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# Renal Transplantation in Patient with Fabry's Disease Maintained by Enzyme Replacement Therapy

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## 1. Introduction

Fabry's disease (FD) is a rare inborn error of glycosphingolipid catabolism can lead to renal failure. The life expectancy is reduced for both genders, and the major causes of death include cardiac death, stroke, or the consequences of end stage of renal disease. This article summarizes the current knowledge about FD and the treatment of kidney transplantation and enzyme replacement therapy in FD.

## 2. About Fabry's disease

FD is a rare sphingolipidosis related and X-linked disorder of glycosphingolipid catabolism caused by deficient lysosomal  $\alpha$ -galactosidase A activity(Fig.1). Deficiency of the enzyme leads to progressive accumulation of the glycosphingolipid globotriaosylceramide (Gb3) in vascular endothelia, heart tissue, connective tissue, peripheral nerves, and the kidneys (Table.1, Fig.2). Male patients typically develop painful acroparesthesia followed by proteinuria, renal failure, cardiac hypertrophy and cerebral white matter lesions. Females are carriers and may present a wider range of symptoms(Fig.3,4). The incidence has been estimated to be 1:117,000 live births and 1:50,000 males. Registries of dialysis patients from the United States and Europe indicate that FD is the cause of end-stage renal disease (ESRD) for approximately 0.2% of patients on dialysis(Fig.5). Renal disease of some form occurs in most patients, with ESRD a common manifestation in hemizygous males that may develop by the fourth to fifth decade of life. The clinical course in heterozygous female patients involves a delayed onset of symptoms and milder progression, although some female patients present with symptoms similar to those seen in classically affected male patients. The analysis of 197 kidney transplant recipients with FD indicates that they have superior graft survival and similar patient survival compared with patients with other causes of ESRD. However, Fabry patients had a higher risk of death compared with a matched cohort of patients with other causes of ESRD. The median lifespan is 50 years for affected male patients and 70 years for female patients. Current therapy for ESRD in patients with FD involves renal transplantation and enzyme replacement therapy (ERT).

