RESULTS OF SONOGRAPHIC AND DOPPLER ULTRASONOGRAPHIC EXAMINATIONS IN CHILDREN WITH MEGAURETER

Yu.M. Ahmedov, I.Yu. Ahmedov, S.A. Shodmonov

Samarkand State Medical University, Uzbekistan

РЕЗУЛЬТАТЫ УЛЬТРАЗВУКОВОГО ИССЛЕДОВАНИЯ И ДОПЛЕРОГРАФИИ У ДЕТЕЙ С МЕГАУРЕТЕРОМ

Ю.М. Ахмедов, И.Ю. Ахмедов, С.А. Шодмонов

Самаркандский государственный медицинский университет, Узбекистан

Abstract. "The use of Doppler imaging in children allows for not only the visualization of renal vessels up to the cortical layer of the parenchyma but also the quantitative assessment of renal blood flow dynamics." The aim of this study was to evaluate the diagnostic significance of dynamic Doppler imaging in assessing intrarenal blood flow and parenchymal status in children with obstructive and reflux megaureter.

Materials and methods. The study included 123 patients, aged 3 months to 17 years, diagnosed with various forms of obstructive uropathy, including vesicoureteral reflux, hydronephrosis, megaureter, and urolithiasis. The participants were categorized into three groups. The control group included 56 healthy children of the same age who had no diagnosed pathology of the urinary system. All participants underwent a thorough clinical evaluation, which included ultrasound assessment of the kidneys, renal vasculature, and bladder, along with excretory urography and voiding cystourethrography. Ultrasound examinations were performed using Aloka SSD-3500 SV devices equipped with convex (6.0–8.0 MHz) and linear (9.0–14.0 MHz) probes.

Results. "The Doppler assessments revealed no deviations in hemodynamic parameters among patients in the first group. In the second group, a significant elevation in the resistance index of the interlobar and segmental arteries was observed, which normalized following treatment, indicating a functionally adaptive response. In contrast, patients in the third group exhibited persistent Doppler abnormalities post-treatment, with the severity of changes suggesting the presence of structural morphological alterations."

Аннотация. Использование доплерографии у детей позволяет не только визуализировать почечные сосуды до коркового слоя паренхимы, но и количественно оценивать почечный кровоток в динамике.

Цель исследования. Оценка информативности динамической доплерографии играет важную роль в диагностике нарушений внутрипочечного кровотока и состояния паренхимы у детей с обструктивным и рефлюксирующим мегауретером. Этот метод исследования позволяет выявлять изменения кровотока, фиксировать патологические процессы на ранних стадиях и оценивать степень тяжести заболевания. Кроме того, с помощью динамической доплерографии можно анализировать структурные и функциональные изменения в ткани почки, отслеживать их прогрессирование и разрабатывать оптимальные стратегии лечения. Таким образом, данный метод способствует повышению эффективности диагностического процесса и формированию терапевтического подхода, соответствующего индивидуальному течению заболевания.

Материалы и методы. В исследование были включены 123 пациента в возрасте от 3 месяцев до 17 лет, страдающих различными формами обструктивной и рефлюкс уропатии, включая везикоуретеральный рефлюкс, гидронефроз, мегауретер и мочекаменную болезнь. В зависимости от клинико-диагностических критериев пациенты были распределены на три группы. Контрольную группу составили 56 соматически здоровых детей аналогичного возрастного диапазона без признаков патологий мочевыделительной системы. Всем участникам исследования проводили всестороннее клинико-диагностическое обследование, включавшее ультразвуковую оценку почек, их сосудистого русла и мочевого пузыря, экскреторную урографию и микционную цистоуретерографию. Ультразвуковые исследования выполнялись на высокочувствительном аппарате Aloka SSD-3500 SV, оснащённом конвексными (6,0–8,0 МГц) и линейными (9,0–14,0 МГц) датчиками, обеспечивающими детальную визуализацию исследуемых структур.

Результаты. По результатам доплерографического исследования: у пациентов первой группы доплерометрические показатели находились в пределах физиологической нормы, отклонений не выявлено. У пациентов второй группы зафиксировано значительное повышение индекса резистентности в междолевых и сегментарных артериях, с последующей его нормализацией после проведённого лечения, что свидетельствует о функционально-адаптивном характере изменений. У пациентов третьей группы отсутствие положительной динамики, по данным доплерографии после лечения, наряду с выраженной степенью сосудистых изменений, указывало на наличие морфологических нарушений.

