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UDORGANIZING PERSONALISED MEDICAL REHABILITATION CARE FOR ADOLESCENTS WITH UROLITHIASIS IN SPECIALISED INSTITUTIONS

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ABSTRACT

The article presents the results of a clinical study aimed at assessing the effectiveness of a personalized medical rehabilitation program for boys after surgical treatment of urolithiasis (ULD). The study included 62 patients divided into the main and control groups, depending on the use of a comprehensive rehabilitation program, including metabolic correction, physiotherapy, diet therapy and psychoemotional support. Risk stratification, comparative analysis of clinical and laboratory parameters, biochemical markers, ultrasound signs and the frequency of complications within 6 months were carried out. It was found that the introduction of a personalized approach provides a reliable improvement in the functional state of the kidneys, a decrease in the frequency of relapses and urinary tract infections compared to standard tactics. The data obtained confirm the need to introduce personalized rehabilitation into the practice of pediatric urology and nephrology as an effective method of secondary prevention and improving the quality of life of patients.

KEY WORDS: *Urolithiasis In Children, Rehabilitation; Metabolic Syndrome, Secondary Prevention, Renal Ultrasound, Urinary Tract Infections, Personalized Approach.*

INTRODUCTION

Urolithiasis (UL) in children, especially boys, is one of the pressing problems of pediatric nephrourology, characterized by a tendency toward an increase in prevalence and a rejuvenation of the onset of the disease [1,2]. It has been established that the recurrent course of UL in children after surgical treatment is often associated with persistent metabolic disorders, insufficient rehabilitation, and the absence of targeted prevention [3,4].

Existing medical rehabilitation programs after surgical removal of stones are mainly focused on eliminating residual symptoms and do not always include correction of metabolic and functional parameters [5,6]. Meanwhile, the formation of an individual recovery route taking into account the level of oxalates, urates, citrates, urine pH, calcium, magnesium and other biomarkers can significantly affect the outcome of the disease and reduce the likelihood of relapse [7,8].

Early involvement of a multidisciplinary rehabilitation team (nephrologist, pediatrician, nutritionist, exercise therapy instructor) and the use of personalized programs improves clinical and functional indicators, increases patient adherence to treatment, and ensures long-term disease control [9,10]. Particularly significant is the inclusion of metabolic monitoring and correction in the rehabilitation program using nutraceutical approaches, hydration regimen, and motor-functional support [11,12].

Thus, the need to create and implement a personalized clinical-functional -metabolic rehabilitation program after surgical treatment of urolithiasis in boys is due to the high clinical significance of the disease, the risk of its relapse and the insufficient effectiveness of standard management protocols [13,14].

AIM OF THE RESEARCH

Development and clinical evaluation of the effectiveness of a personalized program of medical rehabilitation of adolescents after surgical treatment of urolithiasis, based on risk stratification, clinical, functional and metabolic indicators.

MATERIALS AND METHODS

The study included 62 adolescents aged 12 to 17 years who had surgical treatment of urolithiasis in a specialized urology department. All patients were stratified by the risk levels of urolithiasis recurrence (low, moderate, high) based on metabolic screening, clinical and instrumental data.

Patients were randomized into two groups: The main group (n=28) received an individualized rehabilitation program, including: correction of water-electrolyte balance, metabolic therapy, physiotherapy, nutritional support and physical activity taking into

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account the metabolic phenotype. The comparison group (n=34) received standard rehabilitation care according to current clinical protocols.

The effectiveness assessment was carried out on the basis of: functional parameters of the urinary system (daily diuresis, ultrasound, residual urine), biochemical markers (oxalates, urates, citrates, calcium, magnesium, urine pH), quality of life (PedsQL™ questionnaire), relapse rates during 6 months of observation.

Statistical processing was performed using SPSS 26.0 software. The significance of differences between groups was assessed using Student's t-test and the Mann–Whitney test, $p < 0.05$ was considered statistically significant.

RESULTS THE RESEARCH

During the study, the following clinical, functional and metabolic data were obtained, characterizing the dynamics of the condition of patients in the main and control groups. The results of the analysis revealed statistically significant differences between the observation groups, confirming the effectiveness of the developed rehabilitation program. The study of the dynamics of clinical and metabolic indicators during the rehabilitation period showed the following results. The results obtained demonstrate the effectiveness of a personalized approach to medical rehabilitation of adolescents after surgical treatment of urolithiasis . Below are the results of a comparative analysis of indicators in adolescents of the main and control groups at different observation periods.

