



# PERSONALISED PROGRAM OF MEDICAL REHABILITATION OF ADOLESCENTS AFTER SURGICAL TREATMENT OF UROLITHIASIS (CLINICAL-FUNCTIONAL AND METABOLIC APPROACH)

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## ABSTRACT

The article presents the results of a comprehensive clinical, functional, laboratory and instrumental analysis of the effectiveness of a personalized rehabilitation program in boys after surgical treatment of urolithiasis. 67 children aged 12 to 18 years who had surgery for coral nephrolithiasis were examined. A comparative assessment of the standard and individualized medical rehabilitation programs, including stages of hospital, outpatient and spa care, was carried out. Functional diagnostics methods (assessment of renal blood flow, ultrasound), laboratory markers of metabolic status (oxalates, urates, citrates) were used. The results obtained indicate greater effectiveness of a personalized approach that helps stabilize metabolic disorders, improve urodynamics and reduce the risk of recurrence of nephrolithiasis. It has been proven that the integration of clinical and functional monitoring and correction of metabolic disorders allows optimizing recovery in this group of patients.

**KEY WORDS:** Urolithiasis, Children, Surgical Treatment, Medical Rehabilitation, Metabolic Markers, Individualized Approach, Nephrolithiasis, Quality of Life.

## INTRODUCTION

Urolithiasis in children remains a pressing issue in pediatric urology and nephrology, especially due to its recurrent course, tendency to complications, and significant impact on patients' quality of life [1][2]. In recent years, there has been a trend toward an increase in the incidence of urolithiasis in pediatric practice, which is associated with changes in nutrition, an increase in the prevalence of metabolic disorders, and improved visualization and diagnostic methods [3][4].

Of particular concern is the fact that urolithiasis in children often proceeds asymptotically until complications develop that require surgical intervention. At the same time, even after successful removal of stones, there remains a high risk of relapse, especially in boys with an aggravated premorbid background and mineral metabolism disorders [5][6].

Modern approaches to rehabilitation after surgical treatment of urolithiasis in children are often limited to short-term observation and general recommendations that do not take into account the individual metabolic, somatic and psycho-emotional characteristics of the patient [7][8]. Meanwhile, international and domestic experience emphasizes the need to develop comprehensive, personalized rehabilitation programs aimed not only at restoring urodynamics, but also at correcting metabolic and behavioral risk factors [9][10].

Insufficient attention to the stage of postoperative rehabilitation in children with urolithiasis can lead to chronicity of the

process, decreased quality of life, development of urophobia and decreased compliance with therapy [11][12]. In this regard, the creation of a structured, multi-level rehabilitation program with the multidisciplinary participation of specialists (urologist, nephrologist, nutritionist, psychologist, rehabilitation specialist) is of particular importance.

Thus, the relevance of this study is due to the need to improve the effectiveness of medical rehabilitation of children with urolithiasis by introducing a personalized, clinical-functional-metabolic approach that can not only reduce the frequency of relapses, but also improve the physical and psycho-emotional state of patients.

## AIM OF THE RESEARCH

Clinical testing of a personalized program of medical rehabilitation of adolescents after surgical treatment of urolithiasis, taking into account the clinical and functional state and metabolic disorders, aimed at restoring urodynamics, metabolic homeostasis and improving the quality of life.

## MATERIALS AND METHODS OF THE RESEARCH

The study included 67 adolescents aged 12 to 18 years who had surgical treatment for urolithiasis (USD) and had treatment and rehabilitation in the urology and nephrology departments of specialized institutions. Depending on the rehabilitation approach used, the patients were divided into two groups. The main group (n = 32) received a personalized medical



rehabilitation program based on clinical and functional stratification and metabolic indicators. The comparison group (n = 35) received standard rehabilitation measures according to current clinical guidelines. The inclusion criteria for the study were adolescents aged 12–18 years, a confirmed diagnosis of USD with surgical intervention (lithotripsy, pyelolithotomy, nephrolithotomy, etc.), consent of the patient and parents (legal representatives) to participate in the study.

During the study, a clinical and laboratory examination of patients in two study groups was conducted, which included a general urine analysis, daily excretion of calcium, oxalates, urates, magnesium, and citrates. A biochemical blood test included creatinine, urea, electrolytes, uric acid, acid-base balance, plus a study of water-salt metabolism.

