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**POSSIBILITIES OF ECHODOPPLEROGRAPHY IN ASSESSMENT OF RENAL BLOOD
FLOW IN OBSTRUCTIVE UROPATHIES
CHILDREN**

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ABSTRACT

The aim of the study was to study the diagnostic value of dynamic Doppler ultrasonography of intrarenal blood flow and the state of the parenchyma in children with obstructive uropathy. A total of 128 patients with obstructive uropathy of various origins aged from 3 months to 17 year were examined. A comprehensive ultrasound examination of the kidneys using Doppler ultrasonography made it possible to assess the state of the renal blood flow in children with obstructive uropathy.

All patients with obstructive uropathy were divided into 3 groups. Group I included children (29) with urodynamics disorders that do not require surgical treatment, with a disease duration of up to 3 years. Group II consisted of children (59) with various forms of obstruction, dynamically observed before and after treatment (conservative, surgical, or their combination), with a disease duration of 3 to 4 years. Group III was formed by patients (40) with clinical manifestations of chronic renal failure who underwent surgical treatment, with signs of nephrosclerosis, with a disease duration of more than 5 years.

Patients of group II with obstructive uropathies showed a significant increase in the resistance index in the interlobar and segmental arteries and normalization of its values after treatment, which allows us to speak about the functional and adaptive nature of the changes.

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The absence of positive dynamics in the Doppler ultrasound indices in children of the III group after treatment and the severity of their changes indicate the presence of morphological disorders.

KEYWORDS: obstructive uropathy, echodopplerography, renal blood flow, children

抽象的

本研究的目的是研究动态多普勒超声对肾内血流和肾实质状态对梗阻性尿路病变的诊断价值

。总共检查了 128 名年龄从 3 个月到 17 岁的各种原因的梗阻性尿路病患者。使用多普勒超声对肾脏进行全面超声检查可以评估梗阻性尿路病儿童的肾脏血流状态。

所有梗阻性尿路病患者分为 3 组。第 I 组包括不需要手术治疗的尿动力学障碍儿童 (29), 病程长达 3 年。第二组由患有各种形式梗阻的儿童 (59 名) 组成, 在治疗 (保守、手术或其组合) 前后动态观察, 病程为 3 至 4 年。III 组为有慢性肾功能衰竭临床表现、接受手术治疗、有肾硬化征象、病程超过 5 年的患者 (40 例)。

患有阻塞性尿路病的 II 组患者的叶间动脉和节段动脉的阻力指数显著增加, 并且治疗后其值正常化, 这使我们能够谈论这些变化的功能性和适应性。

治疗后 III 组儿童的多普勒超声指数缺乏阳性动态及其变化的严重程度表明存在形态学障碍。

关键词: 梗阻性尿路病, 超声多普勒造影, 肾血流量, 儿童

INTRODUCTION

The diagnosis and treatment of obstructive uropathy in children today remain relevant and widely discussed topics [2, 4]. Despite the ongoing, the problem of prognosis of obstructive uropathy remains unresolved until the end. Observations of children with obstructive uropathy after treatment show a progressive impairment of the renal structure in a number of children, despite successful surgical treatment and the absence of an infectious process [10]. At the same time, there is a decrease in renal functions due to the formation of nephrosclerosis and the development of chronic kidney disease. [5, 7, 12]. The effectiveness of treatment for obstructive uropathy depends on the severity of nephrosclerosis and compensatory shifts in intact

renal tissue. For the choice of treatment tactics for obstructive uropathy, there is a generally accepted examination algorithm: ultrasound examination method, excretory urography, renoscintigraphy, magnetic resonance imaging and computed tomography [1, 3, 11, 14]. Painlessness, safety, the absence of the need for special preparation of the patient, the possibility of constant dynamic observation make the ultrasound examination of the kidneys a priority, especially taking into account the possibility of using Doppler ultrasonography [6, 9]. The latter allows you to assess renal blood flow and more objectively establish the severity of kidney damage. The use of Doppler studies in children makes it possible to visualize not only the vessels of the kidneys up to the cortical layer of the

parenchyma, but also to quantitatively assess the renal blood flow in dynamics [8, 13]. However, there are few clear data on the feasibility and information content of long-term follow-up to assess renal blood flow before and after treatment of obstructive uropathy in children.

The purpose of study was to study the diagnostic value of dynamic Doppler ultrasonography of intrarenal blood flow and the state of the parenchyma in children with obstructive uropathy.

MATERIALS AND METHODS

We examined 128 patients with obstructive uropathy of various origins aged from 3 months

Table 1.

