more representative of the glaucoma status. Another consideration in use of VF is that it is prone to difficulty and variations in test methods. Few can perform it well, there are long learning curves, and artefacts, etc.

In summary, VFs are not uniformly available, are prone to patient error, and can be abnormal due to non-glaucoma pathology. Additionally, using both ONH structure and VF reports could create conflicts if they disagree.

Another consideration is to modify the ISGEO⁵ approach: Thus, develop a stand-alone VF grading scale. If high-quality VF are available, use VF for staging. In the absence of high-quality VF, use DDLS score for staging.

The following tool is to be used by eye care providers at the time of confirmatory glaucoma evaluation.

In view of the foregoing considerations, for structural staging, the disc damage likelihood scale (DDLS) score is adopted; as the DDLS score is designed for stand-alone staging.^{6,7,8} While VF examination is recommended to document optic nerve function at baseline and to monitor glaucoma progression, if the patient is able to perform the test reasonably well. In this case, patients with VF defects involving the central 10 degrees are categorised as having advanced disease and given due attention, even if the ONH scoring corresponds to earlier stage.

To include the use of VF reports in the staging, consider

1. Reliability Criteria of the VF test
2. VF findings correlation with the ONH changes and
3. No media opacity or other non-glaucoma pathology to explain the VF defect: e.g. no central corneal medication toxicity, no central posterior capsular opacity, and no visually significant cataract (can use a cut-off LOCS grade or VA), etc.
4. The category based on mean deviation (MD) can also be considered as long as there is no media opacity that leads to increased MD.

5 Foster PJ, Buhrmann R, Quigley HA, Johnson GJ. The definition and classification of glaucoma in prevalence surveys. Br J Ophthalmol 2002;86:238–242.

6 Bayer A, Harasymowycz P, Henderer JD, et al. Validity of a new disk grading scale for estimating glaucomatous damage: correlation with visual field damage. Am J Ophthalmol. 2002;133:758-763.

7 Henderer JD, Liu C, Kesen M, Altangerel U, Bayer A, Steinmann WC, Spaeth GL. Reliability of the disk damage likelihood scale. Am J Ophthalmol. 2003 Jan;135(1):44-8. doi: 10.1016/s0002-9394(02)01833-0. PMID: 12504696.

8 Kara-José AC, Melo LAS Jr, Esporcatte BLB, Endo ATNH, Leite MT, Tavares IM. The disc damage likelihood scale: Diagnostic accuracy and correlations with cup-to-disc ratio, structural tests and standard automated perimetry. PLoS One. 2017 Jul 20;12(7):e0181428. doi: 10.1371/journal.pone.0181428. PMID: 28727836; PMCID: PMC5519156.

The DDLS step by step⁹

Step No. 1

Perform pupillary dilation if necessary (post iridotomy in angle closure disease). The pupils must be sufficiently large to allow a clear view of the fundus.

Step No. 2

Get an idea of both of the patient’s optic nerve head (ONH) via examination at the biomicroscope with a strong plus lens (e.g. +66.00 D). Determine the vertical size of the disc. For example, if you use a +66.00 D lens (which gives a 1.0x magnification), the graticule on the slit lamp from Haag-Streit AG (Köniz, Switzerland) will indicate the size in millimeters. Multiply this figure by 0.9 for a +60.00 D lens or by 1.3 for a +90.00 D lens.

Step No. 3

Choose one of the patient’s eyes to concentrate on first. Examine the ONH for an area where its outer edge is clearly distinguished from other ocular tissue such as sclera. Then, determine the full circumference of the outer edge.

Step No. 4

Define the inside edge of the neuroretinal rim (outer edge of the cup). Estimate the rim-to-disc ratio by comparing the width of the neuroretinal rim with that of the disc diameter on the same axis. Perform this comparison at several clock positions. If the rim-to-disc ratio is different at various parts of the rim, note the area at which the rim is narrowest and calculate the rim-to-disc ratio there.

Step No. 5

Draw the shape of the optic disc. When sketching the neuroretinal rim’s inner edge, indicate clear demarcation with a thick line and less clear demarcation with a thin or hatched line. Note the course of blood vessels that help determine the rim’s width and any pertinent features of the disc (e.g. notches, pallor, haemorrhage).














Step No. 6

Determine the DDLS by using your drawing of the disc, the narrowest rim-to-disc ratio, the size of the disc, and the DDLS nomogram (Table 1). If the ONH is smaller or larger than average, you must adjust the DDLS score appropriately. An easy method is to stage the ONH as if it were of average size and then increase the stage by one if the ONH is small or decrease the stage by one if it is large. Note the DDLS score in the patient’s chart.

Using the Disc Damage Likelihood Scale (DDLS) score below (Table 1), separately grade the right and left ONH.

9 Spaeth GL. The Disc Damage Likelihood Scale. Using the optic disc to diagnose and manage glaucoma. Available at http://glaucomatoday.com/2005/02/0105_18.html/

Disc damage likelihood scale (DDLS) score

	Narrowest width of rim (rim / disc ratio)				Examples		
New DDLS Stage	For Small Disc < 1.50 mm	For Average Size Disc 1.50 - 2.00 mm	For Large Disc > 2.00 mm	Old DDLS Stage	1.25 mm optic nerve	1.75 mm optic nerve	2.25 mm optic nerve
1	.5 or more	.4 or more	.3 or more	0a			
2	.4 to .49	.3 to .39	.2 to .29	0b			
3	.3 to .39	.2 to .29	.1 to .19	1			
4	.2 to .29	.1 to .19	less than .1	2			
5	.1 to .19	less than .1	0 for less than 45°	3			
6	less than .1	0 for less than 45°	0 for 46° to 90°	4			
7	0 for less than 45°	0 for 46° to 90°	0 for 91° to 180°	5			
8	0 for 46° to 90°	0 for 91° to 180°	0 for 181° to 270°	6			
9	0 for 91° to 180°	0 for 181° to 270°	0 for more than 270°	7a			
10	0 for more than 180°	0 for more than 270°		7b			

Consult the following to determine the patient's stage of glaucoma

DDLS Score	Glaucoma Stage
1-4	Early
5-7	Moderate
8-10	Advanced

Stage for right and left eyes

	Right Eye	Left Eye
DDLS Score		
Stage of Glaucoma		

NOTES

2.2 Risk assessment for progression of vision loss from glaucoma

To be clear – we are trying to identify the patient’s risk of their glaucoma features progressing so that the patient may suffer significant vision impairment in their lifetime. It is not risk of conversion from glaucoma suspect or ocular hypertension (OHT) to developing progression to glaucoma. The pointwise risk assessment can, therefore, be useful as a clinical decision support tool; and be applied to all patients from glaucoma suspects, ocular hypertension to advanced glaucoma patients. The patient’s age is one of the most important factors to be assessed. For example, all patients under age 40 years are high risk as they require their vision to last another 40 years or more, whereas a 90-year old with OHT is at low risk. However, higher baseline age with worse mean deviation (MD) at diagnosis increases the risk of progression of vision loss.¹⁰ Other risk factors are ocular and demographic factors including sex, income, distance from hospital etc. The factors are categorised accordingly, and points allocated to each factor/category.

Risk of progression of vision loss in primary open-angle glaucoma (POAG) and additional factors to be considered for primary angle-closure glaucoma (PACG)

Parameter	Score 1 point for each of the following risk factors	Score 2 points for each of the following risk factors	Score 3 points for each of the following risk factors
Age ¹	>61 years	>40 to 61 years	Up to 40 years
Sex		Male	
Race	Caucasian	Hispanics	African/Caribbean
Socioeconomic status ²	Affluent	Medium	Deprived
Access to health care	Easy	Somewhat difficult	Difficult
Family history of glaucoma	FDR (other than sibling) having glaucoma	Sibling having glaucoma	FDR with blindness due to glaucoma
IOP at baseline ³	Up to 28 mm Hg	29 to 40 mm Hg	>40 mm Hg
Diurnal IOP fluctuation ⁴			>6 mm Hg
IOP control on medical treatment	Achieved on one or two medication	Achieved on more than 2 medications	Not achieved
CCT ⁵	> 555 µ	485 to 555 µ	< 485 µ

¹⁰ Bommakanti N, De Moraes CG, Boland MV, Myers JS, Wellik SR, Elze T, Pasquale LR, Shen LQ, Ritch R, Liebmann JM. Baseline Age and Mean Deviation Affect the Rate of Glaucomatous Vision Loss. J Glaucoma. 2020 Jan;29(1):31-38. doi: 10.1097/IJG.0000000000001401. PMID: 31688371.

Parameter	Score 1 point for each of the following risk factors	Score 2 points for each of the following risk factors	Score 3 points for each of the following risk factors
Myopia	Low myopia (Up to 3 D)	Moderate (3-6 D)	High myopia (>6 D)
Optic disc hemorrhage		Yes	
Vascular risk factors	Single factor present	>1 factor present	Long-standing (>5 years)
Stage of Glaucoma at base-line (worst eye)	Early	Moderate	Advanced
Rate of glaucoma progression on Humphrey MD	Slow (Up to -1 dB/ year)	Moderate (-1 to -2.5 dB/ year)	Rapid (> -2.5 dB/ year)
Prior surgery	Cataract extraction	Trabeculectomy	>1 Trabeculectomy OR implantation of GDD
Other ocular condition that needs immediate attention			Yes
Exfoliation			Yes
History of ocular trauma		Without angle recession	With angle recession
History of steroid use			Long-term (> 1 year)
Compliance to treatment			Poor
Compliance to follow up			Poor
Additional factors to be considered for PACG			
Sex		Female	
Race			Inuit and Asian
Peripheral AC depth		Van Herick grade 2	Van Herick grade 0 or 1
Occludable angle	Present	Present despite functional iridotomy	Heavy indentation on gonioscopy despite functional iridotomy
Hyperopia ⁶	Low (Up to 2 D)	Moderate (2 to 5 D)	High hyperopia (> 5 D)
Fellow eye having angle closure			Yes

FDR – first degree relative; IOP – intraocular pressure; CCT – central corneal thickness; MD – mean deviation; GDD – glaucoma drainage device.

Notes:

1. Life expectancy at birth in SSA region, Source: United Nations Population Division. World Population Prospects: 2017 Revision <https://data.worldbank.org/indicator/SP.DYN.LE00.IN?locations=ZG>
2. Will need definition of socioeconomic status for SSA region.¹¹
3. Arbitrary, further research required to suggest modification
4. Measure hourly between 8am-4pm. Peak expected around 12noon. Subtract the lowest from the highest to get the fluctuation value.
5. As per Ehler's formula, CCT deviation by >35 μ from 520 μ will affect the IOP reading by Goldmann applanation tonometer, more than the test-retest variance of the tonometer
6. Hyperopia is included as a factor to consider in risk assessment.¹²

Consult the following chart to determine the patient's risk of progression to visual disability from glaucoma:

Risk Score	Level of Risk of Progression
Up to 15	Low
16 - 40	Moderate
>40	High

Summary of risk score

Risk Score	
Level of Risk of Progression	

11 Kyari F, Wormald R, Murthy GVS, Evans JE, Gilbert CE, on behalf of the Nigeria National Blindness and Visual Impairment Study Group. Ethnicity and deprivation are associated with blindness among adults with primary glaucoma in Nigeria. Results from the Nigeria National Blindness and Visual Impairment Survey. Journal of Glaucoma. 2016;25(10):e861-872.

12 Carpenter N, Grigorian AP. Hyperopia. Available at <https://eyewiki.aao.org/Hyperopia>

CHAPTER 3 - PATHWAYS/ DECISION ALGORITHMS



The main objective of this section is to simplify, preferably in an algorithm flow format, the pathway to a clinical decision. The important thing is to identify and diagnose a glaucoma condition, and when/ how to treat. These flow charts could be pinned up in the clinic for ease of reference. Key resources with evidence supporting these guidelines are referenced.^{13,14,15,16}

The diagnosis and management of the following glaucoma and related conditions are addressed:

1. Ocular hypertension
2. Early primary open angle glaucoma
3. Advanced primary open angle glaucoma
4. Normal tension glaucoma
5. Acute angle closure glaucoma
6. Chronic angle closure glaucoma
7. Glaucoma and cataract
8. Paediatric glaucoma
9. Neovascular glaucoma
10. Glaucoma management in pregnancy

13 Asia-Pacific glaucoma Society Guidelines, 2016. Available at <https://pdf4pro.com/view/asia-pacific-glaucoma-guidelines-1f2de5.html>

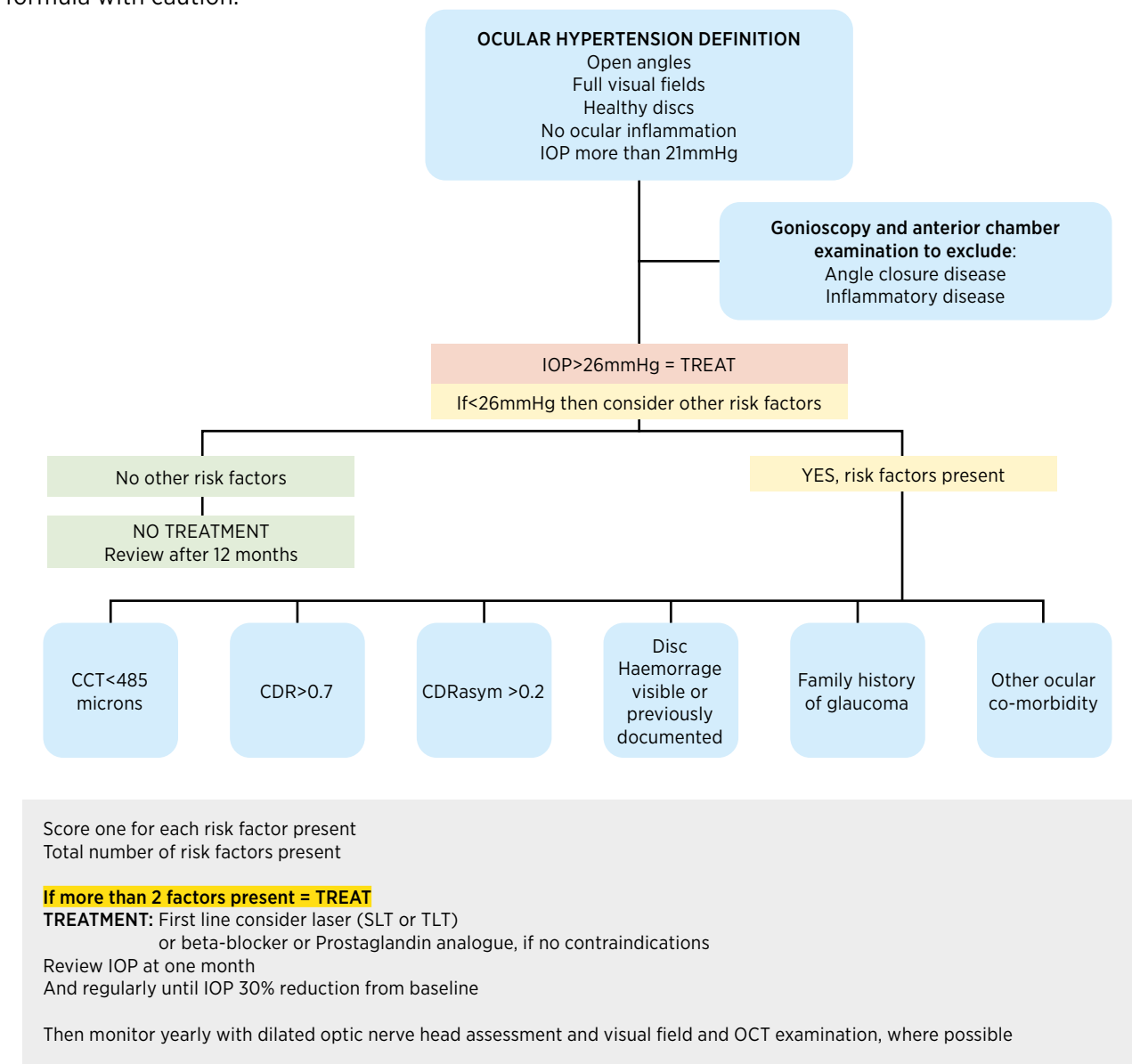
14 ICO Guideline for Glaucoma Eye Care. 2016. Available at <http://www.icoph.org/downloads/ICOGlaucomaGuidelines.pdf>

15 European Glaucoma Society Foundation. Terminology and Guidelines for Glaucoma. 2017. Available at <https://bjo.bmj.com/content/bjophthalmol/101/4/1.full.pdf>

16 COECSA Glaucoma Guidelines for Eastern, Central and Southern Africa. First Edition 2016

3.1 Ocular Hypertension

Ocular hypertension (OHT) is a term reserved for eyes in which the IOP measures above the normal population range, but the ONH and VFs show no signs of glaucomatous damage, and there is no ocular co-morbidity.¹⁷ Additionally, there is normal RNFL on OCT or optic disc photograph, where these imaging equipment are available. The upper limit for “normal” IOPs is considered to be 2 standard deviations (2SD) above the population mean. For example, for the population in Nigeria mean IOP= 14mmHg and SD=4; thus, the upper limit of normal IOP is 22mmHg. The IOP may be corrected for central corneal thickness (CCT) if this can be measured; and in that case, we suggest the use of the Ehlers correction formula with caution.¹⁸

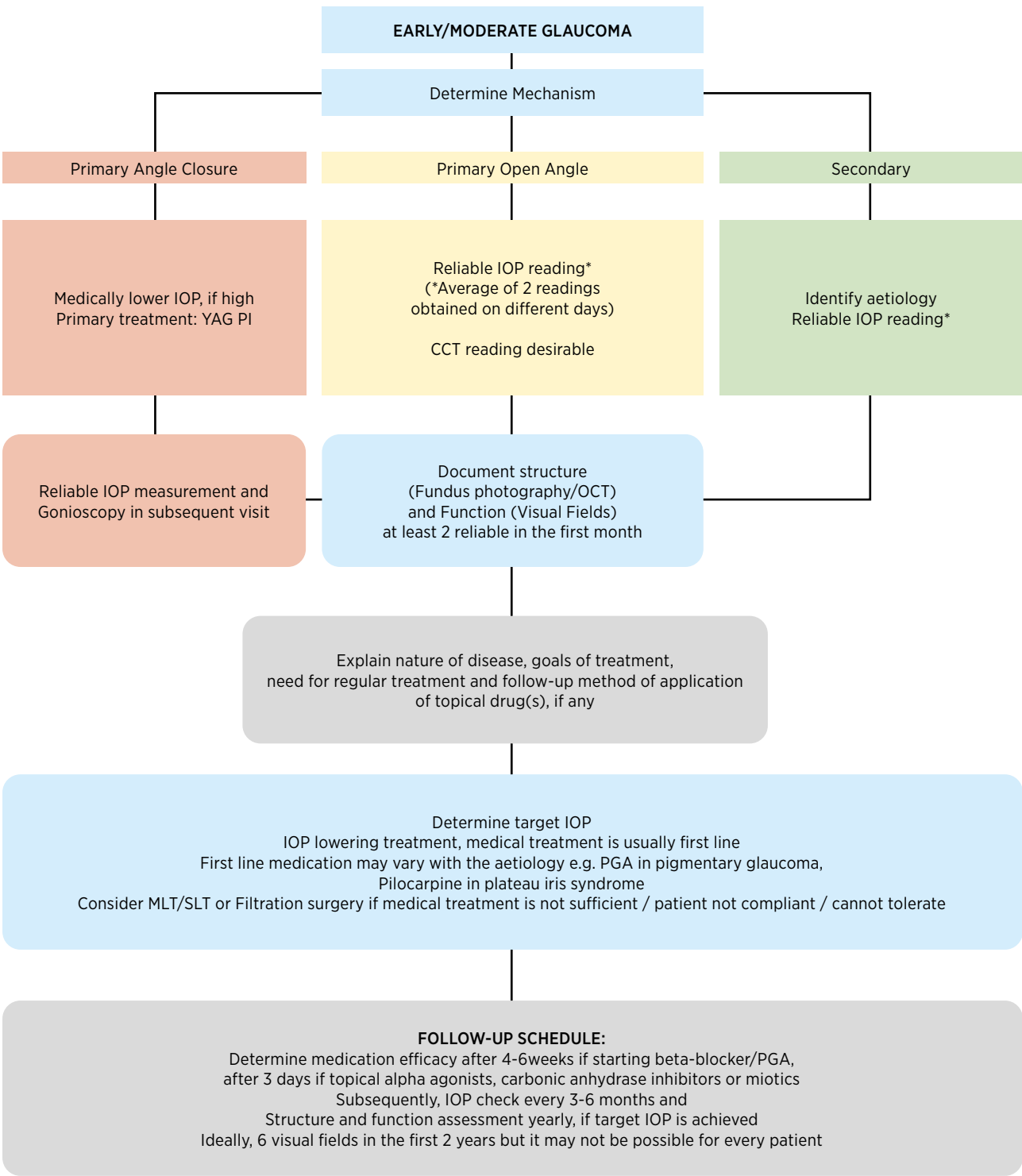


17 Gordon MO, Kass MA, for the Ocular Hypertension Treatment Study Group. The Ocular Hypertension Treatment Study: Design and Baseline Description of the Participants. Arch Ophthalmol. 1999;117(5):573-583. doi:10.1001/archophth.117.5.573

18 Medeiros FA, Weinreb RN. Is corneal thickness an independent risk factor for glaucoma? Ophthalmology. 2012 Mar;119(3):435-436. DOI: 10.1016/j.ophtha.2012.01.018.

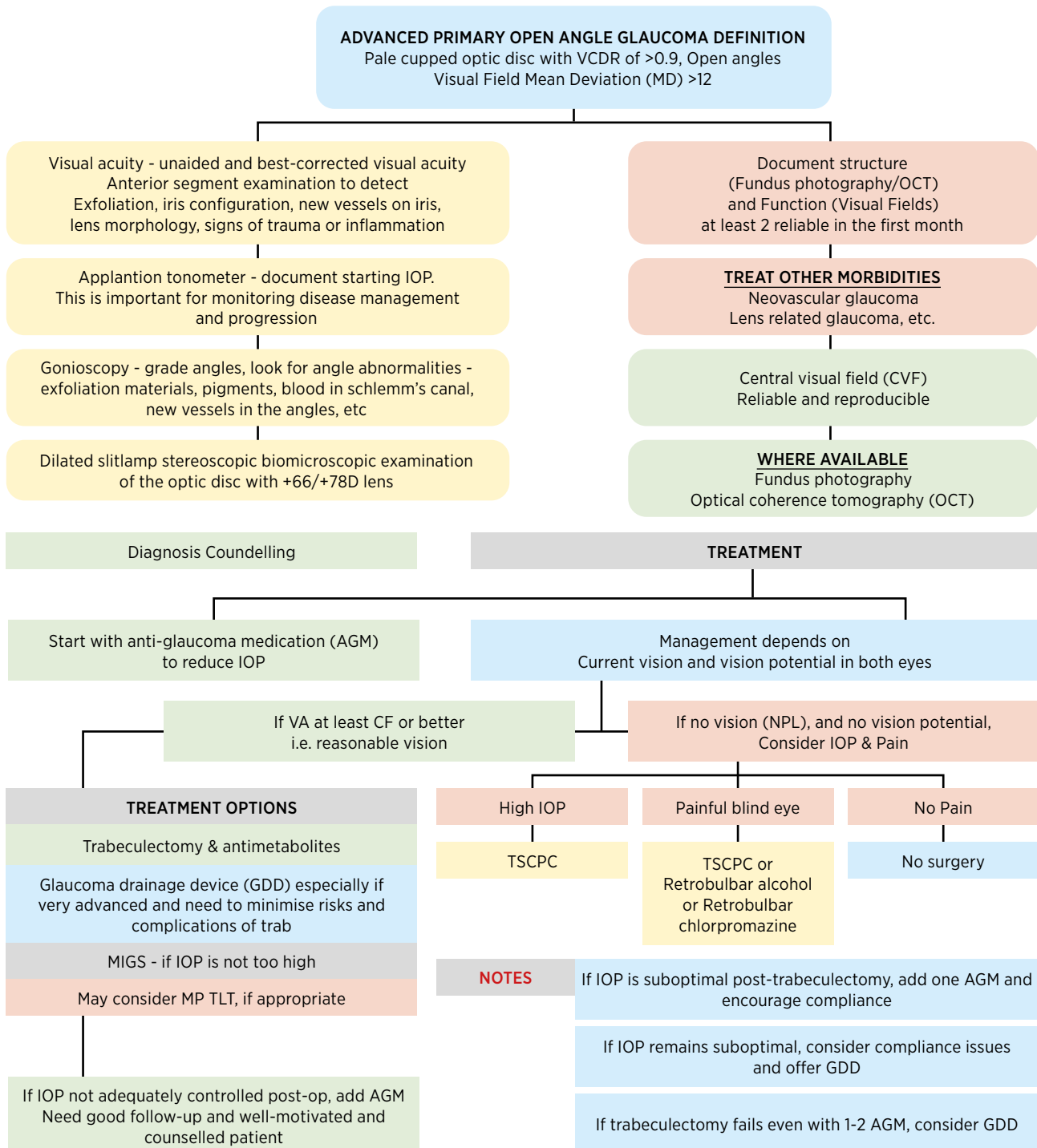
3.2 Early and Moderate Glaucoma

The different types of glaucoma have a common endpoint which is optic nerve head cupping (structural) and visual field defect (functional). The early and moderate glaucoma flow chart provides clinical decision support towards determining the type of glaucoma and its treatment in early/moderate disease. It is to be used together **Form 1**.



3.3 Advanced and End-stage Primary Open Angle Glaucoma

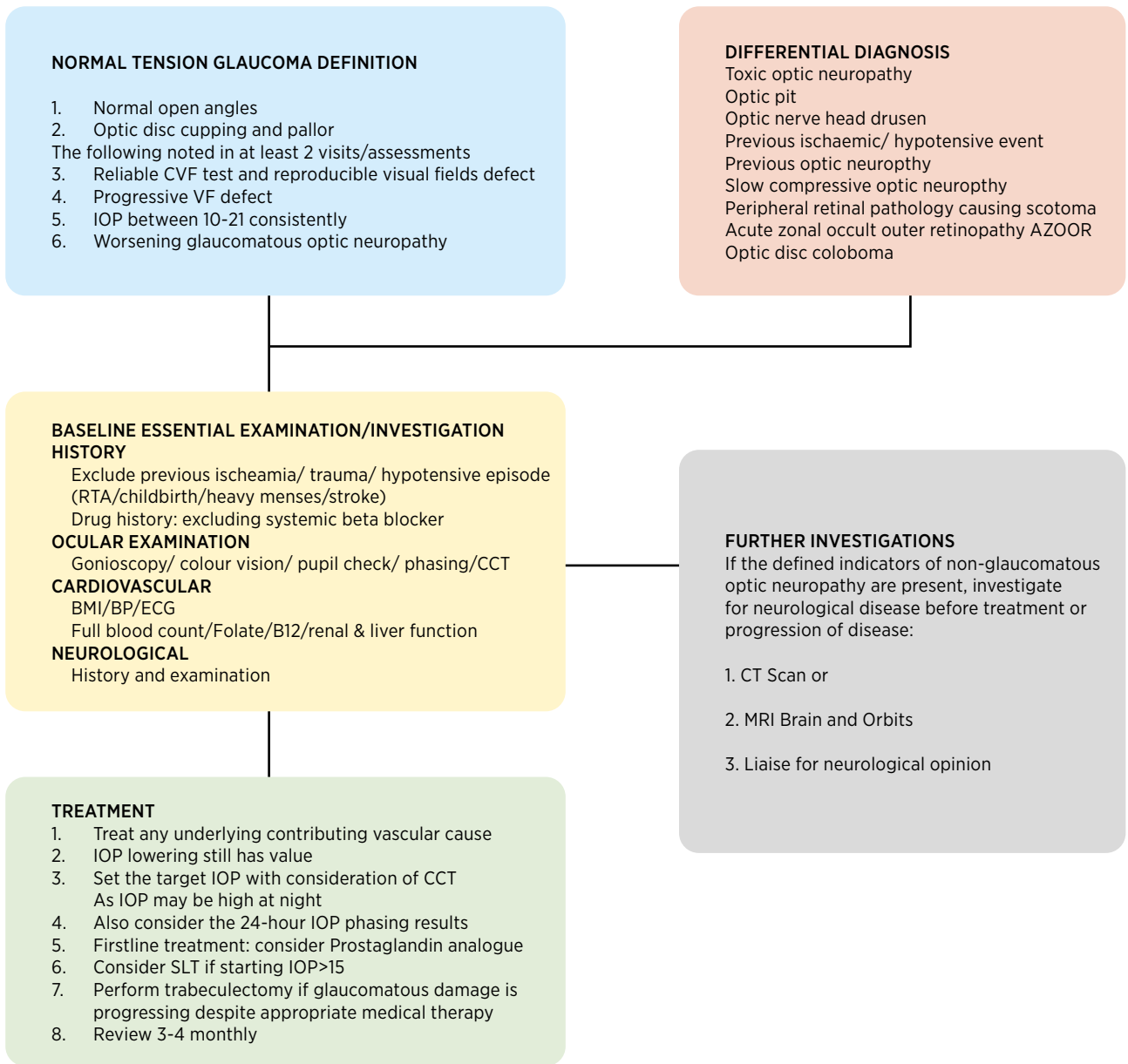
Clinical assessment and documentation of the optic nerve head (ONH) is essential in the diagnosis and monitoring of open-angle glaucoma.¹⁹ The Advanced and End-stage Primary Open Angle Glaucoma Chart is a guide to diagnosis and treatment. It is to be used together with **patient evaluation forms 1 and 2**.