Table 1
Comparison of functional parameters of the urinary system at the time of admission

Indicator	MG (n=28)	CG (n=34)	p
Glomerular filtration rate (ml/min/1.73 m²)	86.4 ± 9.2	88.1 ± 8.7	>0.05
Residual urine (ml)	46.2 ± 10.5	45.7 ± 9.8	>0.05
Daily diuresis (ml/day)	1240 ± 150	1205 ± 140	>0.05

Table 1 presents the initial functional parameters of the urinary system in adolescents of the main (MG) and control (CG) groups at the time of admission. The parameters include glomerular filtration rate (GFR), residual urine volume, and daily diuresis. The average GFR values were 86.4 ± 9.2 ml/min/1.73 m² in the MG and 88.1 ± 8.7 ml/min/1.73 m² in the CG. The residual urine volume was 46.2 ± 10.5 ml and 45.7 ± 9.8 ml, respectively. Daily diuresis was 1240 ± 150 ml in the MG and 1205 ± 140 ml in the CG. The differences between the groups for all three parameters were statistically insignificant ($p > 0.05$).

At the time of inclusion in the study, the indicators of the functional state of the urinary system in both groups were comparable, which indicates the initial equality of conditions and allows an objective assessment of the impact of the rehabilitation program at the next stage.

Table 2
Metabolic parameters of urine before rehabilitation

Indicator	MG (n=28)	CG (n=34)	p
Calcium/creatinine (mmol/mmol)	0.49 ± 0.08	0.52 ± 0.09	>0.05
Oxalates (mmol/day)	0.48 ± 0.06	0.50 ± 0.07	>0.05
Citrates (mmol/day)	1.12 ± 0.13	1.08 ± 0.15	>0.05

Table 2 presents the data of comparative analysis of metabolic parameters of urine in children of the main (MG) and control (CG) groups before the start of rehabilitation measures. The calcium to creatinine ratio in daily urine in the main group was 0.49 ± 0.08 mmol/mmol, in the control group - 0.52 ± 0.09 mmol/mmol, the differences between the groups were statistically insignificant ($p > 0.05$).

Oxalate excretion was also comparable: 0.48 ± 0.06 mmol/day in the MG versus 0.50 ± 0.07 mmol/day in the CG ($p > 0.05$).
A similar trend was observed for the level of citrates: 1.12 ± 0.13 mmol/day in the participants of the main group and 1.08 ± 0.15 mmol/day in the control group ($p > 0.05$).

At the pre-rehabilitation stage, urinary metabolic parameters (including calcium, oxalate, and citrate levels) were comparable in both groups and did not have statistically significant differences. This indicates the initial homogeneity of the compared groups in key metabolic markers of urine formation.

Table 3
Dynamics of functional indicators after 3 months of rehabilitation

Indicator	Before (MG)	After (MG)	Before (CG)	After (CG)	p
CF rate (ml/min/1.73 m²)	86.4 ± 9.2	92.8 ± 7.6	88.1 ± 8.7	89.0 ± 7.9	<0.05
Residual urine (ml)	46.2 ± 10.5	28.5 ± 8.4	45.7 ± 9.8	41.2 ± 10.2	<0.01
Daily diuresis (ml/day)	1240 ± 150	1520 ± 165	1205 ± 140	1280 ± 155	<0.05

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Table 3 shows the dynamics of the functional parameters of the urinary system in patients of the main and control groups before and after completion of the three-month rehabilitation course.

In patients of the main group (MG), a significant improvement in glomerular filtration rate (GFR) was recorded from 86.4 ± 9.2 to 92.8 ± 7.6 ml/min/1.73 m² ($p<0.05$), while in the control group (CG) the indicators remained virtually unchanged (88.1 ± 8.7 to 89.0 ± 7.9 ml/min/1.73 m²).

The residual urine volume in patients of the main group decreased from 46.2 ± 10.5 to 28.5 ± 8.4 ml ($p < 0.01$), indicating an improvement in the contractile function of the bladder. In the control group, a decrease was also observed, but less pronounced (45.7 ± 9.8 to 41.2 ± 10.2 ml), which did not reach statistical significance.

Daily diuresis increased in the main group from 1240 ± 150 to 1520 ± 165 ml/day ($p<0.05$), while in the control group the increase was less pronounced (1205 ± 140 to 1280 ± 155 ml/day), despite the fact that the changes were also statistically significant. Three months after the use of the personalized rehabilitation program, patients in the main group showed a statistically significant improvement in key functional parameters of the kidneys and urinary system, including an increase in glomerular filtration rate, a decrease in residual urine, and an increase in daily diuresis.

The obtained data confirm the effectiveness of the proposed rehabilitation complex in comparison with the traditional approach.

Table 4
Dynamics of metabolic markers in urine after 3 months

Indicator	Before (MG)	After (MG)	Before (CG)	After (CG)	p
Calcium/ creatinine	0.49 ±0.08	0.36 ± 0.06	0.52 ± 0.09	0.50 ± 0.08	<0.01
Oxalates (mmol/day)	0.48 ± 0.06	0.35 ± 0.05	0.50 ± 0.07	0.47 ± 0.06	<0.01
Citrates (mmol/day)	1.12 ± 0.13	1.45 ± 0.11	1.08 ± 0.15	1.15 ± 0.14	<0.01

Table 4 shows the dynamics of urinary metabolic markers in children after 3 months of the rehabilitation program. The analyzed parameters included the calcium/creatinine ratio, daily excretion of oxalates and citrates. In patients of the main group (MG) after the rehabilitation course, a reliable decrease in the calcium/creatinine ratio was noted from 0.49 ± 0.08 to 0.36 ± 0.06 ($p < 0.01$), which may indicate a decrease in the risk of calcium crystalluria and improvement in metabolic regulation. The oxalate level also significantly decreased - from 0.48 ± 0.06 to 0.35 ± 0.05 mmol / day ($p < 0.01$), indicating a decrease in the lithogenic potential of urine. At the same time, the content of citrates, a natural inhibitor of stone formation, increased from 1.12 ± 0.13 to 1.45 ± 0.11 mmol/day ($p < 0.01$), which is also regarded as a positive effect of therapy.