Relevance. "The diagnosis and management of obstructive and reflux megaureter in children remain critical and extensively debated topics in pediatric urology." [2, 4, 15]. Despite ongoing research, the issue of prognostic assessment for obstructive and reflux megaureter remains unresolved. Even after successful surgical treatment and the absence of infectious processes, follow-up observations of children treated for obstructive and reflux megaureter reveal persistent structural abnormalities in the kidneys in some patients. [10]

The progression of nephrosclerosis and chronic kidney disease leads to a decline in renal function [5, 7, 12]. The efficacy of treatment for obstructive and reflux megaureter is largely determined by the extent of nephrosclerosis and the compensatory adaptations in unaffected regions of the renal parenchyma.

To optimize the treatment strategy for obstructive and reflux megaureter, a standardized diagnostic algorithm is employed. This encompasses ultrasound diagnostics, excretory urography, renoscintigraphy, as well as magnetic resonance imaging and computed tomography [8, 9, 11, 14]. Due to its safety, non-invasiveness, absence of special patient preparation requirements, and suitability for long-term dynamic monitoring–particularly with the incorporation of Doppler imaging–ultrasound diagnostics remains the leading instrumental method for renal assessment [6, 9]. Dopplerography enables an objective assessment of renal blood flow and the extent of kidney damage. In children, this method allows not only visualization of renal vessels up to the cortical layer of the parenchyma but also quantitative analysis of intrarenal blood flow dynamics [8, 9, 13]. However, the necessity and informativeness of prolonged dynamic monitoring of renal circulation before and after treatment for obstructive uropathy in children remain insufficiently studied.

This study aims to evaluate the diagnostic utility of dynamic Doppler imaging in assessing intrarenal blood flow and parenchymal status in children with obstructive and reflux megaureter.

Materials and methods. The research cohort comprised 123 patients, aged 3 months to 17 years, diagnosed with various forms of obstructive uropathy and reflux megaureter: 41 children with hydronephrosis, 42 with vesicoureteral reflux, and 40 with urolithiasis (Table 1). It was found that obstructive uropathy and reflux megaureter were more frequently diagnosed in boys (80 patients; 64.8%).

During the follow-up period, a total of 64 children were assessed 6 to 12 months or longer following treatment. The control group consisted of 56 healthy children of the same age, with no diagnosed urinary system pathology. All participants underwent a comprehensive clinical evaluation, which included ultrasound imaging of the kidneys, renal vasculature, and bladder, as well as excretory urography and voiding cystourethrography. Ultrasound examinations were conducted using Aloka SSD-3500 SV devices equipped with convex (6.0–8.0 MHz) and linear (9.0–14.0 MHz) transducers to ensure high-resolution imaging and diagnostic accuracy. Echographic data were analyzed for kidney position, mobility, size, contour, and structure. Bladder examination included an assessment of its size, shape, wall condition, luminal echogenicity, and the width of the lower third of the ureter. [1, 3, 10, 14]

After evaluating kidney status, Dopplerographic studies were conducted to assess the main and intrarenal blood flow (Figure 1). For qualitative analysis, color Doppler mapping was used to visualize renal vessels (segmental, interlobar, and arcuate arteries), assess renal perfusion, and identify areas with reduced blood flow. The next phase involved pulse-wave Doppler imaging to evaluate blood flow parameters at the interlobar and segmental artery levels. [9, 12, 15]

Quantitative assessment of renal blood flow was conducted using the following parameters: peak systolic velocity, end-diastolic velocity, mean linear blood flow velocity, resistance index, acceleration, and acceleration time in each renal segment. A follow-up ultrasound was performed post-micturition to reassess renal and bladder parameters. A comparative analysis before and was performed after treatment to validate the obtained finding.

