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Diagnostic tools for early glaucoma detection: A review

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Abstract
Glaucoma is a chronic neurodegenerative disease characterized by death or loss of retinal ganglion cells and their axons. The loss of retinal ganglion cells results in typical structural changes in the Optic Nerve Head and the Retinal Nerve Fibre Layer. It develops silently without any warning signs. Early detection of glaucoma with different modalities is very important because many peoples who have the glaucoma do not know they have it. The main goal of treatment is to either stop or slow disease progression; it is possible with early assessment. Glaucoma, Most clinicians diagnosed with corresponding structural and functional changes. The essential elements of evolution include: Tonometry, Gonioscopy, Perimetry etc. Additional testing i.e. Imaging Technologies is necessary to asses glaucoma in early stages to prevent further development. This review article provides brief description about new advances in different aspects of glaucoma diagnosis.

Keywords: Glaucoma, Neurodegenerative disease, Optic nerve head, Retinal nerve fibre layer, Imaging Technologies

1. Introduction

In medical practice, Glaucoma is a chronic neurodegenerative disease characterized by death or loss of retinal ganglion cells and their axons. Glaucoma is mainly divided into primary and secondary glaucoma and again primary glaucoma is subdivided in to open-angle and angle-closure glaucoma. Primary open angle glaucoma (POAG) is very common. The disease is now recognized as an optic neuropathy with characteristic structural damage to the optic nerve and visual dysfunction. Progressive loss of retinal ganglion cells (RGCs) by apoptosis involving multiple mechanisms is a recognized feature of glaucomatous optic neuropathy. The structural changes in the optic disc are in the form of thinning of the neuroretinal rim, pallor and progressive cupping of the optic disc, disc hemorrhage, loss of nerve fibre layer and parapapillary atrophy. It is now well accepted that the diagnosis of glaucoma must be based on documented, progressive change in optic disc morphology and reproducible worsening in automated visual field testing [1]. Acute Primary Angle Closure Glaucoma develops when the access of the aqueous humour to the trabecular meshwork is blocked because of the iris has come forward; the outer edge of the iris blocks the eye's drainage canals. It means Aquous humour cannot escape from the eye and the intra ocular pressure rises. The sudden rises in pressure causes very severe pain in the eyeball. Chronic Angle Closure Glaucoma develops slowly, usually without symptoms, although the reason for the rise in eye pressure is similar to acute primary angle closure. Secondary Open Angle Glaucoma occurs as the result of an eye injury, inflammation, tumor, in advanced cases of cataract or diabetes or by certain drugs such as steroids. This form of glaucoma may be mild or severe. The type of treatment will depend on whether it is open-angle or angle-closure glaucoma. Glaucoma specialists should continue to use all of the information at their disposal, because neither VF testing nor imaging will provide all of the necessary data. Take every aspect of the clinical examination—including the structure of the eye, the patient's history, his or her subjective report, IOP, the evidence of adherence to medical treatment, etc. and then add that to all of the different aspects of the exam to making your clinical judgment [2].

2. Discussion

Almost all population-based studies of prevalence and incidence have identified IOP as a risk factor for the presence or development of glaucoma [3]. Follow-up of ocular hypertension (OHT) patients in Ocular Hypertension Treatment Study (OHTS) and European Glaucoma Prevention Study (EGPS) has shown IOP to be a major risk factor for progression to glaucoma [4, 5]. Lee and colleagues found that for each mm Hg rise in long-term IOP variation, the likelihood of visual field progression increased 4-5 times [6].

Glaucoma, Most clinicians diagnosed with corresponding structural and functional changes. Tonometry is a technique used to measure the pressure in the eye ball. In Air Puff type of tonometry, it measures the IOP with warm puff of air is directed at the eye that device does not touch the surface of the eye. In Applanation, the tonometer is placed on the cornea, and it measure the IOP with a small amount of pressure is applied to the cornea. The range for normal pressure is 12-22 mm Hg. Goldmann Applanation Tonometry (GAT) remains the gold standard for measurements of IOP in glaucoma. Which is essentially calibrated to provide a pressure reading based on the degree of indentation of the central cornea produced by the instrument. The degree of indentation is known to be influenced by the central corneal thickness (CCT), which is taken into account when interpreting the measurements. Disadvantage of GAT is that this method only represents a 'snapshot' measure of the IOP, which has in fact been shown to undergo diurnal changes, with more fluctuations in glaucoma patients. Rebound tonometer (I care), which, is particularly useful in children as no anaesthesia is required and it is better tolerated than GAT. Ophthalmoscopy technique is used in glaucoma is to examine the shape and color of the optic nerve etc**.** An optic nerve that is cupped or not a healthy pink color etc is cause for concern. Pachymetry is used to measures the thickness of the cornea. Corneal thickness has the potential to influence eye pressure

readings. If a cornea is thicker than average, pressure readings with a tonometer may be higher.

Assessment of anterior chamber angle through Gonioscopy is also essential in the diagnosis and assessment of Glaucoma. Gonioscopy helps determine whether the angle (where the iris meets the cornea) is open and wide or narrow and closed. Anterior chamber imaging techniques are used to complement the Gonioscopy findings. The techniques include Ultrasound Biomicroscopy, Anterior Segment OCT, Scheimpflug Photography, and the Scanning Peripheral Anterior Chamber Depth Analyser (SPAC). However, these imaging techniques cannot replace Slit lamp gonioscopy, as they cannot assess the peripheral anterior synechiae.

