Original Article

A Study to Estimate the Proportion and Factors Associated with Hypertension in Paediatric Nephrotic Syndrome Patients in a Tertiary Care Centre

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Abstract

Background: Nephrotic syndrome (NS) is a common pediatric renal disorder characterized by proteinuria, hypoalbuminemia, edema, and hyperlipidemia. Hypertension is an important but often under-recognized comorbidity that may contribute to long-term cardiovascular complications. **Material and Methods:** A hospital-based cross-sectional observational study was conducted among 54 children aged 1–18 years with nephrotic syndrome admitted to a tertiary care center. Detailed clinical evaluation, laboratory investigations, and blood pressure assessment using standard pediatric guidelines were performed. Hypertensive patients underwent echocardiographic evaluation for cardiac end-organ damage. Statistical analysis was performed using appropriate tests, with $p < 0.05$ considered significant. **Results:** The prevalence of hypertension was 24.07% (13/54). Sociodemographic factors such as age, gender, and socioeconomic status were not significantly associated with hypertension ($p > 0.05$). Clinical variables showed strong associations, with hypertension being more common in steroid-dependent nephrotic syndrome (69.2%), frequent relapses (76.9%), higher relapse frequency, poor compliance (69.2%), immunomodulator use (53.8%), and prolonged steroid therapy >6 months (90.0%) ($p < 0.05$). Laboratory parameters, including serum albumin, cholesterol, creatinine, and eGFR, were comparable between groups. Echocardiography revealed left ventricular hypertrophy in only one patient (8.3%), with no cases of concentric hypertrophy. **Conclusion:** Hypertension affects nearly one-fourth of children with nephrotic syndrome and is primarily associated with disease severity and treatment-related factors rather than demographic or laboratory variables. Early detection, regular monitoring, and improved treatment adherence are essential to reduce long-term cardiovascular risk.

Keywords: Nephrotic syndrome, Pediatric hypertension, Steroid-dependent nephrotic syndrome, Relapse pattern, Left ventricular hypertrophy.

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Introduction

Nephrotic syndrome (NS) is one of the most common renal disorders in children and represents a clinical manifestation of underlying glomerular disease. It is characterized by heavy proteinuria, hypoalbuminemia, generalized edema, and hyperlipidemia.[1] Nephrotic-range proteinuria is defined as urinary protein excretion greater than 3.5 g per 24 hours or a urine protein-to-creatinine ratio exceeding 2, resulting in significant disturbances in fluid balance and metabolic homeostasis. The global incidence of pediatric NS ranges from 2 to 16.9 per 100,000 children annually, with idiopathic nephrotic syndrome constituting the majority of cases. Among these, minimal change disease is the most common histological subtype and typically shows good response to corticosteroid therapy, although a subset of patients develop steroid resistance or dependence, increasing the risk of complications.[2]

Hypertension has emerged as an important and increasingly recognized comorbidity in children with nephrotic syndrome, significantly influencing both renal and cardiovascular outcomes. Traditionally, NS was believed to be associated with normal or low blood pressure; however, recent evidence suggests that hypertension is common and may persist even during remission phases.[2] The prevalence of hypertension in pediatric NS varies widely, ranging from 8% to 59.1% across different studies.[2] Large cohort data from the INSIGHT study reported that approximately 53% of children with NS developed hypertension or required antihypertensive therapy.[3] Similarly, Indian studies have shown a prevalence of around 54%, while even patients with infrequently relapsing NS demonstrate a considerable prevalence of 32.5%, indicating that the risk spans across disease severities.[4,5]

The pathogenesis of hypertension in NS is multifactorial, involving acute mechanisms such as sodium and water retention

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due to hypoalbuminemia-induced reduction in plasma oncotic pressure, along with neurohormonal activation and altered renal hemodynamics.[2] Chronic factors, including progressive renal damage, reduced glomerular filtration rate, vascular remodeling, and the effects of prolonged corticosteroid therapy, further contribute to sustained hypertension.[2]

Hypertension in pediatric NS is clinically significant due to its association with target end-organ damage, particularly cardiovascular complications. Left ventricular hypertrophy (LVH) and concentric hypertrophy, resulting from chronic pressure overload, are well-recognized findings detectable on echocardiography and are linked to adverse long-term outcomes.[2] Nephrotic syndrome itself is a heterogeneous condition, classified into idiopathic, genetic, and secondary forms, with varying etiologies including infections, systemic diseases, and metabolic disorders.[6] Given its high prevalence and clinical impact, early detection and systematic monitoring of hypertension are essential to prevent long-term complications in affected children.

