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Original article

Renal transplantation in children with emphasis on young patients

J. Laine[1], C. Holmberg[1], K. Salmela[2], H. Jalanko[1], H. Sairanen[1], K. Peltola[1], K. Rönnholm[1], B. Eklund[2], S. Wikström[1], and M. Leijala[1]

[1] I and II Departments of Paediatrics and [2] IV Department of Surgery, University of Helsinki, Helsinki, Finland

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Abstract. We report the results of 41 consecutive renal transplantations performed on 39 children (median age 2.7 years). Twenty-six recipients were less than 5 years old. Twenty-one recipients (13 under the age of 5 years) received cadaver (CAD) grafts. All grafts except 2 were from adult donors and were placed extraperitoneally. Patients were on triple immunosuppression (cyclosporine plus azathioprine plus methylprednisolone). Mean follow-up time was 2.3 years. No vascular and only one ureteral complication was seen. Acute tubular necrosis occurred in 3 patients (7.3%). No grafts were lost due to acute rejection. Three-year patient survival and 1-year graft survival were 100%. The overall 3-year actuarial graft survival was 86%. Three-year survival of grafts from living-related donors (LRD) was 92% and that of CAD grafts 75%. In recipients younger than 5 years, 3-year LRD graft survival was 89% and CAD graft survival 73%. No significant differences in graft survival between recipients of different age groups or between LRD and CAD grafts were found. We conclude that results of renal transplantation in children under 5 years of age are comparable to those of older children, even using CAD grafts, when adult donors and triple immunosuppression are used.

Key words: Renal transplantation – Cadaver donor – Cyclosporine

Introduction

During the last decade renal transplantation has become routine treatment for end-stage renal disease in childhood. Both patient and graft survival have improved so that short-term patient survival of 100% and 1-year graft survival of over 90% have been reported [1, 2]. Major factors have been progress in organ procurement and storage, refinement of surgical techniques and new and more potent immunosuppressive drugs.

The results of renal transplantation in children less than 2–5 years of age have been less impressive than in older patients, especially with grafts from cadaver (CAD) donors. One-year graft survivals of only 38%–57% have been recently reported [3–5]. Because a high proportion of paediatric renal transplant patients in Finland are very young and CAD grafts are commonly used, we report our experience with 41 consecutive renal transplantations performed on 39 children between 1987 and 1992.

Methods

Matching. ABO compatibility and a negative T-cell crossmatch were prerequisites for transplantation. Graft matching was aimed at accepting only grafts with a maximum of three mismatches of which a maximum of one was in each HLA-A, -B and -DR loci. Haploidentity was required of living-related donors (LRD). LRD grafts were all from either parent. Three donor-specific transfusions (DST) (3 ml/kg whole blood each) were given under azathioprine (1 mg/kg per day) protection at 2-week intervals to recipients of LRD grafts. Transplantation was performed within 2 weeks of the last transfusion. LRD graft recipients who had received multiple transfusions in early infancy because of anaemia were not given DST in order to avoid further antigen exposure. CAD graft recipients received three random transfusions. All except 2 CAD grafts were from adult donors. The young donors were aged 4.9 and 15.0 years, respectively. All children with congenital nephrosis of the Finnish type (CNF) were bilaterally nephrectomized when they had reached the weight of 8–9 kg. Other pre-transplant treatment of CNF patients has been previously reported [6, 7]. All patients were at least 3 months on peritoneal dialysis before transplantation (mean duration of dialysis 0.9 years, range 0.2–3.0 years). Nine patients were on continuous ambulatory and 32 on continuous cycling peritoneal dialysis. Only children with a weight of over 9 kg and without major developmental defects were accepted for transplantation.

Anaesthesia. Ceftriaxone 50 mg/kg i. v. was given for antibiotic prophylaxis. Anaesthesia was induced with fentanyl, thiopentone and pancuronium or vecuronium and maintained with an air/oxygen mixture and

Correspondence to: J. Laine, Children's Hospital, University of Helsinki, Stenbäckinkatu 11, SF-00 290, Helsinki, Finland

Table 1. Diagnosis and age (years) of 39 renal transplant patients transplanted between 1987 and 1992

