Management of Neovascular Glaucoma

Essay Presented by

Passant Mohammed Mahmoud Abd Ellatief

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Supervised by

Prof. Dr. Magdy Mohamed Elbarbary

Head of departement of Ophthalmology
Faculty of medicine –Ain Shams University

Dr. Sherein Shafik Wahba

Lecturer of Ophthalmology
Faculty of Medicine –Ain Shams University

Faculty of Medicine
Ain Shams University
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﴿قَالُوا سُبْحَانَكَ لَا عِلْمَ لَنَا

إِلَّا مَا عَلَّمْتَنَا إِنَّكَ أَنْتَ الْعَلِيمُ الْحَكِيمُ﴾

صدق الله العظيم

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NVG	Neovascular Glaucoma
CRVO	Central retinal vein occlusion
OIS	Ocular ischemic syndrome
PRP	Panretinal photocoagulation
VEGF	Vascular endothilial growth factor
IOP	Intraocular pressure
ND:YAG LASER	Neodymium:Yttrium-aluminum-garnet Laser
PPV	Pars Plana Vitrectomy
PDR	Proliferative diabetic retinopathy
Nm	Nanometer
µm	Micrometer
LM	Light Microscope
EM	Electron Microscope
TM	Trabecular meshwork
CB	Ciliary body
°	Degree
PR	Pupillary ruff
CAOD	Carotid artery occlusive disease
CRAO	Central retinal artery occlusion
APD	Afferent pupillary defect
ERG	Electroretinography
RAPD	Relative afferent pupillary defect
NVI	Neovascularization of the iris
ICCE	Intracapsular Cataract Extraction
ECCE	Extracapsular Cataract extraction
e.g:	For example
NVA	Neovascularization of the angle
PAS	Peripheral anterior synechia
O2	Oxygen

CVOS	Central vein occlusion study
BFGF	Basic fibroblast growth factor
IL-6	Interleukin-6
RD	Retinal detachement
FA	Floresceine angiography
AC	Anterior Chamber
DR	Diabetic retinopathy
OAG	Open angle glaucoma
mmHg	Millimeter mercury
NV	Neovascularization
ms	Millisecond
SD	Standard deviation
BRVO	Branch retinal vein occlusion
Hz	Hertz
PRC	Panretinal cryotherapy
RON	Radial optic neurotomy
DRS	Diabetic Retinopathy Study
B-blockers	Beta receptors Blockers
α	Alpha receptors
VEGFR	Vascular endothilial growth factor receptor
DNA	Deoxyribonucleic acid
Fc Portion	Crystallisable portion of the antibody
Kd	Dissociation Constant
mL	Milliliter
mg	Milligram
mL/kg	Milliliter per Kilogram
Fab	Fragment Antigen Binding
5-FU	5-fluorouracil
mm^2	Millimeter square
<	Less than
CCT	Cyclocryotherapy

mm	Millimeter
°c	Degree centigrade
NCTCP	Noncontact transscleral cyclophotocoagulation
CTCT	Contact transscleral cyclophotocoagulation

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Anatomy of the Anterior Chamber Angle

The features of the outflow apparatus are as follows **(Fig.1)**:

