REVIEW OF LITERATURE

A knowledge of the earliest stages of damage in a chronic disease process, preferably at a stage when it is still reversible seems fundamental to an understanding and rational management of the disease. In chronic simple glaucoma, which many ophthalmologists will diagnose only when damage to visual function has already occurred, it is essential to know the earliest reproducible disturbances and their mode of progression in order to ensure that recognition is not unnecessarily delayed and that treatment should not be commenced unnecessarily early in all cases of mild hypertension.

As glaucoma is not a disease ONCE GROWN
But a symptomatic condition (Duke-Elder, 1973), many definitions to define the disease process have been put forward by various ophthalmologists. According to Duke-Elder and Jay (1969) glaucoma does not denote a disease entity but whereas a composite complex of pathological conditions which comprise any raised intraocular pressure which the tissues of
the particular eye in question are unable to stand without damage to their structure or impairment of normal physiological function and with a diurnal variation of more than 5 mm. of mercury.

Heilbr and Kotherington (1970) define glaucoma by an increased intracranial pressure, excavation and degeneration of optic disk and typical nerve fiber bundle damage, producing defects in field of vision. Any or all of these signs may be present at a given examination.

According to Hayreh (1972) glaucoma is a symptomatic condition in which intracranial pressure is too high for a sufficient circulation of blood to be maintained in the papillae for a continued survival of its tissue.

According to Tropek-Dayer (1974) glaucoma may be defined as a persistent or repeated earlier hypertension which eventually causes pathological changes within the eye. Goldmann (1972) defines glaucoma a disease in which the intracranial pressure is too high for continued maintenance of visual sensation.
The diagnosis of chronic simple glaucoma depends upon various factors viz., abnormal intracocular tension, definite field loss, cupping of disc, non-excludable angle of anterior chamber etc.

**Symptoms**

The raised intracocular pressure has been thought to be one of the main causes of the diminution of visual field loss since simple glaucoma has been recognized as a ophthalmological entity and measurement of ocular tension plays an important role in detection of patients suffering from chronic simple glaucoma.

The various methods of measuring the intracocular pressure are,

(a) Digital tonometry - The impossibility of the ocular parts is estimated by the sense of fluctuation perceived on palpation, so its accuracy is therefore never high and depends entirely on the clinical sense and tactus acutissimus of the observer. It is only useful to have gross deviation from normal.

(b) Manometry - Intracocular pressure is measured by a manometer connected to small buret canula which is
introduced into the anterior chamber. This is the
most accurate method. Although good for laboratory
purpose yet can not be employed in clinical practice.

c) Instrumental tonometry - It refers to measurement
of impressibility of the tunic of the eye by deferring
forces applied to these tunics. The impressibility of
these tunic depends on the resistance of the eye ball
to these forces and resistance in turn is dependent on
the intrasaccular pressure and rigidity of the coats of
eye ball. Thus instrumental tonometry gives a measure,
approximate of the intrasaccular pressure. It is of two
types.

(i) Indentation - measures depth of impression
produced upon the anterior wall
by a given force which is
represented by a plunger.

(ii) Application - force necessary to flatten
a known area of cornea is
measured.