	Age at transplant <5 years	Age at transplant >5 years	All patients
Diagnosis			
Congenital nephrosis of Finnish type	23	0	23
Obstructive uropathy	1	5	6
Glomerulonephritis	0	3	3
Polycystic kidney disease	1	1	2
Congenital nephrosis	0	1	1
Congenital nephritis	1	0	1
Hypoplastic kidneys	0	1	1
Renal cortical necrosis	0	1	1
Nephronophthisis	0	1	1
Total	26	13	39
Mean age at transplantation (years) (range)	2.4 (1.2–4.3)	11.6 (5.0–17.6)	5.8

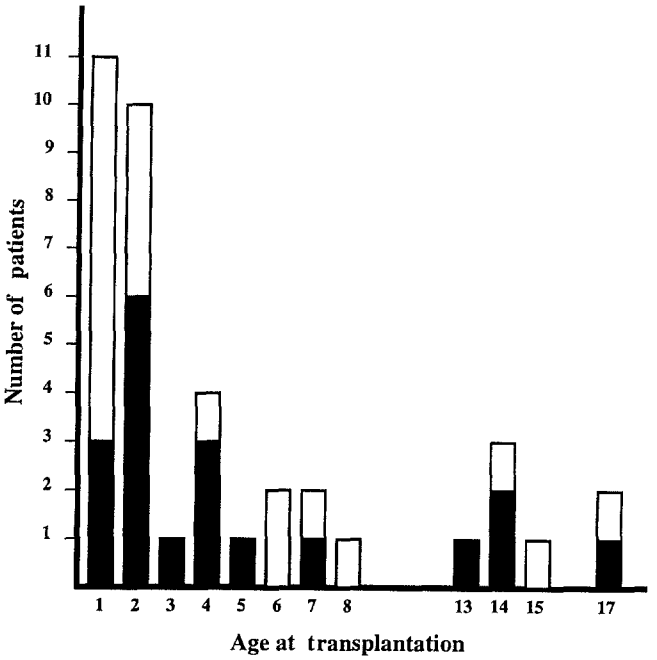

Fig. 1. Age (years) of 39 recipients at first transplantation grouped by graft origin. □, Living-related donor grafts; ■, cadaver grafts

isoflurane or halothane. The radial artery and the jugular vein were cannulated for pressure measurements. Central and peripheral temperatures, end-tidal carbon dioxide and oxygen saturation were monitored and electrocardiography was performed. Dopamine (3 μg/kg per min) and nitroglycerine (0.5–1 μg/kg per min) were started to ensure myocardial support and optimal pre-load in dialysed patients. For volume correction, 4% albumin or irradiated and filtered red blood cells [to avoid graft versus host reactions and cytomegalovirus (CMV) contamination] were administered to keep the haemoglobin concentration at 70–80 g/l; 0.45% saline was used as maintenance fluid.

Surgical technique. Transplantation was facilitated with a curvilinear incision in the lower quadrant and the graft was placed extraperitoneally into either iliac fossa – in small children invariably to the right. The patients were heparinized (1 mg/kg) before vessel clamping for the duration of the operation. Iliac arteries and veins (abdominal aorta and inferior caval vein in small children) were used for anastomosis; 2.5–3.5× magnification was used to perform the anastomosis in small children. Papaverine was injected locally around the newly anastomosed vessels to relieve vasoconstriction. Urinary tract continuity was restored with an open ureteroneocystostomy. After anastomoses, 150–225 mg/kg mannitol was infused. The bladder was drained with a suprapubic catheter.

In the intensive care unit, 40% of the normal maintenance fluid volume was given and urine output replaced 1:1 with 0.45% saline. Oliguria was treated with frusemide boluses (0.5–1 mg/kg). Hypertension was treated with nifedipine, labetalol or hydralazine if necessary. The suprapubic catheter was removed on the 5th post-operative day and the peritoneal dialysis catheter at the end of the 1st week.

Immunosuppression. Cyclosporine (CyA) was started pre-operatively with an individual pharmacokinetically determined dose aiming at a trough blood concentration of 300 μg/l (specific monoclonal radioimmunoassay, Sandimmun kit, Sandoz) at transplantation [8]. Methylprednisolone (MP) (100 mg i. v. in three doses) and azathioprine (1.4 mg/kg i. v. in two doses) were given intra-operatively. Post-operative immunosuppression included: (1) MP 1 mg/kg per day, which was tapered down to 0.25 mg/kg per day at 3 weeks and 0.37 mg/kg every other day (a 25% reduction of the previous daily dose) after 3 months; (2) azathioprine 2 mg/kg per day, which was reduced to 1 mg/kg per day after 2 weeks and increased to 1.4 mg/kg per day after 3 months (when the steroid dose was reduced); (3) CyA, which was kept at a trough blood concentration of 300 μg/l immediately after transplantation and between 50 and 100 μg/l after 6 months. CyA was given in three daily doses to preschool children because of their faster CyA metabolism [9].

