Review of Literature
Glaucoma is one of the leading causes of blindness and is responsible for 3-5% of all blindness in India. Glaucoma may be primary or secondary to some ocular or non-ocular disorder which alter the aqueous dynamics resulting in elevation of intra-ocular pressure. Thus glaucoma refers to a variety of disorders which differs in their clinical presentation, pathophysiology and modes of treatment.

The word glaucoma first appears in the works of Hippocrates (420B.C.) together with amblyopia in the list of eye diseases affecting the elderly. It is an ancient Greek word as glare such as silvers of the sky as dull sheen of an eye, which has lost its brightness. Sams ad din (1806) described glaucoma as migrane of the eye, an illness associated with pain dullness of humour followed by dilation of pupil.

Szily (1884) first time observed the occurrence of glaucoma in case of long-standing mature cataract. Reuss also noticed the occurrence of iridocyclitis and glaucoma in cases of spontaneous cure of senile cataract. Gifford (1900) described the lens-induced glaucoma as the one associated with hypermature cataract and urged its prevention by lens extraction. Instances of this condition are also sighted by Rollet and Genet (1913) Gonzaliz (1919), Daily (1933), Knapp
(1937), Sugar (1949) and Scott (1953). Kaufan (1933) mentioned that in such cases cholesterol crystals were seen in anterior chamber.

Though lens induced glaucoma can be classified in variety of ways we shall be following a working classification. This classification is based on Epstein D.L.; Diagnosis and management of lens induced glaucoma, (1982).

1. Phacolytic glaucoma.

2. Phacomorphic glaucoma.

3. Phacoanaphylactic glaucoma.

4. Glaucoma due to dislocated lens.

5. Lens particle glaucoma

The diagnostic criteria were as follows:

1. **Phacolytic glaucoma**

   IOP of more than 21 mm of Hg.

   Pain.

   Hypermature cataract.

   Corneal oedema  +/-

   Floating lens particle or pseudohypopeon.  +/-

   Anterior chamber depth normal/deep.
2. **Phacomorphic glaucoma.**

   IOP of more than 21 mm of Hg.

   Pain.

   Intrumescent cataract

3. **Phacoanaphylactic glaucoma.**

   IOP of more than 21 mm of Hg.

   Pain.

   Corneal oedema

   History of E.C.C.E. or penetrating injury.

4. **Lens particle glaucoma.**

   IOP of more than 21 mm of Hg

   Pain.

   Corneal oedema

   Chunky Corneal oedema  +/-

   Anterior chamber depth  <1/4 of the peripheral corneal thickness.

   White particles in aqueous with heavy cell flare.
5. **Dislocated lens**

IOP of more than 21 mm of Hg

Pain.

Corneal oedema

Dislocated or sublaxated lens.

Parker Heath (1940) classified secondary lenticular glaucoma lens to be due to:

1. Lens in position.

2. Lens out of position.

Glaucoma with the lens in position can be due to:

- Imperfect differentiation of angle

- Intumescent lens associated with irritative contact with the ciliary processes

- Toxic substances escaping through the permeable capsule of a hypermature cataract

- Desquamation of capsule

- Following uveitis which causes posterior synechiae and iris bombe formation.
- Perforating wounds to the lens
- endophthalmitis phacoanaphylactica.

Glaucoma with the lens out of position can be due to:

- Congenital lental ectopia.

- Subluxation of lens making it come into contact with ciliary processes

- Subluxation into anterior chamber causing pupillary block.

- Subluxation into cornea –phacocele due to corneal perforation.

- Subluxation into anterior, posterior or central vitreous.

- Subluxation into retina or optic nerve head.

Flocks Milton et al conducted a clinical study in 1955 where they observed the clinico-pathological picture of 138 cases. They observed that liquefaction of lens cortex and degeneration of its capsule permitted the escape of lens liquid into the anterior chamber. Capsule rupture was not an essential factor behind it. The lysed cortical material evoked a histiocytic response and consequent plugging of trabecular
spaces by macrophages. It follows that after delivery of the lens, anterior chamber should be irrigated to remove the macrophage laden fluid as far as possible. On biopsy the optic disc nerve and the retina were well preserved. A natural conclusion was made that removal of hypermature lens and irrigation of anterior chamber obtained good visual results.