All patients diagnosed with obstructive uropathy and reflux megaureter were categorized into three groups based on disease severity and treatment strategy. The first group (approximately 24% of patients, n = 26) included individuals with urinary dynamics impairments that did not require surgical intervention, with a disease duration of up to three years. The second group (about 50%, n = 54) comprised patients with varying degrees of obstruction who were monitored longitudinally before and after treatment, which included conservative, surgical, or combined approaches, with a disease duration ranging from three to four years. The third group (roughly 40%, n = 43) consisted of children with chronic kidney failure who had undergone surgical intervention, exhibiting signs of nephrosclerosis and a disease duration exceeding five years. Based on the established diagnosis, 99 patients underwent reconstructive plastic surgery tailored to the type of obstruction, followed by ultrasound, Additionally, Doppler monitoring was conducted during the postoperative period, includ-

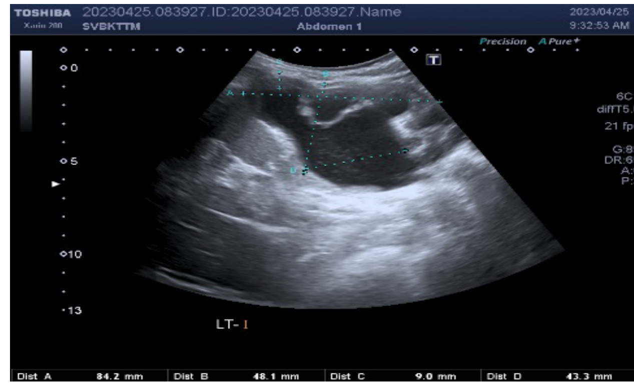

Figure 1. Sonogram of a patient with grade III megaureter

ing short-term assessment on days 5–7, mid-term evaluation at 6–12 months, and long-term follow-up. Surgical interventions for vesicoureteral reflux and megaureter were performed using the Cohen and Politano-Ledbetter techniques, ensuring effective correction of urinary tract abnormalities while hydronephrotic kidney transformation was managed with the Heinz-Andersen-Kuss-Kuchera procedure. In cases of non-functioning renal units, nephrectomy, nephroureterectomy, or heminephroureterectomy was conducted [4, 10, 13]. Statistical analysis was performed using standard data processing methods.

Quantitative indicators were presented as M ± σ, and differences between values were considered statistically significant at $p < 0.05$.

Screening ultrasound diagnostic methods are widely used today, having become routine medical procedures that allow for the detection of numerous diseases at early stages. With the increased use of ultrasound in prenatal diagnostics, there has been a rise in the number of patients with prenatally detected urinary system developmental defects at an early age. [3, 6]

In pediatric practice, ultrasound remains practically the only widely accessible and non-invasive method for determining renal parenchymal thickness and assessing the parameters of the collecting system. Upon admission, all patients underwent translumbar and transabdominal ultrasound examinations. During the ultrasound, the following parameters were evaluated: kidney length and width, renal parenchymal thickness, ureter diameter in its upper, middle, and lower thirds, renal pelvis size, degree of calyceal dilation, and bladder condition. [2, 3, 6]

In megaureter, the sonographic picture changes, showing alterations such as dilation of the ureters and renal cavities, accompanied by an increase in kidney size and ureteral tortuosity. This process is associated with increased hydrostatic pressure in the organ's cavity system, which exerts pressure on the renal parenchyma. As a result of this impact, the renal parenchyma may undergo atrophy. [3, 7, 8]

Table 1. Ultrasound parameters in children with megaureter depending on the degree of damage before surgery

Ultrasound Parameters	Norm (avg.)	Obstructive Megaureter	Refluxing Megaureter
		II degree	III degree
Kidney Length	71.5±2.3	95.5±0.3 ***	113.2±3 **
Kidney Width	35.1±1.5	50.3±0.7 ***	68.3±1.9 ***
Parenchyma Thickness	17.1±1.5	12.2±0.7 **	7.1±0.3 ***
Ureter Diameter	8.0±0.3	11.3±0.4 ***	17.3±0.7 ***

*Note: * – Statistical significance level between groups (* – P<0.05; **– P<0.01; *** – P<0.001).*

Table 2. Stage-by-Stage Ultrasound Monitoring of the Condition of Urinary System Organs

№ Ultrasound Monitoring	Description
1	During the initial visit or disease diagnosis
2	Before surgery – monitoring of baseline (preoperative) parameters
3	After the removal of drainage elements following reconstructive plastic surgeries
4	3–6 months after surgery to assess patency after reconstructive plastic surgeries

The ureter in patients with megaureter is usually dilated regardless of bladder filling. If contractions are observed during examination, it indicates the preservation of its evacuatory function. Depending on the degree of obstruction and reflux, the following characteristics were identified in children.

