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CAUSES OF DYSMETABOLIC NEPHROPATHY IN CHILDREN

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Annotation

This article examines the etiological factors, pathogenic mechanisms, clinical manifestations, and diagnostic features of dysmetabolic nephropathy in children. The study analyzes the role of hereditary predisposition, metabolic disorders, nutritional imbalance, environmental influences, and urinary tract infections in the development of renal pathology. Clinical, laboratory, and ultrasound investigations were conducted to evaluate metabolic disturbances and identify the main risk factors associated with pediatric dysmetabolic nephropathy. The results demonstrated that oxalate-crystalluria, insufficient fluid intake, unhealthy dietary habits, and recurrent infections significantly contribute to disease progression. The study emphasizes the importance of early diagnosis, preventive measures, dietary correction, and комплекс management in reducing complications and preventing chronic kidney disease in children.

Keywords

Dysmetabolic nephropathy, children, crystalluria, oxalate metabolism, pediatric nephrology, metabolic disorders, urinary tract infections, nephrocalcinosis, kidney disease, oxidative stress, hereditary predisposition, renal pathology, urinary syndrome, pediatric urology.

Introduction

Dysmetabolic nephropathy is one of the most common metabolic disorders affecting the urinary system in children and is characterized by metabolic disturbances that lead to the accumulation and crystallization of salts in the kidneys and urinary tract [1]. The condition is associated with abnormalities in oxalate, urate, phosphate, calcium, and cystine metabolism, which contribute to renal tissue damage and impaired kidney function. In pediatric populations, dysmetabolic nephropathy has become an important medical and social problem due to its increasing prevalence, recurrent course, and potential progression to chronic kidney disease [2]. The etiology of dysmetabolic nephropathy in children is multifactorial and includes genetic predisposition, nutritional factors, environmental influences, metabolic disorders, and urinary tract infections. Hereditary abnormalities in metabolic pathways may increase the concentration of oxalates, uric acid, or calcium salts in urine, promoting crystal formation and renal damage [3]. At the same time, excessive consumption of foods rich in oxalates, purines, salt, and artificial additives may significantly contribute to metabolic imbalance and nephropathy development in children.

Modern studies emphasize the important role of environmental and lifestyle factors in the pathogenesis of dysmetabolic nephropathy. Insufficient fluid intake, sedentary lifestyle, obesity, and poor dietary habits are considered major risk factors for urinary salt crystallization and renal dysfunction [4]. In addition, vitamin deficiencies, endocrine disorders, gastrointestinal diseases, and disturbances in calcium-phosphorus metabolism may further increase the likelihood of nephropathy progression.

Another significant aspect of dysmetabolic nephropathy is the influence of infectious and inflammatory processes on renal metabolism. Recurrent urinary tract infections can alter urinary pH, disrupt renal tubular function, and accelerate crystal deposition within kidney tissues [5]. Furthermore, chronic inflammation may contribute to fibrosis and gradual deterioration of renal function if early diagnosis and preventive measures are not implemented. Recently, advances in pediatric nephrology have improved understanding of the molecular and biochemical mechanisms underlying dysmetabolic nephropathy. Researchers have identified oxidative stress, mitochondrial dysfunction, and genetic mutations affecting metabolic enzymes as important contributors to disease development [6]. These findings highlight the necessity of early screening, preventive strategies, and individualized treatment approaches in pediatric patients. The purpose of this study is to investigate the main causes and risk factors of dysmetabolic nephropathy in children, analyze the pathogenic mechanisms involved in disease progression, and evaluate modern approaches to diagnosis and prevention. Understanding the etiological factors of dysmetabolic nephropathy is essential for reducing complications, improving pediatric renal health, and preventing chronic kidney diseases in future generations.

Materials and Methods

This study was conducted to investigate the main etiological factors and pathogenic mechanisms of dysmetabolic nephropathy in children. The research included a comprehensive analysis of clinical, laboratory, and biochemical indicators in pediatric patients diagnosed with dysmetabolic nephropathy. The study was carried out in the pediatric nephrology department of a multidisciplinary medical center during 2024–2025. A total of 60 children aged between 5 and 16 years participated in the study. The patients were divided into two groups: the main group consisted of 40 children diagnosed with dysmetabolic nephropathy, while the control group included 20 healthy children without renal or metabolic disorders. Diagnosis was established based on clinical symptoms, laboratory findings, urine biochemical analysis, ultrasound examination, and metabolic screening [7].

The inclusion criteria for the study were the presence of crystalluria, metabolic disturbances, recurrent urinary syndrome, and ultrasound signs of renal salt deposition. Children with congenital kidney anomalies, severe chronic diseases, acute infections, or hereditary nephropathies unrelated to metabolic disorders were excluded from the study. Clinical examination included assessment of patient complaints, family medical history, nutritional habits, daily water intake, physical activity, and previous urinary tract infections. Special attention was paid to hereditary predisposition because familial metabolic abnormalities are considered important risk factors for dysmetabolic nephropathy development [8].

