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Original Article

Glomerular Diseases in the Colombian Caribbean: Data from the Colombian Nephropathy Registry (NEFRORED®)

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ABSTRACT. Our study aimed to describe the glomerular diseases, both primary glomerular disease (PGD) and secondary glomerular disease (SGD) in the Colombian Caribbean based on the first regional Colombian Nephropathy Registry (NEFRORED®). A descriptive and retrospective study of adult patients with glomerular diseases from the Colombian Caribbean region was made. All diagnoses by renal biopsy with light microscopy and immunofluorescence obtained between January 2008 and June 2018 were recorded. Eight hundred and seventy-one renal biopsies were obtained. The main clinical indication for biopsy was nephritic syndrome (36%). SGD was more frequent than PGD (55% vs. 45%). Within SGD group, lupus nephritis (LN) was the most frequent etiology (83%). Within PGD group, membranous nephropathy (33%) and focal segmental glomerulosclerosis (FSGS) (19%) were the most common glomerular diseases. At a 24-month follow-up, the patients with FSGS and paraproteinemia-mediated glomerular disease had the worst renal survival prognosis. This is the first Colombian Nephropathy Registry in a Caribbean population, demonstrating a high predominance of SGD due to LN.

Introduction

The term glomerular disease refers to a group of pathologies that affect the structure and function of the glomeruli. The development of glomerular diseases involves a complex interplay of genetic, epigenetic, and environmental factors.[1] Primary glomerular diseases (PGDs) are a subgroup in which the glomerular injury is the result of a disease confined to the glomerulus, while in secondary glomerular diseases (SGDs), the glomerular injury is part of a systemic disease (lupus, sepsis,

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paraproteinemias, etc.).[2]

The clinical manifestations of the glomerular diseases are extremely variable from subclinical renal disorders (SRD) to nephrotic syndrome (NS), nephritic syndrome (NepS), acute kidney injury (AKI), and chronic kidney disease (CKD).[3] Regardless of the clinical presentation, renal biopsy is necessary as the main diagnostic method to assess the histopathology, severity, treatment, and prognosis of the glomerular diseases.[4]

Epidemiological aspects of glomerular diseases have been greatly facilitated by the development of registries in several countries.[4-10] Data from registries help to identify the glomerular disease frequency, causes, and relevant clinical, laboratorial, and histological features.[7,8] In Colombian Caribbean region, there are no studies which describe its glomerular disease histopathological profile. From 2008 to the present, the increasing concentration of renal biopsies in the department of pathology of a tertiary referral hospital of the Colombian Caribbean region has allowed to create the Colombian Nephropathy Registry (NEFRORED®).[11]

The aim of this study is to describe the PGDs and SGDs in the Colombian Caribbean from the NEFRORED® registry.

Materials and Methods

This was a descriptive and retrospective study restricted to the Colombian Caribbean region, which is located in the north of Colombia and is mainly composed of eight departments contiguous to the Caribbean. The patients were assessed by the nephrology department in a tertiary referral hospital located in Barranquilla, which is the main reference center of the Colombian Caribbean region since it provides specialized health care to both local subject and referrals from distant towns of the region.

All the studied patients were referred for renal biopsy due to a conventional clinical indication (e.g. hematuria and proteinuria), and they were included in "real time" into the NEFRORED® registry after signing the corresponding informed consent. NEFRORED® is an information and communications technology network developed by the Universidad Simón Bolívar of Barranquilla with the endorsement of the Colombian Association of Nephrology and Arterial Hypertension (ASOCOLNEF – Asociación Colombiana de Nefrología). In this registry, glomerular disease renal biopsies between January 2008 and June 2018 were included. Pregnant women, patients younger than 18 years of age, transplanted patients, and those with incomplete data in the NEFRORED® registry were excluded. Patient enrollment is depicted in Figure 1.

In this study, the breadth conceptual model whereby records contain all desired types of clinical data was used in order to properly capture the clinical state of all patients.[12] From each record, the following data were obtained: sociodemographic data (age and gender), known disease duration before the renal biopsy, syndromic diagnosis (SRD, NS, NepS, AKI, and CKD), and biochemical parameters (creatininemia, 24-h proteinuria, and urinalysis). All these data were collected at the diagnosis time. Pathohistological findings obtained by light microscopy (LM) and immunofluorescence (IF) through polyclonal antisera against immunoglobulin (Ig) G, IgM, IgA, C3, C1q, and kappa and lambda light chains were also registered in NEFRORED®. Electron microscopy (EM) was not used systematically.