Distribution of patients by nosological forms, age and sex (abs,%)

Nosological group	Degree	from 3 months up to 3 years		3-7 years old		8-11 years old		12-17 years old		Total
		The boys	The girls	The boys	The girls	The boys	The girls	The boys	The girls	
Hydronephrosis	I	-	-	3 (2,3)	-	-	-	-	-	3 (2,3)
	II	7 (5,5)	1 (0,78)	10 (7,8)	5 (3,9)	6 (4,7)	4 (3,1)	4 (3,1)	1 (0,78)	38 (29,7)
Vesicoureteral reflux	I-II	-	1 (0,78)	5 (3,9)	9 (7,0)	1 (0,78)	2 (1,6)	6 (4,7)	2 (1,6)	26 (20,3)
	III-IV	3 (2,3)	2 (1,6)	2 (1,6)	5 (1,6)	2 (1,6)	2 (1,6)	3 (2,3)	2 (1,6)	21 (16,4)
Urolithiasis		8 (6,2)	3 (2,3)	18 (14,1)	3 (2,3)	3 (2,3)	1 (0,78)	2 (1,6)	2 (1,6)	40 (31,2)
Total		18 (14,1)	7 (5,5)	38 (29,7)	22 (17,2)	12 (9,4)	9 (7,0)	15 (11,7)	7 (5,5)	128 (100)

All ultrasound examinations were performed using Aloka-SSD-3500 SV devices using convex

to 17 years (41 with hydronephrosis, 47 with vesicoureteral reflux, 40 with urolithiasis) (Table 1).

Obstructive uropathy is most common in boys (83 (64.8%)). In the follow-up period, 64 children were examined (6-12 months or more after treatment). The control group consisted of 56 practically healthy children of the same age who had never had a pathology of the urinary system. All children underwent general clinical examination, ultrasound examination of the kidneys and their vessels and the urinary bladder, excretory urography and vocal cysto-obstructive ureterography.

(6.0-8.0 MHz) and linear (9.0-14.0 MHz) transducers. According to echography, the

position, mobility, size of the kidneys, their contour and structure were assessed. When examining the bladder, the size of the organ, the shape, the condition of the walls, the echogenicity of the lumen, as well as the width of the lower third of the ureter were determined. After assessing the state of the kidneys in the mode, Doppler ultrasonography of the main and intrarenal blood flow was performed. A qualitative assessment of intrarenal blood flow was performed using color Doppler mapping. This made it possible to visualize the renal vessels (segmental, interlobar and arc arteries), to establish the degree of blood filling of the organ, and to determine areas of blood flow depletion. The next step was to determine the nature of the blood flow pattern in the pulsed wave Doppler mode at the levels of the interlobar and segmental arteries. Quantitative assessment of blood flow was based on the determination of such parameters as peak systolic, end diastolic and mean linear blood flow velocities, resistance index, acceleration and acceleration time in each segment of the kidney. Repeated ultrasound examination with determination of the same parameters of the kidneys and urinary bladder was carried out after miction. To confirm the obtained Doppler ultrasound data, a comparative analysis was carried out before and after treatment.

All patients with obstructive uropathy were divided into 3 groups. Group I included children (29) with urodynamic disorders that do not require surgical treatment, with a disease duration of up to 3 years. Group II consisted of children (59) with various forms of obstruction, dynamically observed before and after treatment (conservative, surgical, or their combination), with a disease duration of 3 to 4 years. Group III was formed by patients (40) with clinical

manifestations of chronic renal failure who underwent surgical treatment, with signs of nephrosclerosis, with a disease duration of more than 5 years.

Depending on the established diagnosis, according to indications, 99 patients underwent reconstructive plastic surgery, taking into account the type of obstruction, followed by echographic and Doppler dynamic control in the postoperative period (for 5-7 days, after 6-12 months or more). For vesicoureteral reflux, megaurethra, operations were performed according to the methods of Cohen and Politano-Leadbetter, for hydronephrotic transformation of the kidney - according to the Heins-Andersen-Kuss-Kucher method. In case of a non-functioning organ, nephrectomy, nephroureterectomy, and heminephroureterectomy were performed.

Statistical processing of the results obtained was carried out using standard methods. Quantitative data are presented as $M \pm \sigma$. Differences between values were considered significant at $P < 0.05$.