Perimetry is the science of measuring the peripheral vision ("Peri"= peripheral and "-metry" = measurement). Automated Perimetry remains the gold standard method of assessing functional nerve damage in Glaucoma. There are several summary indices included in the Humphrey visual field analyser [7]. Short – Wave Length Automated Perimetry (SWAP) and Frequency Doubling Technology (FDT) Perimetry, are being explored as replacements to Standard Automated Perimetry (SAP) to provide earlier detection of visual field defects [8]. Visual field is a subjective test that requires patient cooperation, it has been widely used for diagnosis, staging and monitoring the disease, in many patients visual field losses only become detectable after a substantial number of optic nerve fibers has been lost.

2.1 Imaging technologies [9]

There are currently three types of computer imaging techniques are designed to facilitate the objective and quantitative assessment of the Optic Nerve Head (ONH) and the Retinal Nerve Fibre Layer (RNFL): Scanning Laser Polarimetry (SLP, i.e. GDx), Confocal Scanning Laser Ophthalmoscopy (CSLO, i.e. Heidelberg Retinal Tomography [HRT]) and Optical Coherence Tomography (OCT). They can be used to detect early structural damage by focusing on glaucoma-relevant structures of the ONH and surrounding tissues and using a normative database to determine the probability of Glaucoma.

2.2 Scanning Laser Polarimetry (SLP)

SLP is designed to provide objective assessment of the RNFL thickness with potential use for diagnosis and follow-up. SLP is based on the principle that polarised light passing through the birefringence RNFL undergoes a detectable phase shift, which is linearly related to RNFL thickness [10]. The result is a 2D map of retardation around the optic disc. The software provides a discriminating classifier of glaucoma/normality named nerve fibre indicator (NFI), which is fully automated. To detect change over time, regression analysis can be performed.

The current SLP systems (GDx Variable Cornea Compensator [VCC] and GDx Enhanced Corneal Compensator [ECC], Carl Zeiss Meditec, Inc., Dublin, CA) include a variable compensator that allows for individualized eye-specific compensation of anterior segment birefringence. The performance of SLP can be affected by light scattering in the eye leading to a poor signal-to-noise ratio and atypical retardation patterns (ARPs) [11, 12, 13].

The reason for ARPs is unknown, but as ARPs occur more in glaucomatous eyes than in normal eyes it has been hypothesised that it results from low signalto- noise ratio when decreased reflectivity is present [11]. An analysis of the contribution of backscattered light from various depths to the total retardation map using spectral-domain OCT found that atypical retardation patterns in SLT are associated with deep penetration of the probing light beam into the strongly birefringent sclera [14].

2.3 Confocal Scanning Laser Ophthalmoscopy (CSLO)

Confocal Scanning Laser Ophthalmoscopy (CSLO) is an imaging tool that is designed to create a quantitative, 3D topographic picture of the ONH and the posterior segment surface. Based on the measurements of the ONH, the instrument generates a number of stereometric parameters, such as rim volume, rim area, cup shape or cup-to-disc ratio, that allow evaluation of the ONH for glaucomatous damage. It allows optic disc assessment to detect structural glaucomatous changes up to eight years earlier than visual field examination [15].

The HRT III, provides a large ethnic selectable normative database and includes data analysis tools such as Moorfields regression analysis (MRA) and the Glaucoma Probability Score (GPS). MRA is a linear regression that takes into account the relationship between optic disc size and rim area or cup-to-disc ratio. The MRA improves the diagnostic accuracy of the HRT by taking into consideration that neuroretinal rim area is affected by disc size and age [16].

The GPS is an automated approach to the optic disc classifying procedure that eliminates operator-dependent factors, which are a source of variability. It is based on five glaucoma specific parameters of the 3D shape of the optic disc and peripapillary RNFL and provides disease probability values [17].

The glaucomatous change can be assessed by topographic change analysis (TCA). TCA provides localised, objective and quantitative information about changes in the volume of the neuroretinal tissue.

2.4 Optical Coherence Tomography (OCT)

Optical coherence tomography (OCT) is non-invasive, cross-sectional imaging technique that uses a scanning interferometer and a coherent infrared light (of 820–870nm) to obtain cross-sectional retinal images based on the reflectivity of the different retinal layers down to the retinal pigment epithelium [18]. This test is objective, highly repeatable, and requires less patient cooperation than visual field [19]. With the OCT the topography of the ONH can be assessed; however, the most important aspect of the OCT is the quantification of the RNFL thickness, which is measured using peripapillary scanning around the optic disc.

There are some developments of OCT, such as spectral-domain optical coherence tomography (SD-OCT), which permits much faster scanning and better axial resolution than TD-OCT. Spectral-domain OCT can create a 3-dimensional map of the retina and the optic nerve, which can then be measured in individual layers, such as the retinal nerve fiber layer near the optic nerve head, or the retinal ganglion cell and adjacent layers in the macula. Swept-source OCT sweeps light through a number of wavelengths in an interferometer, similar in some ways to both spectral-domain and time-domain OCT. For swept-source OCT, a photo detector instead of a camera or spectrometer is used. 3D OCT is also available and may be used to image the ONH. This spectraldomain optical coherence

tomography instruments were able to confirm the structural glaucomatous damage.

3. Conclusion

Sight loss resulting from glaucoma cannot be reversed. The goal of glaucoma treatment is neuroprotection with lowering intraocular pressure (IOP). Variety of medications and surgical procedures has been available to lower IOP. If glaucoma is detected at early stages, it responds well to medication. So, the visual disability can be prevented or postponed. With advanced technology, understanding, early diagnosis and continuous monitoring are going too easy for clinicians. In this article, few updated information on new advances in glaucoma diagnosis are capsulated.

4. References

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