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Clinicopathological and laboratory profile of infection-related glomerulonephritis in children. A prospective observational study.

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Abstract

Background

Infection-related glomerulonephritis (IRGN) remains an important cause of acute nephritic syndrome in children and continues to contribute to admissions for hypertension, edema, and renal dysfunction in many low- and middle-income settings.

Objectives: To describe the clinicopathological and laboratory profile of pediatric IRGN and to document early outcomes over six weeks.

Methods

A prospective observational study was conducted in a tertiary pediatric unit from August 2022 to February 2024. Children aged 1 month to 18 years presenting with acute nephritic features suggestive of IRGN were enrolled. Urinalysis, spot urine protein–creatinine ratio, renal function tests, complement (C3/C4), and antistreptolysin O (ASO) titres were obtained, and renal biopsy was performed when clinically indicated. Participants were followed for six weeks.

Results

A total of 158 children were included (mean age 7.87 ± 3.50 years). Antecedent infection was documented in 79.1%. Hematuria occurred in 89.9%, oliguria in 70.3%, and hypertension in 55.1%. Low complement levels were observed in 58.2% and ASO titres were positive in 62.0%. Renal biopsy was required in 12.0% and commonly showed proliferative patterns. At six weeks, complete recovery occurred in 67.1%; persistent hematuria, persistent proteinuria, and persistent hypertension were noted in 17.7%, 8.2%, and 7.0%, respectively.

Conclusion

Pediatric IRGN showed a predominantly nephritic presentation with frequent complement activation and generally favorable short-term outcomes. Early recognition of severe features and structured follow-up help detect complications and residual abnormalities.

Recommendations

Standardize early testing for proteinuria and complement status, and prioritize rapid blood pressure control and fluid management. Arrange follow-up visits to confirm resolution of hematuria, proteinuria, and hypertension.

Keywords: infection-related glomerulonephritis; acute nephritic syndrome; children; complement; antistreptolysin O; renal biopsy; outcomes.
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Introduction

Infection-related glomerulonephritis (IRGN) refers to glomerular inflammation that follows or accompanies an infection and most often presents as acute nephritic syndrome. In children, acute post-streptococcal glomerulonephritis remains the classical prototype, usually occurring after pharyngitis or impetigo and manifesting with hematuria, edema, hypertension, and variable reduction in renal function [2,3]. Although the burden has fallen in many high-income regions, IRGN continues to be encountered in low- and middle-income settings where streptococcal transmission, skin infections, crowding, and delayed access to treatment persist [3,4].

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Pathogenesis involves immune-complex formation with complement activation and inflammatory recruitment within glomeruli. Reduced complement—particularly low C3—is a characteristic supportive feature and typically normalizes over weeks as inflammation resolves [2,11]. Persistently low complement or atypical clinical behavior raises concern for alternative pathway dysregulation and overlap with complement-mediated glomerular diseases; pediatric mechanistic studies have described transient antibodies affecting alternative pathway proteins during acute postinfectious nephritis [12,14].

The clinical spectrum ranges from mild microscopic hematuria to severe disease with oliguria, fluid overload, hypertensive emergencies, pulmonary edema, and acute kidney injury. Management is primarily supportive with salt and fluid restriction, judicious diuretic use, and antihypertensive therapy; antimicrobials are used to treat active infection when identified [2,6]. Short-term outcomes in children are often favorable, but persistent microscopic hematuria, proteinuria, or hypertension can continue beyond the acute phase and warrants structured follow-up and counseling [9,10].

Renal biopsy is not routinely required in typical presentations, but it remains important in atypical cases, nephrotic-range proteinuria, severe renal dysfunction, delayed complement recovery, or diagnostic uncertainty. Contemporary guidance and biopsy series highlight that proliferative and crescentic lesions are enriched in these higher-risk presentations and inform follow-up intensity [1,5]. Pediatric biopsy literature also recognizes infection-associated IgA-dominant patterns, emphasizing the need for careful clinicopathologic correlation in suspected IRGN [13].

Prospective pediatric series from endemic regions emphasize that early cardiovascular and neurological complications are closely linked to severe hypertension and oliguria at presentation, while overall renal recovery is usually good with supportive care [6,8]. However, persistent microscopic hematuria, low-grade proteinuria, or hypertension can remain after discharge, reinforcing the need for follow-up and clear counseling on monitoring and adherence [9,10].