¹⁹ 10th Consensus Meeting: Diagnosis of Primary Open Angle Glaucoma. Edited by: R.N. Weinreb, D.F. Garway-Heath, C. Leung, F.A. Medeiros, J. Liebmann. Kugler Publications 2016. Available at <https://wga.one/wga/consensus-10/>

3.4 Normal Tension Glaucoma

Normal-tension glaucoma (**NTG**), also known as low tension or normal pressure glaucoma, is a form of glaucoma in which damage occurs to the optic nerve when the IOP is within the “normal” range for the population. For example, in Nigeria, the upper limit of normal IOP is 22mmHg (mean IOP+2SD). It is important to distinguish NTG from POAG.²⁰

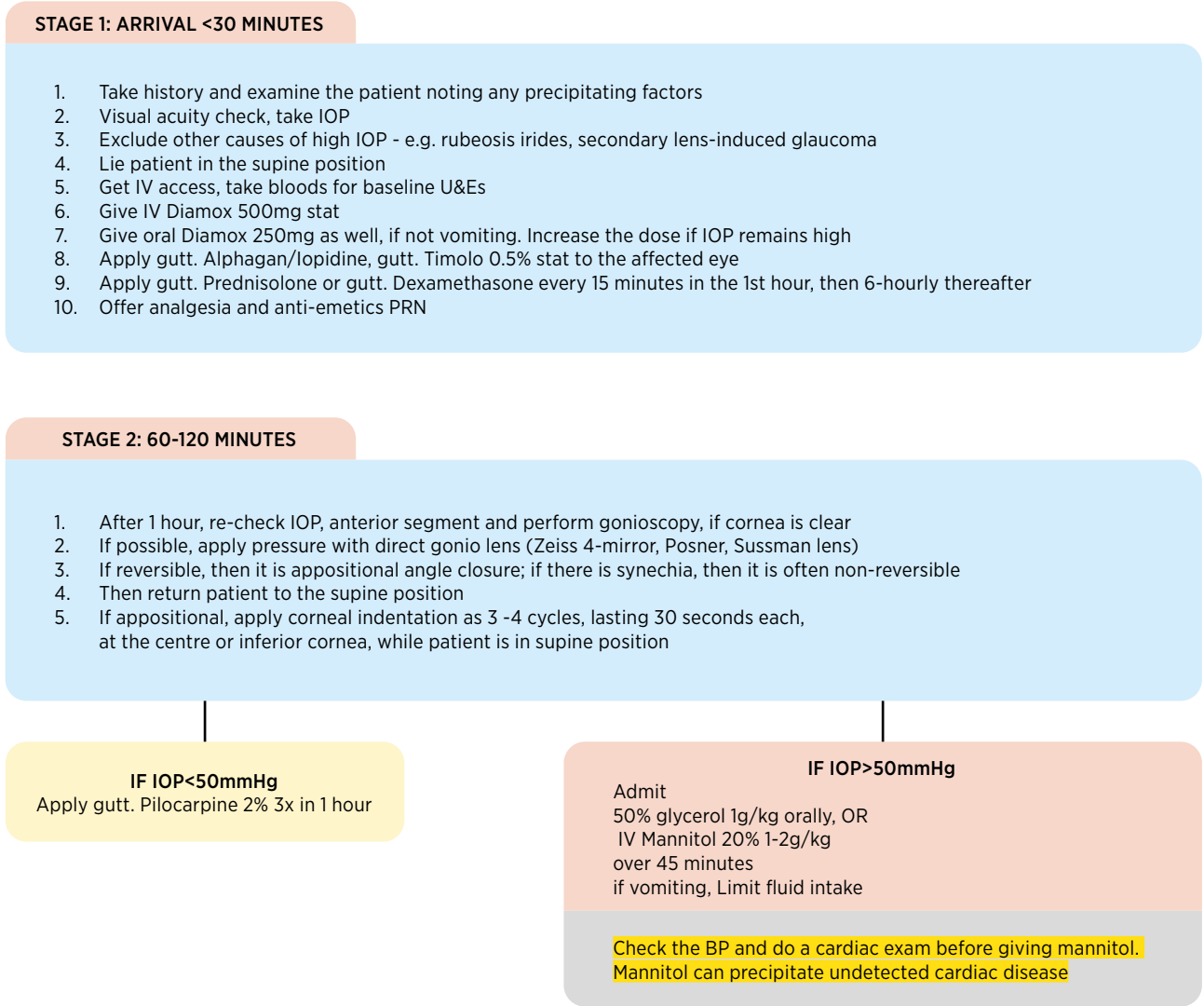


²⁰ Choudhari NS, Neog A, Fudnawala V, George R. Cupped disc with normal intraocular pressure: The long road to avoid misdiagnosis. Indian J Ophthalmol 2011;59:491-7

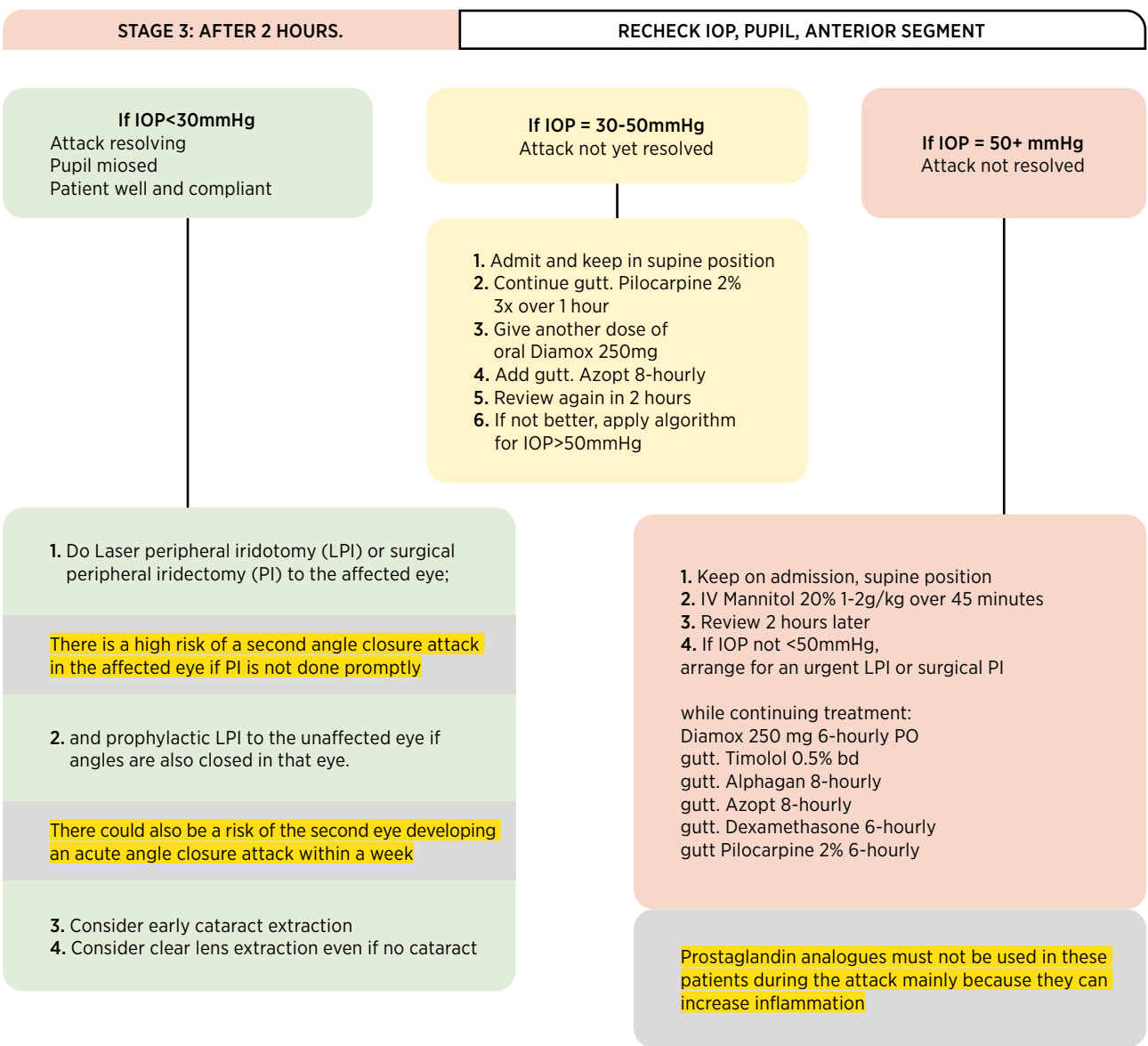
3.5 Acute Primary Angle Closure Glaucoma (PACG)

Acute primary angle closure is an urgent but uncommon dramatic symptomatic event with blurring of vision, painful red eye, headache, nausea, and vomiting. Diagnosis is made by noting high IOP, corneal oedema, shallow anterior chamber, and a closed angle on gonioscopy. Medical or surgical therapy is directed at widening the angle and preventing further angle closure. If glaucoma has developed, it is treated with therapies to lower IOP.²¹

The aim of acute PACG management is to get the IOP <30mmHg before the patient leaves the hospital, as quickly as possible to preserve the optic nerve.



²¹ Khondkaryan A, Francis BA. Angle-closure glaucoma.
Available at <https://www.aoa.org/munnerlyn-laser-surgery-center/angleclosure-glaucoma-19>

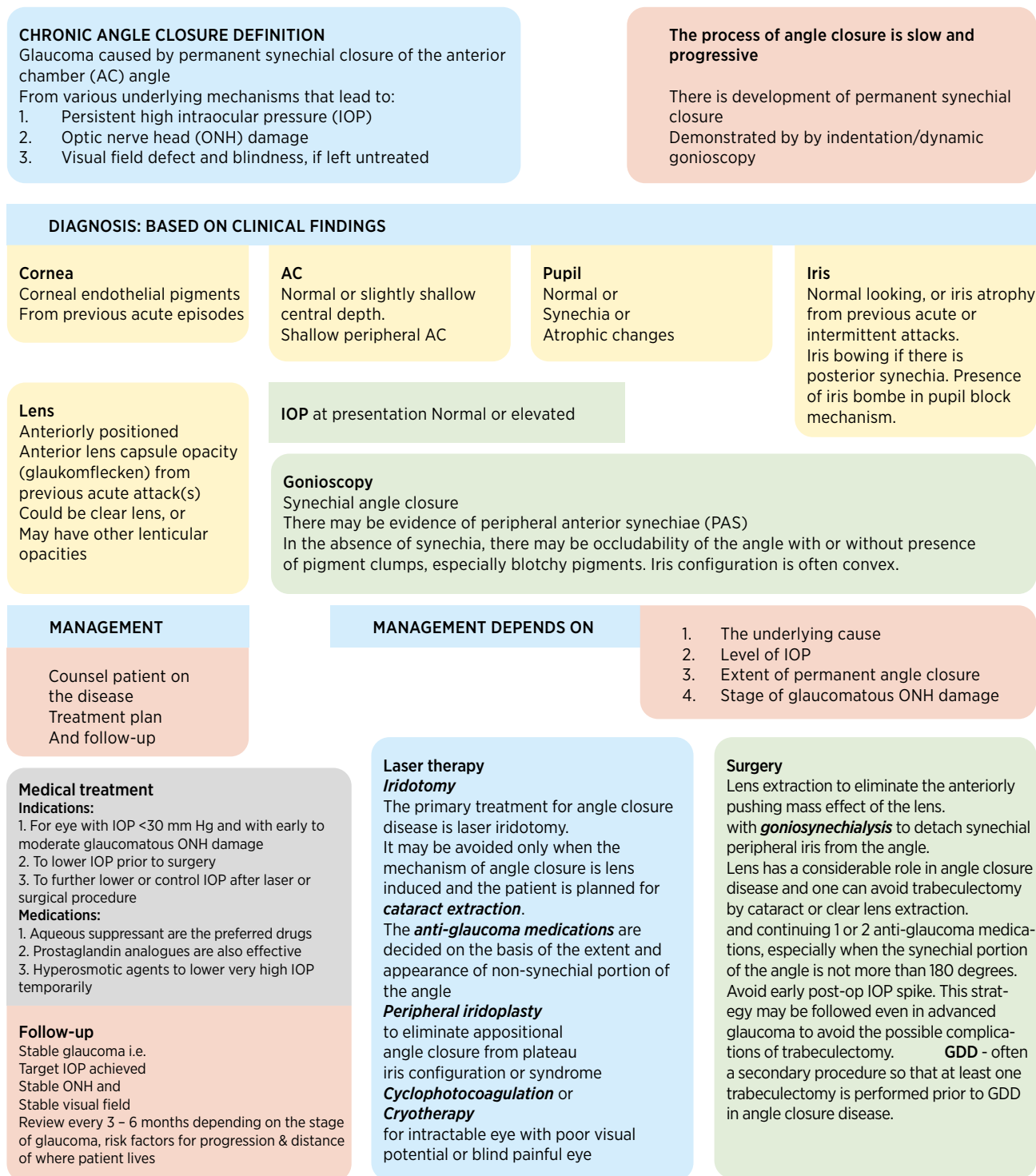


Notes:

- ▶ Carbonic anhydrase inhibitors can make corneal oedema worse
- ▶ Miotics when given frequently and in high concentrations can cause paradoxical raised IOP. So, it is better used when the IOP has reduced.
- ▶ Prostaglandin analogues are effective if the angle is partially open
- ▶ Alpha 2 agonists thought to have neuroprotective properties but no difference in visual field preservation
- ▶ Watch out for metabolic acidosis and electrolyte imbalance
- ▶ Laser PI or paracentesis the most effective means of bringing the IOP down quickly

3.6 Chronic Angle Closure Glaucoma

Chronic angle closure glaucoma refers to glaucoma caused by permanent synechial closure of the anterior chamber angle from various underlying mechanisms, that lead to persistent high intraocular pressure (IOP), optic nerve head (ONH) damage and visual field defect and blindness, if left untreated. The process of angle closure is slow and progressive. There is development of permanent synechial closure determined by indentation/dynamic gonioscopy.



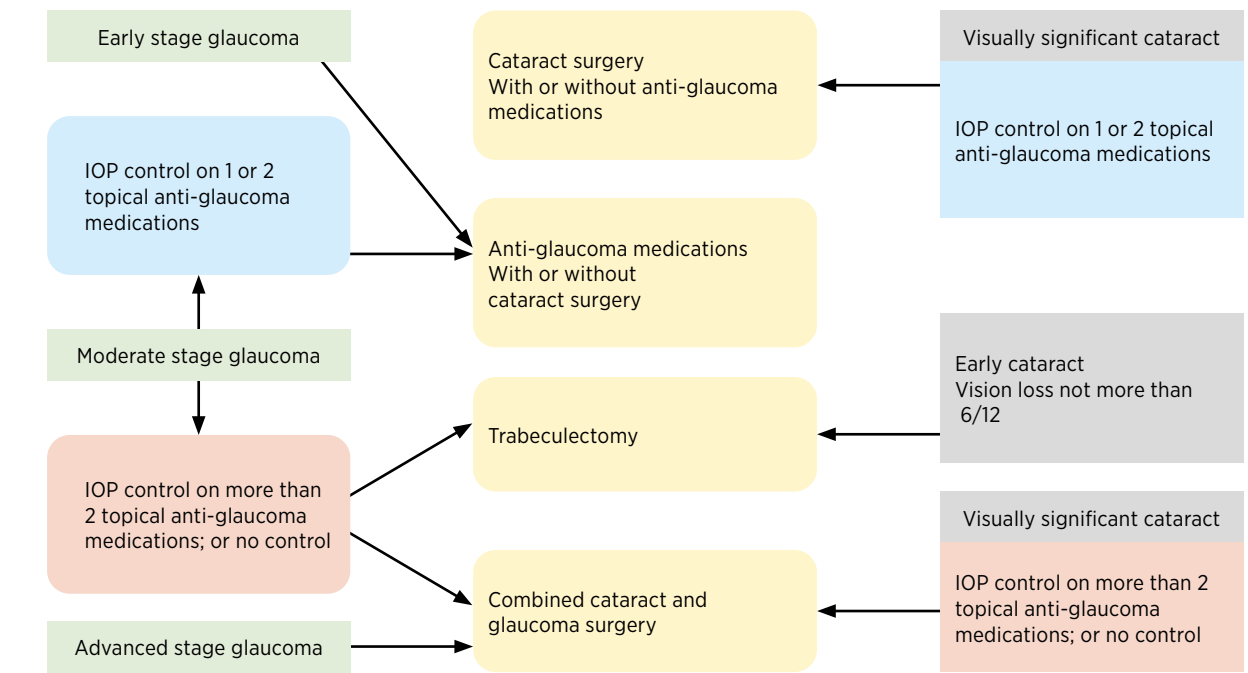
3.7 Glaucoma and Co-existing Cataract

Visually significant cataract and glaucoma often co-exist. A combined cataract and glaucoma surgery in this situation can address both the conditions, besides reducing visits to the operating room, reducing number of follow up visits and the surgical costs to the patient.²²

Fundamental management algorithms depending on the level of cataract or the stage of glaucoma are outlined below. Any of the three fundamental techniques of cataract surgery, viz. extra-capsular, small incision and phacoemulsification can be combined with trabeculectomy. The former two techniques are more suitable in the case of dense cataract, shallow anterior chamber and resource-constrained operating set up. Under certain specific situations, the decisions should be modified.²³

Lens extraction results in more pronounced drop in IOP in PACD than in OAG. In PACD, cataract surgery alone with continuation of one or two topical anti-glaucoma medications may achieve desired IOP control, especially if the synechial (permanent) angle closure is <180 degrees.

In uveitic glaucoma, cataract and glaucoma surgeries should preferably be done under separate sittings to keep the surgery-induced ocular inflammation at a minimum. The surgery should be done under topical or para-bulbar anesthesia in case of advanced glaucoma, in order to reduce the possibility of compartment syndrome leading to macular wipe out. If safe surgery seems difficult under these types of anesthesia, low volume (1-2 ml) peri-bulbar anesthesia supplemented with topical anesthesia or general anesthesia should be considered. One should also avoid application of pressure over the eye, e.g. pinky ball in this situation.



22 Kyari F. Managing cataract surgery in patients with glaucoma. Community Eye Health. 2019;31(104):88-90.

<https://www.cejournal.org/article/managing-cataract-surgery-in-glaucoma-patients/>

23 Choudhari NS. My modifications in SICS IOL Trabeculectomy. LVPEI. https://hyderabadeyeresea-my.sharepoint.com/:v/g/personal/onlinelectures_lvpei_net/EdHCl7MLBOZBigAcZfPUQfABnwsuL7a3M5ORi71to82Z5Q?e=8GIRti

3.8 Paediatric Glaucoma

Glaucoma in children^{24,25,26,27,28,29,30,31} has a major impact on their development and quality of life over their whole life span. Early diagnosis and appropriate therapy can make a huge difference in the visual outcome and can prevent lifelong disability. Surgical treatment is always necessary.



- 24 Papadopoulos M, Khaw PT. Advances in the management of paediatric glaucoma. *Eye (Lond)* 2007;21(10):1319-25.
- 25 Banchio C, Castro RI. Ceguera infantil en la provincia de Neuquén. *Médico Oftalmol.* 2008;21(5):38-40.
- 26 Aponte EP, Diehl N, Mohny BG. Incidence and clinical characteristics of childhood glaucoma: a population-based study. *Arch Ophthalmol.* 2010;128(4):478-82.
- 27 Mandal AK, Chakrabarti D. Update on congenital glaucoma. *Indian J Ophthalmol.* 2011 Jan;59 Suppl(Suppl1):S148-57. doi: 10.4103/0301-4738.73683. PMID: 21150027; PMCID: PMC3038500.
- 28 Ben-Zion I, Tomkins O, Moore DB, Helveston EM. Surgical results in the management of advanced primary congenital glaucoma in a rural pediatric population. *Ophthalmology.* 2011;118(2):231-5.
- 29 Al-Obeidan SA, Osman Eel-D, Dewedar AS, Kestelyn P, Mousa A. Efficacy and safety of deep sclerectomy in childhood glaucoma in Saudi Arabia. *Acta Ophthalmol.* 2012;92(1):65-70.
- 30 9th Consensus Meeting: Childhood Glaucoma. Edited by: R.N. Weinreb, A. Grajewski, M. Papadopoulos, J. Grigg and S. Freedman. Kugler Publications. 2013. Available at <https://wga.one/wga/consensus-9/>
- 31 Congenital Glaucoma – Europe. Available at <https://www.aao.org/topic-detail/congenital-glaucoma-europe>

Classification

1. Primary congenital glaucoma (PCG): from birth to 2 years of life
 - ▶ Neonatal or newborn onset (0-1 month)
 - ▶ Infantile onset (>1 until 24 months)
 - ▶ Late onset or late recognized (>2 years)
 - ▶ Spontaneously non-progressing cases with normal IOP but has typical signs of PCG and may be classified as PCG
2. Late-onset childhood open-angle glaucoma/Early Juvenile (onset >2 to puberty)
3. Secondary childhood glaucoma
 - ▶ Glaucoma associated with non-acquired ocular anomalies e.g. Axenfeld-Rieger syndrome
 - ▶ Glaucoma associated with non-acquired systemic disease or syndrome e.g. Sturge-Weber syndrome, neurofibromatosis (NF-1)
 - ▶ Glaucoma associated with acquired conditions e.g. uveitis, trauma, steroid induced
 - ▶ Glaucoma following childhood cataract surgery

Presentation

Symptoms of paediatric glaucoma

1. Photophobia (sensitivity to light)
2. Epiphora (tearing)
3. Corneal edema (cloudy cornea)

Signs of paediatric glaucoma

1. Buphthalmos (enlarged globe, “big eye”)
2. Photophobia and tearing
3. Corneal edema
4. Breaks in descemet’s membrane (Haab’s striae)
5. Increased intraocular pressure
6. Abnormal optic nerve cupping

Detection of childhood glaucoma

Early identification and referral to a specialised centre are essential for cases of congenital glaucoma. Special attention is required when a baby presents with tearing (epiphora), dislike for light (photophobia), cloudy or large cornea (corneal oedema or buphthalmos).

Management

The management of paediatric glaucoma requires a team approach to lower the IOP, correct existing errors of refraction and anterior segment architecture, and to enable physiologic maturation of the visual pathway to achieve as much vision as possible in the affected cases. If treated promptly and aggressively, useful vision may develop, which in most cases, is far from physiological but much improved compared to decades before when PCG led to blindness in nearly all cases. The treatment for congenital glaucoma is surgical not medical as topical medication is rarely effective. Compliance cannot be expected to be very high in a life-long disease that may lead to blindness.

1. Examination Under Anesthesia (EUA)

The following are the done at EUA:

- a. Confirm glaucoma and find the appropriate diagnosis
- b. Measurement of IOP
- c. Thorough examination of all parts of the eye

Depending on the correct diagnosis, further surgical treatment is planned.

2. Surgical Treatment

The first-line and preferred surgical intervention is goniotomy and trabeculotomy (collectively, “angle surgery”). Goniotomy is performed when the cornea is clear and there is a clear view of the anterior chamber (AC) angle structures. Trabeculotomy is performed when the cornea is cloudy with poor view of the AC angle structures.

Other options include combined trabeculotomy and trabeculectomy, and trabeculectomy with mitomycin C, although not advised for PCG. Glaucoma drainage devices (GDD) e.g. Molteno, Baerveldt, and Ahmed devices are options to be considered depending on availability and indications.

3. Additional Treatment

- a. Spectacles for refractive error - Frequent cycloplegic refraction (every 4–6 months) is often necessary due to rapid IOP changes.
- b. Treat amblyopia and strabismus
- c. Tinted (or transition) lenses (may help with photophobia)

Recommendations for infantile aphakic glaucoma

Paediatric post-cataract patients are at high risk of developing aphakic or pseudophakic glaucoma. The onset of glaucoma may be early in the post-operative period or later in childhood. The average age of onset is approximately 8 years after cataract surgery, but it can occur at any time. Children who undergo surgery for cataract in the first 6 – 9 months of life, such as infants with microphthalmia, nuclear cataracts, or PHPV, are at the highest risk. But any child who has undergone cataract surgery can develop open or closed angle aphakic glaucoma. It is prudent for paediatric cataract surgeons to weigh up between early lens wash out and potential development of glaucoma. The insertion of an IOL does not reduce the risk of glaucoma in these children. Thus, post-cataract patients should be

frequently and regularly examined for glaucoma. Glaucoma screening should be part of every follow-up examination for the remainder of the lives of these children, even when IOP measurements are difficult.

Early signs of infantile aphakic glaucoma may include:

- a. decreased aphakic refraction (reduced plus power from globe elongation)
- b. corneal clouding or enlargement (at an early age)
- c. optic nerve cupping. Note of the optic nerve heads is a necessary part of any post-cataract examination in the clinic or in the operating room.

3.9 Neovascular Glaucoma

Definition

Neovascular glaucoma (NVG) is a type of secondary glaucoma that is mainly associated with neovascularisation of the iris and/or anterior chamber angle with raised IOP.

The diagnosis of NVG includes understanding of the underlying cause, and examination of iris, anterior chamber angle and posterior segment. Depending on the progression of the disease, NVG can be either open-angle or closed-angle glaucoma.

Open-angle NVG

This may result from covering of the angle by proliferative fibrovascular membrane

Diagnosis is based on clinical features

1. Elevated Intraocular pressure
2. New vessels (rubeosis iridis) on the iris surface and pupil
3. Open angle with neovascularisation / fibrovascular membrane on gonioscopy

Management

Medical

1. Treating the underlying cause could lead to complete resolution of the condition and normalisation of the IOP.
2. Treatment of the underlying systemic disease, e.g. blood sugar control, also has a role in controlling the process of neovascularisation.
3. Hypotensive agents – aqueous suppressants can be used to control the IOP
4. Consult or refer to retinal specialist for further management.

Surgical

Surgical intervention is recommended for medically uncontrolled glaucoma after treatment of underlying cause³²

1. Filtration surgery – Trabeculectomy
 - ▶ The chance of failure is high
 - ▶ There is better success after anti-VGEF and or panretinal photocoagulation
 - ▶ Use of anti-fibrotic agent like mitomycin C is helpful
2. Tube-shunt surgery (GDD)
 - ▶ Has a better outcome but more likely to have complications than trabeculectomy.

Laser

Cyclophotocoagulation is useful for refractory glaucoma

Angle-closure NVG

This may result from contracture of fibrovascular membrane

Diagnosis based on clinical features

1. Severely elevated IOP
2. Iris and pupil: new vessels with flatten iris stroma or absence of iris crypts and glistening appearance.
3. Pupil: Less reactive and ectropion uvea
4. Gonioscopy: Prominent peripheral anterior synechia

Management

Medical

1. Consult or refer to retinal specialist for treatment of the underlying cause
2. Hypotensive agents – aqueous suppressants can be used to control the IOP
3. Hyperosmotic agents for temporary control of very high IOP >40 mmHg
4. Topical anti-inflammatory drops to reduce inflammation
5. Atropine to induce cyclopegia and reduce pain of the painful eye

Surgical

- ▶ Trabeculectomy – is prone to complications and high chances of failure; so better to avoid
- ▶ Tube-shunt surgery (GDD) – is the preferred procedure. Tube is safe when placed behind the iris in pseudophakic eyes

Laser

Cyclophotocoagulation or cyclocryotherapy – is useful for eyes with limited visual potential and when other treatment modalities become ineffective.

32 Allingham RR, Damji KF, Freedman S, Moroi SE, Rhee D eds. Surgery of the anterior chamber angle and Iris. Shields Textbook of Glaucoma. 6th ed. Philadelphia, Lippincott Williams & Wilkins, 2011: 294 – 305.