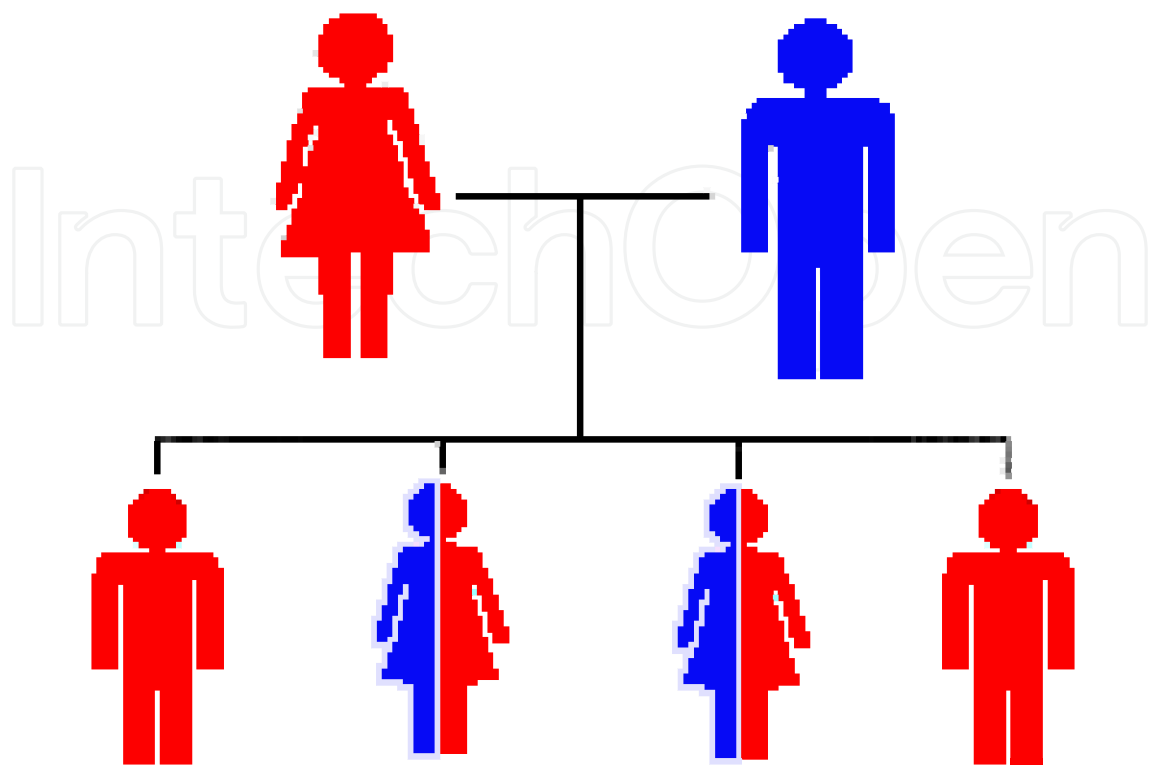


Fig. 1. If a male with Fabry disease and an unaffected (non-carrier) female have children, all of their daughters will be Fabry carriers and none of their sons will be affected with Fabry disease.

Disease		Accumulated material	Deficient enzyme
GM 1 gangliosidosis		GM 1 ganglioside	$\beta$ -galactosidase
GM 2 gangliosidosis	Tay-Sachs Disease	GM 2 ganglioside	$\beta$ -hexosaminidase
	Sandhoff Disease	GM 2 ganglioside	$\beta$ -hexosaminidase
Metachromatic Leukodystrophy		Sulfatide	arylsulfatase A
Ferber Disease		Ceramide	Ceramidase
Gaucher Disease		Glycocerebroside	$\beta$ -glucocerebrosidase
Niemann-Pick Disease		Phosphorylcholine Ceramide	Sphingomyelinase
Krabbe Disease		galactocerebroside	$\beta$ -galactosidase A
Fabry Disease		globotriaosylceramide	$\alpha$ -galactosidase A

Table 1. The classification of sphingolipidosis.