Materials and Methods

After obtaining approval from the Institutional Ethics Committee, this hospital-based cross-sectional observational study was conducted among pediatric patients with nephrotic syndrome admitted to the Department of Paediatrics at Chacha Nehru Bal Chikitsalaya Avum Anusandhan Kendra (CNBC) and Maharaja Yashwantrao (M.Y.) Hospital, Indore, over a period of one year. Written informed consent was obtained from parents or guardians, and confidentiality and voluntary participation were ensured.

The sample size was calculated using a prevalence-based formula, assuming a prevalence of hypertension of 9% among pediatric nephrotic syndrome patients, with a 95% confidence interval and 10% absolute precision. The minimum calculated sample size was 31.5, which was rounded to 40 after accounting for possible non-response. All eligible patients were enrolled consecutively until the required sample size was achieved.

Inclusion Criteria: Children aged 1 to 18 years diagnosed with nephrotic syndrome and admitted during the study period were included.

Exclusion Criteria: Patients with congenital nephrotic syndrome, those with hypertension due to causes other than nephrotic syndrome, and those whose parents or guardians did not provide consent were excluded.

Methodology: After obtaining informed consent, eligible patients were enrolled consecutively at the time of admission. A detailed history including demographic profile, age at onset, disease duration, relapse pattern, steroid responsiveness, drug history, and associated complications was recorded using a predesigned semi-structured proforma. A thorough clinical examination was performed, including general, systemic, and cardiovascular assessment. Anthropometric measurements such as weight and height were recorded.

Blood pressure was measured using an appropriately sized cuff in a calm environment following standard pediatric guidelines. Readings were interpreted using age-, sex-, and height-specific percentile charts, and patients were categorized as normotensive, elevated blood pressure, stage 1 hypertension, or stage 2 hypertension as shown below.

Table 1: Classification of Blood Pressure in Children and Adolescents

Classification	Children (1–12 years) (percentile-based)	Adolescents (>13 years) (mmHg-based)
Normotensive	<90th percentile	<120/80 mmHg
Elevated BP (previously prehypertension)	≥90th percentile to <95th percentile OR 120/80 mmHg to <95th percentile (whichever is lower)	120/<80 to 129/<80 mmHg
Stage 1 Hypertension	≥90th percentile to <95th percentile +12 mmHg OR 130/80 to 139/89 mmHg (whichever is lower)	130/80 to 139/89 mmHg
Stage 2 Hypertension	≥95th percentile +12 mmHg OR ≥140/90 mmHg	≥140/90 mmHg

For screening purposes, simplified age- and sex-specific blood pressure cut-offs were used to identify children requiring further evaluation.

Table 2: Simplified Screening Blood Pressure Values (mmHg) Requiring Further Evaluation

Age (years)	Boys – Systolic	Boys – Diastolic	Girls – Systolic	Girls – Diastolic
1	98	52	98	54
2	100	55	101	58
3	101	58	102	60
4	102	60	103	62
5	103	63	104	64
6	105	66	105	67
7	106	68	106	68
8	107	69	107	69
9	107	70	108	71
10	108	72	109	72
11	110	74	111	74
12	113	75	114	75
≥13	120	80	120	80

All patients underwent routine investigations including urine routine microscopy, serum albumin, serum cholesterol, blood urea, serum creatinine, and complete blood count. Nephrotic syndrome was defined by heavy proteinuria (>3.5 g/24 hours or spot urine protein/creatinine ratio >2), hypoalbuminemia (<2.5 g/dL), and edema. Clinical subtypes such as frequent relapse,

infrequent relapse, steroid dependence, and steroid resistance were defined using standard criteria.

Patients diagnosed with hypertension underwent two-dimensional echocardiography to assess cardiac involvement, particularly left ventricular hypertrophy and concentric hypertrophy as indicators of target end-organ damage.

Outcome Assessment: The primary outcome was the prevalence of hypertension among pediatric nephrotic syndrome patients and its associated clinical factors. Secondary outcomes included the presence of cardiac changes, particularly left ventricular hypertrophy and concentric hypertrophy, as detected on echocardiography.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using IBM SPSS Statistics version 22. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Comparative analyses between hypertensive and normotensive groups were performed using the unpaired t-test for continuous variables and Chi-square or Fisher's exact test for categorical variables. A p-value of less than 0.05 was considered statistically significant.