Smith and Zimmermann (1965) conducted another study where 125 cases of phacolytic glaucoma were reviewed from old files. The cross section from all the eyes was examined noting the configuration of angle of anterior chamber. The object was to determine the frequency of angle recession occurring as a result of trauma. In 25% of cases there was unequivocal evidence of trauma while another 18% had equivocal evidence of contussive damage. A definite history of trauma was found in 50% of cases showing unequivocal changes of trauma, 44% of cases with equivocal changes had a history of trauma. Therefore, phacolytic glaucoma has been thought to occur almost exclusively as a complication of senile hypermature cataract unassociated with other intraocular disease. The present study shows that in early 20% of cases, there is a definite evidence of angle recession. Thus trauma could be implicated in pathogenesis of phacolytic glaucoma. In most cases prompt cataract extraction is curative, unsatisfactory results may be obtained
if there has been considerable subclinical damage to retina and optic nerve prior to the onset of phacolytic glaucoma.

Epstein D.L. et al from patients of phacolytic glaucoma identified high molecular weight soluble proteins later on in 1977. Aqueous humor was obtained at the time of cataract operation from six patients of phacolytic glaucoma diagnosed on basis of acute open angle associated with an apparently leaking hypermature or mature cataract and from six control patients with immature cataract. Three of the latter had primary open angle glaucoma. Quantities of high molecular weight protein (>150 X 106), sufficient to obstruct aqueous outflow were identified in all six cases of phacolytic glaucoma. In none of the controls protein levels were as high. Three of the hypermature cataractous lenses from the cases of phacolytic glaucoma were also examined and were found to have 14 fold greater quantities of high molecular weight proteins in their liquefying cortex than were present in the cortex of immature cataractous lenses. These findings correlated with high molecular weight protein perfusion studies suggested direct obstruction of aqueous outflow channels by liberated high molecular weight soluble lens protein and thus causing phacolytic glaucoma.

Epstein D L (1982) in a review titled ‘Diagnosis and management of lens induced glaucoma’ said that lens
induced glaucoma may occur either as secondary angle closure or open angle glaucoma. Dislocation or swelling of lens can cause pupillary block and subsequent angle closure glaucoma. Leakage of soluble lens particle from a relatively intact cataractous lens can result in a severe secondary open angle glaucoma (phacolytic glaucoma). Heavy molecular weight protein believed to be of lens origin was identified in twelve out of twelve anterior chamber specimens from such patients. This liberated lens protein can directly obstruct the trabecular outflow pathways. After extracapsular cataract extraction or lens trauma, liberated fragments of lens material may mechanically impair the drainage of aqueous humor thorough the outflow channels (lens particle glaucoma). The diagnosis and management of these different lens induced glaucoma were reviewed and surgical removal of the lens and lens material suggested as treatment for good visual rehabilitation. Lens dislocation causing angle closure glaucoma should be treated by peripheral iridotomy especially laser iridotomy or by iridectomy.

Jain IS et al (1983) studied eighty-six cases of phacomorphic glaucoma - its management and visual outcome. They recorded incidence of phacomorphic glaucoma to be 3.91%. In all 86 cases intraocular pressure could be controlled preoperatively with or without mannitol.
Intracapsular cataract extraction was done in 49 eyes, planned extracapsular extraction in nine eyes and combined extractions in nine eyes. 19 eyes had accidental rupture of lens capsule.

93% of cases had normal intraocular pressure at the end of the follow up period without any medication and irrespective of the duration of attack and the type of surgery. Final visual outcome was directly related to the duration of attack. 54.5% of the eyes with less than 2 days of attack regained 6/12 or better visual acuity, whereas if the attack lasted 3 weeks or more visual acuity was no better than hand movements or perception of light.

Optic disc changes in the form of pallor, glaucomatous cupping and atrophic cupping were directly related to the duration of attack of the 59 eyes in which duration of glaucoma was less than 10 days, 45 eyes (76.2%) had clinically normal optic disc. Though bilateral phacomorphic glaucoma was encountered in nearly 14% of the eye cases, they do not recommend prophylactic iridectomy on the fellow eyes as –

a) The occurrence of phacomorphic attack seemed to occur almost 10 years later.
b) The surgical procedure itself may accelerate the formation of a hydrated cataract

c) Observation of acute phacomorphic glaucoma in 3 eyes where an iris inclusion had already been done.