3.10 Managing Glaucoma in Pregnancy and during Lactation

Glaucoma is a progressive optic neuropathy with characteristic optic nerve head changes associated with corresponding visual field defects in which intraocular pressure (IOP) is one of the risk factors. Pregnancy has been shown in several studies to influence IOP as a result of the associated hormonal changes. IOP decreases as pregnancy advances and the decrease is more pronounced in ocular hypertensive pregnant women than non-ocular hypertensive women. Paradoxically, the course of glaucoma progression in pregnancy does not follow the IOP shift. In a study of 15 pregnant glaucoma patients who were followed up throughout pregnancy, 17.9% had visual field progression with stable IOP or increased IOP.³³ Therefore, pregnant glaucoma women must be monitored closely during pregnancy.³⁴

Treatment options for glaucoma include medical, laser and surgery. The safety of a particular treatment option to the fetus and the mother ought to be guided by evidence from well conducted clinical research. However, absence of adequate studies from these patients poses great challenge to clinicians. The paucity of the data has forced physicians to rely on animal studies and case series for decision-making.

Medical Treatment in Pregnancy

Medical treatment of glaucoma in pregnancy involves striking a balance between the risk of glaucoma progression in the mother and the risk of harmful effect of the drugs to the developing fetus. Food and Drug Administration (FDA) classified drugs used in pregnancy into the following classes based on their safety profiles:

1. **Class A:** Controlled studies show no risk. Adequate well-controlled studies in pregnant women have not shown any risk to the fetus
2. **Class B:** No evidence of risk in humans. Either animal studies have shown risk, but human studies have not or, if no adequate human studies have been done, animal studies are negative
3. **Class C:** Risk cannot be ruled out. Human studies are lacking, and animal studies are either positive for fetal risk or inadequate as well. However potential benefits may outweigh the potential risk
4. **Class D:** Definite evidence of risk. Investigational or post-marketing data show some risk to the fetus. But potential benefits may outweigh the potential risk
5. **Class X:** Contraindicated in pregnancy. Studies in animals or human or investigational or post-marketing reports have shown fetal risk which clearly outweighs any benefit to the patient.

The Individual medications used in treatment of glaucoma are assessed based on the above classification. There is currently no anti-glaucoma medication that has satisfied criteria for the Class A category.

33 Brauner SC, Chen TC, Hutchinson BT, Chang MA, Pasquale LR, Grosskreutz CL. The Course of Glaucoma During Pregnancy: A Retrospective Case Series. Arch Ophthalmol. 2006;124(8):1089–1094. doi:10.1001/archophth.124.8.1089

34 Sethi HS, Naik M, Gupta VS. Management of glaucoma in pregnancy: risks or choices, a dilemma? Int J Ophthalmol. 2016 Nov 18;9(11):1684-1690. doi: 10.18240/ijo.2016.11.24. PMID: 27990376; PMCID: PMC5145101.

Beta-Adrenergic Antagonists (Beta-blockers)

FDA classifies beta-blockers as category C medication. They are being used as first-line antiglaucoma drugs in pregnancy by many ophthalmologists due to experience with its systemic utilization in Obstetrics. The use of Beta-blockers in lactation is controversial. While some authors found high concentration of the drugs being secreted in breastmilk, others discovered its low concentration in the breastmilk of the lactating mothers using it. Consequently, its withdrawal during lactation has been advocated to abate adverse effects of the drugs in newborn.

Alpha2-Antagonist

Brimonidine tartrate belongs to category B medications. It is well tolerated during pregnancy; however, it is advisable to discontinue the drugs close to delivery because studies have shown that it penetrates blood-brain barriers thereby causing central nervous system depression and apnea in newborn babies. Although it is not known whether Brimonidine is being secreted in breast milk, the general consensus is that it should be avoided in lactating mothers.

Carbonic Anhydrase Inhibitors

a. Oral Carbonic Anhydrase Inhibitors

Acetazolamide and Methazolamide are oral Carbonic Anhydrase Inhibitors (CAIs) used in treatment of glaucoma and they belong to category C medication. Acetazolamide at high doses has been shown to produce fetal anomalies in animal studies, nevertheless, there is little evidence to show that it adversely affects outcome of pregnancy in humans. If clinical condition warrants, the drug can be administered with appropriate informed consent.

b. Topical Carbonic Anhydrase Inhibitors

There are no reports of fetal complications or adverse reaction in the newborn following the use of topical CAIs in pregnant women; but exposing lactating rats to high dose of CAIs led to weight reduction in their nursing offspring. FDA has categorised Dorzolamide and Brinzolamide as Category C medication.

Prostaglandin Analogues

Bimatoprost, Latanoprost, and Travoprost are prostaglandin-F2 analogues, commonly used in patients with glaucoma. The same class of medication is used systemically to induce labour by stimulating uterine contraction. There are no reports of premature labour with topical use of the drugs though and if there are compelling indication for its utilization as in patients with advanced glaucoma, it could be used. FDA classified Bimatoprost, Latanoprost and Travoprost as Category C medication.

Fixed-Combination Anti-glaucoma Medication

The available fixed -drug combination in the treatment of glaucoma includes timolol-dorzolamide, timolol-brinzolamide, timolol-brimonidine, timolol-latanoprost, timolol-bimatoprost and timolol-travoprost. The safety as well as the effectiveness of the preparation in pregnancy and lactation are not known.

Surgical Management of Glaucoma in Pregnancy

When medication fails or is not an option for IOP control or there is progression of glaucomatous visual filed damage, recourse can be made to surgical treatments.

The available options are:

a. Laser procedures;

these are useful in reducing or eliminating the use of medication which may be potentially harmful to the fetus and its advantages over the conventional filtration surgery are that it can be done with patient in an upright position, requires only topical anesthesia and can be performed as an outpatient procedure. Argon Laser Trabeculoplasty (ALT) and Selective Laser Trabeculoplasty are used for primary open angle glaucoma while Primary angle closure glaucoma is treated by YAG laser iridotomy and laser iridoplasty respectively.

b. Surgery in Glaucoma

The surgical options include traditional filtration surgery and minimally invasive glaucoma surgery. The risks of local and general anesthetics medication as well as preoperative and postoperative drugs should reviewed appropriately. General anesthetics when administered to pregnant woman in the first trimester have been associated with low birth weight and neural tube defect. Furthermore, Lignocaine is categorized as category B while bupivacaine as category C.

Failure rate after glaucoma filtration surgery is high due to the young age of the patient and physiological changes that occur naturally in pregnancy. However, the anti-metabolites, which are commonly used after filtration surgery, such as Mitomycin C and 5 Fluorouracil are FDA category X teratogens and therefore are absolutely contra-indicated in pregnancy.

Filtration surgery without the use of antimetabolites, favors fibrosis of the incision site leading to increased chance of failure. An alternative would be MIGS and/or aqueous shunt surgery for patients who need surgery in pregnancy.

Conclusion

Managing glaucoma in pregnant woman is delicate between reducing IOP to halt the disease progression and the choice of intervention that does not cause adverse effects to the fetus.

CHAPTER 4 - PRACTICAL PROCEDURES/RECIPES
(HOW TO...)



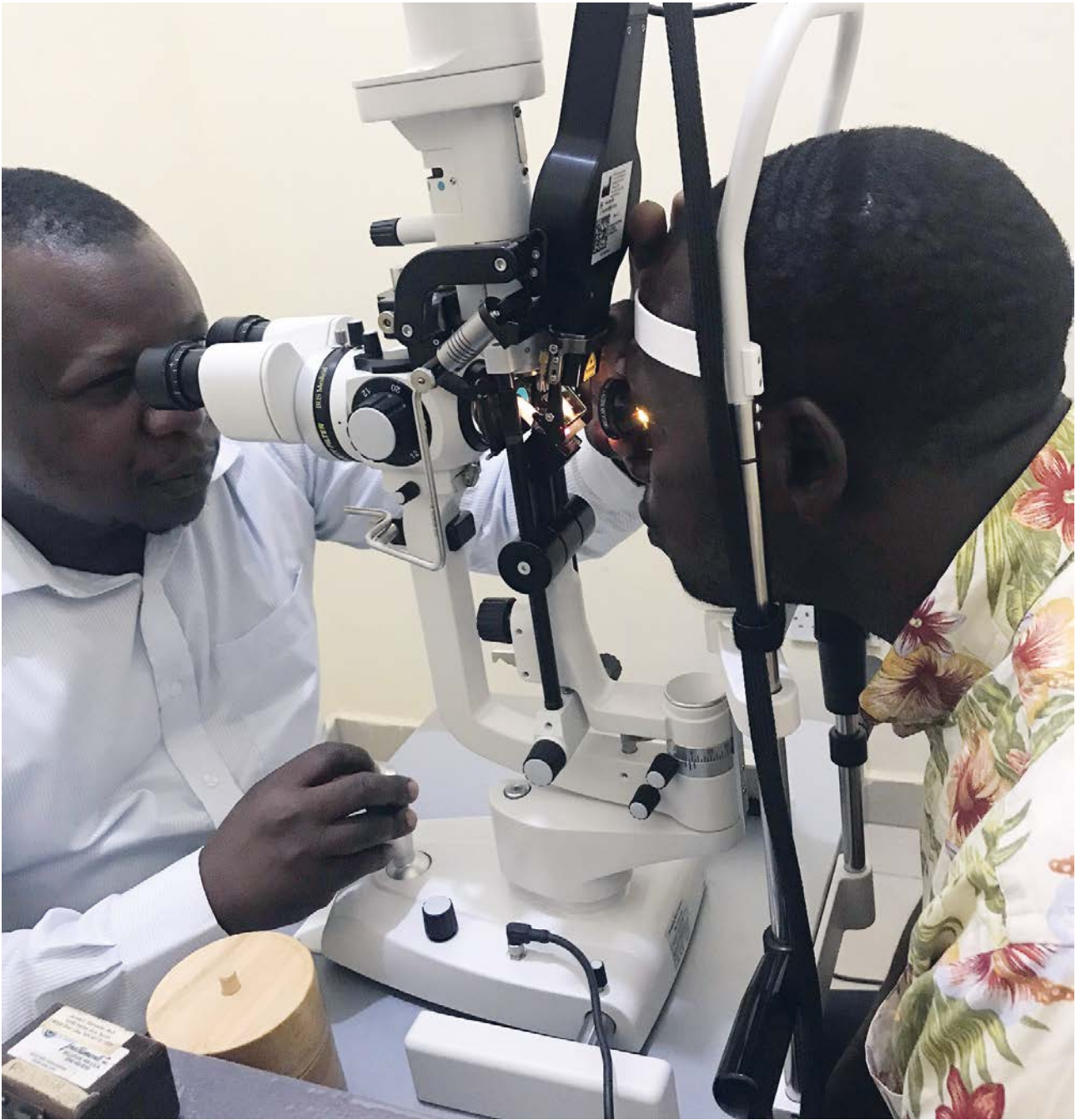
4.1 Examination and Diagnostic Procedures



1a	Perform IOP measurement	<p>Three types of tonometers exist: Indentation, applanation, and contour matching. The Goldmann applanation tonometry still remains the gold standard for diagnosing and managing glaucoma, in eyes of average corneal thickness. For thin corneas, either naturally or after LASIK, dynamic contour tonometry (Pascal-Zeimer Micro-technology, Switzerland) is the best source accurate IOP measurement.</p> <ol style="list-style-type: none">Sue Stevens, Clare Gilbert, and Nick Astbury, "How to Measure Intraocular Pressure: Applanation Tonometry," Community Eye Health Journal, 2012. https://www.cehjournal.org/article/how-to-measure-intraocular-pressure-applanation-tonometry/Heiko Philippin, Peter Shah, and Matthew Burton, "The next Step: Detailed Assessment of an Adult Glaucoma Patient," Community Eye Health Journal, 2012. https://www.cehjournal.org/article/the-next-step-detailed-assessment-of-an-adult-glaucoma-patient/
1b	Calibration for Goldmann applanation tonometer	<ol style="list-style-type: none">Choudhari NS, Richhariya A, Wadke V, Deshmukh SP, George R, Senthil S, Chandra Sekhar G. The Outcomes of a Comprehensive Program for Maintenance of Goldmann Applanation Tonometer. J Glaucoma. 2019 Jun;28(6):507-511. doi: 10.1097/IJG.0000000000001260. PMID: 30950966.For rectification of error (video included in the article; open access) Choudhari NS, Moorthy KP, Tungikar VB, Kumar M, George R, Rao HL, Senthil S, Vijaya L, Garudadri CS. Rectifying calibration error of Goldmann applanation tonometer is easy! Indian J Ophthalmol. 2014 Nov;62(11):1082-1085. doi: 10.4103/0301-4738.146761. PMID: 25494251; PMCID: PMC4290199.
2	Perform Van Herick grading	<p>Gonioscopy involves the examination and analysis of the angle. The Van Herick method of estimating peripheral anterior chamber depth does not replace gonioscopy. Conditions such as Plateau iris with angle-closure may be missed completely. Anterior segment UBM and OCT exams cannot distinguish appositional from synechial closure and thus are not substitutes for gonioscopy especially when making a decision about iridotomy. Indentation gonioscopy is critical to allow one to distinguish between permanent and reversible angle closure. Lenses to be used are the Zeiss, Posner, and Sussman lens as they have smaller diameter corneal contact surface which allow for indentation gonioscopy.</p>

3	Perform gonioscopy	<p>The importance of gonioscopy in the management of glaucoma cannot be stressed enough especially now with the emergence of new surgical treatment modalities for glaucoma such as MIGS procedures and laser trabeculoplasty.</p> <ol style="list-style-type: none"> University of Iowa Carver College of Medicine: Department of Ophthalmology and Visual Sciences, "Gonioscopy," n.d., http://gonioscopy.org/ Optometry Today, A Brief Guide to Gonioscopy, 2015, https://www.youtube.com/watch?v=8yTTbHWxUik https://www.aao.org/disease-review/color-atlas-of-gonioscopy Colour Atlas of Gonioscopy. https://www.aao.org/disease-review/color-atlas-of-gonioscopy
4	Assess the optic nerve	<p>The examination of the optic disc is of fundamental importance in the management of glaucoma. This is best performed with slit lamp biomicroscopy utilizing contact or handheld lenses since it provides good stereopsis and magnification. Attention should be paid to neuroretinal rim contour, as well as presence of retinal nerve fiber layer defects and optic disc hemorrhages which can easily be missed. Over time, disc changes are better identified with optic disc photographs or automated devices. Optic disc photographs are complimentary to slitlamp examination and may pick up findings missed on direct examination.</p> <ol style="list-style-type: none"> Rupert Bourne, "The Optic Nerve Head in Glaucoma," Community Eye Health Journal 25, no. 79 (2013): 55-57. https://www.cehjournal.org/article/the-optic-nerve-head-in-glaucoma-2/ University of Iowa Carver College of Medicine: Department of Ophthalmology and Visual Sciences, Chapter 9: Optic Nerve Head & Nerve Fiber Layer Changes in Glaucoma, 2015, http://curriculum.iowaglaucoma.org/chapter/9.htm
5	Perform, optimise and analyse Humphrey visual fields	<p>Standard achromatic automated perimetry (SAP), or white-on-white testing is most widely used for assessing and monitoring visual field loss in glaucoma. Forecasting threshold estimation strategies (HFA 24-2 SITA Standard or Octopus G2 TOP) are most often used because they save time without sacrificing reliability of test results. SITA Fast procedures take less time but result in more variable patient responses. Other options such as kinetic testing and confrontation visual fields can be used for those patients who cannot successfully be tested on the usual test.</p> <ol style="list-style-type: none"> David C. Broadway, "Visual Field Testing for Glaucoma - A Practical Guide," Community Eye Health Journal, 2012. https://www.cehjournal.org/article/visual-field-testing-for-glaucoma-a-practical-guide/ Moustafa Yaqub, "Visual Fields Interpretation in Glaucoma: A Focus on Static Automated Perimetry," Community Eye Health, 2012. https://www.cehjournal.org/article/visual-fields-interpretation-in-glaucoma-a-focus-on-static-automated-perimetry/ University of Iowa Carver College of Medicine: Department of Ophthalmology and Visual Sciences, Chapter 7: Visual Field Changes in Glaucoma, 2015. http://curriculum.iowaglaucoma.org/chapter/7.htm The sensitivity and specificity of amsler grid tests were high in detecting visual field defects in advanced glaucoma: Gessese GW, Tamrat L, Damji KF (2020) Amsler grid test for detection of advanced glaucoma in Ethiopia. PLoS ONE 15(3): e0230017. https://doi.org/10.1371/journal.pone.0230017
6	Perform and analyse central corneal thickness (CCT)	<p>CCT should be measured in every glaucoma and glaucoma suspect patient, where available. Lower CCT is a risk factor for conversion from Ocular hypertension to glaucoma. Adjusting IOP for the CCT does not provide increased accuracy of the IOP measurement. Accuracy of GAT is increased by taking multiple measurements and averaging the results. CCT can be measured using a number of modalities including optical pachymetry, ultrasound pachymetry, Scheimpflug imaging, optical coherence tomography (OCT), and even magnetic resonance imaging.</p> <ol style="list-style-type: none"> James S Wolffsohn and Leon N Davies, "Advances in Anterior Segment Imaging," Current Opinion in Ophthalmology 18, no. 1 (February 2007): 32-38, https://doi.org/10.1097/ICU.0b013e328011550d. Sibling having glaucoma
7	Perform and analyse optical coherence tomography (OCT)	<p>OCT is a test for structure and function for glaucoma. OCT works by measuring the time delay difference between laser light reflected at various retinal layers and a reflected reference beam. OCT can scan the peripapillary retina (RNFL scan), the optic nerve head, and the macular region. A good quality image is essential for correct interpretation of the exam. A minimal acceptable signal-to-noise ratio is six.</p> <ol style="list-style-type: none"> Angelo P Tanna et al., Practical Pearls for OCT and Visual Fields (American Academy of Ophthalmology, 2019), https://www.aao.org/annual-meeting-video/practical-pearls-oct-visual-fields.

4.2 Glaucoma Laser Procedures



There are different types of lasers with proven efficacy against glaucoma. Lasers, being less invasive and portable, offer some hope for glaucoma care in Africa.³⁵

³⁵ Mohammed AS, Kyari F. Primary Open Angle Glaucoma in Africa: Prospects and Application of Lasers in African Eyes. EyeWiki - American Association of Ophthalmology, 2020, https://eyewiki.org/Primary_Open_Angle_Glaucoma_in_Africa%3A_Prospects_and_Application_of_Lasers_in_African_Eyes.

8	Perform selective laser trabeculoplasty (SLT)	<ul style="list-style-type: none"> ▶ SLT uses the 532nm, frequency doubled, Q-switched Nd:YAG laser, results in the selective absorption of energy by pigmented cells and spares adjacent cells and tissues from thermal energy. ▶ It is easier to use than ALT since the area of the laser spot is 64 times larger than ALT, and large enough to cover entire width of the trabecular meshwork. ▶ SLT acts at a cellular level to specifically trigger thermolysis of pigmented trabecular meshwork (TM) cells, the process of which stimulates the release of proteins and cytokines, and recruitment of macrophages. This restorative mechanism results in the improvement of aqueous humour circulation through the TM and the inner walls of Schlemm's canal, thereby reducing IOP. ▶ SLT may be considered as first-line of treatment in the following: <ul style="list-style-type: none"> • Laser machine available, experience of physician • Level of IOP- 20s • Stage of glaucoma- early, OHT • Type of glaucoma- POAG, OHT, PXG, PDG, steroid induced • Comorbidity- cardiovascular, COPD • Glaucoma in pregnancy ▶ SLT should not be used in neovascular and uveitic glaucomas <ol style="list-style-type: none"> 1. Ellex Medical, Ellex Selective Laser Trabeculoplasty (SLT) Animation, 2019. https://www.youtube.com/watch?v=ywOKumAFASg. 2. Ellex Medical, SLT Clinical Footage: Heavily Pigmented Trabeculum, 2012. https://www.youtube.com/watch?v=qIPJ9PW4.
9	Perform laser Argon Laser Trabeculoplasty (ALT)	<p>ALT produces significant tissue disruption and coagulation damage to the trabecular meshwork, possibly contributing to the limited effectiveness of retreatment</p> <ol style="list-style-type: none"> 1. Theodoros Filippopoulos. Argon Laser Trabeculoplasty. Medscape, 2016. https://emedicine.medscape.com/article/1844064-overview#a7.
10	Perform laser peripheral iridotomy (LPI)	<p>Brimonidine 0.15-0.2% can be used to prevent a transient IOP elevation associated with LPI, or 1% apraclonidine hydrochloride ophthalmic solution</p> <p>Argon LPI: Performed in two steps. The first step is to contract iris tissue, the second step is to penetrate the iris and cleanup the LPI. An LPI-specific laser contact lens such as the Abraham lens should be used</p> <p>Nd-YAG LPI: Laser power depends on the laser used, therefore refer to laser manual to get appropriate power. Number of pulses generally between 1 and 4. Laser power ranges from 1 to 10mJ per burst</p> <p>In a combined argon/YAG LPI, the YAG energy can be reduced for penetration after adequate argon pretreatment using high power, small spot size, and short duration</p> <p>For a thick, dark iris a combined argon/YAG iridotomy may be best. The argon laser thins the iris and coagulates blood vessels and the YAG laser makes the final penetration</p> <ol style="list-style-type: none"> 1. Frank X Cao. Peripheral Iridotomy. Medscape, 2020. https://emedicine.medscape.com/article/1844179-overview
11	Perform argon laser peripheral laser iridoplasty (ALPI)	<p>ALPI can be performed in plateau iris to flatten the plateau and pull iris out of the angle if the angle still appears appositional with elevated pressures after LPI</p> <ol style="list-style-type: none"> 1. Glaucomavids, Argon Laser Peripheral Iridoplasty (ALPI). Robert Ritch, MD. 2008. https://www.youtube.com/watch?v=-2NYixE_0xQ
12	Perform Micropulse Laser Trabeculoplasty (MLT)	<p>This is a relatively new technique: the laser energy is subdivided into low energy short pulses and delivered repetitively with specific "on" and "off" times thereby minimising the heat buildup and hence thermal damage to adjacent tissues. The off interlude allows the temperature of the target tissue to cool down before the next shot. It also fends off spread of energy to adjacent tissue.</p> <ol style="list-style-type: none"> 1. Jella An, Micropulse Laser Trabeculoplasty (MLT) Patient Information, 2019. https://www.youtube.com/watch?v=4LKC5dWdXrM
13	MicroPulse transscleral laser therapy (TLT)	<p>MicroPulse transscleral laser therapy uses repetitive micropulses of active diode laser (On-cycles) interspersed with resting intervals (Off-cycles). This improves the safety profile of the transscleral laser procedure.</p> <ol style="list-style-type: none"> 1. IRIDEX Ophthalmology, Utilizing MicroPulse Transscleral Laser Therapy in My Glaucoma Practice, 2019. https://www.youtube.com/watch?v=aoXe-zDse7Q
14	Perform Continuous wave Transscleral cyclophoto-coagulation (CW-CPC)	<p>CW-CPC is a treatment of last resort reserved for glaucoma unresponsive to maximum medical treatment, eyes that have failed filtration surgery or likely to fail future filtration surgery such as aphakic glaucoma, neovascular glaucoma etc.</p> <ol style="list-style-type: none"> 1. University of Iowa Carver College of Medicine: Department of Ophthalmology and Visual Sciences, Chapter 49: Cyclode-structive Procedures, 2015. http://curriculum.iowaglaucoma.org/chapter/49.htm



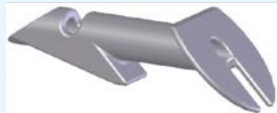
4.3 Surgical Procedures

PENETRATING GLAUCOMA SURGERY

One of the key principles of surgery is to get the basics right such that pre-operative preparation is paramount to success.³⁶



36 Shah P. Avoiding serious complications in trabeculectomy surgery. <https://iop.vision/library/avoiding-serious-complications-trabeculectomy-surgery-1-principles-2>

15	Perform trabeculectomy with releasable sutures and Manage trabeculectomy post-ops	<p>Safe Surgery system: Moorfields Eye hospital:</p> <ul style="list-style-type: none">Position of filtration area: Assess and draw the lid's position in relation to the superior limbus. Ensure that the bleb is ultimately located under the upper lid.Traction suture: Corneal traction suture using a 7-0 black silk suture or 6-0 Vicryl. This avoids superior or rectus hematomaConjunctival incision: Fornix-based flaps provide better scleral exposure. Avoid radial side-relaxing incisions. Avoid the superior rectus tendon when dissecting the pocketScleral flap: Do not cut the side incisions up to the limbus in order to encourage posterior flow(1-2mm from limbus). Cut scleral flap before applying antimetabolite. Preplace sutures in the flap while the eye is still firmAntimetabolites: Prevent exposure of the cut end of the conjunctiva to antimetabolites. This will prevent wound leaks and dehiscence. (Can use conjunctival clamp). Polyvinyl alcohol sponges are preferred, insert about 6 sponges of 5X3mm into the pocket. Treat an area as large as possible including the scleral flap. Apply a concentration of between 0.2-0.5mg/ml for 3 min. Alternatively apply 50mg/ml of 5- fluorouracil. Wash out antimetabolite with 20ml of BSSPerform a paracentesis: Keep blade parallel to limbus to avoid damage to the crystalline lens.Infusion: An anterior segment infusion cannula on a three -way tap through the paracentesis. Adjust the bottle height to control IOPSclerostomy: Use a punch to create an incision as anterior and corneal as possible to reduce bleeding. A 0.5mm sclerostomy is adequatePeripheral Iridectomy: Press gently on the posterior edge of the sclerostomy to present the irisSuturing the scleral flap: Provide adequate tension to restrict flow of aqueous. This is particularly important when antimetabolites are used. Adjustable sutures are placed using 10-0 nylon at each posterior corner of the flap.Conjunctival closure: Create a series of corneal grooves to bury the knots in the cornea. To ensure a watertight wound, take secure bites of both Tenon's and conjunctiva if single closure is used. <ol style="list-style-type: none">Murdoch I. Post-Operative Management of Trabeculectomy in the First Three Months. Community Eye Health Journal. 2012. https://www.cehjournal.org/article/post-operative-management-of-trabeculectomy-in-the-first-three-months/Murdoch I. How I Approach Trabeculectomy Surgery. Community Eye Health Journal. 2006. https://www.cehjournal.org/article/how-i-approach-trabeculectomy-surgery/Henderson HW, Ezra E, Murdoch IE. Early postoperative trabeculectomy leakage: incidence, time course, severity, and impact on surgical outcome. Br J Ophthalmol. 2004 May;88(5):626-9. doi: 10.1136/bjo.2003.018796. PMID: 15090412; PMCID: PMC1772156. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1772156/Murdoch I. When Trabeculectomy Fails. Community Eye Health Journal. 2012. https://www.cehjournal.org/article/when-trabeculectomy-fails/Dan Bettis, Bleb Revision for Hypotony with Trans Conjunctival Flap Sutures, 2016. https://www.youtube.com/watch?v=JRL0ZsPPGMc&feature=youtu.be
16	Use of antimetabolites safely	<p>Trabeculectomy with adjunctive antimetabolites is a widely accepted filtering surgery for treatment of glaucoma.</p> <ol style="list-style-type: none">Mark B Sherwood. The Pros and Cons of Using Mitomycin-C. Review of Ophthalmology, 2016. https://www.reviewofophthalmology.com/article/the-pros-and-cons-of-using-mitomycin-cMaquet JA, Dios E, Aragon J, Bailez C, Ussa F, Laguna N. Protocol for Mitomycin C Use in Glaucoma Surgery. Acta Ophthalmol Scand 2005;83:196-200. https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1600-0420.2005.00437.xIke Ahmed, Trabeculectomy Technique with Mitomycin-C. 2020. https://www.youtube.com/watch?v=HR3MRtvixDU
17	Perform bleb needling	<p>Different techniques of needling with or without antimetabolites can be used. Needles from 30-24G can be used, but 25- and 27 gauge are most commonly used. Needling with antimetabolite is considered more successful than needling without antimetabolites</p> <p>Antimetabolites: If 5FU is used, inject 5mg (0.1ml of 50mg/ml or 0.2ml or 25mg/ml). MMC can be used up to 0.2 mg/ml.</p> <p>Needling can be performed with the patient sitting at the slit lamp or supine with an operating microscope.</p> <p>The interval between initial filtering surgery and bleb needling appears to make no difference with regards to outcomes</p> <ol style="list-style-type: none">Murdoch I. When Trabeculectomy Fails. Community Eye Health Journal. 2012. https://www.cehjournal.org/article/when-trabeculectomy-fails/
18	Perform combined phaco trabeculectomy	<p>PhacoTrabeculectomy must be considered in a glaucoma patient who needs a trabeculectomy with a visually significant cataract, and for whom one surgery may offer economic and social advantages.</p> <ol style="list-style-type: none">Ike Ahmed, Combined Phaco-Trabeculectomy Ike Ahmed 1080pN, 2013. https://www.youtube.com/watch?v=XVeM4ybevc
19	Perform combined small incision cataract surgery (SICS) and trabeculectomy	<ol style="list-style-type: none">Kyari F. Managing Cataract Surgery in Patients with Glaucoma. Community Eye Health Journal 2019; 31 (104): 88-90. https://www.cehjournal.org/article/managing-cataract-surgery-in-glaucoma-patients/Choudhari NS. Online Lecture: My Modifications in SICS IOL Trabeculectomy, 2020. https://hyderabadeyereseam-my.sharepoint.com/:v/g/personal/onlinelectures_lvpei_net/EdHCi7MLBOZBigAcZfPUQfAB-nwsuL7a3M5ORi7It082Z5Q?e=BGIRti (surgical video)Eyefocus, 2nd OSN Scientific Webinar 3, 2020. Management of co-existing cataract with glaucoma. https://youtu.be/k_kvZEAGM6Q (discussion video)
20	The Ex-Press Mini Glaucoma shunt	<p>The medical-grade stainless steel implant provides a reproducible, non-valved opening for the drainage of aqueous humor out of the anterior chamber beneath the scleral flap. There are three models: R-50, P-50, P-200. The basic design includes a 0.4mm external diameter tube that is 2.4mm in length. The internal diameter or lumen can be 50 or 200um depending on the model used.</p>  <ol style="list-style-type: none">Sarkisian SR. The Ex-Press Mini Glaucoma Shunt: Technique and Experience. Middle East Afr J Ophthalmol 2009;16(3):134-137 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2813605/?report=printableOptonol, Ex-PRESS Mini Glaucoma Shunt Implantation under Deep Sclerectomy, 2009. https://www.youtube.com/watch?v=_PzbSBXL0tK



NON-PENETRATING GLAUCOMA SURGERY

These procedures are drainage procedures that restore aqueous humor filtration through a natural membrane, the trabeculo-Descemet's membrane (TDM). The main advantage is the prevention of early complications related to the penetration of the anterior chamber. The main disadvantage is the long and steep learning curve it demands. These procedures include: nonpenetrating deep sclerectomy, viscocanalostomy and canaloplasty.