Results

The present study included 54 children with nephrotic syndrome admitted to a tertiary care center. The mean age at presentation was 5.66 ± 3.06 years, with the majority of patients belonging to the 1–5 years age group (50.0%), followed by 6–10 years (44.4%) and 11–15 years (5.6%). The mean age at disease onset was 4.61 ± 2.40 years, indicating early childhood predominance. A male predominance (63.0%) was observed with a male-to-female ratio of 1.7:1. Most patients belonged to the middle socioeconomic class (61.1%), followed by lower (29.6%) and upper (9.3%) classes. [Table 3]

Table 3: Demographic Profile of Study Population (N = 54)

Variable	Category / Statistic	Frequency (n) / Value	Percentage (%)
Age at Presentation	Mean ± SD	5.66 ± 3.06 years	—
	Median (IQR)	5.25 (3.0 – 7.75) years	—
	Range	1.5 – 14.0 years	—
Age Group	1 – 5 years	27	50.0
	6 – 10 years	24	44.4
	11 – 15 years	3	5.6
	Total	54	100.0
Age at Disease Onset	Mean ± SD	4.61 ± 2.40 years	—
Gender	Male	34	63.0
	Female	20	37.0
	Total	54	100.0
Socioeconomic Status	Lower	16	29.6
	Middle	33	61.1
	Upper	5	9.3
	Total	54	100.0

Regarding disease characteristics, steroid-sensitive nephrotic syndrome (SSNS) was the most common type (77.8%), followed by steroid-dependent (20.4%) and steroid-resistant (1.9%) forms. Nearly half of the patients (44.4%) presented with their first episode, while 33.3% had frequent relapses. Good steroid compliance was observed in 70.4%, although 29.6% showed poor adherence. In terms of treatment exposure, 44.4% were in their first episode without prior steroid use, while 18.5% had prolonged steroid exposure (>6 months). Immunomodulators were used in 14.8% of patients, with levamisole being the most commonly used agent. [Table 4]

Table 4: Clinical Profile and Treatment Characteristics

Variable	Category / Statistic	Frequency (n) / Value	Percentage (%)
Type of Nephrotic Syndrome	SSNS	42	77.8
	SDNS	11	20.4
	SRNS	1	1.9
	Total	54	100.0
Relapse Pattern	First episode	24	44.4
	Infrequent relapse	12	22.2
	Frequent relapse	18	33.3
	Total	54	100.0
Relapse Frequency	Median (IQR)	1.0 (0.0 – 3.0)	—
	Range	0 – 6	—
Steroid Compliance	Good	38	70.4
	Poor	16	29.6
	Total	54	100.0
Steroid Duration	First episode	24	44.4
	≤ 6 months	20	37.0
	> 6 months	10	18.5
	Total	54	100.0
Immunomodulator Use	Yes	8	14.8

	No	46	85.2
	Total	54	100.0
Immunomodulator Type (n=8)	Levamisole	4	50.0*
	Mycophenolate mofetil	3	37.5*
	Cyclophosphamide	1	12.5*

*Percentage calculated among immunomodulator users.

Table 5: Laboratory Parameters (N = 54)

Parameter	Mean ± SD	Median	IQR
Serum Albumin (g/dL)	1.85 ± 0.28	1.85	1.60–2.08
Serum Cholesterol (mg/dL)	377.59 ± 51.57	385.00	332.50–420.00
Serum Creatinine (mg/dL)	0.47 ± 0.05	0.47	0.43–0.50
eGFR (mL/min/1.73m²)	108.70 ± 7.83	109.00	102.00–114.75

Laboratory evaluation showed marked hypoalbuminemia (mean 1.85 ± 0.28 g/dL) and elevated serum cholesterol (mean 377.59 ± 51.57 mg/dL) in all patients. Renal function parameters were preserved, with mean serum creatinine 0.47 ± 0.05 mg/dL and eGFR 108.70 ± 7.83 mL/min/1.73m². All patients had low serum albumin and high cholesterol levels, while renal function remained within normal limits in nearly all cases. All patients had low serum albumin (54, 100%) and high cholesterol (54, 100%), confirming active nephrotic syndrome. Renal function was preserved, with normal creatinine in 53 (98.1%) and normal eGFR in all patients (54, 100%). [Table 5]