Anti-CMV immunoglobulin (Cytotect, Biotest) was given i. v. every 2–4 weeks for 4 months to all patients with a CMV-positive donor. CMV infection was diagnosed if the patient had clinical symptoms and a positive blood culture for CMV [10]. Trimethoprim/sulphamethoxazole prophylaxis for *Pneumocystis carinii* was given 3 days a week for 1 year [11].

Rejection. Acute rejection was defined as fever, an increase in serum creatinine concentration and a blast cell reaction in a fine-needle aspiration biopsy (FNAB) [12]. Core needle biopsies were not used for initial diagnosis. In each patient a FNAB was routinely taken 5 days after transplantation and at least twice a week until the patient was discharged from hospital. In addition, a FNAB was immediately taken if acute rejection was suspected on clinical grounds. Acute rejection episodes were treated with 1.5 mg/kg MP p. o. followed by 3 mg/kg per day of MP divided into four doses p. o. for 5 days or until the blast cell reaction in FNAB subsided. If no response was seen in 5 days, a renal core biopsy was performed and anti-thymocyte globulin (ATG, Fresenius, 3 mg/kg per day) used if acute rejection persisted.

Creatinine clearance (C_{Cr}) was estimated according to the method of Schwartz et al. [13]. Graft survivals were evaluated by standard life-table analysis with all patients included [14]. Student's *t*-test, analysis of variance and Pearson's correlation coefficient with Bartlett chi-squared test were used for statistical analysis.

Results

Patients

The most common diagnosis was CNF, seen in 23 patients (59%) (Table 1). Median age at the first transplantation was 2.7 years (range 1.2–17.6 years). Eleven patients were less than 2 years, 15 2–5 years and 13 more than 5 years old at transplantation. (Table 1, Fig. 1). Significantly more males ($n = 27$) than females ($n = 12$) were transplanted.

Table 2. Characteristics of 41 renal transplant recipients grouped by age and donor source[a]

	LRD		CAD	
	Age at transplant <5 years (n = 13)	Age at transplant >5 years (n = 7)	Age at transplant <5 years (n = 13)	Age at transplant >5 years (n = 8)
1-year graft survival	100%	100%	100%	100%
Acute rejection episodes (per patient)	**0.54** ±0.22*	**0.57** ±0.30	**1.54** ±0.27*	**0.88** ±0.30
Septic infections (n)	5	1	6	3
CMV infections (n)	2	0	1	0
C_{Cr} at discharge (ml/min per 1.73 m^2)	**80.5** ±6.7*	**78.3** ±5.5	**59.7** ±3.2*	**62.3** ±6.2
C_{Cr} 6 months after transplant	**70.1** ±4.7	**66.3** ±4.8	**63.1** ±4.3	**63.2** ±6.0
C_{Cr} 12 months after transplant	**71.1** ±4.7	**69.0** ±9.2	**66.9** ±4.1	**68.7** ±5.4

LRD, Living-related donor; CAD, cadaver donor; CMV, cytomegalovirus; C_{Cr}, creatinine clearance estimated by the formula of Schwartz et al. [13]

* P <0.01

[a] Values are mean ± SEM unless otherwise shown

The patient's mean follow-up time after transplantation was 2.3 years (range 0.1–5.0 years). At transplantation, the mean standard deviation score (SDS) for height was –2.2 and weight relative to height +0.8% of the normal mean for Finnish children [15]. At the last assessment mean height had increased to –1.6 SDS and weight to +6.0%.

Two patients had two transplantations each during the study. In addition, 3 patients who had had their first grafts prior to the study were re-transplanted. Their first grafts had functioned 16–106 months.

Donors, matching and surgical data

There were 21 (51%) CAD grafts and 20 (49%) LRD grafts. CAD donors were slightly younger than LRD donors (mean age 27.7 and 34.0 years, respectively). Thirteen patients who received CAD grafts were less than 5 years and 3 of these less than 2 years old. Among patients receiving LRD grafts, 13 were under the age of 5 years and 8 under 2 years (Table 2).

