Cadaver Kidney Storage for Human Allotransplantation

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The potential value of kidney storage when cadaveric donors are used has been recognised for many years. And now that we believe that histocompatibility is a prerequisite and that a large pool of 200 or more prospective recipients is required, and that this frequently requires transporting the organs considerable distances to the different and scattered transplantation centres with the matched recipients, effective storage is essential. Several different techniques have been used to store canine kidneys but they are not necessarily suitable and applicable to the human, especially when they involve complicated procedures. We believe that a simple rather than a complicated technique is to be preferred and present the results we have obtained at the Hammersmith hospital since 1965.

Our transplantation programme began in 1961 since when we have carried out just over 100 transplants, of which 65 have been from cadaveric donors. Our first cadaver kidney transplant was done in 1963 but regular use of cadaveric donor kidneys did not take place until 1965.

METHOD

As soon as a kidney is removed from a cadaver it is irrigated with 500 ml of Hartmann's solution containing 0.5 g of procaine hydrochloride in normal saline, 5000 international units of Heparin, 100 mg hydrocortisone, 1000 mg glucose and 5.5 ml of 4.3% sodium bicarbonate. The pH of the solution is 7.4, the temperature 38°C and the osmolality 290 mOs/kg. When the venous effluent is cleared of blood a further 500 ml of the same solution at 4°C is used. The cold kidney is then put into a sterile plastic bag containing approximately 50 ml of the cold irrigating solution, the neck of the bag is tied off and the bag containing the kidney is put into an identical sterile bag and placed in a thermos flask containing ice where it remains until the vascular anastomoses are started. The kidneys provided by the London pool were preserved in a similar manner but the solution was based on

Rheomacrodex as described by Brunius et al (1968).

RESULTS

Before giving an account of our results it is necessary to define our ischaemic times. Warm ischaemic time includes the time between the death of the donor and the time the kidney is cooled, together with the time taken for the vascular anastomosis. Cold ischaemic time is the time between the end of the cold irrigation of the kidney and the time the kidney is removed from the cold flask for transplantation.

In 55 of the 65 patients it was possible to compare the onset of effective renal function (in days) with the duration of warm ischaemia in minutes (Figure 1). We have chosen to define the onset of effective renal function

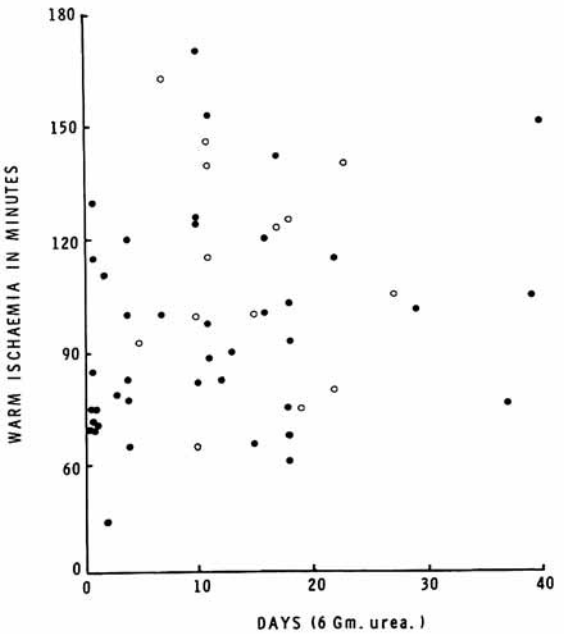

Figure 1. Correlation between warm ischaemic time in mins and onset of effective renal function (excretion of 6 g urea/day) in days

when the transplanted kidney first excretes 6 g of urea. The kidneys preserved with the Hammersmith solution are presented by dots. The others had been preserved with the Rheomacrodex based solution. There is no correlation; for example between day 10 and 12 14 kidneys functioned in which the warm ischaemic times had ranged from 65 to 170 mins.

In 49 of the 65 patients it was possible to compare the glomerular filtration

rates (determined by 24 hour endogenous creatinine clearance) of their kidneys at 3 months with the duration of warm ischaemia (Figure 2). There is no correlation; for example between 80 and 90 mins warm ischaemia there were 11 kidneys with the glomerular filtration rates ranging from 10 to 100 ml/min.

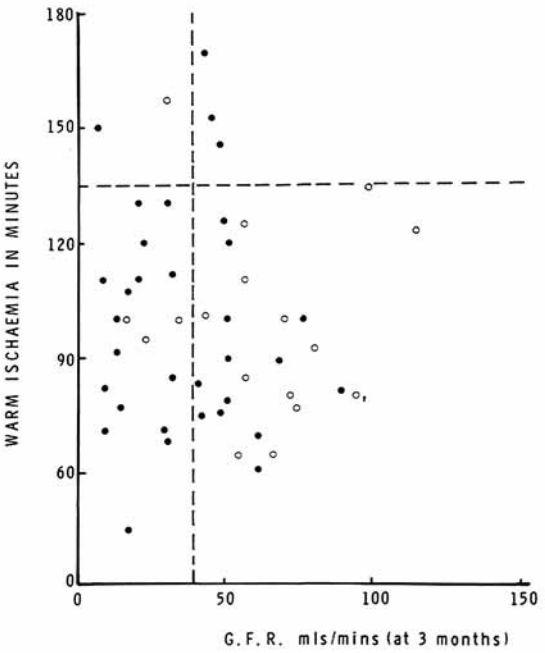

Figure 2. Correlation between warm ischaemic time in mins and the glomerular filtration rate in ml/min at 3 months

In 58 of the 65 patients it was possible to compare the onset of effective renal function (in days) with the duration of cold ischaemia in hours, (Figure 3). There is no correlation; for example between day 10 and 12 13 kidneys functioned in which the cold ischaemic times ranged from one to 14 hours.