Lane Stephen S et al (1988) studied the efficacy of extracapsular cataract extraction as a definitive treatment for phacolytic glaucoma. 5 cases of phacolytic glaucoma that occurred between 1984 & 1986 were studied from retrospective chart review. Extracapsular cataract extraction with placement of a posterior chamber intraocular lens was performed and was curative in all 5 eyes. All patients (100%) maintained intraocular pressures of less than 20 mm of mercury without medical therapy. The best corrected visual acuity for all cases was 20/50 or better (80% had more than 6/12) with 5 months to 5 years follow up. They concluded that extracapsular cataract extraction with posterior chamber intraocular lens placement is a safe and efficacious treatment for phacolytic glaucoma. According to them the phacolytic lens capsule was not more fragile. Although they preferred extracapsular cataract extraction with posterior chamber intraocular lens as treatment of choice for phacolytic glaucoma, they also said that the surgeon should employ the technique with which he was more familiar that is
intracapsular cataract extraction or extracapsular cataract extraction.

Angra SK et al (1991) described an insight into management of cataract induced glaucoma. They studied 40 cases of phacomorphic glaucoma and evaluated the efficacy of medical therapy, intraoperative and postoperative complications, and the effect of high intraocular pressure and surgical trauma on the corneal endothelium.

They found that 55% of the patients were in the group of 50 to 60 years. The incidence of phacomorphic glaucoma was 3.91%. 23 of the patients had immature intumescent cataracts, while 17 had hypermature swollen cataracts. Preoperative intraocular pressure ranged between 34 to 83 mm Hg. Medical therapy given was with topical pilocarpine, oral glycerol, acetazolamide and intravenous mannitol. They found no relationship with duration of attack and height of intraocular pressure. In 37.5% of eyes intraocular pressure could not be controlled with medical therapy. These eyes were found to have extensive peripheral anterior synechiae and longer duration of attack. Inaccurate light projection could be corrected in 9 out of 16 patients with medical treatment alone. Endothelial cell loss was found to be 14.8% after the attack.
Cases were randomly subjected to intracapsular cataract extraction alone or ICCE with trabeculectomy. Striate keratopathy and shallow anterior chamber was more post-operatively in the ICCE group. Control of intraocular pressure post-operatively was better in the combined extraction group. Only in 75% of patients intraocular tension could be normalized post-operatively. In those with longer duration of attack, cataract extraction alone dose not seems to control tension. Better overall visual recovery was achieved in the combined extraction group. Initial faulty light projection does not necessarily mean a poor visual outcome. Final visual acuity was related more to duration of attack than to type of cataract or modality of surgery.

Tomey KF and Rajhi AA (1992) reviewed 10 patients of phacomorphic glaucoma who underwent Nd: YAG laser iridotomy for the initial management of acute angle closure glaucoma. In all the cases the acute angle closure glaucoma could be reversed by iridectomy before cataract extraction. They felt that pupillary block and responds caused the initial angle closure well to the same type of treatment as primary angle closure glaucoma, namely iridotomy. According to them laser iridotomy benefits phacomorphic glaucoma cases in 3 ways:-
1. After iridotomy, the eye is allowed to quiet down from an acute attack and thus be in a better condition for cataract surgery.

2. Pre-operative mydriasis becomes safer.

3. It becomes possible for the surgeon to decide whether glaucoma surgery should be performed simultaneously with cataract extraction.

Lin TH et al (1993) carried out a retrospective study of 995 eyes that underwent cataract surgery between January and March 1990. The study revealed that one in 20 (50 eyes) were of advanced cataracts (hypermature, morgagnian and intumescent). 30% of these cases suffered from cataract related complications pre-operatively: phacomorphic glaucoma (12/50 eyes) phacolytic glaucoma (1/50 eyes) and subluxated cataract without trauma (2/50 eyes). Cataract surgery in these advanced cataracts produced significantly poorer results than the rest. 1 in 4 eyes failed to achieve a visual acuity of 6/12 or better post-operatively, while 1 in 8 eyes did not improve beyond hand movement vision. They concluded that the main reason for poor visual results was lens-induced glaucoma 80%.

Singh G et al (1994) evaluated the results of conventional extracapsular cataract extraction with posterior
chamber intraocular lens in a series of 5 cases of phacolytic glaucoma. 5 cases between the age of 64 and 70 years were taken. Only those cases with minimal lenticular changes and good visual status in the fellow eyes were included in the study to avoid problems of unilateral aphakia. The period between diagnosis and surgery varied between 3-6 days depending on the control of uveitis and glaucoma. The same surgeon operated all the cases, after control of uveal inflammation and intraocular pressure by appropriate medical therapy. In this study, with a mean follow up period of 2 years all patients maintained a normal post-operative intraocular tension of less than 20 mm Hg without any additional medical therapy. The best corrected visual acuity in 80% of cases (4 out of 5) was 6/12 or better. Vision was 6/24 in one case due to senile maculopathy. Hence they concluded that planned extracapsular cataract extraction with posterior chamber intraocular lens implantation is a safe and effective method of visual rehabilitation in cases of phacolytic glaucoma.