Patients were classified according to the World

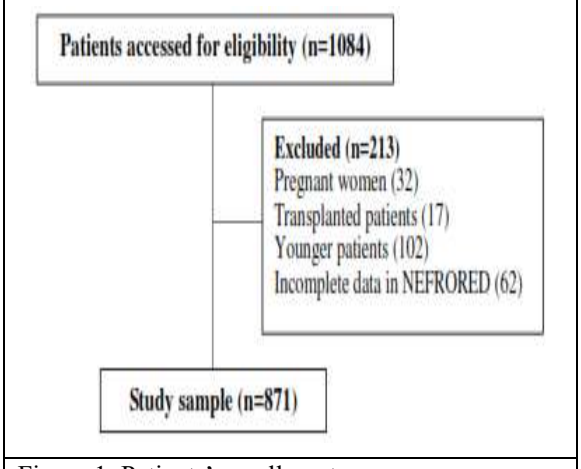

Figure 1. Patients' enrollment.

Health Organization into three age groups: young adults (18–44 years), middle-aged adults (45–64 years), and older adults (≥65 years). All patients signed their informed consent to be biopsied.

Renal biopsy was performed by nephrologists using an automated device with ultrasound guidance.[13] Samples with a minimum of eight glomeruli were analyzed by the nephropathologist.[14] The diagnostic criteria were uniform according to the guidelines of the International Society of Nephrology/Renal Pathology Society.[15,16] Finally, each clinical case was discussed by the nephrology team.[14]

Definitions

Renal biopsy indications were classified into five main diagnoses: SRD, NepS, NS, AKI, and CKD, which were defined as follows:

- SRDs were defined as: hematuria (≥3 red blood cells per microscopic low power field) and/or proteinuria in subnephrotic range (<3.5 g/24 h) and no clinical manifestations
- NS as proteinuria in nephrotic range (>3.5 g/24 h) with edema, low serum albumin (<3.5 g/dL), and dyslipidemia[17]
- NepS as renal hematuria (dysmorphic erythrocytes), hypertension, with or without proteinuria, and renal dysfunction[5,18]
- AKI was defined according to the Kidney Disease Improving Global Outcomes guidelines,[19] with changes that did not fit with NepS definition
- CKD was established by the persistence of an estimated glomerular filtration rate (eGFR) <60 mL/min/m^2 for a period longer than three months.[20]

Glomerular disease classification

The pathohistological findings were classified into two main categories: (a) PGD and (b) SGD.

a. PGDs were subcategorized as follows: (1) Focal segmental glomerulosclerosis (FSGS),[21] (2) membranoproliferative glomerulonephritis (MPGN),[22] (3) membranous nephropathy (MN),[23] (4) minimal change disease (MCD),[24] (5) IgA nephropathy (IgAN),[1] (6) mesangial glomerulonephritis non-IgA mediated,[25] (7) IgM nephropathy (predominance of IgM ≥2+ in more than 50% of the mesangium),[25] and (8) C1q nephropathy (C1qN) (mesangium deposition of C1q ≥2+ and absence of systemic lupus erythematosus).[25]

On the basis of the IF findings, MPGN was classified as immune complex-mediated, complement-mediated (C3 glomerulopathy), or negative IF,[22] C3 glomerulopathy was defined as the presence of dominant C3 staining (≥2 orders in magnitude compared to Igs) on IF microscopy, with minimal or no staining for immunoglobulins.[26] MPGN, FSGS, and MCD were defined when there was no identified secondary etiology.

Pathological features of different FSGS histological variants were defined according to the Columbia Working Classification[27] as follows: perihilar, cellular, collapsing, tip lesion, and not otherwise specified (NOS).