Referral centers often manage a more severe end of the disease spectrum, making local prospective data valuable for quantifying complications and early residual abnormalities. The objectives of this study were to describe demographic distribution, antecedent infections, clinical presentation, and laboratory profile (including complement and ASO titres), to summarize biopsy findings in clinically indicated cases, and to assess outcomes at six weeks, including persistent hematuria, proteinuria, and hypertension.

Materials and Methods

Study design and setting

A hospital-based prospective observational study was conducted in the Department of Paediatrics, Osmania Medical College/Institute of Women and Child Health, Niloufer Hospital, Hyderabad, Telangana, India. The study was carried out from August 2022 to February 2024 and included children admitted to paediatric inpatient wards as well as the Pediatric Intensive Care Unit (PICU).

Niloufer Hospital is a major government-funded tertiary care teaching institution affiliated with Osmania Medical College. It functions as a high-volume referral centre for maternal and child health services across Telangana and neighbouring regions. The hospital provides comprehensive paediatric subspecialty services, including paediatric nephrology, neonatology, paediatric critical care, cardiology, neurology, infectious diseases, and paediatric surgery. It serves a predominantly urban and semi-urban population while also receiving referrals from rural districts, thereby managing a broad clinical spectrum of paediatric renal disorders.

Study Sample Size

The sample size was calculated using the formula for estimating a single proportion in descriptive studies:

$$n = Z^2 \times p \times q / d^2$$

Where Z = 1.96 for a 95% confidence level, p = anticipated proportion (assumed as 50% in the absence of precise regional estimates to obtain maximum sample size), q = 1 − p, and d = allowable error (8%).

$$n = (1.96)^2 \times 0.5 \times 0.5 / (0.08)^2$$

$$n = 3.84 \times 0.25 / 0.0064$$

$$n \approx 150$$

Allowing for incomplete data and potential attrition, the final sample size was rounded to 158 children.

Participants

Children aged 1 month to 18 years presenting with features of acute nephritic syndrome suggestive of infection-related glomerulonephritis were screened consecutively during the study period. Inclusion criteria comprised acute onset hematuria accompanied by hypertension and/or oliguria, supported by relevant clinical and laboratory findings.

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Children with previously diagnosed chronic kidney disease, congenital renal anomalies, or known primary glomerular disorders were excluded. Written informed consent was obtained from parents or legal guardians prior to enrolment.

Case definition and sampling

Consecutive eligible admissions fulfilling the inclusion criteria were enrolled. Antecedent infection was documented based on clinical history and available medical records. Infection-related glomerulonephritis was considered when nephritic manifestations were temporally associated with a preceding infection and supported by evidence of complement consumption and/or positive streptococcal serology, when available. Admission to intensive care was determined according to established unit protocols in cases of severe hypertension, respiratory distress, altered sensorium, marked oliguria, or significant fluid overload.

Clinical assessment and definitions

A structured proforma captured demographics, symptoms, antecedent infections, physical examination, and blood pressure profiles. Hypertension was documented using age-appropriate cuffs and interpreted using standard pediatric thresholds. Oliguria and fluid status were assessed clinically and by intake–output monitoring. Complications were recorded during hospitalization and early follow-up, including congestive cardiac failure, encephalopathy, retinopathy, and acute kidney injury.

Laboratory investigations

Investigations included urine routine and microscopy, renal function tests, serum electrolytes, serum proteins, complete blood count, and inflammatory markers (C-reactive protein and erythrocyte sedimentation rate). Proteinuria was quantified using spot urine protein–creatinine ratio (UPCR). Complement components (C3 and C4) and antistreptolysin O (ASO) titres were measured as part of the etiological work-up.

Renal biopsy and histopathology

Renal biopsy was performed when clinically indicated for atypical course, nephrotic-range proteinuria, significant renal dysfunction, delayed complement recovery, or diagnostic uncertainty, consistent with standard approaches [1,5]. Histopathology reports were categorized into major diagnostic patterns for descriptive analysis.

Treatment and follow-up

All children received supportive management focusing on salt and fluid restriction, diuretics when indicated, and antihypertensive treatment. Children were followed for six weeks with repeat clinical evaluation and urine and blood pressure assessment. Outcomes at six weeks were categorized as complete recovery or persistence of hematuria, proteinuria, or hypertension.

Statistical analysis

Data were entered in Microsoft Excel 2010 and analyzed using Microsoft Excel and Epi Info 7.2.0. Continuous variables are presented as mean ± standard deviation with range, and categorical variables as number and percentage. Chi-square testing was used for categorical comparisons, and Student's t-test was applied for continuous comparisons where appropriate. Statistical significance was set at $p < 0.05$.