INDICATIONS OF TONOMETRY

Many types of impression or indentation
 tonometers have been devised and a great amount
of impressivity has been expended upon their design.
A brief account of development of various tonometers are as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Inventor</th>
<th>Name of Tonometer</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>1863</td>
<td>Von Graefe</td>
<td>Graefe tonometer</td>
<td></td>
</tr>
<tr>
<td>1879</td>
<td>Priestley Smith</td>
<td>Similar to Graefe tonometer</td>
<td></td>
</tr>
<tr>
<td>1905</td>
<td>Schiötz</td>
<td>Schiötz tonometer</td>
<td>measures the depth of the impression produced by a given force acting on the tension of the eye.</td>
</tr>
<tr>
<td>1913</td>
<td>Gradle</td>
<td>Gradle tonometer</td>
<td>It is a modified Schiötz tonometer.</td>
</tr>
<tr>
<td>1915</td>
<td>Ruben</td>
<td>Ruben tonometer</td>
<td>Similar to Schiötz with a horizontal bar to be used in upright position has a</td>
</tr>
<tr>
<td>Year</td>
<td>Inventor</td>
<td>Instrument</td>
<td>Streamlined Instrument</td>
</tr>
<tr>
<td>------</td>
<td>---------------</td>
<td>------------------------------</td>
<td>-----------------------------------------------------</td>
</tr>
<tr>
<td>1919</td>
<td>William McLean</td>
<td>McLean tonometer</td>
<td>Modified Schiotz type with a simple plunger.</td>
</tr>
<tr>
<td>1922</td>
<td>Bedenheimer</td>
<td>Maximum tonometer</td>
<td>Ocular tension is recorded by working of a plunger against a standardized spring.</td>
</tr>
<tr>
<td>1923</td>
<td>Bailliart</td>
<td>Aneroid tonometer</td>
<td>It has a convex plunger surface instead of concave.</td>
</tr>
<tr>
<td>1926</td>
<td>Schiotz</td>
<td>&quot;X&quot; tonometer</td>
<td></td>
</tr>
<tr>
<td>1930</td>
<td>Vogelsang</td>
<td>Ballistic Tonometer.</td>
<td>A complicated method of tonometry depending on photographing the oscillations in the recoil of a minute lever which is allowed to hit the surface under standard condition.</td>
</tr>
<tr>
<td>Year</td>
<td>Inventor</td>
<td>Type of Tonometer</td>
<td>Features</td>
</tr>
<tr>
<td>------</td>
<td>----------</td>
<td>------------------</td>
<td>----------</td>
</tr>
<tr>
<td>1940</td>
<td>J. Miller</td>
<td>Modified Schiötz</td>
<td>Similar to Schiötz except insertion of mirror at the scale to eliminate parallax, also has epicyclic lever system.</td>
</tr>
<tr>
<td>1955</td>
<td>Unger</td>
<td>Electrometer</td>
<td>Having a lighter humor than used by Vogtman.</td>
</tr>
<tr>
<td>1960</td>
<td>Naar</td>
<td>Electronic tonometer</td>
<td>Forces necessary for plunger to make a definite indentation in measured and recorded by a vacuum-electric transducer.</td>
</tr>
</tbody>
</table>

**Explanation**

Various types of tonometers are as follows:

- **Modified Schiötz**: Similar to Schiötz except insertion of mirror at the scale to eliminate parallax, also has epicyclic lever system.
- **Electrometer**: Having a lighter humor than used by Vogtman.
- **Electronic tonometer**: Forces necessary for plunger to make a definite indentation in measured and recorded by a vacuum-electric transducer.
1863 Nakashow
1891 Goldman
1918 New
1929 Api
1951 Maurice
1954 Goldman
1960 Rie Kay et al
1957 Goldman and Schmidt
1958 Perkins U.S.
1863. Nakashow

Area of application is measured with a constant force.

Calibrated the nakashow tensometer.

Improved by inserting bimetallic for reading and dividing image with the help of a guage.

Based on alternative principle of using a variable source to apply to a constant area.

Most commonly used and is based on above principle.

Designed a hand held application tensometer employing the same principle as Goldman's

tensometer applying Inbert-Fisch law.
It does not require a slit lamp and can be used in any position.

Similar to Perkins's tonometer.

The normal intraocular pressure denotes both statistical average pressure and pressure which is compatible with uninterrupted health and function of eye. This pressure need not be the same in every eye and instances occur in which the eye suffers in health and function, yet its pressure remains within the usual range (Machemer, 1971).

This average intraocular pressure of non glaucomatous population has been studied by various workers. It approximates a Gaussian distribution and may be described in statistical terms (Soccor and Shaffer, 1961). By different workers values ranging from 15 to 20 mm of mercury have been recorded.

Soccor (1969) after studying a group of normal population found values ranging from 19 to 25 mm of mercury.
Alimuddin (1986) investigated 1000 eyes (669 male and 331 female) by Schiott's '12' tonometer. He found average tension to be 19.6 mm of mercury.

Abrahamsen and Abrahamsen (1969) performed application and Schiott's tonometry in 250 normal individuals belonging to 22 to 24 years age group. The normal range was 14 to 24 mm of mercury with a mean average of 18 mm of mercury by both the methods. While Desager (1959) found a mean value of 14.5 with Goldmann application tonometer.