Thirteen patients had one mismatch, 14 two and 13 three mismatches in HLA-A, -B and -DR loci combined. One CAD graft recipient had no mismatches. There were no major differences in matching between CAD or LRD transplantation or between different age groups. DST were given to 11 (55%) of the LRD graft recipients. The other patients had received at least three random transfusions.

Mean cold ischaemia time for CAD grafts was 25.1 h (range 19–39 h). Mean blood loss during surgery was 137 ml (50–400 ml). Signs of graft function (onset of diuresis and decrease in serum creatinine concentration) were observed after a mean of 3 h (range 1–15 h) in LRD and 7 (range 1–50 h, 1 recipient with first urine observed on the 12th post-operative day omitted) in CAD grafts. Three patients (7.3%) with acute tubular necrosis were post-operatively dialysed for 1, 12 and 13 days, respectively. In 1 of them onset of diuresis occurred on the day of transplantation but oliguria developed 2 days later. Surgical complications were necrosis of the distal ureter in a patient aged 1.8 years and wound infection in 2 patients both younger than 5 years at transplantation.

Immunosuppression and anti-hypertensive therapy

Triple immunosuppression was given to 34 recipients (83%) throughout the study. Seven patients had azathioprine discontinued due to infection or leucopenia for a mean time of 13 months (range 4–21 months). In 5 patients the drug was reinstituted. MP was administered daily during the azathioprine-free interval. In 1 patient CyA was started at 3 months. All patients except 1 were on triple therapy for the greater part of the study. He was on CyA/MP combination from 6 months onwards.

Mean CyA concentrations and doses and the doses of azathioprine and MP during follow-up are presented in Table 3. No problems in drug monitoring were encountered during *Pneumocystis carinii* prophylaxis. No major differences were observed in recipients of grafts of different origin. However, patients less than 5 years old at transplantation had a significantly higher CyA and MP dosage on discharge than those over 5 years (23.3 vs. 13.1 and 0.37 vs. 0.26 mg/kg per day, P <0.05 and P <0.01, respectively). This difference persisted at 3 months but had disappeared 6 months after transplantation.

Anti-hypertensive therapy was given to 72% of the patients on discharge. One to three years after transplantation only 32%–41% were on it. The most common drugs used were nifedipine and hydralazine.

Infections

Verified septic infections developed in 12 patients. In 5 patients the infection occurred during heavy immunosuppression before discharge. Four had peritonitis (1 patient during dialysis), 2 pneumonia (1 was concurrent with a peritonitis) and 1 pyelonephritis. Later infections were 3 cases of pneumonia and 4 cases of pyelonephritis. All infections were successfully treated with i.v. antibiotics.

Table 3. C_{Cr} as estimated by the method of Schwartz et al. [13], serum creatinine concentration and immunosuppression in 41 renal transplant recipients[a]

	Time after transplantation					
	On discharge ($n = 41$)	0.5 years ($n = 37$)	1 year ($n = 32$)	1.5 years ($n = 25$)	2 years ($n = 21$)	3 years ($n = 14$)
Serum creatinine (μmol/l)	**75.2** ± 27.8	**80.3** ±28.9	**83.8** ±39.5	**88.5** ±53.1	**79.4** ±28.9	**82.1** ±44.3
C_{Cr} (ml/min per 1.73 m^2)	**70.2** ± 19.7	**66.3** ±14.6	**69.5** ±13.8	**70.4** ±15.0	**71.5** ±17.1	**77.6** ±18.6
Blood CyA (μg/l)[b]	**278** ±104	**131** ±56	**106** ±44	**111** ±53	**75** ±41	**64** ±26
CyA (mg/kg per day)[b]	**20.8** ± 13.4	**14.6** ± 9.7	**9.2** ± 4.0	**7.6** ± 3.3	**6.9** ±4.6	**6.3** ±3.3
Aza (mg/kg per day)[b]	**1.2** ± 0.3	**1.3** ± 0.3	**1.2** ± 0.2	**1.2** ± 0.2	**1.2** ±0.2	**1.2** ±0.2
MP (mg/kg per day)[b]	**0.37** ± 0.12	**0.17** ± 0.04	**0.16** ± 0.03	**0.15** ±0.03	**0.18** ±0.16	**0.13** ±0.04

CyA, Cyclosporine; Aza, azathioprine; MP, methylprednisolone

[a] Results given are mean ± SD

[b] Only patients on triple therapy are included

[c] Two patients with chronic rejection have been omitted. Their serum creatinine concentrations were 745 and 450 μmol/l and glomerular filtration rate 9.6 and 10.0 ml/min per 1.73 m^2, respectively

Pneumocystis carinii did not cause any of the infections. Primary varicella infection occurred in 2 patients and there was recurrence in 1 patient. They all received i. v. acyclovir and recovered.