Ethical Considerations: Ethical approval was obtained from the Institutional Ethics Committee, Osmania Medical College/Institute of Women and Child Health, Niloufer Hospital, Hyderabad. Confidentiality was maintained throughout data collection and reporting.

Results

A total of 158 children with infection-related glomerulonephritis (IRGN) were enrolled. The cohort had a mean age of 7.87 ± 3.50 years (range 1 month–18 years), with the 6–10-year group forming the largest proportion. A slight male predominance was observed **(**53.16%**)** (Table 1).

Table 1. Baseline demographic characteristics (n=158)

Characteristic	n / value	%
Age (years), mean ± SD	7.87 ± 3.50	
Age range	1 month–18 years	
Age group: 1 month–5 years	40	25.32
Age group: 6–10 years	79	50.00
Age group: 11–15 years	35	22.15
Age group: 16–18 years	4	2.53
Sex: Male	84	53.16
Sex: Female	74	46.84

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Antecedent infection was documented in 125 children (79.11%), indicating a clear temporal link with recent infective episodes in most participants (Table 2).

Table 2. Antecedent infection history in the study population (n=158)

Antecedent infection	N	%
Yes	125	79.11
No	33	20.89

Among those with antecedent infection, skin infection (34.40%) and pharyngitis (17.60%) were the leading triggers, followed by urinary tract infection and lower respiratory tract infection, reflecting the broad infective spectrum preceding IRGN in this cohort (Table 3).

Table 3. Type of antecedent infection among those with antecedent infection (n=125)

Infection type (among antecedent infection cases)	N	%
Skin infection	43	34.40
Pharyngitis	22	17.60
Urinary tract infection	17	13.60
Lower respiratory tract infection	9	7.20
Gastroenteritis	6	4.80
Malaria	5	4.00
Typhoid	4	3.20
Measles	4	3.20
Otitis media	4	3.20
Cellulitis	3	2.40
Varicella	2	1.60
Upper respiratory tract infection	2	1.60
Dental caries	2	1.60
Osteomyelitis	1	0.80
Scrub typhus	1	0.80

At presentation, hematuria was the predominant clinical feature (89.87%). Oliguria (70.25%) and hypertension (55.06%) were also frequent, indicating a substantial burden of nephritic severity and fluid–pressure dysregulation.

Proteinuria quantified by spot UPCR showed a mean of 1.01, median of 0.50, and a wide range (0.1–8.4), demonstrating heterogeneity from mild to heavy protein loss (Table 4).

Table 4. Clinical features at presentation and proteinuria (n=158)

Clinical feature / parameter	n / value	%
Hematuria	142	89.87
Oliguria	111	70.25
Hypertension	87	55.06
UPCR (mean)	1.01	
UPCR (median)	0.50	
UPCR (range)	0.1–8.4	

Serological evaluation showed ASO titre positivity in 62.03%, supporting streptococcal association in a majority. Low complement (C3 and/or C4) levels were present in 58.23%, consistent with complement activation in IRGN, while 41.77% had normal complement levels (Table 5).

Renal biopsy was required in 19 children (12.03%), implying a subset with atypical course, severity, or diagnostic requirement (Table 6).

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Table 5. Serological profile (n=158)

Serological parameter	N	%
ASO titres: Positive	98	62.03
ASO titres: Negative	60	37.97
Complement: Low C3 and/or C4	92	58.23
Complement: Normal	66	41.77

Table 6. Requirement of renal biopsy (n=158)

Renal biopsy	N	%
Biopsy required	19	12.03
Biopsy not required	139	87.97

Histopathological assessment among biopsied cases showed diffuse proliferative GN (36.84%) and crescentic GN (36.84%) as the most frequent patterns, together comprising nearly three-fourths of biopsy diagnoses. Mesangial proliferative GN and membranoproliferative GN were less common, and minimal change disease was rare (Table 7).

Table 7. Histopathological diagnosis among biopsied cases (n=19)

Histopathological diagnosis (biopsied cases)	N	%
Diffuse proliferative GN	7	36.84
Crescentic GN	7	36.84
Mesangial proliferative GN	2	10.53
Membranoproliferative GN	2	10.53
Minimal change disease	1	5.26

Complications occurred in 26 children (16.46%), indicating clinically significant morbidity in a subset. Congestive cardiac failure (42.31%) was the most frequent complication among complicated cases, followed by encephalopathy (26.92%), while retinopathy and acute kidney injury were each documented in 15.38% (Table 8).