Lerche (1961) found a mean value of 18.6 mm of mercury by application tonometer.

There is significant difference in reading of Schiott and application tonometers. At least two factors seem to take major part, firstly position of the patient, secondarily scleral rigidity. The results of various writers are not akin to each other.

Pelow (1961) measured intraocular pressure of 211 normal individuals, both by Schiott and application tonometer and noticed that intraocular pressure measured by application technique is 2 mm lower than what obtained with Schiott in supine position.
Ansky (1963) in a comparative study of large sample by application and Schiötz tonometer found Schiötz reading approximately 1 mm higher than that of application. He noted mean intracocular pressures by application to be 18.91 mm of mercury while the Schiötz tonometer reading were 16.85 mm of mercury.

Ansky and Solomon (1963) compared the application reading in horizontal position with Schiötz. There was a poor agreement between two systems of measurement. The Schiötz readings were markedly lower to application readings as follows:

- Horizontal application: 17.36 mm ± 0.83
- Schiötz reading: 15.1 mm ± 0.67

Schirmer and Sun Lee (1966) reported application reading averaging 1.1 mm higher than Schiötz when comparing application measurement while seated with Schiötz measurement in supine position. This was based on finding of 163 individuals with normal eyes.

Jackson (1963) did a comparative study of application and Schiötz tonometers adding 1 mm to all reading of application technique as pressure is higher in recumbent than in the upright position.
He observed that 95% of application reading were
the subjects range $\geq 0.5$ mm.

Becker and Gay (1969) carried out application
tonometry in the diagnosis and treatment of glaucoma.
They observed if the corneal rigidity coefficient is
lower than normal, Schiotz measurement with one weight
may fail to detect glaucoma or provide false severity
as to its status of controls while application
tonometry reveals the higher intracocular pressure
in such eyes and results in an accurate diagnosis.
Smith et al. (1967) in a co-operative study reported
entirely different result. They found consistently
higher application reading occasionally of a magnitude
of 10 to 20 mm of mercury. Dapunt (1970) after
examining 100 eyes of 94 consecutive patient over
27 years of age both by Schiotz and Goldman's
application tonometer found greater agreement
between two systems while using 1949 correction
scale of Schiotz. The Schiotz readings were only
0.68 mm lower than the corresponding Goldman reading.

This was the brief account of the various
attempts by different venues to determine the range
of normal intracocular pressure, but the epistemological
problem of what is normal has not been solved.
Amaly (1969) on studying the intracocular pressure of normal 2377 individuals by application tonometer stated that application pressure in general population deviates significantly from the Gaussian distribution, ensnaring that the statistics of latter will grossly underestimate the prevalence of ocular hypertension. Contrary to this, Decembris (1970) on basis of 1235 anamnestically healthy eyes has been able to show that intracocular pressure by application after transformation, is of normal logarithmic distribution with a high degree of probability.

Findings of Holzer and Rotherington (1976) regarding normal and abnormal pressure are well accepted for any glaucoma screening survey. According to them statistically intracocular pressure above 21 mm of mercury (mean ± 3 S.D.) should occur in less than 2.5% of normal population and intracocular pressure of more than 26 mm of mercury (mean ± 3 S.D.) in less than 0.15% of normal population, so any pressure above 21 mm of mercury should be taken into suspicion and above 26 mm of mercury is likely to be pathological.

VISION TESTS

It is crucial to know exactly what the early stages and sequences of change of visual field are
in cases of chronic simple glaucoma, so that a
definite diagnosis of disease can be given at an
early stage. So skillful and thorough examination
of the visual field must be the corner stone of
any attempt at early detection of chronic simple
glaucoma.

The concept of field defects in glaucoma
was put forward more than 100 years ago. Van Graefe
(1869) was first to describe the paracentral scotoma
in the central field in cases of glaucoma. Later
the advent of perimeter shifted the emphasis from
paracentral area to periphery until Bjerrum (1939)
and his disciple Noma (1939) reverted to testing
of visual field with the use of small stimuli and
2 meters across. This was named as cupulo-torsion.
They described enlargement of blind spot as an
early field change in chronic simple glaucoma
followed by nasal scotoma with nasal step.

