

## Editorial: Corneal storage

The first successful human corneal transplant performed in 1905 presented no storage problems: it was from an eye removed because of trauma. In the 1930s Filatov, realising that cooling prolonged the survival of endothelium by slowing metabolism and conserving energy, introduced short term preservation by storing eyes in the humid atmosphere of the so-called moist chamber at 4°C. This has been the traditional level, though corneas can be safely stored at lower temperatures, since the solutes in the aqueous and corneal tissue depress the freezing point of intraocular water to just below 0°C. However, a margin of safety must be allowed for variations in temperature within the refrigerator so that accidental freezing will not occur. Whole eye storage has been criticised because the endothelium is allowed to remain in contact with aqueous and its toxic waste products. It is now rarely practical because of the inevitable delay called for by HIV testing.

Cryopreservation was introduced in 1965. The excised cornea is placed in increasing concentrations of dimethyl sulphoxide (plus albumin and dextrose) before being frozen, and is stored at -197°C. The process of freezing and thawing requires a trained technician and so is expensive and complicated, while there have been an unacceptable number of primary graft failures.

A significant advance was made in 1976 when McCarey and Kaufman introduced a storage medium, eponymously labelled MK. This, in common with other media, is based on TC 199 tissue culture, with the addition of dextran or other oncotic agents which limit the degree of tissue swelling during storage. It allowed the use of corneas for up to four days after removal.

In 1984 Kaufman modified this medium by substituting chondroitin sulphate, a natural polymer, for dextran (the Japanese had used it 20 years earlier). This 'new' medium, K Sol, extended the use of donor corneas to six days after enucleation. Unfortunately the manufacturers have now withdrawn it from general use because some samples were found to be contaminated by infectious organisms. Similar media are undergoing clinical trial at the moment, notably one produced by Chiron, to which epidermoid growth

factor has been added (in experimental conditions it can cause mitotic figures in endothelial cells).

Doughtman in 1976 reported satisfactory results using cornea stored in organ culture at 37°C. The corneas can be safely used for up to 30 days. The technique has been modified and used extensively in Holland and, of late, in Britain. This extended storage helps in providing tissue matched material for patients who are at high risk of rejection.

In this issue of the *BJO* there is an important contribution to intermediate term storage by Taylor and Hunt from the MRC Laboratories in Cambridge. They point out that tissue culture media which maintain cell viability at physiological temperatures for short periods are not suitable for preservation at reduced temperatures. It is not necessary to support metabolism at reduced temperatures, as control of ion and water distribution between intra- and extracellular compartments is best achieved by solutions such as CPTES. The most important constituent of this solution is a pH buffer, 'TES', which maintains ion and water distribution by physical rather than metabolic means. Taylor and Hunt studied stromal thickness, endothelial integrity, and ultrastructure of rabbit corneas, and compared CPTES with Ringer's solution to which glutathione and bicarbonate had been added (we would have been more interested in MK for comparison). Corneas stored in CPTES were significantly thinner than in Ringer's - plus solution (GBR) and endothelium and ultrastructural studies were satisfactory. A minor observation (possibly for clinical use later) is that corneas stored in CPTES are slower in the 'temperature reverse response' by 80 minutes. The buffer TES is remarkably safe and has been used in washout solutions in kidney transplantations.

It is to be hoped that Taylor and Hunt will continue their studies, perhaps on the cat model. The rabbit cornea is not ideal, since the endothelium can regenerate, and indeed the rabbit can preserve a transparent cornea from which the endothelium has been removed. If they can elaborate on their studies, this apparently safe substance could well be introduced into clinical practice.

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