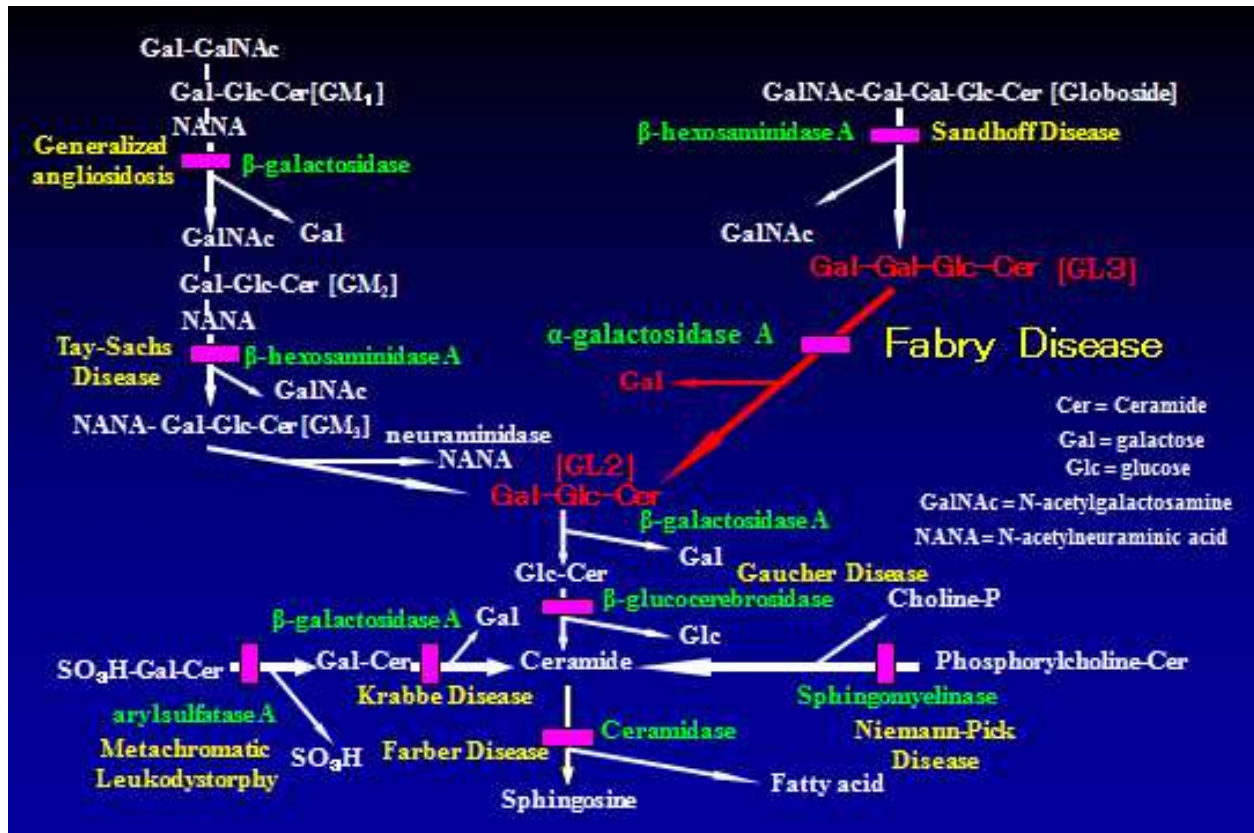


Fig. 2. The classification of sphingolipidosis.



Fig. 3. Clinical features of Fabry's disease; angiokeratomas.



Fig. 4. Clinical features of Fabry's disease; corneal and lenticular opacities.