Hypertension was present in 13 patients (24.07%), while 41 patients (75.93%) were normotensive, indicating that about one-fourth of children were affected. [Graph 1]

Analysis of sociodemographic variables showed no statistically significant association with hypertension ($p > 0.05$ for all variables). [Table 6]

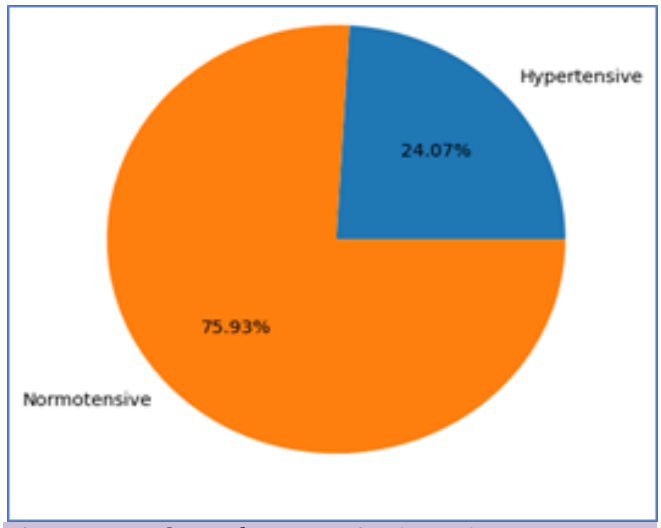

Figure 1: Prevalence of Hypertension (N = 54)

Table 6: Sociodemographic Profile in Relation to Hypertension Status (N = 54)

Variable	Category / Statistic	Hypertension Yes (n=13)	Hypertension No (n=41)	Test Statistic	P value
Age at Presentation (years)	Mean ± SD	6.42 ± 3.58	5.41 ± 2.88	t = 1.036	0.304
Age Group	1 – 5 years	6 (46.2%)	21 (51.2%)	χ^2 = 0.203, df=2	0.903
	6 – 10 years	6 (46.2%)	18 (43.9%)		
	11 – 18 years	1 (7.7%)	2 (4.9%)		
Gender	Male	10 (76.9%)	24 (58.5%)	Fisher's Exact (OR = 2.36)	0.328
	Female	3 (23.1%)	17 (41.5%)		
Socioeconomic Status	Lower	5 (38.5%)	11 (26.8%)	χ^2 = 1.771, df=2	0.412
	Middle	6 (46.2%)	27 (65.9%)		
	Upper	2 (15.4%)	3 (7.3%)		
Age at Disease Onset (years)	Mean ± SD	4.69 ± 2.72	4.59 ± 2.33	t-test	0.894
	Median (IQR)	4.5 (2.5–6.0)	4.0 (2.5–6.0)		

Hypertension showed significant association with disease severity and treatment factors. It was more common in SDNS (69.2%), frequent relapses (76.9%), and high relapse frequency (4–6 relapses: 46.2%). Poor compliance (69.2%) and immunomodulator use (53.8%) were also strongly associated. The strongest association was seen with prolonged steroid use (>6 months: 90.0%) (all $p < 0.05$).

Table 7: Association of Clinical Variables with Hypertension (N = 54)

Variable	Category	Hypertension Yes (n=13)	Hypertension No (n=41)	Total (n=54)	Test Statistic	P value
Type of NS	SSNS	3 (23.1%)	39 (95.1%)	42	Z = -5.444	<0.001*
	SDNS	9 (69.2%)	2 (4.9%)	11	Z = 5.020	<0.001*
	SRNS	1 (7.7%)	0 (0.0%)	1	Z = 1.793	0.073
Relapse Pattern	No relapse	2 (15.4%)	22 (53.7%)	24	Z = -2.420	0.016*
	Infrequent relapse	1 (7.7%)	11 (26.8%)	12	Z = -1.446	0.148
	Frequent	10 (76.9%)	8 (19.5%)	18	Z = 3.826	<0.001*