21	Deep Sclerectomy	Deep sclerectomy is a non-penetrating drainage procedure where Schlemm's canal is deroofed underneath a scleral flap and a deep lamella of corneo-sclera removed to leave a scleral lake. Aqueous percolates through the remaining TM into the area. A shallow filtration bleb is formed. 1. Varga Z, Shaarawy T. Deep Sclerectomy: Safety and Efficacy. Middle East Afr J Ophthalmol 2009;16(3):123-126 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2813598/?report=printable 2. Miguel AIM, Silva AB, et al. Deep Sclerectomy. EyeWiki 2020. https://eyewiki.aao.org/Deep_sclerectomy
22	CO2 laser assisted sclerectomy (CLASS procedure)	CO2 laser-assisted sclerectomy surgery (CLASS) is an enhanced adaptation of manual deep sclerectomy by using a CO2 laser to ablate the scleral tissue leaving a thin membrane just enough for aqueous seepage, but without entering the anterior chamber since the laser energy is absorbed once there is seepage of aqueous. 1. IOptima. CLASS: CO2 Laser-Assisted Sclerectomy Surgery. https://ioptima.co.il/technology/class-procedure/ 2. IOptima Videos, CLASS Performed by Dr. Andre Mermoud, 2014. https://www.youtube.com/watch?reload=9&v=ZikuKRkirag&feature=emb_rel_end
23	Viscocanalostomy	This procedure modifies the deep sclerectomy procedure by injecting hyaluronic acid into Schlemm's canal. This may increase outflow by widening and/or micropuncturing the walls of Schlemm's canal and collector channels 1. Duckworth Kent, Viscocanalostomy, 2016. https://www.youtube.com/watch?v=I6gBI_s_vIQ 2. Ike Ahmed, Georges M Durr, and Devesh K Varma, Viscocanalostomy with ITrack Surgical System, 2019. https://www.aao.org/master-class-video/viscocanalostomy-with-ittrack-surgical-system
24	Canaloplasty	Canaloplasty utilises a microcatheter to pass a nonabsorbable suture through the entire circumference of Schlemm's canal, and by tying down the suture, it generates a centripetal force that expands the canal. 1. Won I Kim. Canaloplasty. EyeWiki 2019. https://eyewiki.aao.org/Canaloplasty

GLAUCOMA DRAINAGE DEVICES

Glaucoma drainage devices (GDD) are also known as aqueous shunts, tube shunts or glaucoma drainage implants. The devices consist of one or more plates connected to a tube.

There are three key design features that distinguish the different implants:

- 1. The presence of a valve
- 2. The surface area of the episcleral plate and
- 3. The material used


25	Perform valved glaucoma drainage device (GDD) surgery	Valved GDD include: The Ahmed devices (New World Medical, Rancho Cucamonga, CA) and The Krupin implant (E. Benson Hood Labs, Inc, Pembroke, MA) 4. Daniel Bettis, Ahmed Valve Glaucoma Surgery - Standard Technique and Surgical Pearls, 2017. https://www.eyerounds.org/atlas-video/ahmed-valve-glaucoma-surgery.htm 5. New World Medical, How Does the Ahmed Valve Work? 2014. https://www.youtube.com/watch?v=noZmHencfko
26	Perform non-valved GDD surgery	The Non-valved GDD include: Baerveldt implants (Advanced Medical Optics, Santa Ana, CA) and The Molteno implants (Molteno Ophthalmic Ltd, Dunedin, New Zealand) 1. University of Iowa Carver College of Medicine: Department of Ophthalmology and Visual Sciences, Chapter 45: Glaucoma Drainage Devices, 2015. http://curriculum.iowaglaucoma.org/chapter/45.htm 2. Glaucoma UK. Aqueous Shunt Implantation. https://www.glaucoma-association.com/about-glaucoma/treatments/surgery/aqueous-shunt/ 3. Wallace Alward, Lecture: Glaucoma Drainage Devices. Cybersight. https://cybersight.org/portfolio/lecture-glaucoma-drainage-devices/ 4. Glaucomavids. How to Insert Baerveldt Glaucoma Implant 350. Chris Teng, MD, 2014. https://www.youtube.com/watch?v=sAneliv8Brw 5. Ike Ahmed, Baerveldt Glaucoma Implant Surgical Technique Ike Ahmed, 2014. https://www.youtube.com/watch?v=dPyTsXB4dY4
27	Manage GDDs post-operatively	Meticulous early postoperative care is required for all implants to monitor and treat either pressure elevation or hypotony and to manage inflammation Higher medication requirements are generally seen after tube shunts than after trabeculectomy to obtain a desired IOP target range. 1. Christopher Kent. Managing & Preventing Tube Shunt Problems. Review of Ophthalmology. 2015. https://www.reviewofophthalmology.com/article/managing--preventing-tube-shunt-problems



4.4 Minimally Invasive Glaucoma Surgeries (MIGS)

MIGS devices can be classified into the following:

- 1. Subconjunctival:
 - a. Xen-45 gel stent (Allergan)
 - b. Innfocus Microshunt (Santen)
- 2. Schlemm’s canal
 - a. Trabecular meshwork implants
 - i. i-Stent G1 (Glaukos)
 - ii. i- Stent inject G2 (Glaukos)
 - iii. Hydrus (Ivantis)
 - b. Trabecular meshwork ablations
 - i. Trabectome (Neomedix)
 - ii. Kahook Dual Blade (New World Medical)
 - iii. High Frequency Deep Sclerotomy, HFDS (Oertli)
 - c. Trabecular meshwork micro catheters
 - i. i-Track ABIC (Ellex)
 - ii. Visco 360 (Sight Sciences)
- 3. Suprachoroidal
 - a. i-stent Supra (Glaukos)
 - b. Cypass (Alcon-Voluntarily withdrawn due to endothelial compromise as of 2018)
- 4. Aqueous humor reduction
 - a. Endoscopic cyclophotocoagulation

28	Perform XEN gel stent	The XEN gel stent is 6mm in length and when hydrated it becomes very soft compressible and tissue conforming. The gel stent is preloaded in a disposable injector with a 27-gauge needle. It creates a patent channel through the sclera allowing aqueous humor to flow from the anterior chamber into the subconjunctival space, creating an ab interno bleb which over time becomes a low-lying drainage area. Its lumen is designed to regulate the outflow and avoid hypotony. 5. London OCEyeClinic, XEN Aquesy - Gel Stent - The London Ophthalmology Centre, 2015. https://www.youtube.com/watch?v=X9FO87SkK88 6. Davinder Grover, XEN45 Video MMC Post Injection, 2018. https://www.youtube.com/watch?v=GNIIJtzOQ-U 7. Ike Ahmed, AqueSys XEN Microfistula Implantation for Glaucoma. 2013. https://www.youtube.com/watch?v=giVl1RDNWog 8. Iqbal K Ahmed, Georges M Durr, and Devesh K Varma, Air XEN Gel Stent Implantation. American Academy of Ophthalmology, 2019. https://www.aao.org/master-class-video/air-xen-gel-stent-implantation
29	Perform Innfocus Micro-Shunt	The MicroShunt features an 8.5mm SIBS tube with an outer diameter of 350um and a 70um diameter lumen. It includes multipurpose planar fixation fins to seal the device in order to prevent leakage and migration 1. Cybersight. Surgery: InnFocus MicroShunt. 2019. https://www.youtube.com/watch?v=VXOb9l7RqSo

30	Perform Kahook dual blade (KDB) goniotomy 	<p>A KDB is an Ophthalmic surgical procedure used to incise and partially remove trabecular meshwork to create an opening into Schlemm's canal by way of the anterior chamber angle. It is performed under indirect visualisation using a goniolens.</p> <ol style="list-style-type: none">1. Iqbal K Ahmed, Georges M Durr, and Devesh K Varma, Kahook Dual Blade Goniotomy. American Academy of Ophthalmology, 2019. https://www.aao.org/master-class-video/kahook-dual-blade-goniotomy2. Mr Dan Nguyen - Cataract & Glaucoma Surgeon, The Kahook Dual Blade (MIGS), 2016. https://www.youtube.com/watch?v=2SYlpwajDo3. Cybersight, Surgery: Goniotomy Using the Kahook Dual Blade - Dr. Malik Kahook, 2018. https://vimeo.com/2749923684. New World Medical, Performing Goniotomy with Kahook Dual Blade, 2017. https://www.youtube.com/watch?v=Zp3ldE_biW8
31	Perform Goniotomy	<p>PhacoTrabecu The goal of goniotomy is to incise the anterior trabecular meshwork to open a route for aqueous humor to enter Schlemm's canal. It is mainly performed in primary congenital glaucoma but it is also widely performed in adult onset glaucomas where the juxtacanalicular portion of the trabecular meshwork adjacent to Schlemm's canal, along with more distal outflow structures are considered to be the main sites of resistance to the aqueous outflow. These include POAG and other secondary open angle glaucomas (PXG, PDG) in the early and moderate stages.</p> <p>Goniotomy technique that involves using a 23 Gauge straight cystotome has also been suggested as low cost effective micro-invasive glaucoma surgery (MIGS) alternative to Africans. (Daniel Laroche et al).</p> <p>Technique</p> <p>Goniotomy is relatively simple and requires minimal equipment and instruments but the surgeon must have good understanding of the angle anatomy. It also requires careful surgical planning and patient positioning.</p> <p>The procedure requires clear cornea for direct visualisation of the angle. In setting of corneal epithelial edema due to high pressure, alcohol debridement of the epithelium can help increase visualization of the angle. Controlled paracentesis will also aid reducing pressure and clearing of the cornea.</p> <p>Preoperative application of Pilocarpine 2% helps to constrict the pupil, open the angle for optimal visualization, and protect the lens from injury during surgery.</p> <p>The surgeon sits opposite from the portion of the angle to be operated with the head of the patient tilted away from the surgeon. The microscope must be tilted to at least 45°. A surgical gonioscope (Barkan lens, Koeppe lens or Swan-Jacob lens) is placed on the cornea with coupling solution. A temporal paracentesis is commonly performed, and viscoelastic substance may be required to maintain the anterior chamber (AC) depth. Alternatively, a needle connected to balanced salt solution (BSS) can be used to maintain the chamber depth.</p> <p>After controlling the eye with locking forceps with a stay suture, the trabecular meshwork is incised on the nasal angle with a goniotomy knife, 23 gauge cystotome or 25- gauge needle attached to irrigation or to a syringe containing viscoelastic. The latter offers the advantage of maintaining the anterior chamber without extra maneuvers. The trabecular meshwork is engaged just posterior to Schwalbe's line and the knife or needle is used to make a circumferential incision for 4 to 5 clock hours (approximately 1200). Care must be taken not to incise too deeply and damage the outer wall of Schlemm's canal. The iris root can be seen falling away from the insertion and exposing the Schlemm's canal with minor bleeding into the AC.</p> <p>Upon knife or needle withdrawal, blood reflux commonly occurs and usually resolves with elevation of the IOP and reformation of the anterior chamber with BSS. Topical apraclonidine 0.5% or diluted intracameral epinephrine (1:16,000) can help to decrease bleeding. At the end of surgery, Pilocarpine 2% drops can be instilled to constrict the pupil to prevent anterior synechia formation. The postoperative regimens include topical pilocarpine, topical antibiotic and steroid.</p> <p>Complications</p> <p>Complications after goniotomy include hyphema, iridodialysis, peripheral anterior synechiae, cyclodialysis, and cataract.</p> <ol style="list-style-type: none">1. Mhamed Yassin, Goniotomy, 2010. https://www.youtube.com/watch?v=cGtEoy4e6kM2. Laroche D, Okaka Y, Ng C. A Novel Low Cost Effective Technique in Using a 23 Gauge Straight Cystotome to Perform Goniotomy: Making Micro-invasive Glaucoma Surgery (MIGS) Accessible to the Africans and the Diaspora. J Natl Med Assoc. 2019 Apr;111(2):193-197. doi: 10.1016/j.jnma.2018.09.006. Epub 2018 Oct 17. PMID: 30342703. https://doi.org/10.1016/j.jnma.2018.09.006

32	Perform gonioscopy assisted transluminal trabeculotomy (GATT)	<p>Trabeculotomy, a time-honoured bleb-less angle procedure, reduces IOP by increasing flow into the natural outflow pathway. It cleaves open a diseased glaucomatous outflow system and improves aqueous flow into Schlemm's canal and adjacent collector channels, thereby avoiding an artificial bleb drainage system. It has evolved from ab externo approach to a minimally invasive gonioscopy assisted ab interno microcatheter (iTrack, Ellex Medical Lasers, Ltd.) circumferential approach.</p> <p>Gonioscopy Assisted Transluminal Trabeculotomy (GATT) procedure is an ab interno sutureless circumferential MIGS.</p> <p>Rationale of the GATT Procedure</p> <p>Flow into the patient's inherent collector system prevents all of the problems associated with trying to establish an artificial drain, through subconjunctival filtration. This minimally invasive approach reduces complications from filtration surgery, particularly bleb-related issues, and instead tries to salvage the natural outflow channels of the eye and facilitates a rapid recovery.</p> <ol style="list-style-type: none">1. Davinder S Grover and Ronald L Fellman. Everything You Need to Know About GATT. Review of Ophthalmology, 2018. https://www.reviewofophthalmology.com/article/everything-you-need-to-know-about-gatt2. Davinder S Grover and Ronald L Fellman. Gonioscopy-Assisted Transluminal Trabeculotomy. Ento Key - Fastest Otolaryngology & Ophthalmology Insight Engine, 2018. https://entokey.com/gonioscopy-assisted-transluminal-trabeculotomy/3. Davinder Grover, GATT Video Davinder Grover, MD; Ronald Fellman, MD, 2014. https://www.youtube.com/watch?v=A_UE5MverIA
33	Perform iStent 	<p>Indications</p> <p>The iStent® trabecular micro-bypass stent is currently FDA approved to be used in conjunction with cataract surgery for the reduction of IOP in open angle glaucoma. By creating a bypass through the trabecular meshwork, the iStent can work in conjunction with cataract extraction to enhance the natural physiologic outflow system.</p> <p>The appropriate patient should have mild to moderate glaucoma; good success has been reported with POAG and secondary open angle glaucoma such as pseudoexfoliation and pigmentary glaucoma.</p> <p>Preoperative gonioscopy should rule out peripheral anterior synechiae (PAS), rubeosis, or other angle abnormalities that may make proper placement difficult.</p> <p>Contraindications</p> <p>This device is contraindicated in eyes with primary or secondary angle closure glaucoma, as access to the trabecular meshwork is restricted. Limitations in visualization of the angle structures due to other reasons also limit the implantation. This device is also contraindicated in patients with pathology that may cause increased episcleral venous pressure such as thyroid eye disease or Sturge-Weber Syndrome.</p> <ol style="list-style-type: none">1. Iqbal K Ahmed, Georges M Durr, and Devesh K Varma, iStent Inject Implantation American Academy of Ophthalmology, 2019. https://www.aao.org/master-class-video/istent-inject-implantation
34	Perform Hydrus implant 	<p>The Hydrus micro-stent (Ivantis, Irvine CA) is a novel Schlemm's canal microinvasive glaucoma surgery (MIGS) device designed to enhance aqueous outflow into Schlemm's canal and into the distal outflow veins via an ab interno approach. It is particularly amenable to combination with cataract surgery.</p> <p>The Hydrus is designed to address the underlying pathology in open-angle glaucoma – increased resistance in the inner wall and collapse of Schlemm's canal– by creating a bypass through the inner wall and stretching the inner wall as well as scaffolding open the canal and preventing collapse.</p> <p>The device is implanted using a handheld injector through a 2.0 mm clear cornea incision using a specially designed cannula to incise the inner wall. It is inserted into Schlemm's canal as an artificial scaffold that dilates the canal and allows aqueous to bypass the trabecular meshwork.</p> <ol style="list-style-type: none">1. Iqbal K Ahmed, Georges M Durr, and Devesh K Varma, Hydrus Implant. American Academy of Ophthalmology, 2019. https://www.aao.org/master-class-video/hydrus-implant

CHAPTER 5 - CURRENT OPINION

In low- and middle-income countries (LMIC) and resource limited settings, not all technological advances in diagnosis or treatment for glaucoma are readily accessible or affordable. As such, priorities need to be determined based on consensus and current opinion.

This section discusses the current opinion with available evidence on the following topics:

1. The role of minimally invasive glaucoma surgery (MIGS) in Sub-Saharan Africa (SSA)
2. Optical coherence tomography (OCT) use in SSA
3. Combined cataract and glaucoma surgery
4. Micropulse transscleral cyclophotocoagulation in seeing eyes
5. Selective laser trabeculoplasty (SLT) and/or Argon laser trabeculoplasty (ALT) as first line treatment for glaucoma
6. Tube surgery versus trabeculectomy in Black African patients
7. Use of Mitomycin/ 5FU versus beta-radiation for trabeculectomy
8. The role of simulated surgical training in trabeculectomy



5.1 Current opinion on use of minimally invasive glaucoma surgery (MIGS) in SSA

Introduction

In the last 5 years, the development of a range minimally-invasive glaucoma surgery (MIGS) have heralded a new era in glaucoma management. The idea being that minimally invasive devices can be used earlier as they have a better safety profile than trabeculectomy or tubes. Furthermore, the lifetime burden of glaucoma eye drops from the patients' perspective is increasingly being recognised internationally and so interventions which delay the need to use drops or reduce the number are desirable. This is even more applicable to SSA patients who on top of the burden of drops to lifestyle, have disproportionate high costs for drops, storage issues, fake drug issues and irregular supply chains to contend with. Thus, being drop free is extremely important in SSA and as such the concept of MIGS as an alternatives to drops, is welcome.

Mechanism of action

The study of MIGS has assisted the glaucoma world in developing its thinking around where the pathology of resistance to outflow in the eye lies. Traditionally 70% of resistance to outflow leading to higher pressures is at the level of the trabecular meshwork so procedures such as Gonio Assisted Trabeculotomy (GAT) and Kahook dual Blade, iStent and trabectome tackle the problem of trabecular resistance. However, if the flow distal to the trabecular meshwork is damaged (Schlemm's canal collapse or collector channel atrophy) then these procedures will be ineffective. Procedures such as canaloplasty or Hydrus insertion in these cases may be more effective. Resistance at various points in outflow may mean that a complete bypass of these structures is required as in a XEN Gel stent or Inn-focus is more likely to be successful. However, these XEN Gel, in-focus, trabeculectomies and GDD still rely on the resistance offered by episcleral venous pressure, which limits pressure reduction to a physiologically around ten. The alternative to get intraocular pressures lower than 10 is to bypass the episcleral vessel route altogether and get flow directly into the supra-choroid space (e.g. CyPass). However, the CyPass microstent has been withdrawn due to concerns of associated endothelial cell loss.

Choosing the right MIGS procedure depends on localising in glaucoma where the area of resistance to outflow. However, identifying local resistance practically is not yet established.

Indications

Where they are used elsewhere in the world, MIGS are often combined or licenced to be specifically used in conjunction with cataract surgery. In most studies, cataract surgery is performed as phaco but the majority of cataracts surgeries performed in SSA are SICS. There is no study looking at their effect when combined with SICS.

The concept of MIGS is that they are minimally invasive, but it is also recognised that their IOP lowering ability is modest, getting pressures to mid-teens. MIGS therefore have a role to play in early to moderate

glaucoma disease and in patients on drops who would like to be independent of drops or are drop intolerant. However, most SSA patients present with advanced disease and need aggressive treatments to get their pressure as low as possible. Financially SSA patients may also have only one opportunity afforded to them to try and get treatment, so the option to 'try and see' before progressing to more invasive treatments may be a luxury that SSA cannot afford.

Patient selection

Selecting the right procedure for the patient depends on understanding the disease and the patient. In general, most MIGS are performed as part of a combined cataract surgery so are more suited to the patient in whom you are primarily considering cataract surgery and may benefit from a combined intervention.

Whilst it is not currently possible test clinically resistance to outflow is, it is possible to apply physiological principles as follows:

- ▶ Juvenile glaucoma is fundamentally a malformation of the trabecular meshwork so the procedures which remove the malformed trabecular meshwork are often very effective.
- ▶ If a patient is older and has had glaucoma for a long time it is likely that even if it started as primary trabecular failure, Schlemm's canal may have collapsed or stiffened and the collector channels may have atrophied so in these cases a trabecular procedure may not be effective.
- ▶ MIGS procedures are unlikely to achieve low-teens pressure and trabeculectomy or tube would be preferable.
- ▶ Most angle surgeries are not suitable for angle closure glaucoma patients. The exception to this is goniosynchiolysis.
- ▶ Inn-focus and XEN implants require sub-conjunctival flow and are subject to the same challenges of fibrosis of tenons as in trabeculectomy. If inflammation or ocular surface disease is potentially a problem then these MIGS are just as likely to fail as a trabeculectomy.

Patients must be able to understand that MIGS offers modest pressure lowering effect but in return for a lower risk profile and that the effect may be temporary. They must show good compliance with clinic attendance and in following medical instructions.

Intra-operative considerations

Most of the MIGS procedures, particularly those performed ab-interno require the ability to work in the angle and understand the anatomy in order to achieve successful implantation of the device. In order to perform this surgery, specialised gonio lenses are required as well as excellent optics on the microscope and the ability of the scope to tilt to 45 degrees. Whilst it may be possible to overcome the costs of the devices and the lenses, the cost of upgrading the microscopes to ones with a good viewing system and those that can tilt may be the major limiting factor for the adaption of MIGS in SSA.

Good viewing of the angle is essential and so some advocate for angle surgery to be performed prior to cataract surgery when the cornea is clearest. However, the removal of the cataract may make some procedures easier when the angle is wider and the Anterior chamber deeper. It may also avoid the potential for complications such as haemorrhage or capsule puncture which may make phaco more complicated.

Post op care

Ophthalmologists who undertake MIGS in SSA must ensure they have a good follow-up arrangement for the patient. They need to know how to look after and manage common complications and not just how to perform the procedure. As there are no studies in predominantly African patients, they need to be prepared for undescribed complications and confident that they have enough expertise to manage them.

Managing complications

Whilst there are the regular complications of intraocular surgery to consider such as infection and haemorrhage with MIGS, there are other complications to be considered. These include hyphaema from angle surgery, endothelial compromise, myopic shifts, uveitis and explantation of devices from and the potential for devices to break and migrate. Most MIGS have got approval with only 2 years study follow-up. In 2018, CyPass was pulled by the manufacturers for their endothelial loss rate which was only revealed after 5 years of outcomes. Hence the need to proceed with caution in MIGS.

Costs

Before undertaking MIGS as a procedure of choice, it is necessary to consider the cost of different devices available, intra-operative gonio lenses and movable consumables. Importation may increase these costs.

5.2 Optical Coherence Tomography (OCT) use in SSA

Optical Coherence Tomography (OCT) is a non-invasive and non-contact technology that provides high resolution cross-sectional images of retinal nerve fibre layer and optic nerve head. It was first described by Huang and colleagues in 1991, OCT is performed similar to B-mode ultrasound except it uses light waves instead of sound waves to create a cross-sectional image.

Prior to advent of OCT, assessment of retinal nerve fibres has been largely subjective and inter-observer variation mars the accuracy of fundal photography for monitoring glaucoma progression. However, arrival of OCT into the scene made objective assessment of retinal nerve fibre, optic nerve head and macular possible. Additionally, OCT has inbuilt software that objectively measures glaucoma progression. Advancement in OCT technology had led to the development of spectral domain and swept source OCT impregnated with normative data for comparison with patient's data.

OCT and Glaucoma Detection

Retinal Ganglion Cells (RGCs) are the main cells affected in glaucoma. The dendrites of RGCs synapse with bipolar and amacrine cells at inner plexiform layer (IPL) while their cell body constitutes the ganglion cell layer (GCL). The axon of RGCs then form the retinal nerve fibre layer (RNFL) and all of it exit at optic nerve head to morph into neuroretinal rim. In glaucoma, structural damage frequently precedes functional loss, therefore, tools that are capable of detecting such structural alteration before the development of functional impairment occupy centre-stage in early glaucoma detection. OCT can evaluate RNFL, macular ganglion cell and optic nerve head changes with high reliability and reproducibility. Hence, OCT is the gold standard for evaluating early glaucomatous optic neuropathy.

OCT and Glaucoma Progression

Glaucoma is a progressive disease albeit the rate of progression varies among different individuals. The overall aim of treatment is to stop or halt the disease progression to a level that the patients' quality of life is not severely affected. Therefore, to realize that goal, objective assessment of glaucoma progression become imperative and one of the primary concerns of ophthalmologists providing care for glaucoma. In moderate to advanced disease, visual field analysis has been used for documenting glaucoma progression. However, OCT assessment of glaucoma progression offers the advantage of detecting pre-perimetric disease and identifying structural progression before functional progression manifest.

OCT in Glaucoma Diagnosis in Sub-Saharan Africa

Early diagnosis and prompt management are the cornerstones of glaucoma blindness prevention. Diagnosis of glaucoma entails optic nerve head evaluation, intraocular pressure measurement and assessment of central visual field. Lack of human resources compounded by inadequate facilities and cost of equipment such as Humphrey Visual Field Analyzer, Fundal Camera and OCT reduced glaucoma diagnostic capacity of most institution in SSA.

OCT has been shown in previous studies to improve glaucoma screening and diagnosis.^{37,38} OCT is however desirable but not mandatory for glaucoma diagnosis and its management. OCT serves as adjuncts in diagnosis and monitoring of disease progression but not without its limitations. Circumpapillary RNFL measurements are affected by the scan circle location, head tilt, Peripapillary atrophy and floor effect. In addition artifacts such as vitreous opacity, retinoschisis and epiretinal membrane can give errors in measurements.³⁹ Lastly the normative database of most available OCT machines are composed of only 20% African/African American data being fully aware of the differences in values between Caucasian and Blacks, this is a huge setback in its accuracy and sensitivity in African setting.⁴⁰

Therefore, its presence improves the quality of care and accuracy of diagnosis but its absence does not negate quality of care.

37 Bussell II, Wollstein G, Schuman JS. OCT for glaucoma diagnosis, screening and detection of glaucoma progression. Br J Ophthalmol. 2014;98(SUPPL. 2):15–9. <https://doi.org/10.1136/bjophthalmol-2013-304326>.

38 Michelessi M, Lucenteforte E, Oddone F, Brazzelli M, Parravano M, Franchi S, et al. Optic nerve head and fibre layer imaging for diagnosing glaucoma. Cochrane Database Syst Rev. 2015;2015(11). <https://doi.org/10.1002/14651858.CD008803.pub2>.

39 Weinreb RN, Garway-Heath D, Leung C, Medeiros F, Liebmann J. Structure: Diagnosis of Primary Open Angle Glaucoma. World Glaucoma Association Consensus Series -10. Kugler Publications, Amsterdam, The Netherlands ISBN: 2016:1-19. <https://wga.one/wga/consensus-10/>.