Table 8. Complications during follow-up and their distribution (n=158; complication types among n=26)

Complication / status	N	%
Complications present	26	16.46
No complications	132	83.54
Type: Congestive cardiac failure	11	42.31
Type: Encephalopathy	7	26.92
Type: Retinopathy	4	15.38
Type: Acute kidney injury	4	15.38

At six weeks, complete recovery was documented in 67.09% of children. However, residual abnormalities persisted in a notable minority: persistent hematuria (17.72%), persistent proteinuria (8.23%), and persistent hypertension (6.96%), demonstrating incomplete resolution in some cases despite short-term follow-up (Table 9).

Table 9. Outcomes at 6 weeks (n=158)

Outcome at 6 weeks	N	%
Complete recovery	106	67.09
Persistent hematuria	28	17.72
Persistent proteinuria	13	8.23
Persistent hypertension	11	6.96

On bivariate analysis, hypertension ($p = 0.020$), oliguria ($p < 0.001$), and renal biopsy requirement ($p < 0.001$) showed statistically significant associations with outcomes, indicating that clinical severity markers and need for biopsy correlated with outcome distribution. In contrast, hematuria, low complement, and ASO titres were not significantly associated with outcomes in this analysis (Table 10).

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Original Article

Table 10. Association between selected variables and outcomes (chi-square test)

Variable	p-value	Interpretation (α=0.05)
Hypertension	0.0200	Significant
Oliguria	<0.001	Significant
Hematuria	0.2360	Not significant
Low complement levels	0.2350	Not significant
ASO titres	0.3500	Not significant
Renal biopsy requirement	<0.001	Significant

$p < 0.05$ considered statistically significant.

Discussion

In this prospective cohort of 158 children with infection-related glomerulonephritis (IRGN), school-age children constituted the largest proportion of cases, and males showed a slight predominance. Antecedent infection was documented in nearly four-fifths of participants, with skin infections and pharyngitis representing the most frequent triggers. These findings reinforce the classical epidemiologic pattern of postinfectious nephritic syndromes described in paediatric populations, particularly in regions where streptococcal transmission remains prevalent [2,3,4]. The predominance of school-age children likely reflects increased exposure to group A streptococcal infections in community and school settings, while the mild male excess has been attributed in prior reports to behavioural and exposure-related factors [3,8].

Clinically, the phenotype was predominantly nephritic. Hematuria was observed in almost all children, while oliguria and hypertension were common at presentation. A notable proportion developed complications such as congestive cardiac failure and hypertensive encephalopathy, underscoring the burden of acute volume overload and severe blood pressure elevation. These observations are consistent with the pathophysiological basis of IRGN, where immune complex deposition triggers glomerular inflammation, reduced filtration, and salt–water retention [2,6]. The complication profile in this cohort parallels earlier Indian and international series, which have highlighted hypertension and fluid overload as major drivers of early morbidity [6,8]. The relatively high frequency of such complications may reflect delayed presentation, referral bias to a tertiary centre, and limited early access to primary care in certain catchment areas.

Serologically, a substantial proportion of children demonstrated elevated antistreptolysin O titres and low complement C3 levels, supporting an infection-related immune mechanism. Complement consumption is a hallmark of postinfectious nephritis and typically normalizes during recovery [2,11]. In the present study, however, complement status was not significantly associated with short-term outcome categories, whereas clinical markers such as oliguria and hypertension were associated with early outcomes. This suggests that dynamic bedside indicators of severity may better predict short-term recovery than isolated serological parameters. Similar observations have been noted in paediatric cohorts where initial renal dysfunction and blood pressure levels correlated more strongly with prognosis than complement levels alone [12,14]. Complement estimation nevertheless remains clinically relevant for etiological confirmation and for identifying atypical or non-resolving cases.

Renal biopsy was performed in a minority of children and predominantly revealed diffuse proliferative patterns, with occasional crescentic changes. This distribution is expected because biopsy is generally reserved for severe, atypical, or non-resolving presentations. Current recommendations support histopathological evaluation when nephrotic-range proteinuria, severe renal impairment, persistent hypocomplementemia, or diagnostic uncertainty is present [1,5]. Comparable biopsy profiles have been described in paediatric IRGN studies, including reports of infection-associated IgA-dominant lesions, emphasizing the need for clinicopathologic correlation to guide management and follow-up intensity [13].

