Monkeys are currently being reared with only monocular occlusion to provide more information on this question. The clinical relevance of these axial length changes in our aphakic monkeys is very significant because removal of cataracts in neonatal children is the first step for providing a clear visual input to the retina. Thereafter, other optical parameters must be considered to achieve a good retinal image. One of these parameters is the disparity of image sizes on the two retinæ and another is the future growth of the eye. From our results, this growth can be reduced by several millimeters in an aphakic eye, and therefore becomes an important factor in predicting the necessary optical corrections.

Key words: primate, aphakia, amblyopia, cataract, ultrasonography

Acknowledgments. The authors thank Dr. Johannes Tigges for reading the manuscript and the veterinarians and their staff at Yerkes Primate Center for assistance in caring for the monkeys.

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References

Effects of Intraocular Pressure and Other Factors on Subretinal Fluid Resorption

Akira Negi,* Shin-ichiro Kawano,* and Michael F. Marmor

We observed the effects of intraocular pressure (IOP), vitreous pressure and gravity on the resorption of small retinal detachments (blebs) made with Hanks' solution or autologous serum. Raising the IOP decreased the absorption time moderately and lowering the IOP increased it. These effects were greater when the RPE had been damaged by sodium iodate or laser burns, but we conclude that IOP makes only a small, limited contribution to normal subretinal fluid absorption. Neither liquefaction of the vitreous nor retinal weight had a significant influence on fluid absorption. Invest Ophthalmol Vis Sci 28:2099-2102, 1987

Fluid injected experimentally into the subretinal space of rabbit eyes will resorb within several hours.1 Subretinal fluid under human rhegmatogenous retinal detachments is also absorbed quickly, once retinal holes have been sealed.2 Our data from previous experiments with non-rhegmatogenous detachments in the rabbit indicate that metabolic activity of the retinal pigment epithelium (RPE) as well as onotic pressure of the choroid are involved in the resorption of fluid.1,3-6 In this paper we investigate the possible contributions of hydrostatic pressure, vitreous pressure, and gravity (retinal weight).

Materials and Methods. These investigations adhered to the ARVO Resolution on the Use of Animals in Research. Dutch rabbits weighing 1.2-1.8 kg were anesthetized with urethane (1.0/kg, IP) after sedation with acepromazine maleate (1 mg/kg, IM). Ketamine hydrochloride (20 mg/kg, IM) was added if necessary. The pupils were dilated with 10% phenylephrine, 1% cyclopentolate and 1% atropine. Small non-rhegmatogenous retinal detachments (blebs) were made by injecting Hanks' balanced salt solution or autologous serum into the subretinal space through a glass micropipette, advanced through a
In some experiments the RPE was damaged selectively by injecting sodium iodate (40 mg/kg IV) 2–4 hr before bleb formation. Electrophysiological recordings confirmed that RPE was destroyed while retinal function remained intact. Argon laser lesions were made in clusters of 15–20 using 200–300 μm spots of 0.05 sec duration, and 100–150 mW intensity. Liquification of the vitreous was achieved by injecting 30 units of hyaluronidase (Wydase, Wyeth Laboratories, Philadelphia, PA) in 0.2 ml Hanks’ solution into the vitreous cavity at least 4 hr before bleb formation. The injection was made as close to the retinal surface as possible, while stirring the posterior vitreous with the needle. To study the effects of retinal weight, blebs were made in both eyes at the same time but the animal was kept on its side so that one bleb always faced down and the other up (except during brief periods of observation).

**Results.** Figure 1 compares the resorption times of blebs made with Hanks’ solution and autologous serum at three different IOPs. Resorption times are somewhat larger for serum than for a balanced salt solution (Hanks’), but with either material the times decrease progressively with increasing IOP. The Hanks’ blebs were, on average, slightly larger than the serum blebs, and since bleb size affects the resorption time, Figure 1 also shows (dashed lines) resorption times for Hanks’ blebs that have been normalized with respect to the size of the serum blebs.