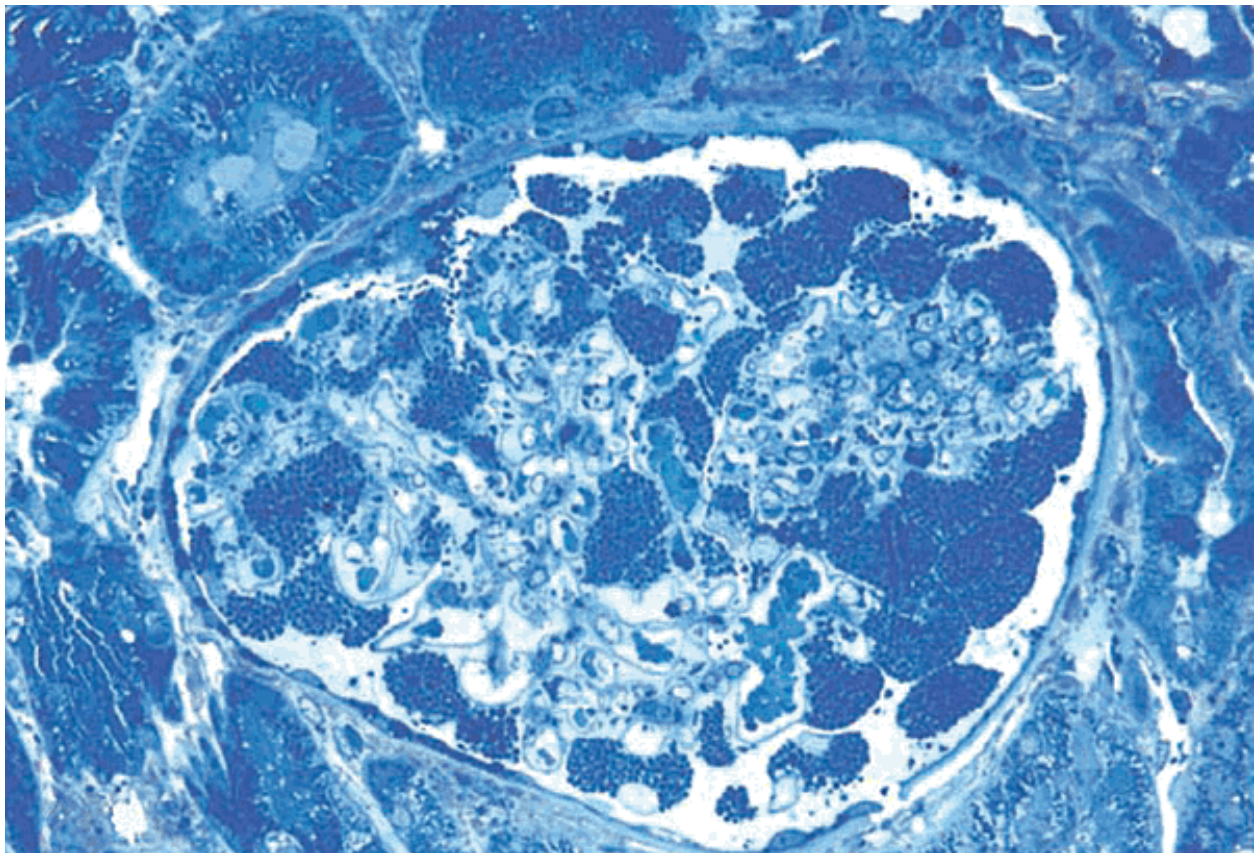


Fig. 5. Ultra structural changes in glomerulus with FD with myelin-like inclusions and subendothelial deposits.

### 3. Renal transplantation in patient with Fabry's disease

Renal transplantation was known to be effective for FD, as previous reports demonstrated that the procedure provided equivalent 5-year patient and graft survivals, as well as improvement of overall prognosis in patients with ESRD due to FD. In contrast, another study found that a renal allograft could not repair the deficient enzyme activity of  $\alpha$ -galactosidase A and noted that the accumulation of Gb3 impaired renal function, which might signify the possibility of recurrence of FD in the renal allograft. According to a previous study from the European Dialysis and Transplant Association/European Renal Association Registry, graft survival at 3 years in 33 patients with FD was not considered as inferior to that of patients with other nephropathies (72% vs. 69%), and patient survival after transplantation was comparable to that of patients aged under 55 years with non-Fabry nephropathies. Excellent graft and patient survival were also reported from the US Renal Data System Registry. FD is therefore not considered a contraindication for renal transplantation. Although a case study has shown that the disease may recur in the transplanted organ, another case study has shown no evidence of disease recurrence in a renal biopsy 8 years after transplantation. A further case study showed extensive Fabry-related renal changes in a renal biopsy from a patient who had received a graft from his sister who was heterozygous for the disease.

### 4. The efficacy of enzyme replacement therapy (ERT)

Enzyme replacement therapy (ERT) for the treatment of Fabry's disease was first performed in the 1970s, however, open-label phase 2 trials were not performed until the 2000s. ERT using recombinant human alpha-galactosidase A (generic names agalsidase alpha and agalsidase beta) was approved for use in Europe in 2001 and in the United States in 2003. Initial randomised controlled trials (RCT) showed that 69% of the treatment group was free of renal microvascular endothelial deposits of globotriaosylceramide (primary endpoint) versus no change in the placebo group after 20 weeks ( $p < 0.001$ ). Although there did not appear to be a difference in quality of life as assessed by the SF-36, another RCT showed a statistically significant decrease in pain severity and improvement in quality of life (primary outcome). This study also showed improvement in renal architectural distortion (mesangial diameter) ( $p = 0.01$ ) and increase in creatinine clearance ( $p = 0.02$ ). In a more recent, larger RCT, 42% of placebo patients versus 27% of treated patients had clinical events (defined as renal, cardiac or cerebrovascular event or death); the time to first clinical event adjusted for baseline proteinuria favoured agalsidase beta but included the null (hazard ratio 0.47, CI: 0.21–1.03;  $p < 0.06$ ). Although overall the results were less than overwhelming, treatment effect was greater in patients with preserved renal function. There are no data currently regarding ERT and affect on mortality.

