Constant perfusion for dry eyes and sockets

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SUMMARY Several techniques have been used to treat dry eye, to irrigate the eye surface, or to apply drugs in solution. The commonest method is to apply drops. But a technique is needed for giving solutions over long periods either as drops or continuously. The apparatus described here consists of a replaceable plastic tank under mechanical pressure attached to capillary tubing which is kept in contact with the inner canthus of the eye. It was found to alleviate symptoms in severe dry eye conditions not alleviated by other methods.

The treatment of dry eyes is by instillation of solutions that imitate tears. Such solutions often contain drugs, such as anti-inflammatory or anti-biotic chemicals. Systemic cholinergic drugs also have a place in the treatment of specific dry eye syndromes, but will not be discussed in the context of constant perfusion. The basic solutions used in constant perfusion are either isotonic saline or buffered saline. While viscosity agents are beneficial to the eye, the size of the capillary tubing used in this method often leads to blocking, and they are therefore best avoided or used in low concentrations.

The object is to obtain a steady flow state from the capillary tube. The friction effect of the tube walls (especially if silicone rubber is used) plus the viscosity of the fluid and the antigravity factors can be overcome by applying a head of pressure in the plastic bag.

$P - \text{viscosity} + \text{friction} + \text{antigravity} \propto \text{steady flow state}$ (see Appendix).

Furthermore, if a small outlet is used the pressure gradient within the bag can be large to obtain a steady flow state. The elasticity of the bag also provides a reservoir of pressure. Thus the need to reset the pressure frequently is avoided.

Ideally lipids should also be used, since in many dry eye conditions they are abnormal or absent. But the lipid-type solvents available are organic, and inorganic oils and gels and not miscible with water. Furthermore, they would not form a molecular surface film as with the precorneal tear film. Petroleum jelly, castor oil, or paraffin oil can be used as substitutes but are best instilled supplementary to the constant perfusion aqueous solution.

The conditions treated by the constant perfusion method are those in which drops used intermittently do not relieve symptoms and those in which, after division of symblepharon keratoplasty or conjunctival or mucous membrane grafting, the areas must be kept wet constantly for several weeks or indefinitely. Such conditions now treated by this method are Stevens-Johnson syndrome, chemical burns, rheumatoid sicca keratitis, lacrimal gland agenesis, drug sensitivity, and ocular pemphigoid. This method could be used for the treatment of acute eye disease requiring intensive drug therapy, such as glaucoma. It has also been used in the operating theatre to keep the eye irrigated throughout an operation.

Apparatus

The device consists of a plastic circular bag, which can hold 20 to 30 ml of fluid (Figs. 1-3). The bag is ring-shaped and held by 2 rigid plastic circular plates and a central screw with a thumb rotating nut for tightening. The bag leads to a Luer-lock outlet. From this is attached a capillary polyethylene tube of sufficient length to pass from the bag suspended at chest level to the inner canthus of the eye (Fig. 4). The tube is held in place by adhesive tape at the nose and ear. The end of the tube at the canthus is melted to form a round bead, and the outlet is a pinhole just behind the end. One filling of the bag can last 24 hours if the pressure is maintained by adjusting the screw knob every 2 or 3 hours (see Appendix).

Other methods tried over the past 6 years are inlet/outlet scleral lens, rotary pump with electric motor, and cylindrical tank with piston driven by solenoid principle, but the method described here is

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superior because of its simplicity and control of outflow. Spectacle attachments for the tubes are impracticable over a 24-hour period.

Associated treatments

It can be used in its simplest form to keep dry eyes wet simply for daily use. In severe cases in which a symblepharon is divided plastic rings are inserted at the time of the perfusion and changed after 6 weeks for shells or shell prostheses. Where sight is possible, contact lenses with optics of hard or soft

Fig. 1 Diagram of apparatus. (a) Plastic end plates. (b) Plastic bolt. (c) Screw with thumbscrew lead. (d) Fitting from tank to capillary tube. (e) Plastic (disposable) tank for fluid

Fig. 2 Apparatus, side view

Fig. 3 Apparatus, front view

Fig. 4 Tank with capillary tubes to inner canthus in long-standing case of Stevens-Johnson syndrome

materials are used. In these cases no tissue grafting proved necessary. The fornices reformed by epithelisation.

Management

The bags are of disposable type but can be cleaned every 24 hours by washing in chlorhexidine aqueous solution 1/10 000 and rinsed in the perfusion solution. The perfusion solution if supplied in quantities greater than 50 ml must contain preservatives and be sterile until opened. Drugs need not of high concentration, since constant perfusion can give effective dosage with lower concentrations (1/10th that used normally).

Complications

Severe dry eye cases while remaining static with regard to further symblepharon formation often progress with increased corneal oedema, vascularisation, and even perforation. Patients are relieved of the severe symptoms, but if unable to manage the device they are at risk. Thus they may inadvertently empty the tank and remain dry for several hours. They may disregard instructions and use infected solutions, with dire consequences.

Conclusion

A simple, inexpensive constant eye perfusion device has been designed for patient and surgeon's use. It is chiefly of value for long-term treatment to alleviate the symptoms of chronic dry eye syndromes, especially those induced by systemic drugs. It is also of use in reforming fornices in dry eyes preparatory to contact lens or artificial eye shell fitting.

Smith and Nephew Research provided materials for the tanks.

APPENDIX

Poiseuille's law

It is only the pressure difference between the ends of the tube that drive the fluid along. Average velocity of liquid flowing in a pipe is related to $p^1 - p^2$ (difference in pressure at ends of pipe) and the cross-section of pipe. It is inversely related to length of pipe and viscosity of the fluid.

In the system described average velocity ($p^1 - p^2$) is good. The cross-section is narrow; thus decreasing velocity and the length of pipe provide a slow outflow. The viscosity is low and counteracts this slightly, provided the material of the tube is of high wettability. In this respect silicone rubber provides greater resistance to flow than polyethylene polymers.