Renal allograft survival in transplant recipients with focal segmental glomerulosclerosis

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ABSTRACT

Introduction: The frequency that idiopathic focal segmental glomerulosclerosis (FSGS) recurs in renal allografts is reportedly 20%-50%, but the epidemiology of secondary FSGS in this setting has scarcely been addressed.

Objectives: The aim of this study was to examine the incidence, etiology, and subtypes of FSGS in renal allograft recipients and allograft survival in recipients with FSGS.

Patients and Methods: As a retrospective review, we examined medical records of 359 consecutive renal allograft recipients (living donors, 329; cadaveric donors, 30). In 121 of these patients, allograft dysfunction or proteinuria prompted biopsies. We compared allograft survival in recipients with and without FSGS. We then determined histologic subtypes of FSGS using the Columbia classification and categorized FSGS as recurrent or de novo, and idiopathic or secondary.

Results: Of 121 subjects who were biopsied, six with inadequate specimens (<10 glomeruli) were excluded. Only 17 of those remaining (n=115) were diagnosed as secondary FSGS. Renal allograft survival did not differ significantly in patients with or without FSGS (P=0.953). Subtypes of FSGS were as follows; not otherwise specified (NOS; n=8), collapsing (n=5), cellular (n=2), and perihilar (n=2).

Conclusion: Secondary FSGS was observed in 14.5% of biopsies of renal allograft recipients and seemed no significant impact on allograft survival.

Implication for health policy/practice/research/medical education:
Focal segmental glomerulosclerosis (FSGS) was observed in 14.5% of biopsies of renal allograft recipients and subtypes of FSGS were as follows; not otherwise specified (47.1%), collapsing (29.4%), cellular (11.8%), and perihilar (11.8%). Secondary FSGS develops in renal allograft due to various etiology including rejection and calcineurin inhibitor nephrotoxicity in addition to glomerular hyperfiltration but seemed no significant impact on allograft survival.

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Introduction
Focal segmental glomerulosclerosis (FSGS) may develop in renal allografts for various reasons. It may recur or arise de novo and may be idiopathic or secondary. The incidence of recurring idiopathic FSGS in renal allografts is reportedly 20%-50% (1-6), with a 2.6% incidence of related allograft loss over 2.96 years (mean interval; 8.2% lost to follow-up) (4) or 12.7% loss in 10 years (95% confidence interval; 7.3-21.6) (7).

Secondary FSGS is rooted in a multiplicity of disorders, such as hyperfiltration (8), reduced renal mass (9), reflux nephropathy (10), obesity (11-16), drugs (17-24), viruses (25-28), or glomerular disease [immunoglobulin A nephropathy (IgAN) (29) and lupus nephritis (30-32) in particular]. Renal allografts may be similarly affected, in conjunction with rejection (33-34), although the epidemiology of secondary FSGS has scarcely been addressed in this regard.

Objectives
The present efforts were focused on the following: 1) incidence and subtypes of FSGS in renal allograft...
recipients, 2) allograft survival in recipients with FSGS, and 3) nature of FSGS (recurrent or de novo, idiopathic or secondary).

**Patients and Methods**

**Study design**

Medical records of 359 consecutive renal allograft recipients (living donors, 329; cadaveric donors, 30) were reviewed in retrospect, all transplantations taking place at Jichi Medical University Hospital between January 2001 to December 2018. A total of 121 biopsies were performed, prompted by allograft dysfunction or proteinuria. Specimens with <10 glomeruli were grounds for exclusion. Qualifying recipients were grouped by FSGS status (presence or absence) to compare renal allograft survival.

Light microscopy served to identify FSGS subtypes (based on the Columbia classification) (35) and subsequently categorize FSGS as recurrent or de novo and idiopathic or secondary. In the absence of pathologic changes or clinical conditions predisposing to FSGS, we presumed FSGS was idiopathic. Otherwise, FSGS was considered secondary.

Obesity was defined as a body mass index (BMI) >25 kg/m², in accord with the Japanese Society for the Study of Obesity. Estimated glomerular filtration rate (eGFR) was calculated as follows; eGFR = 194 × creatinine (Cr) (mg/dL)⁻¹.094 × age (years)⁻⁰.₂⁰⁷ (× 0.739, if female) (mL/min/1.73 m²) (36). Urinary protein excretion was assessed by protein-to-Cr ratios (g/g Cr) of spot urine samples. Banff criteria were the benchmarks for rejection (37).

