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Effective surface cooling of the kidney during vascular anastomosis decreases the risk of delayed kidney function after transplantation

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Abstract The aim of the prospective study was to assess the exact kidney temperature and the effect of surface cooling of the kidney during the time of vascular anastomosis. Twenty-two renal graft recipients were incorporated into our study. We used an electronic temperature measurer provided with a needle-shaped probe pierced into the body of the kidney. The temperature was recorded every 5 min. The mean temperature of the kidney at the beginning of anastomosis (T_0) was 8.87 ± 3.97 °C and 17.95 ± 5.1 °C at the end (T_{end}). The striking finding of this study was that the mean T_{end} delayed kidney function-negative in [ATN(−)] recipients was significantly lower than in the ATN(+) group; respectively, 14.86 ± 3.6 °C and 19.71 ± 5.07 °C. Therefore, we have divided all recipients according to T_{end} (< 15 °C and > 15 °C) in an attempt to assess the direct influence of kidney temperature on early graft function. In nine cases, a temperature below 15 °C was recorded and in 13 cases it exceeded 15 °C at the end of anastomosis. The mean cold ischemia time and anastomosis time were not different in these recipients. Delayed graft function occurred in 14 recipients; in 3 of 9 (33.3 %) recipients from group T_{end} < 15 °C; and in 11 of 13 (85 %) from group T_{end} > 15 °C. One case of primary non-function was observed (T_{end} > 15 °C). This study documents the value of effective cooling of the kidney during the time of vascular anastomosis. Since in most clinical reports the significance of the second warm ischemia was assessed only by the duration of the anastomosis, without measurement of the actual organ temperature, this may explain the different findings in our studies.

Key words Kidneys transplantation · Cooling technique

Introduction

Delayed kidney function after cadaveric kidney transplantation still remains an important problem complicating postoperative patients' management. Among the many factors which may contribute to the development of ischemic kidney damage, the most important can be attributed to profound metabolic, hormonal, and most of all, hemodynamic changes appearing during the preagonal period and to the warm ischemia [1, 3, 4]. This is especially true in countries where, despite legal regulations concerning brain death and exact definitions of its criteria, organ procurement takes place at a time when hemodynamic changes are quite advanced. Duration of cold storage (over 36 h) also contributes to ischemic organ damage [2]. The exact role of so-called second warm ischemia has been unclear. It has been often stated that if the duration of the vascular anastomosis procedure exceeds 40–45 min this may become an additional contributory factor to the development of ATN [4]. However, in a number of clinical studies, statistical analyses have not shown the significance of the second warm ischemia

(WIT2). The purpose of this clinical study was to assess the exact kidney temperature during the vascular anastomosis and to evaluate whether it has any influence on the development of delayed kidney function (ATN).

Patients and methods

Cadaver kidneys were harvested from 14 donors (female : male ratio 2:12) of mean age 33.1 ± 11.6 years. Hypotension (blood pressure < 80 mm Hg) was observed in 7 of 14. The mean dose of dopamine administered to the donor in the last hour was 11.1 ± 7.6 μg/kg per min. During the last hour, urine output > 50 ml was observed in 10 of 14 donors. The mean serum creatinine concentration at the time of harvesting was 1.74 ± 0.84 mg/dl. The kidneys were retrieved en bloc, with the standard in situ perfusion (EC/Ringer) and backtable UW/EC (10/12) flushing. The mean time of cold preservation was 31.6 ± 6.9 h.

Cooling technique

During vascular anastomosis, all kidneys were placed inside the holding net, facilitating intraoperative maneuvers, with attached infusions set. Cold drip infusion (4 °C normal saline solution) was applied on the kidney surface during anastomosis. The time of vascular anastomosis lasted from 23 min to 65 min (mean 33.6 ± 9.2 min).

Temperature measurement

The kidney temperature was measured using an electronic measurer provided with a needle-shaped probe pierced (1-cm-deep) into the kidney cortex. The temperature was recorded every 5 min starting at the beginning of vascular anastomosis (kidney "out of ice", T_0) till the end of the anastomosis (end temperature, T_{end}).

The kidneys were transplanted to 22 recipients of mean age 38.5 ± 9.5 years. Six kidneys were transplanted out of our center. The maximum plasma renin activity (PRA) level (mean) in the reviewed group of recipients was 28.4 ± 29.3 %. Mean human leukocyte antigen (HLA) mismatches were 3.32 ± 0.95.

Results

The mean T_0 was 8.87 ± 3.97 °C. At the end of anastomosis, the T_{end} of the kidney was 18.95 ± 5.1 °C (range from 7.7 °C to 30 °C). The 1-min-temperature rise calculated for the whole group was 0.28 ± 0.14 °C. In 8 of the 22 kidney recipients (36.4 %), the graft functioned well immediately after transplantation. Delayed graft function was observed in 13 patients (59 %). One patient treated with dialysis for ATN developed acute rejection resistant to steroids and lost the graft 56 days after transplantation.

The T_0 of the kidney in the ATN(−) and ATN(+) recipients was similar, 7.74 ± 4.11 °C and 9.52 ± 3.88 °C, respectively (not significant). The T_{end} in the ATN(−) patients was 14.86 ± 3.6 °C and was significantly ($P < 0.03$) lower than in ATN(+) recipients (19.71 ± 5.07 °C). The 1-min-temperature rises in the ATN(+) group was 0.29 ± 0.12 °C and 0.26 ± 0.19 °C in the ATN(−) group.

Since the mean kidney T_{end} in ATN(−) recipients was 14.9 °C, an analysis of the results was performed in the two groups divided according to $T_{end} < 15$ °C or > 15 °C. In nine cases, T_{end} was lower than 15 °C whereas in the remaining 13 cases it was above 15 °C.

The presence of hypotension in the donor, the mean dose of administered dopamine, the cold ischemia time, and the anastomosis time were no different in the two groups. Delayed graft function was observed in 3 of 9 recipients from the $T_{end} < 15$ °C group and 11 of 13 from the $T_{end} > 15$ °C group ($P < 0.03$).

Discussion

As shown in our studies, the kidney temperature at the beginning of anastomosis (T_0) ranged from 7.74 °C [ATN(−)] to 9.52 °C [ATN(+)]. The mean temperature of the organ at the end (T_{end}) of anastomosis was 14.9 °C, being statistically different in ATN(−) and ATN(+) kidneys (14.86 °C versus 19.71 °C, $P < 0.03$).

The analysis of various factors which may have been responsible for the development of ATN during the postoperative period showed that this complication occurred significantly less often in recipients of kidneys with $T_{end} < 15$ °C than in those with $T_{end} > 15$ °C. This documents the value of effective cooling of the kidney during the time of vascular anastomosis. Since in most clinical reports the significance of the second warm ischemia was assessed only by the duration of the anastomosis without measurement of the actual temperature of the organ, this may explain the different findings in our studies [3, 4].

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