COMMUNICATIONS

ANGLE-CLOSURE, PUPIL DILATATION, AND PUPIL BLOCK*

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PREVIOUS papers (Lowe, 1964a) have remarked that when the pupils of eyes with shallow anterior chambers, narrow angles, and open peripheral iridectomies are dilated with homatropine, a considerable proportion of the eyes with persistently narrow angles develop angle-closure, a consequent fall in outflow facility, and a rise in intra-ocular pressure that may reach the fifties within two hours.

When the same eyes have their pupils dilated equally widely with 1 per cent. *l*-adrenaline base or 10 per cent. phenylephrine eye-drops, none of the angles closes, facility of outflow is likely to be increased, and small falls in intra-ocular pressure may occur (Lowe, 1964b).

The angle-closure induced by homatropine in such eyes is caused by peripheral folding of the iris at the time of pupil dilatation, and the last fold of the iris may be in contact with the lateral wall of the angle so firmly that the iris may push forwards as far as Schwalbe's line, completely smothering the trabeculae. Subsequent unpublished experiments have shown that this type of angle-closure is liable to occur with other tropine-style drugs and that the degree of angle-closure is (in general) related to the width of pupil dilatation. Thus it occurs more frequently after 1 per cent. cyclopentolate ("Mydrilate", "Cyclogyl") than after 4 per cent. homatropine, which in turn causes more angle-closure than 4 per cent. eucatropine ("Euphthalmine") or 0.5 per cent. tropicamide ("Mydriacyl").

The tropine-style drugs therefore act in a similar manner (although to varying degree) as pupil dilators. Likewise, they act in a similar manner (and also to a varying degree) in sometimes causing reduction in facility of outflow even in the presence of an open angle.

By contrast, the adrenaline-style drugs—1 per cent. *l*-adrenaline base ("Eppy" 1 per cent.) and 10 per cent. phenylephrine ("Neosynephrine" 10 per cent.)—although equal or more efficient pupil dilators than the tropine group, were found not to cause the iris to fold at the extreme periphery, so that no angles closed in the presence of an open peripheral iridectomy.

Methods of Pupil Dilatation

An explanation of the above phenomenon is now presented.

When pupils are dilated with either the tropine or adrenaline groups of drugs the

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slit-lamp appearances are very similar. Around the pupil the iris becomes thinner as the stroma is collected in a mound or a ridge at the lesser circle. A relatively smooth area then occurs across to the peripheral folds of the iris. These outer folds average three in number, the outermost tending to be hidden by the arcus senilis or the edge of the limbus. The iris stroma therefore slides (to a varying degree) over the pigment epithelium towards the periphery, sliding more under the action of the tropine drugs than with drugs of the adrenaline group.

An explanation appears to lie in pharmacological differences between the two groups. The tropine drugs dilate the pupil by decreasing the activity of the sphincter so that the dilator, acting against a weakened antagonist, pulls the iris more bodily towards the periphery (Fig. 1). Those of the adrenaline group act by stimulating the dilator muscle—but the sphincter maintains its tone. Although pupil dilatation may be wide, the dilator muscle still has an active antagonist so that the iris is not permitted to move so far peripherally and the angle remains open (Fig. 2).

FIG. 1.—Pupil dilatation with tropine-like drugs. The sphincter muscle is paralysed and the iris moves towards the angle which may become closed.

FIG. 2.—Pupil dilatation with adrenaline-like drugs. The stimulated dilator acts against a tonic sphincter and the iris does not move into the angle.

These actions are best studied in eyes with shallow anterior chambers and narrow angles because the narrowness of these angles allows much better gonioscopic demonstration of the effects of pupil dilatation and iris ballooning from relative pupil-block, than do eyes with normal anterior chamber depths and angles. In eyes with open peripheral iridectomies the possibilities of pupil-block-angle-closure are removed and the effects of isolated pupil dilatation may be studied.

Effects of Pupil Block

When pupils are dilated after peripheral iridectomy in eyes with shallow anterior chambers the anteriorly curved surface of the lens appears to be gripped by the pupil edge, almost as though the lens were herniating through the gap of the pupil.

In the presence of an intact iris, eyes with shallow anterior chambers and narrow angles are subject to angle-closure from iris ballooning caused by pupil-block. Pupils of such eyes may need to be dilated to permit ophthalmoscopic or other

examination, but it has been found that whereas homatropine tends to cause angle-closure by pupil dilatation it has been an infrequent cause of acute angle-closure glaucoma. By contrast, although 10 per cent. phenylephrine eye-drops are safe in eyes with peripheral iridectomies, they are highly dangerous in eyes with shallow anterior chambers and intact irides (Lowe, 1965). An explanation of these phenomena is now presented.

When an iris rests on a forward lens the forces of pupil dilatation can be resolved into two components—a posterior and a lateral. Likewise, the force of pupil constriction can be resolved into two components—a medial and an anterior (Fig. 3).

When the tropine drugs dilate pupils they do so by permitting the dilator muscles to pull against a weakened sphincter. Thus the posteriorly acting component of the pupil-dilating force will be located towards the periphery of the iris where contact between iris and lens is less than it is near the pupil. The atonic sphincter will have a reduced medially acting component, so that towards the pupil the iris will press less heavily against the lens, and posterior aqueous will not be obstructed in its passage to the anterior chamber (Fig. 4 A).

The adrenaline-like drugs act by stimulating the dilator in the presence of a tonic constrictor muscle. The posteriorly directed components of pupil dilatation are now seen to be augmented at the periphery while the medially acting component of the sphincter persists (Fig. 4 B). The iris will therefore press more strongly against the lens and increase the obstruction to forward flow of aqueous. Pressure will build up in the periphery of the posterior chamber and tend to force the peripheral iris forwards to close the angle.