40 Chaglasian M, Davey PG, Huang WC, Leung D, Ng E, Reisman CA. The development of a reference database with the Topcon 3D OCT-1 Maestro. Clin Ophthalmol 2018;12:849–857. <https://doi.org/10.2147/OPTH.S155229>.



5.3 Combined cataract and glaucoma surgery

Glaucoma and cataract are age-related disease conditions that frequently co-exist especially in elderly individuals.⁴¹ The presence of either has impact on the management of the other. Cataract makes glaucoma assessment difficult in that optic nerve head assessment and visual field testing suffer significantly in its presence. Furthermore, cataract occasionally causes phacolytic and phacomorphic glaucoma. Conversely, miosis from long-term glaucoma medical therapy hinders cataract evaluation and glaucoma surgery accelerates cataract development and progression. Therefore, when the two conditions co-exist, it presents a management challenge to the ophthalmologist.

The approach to management of co-existing cataract and glaucoma is influenced by visual significance of the cataract keeping in mind that small cataract can disproportionately have large effect on visual function in glaucomatous eye, glaucoma subtypes, IOP control, number of antiglaucoma medication as well as severity of glaucomatous damage.

The following surgical options are recommended depending on the case scenario:

1. Cataract surgery alone
2. Combined cataract and glaucoma surgery
3. Two-staged cataract and glaucoma surgery

41 Kyari F. Managing cataract and glaucoma. Community Eye Health J. 2019;31(104):88–90. <https://www.cehjournal.org/article/managing-cataract-surgery-in-glaucoma-patients/>

Cataract Surgery Alone

The IOP lowering effect of phacoemulsification has been reported in the literature. Qassim et al reported as high as 3mmHg reduction at 3 years after phacoemulsification.⁴² They found that higher preoperative IOP and being on fewer topical glaucoma medications preoperatively were strongly predictive of a larger IOP reduction in a multivariable model. Stand-alone cataract surgery can be offered to glaucoma patients with visually significant cataract whose intraocular pressure is well controlled on one or two medications. Other indications are patients with no significant cupping /glaucomatous visual field loss, older age or increased intraocular pressure and narrow angle.

The advantage of only cataract surgery in glaucoma patients are:

1. Immediate vision restoration,
2. Technically easier
3. Facilitates optic evaluation and visual field
4. Opportunity for later glaucoma surgery if needed
5. Single procedure

The disadvantages of only cataract surgery in glaucoma patients include:

1. Early postoperative IOP elevation
2. Reduced long-term IOP reduction when compared with combined surgery
3. Future filtration surgery is compromised if conjunctiva is violated
4. No change in diurnal IOP fluctuation

The challenges of cataract surgery in glaucoma patients include miotic pupil due to prolonged usage of pilocarpine, zonula dialysis in pseudoexfoliation as well as crowded anterior chamber in patient with angle closure glaucoma.

Combined Cataract and Glaucoma Surgery

The combined cataract and glaucoma surgery include combination of trabeculectomy with phacoemulsification (Phacotrab) or with small incision cataract surgery (Trab-SICS). Phacotrabeculectomy can be performed via single-site incision or separate site incisions. There are merits and demerits of each the approach. Furthermore, phacoemulsification can be combined with other forms of glaucoma surgery such as Glaucoma Drainage Devices (GDD), Express Glaucoma mini Shunt, endocyclophotocoagulation etc. Combined surgery is usually indicated in glaucoma patients with visually significant cataract, poor IOP control with extensive glaucomatous damage or requires multiple antiglaucoma medications for IOP control.

Other indications include:

1. Allergic reaction or contraindication to usage of antiglaucoma medication.
2. Significant cupping and /or visual field loss
3. Monocular status
4. Younger age
5. Unable to tolerate two separate procedures

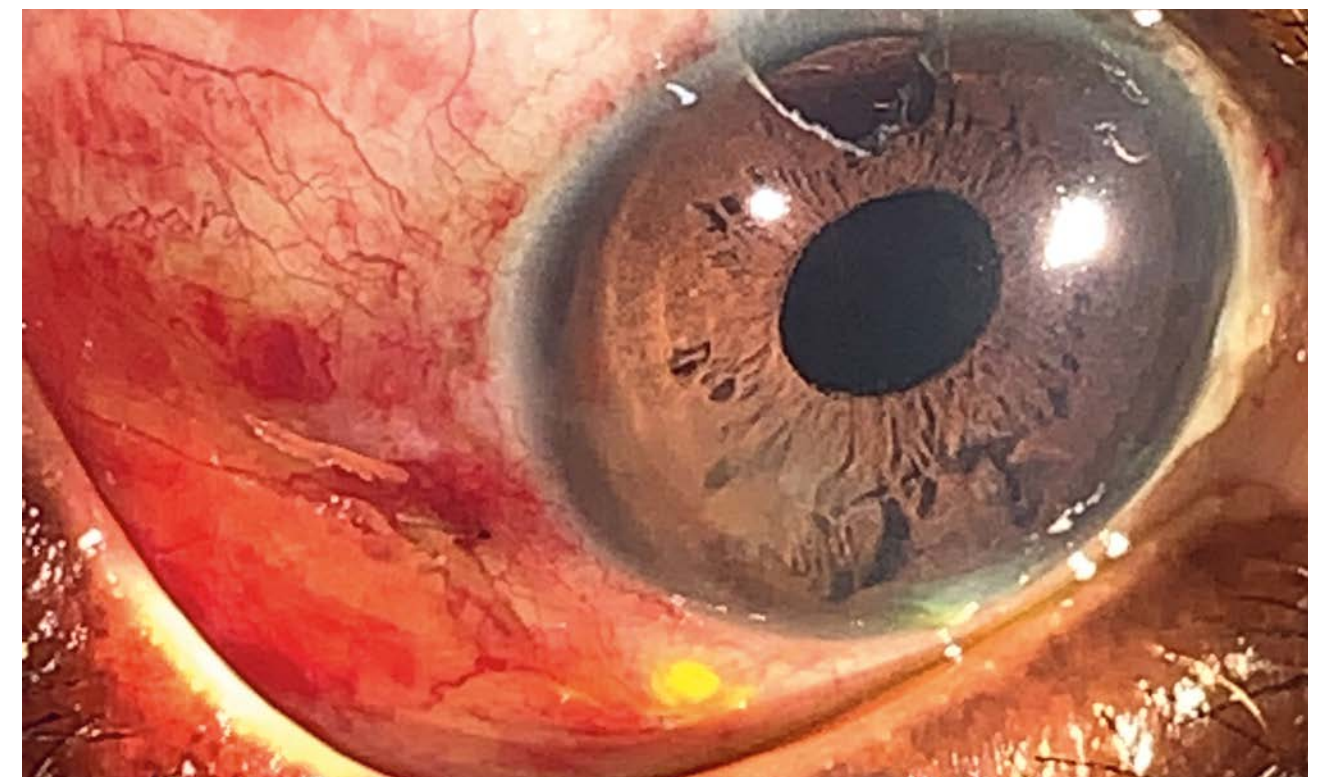
42 Qassim A, Walland MJ, Landers J, Awadalla M, Nguyen T, Loh J, et al. Effect of phacoemulsification cataract surgery on intraocular pressure in early glaucoma: A prospective multi-site study. Clin Exp Ophthalmol. 2020; 48(4):442-49. <https://doi.org/10.1111/ceo.13724>.

Combined surgery offers the advance of relatively rapid visual rehabilitation, decrease glaucoma medication requirement, single procedure and facilitate optic nerve and visual field evaluation. However, its demerits include longer surgical time, increased intraoperative and postoperative complication as well as requirement for more intensive postoperative care.

Two-Staged Cataract and Glaucoma Surgery

The two-staged approach could be glaucoma surgery followed by cataract extraction or cataract surgery followed by glaucoma surgery. The stage surgery has advantage of providing immediate intraocular control and provides opportunity for glaucoma enhancement during subsequent cataract surgery. However, cataract surgery in the presence of bleb is technically difficult and there is increased risk of loss of intraocular pressure control with the cataract surgery.

1. **GLAUCOMA SURGERY FOLLOWED BY CATARACT EXTRACTION:** This is indicated in glaucoma eyes with advanced glaucomatous damage with profound optic nerve damage and extensive visual field loss with high IOP where immediate IOP reduction is needed. It could also be offered in difficult glaucoma such as uveitic glaucoma or neovascular glaucoma where IOL insertion is inappropriate in the acute stage.
2. **CATARACT SURGERY FOLLOWED BY GLAUCOMA SURGERY:** Pseudophakic eyes with poor IOP control despite maximal medical therapy or failed laser trabeculectomy, myriad procedures including filter, GDD, nonpenetrating glaucoma surgery and cyclophotocoagulation can be used. State of the conjunctiva and presence or absence of vitreous in the AC determine the choice of procedure. In the setting of mobile conjunctiva and intact posterior capsule without anterior vitreous loss, filtration surgery is favored. In eyes with conjunctival scarring, GDD is preferable.



Managing Cataract and Glaucoma in Sub-Saharan Africa

Unlike in high-income countries where glaucoma patients present early with most of them able to access care, late presentation of glaucoma is more common in Africa.^{43,44} Furthermore, GDD procedures and phacoemulsification cataract surgery are not as commonly performed as Manual Small Incision Cataract Surgery (MSICS) and trabeculectomy in most African countries. Therefore, combination of trabeculectomy with MSICS (Trab-SICS) seems to be the preferred technique in such settings. In an article published in Community Eye Health Journal,⁴⁵ Kyari described in detail the steps of TrabSICS most suitable for a developing country setting.

In conclusion, although management of co-existing cataract and glaucoma pose a challenge to the attending physician, adequate patients profiling, and proper selection of appropriate technique result in good outcome.

5.4 Micropulse transscleral laser therapy (TLT) in seeing eyes

Glaucoma is an optic neuropathy characterised by acquired loss of retinal ganglion cells (RGCs) and atrophy of the optic nerve leading to vision loss. Elevated intraocular pressure (IOP) is a primary risk factor both for the development of glaucoma and for progression of optic nerve changes and visual field loss in the disease.⁴⁶ Lowering of IOP remains the main proven modality of treatment in glaucoma. This can be achieved either medically; surgically through filtration, microinvasive procedures, tubes/drainage device; or laser.

Cyclodestructive process has been in use since 1930 for treatment of Refractory Glaucomas.⁴⁷ This is achieved through cyclothermy, cyclocryotherapy and cyclophotocoagulation. The secretory non-pigmented epithelium of the ciliary body is the target in cyclodestructive procedure with eventual reduction in aqueous humor secretion and lower IOP.

Laser cyclophotocoagulation was however considered to be the preferred option for cyclodestruction because of higher IOP reduction and milder post-procedure inflammation with better tolerance than cyclocryotherapy.⁴⁸

43 Kyari F, Entekume G, Rabi M, Spry P, Wormald R, Nolan W, et al. A Population-based survey of the prevalence and types of glaucoma in Nigeria: results from the Nigeria National Blindness and Visual Impairment Survey. BMC Ophthalmol. 2015;15(1):176. <https://doi.org/10.1186/s12886-015-0160-6>.

44 Abdull MM, Chandler C, Gilbert C. Glaucoma, "the silent thief of sight": patients' perspectives and health seeking behaviour in Bauchi, northern Nigeria. BMC Ophthalmol 16, 44 (2016). <https://doi.org/10.1186/s12886-016-0220-6>.

45 Kyari F. Managing cataract and glaucoma. Community Eye Health J. 2019;31(104):88–90. <https://www.cehjournal.org/article/managing-cataract-surgery-in-glaucoma-patients/>.

46 Cantor LB. Brimonidine in the treatment of glaucoma and ocular hypertension. Ther Clin Risk Manag. 2006; 2(4): 337–346. <https://doi.org/10.2147/tcrm.2006.2.4.337>.

47 Kumar H, Mansoori T, Warjri GB, Somarajan BI, Bandil S, Gupta V. Lasers in Glaucoma. Indian J.Ophthalmol. 2018;66(11):1539-1553. https://doi.org/10.4103/ijo.IJO_555_18

48 Krupin T, Mitchell KB, Becker B. Cyclocryotherapy in Neovascular Glaucoma. Am J. Ophthalmol. 1978;86:24-26. [https://doi.org/10.1016/0002-9394\(78\)90008-9](https://doi.org/10.1016/0002-9394(78)90008-9).

Initially, NdYAG laser 1064nm was used on the slit lamp and later 810nm Diode laser. Presently, Diode lasers are commonly used. The earlier 810nm Transscleral diode laser photocoagulation done with the G-probe was adopted in the treatment of uncontrolled IOP from neovascular glaucomas, posttraumatic glaucomas, post penetrating keratoplasty glaucoma, inflammatory glaucomas, aphakic/pseudophakic glaucomas.² The continuous wave mode of this model however resulted in many complications with damage to adjacent tissues.⁴⁷

Advances in technology led to the expansion of the scope of cyclophotocoagulation being used in treating seeing eyes with the micropulse diode lasers.

Micropulse diode TLT is a novel technique that was developed as a substitute for the conventional transscleral photocoagulation, with ability to lower intraocular ocular pressure with minimal or no damage to other surrounding structures.⁴⁹

Mechanism of Action

Unlike the transscleral laser diode cyclophotocoagulation G-probe, which uses continuous wave mode and high energy intensity laser (810-nm) to produce a thermal effect on the non-pigmented part of the ciliary epithelium with a resultant decrease in aqueous production, micropulse diode G6-System with P3 probe acts by delivering a fractionated pulse laser with more focal energy to non-pigmented ciliary epithelium. Repetitive short pulses of energy with a duty cycle of 0.5ms "on-time" and 1.1ms "off-time" are delivered, allowing an interval of rest in between. As such, it tends to reduce collateral thermal damage to adjacent tissues thus, keeping non-pigmented tissue below threshold during the off-cycle.⁵⁰

Effect of Laser Cyclophotocoagulation on Seeing Eyes

Micropulse has a better safety profile compared to traditional continuous-wave cyclophotocoagulation, as suggested by some studies. However, because there are not many studies done in Africa, there are no clear guidelines stating the ideal laser parameters that would allow the best balance between high and sustained effectiveness with minimal side effects.

Study done by Jammal et al in Brazil to evaluate the Micropulse Transscleral Diode Cyclophotocoagulation (MTSCPC) in refractory glaucomas reported its safety and effectiveness in reducing intra ocular pressure with reduced need for ocular antihypertensive medication.⁵⁰ Tan et al demonstrated the efficacy and safety of MTSCPC in refractory glaucoma with 80% relative success at 16.3+ 4.5months with no visual loss or hypotony.⁵¹ Another study by Aquino et al compared the safety and efficacy of MTSCPC with the continuous wave mode in refractory glaucomas, this revealed an equal IOP lowering effect but higher complication rate in the Continuous wave arm.⁵²

49 Sanchez FG, Peirano-Bonomi JC, Grippo TM. Micropulse Transscleral Cyclophotocoagulation: A Hypothesis for the Ideal Parameters. Med Hypothesis Discov Innov Ophthalmol. 2018;7(3):94-100

50 Jammal AA, Costa DC, Vasconcellos JPC, Costa VP. Prospective evaluation of micropulse transscleral diode cyclophotocoagulation in refractory glaucoma: 1 year results. Arq Bras Oftalmol. 2019 Jun 27;82(5):381-388. doi: 10.5935/0004-2749.20190076. PMID: 31271570. https://www.scielo.br/scielo.php?script=sci_arttext&pid=S0004-27492019005010102&lng=en&nrm=iso&tlng=en.

51 Tan AM, Chockalingam M, Aquino MC, Lim ZI, See JL, Chew PT. Micropulse transscleral diode laser cyclophotocoagulation in the treatment of refractory glaucoma. Clin Exp Ophthalmol. 2010;38:266-272. <https://doi.org/10.1111/j.1442-9071.2010.02238.x>.

52 Aquino MC, Barton K, Tan AM, Sng C, Li X, Loon SC et al. Micropulse versus continuous wave transscleral diode cyclophotocoagulation in refractory glaucoma: A randomized exploratory study. Clin Exp Ophthalmol. 2015;43:40-46. <https://doi.org/10.1111/ceo.12360>.

In Africa, study done by Schwering et al to investigate if low-dose 810nm transscleral cyclophotocoagulation (TSCPC) can be used as single treatment in Malawian glaucoma patients reported a significant IOP lowering for up to 2 weeks (15 mmHg less from baseline) in most patients which remained stable in 50% of patients after 3 months.⁵³ Similarly in Nigeria, Abdull et al in a study to determine the safety, effectiveness and follow-up rates after trans-scleral diode laser cyclophotocoagulation as primary treatment for seeing eyes with primary open angle glaucoma showed that transscleral diode laser cyclophotocoagulation controlled IOP in almost three quarters of eyes at 12 months with short-term preservation of vision and minimal complications.⁵⁴ In Sub Saharan Africa, micropulse TLT may well be an excellent and safer option in the treatment of moderate to advanced glaucoma with reasonable vision preservation particularly where the probability of patients returning for follow up is low.



- 53 Schwering MS, Kayange P, Klauss V, Kalua K, Spitzer MS. Low-Dose Transscleral Diode Laser Cyclophotocoagulation (TSCPC) as a Potential Single Treatment for Primary Open-Angle Glaucoma (POAG) in Malawi. Graefes. Arch Clin Exp Ophthalmol. 2013; 251(10):2389-93. <https://doi.org/10.1007/s00417-013-2441-1>.
- 54 Abdull MM, Broadway DC, Evans J, Kyari F, Muazu F, Gilbert C. Safety and effectiveness of primary transscleral diode laser cyclophotoablation for glaucoma in Nigeria. Clin Exp Ophthalmol. 2018 Dec;46(9):1041-1047. doi: 10.1111/ceo.13328. Epub 2018 Jun 17. PMID: 29808573; PMCID: PMC6585748. <https://doi.org/10.1111/ceo.13328>.

5.5 Selective Laser Trabeculoplasty and Argon Laser Trabeculoplasty as first line treatment for glaucoma

Laser trabeculoplasty is the application of laser to the trabecular meshwork to increase aqueous outflow and hence reduces intraocular pressure. It is one of the treatment modalities for open angle glaucoma. Argon Laser Trabeculoplasty (ALT) first introduced in 1979 by Wise and Witter⁵⁵ has been proved to be efficacious in different types of glaucoma⁵⁶ and had been used in seminal trials that shaped contemporary glaucoma management.^{57,58} However, the effectiveness of ALT wanes with time and with repeat treatment. Latina and Parker⁵⁹ in 1995 introduced Selective Laser Trabeculoplasty (SLT) in which Q-switched ND-YAG and frequency-doubled ND YAG laser at pulse duration of 10 nanosec to 1 microsec selectively targeted pigmented trabecular meshwork without collateral damage to adjacent tissues. Compared with ALT, SLT has shown greater potential for repeatability due to its lesser ultra-structural damage to trabecular meshwork.⁶⁰

SLT has been shown to demonstrate comparable treatment success when compared to ALT and medication among patients with maximally tolerated medication and newly diagnosed patients, respectively.^{61,62} Furthermore, in previously treated patients with SLT, repeat treatment with SLT produced better result than repeat treatment with ALT.⁵⁶ Although SLT has reasonably good safety profile with many of its side effects being transient and amenable to medication, some rare complications including persistent IOP rise post laser, corneal thinning, and macular edema were reported⁶¹ necessitating continued search for ideal laser for trabeculoplasty. The effort resulted in birth of first sub-threshold laser technique - micropulse laser. Instead of delivering the laser energy in a continuous wave, micropulse laser subdivides the energy into short pulses with specific “on” and “off” times, minimising the heat buildup and hence thermal damage to adjacent tissues.⁶³

Currently ALT, SLT and MLT are the most common trabeculoplasty procedures for open angle glaucoma in practice however the usage of ALT has been diminishing with emergence of much safer techniques.

- 55 James B, Witter SL. A Pilot Glaucoma. ArchOphthalmol. 1979;97:319-22.
- 56 McIlraith I, Strasfeld M, Colev G, Hutnik CM. Selective laser trabeculoplasty as initial and adjunctive treatment for open-angle glaucoma. J Glaucoma. 2006 Apr;15(2):124-30. doi: 10.1097/00061198-200604000-00009. PMID: 16633226.
- 57 Ederer F, VanVeldhuisen PC, Dally LG, Gaasterland DE, Kenneth Sullivan E, Angela Vela M, et al. The advanced glaucoma intervention study (AGIS): 9. Comparison of glaucoma outcomes in black and white patients within treatment groups. Am J Ophthalmol. 2001;132(3):311-20. [https://doi.org/10.1016/S0002-9394\(01\)01028-5](https://doi.org/10.1016/S0002-9394(01)01028-5).
- 58 Stein JD, Challa P. Mechanisms of action and efficacy of argon laser trabeculoplasty and selective laser trabeculoplasty. Curr Opin Ophthalmol. 2007 Mar;18(2):140-5. doi: 10.1097/ICU.0b013e328086aebf. PMID: 17301616.
- 59 Latina MA, Park C. Selective targeting of trabecular meshwork cells: In vitro studies of pulsed and CW laser interactions. Exp Eye Res. 1995;60(4):359-71. [https://doi.org/10.1016/S0014-4835\(05\)80093-4](https://doi.org/10.1016/S0014-4835(05)80093-4).
- 60 Kramer TR, Noecker RJ. Comparison of the morphologic changes after selective laser trabeculoplasty and argon laser trabeculoplasty in human eye bank eyes. Ophthalmology. 2001;108(4):773-9. [https://doi.org/10.1016/S0161-6420\(00\)00660-6](https://doi.org/10.1016/S0161-6420(00)00660-6).
- 61 Wong MOM, Lee JWY, Choy BNK, Chan JCH, Lai JSM. Systematic review and meta-analysis on the efficacy of selective laser trabeculoplasty in open-angle glaucoma. Surv Ophthalmol [Internet]. 2015;60(1):36-50. Available from: <http://dx.doi.org/10.1016/j.survophthal.2014.06.006>.
- 62 Gazzard G, Konstantakopoulou E, Garway-Heath D, Garg A, Bunce C, Wormald R, et al. Selective laser trabeculoplasty versus eye drops for first-line treatment of ocular hypertension and glaucoma (LIGHT): a multicentre randomised controlled trial. Lancet. 2019;393(10180):1505-16. [https://doi.org/10.1016/S0140-6736\(18\)32213-X](https://doi.org/10.1016/S0140-6736(18)32213-X).
- 63 Ma A, Yu SWY, Wong JKW. Micropulse laser for the treatment of glaucoma: A literature review. Surv Ophthalmol [Internet]. 2019;64(4):486-97. Available from: <https://doi.org/10.1016/j.survophthal.2019.01.001>.

Mechanisms of Action

The exact mechanism by which laser trabeculoplasty reduces IOP is not known however there are two proposed theories; Mechanical theory and Biological theory to explain IOP reduction in ALT and SLT.

The mechanical theory postulates that argon laser generates electromagnetic energy which gets converted to thermal energy when it contacts the trabecular meshwork tissue. Heat is released causing tissue contraction that result in a mechanical stretching of the surrounding uveoscleral trabecular meshwork and widening of Schlemm's canal.⁶⁴

The Biological theory states that the lowering of intraocular pressure by ALT and SLT is as a result of laser thermal energy stimulating cellular activity in the trabecular meshwork. This has been corroborated by demonstration of increased recruitment and number of macrophages in trabecular meshwork. Addition, ALT has been shown to upregulate the expression of interleukin 1 (IL-1) and Tumor Necrosis factor in area treated by trabeculoplasty. These biological changes initiate cascade that lead to remodeling of extracellular matrix with consequent increased outflow of aqueous humor.⁶⁴

Kramer et al⁶⁵ compared histopathological changes in human trabecular meshwork following treatment with ALT versus SLT. They discovered that while treatment with ALT demonstrated crater formation in the uveal meshwork at the junction of the pigmented and nonpigmented TM as well as evidence of coagulative necrosis, treatment with SLT showed no evidence of coagulative damage or disruption of the corneoscleral or uveal trabecular beam structure. Therefore, it can be concluded that ALT causes combined mechanical and biological changes while SLT mainly elicits biological response with minimal or no mechanical damage.

The exact mechanism of MLT remains poorly understood, and only postulations exist. Researchers have hypothesised that ALT, SLT, and MLT induce a common cellular biochemical reaction. It is possible that MLT's lower level of laser energy is already sufficient to stimulate this therapeutic pathway in viable cells of the TM, without the excessive coagulative and cellular damage seen from the higher levels of energy in ALT and SLT.

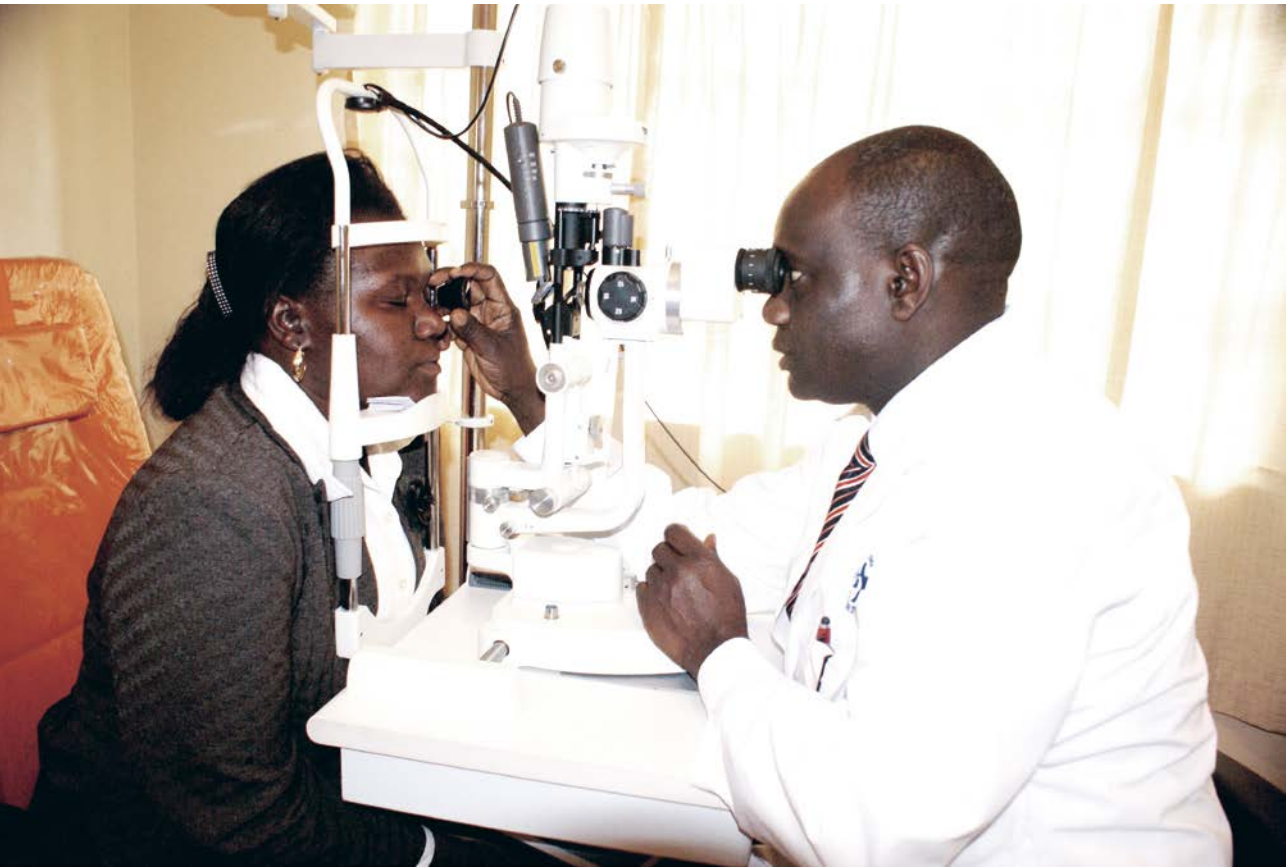
Indications

The risk/benefit ratio of laser trabeculoplasty versus filtration surgery is such that it should be performed in all patients with POAG before embarking on filtration surgery except in young patients with Juvenile open angle glaucoma in whom laser trabeculoplasty rarely works.

64 Stein JD, Challa P. Mechanisms of action and efficacy of argon laser trabeculoplasty and selective laser trabeculoplasty. *Curr Opin Ophthalmol*. 2007 Mar;18(2):140-5. doi: 10.1097/ICU.0b013e328086aebf. PMID: 17301616.

65 Kramer TR, Noecker RJ. Comparison of the morphologic changes after selective laser trabeculoplasty and argon laser trabeculoplasty in human eye bank eyes. *Ophthalmology*. 2001;108(4):773-9. [https://doi.org/10.1016/S0161-6420\(00\)00660-6](https://doi.org/10.1016/S0161-6420(00)00660-6).