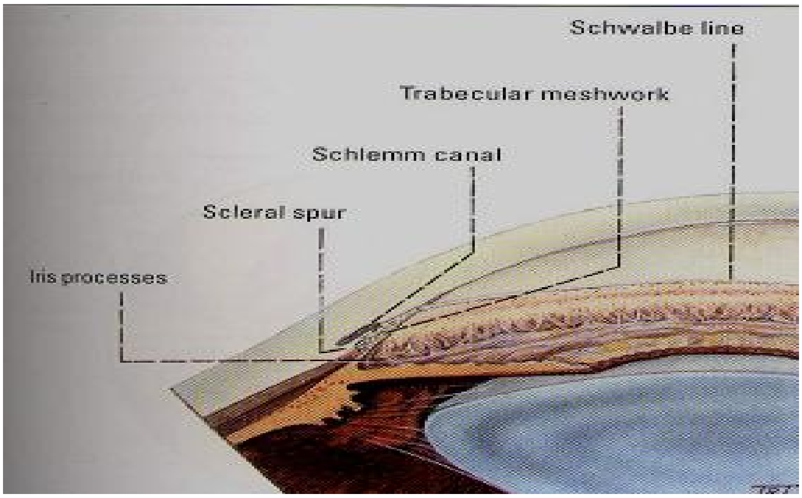

Figure 1: Structure of the angle **(Kanski J,2003).**

1. Internal scleral sulcus
   - Sulcus
   - Schwalbe's ring
   - Scleral spur
2. Trabecular meshwork
   - Uveal meshwork
   - Corneoscleral meshwork
   - Trabecular structure
   - Iris processes
   - Pericanalicular connective tissue
   - Extracellular matrix
3. Canal of Schlemm and collector channels
   - Schlemm's canal

- Endothelial lining
- Giant vacuoles
- Collector channels **(Anthony J et al,1997)**.

The internal scleral sulcus:

The sulcus:

It is circular grooves on the inner aspect of the corneoscleral limbus, extending from the termination of Descemet's membrane anteriorly, demarcated by Schwalbe's ring, to the scleral spur posteriorly. The portion of the spur which forms the posterior boundary of the sulcus is sometimes called the scleral roll. The sulcus completely accommodates the canal of Schlemm externally and the corneoscleral portion of the trabecular meshwork internally **(Drecoll E,1998).**

Schwalbe's Ring:

It is the anterior border ring of the trabecular region and contains circularly arranged collagen fibers (periodicity 64 nm) intermixed with elastic fibers. With age, there are also patches of long spacing or "curly collagen". The ring marks the transition between the corneal endothelium and trabecular cells and termination of Descemet's membrane **(Anthony J et al,1997).** The Descemet's membrane may split at times to enclose the inner and outer aspect of Schwalbe's ring and may show fine extensions into the cortical zone of the uveal trabeculae **(Tamm E et al,1992).**

Scleral Spur:

The scleral spur is a wedge-shaped circular ridge which marks the deep aspect of the sclerolimbal junction. It receives the insertion of the anterior tendons of the longitudinal ciliary muscle on its inner aspect **(Karer A et al,1990).**

The scleral spur contains collagen and elastic tissue with a circular arrangement like that of the trabecular beams of the corneoscleral and cribriform or juxta-canalicular meshwork with which it blends **(Drecoll E et al,1998).** It has been shown that there are contractile, myofibroblast-like cells oriented circumferentially within the scleral spur, which have sparse mitochondria and are rich in smooth muscle alpha actin and myosin **(Tamm R et al,1992).**

The scleral spur cells **(SSC)** form tendon like contacts with the elastic fibers of the scleral spur which are continuous with those of the adjacent trabecular meshwork. Thus changes in SSC tone might modulate outflow resistance by altering trabecular architecture. Some trabecular meshwork cells stain also positively for smooth muscles alpha actinin and smooth muscle actin **(Flugel C et al,1992).**

Trabecular Meshwork:(Fig.2)

Figure 2: Scanning electron microgram of trabecular meshwork **(Kanski J,2007).**

The trabecular meshwork is a spongework of connective tissue beams which are arranged as superimposed perforated sheets **(Fig.2)**. The beams are disposed circularly in the chamber angle and extend from Schwalbe's ring anteriorly to the scleral spur and junction of iris and ciliary body posteriorly. The inner portion of the trabecular meshwork is referred to as the uveal meshwork and the outer portion, connected to the spur and closer Schlemm's canal, is the corneoscleral meshwork. Between the outermost corneoscleral trabecular sheet and the endothelial lining of Schlemm's canal is a cell-rich zone, the peri- or juxta-canalicular connective tissue zone (or endothelial or cribriform meshwork) **(Anthony J et al,1997).**