Mandal AK (1994) described endocapsular surgery and capsular bag fixation of intraocular lens in 19 cases of phacolytic glaucoma. Anterior capsulotomy is the key step in endocapsular cataract surgery. This is easier in immature cataracts but requires great care in eyes with phacolytic
glaucoma with hypermature morgagrian cataracts, where the capsule is fragile, zonules are weak and view obscured by milky white fluid cortex leaking from the taut capsular bag into anterior chamber. To overcome these difficulties, he recommended aspiration of milky fluid cortex from the capsular bag before capsulotomy so that a minimal amount of irrigating solution is required for cortical clean up. This he called the “dry technique” of extracapsular cataract extraction in morgagrian cataract. He also recommended a V-shaped anterior capsulectomy with angled vannas scissors to avoid zonular dialysis. Before the nucleus is delivered, methylcellulose is injected between the nucleus and posterior capsule to severe adhesions that are sometimes present between the nucleus and the posterior capsule. Posterior chamber intraocular lens was implanted in 8 out of 19 eyes. Extracapsular cataract extraction was done in 11 eyes. 16 eyes (84.2%) achieved visual acuity 6/12 of which 8 were those with intraocular lens and 8 with extracapsular extraction alone. Relatively poor visual acuity in remaining 3 eyes was due to delayed presentation causing glaucomatous damage to the optic nerve. Post operative I.O.P. of <20mmof Hg was achieved in all eyes without anti-glaucoma medication.
Barnhorst D et al (1996) reported an unusual case of lens induced glaucoma that occurred 65 years after congenital cataract extraction. It was a case of lens particle glaucoma caused by pieces of lens material, which are loosened when the lens capsule is disrupted by trauma or during an operation. However, increased I.O.P. in these cases usually occurs a few days after trauma or operation and rarely years later. The patient underwent a pars plana vitrectomy to remove the yellow cortical lens matter. Six months later best-corrected visual acuity was 6/12 tension by applanation tonometry was 21 mm of Hg and ant chamber and vitreous cavity had no cells or flare. In this patient the moderately large amount of residual lens material probably increased the risk of lens induced glaucoma. Perhaps it took many years for the lens matter to denature into high molecular weight protein and subsequently break into small pieces and release soluble lens protein resulting in lens particle and phacolytic glaucoma.

Pranja N V et al (1996) studied the clinical models of presentation and post operative usual results in 93 patients with lens induced glaucoma of which 59 were of phacomorphic glaucoma and 44 were of phacolytic glaucoma. All the patients were subjected to planned extracapsular cataract extraction. 44% had a posterior chamber intraocular
lens implantation following surgery. 57% eyes with phacomorphic glaucoma and 61% with phacolytic glaucoma recovered visual acuity of 6/12 or better. They found that there was no significant difference in the visual acuity between those patients who had an intraocular lens implantation and those who did not (p=0.18). They found a slight female preponderance (54%) of lens induced glaucoma. The fellow eye in the case of patients with phacomorphic glaucomas had immature cataract in 80% patients, while in the case of phacolytic glaucoma, they were predominantly aphakic (72%). The mean I.O.P. in the case of phacomorphic glaucoma was marginally higher (45+/−12 mm of Hg) than in phacolytic, in whom it was 40+/−11 mm of Hg. They also studied the risk factors determining the final visual acuity. They concluded that age more than 60 years and patients in whom the glaucoma was present for more than 5 days had a significantly higher risk of poor visual outcome post-operatively.

Mandal A K in 1997 in a review titled “An alternative way to manage patients with Morgagnian cataracts and Phacolytic glaucoma claimed that a simple technique of endocapsular surgery and capsular bag fixation of intraocular lens was safe and effective way of treating patients of phacolytic glaucoma. He studied 37 cases of phacolytic
glaucoma over a period of five years. A visual acuity of 6/12 or more was achieved in 66.7% of those who underwent extracapsular cataract extraction and 84.6% in those with extracapsular cataract extraction with posterior chamber intraocular lens implantation. I.O.P. was well controlled in all patients without anti-glaucoma medication. Poor visual recovery was attributable to glaucomatous disc damage. The duration and elevation of I.O.P. did not cause any clinically detectable damage in the outflow pathway even when associated with significant glaucomatous disc damage. Hence he concluded that addition of trabeculectomy to cataract extraction is superfluous in control of intra-ocular pressure in patients with phacolytic glaucoma operated within 2 to 3 weeks of onset of symptoms.