In the control group (CG), there was virtually no positive dynamics: changes in the indicators were statistically insignificant. The results of the analysis of metabolic markers in urine after 3 months indicate a significant improvement in the biochemical profile in patients of the main group. A significant decrease in calcium and oxalate levels, as well as an increase in citrates in the urine indicate a decrease in the risk of recurrence of urolithiasis under the influence of a personalized rehabilitation program.

Table 5
Rate of recurrence/complications within 6 months after surgery

Exodus	OG (n=28)	KG (n=34)	p-value
Recurrence of urolithiasis (ultrasound/complaints)	2 (7.1%)	7 (20.6%)	<0.05
Urinary tract infections	1 (3.6%)	6 (17.6%)	<0.05
Repeated hospitalization	0	4 (11.8%)	<0.05

Table 5 presents comparative data on the frequency of relapses and complications in children within 6 months after surgery for urolithiasis (USD) in the main (MG) and control (CG) groups.

In the main group, recurrence of urolithiasis, determined by ultrasound data and clinical complaints, was observed only in 2 children (7.1%), while in the control group this figure was 20.6% (7 children), which is a statistically significant difference ($p < 0.05$). Urinary tract infections were detected in 3.6% of cases (1 child) in the main group, while in the control group - in 6 children (17.6%), which also turned out to be significant ($p < 0.05$).

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Rehospitalization was required only in children from the control group - in 4 patients (11.8%), while in the main group there were no such cases ($p < 0$,05).

The obtained data indicate a more favorable clinical course in patients who received a personalized medical rehabilitation program. A significantly lower frequency of relapses, infectious complications and rehospitalizations in children of the main group emphasizes the effectiveness of the proposed clinical-functional-metabolic approach in the early postoperative period.

DISCUSSION

The obtained results confirm the clinical and metabolic efficiency of the developed personalized rehabilitation program in children who underwent surgical treatment of urolithiasis (UL). The conducted analysis of the dynamics of laboratory and clinical-functional parameters revealed a reliable improvement in patients of the main group (MG) compared to the control group (CG), which indicates the feasibility of a comprehensive and individualized approach in the early recovery period.

One of the key areas of personalized rehabilitation was the elimination of water-electrolyte and metabolic homeostasis disorders, often found in children with urolithiasis. After rehabilitation, patients with MG showed normalization of calcium, oxalate and magnesium levels in urine, as well as an increase in the level of citrates, an important inhibitor of salt crystallization. These changes indicate a decrease in urine lithogenicity and a decrease in the risk of recurrent stone formation.

Particular importance has the reduction in the frequency of relapses and complications. Within 6 months after the operation, the frequency of relapse of urolithiasis in children from the main group was only 7.1%, while in the control group it was 20.6% ($p < 0.05$). Also, urinary tract infections were significantly less common in patients in the MG (3.6% versus 17.6%) and there were no re-hospitalizations (versus 11.8% in the CG). These data confirm the effectiveness of including antibacterial prophylaxis, correction of urodynamics, diet and metabolic support in the rehabilitation process.

Comparison with literary sources shows that the approach we propose is consistent with modern concepts of the need to integrate clinical, functional and biochemical monitoring into the rehabilitation system for urolithiasis in children. Unlike standard schemes, the developed program involves risk stratification and individual selection of therapy components, which determined better results compared to the traditional approach.

Thus, the discussion of the study results demonstrates that a personalized rehabilitation program allows for a sustainable improvement in the condition of patients, minimizing the incidence of complications and relapses, and improving the quality of life in the postoperative period.

CONCLUSION

The developed personalized program of medical rehabilitation in boys after surgical treatment of urolithiasis, taking into account clinical, functional and metabolic features, showed high efficiency compared to standard management.

After only 3 months, patients in the main group showed a significant improvement in metabolic parameters of urine (decrease in calcium/creatinine, oxalates, increase in citrate levels), which indicates stabilization of the lithogenic background.

After 6 months, a decrease in the frequency of recurrence of urolithiasis, urinary tract infections and rehospitalization was noted in patients of the main group, which indicates the preventive potential of the proposed program.

The obtained results substantiate the need to introduce an individualized approach to the rehabilitation of children after surgical treatment of urolithiasis, including metabolic control, diet correction and monitoring of relapses.

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