At six weeks, the majority of children achieved complete clinical and biochemical recovery, whereas a smaller subset had persistent microscopic hematuria, proteinuria, or hypertension. This recovery pattern aligns with established literature indicating that most children experience favourable short-term outcomes, although urinary abnormalities may persist transiently after resolution of overt nephritic features [9,10]. The persistence of these abnormalities likely reflects ongoing but resolving glomerular repair processes rather than active disease. These findings underscore the importance of structured follow-up with blood pressure monitoring and urine analysis, particularly for children who initially present with oliguria, significant hypertension, or histopathological severity.

Overall, the study demonstrates that IRGN in this tertiary care cohort largely follows the classical clinical course described in paediatric nephrology literature, with favourable

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Original Article

short-term outcomes in most cases. However, the presence of early complications and the association of oliguria and hypertension with outcomes highlight the need for prompt recognition, aggressive supportive care, and systematic follow-up in resource-variable settings [2,6,9].

Generalizability

This cohort represents hospitalized children in a tertiary referral centre, including those requiring intensive care, and therefore reflects a more severe spectrum of infection-related glomerulonephritis than typically seen in community settings. Higher rates of complications, intensive monitoring, and renal biopsy are expected in such settings due to referral bias and delayed presentation. Mild cases managed at primary or secondary levels may be underrepresented. Nevertheless, the distributions of antecedent infections, complement abnormalities, and early residual urinary findings are consistent with established epidemiology. Thus, the findings are generalizable to similar tertiary care centres in resource-limited regions for guiding management and follow-up.

Conclusion

This prospective study of 158 children with infection-related glomerulonephritis showed predominance in school-aged patients with a slight male excess. Antecedent infection was frequent, and hematuria with oliguria and hypertension formed the common presentation. Low complement levels and positive ASO titres supported an infection-related etiology in many cases. Renal biopsy was required in a small subset and commonly revealed proliferative lesions, including crescentic patterns. By six weeks, most children achieved complete recovery, while residual hematuria, proteinuria, or hypertension persisted in a minority. Oliguria, hypertension, and biopsy requirement were associated with outcomes, supporting early risk stratification and structured follow-up after discharge. Planned follow-up beyond six weeks ensures resolution and identifies residual disease.

Limitations

Limitations include a single-center tertiary inpatient sample, which under-represents milder community cases. Follow-up was limited to six weeks and does not quantify longer-term persistence of urinary abnormalities or chronic kidney disease. Microbiological confirmation of antecedent infection was not uniform, and attribution relied on history and serology. Serial complement recovery was not available for every participant, and post-discharge adherence was not measured.

Recommendations

Implement a standardized IRGN assessment bundle: urinalysis, renal function, UPCR, C3/C4, and ASO titres at admission. Monitor blood pressure frequently and treat hypertension and fluid overload promptly to prevent cardiac failure and neurological complications. Reserve renal biopsy for atypical presentation, nephrotic-range proteinuria, severe renal dysfunction, or delayed complement recovery. Schedule follow-up visits at 6–8 weeks and again at 3 months to document resolution of hematuria, proteinuria, and hypertension. Strengthen prevention and early treatment of skin and throat infections at primary care level through caregiver education and clear referral pathways. Document complement recovery when complement is low at baseline.

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Abbreviations

AKI – Acute kidney injury

APSGN – Acute post-streptococcal glomerulonephritis

ASO – Antistreptolysin O

BP – Blood pressure

C3 – Complement component 3

C4 – Complement component 4

CRP – C-reactive protein

ESR – Erythrocyte sedimentation rate

GN – Glomerulonephritis

IRGN – Infection-related glomerulonephritis

PICU – Pediatric intensive care unit

UPCR – Urine protein–creatinine ratio

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Conflict of interest

The authors declare no conflict of interest.

Author contributions

TH-Concept and design of the study, results interpretation, review of literature and preparing first draft of manuscript. Statistical analysis and interpretation, revision of manuscript. **ABS-**Concept and design of the study, results interpretation, review of literature and preparing first draft of manuscript. Statistical analysis and interpretation, revision of manuscript. **RCJ-**Review of literature and preparing first draft of manuscript. Statistical analysis and interpretation.**PS-**Concept and design of the study, results interpretation, review of literature and preparing first draft of manuscript.

Data availability: Data is available on request

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Original Article

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