shadowing of scleral tissue and of overlapping and inverted images. Anyhow, iOCT was the best option to obtain a high resolution for imaging superficial areas. Instead iUBM was useful in detecting deeper structures, giving sharper images to measure morphological changes of AC structures. However, the image acquisition required interrupting surgery and the contact of the probe with the eye.

Intraoperative real-time image-guided surgery represents the future even if it still requires further efforts to make the instrumentation functional and simple to use.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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Comment on: Pressure and velocity in intraocular and subarachnoid space fluid chambers: an inseparable couple

Joshua P. Harvey [1]

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To the Editor,

I thank Killer et al. for their interesting article regarding the relationship between pressure and velocity, and its implications on aqueous humour turnover [1]. The authors use a combination of the Bernoulli and the Navier-Stokes equations to demonstrate that flow rate of a fluid is a function of both its pressure and velocity. The authors conclude that a high pressure, IOP, results in a lower aqueous velocity. They go onto hypothesise that a low aqueous velocity leads to a reduced turnover of toxic substances in the anterior chamber which likely plays an important role in the pathogenesis of glaucoma. The assumption in their conclusion is that aqueous flow remains constant. If, however, flow were to increase as a function of IOP then velocity may remain constant, or may even increase, thus breaking the inseparable coupling of pressure and velocity alluded to in the authors' title.

The Goldman equation demonstrates that in fact aqueous flow does vary with IOP:

$$C = F/(\mathrm{IOP} - \mathrm{P_e})$$

Rearranged:

$$F = C \times (\mathrm{IOP} - \mathrm{P_e})$$

where C is outflow facility, F is outflow rate and P_e is episcleral venous pressure.

Therefore, as IOP increases, so does the outflow rate. A number of experiments have demonstrated this to be true, and that aqueous flow does not remain constant as the authors have assumed (Fig. 1) [2].

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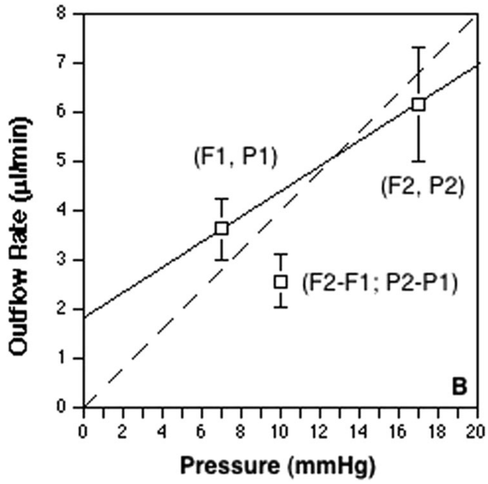

Fig. 1 Aqueous outflow as a result of changes of anterior segment pressure. Taken with permission from Tian et al. experiment on monkey organ-cultured anterior segment data. The dashed line represents a hypothesised relationship between outflow rate and pressure

Outflow facility as a function of intraocular pressure in cultured anterior segments of enucleated monkey eyes (Fig. 1). The solid line represents a secant between F1, P1 and F2, P2. This line is unlikely to be physiological at all IOPs given it has a positive y intercept. The relationship between F and P is therefore positive, but nonlinear [2].

In comparison to aqueous drainage, its production has been shown to be relatively independent of IOP fluctuations [3, 4]. However, the continuity equation dictates that once IOP stabilises, aqueous production must equal aqueous drainage.

$$A_1 v_1 = A_2 v_2$$

Where A is the cross sectional area of the fluid and v is velocity.

In the setting of increased aqueous outflow secondary to raised IOP there are only two possible responses regarding aqueous production. The first possibility is increased outflow will cause a reduction in IOP, which will then lead to the aqueous drainage returning to normal. This is well demonstrated with computational modelling and likely demonstrates a homeostatic response in normal eyes [2]. The second possibility is that despite increased aqueous drainage, IOP remains high and therefore aqueous production must rise to match drainage.

Neither of these situations support the inversely proportional relationship between pressure and velocity that Killer et al. have described. It is true that in an idealised single-fluid compartment described by the Bernoulli equation, if there is a steady state flow, a raised IOP will be accompanied by a reduction in velocity. However, it is unlikely that such a system accurately represents the physiological eye. Furthermore, experimental evidence contradicts the author's hypothesis by demonstrating that a raised IOP results in greater flow, with significant increases in outflow. It is therefore possible that the authors have erroneously attributed a change in aqueous velocity as a primary mechanism in the pathophysiology of glaucoma.

Compliance with ethical standards

Conflict of interest The author declares that he has no conflict of interest.

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