	ALT	SLT	MLT
Laser type	Argon green or blue green	Argon green or blue green	Argon green or blue green
Energy	300 to 1000mW	300 to 1000mW	300 to 1000mW
Spot size	50µm	50µm	50µm
Duration	0.1sec	0.1sec	0.1sec
Location of treatment	ATM/PTM junction	ATM/PTM junction	ATM/PTM junction
Extend of treated Area (in degrees)	180-360°	180-360°	180-360°
Number of spots	50-100	50-100	50-100
Duty cycle	Nil	Nil	Nil
End point	Blanching	Blanching	Blanching



Glaucoma Laser Trial⁶⁶ compared efficacy and safety of starting treatment for POAG with ALT versus starting treatment with topical medication. One eye of each patient was randomly assigned to argon laser trabeculoplasty as initial treatment. The patient's fellow eye was assigned to 0.5% timolol. Treatment was prescribed subsequently for either eye, if necessary, for IOP control. There was no difference in IOP reduction between the two treatment groups after 7-year follow up, however laser-first eyes had slightly more improved visual function. It is worth of note to state that more than 50 % of the laser-first eyes needed medication for IOP control subsequently. IOP spikes and high incidence of peripheral anterior synechia were observed in ALT-treated eyes.⁶⁷ Therefore, ALT could not be recommended as first- line in POAG patients.

The efficacy of Micropulse Laser Trabeculoplasty (MLT) has been reported with varied success depending on extend of the area treated and the type of glaucoma. In a systemic review by Ma et al,⁷² MLT reduced IOP in POAG by 17.2 to 21.6% while in secondary open angle glaucoma IOP reduction was in the range of 19.5 to 31.5%. However, there is lack of high-power prospective studies comparing MDLT with more conventional laser techniques.

72 Ma A, Yu SWY, Wong JKW. Micropulse laser for the treatment of glaucoma: A literature review. *Surv Ophthalmol* [Internet]. 2019;64(4):486–97. Available from: <https://doi.org/10.1016/j.survophthal.2019.01.001>.

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5.6 Tube shunt surgery versus trabeculectomy in Black African patients

Prior to the tube versus trabeculectomy study (TVT),^{73,74} tube shunt surgeries were generally reserved for managing refractory glaucoma. The TVT study provided evidence to support its use in less severe glaucoma such as glaucoma following cataract surgeries or poor intraocular pressure control (IOP) following trabeculectomy. The TVT study was a randomized multicenter trial which compared the efficacy and safety of trabeculectomy with mitomycin C (MMC) and tube shunt surgery in eyes with failed trabeculectomy or eyes with prior ocular surgery. The shunt used in this study was the 350mm² Baerveldt glaucoma implant (non-valved). Thirty-five percent of subjects in the TVT study were Blacks. Racial status did not predict risk of failure in the multivariate analysis.

The results of the study at one year⁷³ showed that the Baerveldts tube implant controlled IOP better than trabeculectomy and MMC. Persistent hypotony and re-operation was more among the patients who had trabeculectomy and MMC. The IOP reduction at one year in both groups was similar. The trabeculectomy with MMC group were less likely to require supplemental medical therapy at one year.

Similarly, at five years,⁷⁴ tube shunt surgery had a higher success rate compared to the trabeculectomy with MMC group. There was a higher re-operation in the trabeculectomy with MMC group compared to the tube group. Although in the first 2 months the group that had trabeculectomy with MMC had lower IOP, this became similar by the 3rd month postoperatively. At three years there was no difference in medication use. Postoperative complications were reported to be higher in the trabeculectomy with MMC group compared to the tube shunt group although serious complications were similar in both groups.

These results provide evidence for more general use of tube implant surgeries in glaucoma care. Tube shunt implant is even more important in Sub Saharan Africa where medical management of glaucoma is impractical and hampered by counterfeiting, limited availability and compliance with topical drops, particularly among poor and rural patients. Trabeculectomy on the other hand can be associated with complications such as bleb leaks, infections, and reoperations.

There are other reasons to consider the use of tube implant surgery in Sub-Saharan Africa. Glaucoma can be very aggressive and unresponsive to both medical therapy and trabeculectomy in some patients. Tube surgery can serve as a treatment option when trabeculectomy with MMC has failed or when patients develop glaucoma after cataract surgery. It should also be considered in glaucoma patients with very advanced disease, tunnel vision, high intraocular pressure which cannot be reduced satisfactorily with medication. In this scenario, a surgical procedure with minimal risk such as tube shunt surgery may be considered.

73 Gedde SJ, Schiffman JC, Feuer WJ, Herndon LW, Brandt JD, Budenz DL. Treatment outcomes in the tube versus trabeculectomy study after one year of follow-up. *Am J Ophthalmol.* 2007;143(1):9-22. doi:10.1016/j.ajo.2006.07.020.

74 Gedde SJ, Schiffman JC, Feuer WJ, Herndon LW, Brandt JD, Budenz DL. Treatment outcomes in the Tube Versus Trabeculectomy (TVT) study after five years of follow-up. *Am J Ophthalmol.* 2012;153(5):789-803.e2. doi:10.1016/j.ajo.2011.10.026. <https://doi.org/10.1016/j.ajo.2011.10.026>.

Some studies have reported the efficacy of the Ahmed valved tube implant surgery in Africa Complete success following tube implant surgeries was reported in 66.7% of eyes,⁷⁵ while 76.9-83.3% had qualified success 6 months after the surgery.^{75,76} A similar study also reported surgical success in 79% of patients at 2 months follow up.⁷⁷ Another study using a non-valved tube implant shunt also reported complete success in 50% and qualified success in 90% of their patients at one year follow up.⁷⁸ Some of the indications for tube shunt surgeries in these studies were refractory glaucoma, failed trabeculectomy, failed angle surgeries (trabeculotomy and goniotomy) primary open angle glaucoma exfoliative glaucoma, angle closure glaucoma and other forms of refractory glaucoma suggesting a wide range of indications. These studies recruited a small cohort of patients and therefore results cannot be generalised.

Larger standardised studies are needed to assess the efficacy, safety and complications of tube surgeries in Africans. Randomized controlled trials are also needed to compare the efficacy and safety of trabeculectomy with MMC versus tube shunt surgery in indigenous Africans. The results of these studies will provide much needed evidence to evaluate the efficacy of tube shunt surgeries versus trabeculectomy with MMC in glaucoma patients in SSA.

There are some barriers to the use of tube shunt devices in SSA. The Ahmed valved tube shunt device and the Baerveldts non valved tube shunt devices are the commonest forms of shunt devices and they are very expensive compared to the gross domestic product of many countries in SSA. A large proportion of patients in SSA pay for health care out of pocket and therefore may be unable to pay for these shunt devices. However, the introduction of the Aurolab Aqueous Drainage Implant (AADI) a cheaper non valved tube shunt device may be more affordable, and available in SSA: Another barrier to its use is the availability of ophthalmic surgeons who have the required surgical skills to perform the surgeries. The intensive training of glaucoma specialists in SSA in the past years especially supported by the Commonwealth Eye Health Consortium (CEHC) will reduce this barrier over the next coming years.

In conclusion, glaucoma management is a huge problem in SSA. Glaucoma shunt surgeries offer a potentially effective and safe option for IOP control. However long-term outcomes and well-designed randomised trials among Africans will provide much needed evidence for their use in this population.

75 Gessesse GW. The Ahmed Glaucoma Valve in Refractory Glaucoma: Experiences in Southwest Ethiopia. *Ethiop J Health Sci.* 2015;25(3):267-272. <https://doi.org/10.4314/ejhs.v25i3.10>.

76 T/Giorgis A. Initial clinical experience of tube-shunt surgery in Ethiopian patients with refractory glaucoma. *Ethiop Med J.* 2012;50(2):159-165.

77 Kiage DO, Gradin D, Gichuhi S, Damji KF. Ahmed glaucoma valve implant: experience in East Africa. *Middle East Afr J Ophthalmol.* 2009;16(3):151-155. <https://doi.org/10.4103/0974-9233.56230>.

78 Olawoye O, Sarimiye T, Ashaye A, Hwang YH, Han JC, Ahn BH. Surgical outcomes of membrane-tube-type glaucoma shunt device in indigenous West Africans. *Clin Ophthalmol.* 2018;12. <https://doi.org/10.2147/OPTh.S148325>.

5.7 Use of Mitomycin/ 5FU versus beta-radiation for trabeculectomy

In Sub Saharan Africa (SSA), medical management of glaucoma is hampered by counterfeit non-potent (fake) drugs, limited availability especially in the rural areas, compliance, and affordability. Therefore, surgical management has been advocated as first line of management in SSA. The problems associated with medical therapy make trabeculectomy more effective in reducing intraocular pressure (IOP) compared to medical management.

The goal of trabeculectomy surgery is to lower IOP by creating a fistula for the controlled flow of aqueous humor from the anterior chamber to the sub-conjunctival space. It remains the most common surgical procedure to treat glaucoma in SSA. The procedure however has a higher failure rate in Africans compared to Caucasians because of the stronger scarring response and the aggressive wound healing process. Sub-conjunctival scarring is a major concern in the management of glaucoma especially in Africa because it leads to earlier failure of the drainage surgery.

Antifibrotic agents such as mitomycin C (MMC) and 5 Fluorouracil (5FU) have been used to reduce scarring during wound healing postoperatively especially in Africans. This increases the likelihood of a long-term survival of the blebs. In a systematic review by Cabourne et al,⁷⁹ the use of MMC reduced the risk of trabeculectomy failure slightly more than 5 FU at one year follow up. MMC achieved a slightly lower IOP than 5FU at one year (mean difference -3.05mmHg 95% CI -4.60 to 1.50) especially in high risk populations such as Africans (MD - 4.18 mmHg, 95% CI -6.73 to -1.64) compared to the low-risk group (MD -1.72 mmHg, 95% CI -3.28 to -0.16). Patients who had trabeculectomy with MMC used fewer anti-glaucoma medications post-operatively compared to patients who used 5FU. The effects of both anti-fibrotics on visual outcome was similar. Complications such as cataract formation, bleb leaks wound leaks and hypotony were slightly more in patients who used MMC compared to 5FU. These results are similar to findings in another study in SSA⁸⁰ which compared 5FU and MMC, and reported that the MMC group was less likely than the 5FU group to require medications or needle revisions to control IOP. Hypotony however was more in patients with MMC compared to patients who used 5FU. MMC does have the advantage of achieving lower pressures compared to 5FU however it is associated with a higher rate of complications. This disadvantage with its higher toxicity, lower pharmacological stability and higher cost makes it imperative to consider other ways of preventing wound scarring post trabeculectomy in Africans.

Beta irradiation can also reduce scarring post trabeculectomy. It has some advantages that may make it more relevant in the African context. It is a rapid simple procedure that can slow down the healing process post trabeculectomy. Beta irradiation improves survival of blebs following trabeculectomy by causing growth arrest due to its effects on P450 without leading to destruction of cells. The beta irradiation is applied using a Strontium-90 applicator at the completion of surgery. This applicator helps to deliver precise dose of treatment to exact bleb area. A single dose of 750cGy or 1000 cGy is often used.

79 Cabourne E, Clarke JCK, Schlottmann PG, Evans JR. Mitomycin C versus 5-Fluorouracil for wound healing in glaucoma surgery. Cochrane database Syst Rev. 2015;(11):CD006259. <https://doi.org/10.1002/14651858.CD006259.pub2>.

80 Anand N, Dawda VK. A comparative study of mitomycin C and 5-Fluorouracil trabeculectomy in west Africa. Middle East Afr J Ophthalmol. 2012;19(1):147-152. <https://doi.org/10.4103/0974-9233.92132>.

The beta irradiation machine is sturdy with little cost on maintenance. There are no running costs compared with 5FU and MMC and it is technically simple to perform. In addition, results from its use have been very encouraging. In a recent randomized controlled trial of MMC and Beta irradiation in South Africa, Cook et al⁸¹ reported that eyes treated with trabeculectomy augmented with beta irradiation were 3.15 (95% CI 1.40–7.10) times more likely to have a functioning bleb compared with eyes treated with trabeculectomy augmented with MMC and this was statistically significant (P=0.009). Patients who had beta irradiation were also 5.55 times more likely to have an IOP less than 16mmHg (complete success) without any adjunctive anti-glaucoma medications compared with patients who had trabeculectomy and MMC (P=0.008). There were however more complications in the beta irradiation group with 47% of the functioning bleb in this group having cystic and unhealthy blebs compared with 28% of the functioning bleb in the MMC group but this was not statistically significant (P=0.13).

This result suggests that beta irradiation may be more effective in preventing bleb fibrosis, scarring and failure compared to the use of MMC although beta irradiation may be more associated with a high risk of complications. Kirwan et al⁸² in a systematic review of randomized controlled trials comparing trabeculectomy alone with trabeculectomy and beta irradiation, reported that patients who had beta irradiation had a lower risk of postoperative surgical failure although the procedure was associated with a higher risk of cataract. Beta irradiation looks promising especially in developing countries of SSA. Advantages of this procedure include precision, simple technology, efficacy and low cost. Few studies have been done to compare MMC and beta irradiation in SSA. More well-designed randomized trials are needed among indigenous Africans to further elucidate this technology in reducing bleb scarring post trabeculectomy.

81 Cook C, Perrott A, Mustak H, Courtright P, Wetter J, Du Toit N. Randomised clinical trial of trabeculectomy with mitomycin-C versus trabeculectomy with beta radiation. South African Ophthalmol J. 2018;13(4):11-14.

<https://journals.co.za/content/journal/10520/EJC-136ba7e6dd>.

82 Kirwan JF, Rennie C, Evans JR. Beta radiation for glaucoma surgery. Cochrane database Syst Rev. 2012;(6):CD003433. doi:10.1002/14651858.CD003433. <https://doi.org/10.1002/14651858.cd003433.pub3>.

5.8 The role of simulated surgical training in trabeculectomy



Trabeculectomy remains the gold standard surgical intervention for reducing intraocular pressure in glaucoma patients despite the wide range of novel minimally invasive glaucoma surgeries. It is the commonest surgical modality for glaucoma in some developed countries like Scotland, England and Wales⁸³ as well as in Sub-Saharan Africa^{84,85} with tube surgery reserved for patients with failed trabeculectomy or refractory glaucoma.

In patients receiving trabeculectomy, the drainage surgery must achieve a stable reduction in IOP with the ultimate aim of improving visual function and quality of life of patients. Glaucoma is responsible for the commonest cause of irreversible blindness globally, there is a lot of focus on cataract surgery during residency training in Africa with little attention given to trabeculectomy. Manual Small Incision Cataract Surgery (MSICS) is the cataract surgery commonly performed in sub-Saharan Africa. Trabeculectomy

83 Kirwan JF, Lockwood AJ, Shah P, Macleod A, Broadway DC, King AJ, et al. Trabeculectomy in the 21st century: A multicenter analysis. *Ophthalmology* 2013;120(12):2532–9. Available from: [https://www.aaojournal.org/article/S0161-6420\(13\)00689-1/fulltext](https://www.aaojournal.org/article/S0161-6420(13)00689-1/fulltext).

84 Kyari F, Nolan W, Gilbert CE. Ophthalmologists' practice patterns and challenges in achieving optimal management for glaucoma in Nigeria: Results from a nationwide survey. *BMJ Open* 2016;6:e012230. <https://bmjopen.bmj.com/content/bmjopen/6/10/e012230.full.pdf>

85 Adegbehingbe B., Majemgbasan T. A review of trabeculectomies at a Nigerian teaching Hospital. *Ghana Med J*. 2010;41(4):176–80. <https://doi.org/10.4314/gmj.v41i4.55287>.

unlike cataract surgery is technically demanding, requiring careful tissue (especially conjunctiva) handling and suturing.⁸⁶ Mastering these techniques requires dedicated time and practice.⁸⁷ Globally, surgical education for glaucoma is challenging. Opportunities and surgical experience for trainees are often fluctuating.⁸⁸ In the USA, the mean number of trabeculectomies performed by trainees is four. Similarly, in sub-Saharan Africa the mean number performed by senior trainees was also low.⁸⁹ In Nigeria, trained ophthalmologists perform on the average one trabeculectomy in a month. This was significantly associated with insufficient exposure to the surgery during residency training and patients' poor acceptance of the surgery.⁹⁰

Trained ophthalmologist are therefore losing the skill and trainees are not acquiring the necessary skill in trabeculectomy.⁸⁶ Simulation surgery has become an essential tool in training of surgeons over the last couple of years.⁹¹ Simulation surgery may be with or without the use of computers, and it is an attractive model because it avoids the use of patients for skills practice enabling and ensuring that trainee surgeons have adequate training to master the skill to be learnt in a stress free environment before treating humans.^{91, 92}

Simulation surgery may be with organic or non-organic simulators. Organic simulators, consisting of live animal and fresh human cadaver models, whereas the inorganic simulators comprise virtual reality simulators and synthetic bench models. Skills learned in simulation surgeries are standardised and safe and are reproducible in real life scenarios;^{93,94} trabeculectomy is no exception. Psychomotor skills, hand-eye coordination, and ambidextrous are essential surgical skills.⁹³ These may be useful in trabeculectomy. Simulation training in surgical education has been studied extensively worldwide, however, there is very limited evaluation of the use of simulation training for surgical skills in SSA. Simulation skills described in the literature and evaluated in SSA, involve specialties of general surgery, Otorhinolaryngology, Obstetrics and Gynaecology and Urology.⁹⁵ In SSA, simulation surgery training is not limited to trainees but also to trainers desirous of learning new techniques.⁹⁴

86 Troutbeck R, Lee GA, Sanfilippo P, Fleming B. Trabeculectomy: A training dilemma. *Eye*. 2007;21(2):183–6.

<https://doi.org/10.1038/sj.eye.6702159>.

87 Porteous AM, Ahmed F. A novel wet-lab teaching model for trabeculectomy surgery. *Eye* [Internet]. 2018;32(9):1537–50. Available from: <http://dx.doi.org/10.1038/s41433-018-0093-4>.

88 Chadha N, Warren JL, Liu J, Tsai JC, Teng CC. Seven-and eight-year trends in resident and fellow glaucoma surgical experience. *Clin Ophthalmol*. 2019;13:303–9. <https://doi.org/10.2147/OPHT.S185529>.

89 Dean WH, Buchan J, Admassu F, Kim MJ, Golnik KC, McNaught A, et al. Ophthalmic simulated surgical competency assessment rubric (Sim-OSSCAR) for trabeculectomy. *BMJ Open Ophthalmol*. 2019;4(1):1–7. <https://doi.org/10.1136/bmjophth-2019-000313>.

90 Kizor-Akaraiwe N N OCE. Practice of trabeculectomy by ophthalmologists in Nigeria. *Niger J Clin Pr*. 2017;20:507–11. <https://doi.org/10.4103/1119-3077.196992>.

91 Agha RA, Fowler AJ. The role and validity of surgical simulation. *Int Surg*. 2015;100(2):350–7. <https://doi.org/10.9738/INTSURG-D-14-00004.1>.

92 Sutherland LM, Middleton PF, Anthony A, Hamdorf J, Cregan P, Scott D, et al. Surgical simulation: A systematic review. *Ann Surg*. 2006;243(3):291–300. <https://doi.org/10.1097/01.sla.0000200839.93965.26>.

93 Tan SSY, Sarker SK. Simulation in surgery: A review. *Scott Med J*. 2011;56(2):104–9. <https://doi.org/10.1258/smj.2011.011098>.

94 Agha RA, Fowler AJ. The role and validity of surgical simulation. *Int Surg*. 2015;100(2):350–7. <https://doi.org/10.9738/INTSURG-D-14-00004.1>.

95 Campain NJ, Kailavasan M, Chalwe M, Gobeze AA, Teferi G, Lane R, et al. An Evaluation of the Role of Simulation Training for Teaching Surgical Skills in Sub-Saharan Africa. *World J Surg* [Internet]. 2018;42(4):923–9. Available from: <https://doi.org/10.1007/s00268-017-4261-7>.

There have been a number of subtle modifications in trabeculectomy all aimed at ultimately preserving the vision in patients by minimising complications while maintaining a desired intraocular pressure. The Safe technique using releasable sutures is one of these techniques.⁹⁶

Simulation surgery affords both trainer and trainee practice adequately as well as the ability to learn and modify known techniques. There are few simulation models for trabeculectomy described in the literature. Porteous and Ahmed describe an innovative wet lab model specific for trabeculectomy using green apples, cling film, and disposable instruments. This utilises readily available and inexpensive items.⁹⁷ The skin and cortex of a green apple possess a firm consistency which lends itself to the creation of the scleral flap without the tissue easily disintegrating and when the flap is opened the thickness and uniformity of the flap can be assessed. The curvature of the apple being similar to the curvature of the eye, allows the trainee to practice tilting the crescent blade to ensure the curvature is followed when extending side-ways. In this scenario, the cling film, wrapped around a half cut apple simulates the conjunctiva.

Harvesting porcine head has been described for use by residents in Nigeria for multiple intra and extraocular surgery including trabeculectomy.⁹⁸ Lee et al have also described a teaching model for trabeculectomy using freshly exenterated pig eyes fixed in 10% formaldehyde solution for 5 to 12 hours.

This step is essential for firming of the pig eye tissues, to simulate human tissue consistency.⁹⁹ After this step the eye is rinsed, and re-inflated with normal saline via the optic nerve until firm. Good fixation is essential as many of the steps in trabeculectomy require counteraction. This fixation is achieved by mounting the pig eye on a foam eye with short 25 G needles or on a dummy head. All these items can easily be obtained in the setting of any Sub Saharan African country and thus can easily be reproducible for teaching purposes. Details of the steps of trabeculectomy using releasable sutures, techniques for maximising the use of the pig eye as well as basic surgical instrument required are detailed in the text.¹⁰⁰ Of note is that the conjunctiva in the pig is thinner and the sclera thicker than the human eye.

The releasable suture technique is technically demanding but this teaching model makes it possible for the trainee surgeon to repeat a number of times until one is proficient. It is impossible, however, to simulate all surgical steps such as poor surgical access, blood obscuring the operating field requiring cautery, and patient movement. Creating blood to obscure the operating field and patient movement may be steps which may be simulated using a computer-based system and are worth exploring. The vital step of adjusting the suture tension on the scleral flap thereby limiting the aqueous flow through the sclerostomy and hence titrating the intraocular pressure also cannot be simulated on the pig eye.

96 Dhingra S, Khaw PT. The Moorfields Safer Surgery System. Middle East Afr J Ophthalmol. 2009;16(3):112-5.

97 Porteous AM, Ahmed F. A novel wet-lab teaching model for trabeculectomy surgery. Eye [Internet]. 2018;32(9):1537-50. Available from: <http://dx.doi.org/10.1038/s41433-018-0093-4>.

98 Ezeanosike E, Azu-Okeke JC, Achigbu EO, Ezisi CN, Aniemeka DI, Ogonnaya CE, et al. Cost-Effective Ophthalmic Surgical Wetlab Using the Porcine Orbit with a Simple Dissection Protocol. Open J Ophthalmol. 2019;09(04):183-93. <https://doi.org/10.4236/ojoph.2019.94020>.

99 Lee GA, Chiang MYM, Shah P. Pig eye trabeculectomy - A wet-lab teaching model. Eye. 2006;20(1):32-7. <https://doi.org/10.1038/sj.eye.6701784>.

100 Lee GA, Chiang MYM, Shah P. Pig eye trabeculectomy - A wet-lab teaching model. Eye. 2006;20(1):32-7. <https://doi.org/10.1038/sj.eye.6701784>.

This may be another step that could be explored using computer bases systems or by filling the anterior chamber with saline. The aim of the pig eye prepared in formalin model however, is to master all the other steps so that additional surgical challenges can be more easily overcome.

Beyond skills acquisition, the simulation models provide the trainees and trainers the rare opportunity to replicate and repeat surgical scenarios with consistency for the purpose of skills assessment and quality improvement.¹⁰¹ The tool assesses Competencies of Practical skills using specific Competency based system known as Ophthalmology Surgical Competency Assessment Rubrics (OSCARS). The idea is to deconstruct the entire procedure into sequential steps which are analysed and given a score that can be compared against future attempts; a good way to improve learning. The Rubric for assessing trabeculectomy proficiency has been developed and accredited by International Council of Ophthalmology.¹⁰²

To the best of our knowledge there is very little published evidence on computer-based simulation surgery system for trabeculectomy. Computer based simulation systems are available for vitreo-retinal surgery and cataract surgery.¹⁰³

Simulation surgery improves learning and has the potential to meet the needs of trainees and satisfy the regulatory needs of the profession.¹⁰⁴ With the need for more trabeculectomy surgery in SSA to manage glaucoma patients and with little exposure to glaucoma surgery for trainees in ophthalmology, it is pertinent that more investments are made to make simulation surgical training easily and more readily available.

101 Walkden A, Au L, Fenerty C. Trabeculectomy Training: Review of Current Teaching Strategies. Adv Med Educ Pract. 2020;11:31-6. <https://doi.org/10.2147/amep.s168254>.

102 Green CM, Salim S, Edward DP, Mudumbai RC, Golnik K. The Ophthalmology Surgical Competency Assessment Rubric for Trabeculectomy. J Glaucoma 2017;26(9):805-809. <https://doi.org/10.1097/IJG.0000000000000723>.

103 Tan SSY, Sarker SK. Simulation in surgery: A review. Scott Med J. 2011;56(2):104-9. <https://doi.org/10.1258/smj.2011.011098>.

104 Agha RA, Fowler AJ. The role and validity of surgical simulation. Int Surg. 2015;100(2):350-7. <https://doi.org/10.9738/INTSURG-D-14-00004.1>.

PART 2: Glaucoma Service Delivery - Setting up an Integrated Glaucoma Programme

Part 2 of the glaucoma toolkit is a programme-focused section with the aim of setting up an integrated glaucoma care programme.



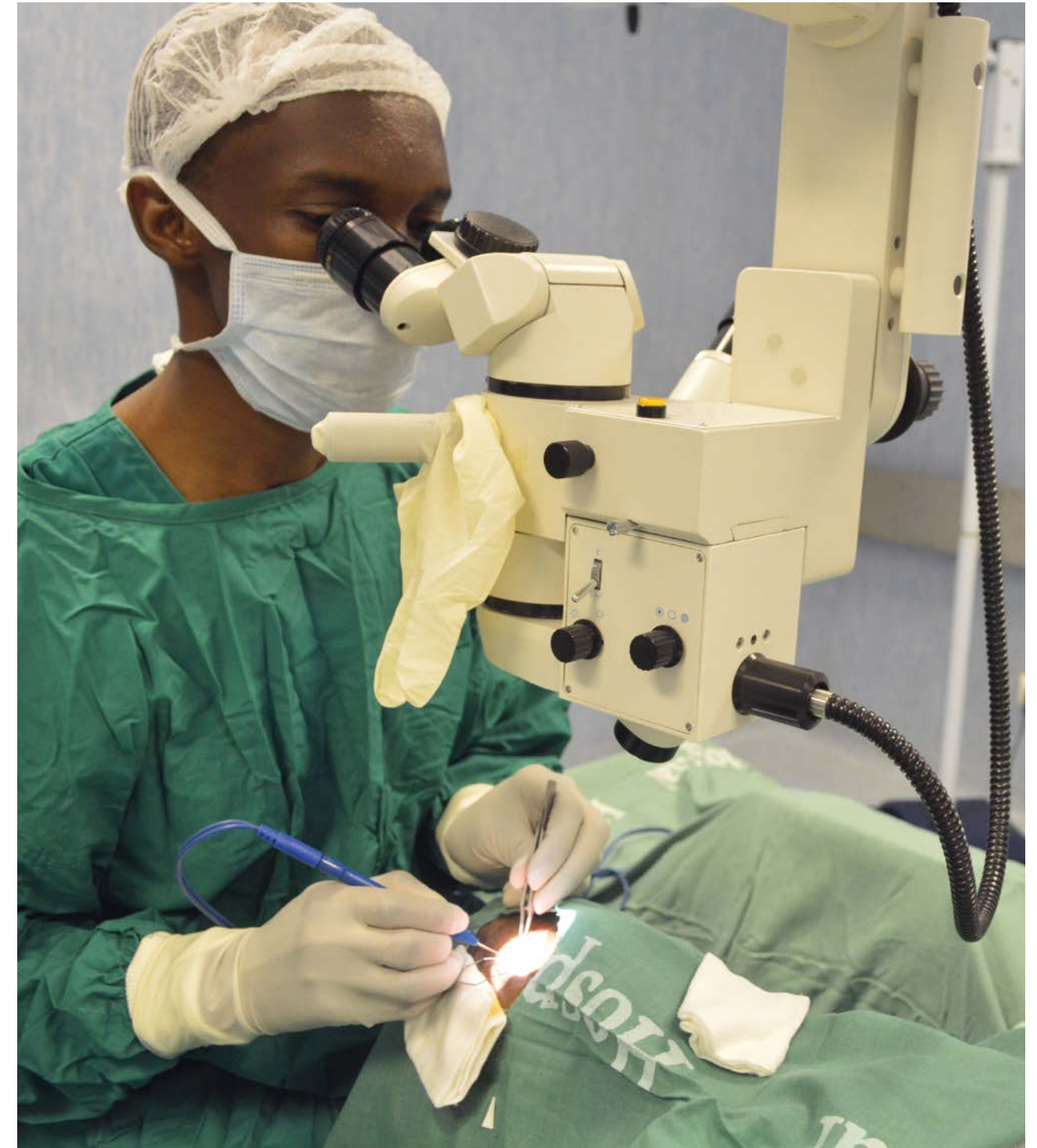
The following are discussed in chapters:

1. Levels of glaucoma care – Who does what and where; integration and health systems strengthening
2. Models of service delivery and financing of glaucoma care; facilitating early diagnosis and improving follow-up
3. Equipment list for a glaucoma service
4. Advocacy to include key messages to policy makers, planners and providers; and raising awareness in the general population

There is a local information page which is a form to be completed for your area/ community.