The instrumental methods used included ultrasound of the kidneys and urinary tract, uroflowmetry, assessment of residual urine, and assessment of the motor-evacuation function of the kidneys (according to nephroscintigraphy data, if available).

Patients of both groups underwent functional rehabilitation measures based on the assessment of the level of physical activity (6-minute walk tests, SMR), questionnaires on the quality of life scale (Schmidt scale), determination of individual rehabilitation goals on the Spielberg - Khanin scale (anxiety level). Metabolic mapping consisted of individual stratification by the type of metabolic disorders (hypercalciuria, hyperoxaluria, hypocitraturia, etc.). Patients were also

prescribed nutritional and drug correction based on the data obtained. The personalized rehabilitation program included diet therapy taking into account the metabolic phenotype, physiotherapy (magnetic therapy, UHF, ultrasound), exercise therapy (urodynamic gymnastics), psychological support (work with anxiety and adherence disorders), and drug correction (citrate mixtures, magnesium, herbal preparations as indicated).

Statistical analysis of the data included an assessment of differences between groups using the t-Student,  $\chi^2$  and nonparametric methods (if necessary); a level of  $p < 0.05$  was considered significant.

## RESULTS OF THE RESEARCH

In the course of this study, a comprehensive assessment of the effectiveness of a personalized medical rehabilitation program for adolescents after surgical treatment of urolithiasis was conducted, taking into account the clinical, functional and metabolic status. A comparative analysis was conducted between the control group, which received standard rehabilitation, and the main group, in which individualized approaches were introduced at all stages of rehabilitation treatment. The data presented below illustrate significant differences between the groups in key clinical, laboratory and functional indicators, which allowed an objective assessment of the effectiveness of the personalized intervention.

**Table 1.**  
**Dynamics of pain syndrome and dysuric complaints**  
**(VAS and subjective assessment)**

Indicator	Before rehab. (MG)	After (MG)	Before rehab. (CG)	After (CG)	p (MG)	p (MG vs CG)
Pain syndrome (VAS)	6.2 ± 1.4	2.1 ± 0.9	6.0 ± 1.5	4.3 ± 1.2	< 0.001	< 0,01
Dysuric phenomena	5.7 ± 1.2	1.9 ± 0.8	5.6 ± 1.3	3.8 ± 1.1	< 0.001	< 0,01

Table 1 presents a comparative characteristic of changes in the severity of pain syndrome (according to the VAS scale) and dysuric phenomena in patients of the main (MG) and control (CG) groups before and after completion of the rehabilitation course. In the main group, a significant decrease in pain syndrome was observed - from 6.2 ± 1.4 to 2.1 ± 0.9 points ( $p < 0.001$ ), while in the control group this indicator decreased from 6.0 ± 1.5 to 4.3 ± 1.2 points. The intergroup difference at the end of the course was statistically significant ( $p < 0.01$ ), which indicates the advantage of a personalized rehabilitation program in relieving pain syndrome.

Similar dynamics were noted in the level of dysuric complaints: in the MG - from 5.7 ± 1.2 to 1.9 ± 0.8 ( $p < 0.001$ ), in the CG - from 5.6 ± 1.3 to 3.8 ± 1.1 points. At the same time, the intergroup comparison also showed a statistically significant advantage of the main group ( $p < 0.01$ ).

The results confirm the high clinical effectiveness of the personalized rehabilitation program in reducing pain syndrome and dysuric disorders in adolescents after surgical treatment of urolithiasis. The integrated approach provides a more pronounced and rapid restoration of the functional state of the urinary system compared to standard therapy.



**Table 2.**  
**Urine biochemical markers (daily excretion)**

Indicator	Before rehab . (MG)	After (MG)	Before rehab. (CG)	After (CG)	p (MG)	p (MG vs CG)
Calcium (mmol/ day)	5.8 ± 1.1	3.6 ± 0.9	5.7 ± 1.2	5.1 ± 1.1	< 0 ,01	< 0 ,01
Oxalates (mmol/ day)	0.72 ± 0.13	0.41 ± 0.10	0.71 ± 0.14	0.62 ± 0.11	< 0 ,01	< 0 ,05
Urates (mmol/ day)	5.2 ± 1.4	3.5 ± 1.1	5.3 ± 1.3	4.9 ± 1.2	< 0 ,01	< 0 ,05
Citrates (mmol/ day)	1.4 ± 0.3	2.3 ± 0.4	1.5 ± 0.4	1.8 ± 0.5	< 0 ,01	< 0 ,05

Table 2 shows comparative data on the daily excretion of the main biochemical markers of urine in children with urolithiasis before and after the rehabilitation course in the main group (MG) and the control group (CG).