All patients were screened in order to exclude common secondary causes including hepatitis B, C, human immunodeficiency virus, and cytomegalovirus-related infection, diagnosis of type 1 or 2 diabetes mellitus, obesity, bisphosphonates and cyclooxygenase-2 inhibitor medication, lupus and malignancy (solid tumors).[21,23]

b. SGDs were subcategorized as follows: (1) Lupus nephritis (LN), (2) infection-mediated GN, (3) diabetic nephropathy, (4) paraproteinemias-mediated glomerular diseases (renal amyloidosis and multiple myeloma), (5) genetic nephropathies (Alport syndrome, thin basement membrane disease, or other hereditary pathologies), (6) cryoglobulinemia, and (7) vasculitis (microscopic polyangiitis, Wegener's granulomatosis, panarteritis nodosa, or anti-neutrophil cytoplasmic antibody [ANCA]-related vasculitis) were included.

Statistical Analysis

Categorical variables were analyzed through

absolute and relative frequencies. Range, mean, and mode were used to analyze the continuous variables. The Mann–Whitney test was used to compare the distribution of quantitative variables between PGD and SGD. Chi-square was tested when the variable was qualitative. Renal survival was evaluated by the Kaplan–Meier method. Differences between survival curves were calculated by log-rank sum testing from the time of baseline biopsy. A P <0.05 (by two-tailed testing) was considered to indicate statistical significance. Data were stored in a MySQL® database and then exported to R-CRAN statistical software.[28]

Results

One thousand and eighty-four renal biopsies were recorded in the NEFRORED® registry over a period of 10 years, of which 871 met the selection criteria (Figure 1). It documented a predominance of renal biopsies in young adults (66%) and female (67%) patients. The mean age was 39 ± 14 years. The most frequent renal biopsy indication was NepS (36%), followed by SRDs (31%) and NS (22%). Around 42% of patients had waited more than six months to perform a renal biopsy.

Table 1 presents evaluations of the epidemiological, clinical, and laboratory profiles of patients, according to glomerular disease etiology. There was a significant difference between PGD and SGD groups regarding gender, time to biopsy, serum creatinine, and proteinuria.

Primary glomerular diseases

Within PGDs 388/871 (45%), the main renal biopsy indication was NS (22%), and MN 128/388 (33%) was the most frequent PGD (Table 2 and Figure 2a).

On the basis of the IF findings in MPGN, 24/57 cases (42%) revealed complement-mediated C3 glomerulopathy, 15/57 (26%) were immune complex-mediated, and 18/57 (32%) cases revealed negative IF. A silver stain LM is presented in Figure 2b.

Frequencies of FSGS histological subtypes were as follows: NOS 34/75 (45%), cellular 17/75 (23%), perihilar 15/75 (20%), collapsing 5/75 (7%), and tip lesion 4/75 (5%)

Secondary glomerular diseases

SGDs 482/871 (55%) were the most frequent glomerular diseases. NepS was the main renal biopsy indication (36%). LN represented 83% of SGDs (Table 2) with a predominance of class IV (69%) (Figure 2c1, c2), followed by class III (19%). A detailed description of LN pathohistological pattern frequency is depicted in Figure 3.

Poststreptococcal GN 21/35 (60%) was the main etiology of infection-mediated GN; endocapillary GN with mesangial and capillary granular immune deposition was the main pathohistological finding in these cases.

Table 1. Primary and secondary glomerular disease distribution according to clinical and laboratory profiles.

Factor evaluated	Etiology		*P*
	Primary	Secondary	
Age±SD (years)	40±14.8	38±13.2	0.067
Sex, *n* (%)			
Male	204 (53%)	86 (18%)	<0.002[1]
Female	184 (47%)	397 (82%)	
Time to biopsy* (Months)	12.4±9.7	6.5±5.5	<0.002
Serum creatinine (mg/dL)	1.78±1.02	1.41±0.69	0.002
eGFR** (mL/min)	54.6±33.6	61.2±35.6	0.382
Proteinuria (g/24 h)	3.1±2.2	2.6±1.3	<0.001

[1]*P*-value of the Chi-square test, *Known duration of disease before doing renal biopsy, **eGFR was calculated applying MDRD (Modification of diet in renal disease) equation. eGFR: estimated glomerular filtration rate.

Table 2. Histological pattern distribution of the glomerular diseases according to clinical and laboratory profiles.