Ultrasound data analysis in children with megaureter, regardless of its cause, revealed that before surgery, the length and width of the affected kidney, as well as the ureter diameter in grade III megaureter, significantly exceeded the corresponding parameters in patients with grade II megaureter (Table 2). This difference was statistically significant ($p < 0.001$) and was observed regardless of the patients' age. Moreover, in grade III megaureter, the thickness of the renal parenchyma of the affected kidney was also significantly lower compared to grade II megaureter. [4, 5, 7]

The universality, non-invasiveness, and sufficient informativeness of ultrasound allowed for step-by-step monitoring of the condition of the urinary system organs in children with megaureter. Ultrasound examination of the parenchyma and the size of the upper urinary tract provided an opportunity for active monitoring at all stages of disease treatment. All patients underwent an assessment of normal ureteral contractility, including the examination of bladder volume, ureteral diameter in the distal section, and the area of the calyceal-pelvic segment. Contractile ability was evaluated based on the number of contractions per minute, including full contractions (leading to complete closure of the ureteral walls) and partial contractions (reducing the diameter by 1/2–1/3). These measurements were conducted after prior oral hydration in all patients.

Normally, the frequency of spontaneous contractions can range from 2 to 7 per minute, increasing to 4 or more per minute with diuretic stimulation [50]. Based on the results of the conducted sonography, all patients were conditionally divided into two subgroups: the first with low ureteral

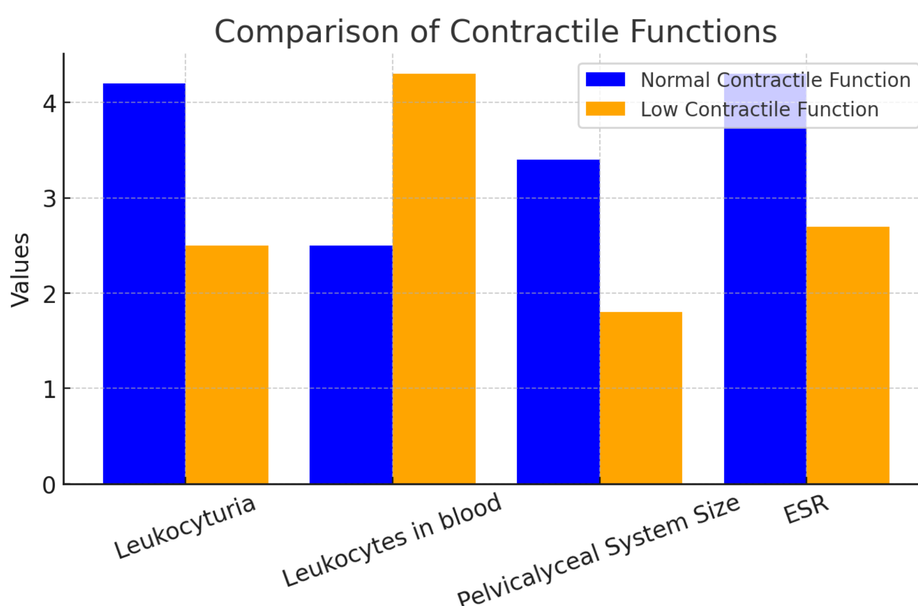

Figure 2. Graph of indicators in patients with normal and reduced ureteral contractility (n=123)