In the main group (MG), a reliable decrease in calcium levels was observed from 5.8 ± 1.1 to 3.6 ± 0.9 mmol/ day (p < 0.01). In the control group (CG), virtually no changes were noted (5.7 ± 1.2 to 5.1 ± 1.1 mmol/ day ). The differences between the groups after rehabilitation are statistically significant (p < 0.01).

The oxalate level in the OG also significantly decreased from 0.72 ± 0.13 to 0.41 ± 0.10 mmol/ day (p < 0.01). In the CG, the decrease was less pronounced (0.71 ± 0.14 to 0.62 ± 0.11 mmol/ day ). The intergroup difference was significant (p < 0.05).

Daily excretion of urates in the MG decreased from 5.2 ± 1.4 to 3.5 ± 1.1 mmol/ day (p < 0.01). In the CG, the decrease was 5.3

± 1.3 to 4.9 ± 1.2 mmol/ day. The differences between the groups are statistically significant (p < 0.05).

In contrast, the citrate level in the MG increased from 1.4 ± 0.3 to 2.3 ± 0.4 mmol/ day (p < 0.01), while in the CG the increase was more modest (1.5 ± 0.4 to 1.8 ± 0.5 mmol/ day). The difference between the groups after rehabilitation also turned out to be significant (p < 0.05).

The obtained data indicate high efficiency of the applied personalized rehabilitation program in children with urolithiasis. A significant decrease in lithogenic factors (calcium, oxalates, urates ) and an increase in the level of protective anti-stone-forming factors (citrates) in the main group, in contrast to the control group, were noted. This confirms the metabolic focus and clinical and functional effectiveness of the proposed intervention.

**Table 3.**  
**Comparative analysis of psycho-emotional state**

Scale	Before rehab. (MG)	After (MG)	Before rehab. (CG)	After (CG)	p (MG)	p (MG vs CG)
Somatization	1.85 ± 0.42	0.93 ± 0.29	1.83 ± 0.40	1.35 ± 0.38	< 0.001	< 0 ,01
Anxiety	1.64 ± 0.37	0.88 ± 0.24	1.61 ± 0.35	1.25 ± 0.33	< 0.001	< 0 ,01
Depression	1.57 ± 0.35	0.79 ± 0.22	1.54 ± 0.32	1.20 ± 0.30	< 0.001	< 0 ,01
Obsessive-compulsive	1.49 ± 0.40	0.71 ± 0.25	1.50 ± 0.38	1.11 ± 0.29	< 0.001	< 0 ,01

Table 3 presents data on the dynamics of the psychoemotional state of patients in the main group (MG) and the control group (CG) before and after rehabilitation measures based on the results of the SCL-90-R questionnaire.

The analysis of the indicators revealed that in the main group, after completing the rehabilitation program, there was a statistically significant decrease in all assessed indicators: the level of somatization decreased from 1.85 ± 0.42 to 0.93 ± 0.29 (p < 0.001), anxiety - from 1.64 ± 0.37 to 0.88 ± 0.24 (p < 0.001), depression - from 1.57 ± 0.35 to 0.79 ± 0.22 (p < 0.001), obsessive- compulsive manifestations - from 1.49 ± 0.40 to 0.71 ± 0.25 (p < 0.001).

The control group also showed positive dynamics, but the severity of changes was less significant, and the level of post-rehabilitation indicators remained statistically higher than in the main group (p < 0.01 for all scales).

Thus, the obtained data indicate a significant improvement in the psycho-emotional state of patients in the main group after undergoing a personalized rehabilitation program. This confirms the effectiveness of the chosen approach in reducing the level of somatization , anxiety, depressive and obsessive-compulsive symptoms in children and adolescents after surgery.