Primary glomerular diseases	No. of cases (%)	Age (year)	Male n (%)	Female n (%)	Time to biopsy* (Months)	SCr (mg/dL)	eGFR** (mL/min)	Proteinuria (g/24 h)
MN	128 (33%)	46±14.9	74 (58%)	54 (42%)	12.7±10.2	1.48±0.61	60.6±32.6	4.2±1.6
FSGS	75 (19%)	42±14.7	40 (53%)	35 (47%)	11.2±10.7	2.41±1.01	36.3±28.3	3.4±1.3
IgAN	63 (16%)	35±10.4	31 (49%)	32 (51%)	10.8±9.8	1.64±0.47	49.7±20.5	1.3±0.6
MPGN	57 (15%)	37±12.1	27 (47%)	30 (53%)	12.1±9.1	2.06±1.85	66.2±46.1	2.3±2.1
MesGN	40 (10%)	40±16.3	17 (43%)	23 (57%)	13.2±9.7	1.36±0.47	63.5±33.6	2.2±1.2
MCD	13 (3%)	27±8.5	9 (69%)	4 (31%)	14.3±8.9	1.74±0.36	50.6±17.8	3.9±1.5
IgMN	8 (2%)	42±17.7	5 (63%)	3 (37%)	11.7±9.2	1.13±0.22	73.4±23.4	3.1±2.6
C1qN	4 (1%)	47±19.8	1 (25%)	3 (75%)	8.5±5.6	1.62±0.21	42.4±12.3	2.4±1.2
Secondary glomerular diseases	**No. of cases (%)**	**Age (year)**	**Male n (%)**	**Female n (%)**	**Time to biopsy* (Months)**	**SCr (mg/dL)**	**eGFR** (mL/min)**	**Proteinuria (g/24 h)**
LN	402 (83%)	38±12.7	53 (13%)	349 (87%)	6.1±3.2	1.37±0.72	63.1±36.7	2.7±1.3
Infectious	35 (7%)	33±8.5	13 (37%)	22 (63%)	3.1±1.3	1.41±0.5	54.5±34.8	1.5±0.55
Diabetic nephropathy	27 (5%)	58±9.2	12 (44%)	15 (66%)	12.7±6.3	1.42±0.36	52.9±22.7	4.1±1.2
Paraproteinemias	7 (1%)	31±4.02	2 (29%)	5 (71%)	5 ±3.5	1.97±0.55	37.7±11.5	3.6±2.1
Vasculitis	6 (1%)	56±12.5	3 (50%)	3 (50%)	2.5 ±0.9	1.65±0.16	40.8±7.78	1.1±0.37
Congenital nephropathies	3 (1%)	33±7.03	2 (67%)	1 (33%)	49 ±7.87	1.16±0.31	74.1±17.6	1.4±0.75
Cryoglobulinemia	3 (1%)	30±5.6	1 (33%)	2 (67%)	29.7 ±9.7	1.8±0.33	39.4±7.55	1.8±1.5

*Known disease duration before the renal biopsy (Months), **eGFR was calculated by applying MDRD (Modification of diet in renal disease) equation, SCr: Serum creatinine, eGFR: estimated glomerular filtration rate, MN: Membranous nephropathy, FSGS: Focal segmental glomerulosclerosis, IgAN: IgA nephropathy, MPGN: Membranoproliferative glomerulonephritis, MesGN: Mesangial glomerulonephritis, MCD: Minimal change disease, IgMN: Immunoglobulin M nephropathy, C1qN: C1q nephropathy, LN: Lupus nephritis.

