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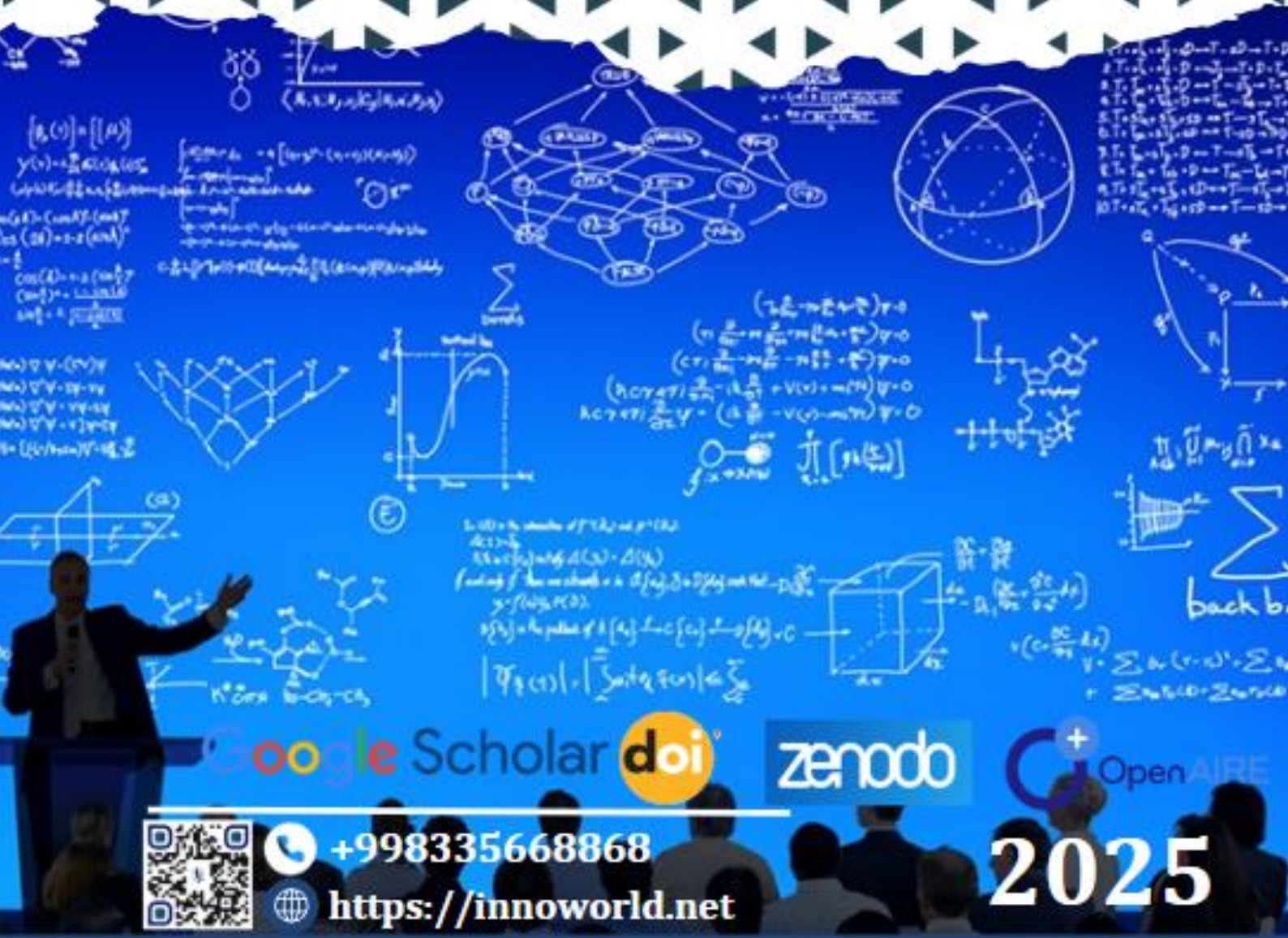

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Current Strategies for Early and Late Rehabilitation of Pediatric Patients with Congenital Anomalies of the Digestive Tract.

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Abstract. Congenital anomalies of the digestive tract (CADT) represent a diverse group of pathologies that continue to pose diagnostic and therapeutic challenges in pediatric surgery. Early surgical correction ensures anatomical restoration, yet the postoperative period is often complicated by long-term functional disturbances that require targeted rehabilitation.