FIG. 3.—Components of iris muscle activity. C.A., Anterior component of constrictor activity. C.M., Medial component of constrictor activity. D.L., Lateral component of dilator activity. D.P., Posterior component of dilator activity.

FIG. 4.—A, Pupil dilatation with tropine-like drugs. The sphincter is paralysed and the posterior component of the dilator acts peripherally. B, Pupil dilatation with adrenaline-like drugs. The dilator is stimulated and its posterior components are augmented, while the medially directed component of the sphincter persists.

Practical Applications

Pupil Dilatation with Intact Iris

When pupils need to be dilated in eyes with shallow anterior chambers, narrow angles, and intact irides the adrenaline-type drugs are highly dangerous. Many

ophthalmologists think that their quick action and quick recovery gives increased safety, but the effects of pupil-block can be disastrous (Lowe, 1965). Becker, Gage, Kolker, and Gay (1959) showed that 10 per cent. phenylephrine can overcome the effect of even highly potent miotics, so that the pupil dilatation of phenylephrine may be difficult to reverse. When miotics are used after adrenaline-like pupil dilators, the pupil-block is likely to be increased by the increased stimulation of the sphincter and its enhanced medial component pressing the iris more forcibly against the lens.

Pupil dilatation is safer with the tropine group of drugs. Cyclopentolate, by causing wide pupil dilatation, appears less safe than homatropine (or homatropine and cocaine), whereas drugs with evanescent and mild action appear to be even safer ("Tropicamide", "Mydracil"). The action of "Tropicamide" begins to diminish after approximately half an hour, and pupil activity begins to return shortly afterwards. It is probably the safest of the commercially available pupil dilators for eyes with shallow anterior chambers and intact irides. Under test, "Tropicamide" has been observed to cause angle-closure and high pressures in some eyes, but its effects can usually be readily reversed with 0.25 per cent. eserine eye-drops.

Post-operative Pupil Dilatation

Posterior synechiae readily form in some eyes after peripheral iridectomy for the prophylaxis or treatment of angle-closure glaucoma. This is caused not only by the traumatic iritis, but by the pupil resting against the lens and not being lifted by the forward flow of aqueous, which is impeded less in passing through the peripheral iridectomy than through the pupil (Kessler, 1956).

Daily pupil mobility greatly reduces the formation of these posterior synechiae. The best eye-drop appears to be 10 per cent. phenylephrine ("Neosynephrine" 10 per cent.). Not only is it a powerful pupil dilator, but it will not fold the peripheral iris into the angle; thus it will not encourage the formation of peripheral anterior synechiae. Its evanescent action permits subsequent pupil constriction without the addition of a miotic. Care must be taken that the peripheral iridectomy is of full iris thickness, because if only the anterior leaf of the iris were removed the phenylephrine would be likely to induce a severe acute angle-closure glaucoma.

To achieve adequate pupil dilatation, several applications of 10 per cent. phenylephrine eye-drops may be needed, instilled at intervals of 5 to 10 minutes, and nursing staffs need to be drilled in these matters. Some pupils will not dilate sufficiently with phenylephrine alone and a drop of cyclopentolate or homatropine may be necessary to achieve the desired pupil movement.

The tropine drugs, such as cyclopentolate or homatropine are now not favoured for pupil dilatation after sealed peripheral iridectomy, because they tend to cause angle-closure and encourage the formation of peripheral anterior synechiae. Pupil mobility is not as active with them as with phenylephrine.

Pupil Dilatation after Filtering Operations

After exterior filtering operations, anterior chambers are likely to have a period of shallowness. If the anterior chamber becomes so flat that the anterior surface of the

lens remains in contact with the corneal endothelium, lens opacities are very likely to form. These may show as numerous *glaukomflecken* (Lowe, 1964c), or more lasting cortical opacities that will permanently reduce vision.

The adrenaline-like drugs appear to encourage the forward movement of the lens, whereas by tightening the zonule the tropine drugs pull the lens more posteriorly (Chandler and Grant, 1962). Therefore to achieve pupil dilatation after drainage operations tropine eye-drops should be used rather than those of the adrenaline group. In eyes with shallow anterior chambers the risk of the formation of peripheral anterior synechiae must be weighed against the risk of lens damage or increased shallowness of the anterior chamber. The less effective the drainage operation the more quickly the anterior chamber will re-form and the more the angle should be preserved—adrenaline-like drugs would then be indicated. The more shallow or absent the anterior chamber (with or without malignant glaucoma) the greater the indication for the tropine alkaloids (especially with atropine for flat chambers), and the more the angle has to be sacrificed to guard the lens.

Summary

Pupil-dilating eye-drops fall into two main groups—the tropine-like and the adrenaline-like drugs. For eyes with shallow anterior chambers and narrow angles there are different conditions for preferring one group or the other. In the presence of intact irides, the mild tropine-like drugs are best for dilating pupils. Although pupil-dilatation glaucoma is more likely with the tropine group, the risk of pupil-block is less than with the adrenaline group. Further, the effects of the less potent tropine drugs ("Tropicamide") are more readily reversed by miotics, than the effects of the adrenaline group.

After peripheral iridectomy the risk of pupil-block is removed, and drugs of the adrenaline group (10 per cent. phenylephrine) are preferred because they will not close narrow angles, whereas the tropine group will close some angles despite open peripheral iridectomies.

Following exterior filtering operations, a strong tropine drug (atropine) is necessary in the presence of flat anterior chambers.

Explanations are given for these different effects.

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