In 42 of the 65 patients it was possible to compare the glomerular filtration rates of their kidneys in ml/min with the duration of cold ischaemic times in hours (Figure 4). There is no correlation; for example between 5 and 7 hours of cold ischaemic time the glomerular filtration rates ranged from 15 to 120 ml/min. We do not know the limit of cold ischaemia tolerated by a preserved kidney but we have successfully transplanted a kidney after 14 hours cold ischaemia.

No significant difference was observed when the kidneys were irrigated

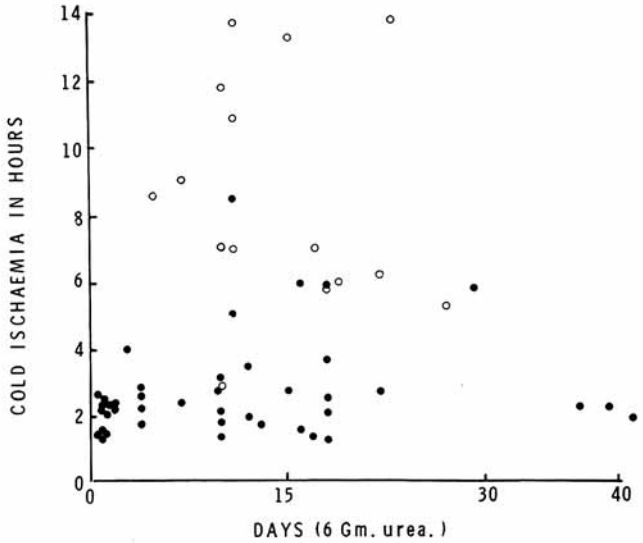

Figure 3. Correlation between the cold ischaemic time in hours and onset of effective renal function (excretion of 6 g urea/day) in days

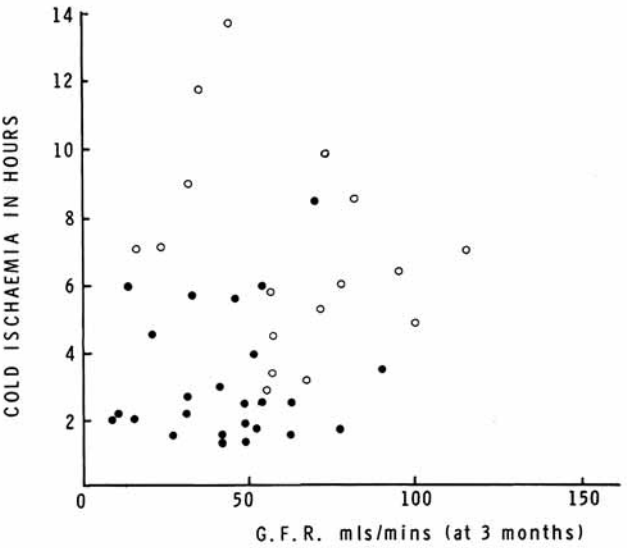

Figure 4. Correlation between the cold ischaemic time in hours and the glomerular filtration rate in ml/min at 3 months

with the Hammersmith or the Rheomacrodex based solution and the longest total ischaemic times of successful transplants (16 and 12 hours) were obtained with kidneys irrigated respectively with Rheomacrodex based solution and the Hammersmith solution.

DISCUSSION

Short ischaemic time gave the best results but there was a wide range between the onset of effective renal function and the warm ischaemic times. The variation no doubt reflected the ante-mortem circulatory state of the donors. There was no apparent difference between the results obtained after using either the Hammersmith or the Rheomacrodex based solution. We believe that cadaver kidneys should not be used when the warm ischaemic time exceeds 130 min.

A kidney can either be irrigated, as we have done, or continually perfused. Using the Hammersmith solution with a pump to deliver a perfusion of 15 ml/min and providing 0.6 ml/min of Oxygen, autotransplanted dog kidneys were severely damaged after storage at $4^{\circ}C$ for 18 hours. In contrast, dog kidneys irrigated with this solution (not oxygenated), although damaged, did function. The claims made by Collins et al (1969) from studies in dogs seem encouraging but our results so far have not confirmed their work. As a result of our clinical and laboratory experience, we prefer simple irrigation for cadaver kidney storage in the human, and use the cheaper modified Hartmann's solution rather than the Rheomacrodex based solution.

REFERENCES

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