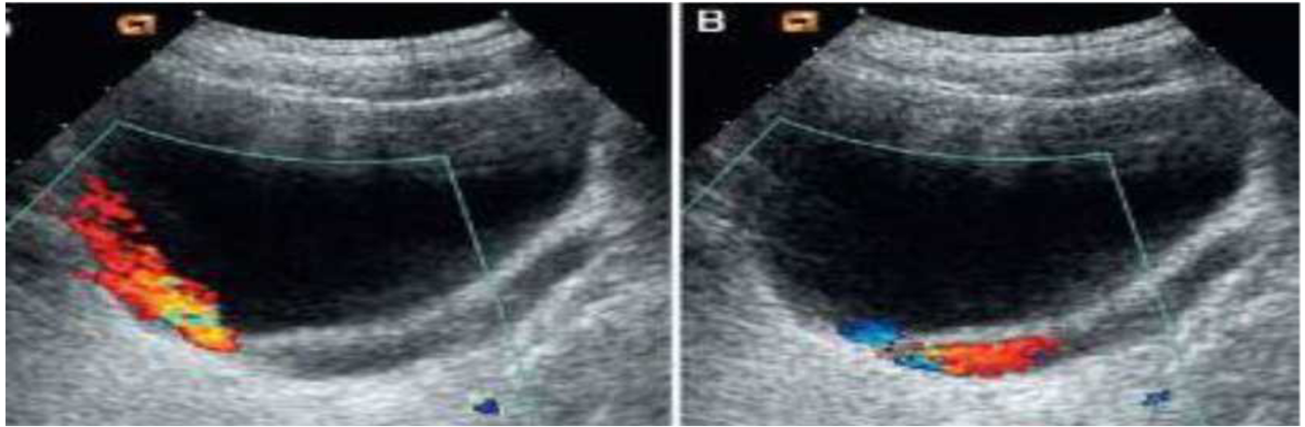

Figure 2. Dopplerographic Image of a Patient with Megaureter (MG)

contractility (0–3.5 per minute) and the second with normal contractility (4–7.6 per minute). No age differences were identified between these groups. [12, 14, 15]

The study of ureterovesical urine ejections was conducted in 80 children with obstructive and refluxing megaureter using pulsed-wave Doppler sonography.

In patients with the refluxing form of megaureter, signs of dynamic obstruction were recorded: a reduction in frequency to 1–3 ejections per minute, as well as reverse urine flow into the distal ureter from the bladder, a decrease in ejection time, and a reduction in peak velocity (Table 3).

The above data indicate that Doppler examination of the evacuation function of the upper urinary tract provides information that can be useful for assessing urodynamic disorders and developing a treatment strategy for children with megaureter. The use of Doppler methods to evaluate ureteral ejections enables monitoring the degree of ureteral obstruction. Statistical analysis determined the method's sensitivity at 86%, diagnostic accuracy at 66%, and specificity at 79%. [11, 15]

Conclusions: All patients included in the study underwent an evaluation of the effectiveness of this method. In 102 patients with megaureter, the method confirmed the diagnosis in 82 cases, while 20 cases yielded false-negative results. In the comparison group, 12 cases resulted in false-positive findings, while ultrasound conclusions were accurate in 9 patients (Table 4). [1, 2, 4]

Statistical analysis determined the method's sensitivity at 80.4%, diagnostic accuracy at 74%, and specificity at 42.8%.

Analysis of the data obtained from subgroup examinations revealed significant differences in the severity of urinary dynamic disorders among children. Leukocyturia was recorded in a higher number of patients with low ureteral contractility (80%), and in 20% of this subgroup, it correlated with changes in general blood analysis. The TPP area in children with low ureteral contractility ranged from 40% to 90% relative to normal values. In these children, the severity of ureteral dilation was markedly greater compared to those with intact ureteral contractility.

Table 3. Dopplerographic Indicators of Patients with Megaureter (MG)

Type of Megaureter	Number of Patients (x)	Dopplerometry			Dopplerometry	
		Frequency	Duration	Speed 1	Tc (s)	Vmax (m/s)
Group	21	2.8±0.15	2.1±0.3	0.24±0	-	-
Obstructive	28	0.5±0.1	3.72±0.2	0.26±0	-	-
Refluxing	31	2.4±0.2	1.74±0.26	0.29±0	1.40±0.06	0.12±0.03

*Note: * – Level of statistikal significance between groups.*

Table 4. Effectiveness of Sonography in Megaureter Diagnosis

Conclusion of Ultrasound on the Presence of MG		Conclusion of Ultrasound on the Absence of MG	
MG Present	IP 82	MG Present	LP 12
MG Absent	LO 20	MG Absent	IO 9
Total	102	Total	21

Note: IP – True Positive Result; LP – False Positive Result; LO – False Negative Result; IO – True Negative Result.