Later on Traquair (1929, 1948) whose
painstaking cupulo-torsion remains a classic discovered
small detached scotomas can arrive as below the blind
spot with small test objects as an early field change.
Anliss and Fawz (1967) reported that most frequent early field defects in chronic simple glaucoma are circumscribed paracentral scotomas in centre of 30° of visual field.

Bennett (1969) carried out a study in a group of people in whom one eye showed the advanced changes of open angle glaucoma and other eye was apparently not damaged to 1 mm/1000 white target. Static and kinetic perimetry was performed by Tübinger perimeter (a perimeter similar to Goldmann) to plot the photopic visual thresholds at 1° intervals along the oblique meridians. The classical changes in the second eye were found to be small absolute paracentral scotoma with their long axis usually directed in the line of ascent of nerve fibres surrounded by a zone of relative scotoma and separated from the blind spot by completely normal field or very much less disturbed area of visual function.

Harrington (1971) observed that upper nasal field is more frequently damaged in adult onset glaucoma. Russel (1965) also had similar view.

Ansky (1971) while studying the earliest changes in field of vision in chronic simple glaucoma
found peripheral nasal step and temporal sector shape defects as an early change.

Le Bihan and Becker (1971) determined the frequency of characteristic peripheral nasal defects with step like features in 81 consecutive patients with primarily open angle glaucoma. Circular static perimetry was done using various size test objects and positive finding were confirmed by meridional static and kinetic perimetry. Out of 81 eyes exhibiting characteristic glaucoma field loss, peripheral nasal field defects with step features were present in 31 (38%) eyes, 13 of which also had a central field defect. Thus these findings attest the importance of isolated peripheral nasal step as an useful diagnostic sign.

Drance and Feld (1973) finding an occasional step, temporal to blind spot, emphasized a need for careful search of this area.

Drance and Warner (1977) studied retrospectively 22 eyes of 22 patients with initially normal visual field in which a field defect developed subsequently. Field were recorded both on kinetic and static perimetry. There were some prior disturbances in 13 out of 22 eyes. These
disturbances consisted either of scatter or minor depression of sensitivity in the area of field where the definite defect subsequently appeared while in a control group only 6 of 22 eyes showed these types of disturbances. These findings were statistically significant ($X^2 = 4.539, p < 0.05$, Fisher exact test 0.033). So they advocated a need for searching of these types of disturbances as an early change in glaucomatous eyes.

Singhania (1979) by using an original method of kinetic and static analysis examined the nasal visual field of normal and glaucoma suspects. He concluded that a nasal step less than 4° wide with a depth of $\leq 0.5$ log unit in nearly a physiological sign of anatomic and functional asymmetry of the retina while bigger than this is a characteristic glaucomatous field defect, as an isolated system in Bjerrum area. It is easily detectable by kinetic perimetry and can be used as a sensitive marker in early diagnosis and follow up of chronic simple glaucoma.

vanmer (1968) stressed the studying of temporal field. In a study of 151 glaucomatous eyes with typical nerve fiber bundle defects he found that 6 (3%) had isolated temporal field defect.
In a prospective evaluation of
reliability and efficiency of an optimized visual
field screening protocol the glaucoma subjects
(1981) tested 146 eyes of 73 patients, with increased
intracranial pressure, by Goldman perimeter using
kinetic and static perimetry static techniques. No
noticable acute severe initial defects. In 43 eyes
showing glaucomatous defects, none the worse after
intraocular defects or diplopia in the region below
or above the blind spot (10 eyes i.e. 36%).

Khanum (1996) after examining 50 eyes of
patients suspected by Goldman perimeter using both
kinetic and static methods concluded that static
perimetry is useful when kinetic perimetry fails
to show any change.

Khanum et al. (1984) by examining 500 visual
fields of 150 consecutive patients who had glaucoma
or increased intracranial pressure by Goldman
perimeter, found existence of peripheral nasal stepoff
in 60 of the 500 visual fields (21.6%) with a
detectable asymmetry.

SUMMARY

The phenomenon of the cupping of the optic
nerve was first described initially by Auenbrugger (1780).
Jasper (1954) with the introduction of ophthalmoscope. The pale cupped disc found in final stages of glaucoma was known to Van Genda (1954). Since then many authors have described changes that occur in the optic disc in chronic simple glaucoma with particular interest in changes which may occur in the early stages of disease as there is increasing evidence that early cupping is reversible (Elkinson, 1975). Feinraim and Reuschler (1982) also noticed reversal of glaucomatous cupping in six cases after control of intraocular tension.