**Histologic studies**

We used standard techniques to prepare tissues for light, immunofluorescence, and electron microscopic examinations. For light microscopy, formalin-fixed samples were processed routinely, embedded in paraffin, cut at 1 μm, and variably stained (hematoxylin & eosin, periodic Acid-Schiff, silver methenamine-Masson trichrome, and Elastica van Gieson methods). Paraffin-embedded sections were also immunostained for deposition of C4d, as previously described (38). Frozen sections (3 μm) were obtained for immunofluorescence microscopy, using polyclonal FITC-conjugated antibodies to IgG, IgM, IgA, C3, C1q, and fibrinogen.

**Ethical approval**

Informed consent was obtained from each patient enrolled in this study. The study protocol conforms to the ethical guidelines of the 1975 Declaration of Helsinki. This research was approved by the ethical committee of Jichi Medical University Hospital (IRB approval number RINDAI 16-066).

**Statistical analysis**

All data were expressed accordingly as mean ± SD or median (range). Chi-square test was applied to categorical variables, using Student’s t-test or Mann-Whitney U test to assess continuous variables. Renal allograft survival was analyzed by Kaplan-Meier method, with log-rank test. The impact of FSGS on death-censored graft survival was gauged via Cox proportional hazards model, adjusting for baseline imbalances in recipient groups with or without FSGS. EZR freeware (v1.35; R Foundation for Statistical Computing, Vienna, Austria) (39) was invoked for all computations, setting significance at P<0.05.

**Results**

Of renal allograft recipients (n=121) who were biopsied, six with inadequate specimens (<10 glomeruli) were excluded. However, changes of FSGS were absent in all six. In the remaining 115 patients, a diagnosis of FSGS was established for 17.

Characteristics of allograft recipient groups, with or without FSGS at biopsy, are shown in Table 1. Although urinary protein excretion at biopsy and transplant-to-biopsy interval were significantly greater in patients with (vs without) FSGS (P=0.00146 and P=0.00151, respectively), the presence or absence of FSGS had no significant impact on renal function at biopsy (P=0.287) or death-censored graft survival (P=0.953) (Figure 1). Once adjusted for transplant-to-biopsy interval and urinary protein excretion (in Cox proportional hazards analysis), death-censored graft survival proved similar, regardless of FSGS status (adjusted hazard ratio for death-censored graft loss in recipients with FSGS=3.70, 95% confidence interval: 0.733-18.7; P=0.113).

Characteristics of the 17 recipients with FSGS are shown in Table 2. Histologic subtypes of FSGS were as follows; not otherwise specified (NOS; n=8), collapsing (n=5), cellular (n=2), and perihilar (n=2) (Figure 2). No allograft recipient with FSGS had known native kidney involvement. However, the status of native kidneys was lacking in eight. On the other hand, there were signs of diabetic nephropathy (n=4), IgAN (n=2), polycystic kidney disease (n=2), or Henoch-Schönlein purpura nephropathy (HSPN; n=1). FSGS was presumed secondary in all 17 patients, based on associated pathologic findings or clinical features. Likely precipitating events or conditions were calcineurin inhibitor (CNI) toxicity (n=10), chronic active antibody-mediated rejection (ABMR; n=8), obesity (n=7), arteriosclerosis (n=3), reflux nephropathy (n=2), recurrent IgAN (n=2), or recurrent HSPN (n=1).

**Discussion**

During the course of this study, FSGS was identified in 14.5% of renal allograft recipients who required biopsies.
Renal allograft survival

Table 1. Characteristics of recipient groups with or without FSGS at biopsy

|                         | FSGS (n=17) | non-FSGS (n=98) | P value |
|-------------------------|-------------|-----------------|---------|
| Sex, male (%)           | 70.6        | 59.2            | 0.535   |
| Age (y)                 | 46.9±13.2   | 48.7±13.8       | 0.606   |
| BMI (kg/m²)             | 23.1 (17.5-30.3) | 21.9 (15.1-40.3) | 0.595   |
| Living donor (%)        | 94.1        | 90.8            | 1.000   |
| Hypertension (%)        | 88.2        | 71.4            | 0.274   |
| Diabetes mellitus (%)   | 29.4        | 28.6            | 1.000   |
| ARB or ACE-I (%)        | 58.8        | 32.7            | 0.0725  |
| Transplant-to-biopsy interval (days) | 2249 (96-5391) | 356 (5-6032)     | 0.00151 |
| Serum creatinine (mg/dL) | 2.78±1.36   | 2.35±1.53       | 0.287   |
| Urinary protein excretion (g/g Cr) | 1.52 (0.31-7.68) | 0.48 (0-6.43)     | 0.00146 |
| Microhematuria (%)      | 35.3        | 24.5            | 0.376   |

FSGS, focal segmental glomerulosclerosis; BMI, body mass index; ARB, angiotensin receptor blockers; ACE-I angiotensin-converting enzyme inhibitor.