RESULTS AND DISCUSSION

According to the data of echographic examination of the kidneys in children of group I, normal differentiation of the parenchymal layers was determined in 29 (22.6%), moderate dilatation of the pelvis in 3 (2.3%). Based on the data of excretory urography, the diagnosis was made of vesicoureteral reflux of I-II degrees in 2 (1.6%), and hydronephrosis of stage I in 3 (2.3%). Doppler examination of these patients did not reveal changes in the vascular pattern (Figure 1A). With Doppler measurements, the values of speed indicators and resistance index practically did not differ from the control group (Table 2). In children of group II, an even contour, normal size of the kidney, and persisting

differentiation of the layers were determined. Against this background, dilatation of the renal pelvis system was visualized (Figure 1B). Based on the data of excretory urography, these children were diagnosed with stage II hydronephrosis in 14 (10.9%), and stage III-IV vesicoureteral reflux in 4 (3.1%). According to the data of color Doppler mapping, the depletion of blood flow in the cortical layer was determined (Figure 1C). In the pulse-wave Doppler mode, before treatment, against the background of unchanged peak systolic blood flow velocity, a decrease in the end diastolic velocity and an increase in the resistance index were noted in both the interlobar and segmental arteries. After treatment, there was a positive trend, expressed in an increase in the final diastolic blood flow velocity and a decrease in the resistance index. With color Doppler mapping, renal blood flow returned to normal after treatment. In children of group III, when

scanning the kidneys, pronounced echographic changes were revealed: an uneven contour, a decrease or increase in the size of the kidney, a decrease or absence of differentiation of the kidney layers, thinning of the cortical layer (28 (21.8%)), hyperechoic parenchyma, pronounced dilatation and thickening of the walls pyelocaliceal system (32 (25.0%)), dilatation of the ureter (8 (14.1%)). In the mode of color Doppler mapping, the following were determined: a significant depletion of blood flow in the cortical layer, deformation of the main trunk of the renal artery, dysplasia of intraorgan vessels (up to the absence of their visualization) (Figure 1C).



Picture 1. Echograms of the kidneys (B-mode + color Doppler mapping) in groups I (A), II (B) and III (C)

Table 2.
Doppler indices of intrarenal blood flow in children with obstructive uropathy in dynamics

Options	Before treatment		After treatment	
	Interlobar arteries	Segmental arteries	Interlobar arteries	Segmental arteries
	I group			

Peak systolic blood flow velocity, cm / s	21,4±2,0	31,6±8,2	21,7±2,3	31,4±3,4
End diastolic blood flow velocity, cm / s	6,8±1,1*	8,5±2,4*	6,9±2,1	8,4±0,6*
Resistance index	0,68±0,10	0,73±0,10	0,68±0,10	0,73±0,10
Acceleration, cm / s ²	100,5±38,0	124,2±47,2	102,5±34,2	126,8±32,8
Acceleration time, s	0,16±0,07	0,14±0,08	0,14±0,08	0,13±0,14
	II group			
Peak systolic blood flow velocity, cm / s	20,4±2,7*	34,2±5,4*	20,6±1,8*	31,2±2,6*
End diastolic blood flow velocity, cm / s	5,5±1,2*	7,7±1,9**	5,7±1,3**	8,6±1,5**
Resistance index	0,73±0,07*	0,77±0,05**	0,72±0,06**	0,73±0,05**
Acceleration, cm / s ²	98,2±29,2	142,4±47,5	92,2±27,9	150,1±56,2
Acceleration time, s	0,13±0,06	0,12±0,06	0,11±0,07	0,12±0,07
	III group			
Peak systolic blood flow velocity, cm / s	23,8±3,0*	35,4±6,9*	19,9±1,9*	30,9±2,7*
End diastolic blood flow velocity, cm / s	4,7±0,7**	6,9±1,9**	4,4±0,8**	6,5±1,0**
Resistance index	0,80±0,10**	0,80±0,10**	0,78±0,10**	0,79±0,04**
Acceleration, cm / s ²	106,2±32,6	138,4±49,3	91,1±29,8	152,0±43,4
Acceleration time, s	0,13±0,06	0,12±0,07	0,14±0,06	0,12±0,07
	Control group			
	Interlobar arteries		Segmental arteries	
Peak systolic blood flow velocity, cm / s	24,4±1,0		39,8±1,8	
End diastolic blood flow velocity, cm / s	9,2±0,8		10,9±0,8	
Resistance index	0,63±0,05		0,67±0,05	
Acceleration, cm / s ²	120,6±55,3		218,7±31,6	
Acceleration time, s	0,13±0,06		0,13±0,01	

Note: * - reliability of differences when compared with the control group at $P < 0.05$, ** - at $P < 0.001$; interlobar arteries, segmental arteries.