Figure 2 shows the effects of IOP on fluid resorption after damaging the RPE barrier. Hanks’ blebs were studied after diffuse injury to the RPE with systemic sodium iodate; serum blebs were studied by making detachments over clusters of fresh argon laser burns. Note that both Hanks’ and serum resorption times were more sensitive to IOP over damaged RPE than over intact RPE (Table 1).
Experiments were also performed to judge the effects of vitreous pressure and gravity (retinal weight) on subretinal fluid resorption. To eliminate pressure on blebs from the vitreous gel, the vitreous was liquefied with hyaluronidase before blebs were formed (using care to avoid collapse of the eye from loss of fluid through the scleral slit). The average resorption time after vitreous liquefaction for blebs with 3.0–3.25 mm diameter was 212 ± 38 min (n = 22), which did not differ significantly from controls. These same animals were used to judge the influence of retinal weight by comparing the resorption times in one eye kept facing upwards with those in the fellow eyes that faced downwards during resorption. The average resorption times of the blebs with 3.0–3.25 mm diameter were 197 ± 39 min (n = 8) for upward-facing blebs, and 206 ± 35 min (n = 7) for downward-facing blebs. These values do not differ significantly.

Discussion. We have shown previously that at least 70% of fluid removal over intact RPE is metabolically driven and that osmotic pressure from the choroid helps clear the remainder. The present results suggest that some of the remaining fluid is also driven out by hydrostatic pressure. With either Hanks’ solution or serum in the subretinal space, and with either an intact or damaged RPE blood-retinal barrier, lowering the IOP increased the absorption time and raising the IOP decreased it. The relative effects of IOP (percentage change per mmHg) were much greater when the barrier was damaged than when it was intact, since the active transport systems were short-circuited. The very rapid absorption of Hanks’ solution over iodate-damaged RPE results, presumably, from the osmotic pressure in the choroid.

These results are not surprising, insofar as IOP acts physically to drive fluid through the retina, into the choroid and possibly across the sclera. This driving force is generated by the overall pressure gradient between vitreous and the exterior of the globe. To the extent that there is any fluid flow in response to IOP, the flow resistance of the retina will serve to move it against the eye wall and help push out any fluid trapped in the subretinal space. The question of clinical importance, however, is not whether IOP can affect subretinal fluid absorption but whether the effect is large enough to alter absorption under clinically-encountered pathologic conditions.

Our data show that, over an intact RPE, relatively large fluctuations of IOP (eg 0–16 mmHg or 16–38 mmHg) caused only a modest change in the absorption rate. Thus, IOP and retinal flow resistance apparently make only a limited contribution to retinal-RPE apposition, and minor (or “normal”) IOP fluctuations are unlikely to alter the status of clinical detachments, whether rhegmatogenous or non-rhegmatogenous. However, severe hypotension might compromise repair, and glaucomatous pressure might have some beneficial effect on retinal separation (if not the optic nerve).

Vitreous structure could influence subretinal resorption through direct pressure of the gel on the retina, or by adding to the flow resistance of fluid moving across the retina. Foulds postulated a number of years ago that vitreous gel may also tamponade retinal holes, preventing free access of liquid vitreous. We found that liquefaction of the vitreous with hyaluronidase had no significant effect on fluid resorption (although it is possible that some cortical gel persisted). Our negative finding does not, of course, rule out other roles for the vitreous in forming or sustaining clinical or experimental retinal detachments. For example, vitreous strands adherent to retina can produce tears, and vitreous liquefaction has proven necessary to sustain an experimental detachment.

Finally, our data confirm that retinal weight is insignificant relative to other factors that serve to control the accumulation or absorption of subretinal fluid. Gravity has obvious effect on free retinal flaps in eyes with giant tears, and on the movement of subretinal fluid under large detachments, but it apparently does not influence fluid transport across the RPE to any significant degree.

Key words: retinal pigment epithelium, subretinal fluid, intracellular pressure, ionic fluid transport

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References

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<thead>
<tr>
<th>Table 1. Ratio of bleb resorption times: at 0 mmHg</th>
<th>Over normal RPE</th>
<th>Over damaged RPE</th>
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<tbody>
<tr>
<td>Blebs filled with:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hanks’ solution</td>
<td>1.39</td>
<td>3.27</td>
</tr>
<tr>
<td>Serum</td>
<td>1.21</td>
<td>1.49</td>
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Effect of RPE damage on the ratio of bleb absorption times at low versus high IOP.