Thirteen recipients (33%) and 31 donors (76%) were positive for CMV antibodies prior to transplantation. Nineteen CMV-positive grafts were transplanted to CMV-negative recipients. Ten were from LRD and nine from CAD donors.

Three patients (all under the age of 5 years) had a CMV infection. Two were CMV-negative recipients of a CMV-positive graft. They were successfully treated with i. v. gancyclovir (Cymevene, Syntex). The third infection was in a CMV-positive recipient with a CMV-positive graft. As gancyclovir was not available at the time, she was treated with i. v. anti-CMV immunoglobulin, with success.

Acute rejection episodes

A total of 39 episodes of acute rejection were diagnosed in 25 patients. All episodes were confirmed by FNAB. Ten patients had 2 and 2 patients had 3 episodes. Thirty-four rejections (87%) occurred during the first 70 days after transplantation and only 1 during the first 5 days. Three rejection episodes took place later during the first 12 months and 1 during both the 2nd and 3rd year after transplantation. Only 5 early episodes did not respond to steroid treatment. They were treated with ATG. Two vascular rejections were treated with plasmaphaeresis and 1 of them with cyclophosphamide as well. All acute rejection episodes were reversed and did not lead to graft loss.

Rejection episodes occurred more frequently in CAD than in LRD grafts (1.29 vs. 0.55 per graft, $P < 0.02$), especially in recipients younger than 5 years (1.54 vs. 0.54 per graft, $P < 0.01$). There was no effect of graft source on the number of acute rejections in recipients older than 5 years (0.88 vs. 0.57, $P = 0.48$). Also, there was no correlation between recipient age and the number of rejection episodes.

Graft function

Mean serum creatinine concentration was between 75 and 89 μmol/l after transplantation, except for the 24-month assessment when it was 127 μmol/l. The exception was due to 2 patients who had developed chronic rejection and uraemia and whose serum creatinine concentrations were 450 and 745 μmol/l (Table 3).

Mean C_{Cr} was estimated at 70.2 ml/min per 1.73 m^2 on discharge and remained stable during follow-up in the patients with a functioning graft (Table 3). There were no significant differences in the mean C_{Cr} of all patients between control times. However, CAD graft recipients less than 5 years old had a significant increase in C_{Cr} between discharge and 18 months (77.4 vs. 85.2 ml/min per 1.73 m^2, $P < 0.05$). In the LRD graft recipients of the same age group an increase was observed between 18 and 36 months (91.7 vs. 102.0 ml/min per 1.73 m^2, $P < 0.05$).

CAD grafts functioned less well than LRD grafts during the first months after transplantation. The serum creatinine concentration was higher on discharge and at 3 months (85 vs. 65 μmol/l and 82 vs. 67 μmol/l, respectively, $P < 0.05$) and the C_{Cr} lower (60.6 vs. 79.7 ml/min per 1.73 m^2 and 62.0 vs. 73.8 ml/min per 1.73 m^2 respectively, $P < 0.01$). Recipient age or graft origin did not affect function later, although the C_{Cr} tended to be lower in CAD grafts. Donor or recipient CMV status at transplantation did not affect graft function.

Patient and graft survival

All patients are alive. Actuarial graft survival was 100% 1 year and 86% 3 years after transplantation. Three-year survival was 92% for LRD and 75% for CAD grafts. Three-year graft survival in recipients less than 5 years old was 89% for LRD and 73% for CAD. Nine recipients (6 LRD, 3 CAD) less than 2 years old have been followed for over a year. Their actuarial 3-year graft survivals are 80% and 67%, respectively. There were no significant differences between the survival of grafts of different origin in