Moreover, a purified recombinant  $\alpha$ -galactosidase A enzyme (Fabrazyme®) was synthesized and administration in non-transplanted FD patients was reported to markedly reduce serum ceramide levels. A detailed report revealed few serious adverse events in a total of 401 patients receiving long-term treatment; as in this study, most adverse events consisted of mild infusion reactions. Patients given recombinant  $\alpha$ -GalA at 1 mg/kg once every two weeks showed decreased microvascular endothelial deposits of Gb3 in skin over a period of 20 weeks and plasma Gb3 also decreased. In addition, in patients who received ERT for 30-36 months, serum creatinine and estimated glomerular filtration rate values remained stable,

while the level of plasma Gb3 remained in a normal range after ERT. More recently, Cybulla et al. explored the effects of agalsidase alfa in transplant patients with FD. Allograft function of 20 patients from the Fabry Outcome Survey registry was analyzed after approximately 3.5 years (median) of agalsidase alfa therapy at the standard dose of 0.2 mg/kg every other week. After 2 years of ERT, there was a slight but nonsignificant increase in serum creatinine (1.4 mg/dl at baseline versus 1.6 mg/dl) and a decrease in eGFR (59.2 ml/min/1.73 m<sup>2</sup> at baseline versus 51.1 ml/min/1.73 m<sup>2</sup> at 2 years). Similar to the previously mentioned study, proteinuria remained stable during this time period. In contrast, ERT may be less effective to improve renal or cardiac function in cases with progressive damage to tissue, as it would likely be difficult to recover the function. Therefore, renal transplantation in conjunction with ERT might achieve better improvement of the graft and overall survival of FD patients.

Mignani et al. reported that plasma Gb3 was decreased by 23-50% after ERT in renal transplant patients with FD. In addition, Inderbitzin et al. treated a patient with persistent FD-related acroparesthesia and found that ERT for 100 months after renal transplantation resulted in an excellent clinical course. In another study, Mignani et al. also reported 3 patients who underwent ERT after renal transplantation, who had maintained renal function and improved cardiac function. In each of those cases, ERT was performed after renal transplantation, whereas we previously reported a rare case of successful cadaveric renal transplantation in patient with FD maintained by ERT with an excellent clinical course. We treated a 48-year-old male patient with a typical clinical history of FD from childhood (intermittent fever, cutaneous angiokeratoma, pain attacks in arms and legs). At the age of 25, renal function disorder with proteinuria was pointed out and hemodialysis started at 26 years old. He was diagnosed with FD based on deficient lysosomal  $\alpha$ -galactosidase A activity at the age of 46 and began ERT by injection of recombinant  $\alpha$ -galactosidase e.g. Agalsidase beta at 1mg per kg bodyweight once every two weeks in August 2004. After the induction of ERT, he still had diffuse angiokeratoma of the body and intermittent abdominal pain. Echocardiographic evaluation suggested hypertrophic obstructive cardiomyopathy with left ventricular hypertrophy.

On December 17, 2005, cadaveric renal transplantation was performed (Fig.6) for the patient. The initial immunosuppressive agents were cyclosporine, mycophenolate mofetil, steroids, and basiliximab, with the cyclosporine trough levels kept at 100-150 ng/ml. No rejection or other complications appeared during the immediate follow-up period, and he withdrew from hemodialysis 23 days after transplantation. At discharge, serum creatinine was reduced to about 1.9 mg/ml and was at a steady-state level. At the same time, the disappearance of the skin lesions and abdominal pain was noticed. At 12 and 24 months after transplantation, graft biopsies were performed, as the serum creatinine level increased to 2.2~2.3 mg/dl. Histological results demonstrated acute cellular rejection, however, there were no abnormal deposits of accumulated glycosphingolipids in the glomerular podocytes or tubular epithelial cells. Electron microscopy revealed normal glomerular cells with a slight increase in the mesangial matrix (Fig.7).

There were no dense deposits. The acute rejection responded to intravenous deoxyspergualin and serum creatinine decreased to 2.0 mg/dl. Since transplantation, ERT has been continued once every two weeks and no complications as a result of that therapy have been recognized.

