



# Epidemiology and Clinical Characteristics of Pediatric Acute Postinfectious Glomerulonephritis in Montenegro: A Nationwide Retrospective Study

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Acute postinfectious glomerulonephritis (APIGN) remains a leading cause of acute nephritic syndrome in children, particularly in low- and middle-income countries.<sup>1,2</sup> Although its incidence has declined markedly in high-income regions, APIGN continues to reflect disparities in socioeconomic status, access to primary healthcare, and the effectiveness of prevention and early treatment of common infectious diseases.<sup>3-5</sup> Data from the Balkan region are limited, with most studies being single-center or including mixed adult and pediatric populations.<sup>6-8</sup> To date, no nationwide pediatric data from Montenegro have been reported.

We retrospectively reviewed medical records of patients under 16 years of age diagnosed with APIGN and treated at the Institute for Children's Diseases, Clinical Center of Montenegro—the country's only tertiary pediatric referral center—between 2006 and 2022. The study was approved by the Ethical Committee of the Clinical Center of Montenegro (approval number 03/01-6507/1, date: 21.03.2025). Because all children in Montenegro requiring hospital-based nephrology care are treated at this facility, this cohort provides a comprehensive overview of the national pediatric burden of APIGN. Clinical, laboratory, and demographic data were extracted from medical records. Diagnosis was based on evidence of acute nephritic syndrome following a documented infection.<sup>1,5</sup>

A total of 64 children were included. Based on an estimated pediatric population of 100,000–120,000, the average annual incidence was approximately four cases per 100,000 children, consistent with other middle-income countries and substantially higher than rates reported in high-income regions.<sup>2,9</sup> Most patients were boys (73%), with a median age of 7.8 years. APIGN was uncommon in children under three years, consistent with previous observations that immune

system maturity influences disease susceptibility.<sup>5</sup> A clear seasonal pattern emerged, with the majority of cases occurring in autumn and winter, coinciding with increased circulation of respiratory infections and closer contact among children in schools and kindergartens.<sup>4,10</sup>

Signs of preceding infection were observed in most patients.  $\beta$ -hemolytic streptococcus was implicated in over 75% of cases, and 82% of patients had elevated anti-streptolysin O titers, confirming that acute poststreptococcal glomerulonephritis is the predominant cause.<sup>3,5,9</sup> This pattern aligns with findings from neighboring Balkan countries and other middle-income regions, where streptococcal infections remain a major public health concern.<sup>7-9</sup> These results underscore the ongoing importance of early detection and prompt treatment of streptococcal infections in primary care.

Hematuria was nearly universal at presentation. Approximately three-quarters of patients exhibited edema, hypertension, and oliguria. Hypertension, a major contributor to neurological and cardiovascular complications, was present in nearly 75% of cases. Although more than half of the children experienced mild to moderate complications, the frequency and spectrum of complications were similar to those reported previously.<sup>10-12</sup> Acute kidney injury affected nearly two-thirds of patients. Extrarenal manifestations included ascites (21%), pleural effusion (16%), hepatomegaly (14%), splenomegaly (5%), and neurological symptoms such as convulsions (8%) and encephalopathy (14%). Despite these complications, none required dialysis, and all patients recovered renal function during hospitalization, indicating favorable short-term outcomes.

Hypocomplementemia was a prominent laboratory feature in our cohort. Decreased C3 levels were observed in over 90% of patients,



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whereas C4 levels were reduced in approximately one-quarter. Notably, lower C3 values tended to occur in children with acute kidney injury and those presenting with more severe clinical manifestations, suggesting a link between complement consumption and disease activity. Although these associations did not reach statistical significance, the observed trend is biologically plausible and aligns with the immune-mediated pathogenesis of APIGN, in which complement activation and deposition at the glomerular basement membrane play a central role.<sup>13,14</sup> A small proportion of patients had normal C3 levels at presentation, confirming that normal complement levels do not exclude the diagnosis of APIGN.<sup>5,13</sup> Collectively, these findings support the potential utility of serum C3 as a marker of disease severity and highlight the need for prospective studies to further evaluate its prognostic value in pediatric APIGN.

Approximately 10% of patients exhibited nephrotic-range proteinuria, consistent with or slightly exceeding rates reported in previous pediatric studies.<sup>10,11,15</sup> This observation underscores

**TABLE 1.** Demographic, Clinical, and Laboratory Features of Children with Acute Postinfectious Glomerulonephritis in Montenegro (n = 64).

#### Demographic characteristics

Male sex, n (%)	47 (73%)
Age, median (years)	7.8
Estimated annual incidence	~ 4 per 100,000 children
Seasonal predominance	Autumn/winter
Evidence of preceding infection	
β-hemolytic streptococcus infection, n (%)	> 75%
Elevated ASO titer, n (%)	82%

#### Clinical presentation

Hematuria, n (%)	~ 100%
Edema, n (%)	~ 75%
Hypertension, n (%)	~ 75%
Oliguria, n (%)	~ 75%
Nephrotic-range proteinuria, n (%)	~ 10%

#### Complications

Acute kidney injury, n (%)	~ 66%
Ascites, n (%)	21%
Pleural effusion, n (%)	16%
Hepatomegaly, n (%)	14%
Splenomegaly, n (%)	5%
Convulsions, n (%)	8%
Encephalopathy, n (%)	14%
Dialysis required	0

#### Laboratory findings

Decreased C3, n (%)	> 90%
Decreased C4, n (%)	~ 25%

ASO, anti-streptolysin O.

the broad clinical spectrum of APIGN, ranging from mild nephritic syndrome to cases with nephrotic features. The frequency of extrarenal complications was higher than previously reported, potentially reflecting referral bias at a tertiary care center, increased diagnostic vigilance, or delayed presentation in some cases.<sup>12</sup> Laboratory and clinical data are summarized in Table 1 as median values or n (%).

This study represents the first comprehensive nationwide analysis of pediatric APIGN in Montenegro. Our findings indicate that APIGN remains common and exhibits epidemiological and clinical patterns similar to those reported in other middle-income countries.<sup>2,6,10</sup> The apparent decline in case numbers in recent years may reflect improved access to primary healthcare, greater availability of microbiological testing, and earlier initiation of appropriate antibiotic therapy.<sup>4,5</sup> The limitations of this study include its retrospective design and the absence of long-term follow-up. Future prospective research should focus on long-term renal outcomes, recovery trajectories, and predictors of persistent hypertension or proteinuria.<sup>11,15</sup> Nevertheless, these data provide valuable regional insights and reinforce APIGN as a significant marker of pediatric public health in the Balkans.

**Ethics Committee Approval:** The study was approved by the Ethical Committee of the Clinical Center of Montenegro (approval number 03/01-6507/1, date: 21.03.2025).

**Informed Consent:** Retrospective study.

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