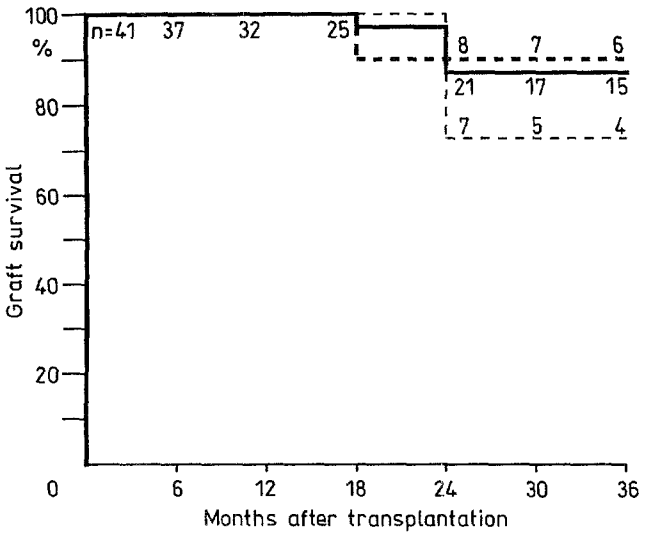

Fig. 2. Actuarial graft survival grouped by graft origin and recipient age. —, All children aged 1–17 years; ■ ■ ■, living-related donor grafts in children <5 years; – – –, cadaver grafts in children <5 years

any age group (Fig. 2). Original disease did not significantly affect survival.

Four grafts – 1 LRD and 3 CAD – were lost; 3 in patients less than 5 years old at transplantation. All losses were due to chronic rejection – 1 because of non-compliance. Two grafts in CNF patients were lost after massive proteinuria following a CMV and a possible Epstein-Barr virus (EBV) infection (elevated EBV IgM). The lost grafts survived a mean of 26.8 months (range 22–30 months). There was no difference in matching, graft age, age at transplantation, cold ischaemia, early graft function or number of acute rejection episodes between the lost and the surviving grafts. Two patients have been successfully retransplanted.

Discussion

Although LRD kidney transplantation in childhood has produced excellent results, graft survival in young children receiving CAD grafts has been poor. The North American Pediatric Renal Transplant Cooperative Study (NAPRTCS) recently reported an overall 1-year graft survival of 76% and a 3-year survival of 62% in CAD graft recipients. In their series, 1-year CAD graft survival in recipients younger than 2 years was 46% [3]. In contrast, the European Dialysis and Transplantation Association Registry Committee (EDTA) reported 1-year CAD graft survivals of 65%, 78% and 76% for recipients aged 0–5, 5–10 and 10–15 years, respectively [16]. The most recent studies are by Fitzpatrick et al. [4] who report 1- and 3-year CAD graft survivals of 57% in recipients less than 5 years old and by Briscoe et al. [5], who report 1-year CAD graft survival of 38% in recipients less than 2 years of age.

Although both EDTA and NAPRTCS report a large number of patients, the patients are from numerous centres, many with only a small number of recipients less than 5 years of age. In these multi-centre reports both surgical and medical treatment vary within the series. For example, only 69%–81% of CAD graft recipients, depending on the year of transplantation, received triple immunosuppression in the NAPRTCS report. The same problem of varying protocols also applies to studies reporting the experience of a single centre over a decade or more [1, 5]. Assessing the efficacy of a certain treatment is difficult when multiple modes of therapy have been used. All patients reported here have been treated by the same team (surgeons and paediatricians) according to a single protocol. Therefore the results can be clearly attributed to the protocol described.

No major difference in patient and graft survival between young recipients of LRD and CAD grafts could be seen at our centre. The present results for young CAD graft recipients are substantially better than in most recent reports [1, 3–5] but in accordance with the experiences of the Minnesota [1] and the Los Angeles groups [17] using sequential immunosuppression. However, they only report 1-year results of 5 and 11 patients respectively on this therapy.

Low donor age has been shown to have a negative effect on graft survival [18]. This has been proposed to be due to high immunoresponsiveness of young recipients causing irreparable damage to small grafts. Surgical problems and graft thrombosis are also more common [19]. These difficulties were avoided in our series where young donors were not available. In other reports, paediatric donors have comprised 36%–100% of all CAD donors. In the NAPRTCS study, 39% of CAD donors were aged less than 10 years. Of eight CAD grafts studied by Briscoe et al. [5], six were from paediatric donors and one of them was lost due to graft thrombosis. Fitzpatrick et al. [4] reported a mean donor age of only 7.8 years. In their study four of ten graft losses occurred due to renal vein thrombosis. The Los Angeles group [17] had four donors younger than 6 years.