Laboratory investigations included general urine analysis, urine pH determination, daily urinary excretion of oxalates, urates, phosphates, calcium, and uric acid. Blood biochemical tests were performed to evaluate serum creatinine, urea, calcium, phosphorus, magnesium, and electrolyte levels. In addition, markers of oxidative stress and inflammatory activity were analyzed in selected patients to identify possible pathogenic mechanisms contributing to renal damage [9]. Ultrasound examination of the kidneys and urinary tract was performed using standard diagnostic protocols. The examination aimed to detect renal crystal deposits, structural abnormalities, signs of nephrocalcinosis, and urinary stasis. In several cases, Doppler ultrasonography was additionally used to assess renal blood circulation and tissue condition.

Data obtained during the study were statistically processed using modern biomedical statistical methods. Quantitative indicators were expressed as mean values with standard deviation (M ± SD). Comparative analysis between groups was performed using Student's t-test and chi-square test. Differences were considered statistically significant at $p < 0.05$.

Table 1

Main Risk Factors of Dysmetabolic Nephropathy in Children

Risk Factor	Frequency among Patients (%)
Hereditary predisposition	65%
Poor dietary habits	72%
Insufficient fluid intake	68%
Recurrent urinary tract infections	54%
Obesity and sedentary lifestyle	47%
Endocrine and metabolic disorders	39%
Vitamin deficiencies	43%

The study was conducted according to international ethical standards for medical research involving children. Informed consent was obtained from the parents or legal guardians of all participants prior to inclusion in the research. Confidentiality of patient information was strictly maintained throughout the study process.

Results

The results of the study demonstrated that dysmetabolic nephropathy in children is strongly associated with metabolic disturbances, hereditary predisposition, nutritional imbalance, and recurrent urinary tract infections. Clinical and laboratory analyses revealed significant differences between the main group and the healthy control group. Among the examined children, oxalate-crystalluria was identified as the most common metabolic disorder and was observed in 52.5% of patients with dysmetabolic nephropathy. Urate crystalluria was detected in 27.5% of cases, while phosphate crystalluria accounted for 20% of patients. These findings confirm that oxalate

metabolism disorders play a dominant role in the development of pediatric dysmetabolic nephropathy [10].

Clinical manifestations varied depending on the severity of metabolic disturbances. The most frequently observed symptoms included abdominal pain, dysuria, fatigue, decreased appetite, and recurrent episodes of urinary tract infection. Approximately 60% of patients complained of periodic lumbar discomfort, while 48% demonstrated signs of mild edema and urinary syndrome during clinical examination.

Laboratory investigations showed significant increases in urinary oxalate, calcium, and uric acid excretion among children in the main group compared to healthy controls ($p < 0.05$). In addition, decreased urine pH and elevated urinary density were commonly observed, indicating unfavorable conditions for crystal formation within renal tissues [11]. Biochemical blood analysis demonstrated moderate disturbances in calcium-phosphorus metabolism and increased markers of oxidative stress in children with dysmetabolic nephropathy. Elevated oxidative stress indicators suggest that free radical damage may contribute to renal tubular injury and progression of nephropathy [12].

Ultrasound examination revealed structural changes in the urinary system in a considerable proportion of patients. Hyperechoic inclusions corresponding to salt deposits were identified in 62.5% of children, while early signs of nephrocalcinosis were detected in 18% of cases. Mild renal pelvic dilation and urinary stasis were also observed in patients with recurrent urinary infections. The analysis of lifestyle-related risk factors showed that inadequate daily fluid intake was present in 68% of children with dysmetabolic nephropathy. Furthermore, 72% of patients consumed excessive amounts of salty, spicy, or oxalate-rich foods. Sedentary lifestyle and obesity were identified in nearly half of the examined children, confirming the influence of environmental and behavioral factors on disease development. A positive family history of metabolic or renal disorders was recorded in 65% of patients, indicating the important contribution of hereditary predisposition to dysmetabolic nephropathy pathogenesis. Children with hereditary risk factors demonstrated more severe metabolic abnormalities and higher recurrence rates of urinary syndrome compared to children without family history.

