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The impact of proteinaceous solutions on the outflow facility of micro-tubes

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Abstract

Purpose : Micro-tubes are increasingly used in minimally invasive glaucoma surgery (MIGS) for better outflow control and to prevent hypotony. MIGS devices can be implanted as stand-alone procedures or in conjunction with cataract surgery. They may be exposed to high aqueous protein concentrations and blood intra-operatively and post-operatively, and may come into contact with blood from the anterior chamber, Schlemm's canal or subconjunctival space. The purpose of this study was to investigate the impact of proteinaceous solutions simulating physiological aqueous humour and serum albumin concentrations on the outflow facility of micro-tubes.

Methods : A range of 50 µm internal diameter tubes made of PEEK (360 µm outer diameter) were connected to a microfluidic set-up (Fluigent, France) for an outflow facility ranging from 0.12±0.01 µl/min/mmHg to 0.25±0.01 µl/min/mmHg. Proteinaceous solutions of Bovine serum albumin (BSA) (Sigma, Germany) with concentrations from 0.25mg/ml (aqueous) to 80mg/ml (above serum level) were injected into the micro-tubes using flow rates from 0.7 to 7 µl/min equivalent shear rates of 950–9500 s^{-1}. BSA has 80% homology with human serum albumin. All measurements were recorded at a temperature of 20°C. Statistical analysis was performed using ANOVA comparing each proteinaceous solution with control. The theoretical outflow facility based on Hagen-Poiseuille law was compared with the experimental measurements using regression analysis.

Results : There was no significant change in outflow facility with distilled water compared with physiological aqueous albumin levels (BSA concentrations: 0.25, 0.5, 1.0 mg/ml). When the BSA concentrations were increased to serum level (10, 15, 30, 40 mg/ml), the outflow facility decreased up to 15±3% for 40mg/ml. In elevated BSA concentrations (60 and 80mg/ml) found in ocular conditions such as anterior granulomatous uveitis, the outflow facility decreased by 27±3% for 80mg/ml.

Conclusions : The outflow facility was characterised at physiological aqueous flow rates and was found to be significantly reduced at elevated albumin concentrations. Such high aqueous protein content can be found intra- or post- glaucoma surgery, and ocular conditions such as chronic uveitis. These findings may have significant implications for the clinical use of devices with small lumens in these circumstances.

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