Allograft survival did not differ significantly (P=953) as a result; and in all 17 recipients with FSGS, it was considered a secondary manifestation. Although we cannot state this with certainty, no decisive evidence of idiopathic FSGS emerged. Instead, CNI toxicity (58.8%), chronic active ABMR (47.1%), obesity (41.2%), arteriosclerosis (17.6%), reflux nephropathy (11.8%), recurrent IgAN (11.8%), and recurrent HSPN (5.9%) were variably implicated. Such findings are presumptive but are well corroborated by earlier probes into pathologic or clinical underpinnings of secondary FSGS.

As the leading cause of secondary FSGS herein, CNI toxicity may inflict hyperfiltration injury and subsequent arteriolar hyalinosis, with global glomerulosclerosis (40) or glomerular ischemia (17,41). Indeed, severe arteriolar hyalinosis was visible in all 10 of our patients with overt CNI toxicity. Others (33,34) have also reported FSGS following rejection, although the inherent mechanism is still unclear. Immunologic injury to endothelium and podocytes may be involved. Obesity may contribute to glomerular hyperfiltration, heightening filtration pressures of proximal glomerular capillaries to result in sclerosis near

Figure 1. Kaplan-Meier analysis of death-censored graft survival. FSGS, focal segmental glomerulosclerosis.

Figure 2. Renal allograft biopsies (Periodic acid-Schiff stain, original magnification × 400): (a) Collapsing variant (Case 6) showing capillary collapse and prominent epithelial cell hypertrophy and hyperplasia; (b) Cellular variant (Case 4), marked by segmental expansion of glomerular tuft and endocapillary foam cells; (c) Perihilar variant (Case 10) with segmental hyalinosis and sclerosis near vascular pole; and (d) NOS (Case 17) demonstrating segmental capillary obliteration by extracellular matrix. NOS, not otherwise specified.
vascular poles (11,42). Changes of FSGS have similarly been noted in many (101/128) cases of IgAN, again linked to podocyte injury (29). FSGS in reflux nephropathy likely results from nephron loss, imposing hyperfiltration on those left intact (10). Unilateral kidney recipients seem prone to glomerular hyperfiltration as well. A critical factor may be the duration of these conditions, because transplant-to-biopsy intervals proved significantly longer in our patients with FSGS.

There are data to indicate that graft survival is significantly worse in recipients with (vs without) de novo FSGS (43). Unfortunately, further categorization as idiopathic or secondary is lacking at the source, therefore the cited outcomes may in part reflect idiopathic de novo FSGS, the prognosis of which is poor. In our patients, FSGS was largely presumed to be secondary and whether present or not had no significant impact on renal allograft survival. Hence, the prognosis of renal allograft recipients is seemingly unaltered by secondary FSGS.

**Conclusion**

According to our data, only 14.5% of renal allograft recipients undergoing biopsies for allograft dysfunction or proteinuria showed evidence of FSGS which was considered secondary in all instances. Secondary FSGS was seemed to have no significant impact on allograft survival.

**Limitation of the study**

This study has several acknowledged limitations. The

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**Table 2. Characteristics of recipients with FSGS**