CHAPTER 6 – LEVELS OF GLAUCOMA CARE

This chapter describes who does what and where; with integration and health systems strengthening.



6.1 Levels of Competency for Disease Status



The World Health Organization (WHO) and health systems have a set method of looking at disease therapy in populations based on levels of care (community, primary, secondary and tertiary levels of care). In reality, this is often subverted by actions of individuals seeking higher levels of care than their disease requires or alternatively not reaching the appropriate level of care with severe disease. A second point is that various professions and allied medical care providers assume widely varying roles in different countries and even within single countries. This is further compounded by the division between government and non-governmental care provision.

For the purposes of these guidelines and glaucoma toolkit, we have taken a simplistic approach. Firstly, we are providing guidelines from a disease severity perspective. Secondly, the care required for each degree of disease severity is given in terms of competencies not status of care provider.

We present four levels of glaucoma care. At each level it would be expected that a care provider/team has been trained and shown to be competent in all aspects within that level of care (including all lower level competencies). Higher levels would be expected to train others to all lower levels of competency. We have deliberately avoided specific recommendations on therapeutic avenues since these are prone to change with time and availability. We also consider the reality that glaucoma treatment, unlike cataract surgery, is not a once-off. As such, glaucoma patients continue to pool in the clinic and as one continues to build up the clinic, this may become a real challenge of workload. Thus, the presented guideline on levels of competency provides a framework by which services may safely expand.

Competency level 1: Those at risk of developing glaucoma

This is the general population. Focused examples might be older age, first-degree (close) relatives of those with glaucoma, ocular hypertensives etc.

The care provider should have the following:

- ▶ Ability to explain disease and therapy to individuals, groups and via mass-media
- ▶ Ability to organize outreach activities for public health education and case finding
- ▶ Ability to identify individuals with moderate or severe glaucoma

Competency level 2: Stable glaucoma

The care provider should have the following:

- ▶ Ability to explain and provide ongoing therapy supporting adherence
- ▶ Ability to provide ongoing review for individual diagnosed with glaucoma
- ▶ Ability to detect progression of glaucoma

Competency level 3: Moderate to severe glaucoma

The care provider should have the following:

- ▶ Ability to diagnose glaucoma and its sub-types
- ▶ Ability to grade severity and provide care plan for individual with glaucoma
- ▶ Ability to treat non-complex and non-sight threatening glaucoma
- ▶ Ability to manage progression of glaucoma
- ▶ Ability to identify patients in need of more complex care
- ▶ Ability to lead and oversee finance for team at competency levels 1 and 2.

Competency level 4: Complex & sight threatening glaucoma

E.g. secondary glaucomas, paediatric glaucoma, severe visual field loss in younger individuals, refractive to therapy

The care provider should have the following:

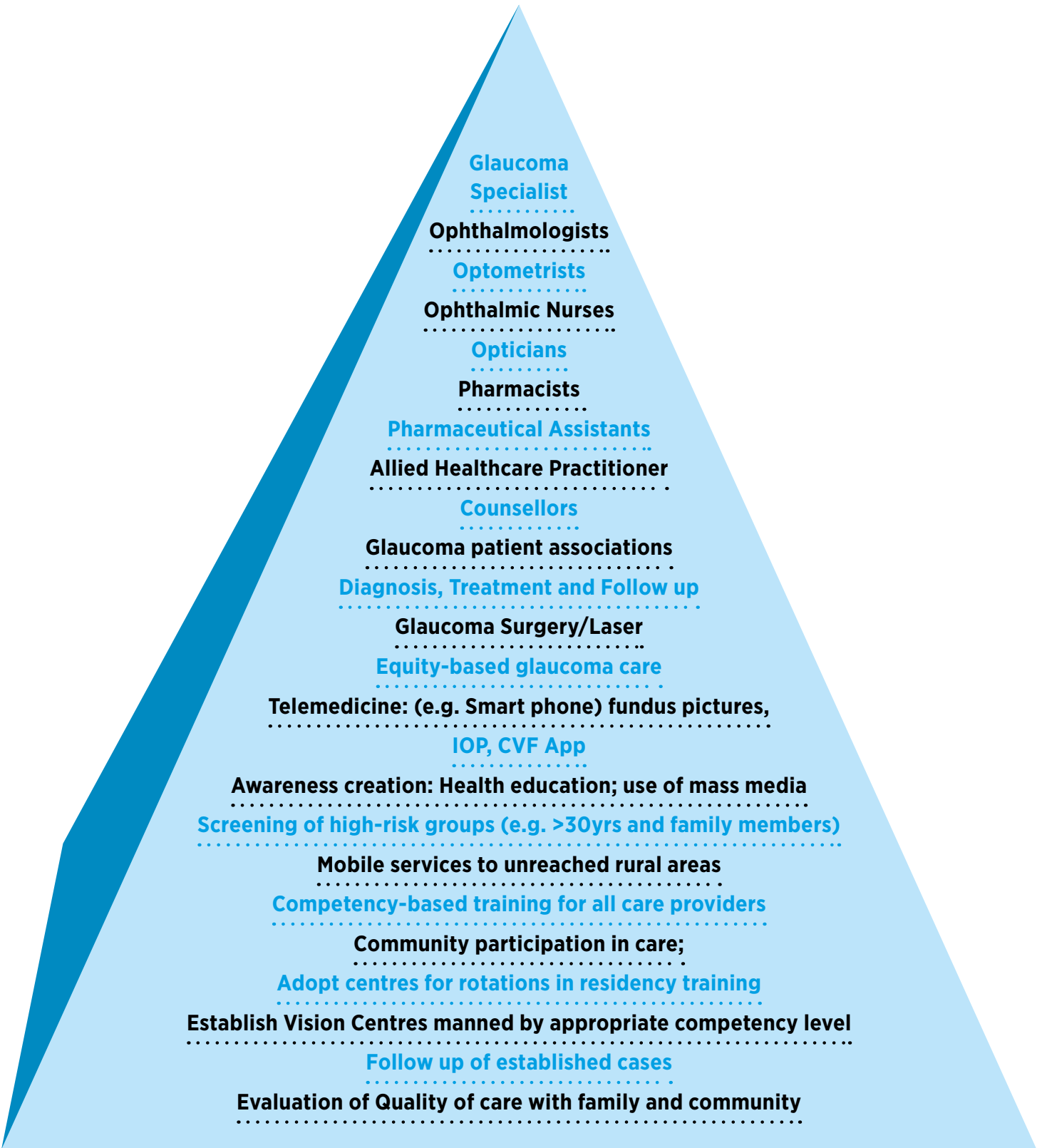
- ▶ Glaucoma sub-specialist skills capable of all modes of therapy
- ▶ Ability to lead and oversee finance for team at competency levels 1, 2 and 3
- ▶ Ability to encourage and oversee data management including audit and research at all levels of competency

Notes of intention:

- ▶ Diagnosis of glaucoma would include all required investigations and skills to differentiate glaucoma sub-types.
- ▶ Diagnosis is made at level three whilst ongoing management is at level two.
- ▶ Sub-specialist skills will encompass all appropriate and available for the given country and situation.

6.2 Everybody Matters

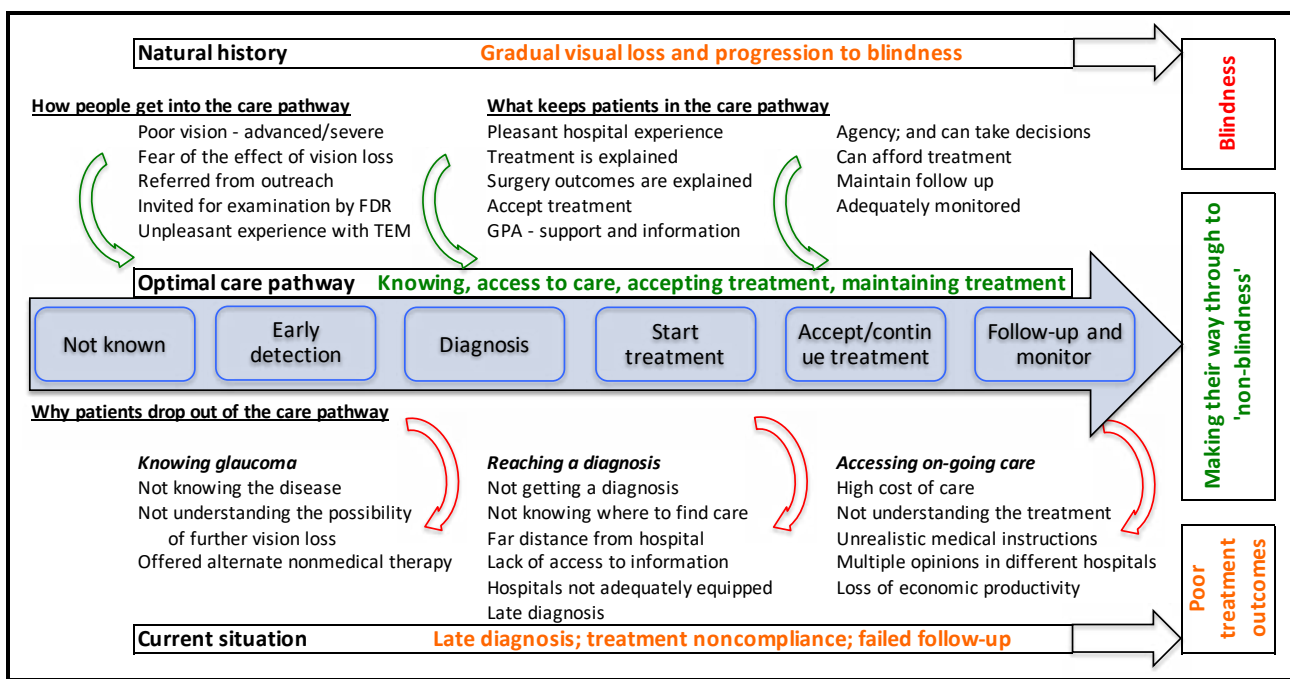
Everybody matters means everybody has to be involved as a member of the glaucoma care team.



CHAPTER 7 - MODELS OF SERVICE DELIVERY AND FINANCING OF GLAUCOMA CARE

This is a challenging topic as it is new and will require more of highlighting relevant literature/case study than definitive advice.

In earlier studies, we conceptualised a framework for an optimal glaucoma care pathway (see the central flow below) and imagined that patients would take those steps to avoid blindness. The pathway involved getting to know glaucoma, having a diagnosis, accepting the treatment offered, compliance with treatment and maintaining monitoring and follow-up. We also determined how patients get into the biomedical care pathway and what keeps them in the system to continue on-going care. We also determined why patients drop out of the care pathway.¹⁰⁵



105 Kyari F, Chandler CI, Martin M, Gilbert CE. So let me find my way, whatever it will cost me, rather than leaving myself in darkness: Experiences of glaucoma in Nigeria. Glob Health Action 2016;9:31886. <http://dx.doi.org/10.3402/gha.v9.31886>.

7.1 Models of glaucoma care

In this section, we sought to describe different models of delivery of glaucoma care in a Sub-Saharan Africa setting which improve access to early diagnosis, appropriate treatment and improved follow-up. However, different clinics/services have adopted their own approaches and demonstrated the effectiveness of glaucoma detection and treatment interventions, and there was limited number that showed a programmatic model of care delivery in the SSA context.¹⁰⁶ In a diagonal model of care in India, an experienced glaucoma specialist supported the care of glaucoma patients in rural and under-served areas. The support consisted triaging glaucoma patients for defined protocols of treatment, glaucoma specialist visit at regular intervals and remote online clinical decision support to the comprehensive ophthalmologist at the location. A review of the model showed better clinical outcomes of glaucoma care in an under-served geographic area.¹⁰⁷

Adapting this model, the glaucoma toolkit is being piloted in Gondar, Ethiopia in the “Silent Thief of Sight” programme of Light for the World.¹⁰⁸ The comprehensive ophthalmologists from two secondary centres have undergone training in glaucoma surgery and glaucoma care with the glaucoma specialist at the tertiary centre. Glaucoma diagnosis and treatment interventions will be in a similar diagonal model, with protocols of care, decision support and structured/regular visits by the glaucoma specialist.

106 Karim F. Damji, Samir Nazari, Abeba Giorgis, Dan Kiage, Sheila Marco, Heiko Philippin, Neema Daniel & Samreen Amin(2017) STOP Glaucoma in Sub Saharan Africa: enhancing awareness, detection, management, and capacity for glaucoma care, Expert Review of Ophthalmology, 12:3, 197-206, DOI: 10.1080/17469899.2017.1295848
107 Choudhari NS, Mundhe G, Khanna R, Rath V, Garudadri CS. Toward Better Health Outcomes in Rural and Under-served Areas: L. V. Prasad Eye Institute's Diagonal Model of Glaucoma Care. Ophthalmic Epidemiol. 2019 Dec;26(6):420-429. Epub 2019 Jul 25. PMID: 31340705. <https://doi.org/10.1080/09286586.2019.1646292>.
108 Light for the World International. The Silent Thief of Sight. <https://www.light-for-the-world.org/silent-thief-sight>.

7.2 Potential avenues for financing care in a sustainable way

Blindness from glaucoma is associated with socio-economic deprivation, and this was presumed to be a reflection of poor access to care and poor adherence to treatment impinged on financial constraints and affordability of care.¹⁰⁹ Research to define mechanisms for financing eye care is required. Low per capita income levels and high glaucoma treatment costs hinder widespread effective glaucoma care interventions. The following possible solutions have been put forth:^{110, 111}

1. Glaucoma has been considered by WHO as a priority eye condition to be included in the health benefit package of eye care interventions (PECI).¹¹²
2. One way of reducing cost of care is to develop low cost generic anti-glaucoma medication or set up a bulk purchase, shared cost procurement mechanism for medications and glaucoma surgical instruments and consumables such as drainage devices and antimetabolites.
3. Providing favourable financing options for diagnostic and surgical equipment will save heavy up-front spending by the care-provider which are invariably transmitted to the user.
4. Surgical training costs could be reduced by setting up regional surgical skills transfer centres, which include simulated surgery training. This will also improve the quality of surgery and possible increase the numbers of glaucoma surgery.
5. On a more local level, clear and accurate information on cost should be given to prospective patients. For example, unacceptable for patients to be told that the surgery is free, but they later come to realise that they have to pay for the consumables and medicines. Treatment packages with flexible payment schedule are proposed: e.g. Surgical package to include pre-op assessment, surgical, medicines and accommodation charges and 3 months post-op care.
6. It will be a big boost to glaucoma control if national/state/district/local governments consider including glaucoma surgery and medicines in health insurance and social enterprise financing schemes.

109 Kyari F, Adekoya B, Abdull MM, Mohammed SA, Garba F. The Current Status of Glaucoma and Glaucoma Care in Sub-Saharan Africa. Asia Pac J Ophthalmol (Phila). 2018 Nov-Dec;7(6):375-386. <https://doi.org/10.22608/APO.2018392>.

110 Andrew F. Smith, Guy Negretti, Aaron Mascaro, Desta Bokre, Helen Baker, Kazim Dhalla & Ian E. Murdoch (2018) Glaucoma Control Strategies in Sub-Saharan Africa: A Review of the Clinical and Health Economic Evidence, Ophthalmic Epidemiology, 25:5-6, 419-435. <https://doi.org/10.1080/09286586.2018.1501499>.

111 Kyari F, Gilbert C, Blanchet K, Wormald R. Improving services for glaucoma care in Nigeria: Implications for policy and programmes to achieve universal health coverage. Br J Ophthalmol 2017;101(5):543-547. <https://bj.o.bmi.com/content/101/5/543>.

112 Keel S, Evans JR, Block S, et al. Strengthening the integration of eye care into the health system: methodology for the development of the WHO package of eye care interventions. BMJ Open Ophthalmology 2020;5:e000533. <https://doi.org/10.1136/bmjophth-2020-000533>.

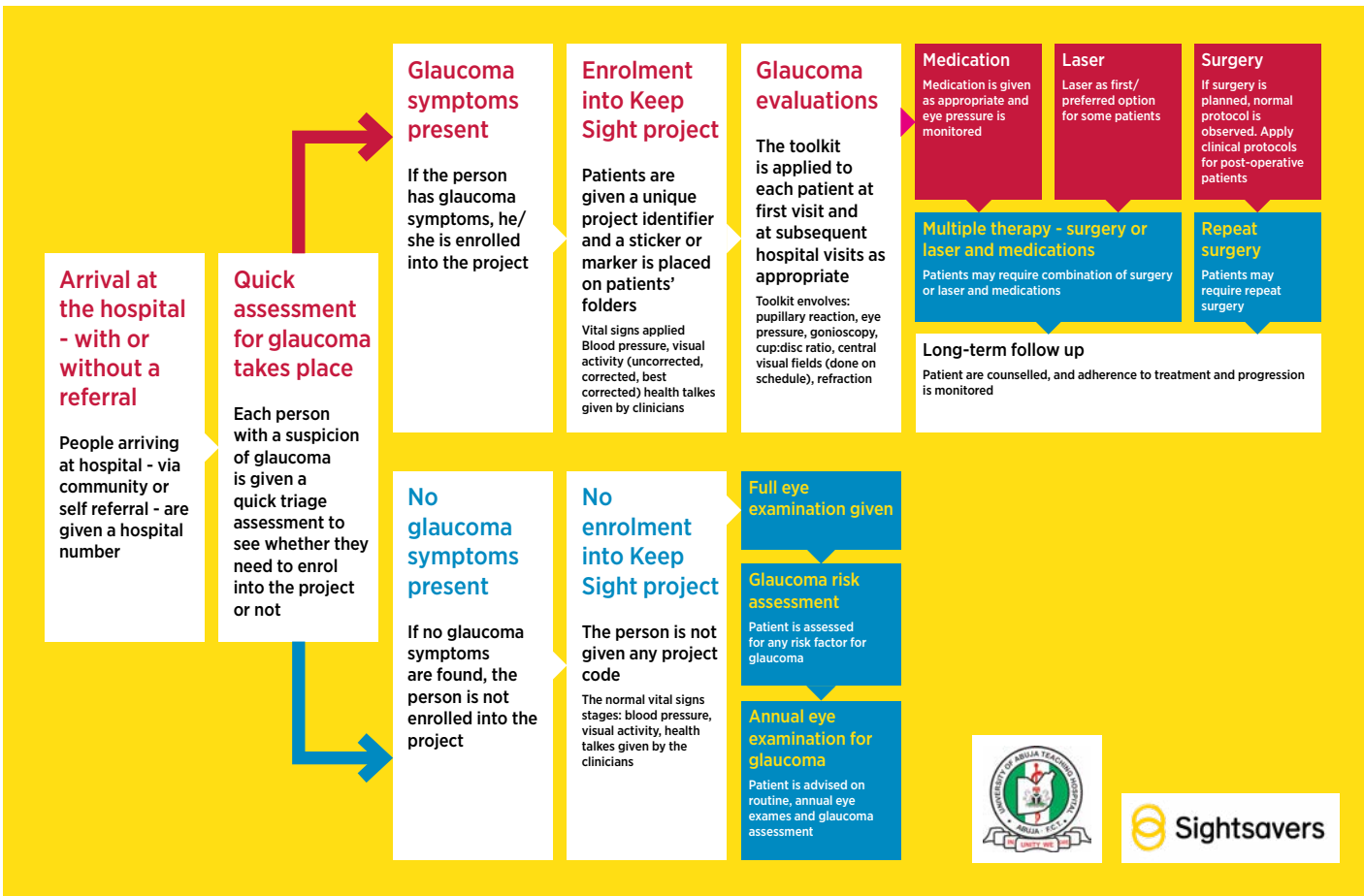
7.3 Improving access and usage of eye care systems

Still in the conceptualisation and pilot stages, the Allergan KeepSight Project of Sightsavers aims to strengthen health systems to identify people at risk of going blind from glaucoma, improve earlier detection and provide appropriate treatments and effective long-term care (see Patient Journey chart below). These are envisaged to be the effect of the planned community-based screening, health education for glaucoma awareness, improved access to screening opportunities and uptake of treatments, underpinned by community participation in glaucoma control activities.

The glaucoma toolkit is being piloted in this project along the following components: community-based case finding and screening using the programmatic component and sections on levels of competence; Hospital-based screening, diagnosis and treatment in Gwagwalada, Abuja, Nigeria; and Establishment and testing of behaviour change which may enhance voluntary screening for glaucoma.

Other possible strategies to consider are shared care, tele-glaucoma and artificial intelligence (AI) assisted clinical decision support. Glaucoma care service linked to a low vision and rehabilitation programme and social care services will be wide in spread and usefulness.

Glaucoma patient journey



NOTES

CHAPTER 8 - EQUIPMENT LIST FOR A GLAUCOMA SERVICE

The IAPB Essential List for Glaucoma available at <https://iapb.standardlist.org/essential-lists/essential-list-glaucoma/> is quite comprehensive and lists a range of equipment, instruments, consumables and pharmaceuticals required to provide quality glaucoma services.

The IAPB Essential List for Glaucoma facilitates towards:

- ▶ Provision of quality glaucoma services
- ▶ Integrated, sustainable, excellent, equitable (ISEE) comprehensive eye care programmes
- ▶ Low vision and rehabilitation programmes
- ▶ Social support services

In this section, we present selected “must have” basic equipment for a glaucoma service.¹¹³

Clinical Assessment	Minimal Equipment (Low Resource Settings)	Optional Equipment (Intermediate/High Resource Settings)
Visual Acuity	Near reading card or distance chart with 5 standard letters or symbols Pinhole	3-or 4-meter visual acuity lane with high contrast visual acuity chart
Refraction	Trial frame and lenses Retinoscope, Jackson cross-cylinder	Phoropter Autorefractor
Pupils	Pen light or torch	
Anterior Segment	Slit lamp biomicroscope Keratometer	Corneal pachymeter
Intraocular Pressure	Goldmann applanation tonometer Portable handheld applanation tonometer Schiotz tonometer	Tonopen Pneumotonometer
Angle Structures	Slit lamp gonioscopy Goldmann, Zeiss/Posner goniolescopes	Anterior segment optical coherence tomography Ultrasound biomicroscopy
Optic Nerve (dilated if angle open)	Direct ophthalmoscope Slit lamp biomicroscopy with handheld 78 or 90 diopter lens	Fundus photography Optic nerve image analyzers Confocal scanning laser ophthalmoscopy Optical coherence tomography Scanning laser polarimetry
Fundus	Direct ophthalmoscope Head mounted indirect ophthalmoscope with 20 or 25 diopter lens Slit lamp biomicroscopy with 78 diopter lens	12 and 30 diopter lenses 60 and 90 diopter lenses
Visual Field	Manual perimetry or automated white on white perimetry	Frequency doubling technology Short wave automated perimetry

¹¹³ ICO Guideline for Glaucoma Eye Care. 2016. Available at <http://www.icoph.org/downloads/ICOGlaucomaGuidelines.pdf>.

CHAPTER 9 – ADVOCACY AND RAISING AWARENESS



9.1 Advocacy

Advocacy is a planned form of influencing in order to achieve a specific outcome. It involves representing the needs and interests of disadvantaged groups (e.g. vision-impaired people with glaucoma) to those who can influence change (e.g. policy makers, planners, heads of clinical care institutions, eye health practitioners, etc.). The effectiveness of advocacy initiatives depends on the close collaboration and inclusion of all relevant stakeholders, on agreeing on joint positions and priorities, and on carrying them forward.

An influencing strategy has 3 elements:

1. Target audience
2. Influencing objectives, for those audiences
3. Key messages to be used to engage them



9.2 Raising Awareness

Raising awareness in general population typically involves a sustained effort to educate the public and boost their knowledge about a certain thing – in this case, glaucoma. Just as in advocacy, the target audience is to be defined and easily understood key messages transmitted using all angles through mass media, social media and various other channels of communication to the public. Activities such as free eye examination, public health talks, awareness walks etc for observing special health days also boost awareness e.g. World Sight Day (October), World Glaucoma Week (March), World Diabetes Day (November), etc.

9.3 Key Messages

In this section, we present relevant information that can be fashioned into key messages to communicate to the public (with good evidence base) for advocacy and raising awareness in the general public. These messages can be adapted to the local language, simple English or technical language depending on the target audience. They can also be used as content of glaucoma patient information leaflets for clinicians to give to patients.

What is glaucoma?

Glaucoma is a neurological disease affecting the optic nerve causing loss of peripheral vision and ultimately blindness. Certain characteristics such as raised eye pressure (intraocular pressure), increased age (40 years and above), African-Caribbean origin, and family history of glaucoma¹¹⁴ are associated with increased risk of the disease.

The problem with glaucoma in Africa

Glaucoma is a public health problem in sub Saharan Africa,¹¹⁵ for the following reasons:

1. The prevalence of blindness due to glaucoma is higher than in other regions of the world
2. It has a more aggressive course leading to blindness faster in a shorter period of time compared to Caucasians,^{116, 117}
3. There is a higher rate of the disease among young people,¹¹⁸
4. Patients present to hospital late and are diagnosed with advanced disease often blind in one eye.¹¹⁹
5. There is poor acceptance of surgery, the preferred treatment in Africa,^{120,121} as patients experience no immediate visual benefit and are fearful of the procedure.¹²²
6. There is poor adherence to medication for so many reasons ranging from non-availability to forgetfulness to use the medicines.¹²³
7. People of African origin are less responsive to both medical and surgical treatment options used for glaucoma.¹²⁴

114 Tielsch JM. The epidemiology and control of open angle glaucoma: a population-based perspective. Annu Rev Public Health 1996;17:121-36. <https://doi.org/10.1146/annurev.pu.17.050196.001005>.

115 Kyari F, Abdull MM, Bastawrous A, et al. Epidemiology of glaucoma in sub-saharan Africa: prevalence, incidence and risk factors. Middle East Afr J Ophthalmol 2013;20(2):111-25. <https://doi.org/10.4103/0974-9233.110605>.

116 Verrey JD, Foster A, Wormald R, Akuamo C. Chronic glaucoma in northern Ghana--a retrospective study of 397 patients. Eye (Lond) 1990;4 (Pt 1):115-20. <https://doi.org/10.1038/eye.1990.14>.

117 Sommer A, Tielsch JM, Katz J, et al. Relationship between intraocular pressure and primary open angle glaucoma among white and black Americans. The Baltimore Eye Survey. Arch Ophthalmol 1991;109(8):1090-5.

118 Sommer A, Tielsch JM, Katz J, et al. Racial differences in the cause-specific prevalence of blindness in east Baltimore. N Engl J Med 1991;325(20):1412-7. <https://doi.org/10.1056/nejm199111143252004>.

119 Abdull MM, Gilbert CC, Evans J. Primary open angle glaucoma in northern Nigeria: stage at presentation and acceptance of treatment. BMC Ophthalmol 2015;15(1):111. <https://doi.org/10.1186/s12886-015-0097-9>.

120 Rotchford A. What is practical in glaucoma management? Eye 2005;19(10):1125-32. <https://doi.org/10.1038/sj.eye.6701972>.

121 Bowman RJC, Hay a, Wood ML, Murdoch IE. Combined cataract and trabeculectomy surgery for advanced glaucoma in East Africa: visual and intra-ocular pressure outcomes. Eye (London, England) 2010;24:573-7. <https://doi.org/10.1038/eye.2009.132>.

122 Abdull MM, Chandler C, Gilbert C. Glaucoma, "the silent thief of sight": patients' perspectives and health seeking behaviour in Bauchi, northern Nigeria. BMC Ophthalmology 2016;16(1):1-9. <https://doi.org/10.1186/s12886-016-0220-6>.

123 Kyari F, Abdull MM. Managing a patient with open-angle glaucoma: a case study. Community Eye Health. 2012;25(79-80):71-2. PubMed PMID: 23520424; PubMed Central PMCID: PMC3588137. https://www.cehjournal.org/wp-content/uploads/download/ceh_25_79.80_071.pdf.