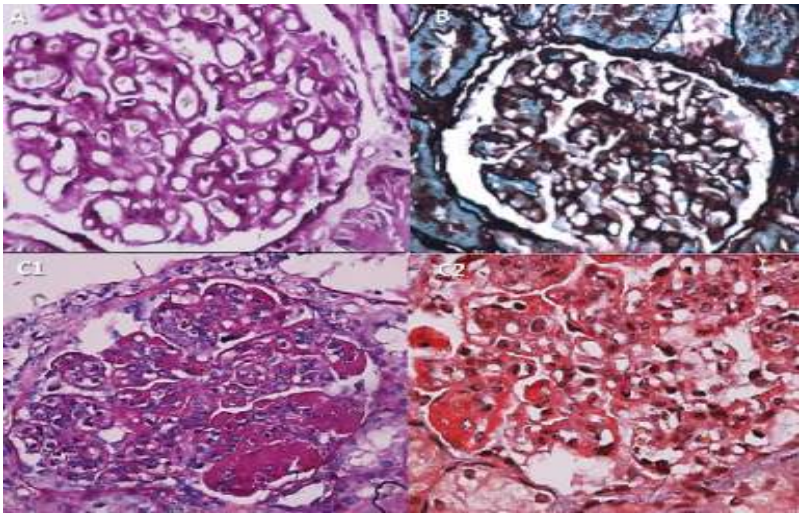

Figure 2. Light microscopy of the most frequent glomerular diseases, membranous nephropathy - H&E, membranoproliferative glomerulonephritis - silver stain (B), Class IV lupus nephritis - H&E (C1) and PAS (C2) stains.

Regarding paraproteinemia-mediated glomerular disease 7/482 (1%), five cases with renal amyloidosis revealed orange amorphous glomerular amyloid depositions, interstitial fibrosis, and inflammation. A crescentic pattern was observed in two cases with multiple myeloma.

Renal vasculitis 6/482 accounted for 1% of the SGDs and their histological patterns were as follows: three patients with ANCA-related vasculitis (extensive glomerulosclerosis), one patient with microscopic polyangiitis (interstitial fibrosis), one patient with panarteritis nodosa (glomerulosclerosis and tubular atrophy), and one patient with Wegener's granulomatosis (tubular atrophy).

Renal biopsy indication

The three main indications for renal biopsy were evaluated according to the pathohistological findings. In patients with NepS and SRD, the

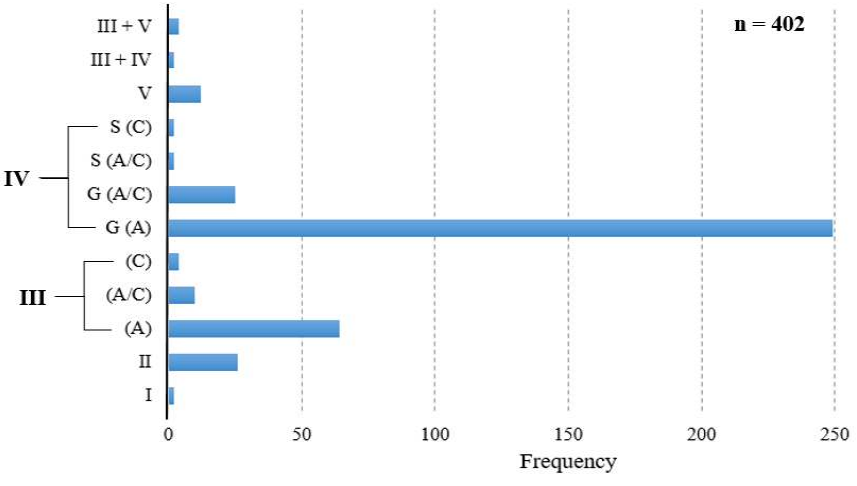

Figure 3. Lupus nephritis histopathological patterns frequency. International Society of Nephrology/Renal Pathology Society classification.[15,16]

Table 3. Clinical presentation of the glomerular diseases.

Glomerular diseases	No. of cases (%)
Nephritic syndrome	
LN	236 (70%)
IgAN	53 (16%)
Infectious	24 (7%)
MPGN	22 (6%)
MesGN	13 (4%)
Total	348 (100%)
Subclinical renal disorders	
LN	97 (53%)
FSGS	30 (16%)
MN	29 (16%)
MesGN	17 (9%)
IgAN	10 (5%)
Total	183 (100%)
Nephrotic syndrome	
MN	86 (50%)
FSGS	31 (18%)
LN	30 (17%)
Diabetic nephropathy	13 (8%)
MPGN	12 (7%)
Total	172 (100%)

LN: Lupus nephritis, IgAN: IgA nephropathy, MPGN: Membranoproliferative glomerulonephritis, MesGN: Mesangial glomerulonephritis, FSGS: Focal segmental glomerulosclerosis, MN: Membranous nephropathy.

main cause was LN. MN (50%) was the most common glomerular disease presented as NS (Table 3).