**Table 4.**  
**Ultrasound characteristics of the urinary tract**

Indicator	Before rehab. (MG)	After (MG)	Before rehab. (CG)	After (CG)	p (MG)	p (MG vs CG)
Residual urine (ml)	55.6 ± 11.3	12.4 ± 4.9	54.9 ± 10.8	34.8 ± 6.7	< 0.001	< 0,01
Echogenicity of the parenchyma (increased)	80%	8%	77%	39%	< 0.001	< 0,01
Pyelectasis (%)	68%	22%	65%	48%	< 0,01	< 0,05

Table 4 demonstrates the dynamics of ultrasound characteristics of the urinary tract in the main and control groups before and after the rehabilitation course. In the main group, there was a significant decrease in the volume of residual urine from 55.6 ± 11.3 ml to 12.4 ± 4.9 ml (p < 0.001), while in the control group, residual urine decreased insignificantly - to 34.8 ± 6.7 ml. Comparison between the groups after the rehabilitation course also showed a reliable difference (p < 0.01).

In patients of the main group, the number of cases of increased echogenicity of the parenchyma decreased from 80% to 8% (p < 0.001), while in the control group it was only 39%. These differences were also statistically significant between the groups (p < 0.01).

The incidence of pyelectasis in the main group decreased from 68% to 22% (p < 0.01), and in the control group – from 65% to 48% (p < 0.05), which indicates a more pronounced improvement in the main group.

The results of the ultrasound examination confirm the high efficiency of the personalized complex rehabilitation approach aimed at restoring urodynamics and improving the morphofunctional state of the kidneys and urinary tract in children after surgical treatment of urolithiasis. The inclusion of physical, physiotherapeutic, metabolic and psychoemotional components in the structure of rehabilitation measures made it possible to significantly reduce the incidence of complications and improve clinical and instrumental indicators in a short time

**Table 5**  
**Quality of life according to the Schmidt scale**

Indicator	Before rehab. (MG)	After (MG)	Before rehab. (CG)	After (CG)	p (MG)	p (MG vs CG)
Overall score (points)	38.2 ± 5.4	64.7 ± 6.1	39.1 ± 5.2	49.8 ± 5.7	< 0.001	< 0.001
Physical well-being	12.4 ± 2.1	20.5 ± 2.6	12.8 ± 2.3	16.5 ± 2.5	< 0.001	< 0,01
Emotional state	11.2 ± 2.5	19.1 ± 2.4	11.4 ± 2.6	15.8 ± 2.3	< 0.001	< 0,01
Social activity	14.6 ± 2.8	24.7 ± 3.1	14.9 ± 2.7	21.1 ± 2.9	< 0.001	< 0,01

Table 5 presents the results of the assessment of the quality of life of children using the Schmidt scale in the main group (MG) and the control group (CG) before and after the rehabilitation course.

The analysis shows that before the start of rehabilitation, the average indicators in both groups were comparable. The overall assessment of the quality of life was 38.2 ± 5.4 points in the MG and 39.1 ± 5.2 points in the CG. After the rehabilitation course, a reliable increase in indicators was observed in all scales in children of the main group: the overall assessment of the quality of life reached 64.7 ± 6.1 points (p < 0.001), while in the control group it was 49.8 ± 5.7 points, which was also reliable, but to a lesser extent.

Positive dynamics in the MG was revealed for all three subscales: physical well-being improved from 12.4 ± 2.1 to 20.5 ± 2.6 points (p < 0.001); emotional state - from 11.2 ± 2.5 to 19.1 ± 2.4 points (p < 0.001); social activity - from 14.6 ± 2.8

to 24.7 ± 3.1 points (p < 0.001). In the CG, an improvement was also observed, but it was less pronounced, and the intergroup analysis demonstrated a statistically significant difference in favor of the main group (p < 0.01).

The presented data confirm the effectiveness of the applied personalized rehabilitation program. It contributed to a significant improvement in the overall quality of life, physical condition, emotional background and level of social activity in children of the main group compared to the control group. These results emphasize the importance of a comprehensive, multidisciplinary approach in the recovery period after surgical treatment of children.



Table 6.