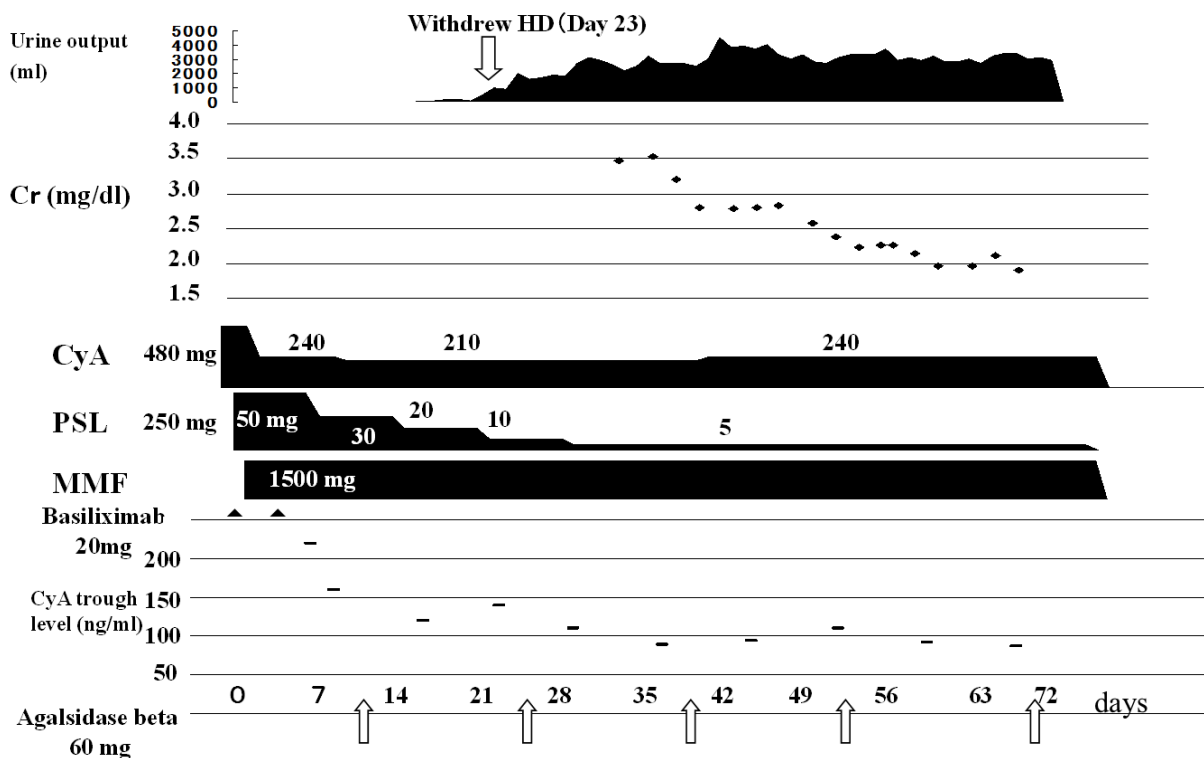


Fig. 6. Clinical course of the patient. Cr creatinine; CsA, cyclosporine; HD, hemodialysis; MMF, mycophenolate mophetil; PSL, prednisolone.