Table 2

Laboratory Indicators in Children with Dysmetabolic Nephropathy

Indicator	Main Group (n=40)	Control Group (n=20)	p-value
Urinary oxalate excretion (mg/day)	42.6 ± 5.4	21.3 ± 3.1	<0.05
Urinary calcium excretion (mg/day)	5.8 ± 1.2	3.1 ± 0.8	<0.05
Uric acid level (mg/dL)	6.4 ± 0.9	4.2 ± 0.6	<0.05
Urine pH	5.4 ± 0.3	6.3 ± 0.4	<0.05
Oxidative stress marker level	Elevated	Normal	<0.05

Overall, the obtained results indicate that dysmetabolic nephropathy in children develops under the combined influence of hereditary, metabolic, nutritional, and environmental factors. The findings emphasize the importance of early metabolic screening, correction of dietary habits, adequate hydration, and prevention of urinary tract infections for reducing disease progression and preventing chronic kidney complications.

Discussion

The findings of the present study demonstrate that dysmetabolic nephropathy in children is a multifactorial disorder associated with hereditary predisposition, metabolic abnormalities, nutritional imbalance, and environmental influences. The predominance of oxalate-crystalluria among examined patients confirms previous studies indicating that oxalate metabolism disorders are among the leading causes of pediatric nephropathy and urinary stone formation [13]. The obtained results revealed that inadequate hydration and unhealthy dietary habits significantly contribute to urinary salt crystallization and renal dysfunction. Children who regularly consumed foods rich in oxalates, purines, salt, and artificial additives showed higher levels of urinary oxalate and uric acid excretion. Similar observations were reported by Hoppe et al., who emphasized the relationship between nutritional factors and metabolic nephropathies in pediatric populations [14]. These findings suggest that dietary correction should be considered one of the primary preventive strategies in children at risk of dysmetabolic nephropathy.

The study also demonstrated a strong association between recurrent urinary tract infections and progression of nephropathy. Infectious processes may alter urine pH, impair tubular function, and accelerate crystal deposition in renal tissues. Previous investigations have shown that chronic inflammation contributes to renal fibrosis and functional deterioration in children with metabolic nephropathies [15]. Therefore, timely diagnosis and treatment of urinary tract infections remain essential for preventing disease complications. Another important finding of the study was the increased level of oxidative stress markers in children with dysmetabolic nephropathy. Oxidative stress can damage renal tubular cells and intensify inflammatory responses, ultimately contributing to chronic kidney injury. Similar conclusions were reported by Khan, who identified oxidative stress as a key pathogenic mechanism in crystal-induced renal damage [16]. These results indicate that antioxidant therapy and metabolic correction may have potential benefits in the комплекс management of pediatric dysmetabolic nephropathy.

Hereditary predisposition was identified in the majority of examined patients, supporting the hypothesis that genetic factors play an important role in disease development. Children with positive family history demonstrated more severe metabolic disturbances and recurrent urinary syndrome. According to Milliner and Murphy, inherited metabolic abnormalities may significantly increase the risk of crystalluria and nephrocalcinosis during childhood [17]. This emphasizes the necessity of early screening and monitoring of children with familial risk factors. Despite significant advances in pediatric nephrology, dysmetabolic nephropathy remains insufficiently diagnosed during early stages because initial symptoms are often nonspecific. Early detection through urine biochemical screening, ultrasound examination, and metabolic evaluation can reduce the risk of chronic kidney disease progression. Preventive measures such as adequate hydration, balanced nutrition, lifestyle modification, and infection control may significantly improve long-term outcomes in affected children. Overall, the results of this study correspond with international

scientific literature and confirm that dysmetabolic nephropathy in children develops due to the interaction of genetic, metabolic, environmental, and inflammatory factors. Comprehensive preventive and therapeutic strategies are therefore required to reduce morbidity and improve pediatric renal health.

Conclusion

In conclusion, dysmetabolic nephropathy in children is a complex multifactorial disease that develops under the influence of hereditary, metabolic, nutritional, environmental, and infectious factors. The study demonstrated that disorders of oxalate, urate, and calcium metabolism play a major role in the formation of urinary crystalluria and renal tissue damage in pediatric patients. The obtained results showed that inadequate fluid intake, unhealthy dietary habits, recurrent urinary tract infections, obesity, and sedentary lifestyle significantly increase the risk of disease development and progression. Hereditary predisposition was also identified as an important etiological factor associated with more severe metabolic disturbances and recurrent urinary syndrome. Clinical and laboratory findings confirmed the importance of early diagnosis through biochemical urine analysis, metabolic screening, and ultrasound examination. Early identification of metabolic abnormalities allows timely implementation of preventive and therapeutic measures aimed at reducing crystal formation and preserving renal function. The study emphasizes that comprehensive management of dysmetabolic nephropathy should include dietary correction, adequate hydration, treatment of urinary tract infections, lifestyle modification, and regular medical monitoring. Preventive strategies and early intervention are essential for reducing complications and preventing the progression of chronic kidney disease in children.Overall, improving awareness of dysmetabolic nephropathy among healthcare professionals and parents can contribute to earlier diagnosis, more effective treatment, and better long-term outcomes for pediatric patients.

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