This study aimed to analyze the effectiveness of a comprehensive rehabilitation strategy applied during both early and late postoperative periods in children with congenital digestive tract anomalies.

The study included 137 pediatric patients aged from newborn to 15 years who underwent surgery for various forms of CADT at the Republican Scientific Center of Emergency Medical Care (Tashkent, Uzbekistan) between 2014 and 2024. Patients were divided into two groups: the comparison group (n=75) received conventional postoperative care, while the main group (n=62) was treated under an optimized rehabilitation program integrating local and systemic approaches. Statistical analyses were conducted using descriptive and comparative methods, with significance set at $p < 0.05$. Implementation of the multidisciplinary rehabilitation protocol led to a marked reduction in both the frequency and severity of early postoperative complications (from 54.7% to 29.0%; p=0.004) and late functional disorders (from 44.0% to 18.5%; p=0.008). Hospitalization time was shortened (from 14.2 ± 0.5 to 11.1 ± 0.4 days; p<0.001), while overall recovery indicators—nutritional status, bowel function, and quality of life—improved significantly compared to standard management.

The introduction of an evidence-based, stage-specific rehabilitation system for children with congenital digestive tract anomalies significantly enhances postoperative outcomes and accelerates functional recovery. These findings emphasize the need to integrate structured rehabilitation into standard pediatric surgical care protocols.

Keywords: congenital digestive tract anomalies, pediatric surgery, postoperative rehabilitation, early outcomes, long-term outcomes.

Introduction

Congenital anomalies of the digestive tract (CADT) remain among the most complex conditions in pediatric surgery, both in terms of diagnosis and

treatment outcomes. Advances in neonatal intensive care, anesthesia, and surgical techniques have dramatically improved survival rates; however, achieving optimal long-term functional results remains a major challenge. Despite successful anatomical correction, many patients continue to experience persistent gastrointestinal dysfunction, growth delays, and psychosocial adaptation difficulties [1–4].

The causes of these complications are multifactorial and include delayed diagnosis, the severity of the underlying malformation, associated anomalies, and postoperative complications. Moreover, the absence of standardized rehabilitation protocols often leads to inconsistent outcomes across treatment centers [5–7].

A number of studies have emphasized the importance of postoperative rehabilitation as a determinant of successful long-term recovery in children with CADT. Rehabilitation not only restores gastrointestinal motility and nutrient absorption but also supports immune and metabolic stability, reduces the risk of adhesive processes, and prevents recurrent intestinal obstruction [8–11]. Nevertheless, rehabilitation is still frequently underestimated in pediatric surgical practice, with limited implementation of structured, multidisciplinary approaches [12].

In recent years, attention has shifted toward the development of comprehensive systems of care that include early physiotherapeutic, dietary, and pharmacological interventions alongside continuous monitoring and individualized treatment planning [13–15]. These approaches aim to bridge the gap between immediate postoperative recovery and sustained long-term adaptation.

Given these considerations, there is an evident need for systematic research to evaluate the effectiveness of integrated rehabilitation programs in pediatric patients with CADT.

The purpose of this study was to assess the early and long-term outcomes of children with congenital anomalies of the digestive tract treated under a multidisciplinary rehabilitation protocol, comparing these results with outcomes achieved using conventional postoperative management.

Materials and Methods

This clinical study analyzed the treatment and rehabilitation outcomes of 137 pediatric patients with congenital anomalies of the digestive tract (CADT) who underwent surgical correction at the Republican Scientific Center of Emergency Medical Care in Tashkent, Uzbekistan, between 2014 and 2024.

2.1. Study Design and Groups

The patients were divided into two cohorts based on the postoperative management strategy:

– The comparison group (n = 75; 54.7%) included children who received standard postoperative care between 2014 and 2019.

– The main group (n = 62; 45.3%) consisted of patients treated from 2020 to 2024 under an optimized rehabilitation protocol developed and implemented at the center.

The study included children of both sexes ranging from newborns to 15 years of age (mean = 6.8 ± 0.3 years).

2.2. Inclusion and Exclusion Criteria

Inclusion criteria covered patients diagnosed with congenital anomalies requiring surgical correction—such as esophageal atresia, duodenal and jejunal atresia, anorectal malformations, Hirschsprung's disease, and meconium ileus.

Exclusion criteria involved patients with malignant gastrointestinal tumors, severe systemic infections, or genetic syndromes incompatible with life.