	relapse					
Relapse Frequency	0	2 (15.4%)	22 (53.7%)	24	Z = -2.420	0.0155*
	1–3 relapses	5 (38.5%)	17 (41.5%)	22	Z = -0.192	0.8478
	4–6 relapses	6 (46.2%)	2 (4.9%)	8	Z = 3.650	0.0003*
Drug Compliance	Good	4 (30.8%)	34 (82.9%)	38	Fisher's Exact (OR = 10.929)	0.0008*
	Poor	9 (69.2%)	7 (17.1%)	16		
Immunomodulator Use	Yes	7 (53.8%)	1 (2.4%)	8	Fisher's Exact (OR = 46.67)	0.0001*
	No	6 (46.2%)	40 (97.6%)	46		
Steroid Duration	First episode	2 (8.3%)	22 (91.7%)	24	$\chi^2 = 29.198$, df=2	<0.0001*
	≤ 6 months	2 (10.5%)	18 (90.0%)	20		
	> 6 months	9 (90.0%)	1 (10.0%)	10		

*Statistically significant ($p < 0.05$)

No significant association was found between hypertension and laboratory parameters. Serum albumin (1.82 vs 1.86 g/dL), cholesterol (378.85 vs 377.20 mg/dL), creatinine (0.46 vs 0.47 mg/dL), and eGFR (110.85 vs 108.02 mL/min/1.73m²) were comparable between groups ($p > 0.05$). [Table 8]

Table 8: Association of Laboratory Parameters with Hypertension (N = 54)

Parameter	Statistic	Hypertension Yes (n=13)	Hypertension No (n=41)	Total	Test Statistic	P value
Serum Albumin (g/dL)	Mean ± SD	1.82 ± 0.33	1.86 ± 0.27	—	t = −0.528	0.6000
Serum Cholesterol (mg/dL)	Mean ± SD	378.85 ± 55.94	377.20 ± 50.83	—	t = 0.100	0.9210
Serum Creatinine (mg/dL)	Mean ± SD	0.46 ± 0.06	0.47 ± 0.04	—	t = −0.961	0.3412
eGFR (mL/min/1.73m²)	Mean ± SD	110.85 ± 9.13	108.02 ± 7.37	—	t = 1.135	0.2616
Creatinine Status	Normal	12 (92.3%)	41 (100%)	53	Fisher's Exact	0.2407
	Low	1 (7.7%)	0 (0%)	1		
eGFR Status	Normal	13 (100%)	41 (100%)	54	Not applicable	—
	Low	0 (0%)	0 (0%)	0		
	High	0 (0%)	0 (0%)	0		

Among 12 hypertensive patients evaluated, LVH was present in 1 patient (8.3%), while no cases of concentric hypertrophy (0%) were observed, indicating minimal cardiac involvement. [Table 9]

Table 9: Echocardiographic Findings in Hypertensive Patients (n = 12/13)

Parameter	Category	Hypertension Yes (n=12)	Percentage (%)	Total Evaluated	Remarks
Left Ventricular Hypertrophy (LVH)	Present	1	8.3	12	Low prevalence
	Absent	11	91.7	12	Majority without LVH
Concentric LV Hypertrophy	Present	0	0	12	No cases observed
	Absent	12	100	12	Uniform absence

Discussion

The present study evaluated the prevalence of hypertension and its associated factors among children with nephrotic syndrome, along with assessment of cardiac end-organ damage. The prevalence of hypertension was 24.07%, which lies within the broad range reported in previous studies (8%–59.1%).[2] However, it is lower than the 53% reported in the INSIGHT cohort by Robinson et al,[3] (2025) and 54% reported by Manasa et al. (2019),[4] while being comparable to findings by Fathima et al. (2023),[5] and Al Ubaidy et al. (2022),[7] who reported prevalence around 30%–32%. This variation can be attributed to differences in study design, patient population, proportion of steroid-sensitive disease, and timing of blood pressure measurement.

Sociodemographic factors were not significantly associated with hypertension. The mean age at presentation and age distribution did not differ significantly between hypertensive and normotensive groups, which is consistent with findings reported by Skrzypczyk et al. (2024).[8] Although a higher proportion of males were hypertensive, the association was not statistically significant, similar to observations by Manasa et al. (2019).[4] Socioeconomic status also showed no meaningful relationship with hypertension, indicating that baseline demographic characteristics do not play a major role in determining blood pressure status in pediatric nephrotic syndrome.