Conclusion. A thorough ultrasound assessment of the kidneys, especially when incorporating Doppler ultrasonography, provides an objective evaluation of renal blood circulation in children and adolescents with obstructive uropathy. This approach facilitates precise identification and continuous monitoring of vascular alterations. The capability to track renal blood flow throughout conservative treatment and post-surgical recovery establishes ultrasound as a vital and indispensable diagnostic tool in urology and surgery. This technique is essential for diagnosing conditions, assessing treatment efficacy, and detecting complications at an early stage.

Литература/References

1. Akhmedov I. Yu., Yatsik S. P., Akhmedov Yu. M. Megaureter v detskom vozraste (obzor literatury) // Jurnal reproduktivnogo zdorovya i uro-nefrologicheskikh issledovaniy. – 2023. – T. 4. – № 1. In Russian
2. Akbarov N. features of regression of congenital hydronephrosis in the long-term period after surgery in children. International Journal of Scientific Pediatrics 2022;1:31–7. https://doi.org/10.56121/2181- 2926-2022-2-31-37.
3. Baum M. Progression of chronic kidney disease in children. Curr Opin Pediatr 2018;30:216–9. https://doi.org/10.1097/MOP.0000000000000593.
4. Stehr Maximilian, and Frank-Mattias Schäfer. Der Primär Obstruktive Megaureter (POM)–Eine Domäne konservativer Therapie [Primary ob structive megaureter: a domain of conservative treatment]. Aktuelle Urol 51.2 (2020): 127-31
5. Gafurov Adham, Sherzod Toshboev, and Zoirzhon Turakulov. Vozmojnosti ekhodopplerografii v otsenke pochechnogo krovotoka pri obstruktivnykh uropatiyakh u detey // Mejdunarodnyy jurnal nauchnoy pediatrii 2.1 (2023): 13-18. In Russian
6. Gagikovich BA, Pavlovich YAS, Nikolaevich NS, Anatolyevna VE, Valerievna SA. Modern view on the diagnosis of vesicoureteral reflux in children. Reproductive Health of Children and Adolescents 2021;17:16–32.
7. Mahmudovich Ahmedov Yusufjon, et al. Characteristics of megaureter reconstructive-plastic operations in children. Academy 4 (55) (2020): 109-112.
8. Makovetskaya GA, Mazur LI, Balashova E A, Terekhin S. Congenital obstructive uropathies in children: a nephroprotective strategy. Pediatrics Journal named after Mr Speransky 2017:38–43.
9. Morozova Olga, et al. Urinary biomarkers of latent inflammation and fibrosis in children with vesicoureteral reflux. International Urology and Nephrology 52 (2020): 603-610.
10. Mavlyanov F., and Yu. Akhmedov. Lechenie vrojdennykh obstruktivnykh uropatiy u detey. Jurnal Problemy Biologii i Meditsiny 1 (93) (2017): 198-201. In Russian
11. Rudin Yu. E. GBOU VPO "Rossiyskiy natsional'nyy issledovatel'skiy meditsinskiy universitet im. NI Pirogova' Minzdrava Rossii." (2021). In Russian
12. Riahinezhad M, Sarrami AH, Gheisari A, Shafaat O, Merikhi A, Karami M, et al. How may Doppler indices help in the differentiation of obstructive from nonobstructive hydronephrosis? J Res Med Sci 2018;23:76. https://doi.org/10.4103/jrms.JRMS_627_17.
13. Ruiz-Martínez A, Sierra-Díaz E, Celis-de la Rosa AJ, Valenzuela Hernández MÁ, González Flores MG, Belmonte Hernández MV. Renal Doppler ultrasound resistive index vs. renal scintigraphy with 99mTc-DTPA as diagnostic test for ureteropelvic junction obstruction in children. Actas Urol Esp (Engl Ed) 2019;43:419–24. https://doi. org/10.1016/j.acuro.2019.02.005.
14. Sun J, Deng G, Wang F, Mo J. Renal Hemodynamic Changes and Postsurgical Recovery in Children Treated for Ureteropelvic Junction Obstruction. Ultrasound Q 2020;36:20–3. https://doi.org/10.1097/RUQ.0000000000000477.
15. Voevodin S.M., Yusufov A.A., and Shemanaeva T.V. Ekhograficheskie podkhody k diagnostike i otsenke obstruktivnykh uropatiy u beremennykh. Ginekologiya 26.3 (2024): 297-300. In Russian