Uveal meshwork

The inner uveal meshwork (1-2 layers) is made up of cord-like trabeculae which interlace, and taper anteriorly. The innermost trabeculae may pass from the ciliary muscle almost to the region of Schwalbe's ring. Posteriorly, there are two to five layers and the outer layers have a more circular orientation and a more flattened profile concentric with the limbus, resembling that of the corneoscleral sheet **(Spencer H et al,1968).** The cellular lining of the uveal trabeculae is contineous anteriorly with keratocytes in the deeper region of the cornea and its endothelium **(Anthony J et al,1997).**

The corneoscleral meshwork

Each band is made of a network of beams (trabeculae) most of them run circumferentially with interanastomosing criss-cross bands to form meshwork with oval stomata. The intertrabecular spaces of the outer layers of the corneoscleral sheets vary between 5 to 12µm, therefore narrower than the uveoscleral meshes. The spaces decrease in size from within outwards **(Spencer H et al,1968).**

There are approximately 8 to 15 trabecular layers with a total width of 120-250 µm. Anteriorly the sheets converge, obliterate the intertrabecular spaces and merge with the inner corneal lamellae and the trabecular cells interface with the keratocytes. Posteriorly they are inserted into the scleral roll **(Tripathi R et al,2003).**

The iris processes **(Fig.3)**

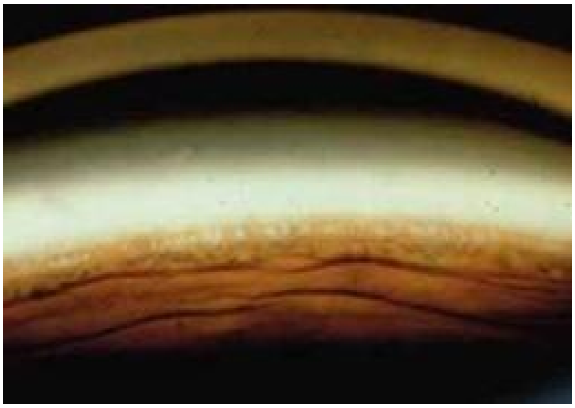

Figure 3: Iris processes **(Hutchinson K et al,2005).**

These are broad-based flat triangular bands which taper anteriorly and bridge the angle recess from the iris root to the uveal trabaculae into which they merge. Sometimes, they reach the level of the scleral spur, and occasionally to Schwalbe's line. They are usually sparse in number and are found in about one-third of the normal population. Their structure resembles that of the iris tissue with which they are continuous. Broad iris processes partially obscure the angle recess **(Tripathi C 1974).**

They are phylogenetically homologous with pectinate ligaments of ungulates and other animals, but do not perform the same supportive function to the iris root **(Nishida S et al,2005).**

Peri- or juxtacanalicular connective tissue

It has a thickness of 2-20 μm and it is interposed between the endothelial lining of the canal and the outermost corneoscleral trabecular sheet. This region consists of 2-5 layers of loosely arranged cells, embedded in an extracellular matrix. The cells exhibit long slender processes, and attach to one another irregularly by maculae occludentes, desmosomes and gap junctions. Spaces exist between the cells, are up to 10μm in width, through which aqueous humour can percolate to reach the lining endothelium of Schlemm's canal **(Tripathi R et al,2003).**

After a long controversy about the presence or absence of open communication between anterior chamber and canal of Schlemm, it is now believed, based on studies by light microscope **(LM)**, electron microscope **(EM)**, morphometric and tracer techniques, that the vacuolar configuration of the endothelium provide a mechanism for direct communication between the extracellular spaces of trabecular zone and the canal of Schlemm. This is probably the route of entry of aqueous to the canal of Schlemm **(Anthony J et al,1997).**

Canal of Schlemm:

The canal of Schlemm is 36 μm in circumference, lying in the outer portion of internal scleral sulcus, it conducts aqueous humour from the trabecular region to the episcleral venous plexus via the collector channels **(Nishida S et al,2005).**

The canal of Schlemm is oval in cross section with the long axis lying to the inner surface of the trabeculae; its anterior angle is sharper than the posterior border, its average meridional measurement is 200-400 μm and in the shorter axis is 10-25μm **(Tripathi R et al,2003).**