Renal survival

At the time of biopsy, 39 (4%) cases had CKD. During a 24-month follow-up, a total of 85 (9.7%) required renal replacement therapy. Renal survival was defined as progression to CKD. Figure 4 shows the renal survival curves for each glomerular disease histological pattern. The histological patterns associated with poorer renal prognosis were FSGS, IgAN, paraproteinemia-mediated glomerular disease, and vasculitis.

Discussion

NEFRORED® is the first Colombian Nephropathy Registry in a Caribbean population. Conversely to other studies,[8,29-31] this registry demonstrated a predominance of SGDs over PGDs (55% vs. 45%) due to the high frequency of LN. Within SGDs, LN accounted for 83% of the biopsies which is a higher proportion than other registries.[30,32] However, the lower frequency of the other glomerular diseases could have inflated the relative frequency of the LN in our population.

A comparative analysis of PGDs and SGDs encountered a similar mean age among the groups. In a subanalysis by age, in accordance with a Brazilian cohort by Polito et al,[33] PGDs prevailed in all age groups with a significant difference for patients aged ≤40 years.

The glomerular disease incidence varies according to the biopsy resources and policies. IgA has been documented as the most common PGD in eastern Asia, Europe, and North America,[6,29,34] while FSGS predominates in Africa, South America, and the Middle East.[21,31,33,35] Besides, in the last decades, it has been documented that there is a global trend toward the increase in the number of cases

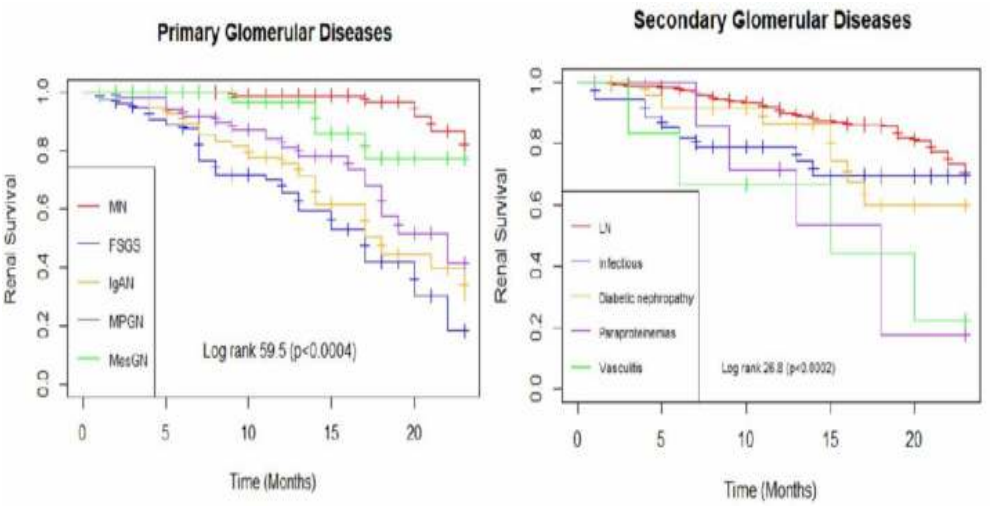

Figure 4. Kaplan–Meier analysis. Probability of progression to chronic kidney disease. Survival curves were statistically tested with log-rank test.

MN: Membranous nephropathy, FSGS: Focal segmental glomerulosclerosis, LN: Lupus nephritis, IgAN: Immunoglobulin A nephropathy, MPGN: Membranoproliferative glomerulonephritis, MesGN: Mesangial glomerulonephritis.

compatible with FSGS.[21,36] LN has been reported as the most frequent SGD in renal biopsy registries worldwide.[3-5,35,37]

In Latin America, the Brazilian Registry of glomerular diseases is the most extensive with a total of 9617 renal biopsies in which it was demonstrated that PGDs were more frequent than SGDs. Similar to our study, FSGS (24.6%) and MN (20.7%) were the most common PGDs. LN (45.5%) was the main etiology among SGDs, followed by postinfectious GN (18.9%). NS (39%) was the main clinical indication for renal biopsy.[33]