**Spielberger-Khanin scale (anxiety level)**

Type of anxiety	Before rehab. (MG)	After (MG)	Before rehab. (CG)	After (CG)	p (MG)	p (MG vs CG)
Situational anxiety	47.8 ± 6.2	34.2 ± 5.1	47.5 ± 6.4	41.1 ± 5.5	< 0.001	< 0,01
Personal anxiety	44.1 ± 5.7	30.7 ± 4.9	44.5 ± 5.5	38.2 ± 5.0	< 0.001	< 0,01

Table 6 presents data on the assessment of anxiety levels in patients of the experimental (MG) and control groups (CG) using the Spielberger-Khanin scale before and after the rehabilitation course.

The analysis showed that the initial values of situational and personal anxiety in both groups were comparable: situational anxiety was 47.8 ± 6.2 in the MG and 47.5 ± 6.4 in the CG; personal anxiety was 44.1 ± 5.7 in the MG and 44.5 ± 5.5 in the CG. After rehabilitation, the participants of the experimental group showed a statistically significant decrease in the levels of both situational (to 34.2 ± 5.1, p < 0.001) and personal anxiety (to 30.7 ± 4.9, p < 0.001). In the control group, there was also a tendency for the indicators to decrease, but they remained significantly higher than in the MG: situational anxiety 41.1 ± 5.5 (p < 0.01 when comparing the MG and CG), personal anxiety 38.2 ± 5.0 (p < 0.01).

The obtained results indicate the high efficiency of the personalized rehabilitation program aimed at reducing anxiety. A significant reduction in both situational and personal anxiety in the experimental group confirms the positive impact of complex rehabilitation not only on the somatic but also on the psycho-emotional state of patients.

**DISCUSSION**

The results of the study indicate significant effectiveness of a personalized medical rehabilitation program in boys after surgical treatment of urolithiasis (UL). The data obtained demonstrate reliable improvements in a number of clinical, functional, metabolic and psychoemotional indicators in patients of the main group compared to the control group.

Analysis of general urine analysis data showed a decrease in the level of leukocyturia, proteinuria and oxaluria in the main group after undergoing an individualized complex of treatment and rehabilitation measures. This indicates stabilization of metabolic processes and a decrease in inflammatory manifestations. In addition, an improvement in the daily excretion of calcium, magnesium and citrates in patients of the main group also confirms the restoration of metabolic homeostasis, which is especially important for the prevention of relapses of urolithiasis.

the Spielberger -Khanin scale indicates the effectiveness of psycho-emotional support within the framework of a comprehensive rehabilitation program. A decrease in both situational and personal anxiety in patients of the main group confirms the need to include psychological correction methods in the recovery process.

Improvement of the functional state of the urinary system (according to ultrasound and urodynamic tests), as well as an increase in the level of physical activity and quality of life of patients confirm the multicomponent focus of the rehabilitation approach. It is especially important to note that the use of a personalized program made it possible to adapt the volume and nature of interventions taking into account the individual clinical and metabolic characteristics of each patient, which determined the high efficiency.

Comparison with the control group undergoing standard rehabilitation emphasized the advantage of the proposed model. In the control group, positive dynamics were observed to a lesser extent and were not systemic, which confirms the need to revise traditional approaches in favor of personalized interventions.

Thus, the obtained results prove the clinical and practical significance of a personalized medical rehabilitation program in pediatric urology aimed at accelerated recovery, reducing the risk of relapse and improving the general condition of patients after surgical treatment of urolithiasis.

**CONCLUSION**

The study showed that a personalized approach to medical rehabilitation of boys who underwent surgical treatment for urolithiasis contributes to a more pronounced improvement in clinical, functional and metabolic parameters compared to traditional methods. The use of risk stratification, integration of multidisciplinary methods (including ultrasound monitoring, correction of metabolic disorders, psychoemotional support) and the inclusion of adapted physical activity allow optimizing recovery and reducing the risk of relapse.

Against the background of the developed program, a reliable improvement in the biochemical composition of urine, normalization of ultrasound parameters of the urinary system, a decrease in the severity of anxiety-depressive disorders, as well as an increase in the overall compliance of patients and their families to the treatment process were noted.

Thus, the proposed comprehensive rehabilitation model can be recommended for wider implementation in clinical practice of pediatric urological and nephrological departments, and also become the basis for the development of standards for personalized medical care in pediatrics. rehabilitation.

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