In contrast, clinical variables demonstrated strong and significant associations with hypertension. The type of nephrotic syndrome emerged as an important determinant. Steroid-dependent nephrotic syndrome (SDNS) was strongly associated with hypertension, whereas steroid-sensitive nephrotic syndrome (SSNS) was predominantly seen among normotensive patients. These findings are consistent with Skrzypczyk et al (2024),[8] who reported that hypertension is significantly more common in steroid-dependent and steroid-resistant forms, and with Robinson et al (2025),[3] who showed higher risk among these subgroups. The likely explanation is the cumulative effect of prolonged steroid exposure, more severe underlying renal pathology, and the need for additional immunosuppressive therapies.

Relapse pattern and frequency also showed a clear association with hypertension. Patients with frequent relapses had a significantly higher prevalence of hypertension, and those with higher relapse frequency (4–6 episodes) were particularly affected. These findings align with studies by Al Ubaidy et al. (2022),[7] and Robinson et al (2025),[3] which demonstrated increased hypertension risk among frequent relapsers. Repeated

relapses may lead to cumulative hemodynamic alterations, repeated activation of neurohormonal pathways, and progressive vascular changes, contributing to sustained elevation of blood pressure.

Treatment-related factors played a crucial role. Poor drug compliance was significantly associated with hypertension, highlighting it as an important and potentially modifiable risk factor. Inadequate adherence can lead to uncontrolled disease activity, increased relapse frequency, and higher cumulative steroid exposure. Similarly, immunomodulator use was strongly associated with hypertension. However, this association likely reflects disease severity, as patients requiring immunomodulators generally have more severe or refractory disease.

Steroid exposure duration showed the strongest association with hypertension. Patients receiving steroids for more than six months had a markedly higher prevalence of hypertension. This finding is supported by Skrzypczyk et al. (2024),[8] who demonstrated a positive correlation between steroid dose and blood pressure. The hypertensive effects of corticosteroids are well established and include sodium and water retention, increased vascular resistance, and enhanced sensitivity to vasoconstrictors.

Laboratory parameters did not show any significant association with hypertension. Serum albumin, cholesterol, creatinine, and eGFR were comparable between hypertensive and normotensive groups. Although hypoalbuminemia and hypercholesterolemia were universally present, they did not influence blood pressure status. Renal function remained preserved in the majority of patients, which may explain the lack of association. These findings differ from those of Al Ubaidy et al. (2022),[7] who reported higher hypertension rates in patients with impaired renal function, suggesting that renal dysfunction may play a role in more severe disease settings.

Echocardiographic evaluation revealed minimal cardiac involvement. Left ventricular hypertrophy was present in only a small proportion of patients, and no cases of concentric hypertrophy were observed. This is lower than the findings reported by Fathima et al. (2023),[5] who observed structural cardiac changes in a higher proportion of hypertensive patients. The lower prevalence in the present study may be due to shorter duration or milder severity of hypertension. As reported by Mandal et al. (2024),[9] early cardiac changes may be subtle and not always detectable on routine echocardiography, emphasizing the need for long-term follow-up.

The study has certain limitations. The cross-sectional design limits the ability to establish causal relationships. The sample size is relatively small, and echocardiography was not performed in normotensive patients, limiting comparative analysis. Additionally, ambulatory blood pressure monitoring was not used, which may underestimate the true prevalence of hypertension, as highlighted by Aytaç et al. (2025),[10] and Shatat et al. (2019).[2]

In conclusion, hypertension in pediatric nephrotic syndrome is primarily associated with disease severity, relapse burden, and treatment-related factors, particularly steroid dependence, frequent relapses, poor compliance, and prolonged steroid therapy. Sociodemographic and laboratory parameters do not appear to significantly influence hypertension, and cardiac end-organ damage remains minimal in early stages.

Conclusion

This study demonstrates that hypertension is a significant comorbidity in pediatric nephrotic syndrome, affecting 24.07% of patients. It was not associated with demographic factors but showed strong links with disease severity and treatment-related variables, including steroid dependence, frequent relapses, prolonged steroid use, poor compliance, and immunomodulator therapy. Laboratory parameters and renal function were not predictive. Cardiac involvement was minimal, with only one case of LVH. These findings highlight the importance of routine blood pressure monitoring, early risk stratification, and improving treatment adherence to reduce long-term cardiovascular complications in children with nephrotic syndrome.

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Conflicts of interest

There are no conflicts of interest.

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