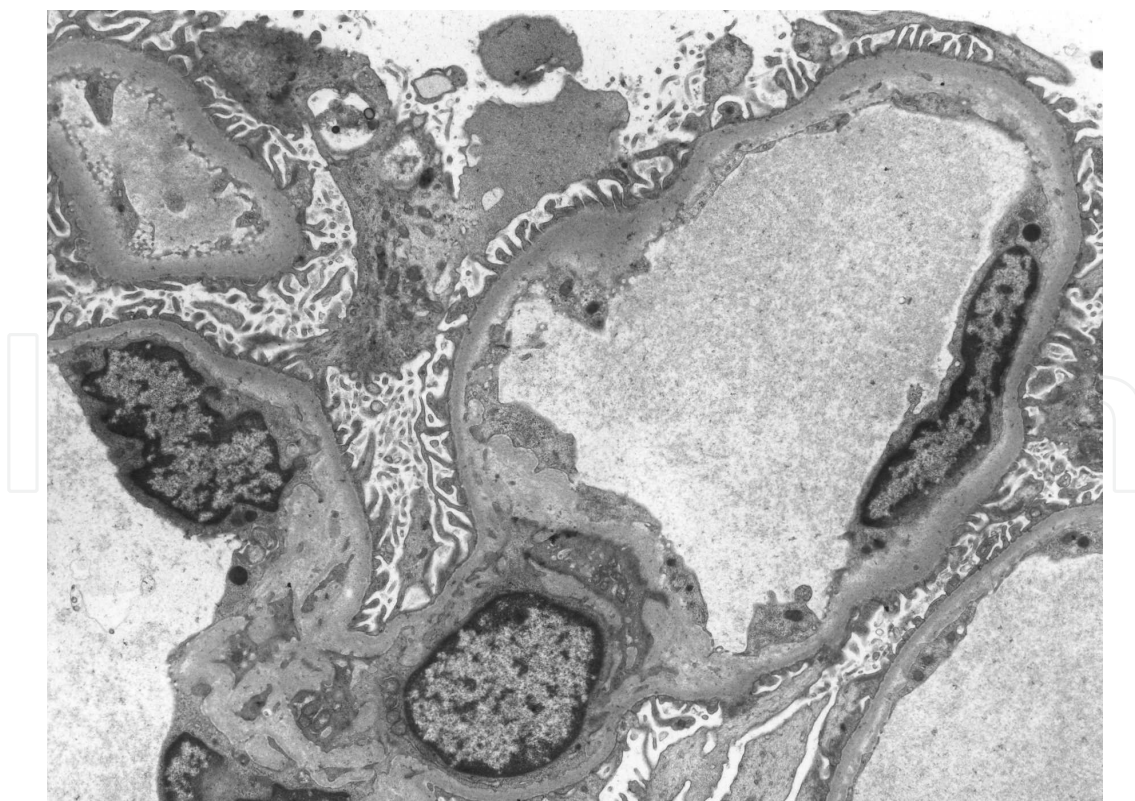


Fig. 7. Electron microscopy of normal glomerulus from kidney graft. Occasional foci of podocyte fusion are present.



The recurrence of FD in patients with a transplanted kidney has rarely been reported. Findings of small amounts of Gb3 deposits in renal grafts have been limited to vascular endothelial cells and tubular epithelial cells. We consider that renal transplantation combined with ERT reduces the risk of recurrence of FD in a transplanted kidney. However, further data are required to confirm whether such treatment will confer long-term renoprotective effects on renal transplantation.

An important problem facing FD patients is that a successful kidney graft survives for 10-15 years, however, cardiovascular complications related to metabolic disease may occur during that time. FD generally progresses systemically after renal transplantation and cardiac ceramide deposition ultimately determines the fate of these patients in the second decade after renal transplantation. Since ERT improves cardiac involvement in FD patients, renal transplantation combined with ERT may be the best therapy for ESRD at the present time. Additional clinical studies are needed to determine the effects of this combination on the overall prognosis of FD.

## 5. Conclusion

Renal transplantation is effective for FD and improves patient and graft survivals as well as overall prognosis in patients with ESRD due to FD. And ERT is well tolerated in patients with FD who have undergone renal transplantation.

In summary, some studies indicate that kidney transplantation and ERT are viable options for patients with ESRD due to FD. Although ERT appears to stabilize renal function, further data are required to confirm whether such treatment will confer long-term renoprotective effects on kidney transplant patients.

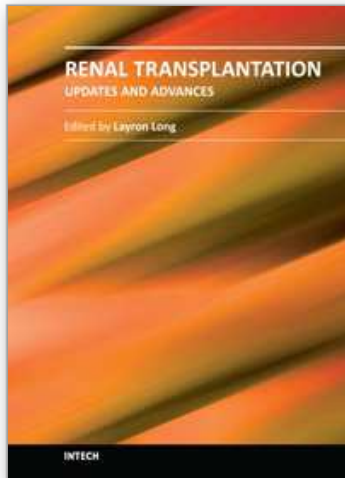
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