Grafts with two or less mismatches in HLA-A, -B and -DR loci combined seem to have increased short- and long-term survival [2]. The majority of our grafts fall into this group. In addition, double DR-mismatched grafts are generally not accepted at our institution. Fitzpatrick et al. [4] found an increased likelihood of graft loss in double DR mismatches, although in a large study this finding was inconclusive [20]. Matching in LRD transplantation has been largely the same in all reports, but in CAD transplantation our matching has been more strict, the same criteria for acceptance being used for both donor sources [3–5].

In LRD transplantation our policy has been to give DST if the patient has not previously had many transfusions. This is contrary to the declining worldwide use of DST due to the disappearance of the DST effect in most series [21]. However, in our centre no T-cell crossmatch has become positive and no LRD transplantation has been abandoned. Because of the favourable results, we have not thus far changed our protocol.

Acute rejection episodes were less often diagnosed in our series than in some other studies [3, 4]. In these reports

acute rejection has been defined either as the start of anti-rejection treatment [3] or a rise in serum creatinine concentration not attributable to other causes [4]. In the latter report, diagnosis was confirmed by needle biopsy in 30% of cases. Our criteria for acute rejection are more strict than these and this may explain the difference in the frequency of rejection episodes. In contrast, the Minnesota group verified all rejections by biopsy and found no rejections in 67% of the recipients, although graft losses due to acute rejections occurred [1]. This much higher percentage of patients without rejection episodes than at our institution may reflect increased immunosuppression due to use of sequential therapy in addition to different diagnostic criteria.

At our institution FNABs are liberally performed because of the easy access to the graft made possible by extraperitoneal placement. Rejections are therefore unlikely to be missed. Diagnosis within a few hours enables the physician to treat rejections in their very early phase before they become fulminant. Early diagnosis and treatment of acute rejections may diminish their overall frequency, thus increasing graft survival and protecting graft function. Acute rejections may account for 17%–25% of all lost grafts [1, 3–5], but at our centre no grafts were lost for this reason.

The general condition and nutritional status of a small child at the time of transplantation probably has an impact on outcome, especially with respect to infections and other early complications. This is particularly true for patients with a congenital nephrotic syndrome who have had a life-long protein loss. Even the best reports show a substantial and universal failure of growth at the time of transplantation [22]. Most of our patients aged less than 5 years have this severe disease. During recent years aggressive nutritional support and protein substitution combined with pre-transplant nephrectomy and dialysis have been used at our centre to improve the nutritional status of these children. Currently they grow normally prior to transplantation [6].

In contrast to most other centres we have exclusively used extraperitoneal placement of adult grafts. With this technique intra-abdominal complications, i.e. ileus can be avoided. No vascular and only one ureteral complication has been seen. We have not encountered problems in fitting grafts from adult donors to young children weighing over 9 kg.

Graft function is satisfactory in our patients and there is no uniform trend towards higher serum creatinine concentrations and lower C_{Cr} in surviving grafts. Neither does our data give evidence of poor graft function of children less than 5 years old at the time of transplantation. The poorer function of CAD grafts in the early post-transplantation period may be due to preservation damage and higher frequency of rejections.

In contrast to centres where CyA is commenced after establishment of graft function, blood CyA concentration is pre-operatively raised to 300 µg/l at our institution. Despite this onset of diuresis was usually observed during the first few hours after transplantation and the need for post-operative dialysis was rare. Also, long-term deterioration of graft function could not be shown, although we aim at high drug concentrations. This may be due to our practice of dividing CyA into three doses in pre-school children. Such dosing, when used applying individual pharmacokinetic profiles [8], keeps the blood levels of the drug more constant avoiding high and possibly damaging peak concentrations common with the traditional dosing.

Equally good short-term results can be achieved in cadaveric renal transplantation of young recipients with sequential and triple immunosuppression. Both modes of treatment have their potential problems – an increased risk of infection and possibly of malignomas with sequential and nephrotoxicity with triple therapy. Only long-term follow-up providing information about frequency of chronic rejection and side effects can establish the superiority – if any – of either treatment. In conclusion our findings indicate that renal transplantation in young children, even with grafts from CAD donors, can be as successfully performed as in older children.

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