Data of 2561 glomerular disease diagnoses from three centers (Brazil, Colombia, and Mexico) revealed a higher frequency of LN (38%) compared to other registries worldwide.[1] In Asian countries such as China (45.2%), IgAN is the most frequent PGD. In Latin America (Table 4), the registries from Mexico (47%),[38] Brazil (43%),[33] and Uruguay (29.3%)[31] demonstrated the predominance of FSGS within PGDs, and conversely, the NEFRORED® registry revealed a high frequency of MN in our population, which is similar to some European series.[9,10] Many differences worldwide in specific prevalence or incidence of glomerular diseases can probably be explained by the fact that some centers only take biopsies when the histological diagnosis would affect the treatment or when the patients have a high risk to present a progressive renal disease.[5,39]

In Colombia Caribbean region, it was revealed that MN was the most frequent PGD. However, in both registries demonstrated high frequency of LN (17.8% vs. 46.1%).[40]

The reason for the high prevalence of LN and MN within renal biopsies is unknown; however, it is possible that genetic, environmental factors, multiethnicity, or the elevated frequency of infections in our population are associated with this phenomenon.[39] The ethnic group heterogeneity and the high frequency of LN and proliferative classes have influenced poor outcomes.[41-43] The population of the Colombian Caribbean region consists of a pluriethnic mix gene pool and it is the result of the crossover of native Latin-Americans, Europeans, and Afro-descendent.[44,45]

Within renal biopsies performed due to NepS and SRD, LN was the most frequent cause and it differs from other series[29,33] in which IgAN

Table 4. Epidemiology of the most frequent primary glomerular diseases and secondary glomerular diseases in Latin America.

Author (year)	No. of biopsies[#]	Region/ Country	Biopsy date-ranges	PGD (%)	SGD (%)
Kasamatsu et al[4]	1072	Paraguay	1989–2005	**MesGN** (39.8)	**LN** (85.9)
Costa et al[5]	1151	Northeast of Brazil	1998–2016	**FSGS** (43)	**LN** (67)
Polito et al[33]	9617	Brazil	1993–2007	**FSFS** (26.6)	**LN** (45.5)
Malafronte et al[8]	2086	Southeast of Brazil	1999–2005	**FSFS** (29.7)	**LN** (66.2)
Mazzuchi et al[31]	2058	Uruguay	1980–2003	**FSFS** (32.6)	**Vasculitis** (38.7)
Chávez-Valencia et al[38]	163	Mexico	2003–2011	**FSFS** (47)	**LN** (14)
Arias et al[39]	1040	Northwestern of Colombia	1998–2007	**FSFS** (34.8)	**LN** (17.8)

PGD: Primary glomerular disease, SGD: Secondary glomerular disease, MesGN: Mesangial glomerulonephritis, LN: Lupus nephritis, FSGS: Focal segmental glomerulosclerosis.
[#]Total biopsy reports by each study.

was the main glomerular disease associated with both clinical presentations. In the Italian registry, IgAN was the most frequent PGD and the most common clinical presentation was NepS and SRD. Rivera et al[46] demonstrated in a Spanish cohort of 8722 renal biopsies that IgAN was the main etiology of SRD in all age groups.

At the 24-month follow-up, the patients with FSGS had the worst renal survival prognosis. A Korean cohort, which included 111 patients,[47] revealed that perihilar pattern had less probability to achieve complete or partial remission of renal function. Renal function marked the prognosis of the patients. A further study is required in order to identify the FSGS histological pattern more associated with poor prognosis in our region.

In this study, the limitations were as follows: On one hand, EM was not systematically used, and on the other hand, due to the lack of standard methods for clinical measurement of GFR, such as inulin or iothalamate clearances, serum creatinine and creatinine-based eGFR were used for monitoring patients' GFR.[48]

This is the first Colombian Nephropathy Registry in a Caribbean population as a contribution to the understanding of the glomerular disease profile in Colombian Caribbean, demonstrating a high predominance of SGD due to LN, with possible implications on the planning of health politics, as glomerular diseases are among the main causes of stage 5 CKD[49,50] and could also result in benefits in patient care.

Data Availability

The pathological reports of the 871 records with GD-diagnosed biopsies and their medical records were available at the NEFRORED® database. This study was conducted in accordance with the World Medical Association Declaration of Helsinki principles and ethical approval was obtained as per the Clinica de la Costa protocols.

Compliance with Ethical Standards

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments

or comparable ethical standards.

Informed consent: Informed consent was obtained from the patients.

Conflict of interest: None declared.

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