| Case | Transplant-to-biopsy interval (days) | BMI (kg/m²) | Native kidney disease | Immunosuppressant regimen | Serum creatinine (mg/dl) | Urinary protein excretion (g/g Cr) | FSGS subtype | Coexisting pathologic findings or clinical features suggesting etiology of secondary FSGS |
|------|-------------------------------------|-------------|-----------------------|---------------------------|-------------------------|-------------------------------|--------------|----------------------------------------------------------------------------------|
| 1    | 5391                                | 30.3        | DMN                   | CyA MMF MP                | 2.25                    | 1.95                          | NOS          | Rejection, CNI toxicity, obesity                                                  |
| 2    | 3376                                | 22.9        | IgAN                  | TAC MMF MP                | 1.55                    | 1.04                          | NSO          | Recurrent IgAN, CNI toxicity                                                     |
| 3    | 3165                                | 19.7        | Unknown               | TAC MZR MP                | 2.72                    | 1.54                          | Collapsing  | CNI toxicity, arteriosclerosis                                                   |
| 4    | 2980                                | 27.5        | Unknown               | CyA MMF                   | 2.27                    | 0.45                          | Cellular     | CNI toxicity, obesity, Reflux nephropathy                                        |
| 5    | 2875                                | 23.8        | Unknown               | TAC MMF                   | 2.18                    | (3+)                          | NOS          | CNI toxicity                                                                  |
| 6    | 2725                                | 17.5        | IgAN                  | TAC MZR MP                | 2.3                     | 1.88                          | Collapsing  | Recurrent IgAN, CNI toxicity                                                     |
| 7    | 2267                                | 26.8        | HSPN                  | TAC AZA MP                | 2.59                    | 1.5                           | Collapsing  | Recurrent HSPN, CNI toxicity, obesity                                            |
| 8    | 2249                                | 27.0        | PKD                   | TAC MMF MP                | 3.71                    | 3.32                          | Peri hilar   | Rejection, CNI toxicity, obesity                                                |
| 9    | 2221                                | 18.2        | Unknown               | TAC MMF MP                | 2.09                    | 1.52                          | Cellular     | Rejection, CNI toxicity                                                          |
| 10   | 2119                                | 28.7        | Unknown               | TAC MMF                   | 2.59                    | (3+)                          | peri hilar   | Obesity                                                                        |
| 11   | 1721                                | 23.1        | DMN                   | TAC MMF                   | 1.72                    | 0.64                          | NOS          | Rejection, CNI toxicity, arteriosclerosis                                        |
| 12   | 1147                                | 25.2        | DMN                   | TAC MMF EVR               | 1.97                    | 1.67                          | NOS          | Rejection, obesity                                                              |
| 13   | 1099                                | 22.9        | Unknown               | TAC EVR MP                | 2.79                    | (2+)                          | Collapsing  | Rejection                                                                      |
| 14   | 447                                 | 29.6        | DMN                   | TAC MMF                   | 3.6                     | 7.68                          | Collapsing  | Rejection, obesity                                                              |
| 15   | 201                                 | 18.4        | PKD                   | TAC MMF                   | 6.76                    | 0.65                          | Arteriosclerosis        |                                                                                   |
| 16   | 133                                 | 18.1        | PKD                   | TAC MMF EVR               | 1.64                    | 0.37                          | NOS          | Reflux nephropathy                                                             |
| 17   | 96                                  | 19.7        | Unknown               | TAC MMF                   | 2                       | 0.31                          | NOS          | Rejection                                                                      |

FSGS, focal segmental glomerulosclerosis; BMI, body mass index; DMN, diabetic nephropathy; CyA, cyclosporine A; MMF, mycophenolate mofetil; MP, methylprednisolone; NOS, not otherwise specified; CNI, calcineurin inhibitor; IgAN, immunoglobulin A nephropathy; TAC, tacrolimus; MZR, mizoribine; HSPN, Henoch-Schonlein purpura nephropathy; AZA, azathioprine; PKD, polycystic kidney disease; EVR, everolimus.

Chronic active antibody-mediated rejection evident in all patients with rejection. Dipstick urinalysis only in cases 5, 10, and 13 (urinary protein excretion unavailable).
status of native kidneys in a segment of allograft recipients was unknown, prohibiting FSGS designation as recurrent or de novo. In addition, our method of separating idiopathic and secondary FSGS (based pathologic changes or clinical features) was not foolproof. Finally, biopsies were not obtained from every patient with renal allograft dysfunction or proteinuria, therefore the incidence of FSGS we have determined may be inaccurate.

Authors’ contribution
TaS participated in research design, performance of the research, and writing the paper. KN participated in research design, performance of the research, and writing the paper. YK participated in research design, performance of the research, and writing the paper. TK participated in research design, performance of the research, and writing the paper. TY participated in research design, performance of the research, and writing the paper.

Conflicts of interest
The authors have declared that no conflict of interest exists.

Ethical considerations
Ethical issues have been completely observed by the authors.

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