The decision whether or not the optic disc shows early glaucomatous changes is one that has to be made frequently in clinical practice.

Studies of normal population have shown that while there is a wide diversity in the appearance of the normal optic disc, in a single subject the two discs are remarkably similar. In a group of 1000 patients studied by Kapfhammer (1964) only 16 (1.6%) showed asymmetrical cups in two eyes. Similar findings were noted by family and Symeck (1969). In 1000 subjects the cup disc diameter ratio of one eye of an individual varied ±0.5 or more from that of fellow eye in only 1% of cases.
Flaherty (1970) studied a series of 500 normal patients, 100 onset hypertensive patients, and 53 established cases of chronic open angle glaucoma. He found asymmetrical cupping of optic discs in 1.0% of normal individuals, in 38% of the cases with onset hypertension but without field defects and in 32% cases with established glaucoma. So he stressed that a search for disc asymmetry should be an integrated part of glaucoma screening.

According to Fisher et al. (1970) cupping of optic discs is the single most reliable sign in diagnosing simple glaucoma. For it is probable that asymmetry of disc precedes the development of field defects.

Ansky (1970) studied 83 subjects having an IOP of 20 mm or above, a glaucomatous field defect and open angle on gonioscopy. In four of the individuals with unexposed involvement of visual field, the c/3 test was longer in the affected eye in 28 subjects. Thus with careful ophthalmoscopic examination, one could have suspected glaucoma on the basis of this inequality in 61% of this group.
According to Tolosa et al. (1973) a difference in cup-disc horizontal ratio of greater than 0.2 in the two eyes is present in less than 1% of normal individuals but in 13% of patients with bilateral glaucoma and 26% with unilateral glaucoma. They also concluded that when the vertical cup-disc ratio is greater than the horizontal cup-disc ratio by at least 0.2 and the horizontal ratio is more than 0.6 the presence of field loss should be suspected.

Klastorin and Anderson (1976) after examining 70 normal and 80 glaucomatous patients have emphasized the significance of vertically oval cup even if it be small and surrounded by what appears to be rim of healthy tissue.

According to Klastorin and Phillips (1976) in some glaucomatous subjects the shape of disc influences the shape of physiological cup within 5%. A vertically oval cup tending to occur in vertically oval disc.

Glaser (1976) after examining 126 normal eyes (33 non-glaucomatous, 10 under hypertension and 83 fellow eyes of unilateral glaucoma) and 68 eyes with glaucoma field defects found that
ratio expressing the evauation of cup was less than 1.0 in "un" glaucomatous eyes, indicating that the physiological cup in an on average, horizontally oval, the ratio slightly exceeds 1.0 in eyes with raised tension but no field defects, whether these were in patients with similar hypertension or were the fellow eyes of patient with unilateral simple glaucoma. When a field defect could be established the mean ratio increased to 1.2. These results thus strongly support the view that an early change in glaucomatous disc is vertical elongation of the cup.

In a study conducted by McKinnon (1976), he found that disc with cup area of more than 52% were highly susceptible to damage by glaucoma.

Nithching and Sympth (1977) after examining stereoscopic photographs of disc of 256 eyes from 256 patients found that glaucomatous field defect can be predicted in 83% of glaucoma cases on the basis of disc-cup appearance.

According to Semer (1978) in majority of patients who developed field defects, early dissimilarity of disc probably produce disturbances in the visual field so an observed change. In the
architecture or colour or both of the optic nerve head, is a reliable sign of glaucoma. He also stated that asymmetry of the neuroretinal rim of the optic nerve occurs rarely in normal population and when associated with raised intraocular pressure should constitute strong evidence of acquired tissue change.

In a study undertaken by Chawla and Chatterjee (1972) in 168 cases with disc cup asymmetry 13 cases (14.86%) were found to be glaucomatous on first visit, while 72 cases (42.98%) were proved to be glaucomatous on subsequent visit thus making the glaucomatous group of 87 cases (51.81%), indicating asymmetry of cup as an important diagnostic tool.