124 Racette L, Wilson MR, Zangwill LM, et al. Primary Open-Angle Glaucoma in Blacks: A Review. Survey of Ophthalmology 2003;48(3):295-313.

How can glaucoma be treated?

Of all the risk factors for glaucoma, the only modifiable risk factor is IOP. Lowering the IOP has been associated with reduced progression of visual field defects.¹²⁵ Many different treatments exist and most aim to reduce IOP. Which treatment is given depends on several factors, e.g. stage of disease at presentation, the socio-economic and demographic features of the patient (level of awareness, family support, household economic situation, distance to health facility etc.), the resources available and the preference of the patient. A once-off treatment, surgery or laser, is probably the best option for advanced disease in many Africans, those who are poor and lack support, and where facilities for monitoring and follow up are lacking or the patient is not motivated.^{126, 127}

1. Medical treatment

The medical treatment options use different classes of drugs.¹²⁸ Topical ocular hypotensives are the most frequently used and are effective not just in treating high IOP, but in delaying or preventing the onset of glaucoma in African American individuals who have ocular hypertension.¹²⁹

Drops and how to take them

Whatever type of medicine is prescribed, it is important that patients are given the correct prescription and obtain the drug prescribed, store it in an ideal environment, use the drugs as prescribed at their right times and continue to do so as instructed. It is essential that patients and their carers are taught how to instil these medications correctly as this will reduce waste.¹³⁰ This is vital because many glaucoma patients in addition to visual impairment may have other age-related chronic disease like tremors or arthritis which make the seemingly simple act of instillation difficult.

[https://doi.org/10.1016/s0039-6257\(03\)00028-6](https://doi.org/10.1016/s0039-6257(03)00028-6).

125 The Advanced Glaucoma Intervention Study (AGIS): 7. The relationship between control of intraocular pressure and visual field deterioration. The AGIS Investigators. Am J Ophthalmol 2000;130(4):429-40. [https://doi.org/10.1016/S0002-9394\(00\)00538-9](https://doi.org/10.1016/S0002-9394(00)00538-9).

126 Bourne RR, Taylor HR, Flaxman SR, et al. Number of People Blind or Visually Impaired by Glaucoma Worldwide and in World Regions 1990 - 2010: A Meta-Analysis. PLoS One 2016;11(10):e0162229. <https://doi.org/10.1371/journal.pone.0162229>.

127 Quigley HA, Broman AT. The number of people with glaucoma worldwide in 2010 and 2020. Br J Ophthalmol 2006;90(3):262-7. <https://doi.org/10.1136/bjo.2005.081224>.

128 Kyari F, Abdull M, Kiage D, Ogunro A. Medical treatment of open-angle glaucoma. Community Eye Health. 2012;25(79-80):77-9. PubMed PMID: 23520427; PubMed Central PMCID: PMC3588128. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3588128/pdf/iceh_25_79-80_077.pdf.

129 Sommer A, Tielsch JM, Katz J, et al. Relationship between intraocular pressure and primary open angle glaucoma among white and black Americans. The Baltimore Eye Survey. Arch Ophthalmol 1991;109(8):1090-5. <https://doi.org/10.1001/archophth.1991.01080080050026>.

130 Faal, H. Conversations with glaucoma patients. https://www.cehjournal.org/wp-content/uploads/download/ceh_25_79.80_054.pdf.

2. Surgical treatment

Although surgery has been demonstrated to be the best treatment option for controlling eye pressure, acceptance is poor in African patients,¹³¹ mainly because of fear and the lack of visual improvement after the surgery. There are many surgical options but the most effective involves creating a new channel in the eye to increase outflow of aqueous humour to lower the pressure, an operation called trabeculectomy. Other surgical techniques including new minimally invasive surgical procedures and implants are also available.

Trabeculectomy is the operation of choice in African populations^{132,133} where it offers good IOP control, but it has a higher risk of failure in from excessive scarring than in Caucasians eyes so appropriate precaution are used to avoid this. The outcome of trabeculectomy in Africa is variable but it generally offers good IOP control in majority of patients.

3. Laser treatment

Laser treatment is used to either decrease the production of aqueous or increase its drainage. Different types of Laser are used but all aim to decrease the eye pressure to prevent further damage to the eye. The advantage of laser treatment is its non-invasiveness, good control of eye pressure for a long period and ability to be repeated if it fails. Main disadvantage is lack of availability in many eyecare centres in Africa. This treatment uses different types of laser with different techniques. The more popular options include, Selective Laser Trabeculoplasty (SLT) Argon Laser Trabeculoplasty (ALT), Micropulse laser trabeculoplasty, (MLT). Laser trabeculoplasty increases outflow of aqueous and offers good short term IOP control. Another option called cyclodestruction has been in use for refractory glaucoma especially for pain relief. It is usually carried out with the diode (continuous mode or micropulse) or Nd-YAG lasers through the sclera or under direct vision combined with cataract surgery (endocyclophotocoagulation). Trans scleral diode laser cyclophotocoagulation is receiving increasing support not only for eyes with refractory glaucoma but also those with uncontrolled IOP with residual good vision.^{134,135}

131 Quigley HA, Buhrmann RR, West SK, et al. Long term results of glaucoma surgery among participants in an east African population survey. Br J Ophthalmol 2000;84(8):860-4. <https://doi.org/10.1136/bjo.84.8.860>.

132 Bekibele CO. Evaluation of 56 trabeculectomy operations at Ago-Iwoye, Ogun State, Nigeria. West Afr J Med 2001;20(3):223-6.

133 Anand A, Negi S, Khokhar S, et al. Role of early trabeculectomy in primary open-angle glaucoma in the developing world. Eye (Lond) 2007;21(1):40-5. <https://doi.org/10.1038/sj.eye.6702114>.

134 Rotchford AP, Jayasawal R, Madhusudhan S, et al. Transscleral diode laser cycloablation in patients with good vision. Br J Ophthalmol 2010;94(9):1180-3. <https://doi.org/10.1136/bjo.2008.145565>.

135 Abdull MM, Broadway DC, Evans J, Kyari F, Muazu F, Gilbert C. Safety and effectiveness of primary transscleral diode laser cyclophotoablation for glaucoma in Nigeria. Clin Exp Ophthalmol. 2018 Dec;46(9):1041-1047. doi: 10.1111/ceo.13328. Epub 2018 Jun 17. PMID: 29808573; PMCID: PMC6585748.

Key messages to different levels of decision makers

Facility level

1. Inclusion of glaucoma screening as part of every eye check-up especially in people over 35 years coming to eye clinics for reading glasses.
2. Creation of special glaucoma control units in communities and facilities
3. Encouraging change in acceptance and adherence to treatment and follow up through proper counselling.
4. Encouraging the creation and functioning of glaucoma support groups in hospital and communities

Community level

1. There is very low level of awareness of the risk of having primary open angle glaucoma. Community leaders to participate in awareness creation to encourage eye check-up in ensuring reduction of blindness prevalence from glaucoma in their constituency.
2. Increasing awareness creation by education through the mass media and at every available social occasion to emphasise the need for regular eye check-up to catch the disease early to prevent blindness,
3. Increased awareness creation using social media
4. Eliminating stigma associated with blindness in communities

Health Manager/ Hospital Director

1. Although there are policies and budgetary allocations for other health services, no existing policy or budget line that addresses glaucoma is established in government institutions.
2. There are several non-governmental organisations (NGOs) working in collaboration with government agencies but none of these presently has glaucoma as its main focus. There is a need to prioritise glaucoma for control.

Health Commissioners

1. There is reduced access to treatment especially in rural areas, state infrastructure needs to be able to support easy access to eye care facilities for patients.
2. Proper rehabilitation of those who are blind should be an integral part of continuing care in health institutions.
3. There is a lack of primary eye care and awareness which can be addressed by implementing the integration of primary eye care into mainstream primary health care.
4. Health facilities are poorly equipped to manage the disease so there is need for mobilisation and training of more human resource for glaucoma care.
5. There is inadequate human resource in health facilities to manage the disease
6. There are limited treatment options available to many physicians to treat the disease.
7. There is very poor adherence to medicines for treating the disease
8. There is need for more research into the epidemiology of the disease to update the existing data

Health Financing (economic argument)

1. Advocacy to governments and opinion leaders to create awareness for glaucoma and improve budgetary allocations for its care
2. The search for more sustainable means of funding glaucoma care in the community.

State / Federal Ministry of Health

1. There is an existing government policy on integration of primary eye care into primary health care to enable screening and early detection of most causes of blindness including possibly glaucoma at primary level. We need to advocate for proper implementation of this objective.
2. Although there are policies and budgetary allocations for other health services, no existing policy or budget line that addresses glaucoma is established in government institutions. There is a need for this provision in the budget of ministries and governments.
3. There are several non-governmental organisations (NGOs) working in collaboration with government agencies but none of these presently has glaucoma as its main focus. There is need to encourage a glaucoma control program in partnership with the relevant NGOs.

Benefits to community for taking recommended actions

1. Reduction in the prevalence of blindness in the community thus reducing level of dependency.
2. Improved social standing of individuals by avoiding stigma attached to blindness in many communities.
3. Improved quality of life for patients through improved access to treatment and rehabilitation for those already blind.
4. Improved vision will result in greater future productivity which will have a positive impact on economic growth and social integration.

Resources:

1. International Agency for the Prevention of Blindness. Advocacy for Eye Health: A Practical Guide. Part 1: The Advocacy & Campaigning Cycle. Available at https://www.iapb.org/wp-content/uploads/Advocacy_Guide_6-2_0.pdf
2. International Agency for the Prevention of Blindness. Advocacy for Eye Health: A Practical Guide. Part 2: The Toolkit. Available at https://www.iapb.org/wp-content/uploads/Advocacy_Toolkit_6-2_0.pdf

PART 3: Information



CHAPTER 10 - MONITORING, EVALUATION AND LEARNING

The Africa Glaucoma Guideline and Toolkit will be operationalised for glaucoma service delivery. Implementation entails training for all competency levels of care, glaucoma case detection strategies, earlier diagnosis, commencing treatment, adherence to treatment and follow-up. Thus, there is a need to develop and maintain a robust recording and reporting pathway that will ensure that all relevant health data are captured for evaluation and learning.

10.1 Pre-programme situational analysis

Indicate the following about the current situation of glaucoma care:

1. Define the burden of disease and the need for treatment
2. Take inventory of human and non-human resources available
3. Perform gap analysis to identify the number of people requiring treatment/rehabilitation, the equipment and medicines required and other unmet needs.

Identify the glaucoma programme’s objectives. What does the programme seek to improve? (Examples: screening for case detection, increasing clinical and/or surgical volume, improving adherence to treatment and follow-up, reducing blindness, etc).

	PARAMETER	INFORMATION
1	Location - city, state, region, country	
Local Epidemiology		
2	Prevalence of glaucoma (RAAB or survey) – local or national results with dates	
3	Estimated number of people with glaucoma in the catchment area (extrapolate per million population)	
4	Potential number/proportion of undiagnosed glaucoma patients (%)	
5	Is there a local name for glaucoma? Mention	
Community glaucoma care and support		
6	Is there a local eye care support system such as glaucoma ambassadors or glaucoma patients association?	
7	Identify glaucoma service centres (existing or potential) at the primary, secondary and tertiary level in relation to the eye unit/clinic Are they linked to work together and can develop a model of glaucoma care continuum?	

10.2 On-going or post-programme analysis

Define the indicators that inform the achievement of the objectives. (Example: training of personnel; if screening, what aspect do you wish to assess? Effectiveness of the personnel conducting screenings, sensitivity/specificity of the test, number of people screened, number who follow-up after screening, number of screening events, number of new cases identified, etc)

Define the expectations—what outcome is considered a success? (if screening and the indicator is number of cases detected, indicate the target number expected in a given period of time)

Develop data collection methodology. Who collects the data? Where is it drawn from? How is it aggregated?

Analyse the data and assess the outcome: are the objectives being met? If so, is there room for incremental improvement? If not, can failure analysis identify flaws in the system, and can these be remedied?



10.3 Indicators for assessing a glaucoma care programme

Examples of a number of indicators and format of reporting are shown in the following charts. These are being piloted by the Sightsavers “Keep Sight project” in Abuja, Nigeria. Collect data monthly for at least 12 months* *for breakout see table below.

Quantitative data I

	INDICATORS	Linked activity/ Tool	TARGET	Month 1	Month 2	Month 3* then continue monthly for at least 12 month	Total (month 1 to 12)
A	HRD						
1	Number Ophthalmologists trained on basic Glaucoma protocols (before and After)	Training sessions					
2	Number Optometrists trained on basic Glaucoma protocols	Training sessions					
3	Number other Health staff trained on Glaucoma protocols	Training sessions					
B	Screening						
4	Number of Individuals above 40 years screened/ Risk assessment/ First screening at community level (VC/ Camp/ others) Primary screening	Glaucoma upgraded outreach activities					
5	Number of Individuals above 40 years First screening/ screened at Hospital level (Primary and secondary screening)	Glaucoma upgraded Protocol at the hospital					
6	Number of ‘Glaucoma suspects’ identified at community level (VC/ Camp/ others)	Glaucoma suspect criteria					
	Number of ‘Glaucoma suspects’ Examined at Hospital level (referred from screening outside)						
7	Number of ‘Glaucoma suspects’ Examined at Hospital level (Internal referrals)	Glaucoma suspect criteria					
	Source of information about the glaucoma test*						
	Number of ‘Glaucoma suspects’ Examined at Hospital level (referred from screening outside)						

Quantitative data II

	INDICATORS	Linked activity/ Tool	TARGET	Month 1	Month 2	Month 3* then continue monthly for at least 12 month	Total (month 1 to 12)
C	Diagnosis						
8	Number of cases of POAG diagnosed	Glaucoma diagnosis criteria					
9	Number of cases of Angle closure glaucoma diagnosed	Glaucoma diagnosis criteria					
10	Number of cases of other Glaucomas diagnosed (including Lens induced glaucomas)	Glaucoma diagnosis criteria					
D	Treatment						
11	Number of Cases treated with LASER procedures for Glaucoma	Glaucoma treatment protocol					
12	Number of cases treated with Surgical procedures for Glaucoma (Trabeculectomy*)	Glaucoma treatment protocol					
13	Number of cases treated with Surgical procedures for Glaucoma (Combined Cataract + Trabeculectomy)	Glaucoma suspect criteria					
14	Number of Cases Started on Medical treatment for Glaucoma (eye drop)	Glaucoma treatment protocol					
15	Number of Cases referred to other services (including provided with LVA)						
E	Follow up and Adherence						
16	% of Cases on treatment completing 3 monthly follow-up for Glaucoma	Glaucoma treatment protocol					
17	% of Cases on treatment completing 6 monthly follow-up for Glaucoma	Glaucoma treatment protocol					
18	% of Cases on treatment completing 12 monthly follow-up for Glaucoma	Glaucoma treatment protocol					

Quantitative data III

	INDICATORS	Linked activity/ Tool	TARGET	Month 1	Month 2	Month 3* then continue monthly for at least 12 month	Total (month 1 to 12)
F	Outcome/ Impact (Annual)						
19	% of Glaucoma cases who have Moderate/ Severe VI at Diagnosis (Ratio) due to Glaucoma	Glaucoma case data-base					
	# of Glaucoma cases who have Moderate/ Severe VI at Diagnosis (Ratio) due to Glaucoma						
20	% of Glaucoma cases who are BLIND at Diagnosis due to Glaucoma	Glaucoma case data-base					
	Number of Glaucoma cases who are BLIND at Diagnosis (Distance Vision)						
	Number of Glaucoma cases who are BLIND at Diagnosis (Visual field)						
21	% of Glaucoma cases who progress to Moderate/ Severe VI	Glaucoma case data-base					
22	% of Glaucoma cases who progress to Blindness	Glaucoma case data-base					

Monitoring sheet I

	INDICATORS	DESCRIPTION		Tool	Total	Female	Male
A	HRD						
1	Change in knowledge/ Practice of Ophthalmologists with respect to Glaucoma	Effectiveness of Glaucoma training for Ophthalmologists		? Pre-post training evaluation/ feedback tool/ Specific qualitative study to assess training impact			
2	Change in knowledge/ Practice of Optometrist/ Ophthalmic technicians with respect to Glaucoma	Effectiveness of Glaucoma training for Ophthalmologists		? Pre-post training evaluation/ feedback tool/ Specific qualitative study to assess training impact			
3	Change in knowledge/ Practice of Health workers with respect to Glaucoma	Effectiveness of Glaucoma training for Ophthalmologists		? Pre-post training evaluation/ feedback tool/ Specific qualitative study to assess training impact			
B	Screening						
	Self-reported source of information about the screening activity by people reporting for screening (Outreach)	Effectiveness of communication channels for increasing screening uptake by target individuals		Exit interview in screening camps/ hospital OR structured Qualitative study			
	Self-reported source of information about the screening activity by people reporting for screening (Hospital)	Effectiveness of communication channels for increasing screening uptake by target individuals		Exit interview in screening camps/ hospital OR structured Qualitative study			
	Impact on other services (e.g. % change in OPD numbers, Cataract surgeries etc.)		change in practice, Impact on other services, time-motion study,				
4	Number of Individuals above 40 years screened/ Risk assessment/ First screening at community level (VC/ Camp/ others) Primary screening			Glaucoma upgraded outreach activities			
5	Number of Individuals above 40 years First screening/ screened at Hospital level (Primary and secondary screening)		Impact on other services	Glaucoma upgraded Protocol at the hospital			

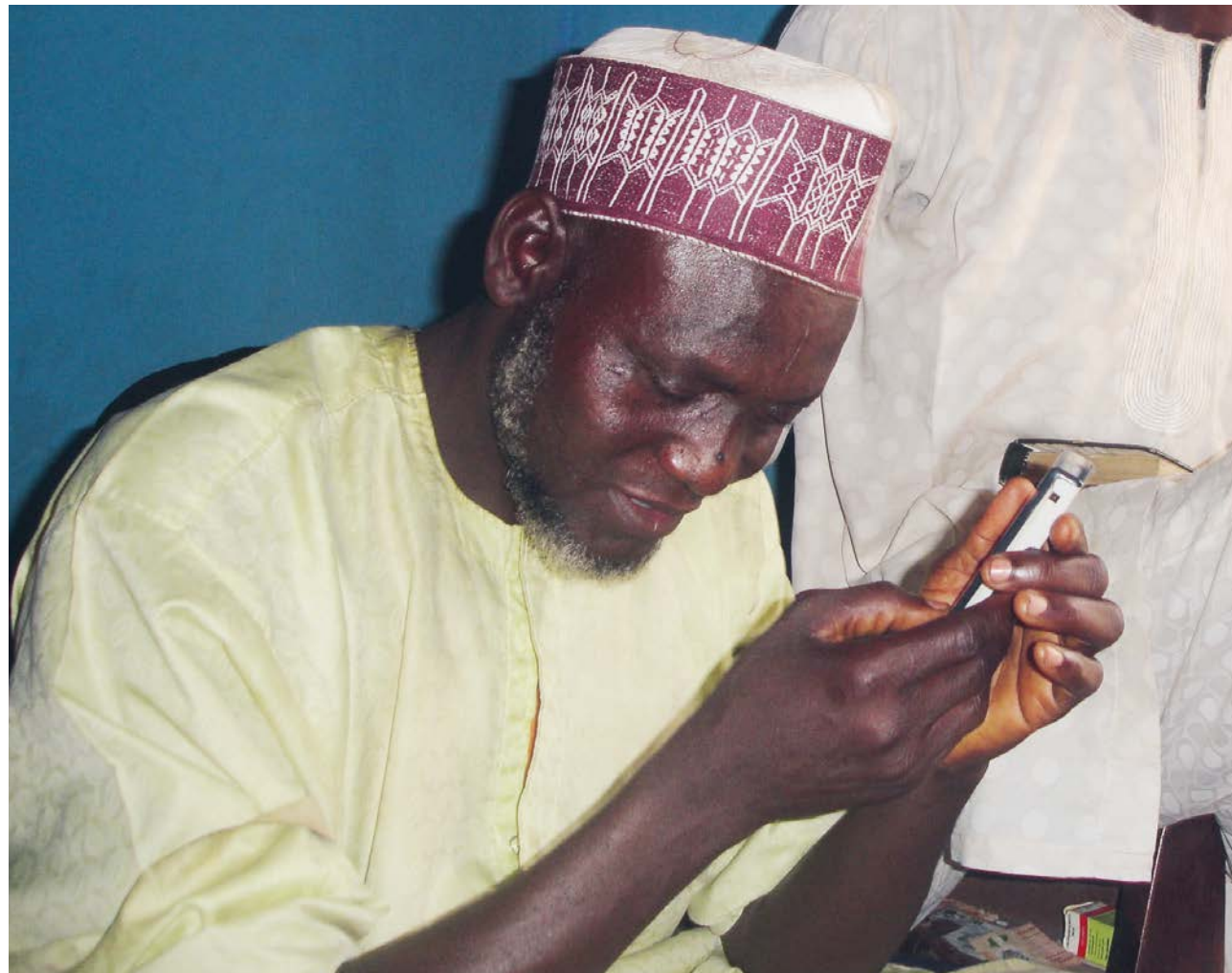
	INDICATORS	DESCRIPTION		Tool	Total	Female	Male
*	Source of information about the screening*		? some categories followed by Open questions within the form				
6	Number of 'Glaucoma suspects' identified at community level (VC/ Camp/others)			Glaucoma suspect criteria			
	Number of 'Glaucoma suspects' Examined at Hospital level (referred from screening outside)						
7	Number of 'Glaucoma suspects' examined at Hospital level (Internal referrals)			Glaucoma suspect criteria			
	Source of information about the glaucoma test *		? some categories followed by Open questions within the form				
C	Diagnosis						
8	Number of cases of POAG diagnosed			Glaucoma diagnosis criteria			
9	Number of cases of Angle closure glaucoma diagnosed			Glaucoma diagnosis criteria			
10	Number of cases of other Glaucoma diagnosed (including Lens induced glaucoma)			Glaucoma diagnosis criteria			
D	Treatment						
11	Number of Cases treated with LASER procedures for Glaucoma			Glaucoma treatment protocol			
12	Number of cases treated with Surgical procedures for Glaucoma (Trabeculectomy*)		or 12+13	Glaucoma treatment protocol			
13	Number of cases treated with Surgical procedures for Glaucoma (Combined Cataract + Trabeculectomy)			Glaucoma treatment protocol			
14	Number of Cases Started on Medical treatment for Glaucoma (eye drop)			Glaucoma treatment protocol			

	INDICATORS	DESCRIPTION		Tool	Total	Female	Male
15	Number of Cases referred to other services (including provided with LVA)						
E	Follow up and Adherence						
16	% of Cases on treatment completing 3 monthly follow-up for Glaucoma			Glaucoma treatment protocol			
	Patient level adherence measures and what helped them do so?*		? Tool to be developed (Counselor or other health staff)				
17	% of Cases on treatment completing 6 monthly follow-up for Glaucoma			Glaucoma treatment protocol			
18	% of Cases on treatment completing 12 monthly follow-up for Glaucoma			Glaucoma treatment protocol			
F	Outcome/ Impact (Annual)						
19	% of Glaucoma cases who have Moderate/ Severe VI at Diagnosis (Ratio) due to Glaucoma			Glaucoma case database			
	Number of Glaucoma cases who have Moderate/ Severe VI at Diagnosis (Ratio) due to Glaucoma						
20	% of Glaucoma cases who are BLIND at Diagnosis due to Glaucoma			Glaucoma case database			
	Number of Glaucoma cases who are BLIND at Diagnosis (Distance Vision)		Gender				
	Number of Glaucoma cases who are BLIND at Diagnosis (Visual field)						
21	% of Glaucoma cases who progress to Moderate/ Severe VI			Glaucoma case database			
22	% of Glaucoma cases who progress to Blindness			Glaucoma case database			

CHAPTER 11 – RESEARCH DEVELOPMENT AND INNOVATION (RDI) FOR GLAUCOMA SERVICES

Despite the many challenges of glaucoma in SSA, there is a need to streamline glaucoma control activities and provide evidence-based care. We need to collaborate and set the research agenda for glaucoma in Africa – moving away from problem statement to solutions-based research evidence and strategies. Furthermore, data and information are required for advocacy with policy makers and for the engagement of civil society to improve health education, knowledge and public awareness. Once we identify priority areas of research, we can collaborate to collectively produce peer-reviewed grant proposals, making powerful applications; incorporating best practices in reporting, accountability and transparency through good financial grant practice. This will improve research integrity and credibility especially where multi-centre studies will be conducted.

In this section, we suggest areas of priority and future glaucoma research in Africa.



11.1 Top Priority Areas for Glaucoma Research

1. Define effective treatment
2. Determine approaches to earlier detection of cases
3. Develop and specify clinical guidelines and protocols of management

1. Define treatment modality

The treatment recommended for glaucoma in Africa depends on many factors. For example, medical therapy, which is often the first line of treatment is constrained by high cost, poor compliance and uncertain potency of poorly stored topical medications. Trabeculectomy, which is a preferred choice of surgical treatment is limited by poor acceptability by patients and reluctance and limited skills of eye surgeons. Some laser therapeutic options seem safe but are constrained by a high initial capital outlay for the laser machines. The priority is to determine an appropriate choice of one-off treatment modality that is effective, acceptable, affordable, non-invasive and sustainable.

The proposal is to have multi-centre randomised controlled trials (RCTs) comparing treatment outcomes and economic advantages of intraocular pressure (IOP) lowering therapies.

For example:

1. Surgical treatment versus Laser treatment
2. Comparison of different Laser therapies
3. Determining the number of times and frequency of repeat Laser therapy

2. Determine approaches to earlier detection of glaucoma

Another priority for research is optimising case detection of glaucoma patients in healthcare facilities. These could be early detection through tests that detect early functional deficits e.g. visual field testing or detection of early structural damage including electrophysiologic tests and imaging techniques.

As well as approaches to earlier detection of cases in the community, with a clear care pathway from community to clinic. This could be in the form of a community-based implementation research involving behavioural change in the population.

3. Develop and define clinical guidelines, protocols of care and care teams

This document is a toolkit to assist practitioners to develop their algorithm of choice of therapy and continued management. Consider the use of weighted scores for patient, facility and community characteristics; taking into account local realities and informed patients' preferences

For example, involve monitoring of outcomes tools for young patients with moderate glaucoma who may be advised to have trabeculectomy with adjunctive antimetabolite; or older adults being treated with topical prostaglandin analogue.

Implementation/operational research and evaluating protocols and models of care will gear towards addressing gaps with evidence, driving better services and optimum glaucoma care. Furthermore, implementation research may be designed to assess whether the use of clinical guidelines and protocols improve practice patterns.

11.2 Other areas of research

Epidemiological research

More population-based research, including electrophysiological studies, is needed to clarify the nature of glaucoma in many more populations in Africa, to determine reasons for its variation and to better define target risk groups.

Genome-wide association studies (GWAS)

Glaucoma in Black Africans is more aggressive, with an earlier age onset than glaucoma in Caucasians and Asians. One question is: is it an issue of Place or Race? Could it be due to environmental factors and access to early, appropriate and effective treatment or are there genetic components to explain these? Perhaps the answer could be found in GWAS (ongoing in some centres) and whole exome sequencing for marking and risk profiling of glaucoma patients.^{136,137}

Social sciences/qualitative research

This is important in order to identify the factors and barriers to awareness and knowledge of blinding eye diseases; and compliance and adherence to treatment of glaucoma in SSA and quality of life studies. The piloting of the glaucoma toolkit by the Sightsavers “Keep Sight” project includes behavioural change strategies. Novel ideas could be developed towards research.

Health systems research

Studies that also provide evidence for policy makers and management to facilitate systems for the management of the disease are important.

Health economics research

These will define issues such as cost-benefit of the different options of glaucoma treatment, the economic burden of the disease and health insurance coverage for glaucoma patients. The exciting novel package of eye care interventions (PECI) which being developed by WHO includes some research component in phases.¹³⁸

Innovative interventions

The use of Tele-medicine, including use of smart-phone technology, optimised by artificial intelligence (AI) is envisaged to improve equitable access to care for eye health including glaucoma (Tele-glaucoma). Simulated surgical training and skills transfer has been shown to be a viable option for effective surgical teams training. These innovative interventions could be adapted locally, recorded scientifically and evaluated to determine which surgical procedures to include, processes and impact in our environments.

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11.3 Africa Glaucoma Research and Data Repository

The intended and envisaged outcomes of these research studies are institutional strengthening, high quality optimal glaucoma service in the hospitals, earlier presentation and detection of glaucoma in the communities with 2-way referral/feedback systems towards the ultimate goal of control of glaucoma blindness and vision loss.

To maximise the benefits of collaboration and shared learning, we suggest the development of an Africa glaucoma research and data repository together with the proposed Africa glaucoma clinical and research network.

A unified Electronic Medical Records (EMR) for glaucoma patients is also proposed. This will be guided by data sharing and data protection laws and regulations.





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