2.3. Etiological and Clinical Distribution

The distribution of anomalies was as follows:

– Esophageal atresia: 22 cases (16.1%)
– Duodenal atresia: 28 cases (20.4%)
– Jejunoileal atresia: 24 cases (17.5%)
– Hirschsprung's disease: 19 cases (13.9%)
– Anorectal malformations: 33 cases (24.1%)
– Meconium ileus and others: 11 cases (8.0%)

Most children (72.3%) were operated on during the neonatal period, while the remainder underwent delayed reconstructive interventions due to medical contraindications or late diagnosis.

2.4. Rehabilitation Strategy

The optimized rehabilitation program for the main group incorporated both systemic and local components:

✓ Systemic rehabilitation included nutritional correction (age-appropriate parenteral and enteral feeding), probiotic therapy to restore intestinal microbiota, immune modulation, and targeted pharmacotherapy for comorbidities.

✓ Local rehabilitation focused on early activation, physiotherapy (low-frequency magnetic stimulation and laser therapy), peristomal and surgical wound care, and prevention of adhesive disease.

Parents were provided with detailed education on home-based stoma and wound care, diet management, and the importance of regular follow-up.

In contrast, the comparison group received traditional management limited to wound dressing, general pharmacological support, and routine monitoring without structured rehabilitation elements.

2.5. Evaluation Criteria

The study assessed early postoperative outcomes (within 30 days) and long-term outcomes (after 6 months and up to 3 years). The following indicators were analyzed:

✓ Frequency and severity of postoperative complications, classified according to Clavien–Dindo (2004) [16];

✓ Functional results (intestinal motility recovery, stool frequency, feeding tolerance);

✓ Growth dynamics and nutritional status;

✓ Duration of hospitalization and time to complete recovery.

2.6. Statistical Analysis

All statistical analyses were performed using SPSS 25.0. Descriptive statistics (mean, standard deviation, and percentage) were calculated for all variables. Group differences were assessed using the χ^2 test and Student's t-test. Differences were considered statistically significant at $p < 0.05$.

Results and Discussion

3.1. Early Postoperative Outcomes

Early postoperative complications occurred in 41 (54.7%) patients in the comparison group and 18 (29.0%) in the main group, demonstrating a statistically significant reduction following the introduction of the rehabilitation program ($\chi^2 = 8.53$; $p = 0.004$).

The most frequent complications in both groups included wound infection, pneumonia, intestinal paresis, and anastomotic insufficiency (Table 1).

Table 1. Structure and frequency of early postoperative complications

Type of complication	Comparison group (n=75)	Main group (n=62)
Wound infection	9 (12.0%)	4 (6.5%)
Pneumonia	10 (13.3%)	5 (8.1%)
Intestinal paresis	8 (10.7%)	3 (4.8%)
Anastomotic leakage	5 (6.7%)	2 (3.2%)
Sepsis	3 (4.0%)	1 (1.6%)
Electrolyte imbalance	6 (8.0%)	3 (4.8%)
Total	41 (54.7%)	18 (29.0%)

The average duration of early complications was also reduced—from 6.8 ± 0.4 days in the comparison group to 4.2 ± 0.3 days in the main group ($t = 3.94$; $p < 0.001$).

3.2. Systemic and Local Complications

Systemic complications (such as respiratory or cardiovascular dysfunction) were registered in 32.0% of children in the comparison group and 14.5% in the main group ($p = 0.011$). Local complications related to wound or stoma care occurred in 22.7% versus 9.7%, respectively ($p = 0.025$).

3.3. Length of Hospitalization and Recovery Time

The mean duration of hospitalization was significantly shorter in the main group (11.1 ± 0.4 days) compared to the comparison group (14.2 ± 0.5 days) ($t = 4.33$; $p < 0.001$).

Additionally, the time to achieve full enteral feeding decreased from 8.3 ± 0.4 days to 5.6 ± 0.3 days (p = 0.002).

3.4. Long-Term Outcomes

Long-term follow-up (from 6 months to 3 years) was achieved in 67 (89.3%) of comparison group patients and 59 (95.2%) of main group patients.

Persistent functional disorders—such as chronic constipation, abdominal pain, or delayed growth—were recorded in 44.0% of the comparison group and 18.5% of the main group (χ^2 = 7.14; p = 0.008). Among these, recurrent intestinal obstruction occurred in 10.7% vs. 3.2%, respectively.

Nutritional outcomes showed clear improvement: children in the main group reached normal body weight for age in 85.5% of cases, compared to 61.3% in the comparison group (p = 0.014).