According to clinical, laboratory and instrumental research methods, these children were found to have a megaureter, chronic kidney disease 0-1-2. Doppler indices were as follows:

against the background of unchanged peak systolic blood flow velocity in the interlobar and segmental arteries (if they were visualized), the end diastolic velocity was reduced in relation to

the control, I and II groups. The index of resistance in interlobar and segmental vessels was increased. According to the data of dynamic ultrasound examination, there was a slight uniform decrease in speed indicators with a persisting high index of resistance, despite the treatment (table 2). Despite the fact that in groups II and III the mean values of blood flow indices significantly differed among themselves, in a number of patients in these groups (25 children) there was an overlap of data, including the values of the resistance index. With obstructive uropathy, an increase in urethral pressure occurs, which leads to changes in the connective tissue frame of the arteries and veins of the kidney. The time of appearance and the depth of changes in the connective tissue framework of the vessels are in direct proportion to the diameter of the vessel and the thickness of its wall. The smaller the caliber of the vessel and the thinner its wall, the earlier and more intensively changes occur. Narrowing of the lumen of blood vessels with perivascular fibrosis and thickening of the walls at the level of the glomeruli leads to hypoxia and impaired microcirculation. It has been proven that changes occur not only in the vessels, but also in the adjacent parts of the organ. In the zone of increased tissue pressure, the reaction of all fragments of the vascular bed begins simultaneously, manifests itself as a violation of microcirculation and leads to necrosis, which ends with the replacement of vessels with scar tissue. In the areas of the kidney adjacent to the zone of increased tissue pressure, vascular changes are completed with complete or partial obliteration and the formation of one or more arteries of a smaller caliber in the lumen of the arteries. Morphobiopic examination first reveals signs of tubular atrophy, fibrosis, then glomerular sclerosis [5, 7]. Reliable detection of

nephrosclerosis is possible only on the basis of morphological studies. It can be indirectly judged on the basis of data from excretory urography [11]. Undoubtedly, these data are of great practical importance in making the final diagnosis and determining treatment tactics [14]. But these methods are still far from being safe for the child, are invasive and expensive, and have their limitations. At the present stage, static renoscintigraphy is the gold standard for detecting cortical lesions and determining the volume of intact renal parenchyma in obstructive uropathy [9], which allows you to visualize the renal parenchyma, determine the foci of sclerosis, assess the dynamics of kidney damage. The limitation of the method is that it is aimed only at the renal parenchyma and does not allow assessing the collecting system and differentiating the cause of a focal or diffuse decrease in the accumulation of a radioactive pharmacological preparation [9]. Taking this into account, we carried out an ultrasound examination of the kidneys, including a Doppler study of the intrarenal vessels, in order to determine its diagnostic significance. Doppler study of renal vessels in children of group I showed no changes in speed parameters and resistance index. These data were confirmed by the results of laboratory and X-ray studies. Comparative analysis of all the results obtained, as well as positive dynamics in the follow-up period, allowed us to assume the likelihood of no changes in the walls of the vessels of the medulla and cortical layers, as well as in the adjacent kidney tissues in children of group I. Comparison of the data on changes in speed indicators, resistance index, acceleration and acceleration time in group II with the results obtained in group I made it possible to assume that after the treatment aimed at relieving obstruction,

eliminating an active infectious process, there is a decrease in increased intraurethral pressure and increased tissue pressure. ... All this leads to a uniform opening of the lumen of segmental and interlobar vessels, restoration of microcirculation, and improved perfusion inside the kidney. Such positive dynamics is possible only under the conditions of the absence of morphological changes in the walls of the vessels of the kidney and their persisting tone (indirectly, the absence of morphological changes in the structure of the vascular wall and the persisting tone of the vessels can be judged by the acceleration and acceleration time). It is possible that these children had a functional character of spasm of intrarenal vessels, and there were no morphological changes in their wall and adjacent tissues. Lack of dynamics in indicators in children of group III after 6 - 12 months after treatment, apparently, is associated with a decrease in the elasticity of the vascular wall and an increase in vascular tone due to irreversible morphological changes in the vascular walls and tissues adjacent to the vessels, due to the development of diffuse sclerosis of the stroma, blood vessels and glomeruli, tubular atrophy [10]. Vessels with consistently high values of the resistance index probably corresponded to the sites of parenchymal nephrosclerosis.

CONCLUSIONS

A comprehensive ultrasound examination of the kidneys using Doppler ultrasonography makes it possible to assess the state of the renal blood flow in children with obstructive uropathy. The possibility of dynamic monitoring of the state of the vascular bed during conservative treatment, after surgical interventions makes the ultrasound method in demand in urology and surgery.

In patients of group II with obstructive uropathy, a significant increase in the resistance index in the interlobar and segmental arteries and the normalization of its values after treatment (conservative, surgical, or their combination) were established, which allows us to speak about the functionally adaptive nature of the changes. The absence of positive dynamics in the Doppler sonography indicators in children of group III after treatment and the severity of their changes suggest the presence of morphological disorders.

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