3.5. Severity of Complications

According to the Clavien–Dindo classification (2004) [16], mild complications (Grades I–II) predominated in the main group (19.4%) compared with the comparison group (26.7%). Severe complications (Grades III–V) were less frequent under the optimized protocol (9.6%) than with standard management (28.0%) (χ^2 = 9.84; p = 0.002).

3.6. Quality of Life Assessment

Based on parental and clinician surveys using a modified pediatric quality-of-life questionnaire, overall satisfaction with postoperative recovery increased from 64.0% in the comparison group to 88.7% in the main group (p = 0.003).
Children managed under the structured rehabilitation system demonstrated improved physical activity, reduced digestive discomfort, and faster return to normal social adaptation.

The outcomes of this study confirm that the introduction of a structured rehabilitation system substantially improves both early and long-term postoperative results in children with congenital anomalies of the digestive tract (CADT). The most significant effects were reflected in reduced postoperative complication rates, shortened hospital stays, and improved functional and nutritional recovery.

Our results align with prior studies emphasizing the critical role of postoperative rehabilitation in pediatric surgery. According to recent reports, complication rates following surgical correction of CADT may reach 50–70%, particularly in neonates and infants with comorbidities [17–19]. The early postoperative period is characterized by a high incidence of intestinal dysmotility, wound infections, and respiratory complications due to immaturity of physiological systems and the need for prolonged parenteral support [20].

In this study, implementing a rehabilitation framework that integrated nutritional optimization, physiotherapy, and microbiota restoration reduced the incidence of both local and systemic complications by nearly twofold. These findings are consistent with international evidence showing that structured postoperative rehabilitation significantly improves gastrointestinal function, enhances immunity, and reduces the occurrence of adhesive processes [21–23].

Restoration of intestinal motility is one of the main challenges in the early postoperative phase of CADT treatment. The use of physiotherapeutic techniques such as low-frequency magnetic stimulation and low-intensity laser therapy has demonstrated effectiveness in enhancing intestinal peristalsis and reducing postoperative paresis duration [24,25]. Similarly, optimizing enteral nutrition in the immediate postoperative period has been shown to stimulate mucosal regeneration and reduce metabolic stress, thereby shortening recovery time [26].

Another essential component of rehabilitation involves maintaining microbial homeostasis through the administration of probiotics containing *Lactobacillus* and *Bifidobacterium* strains. This approach supports the restoration of the intestinal barrier, improves nutrient absorption, and minimizes infection-related complications [27,28].

From a broader perspective, the study supports the shift in pediatric surgery toward a multidisciplinary rehabilitation model, where surgical, nutritional, physiotherapeutic, and psychosocial interventions are applied concurrently. The systematization of rehabilitation ensures not only faster recovery but also improved long-term adaptation, which is particularly important for patients who undergo multiple reconstructive procedures or live with residual functional disorders [29–31].

Our findings also highlight the importance of continuous parental involvement in postoperative care. Educating caregivers about nutrition, wound care, and early recognition of complications significantly contributed to better adherence and reduced hospital readmissions. This aligns with previous research demonstrating that family-centered education programs improve both short-term recovery and overall quality of life for pediatric surgical patients [32,33].

Despite these encouraging outcomes, several limitations should be acknowledged. The single-center design and moderate sample size may limit the generalizability of the findings. Furthermore, long-term follow-up beyond three years would be necessary to fully evaluate the sustainability of functional improvements and growth outcomes.

Nonetheless, the observed improvements in recovery rates, reduction of complications, and enhancement of quality of life strongly support the inclusion of structured rehabilitation as a standard element of care for children undergoing surgery for congenital digestive tract anomalies.

Conclusion

The implementation of a comprehensive, stage-specific rehabilitation system for pediatric patients with congenital anomalies of the digestive tract significantly enhances early and long-term postoperative outcomes. This multidisciplinary approach—combining nutritional optimization, microbiota correction, physiotherapy, and caregiver education—effectively reduces complication rates, shortens hospitalization time, and improves functional recovery and quality of life.

The study underscores the critical importance of integrating structured rehabilitation into standard pediatric surgical practice. Early initiation of individualized rehabilitation programs, accompanied by continuous monitoring and multidisciplinary support, ensures better adaptation, sustained gastrointestinal function, and favorable psychosocial development.

Future multicenter studies with larger cohorts are needed to establish unified evidence-based protocols that can further optimize recovery in children with congenital digestive tract anomalies.

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