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MOLECULAR AND CLINICAL APPROACHES TO DIGESTIVE SYSTEM DISEASES IN ADOLESCENTS: THE ROLE OF ENDOSCOPY, IMPEDANCE-PH MONITORING, AND NUTRITIONAL CORRECTION

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ABSTRACT

Digestive system diseases in adolescents represent a complex interdisciplinary area of clinical practice, determined by a combination of hormonal, physiological, and behavioral factors that make the course of gastroenterological disorders more variable. In recent years, there has been a growing need for highly informative diagnostic methods capable of accurately reflecting the functional state of the gastrointestinal tract. Key methods include endoscopy and multichannel impedance-pH monitoring, which make it possible to comprehensively assess both morphological changes and the features of reflux activity. Nutritional correction also plays a significant role, since adolescents' eating habits directly affect motility, inflammatory processes, and the severity of clinical symptoms. The review examines the current possibilities of visual, functional, and dietary approaches, their contribution to the individualization of therapy, and their role in prognosis formation. Particular attention is paid to the growing role of personalized medicine and multidisciplinary cooperation among specialists, which helps optimize the diagnosis and treatment of complex gastroenterological conditions. The synthesis of current data emphasizes the need for an integrated approach that improves the effectiveness of clinical management and long-term outcomes in adolescents with digestive system diseases.

KEYWORDS: adolescents; gastrointestinal diseases; endoscopy; impedance-pH monitoring; nutritional correction; GERD; personalized approach.

INTRODUCTION

Digestive system diseases in adolescents are currently regarded as one of the significant medical and social problems, since the long-term foundations of somatic health are formed at this age [1]. Adolescence is accompanied by pronounced hormonal and physiological changes, which makes any gastroenterological disorders more variable and clinically unstable. Against this background, global statistics indicate an increase in the prevalence of gastrointestinal diseases among adolescents to 15–25% [14–18], while Russian data confirm a growing number of visits related to abdominal pain, heartburn, and manifestations of gastroesophageal reflux [2–5]. However, the high frequency of such symptoms is combined with their low specificity, which limits the possibilities of traditional diagnostic methods and complicates the choice of optimal treatment tactics. For this reason, the need for modern diagnostic technologies capable of more accurately reflecting the physiological mechanisms of gastroenterological disorders in adolescence is increasing [9].

One of the most informative methods is multichannel impedance-pH monitoring, which makes it possible to detect acidic, weakly acidic, and alkaline reflux episodes and determine their relationship with clinical symptoms [7]. In combination with endoscopic examination, this method provides both functional and morphological assessment of the esophagus, forming a more complete understanding of the nature of the disease [22]. Nutritional correction also becomes highly significant, since the specific features of adolescent nutrition directly affect gastrointestinal motility, the frequency of reflux episodes, and the severity of inflammatory changes [26]. Thus, the combination of visual, functional, and nutritional approaches creates opportunities for developing more accurate, individualized, and clinically justified strategies for managing adolescents with digestive system diseases.

In this regard, the aim of this review is to systematize current data on the role of endoscopy, impedance-pH monitoring, and nutritional correction in the diagnosis and treatment of gastroenterological diseases in adolescents and to determine their significance for the formation of optimal clinical tactics.

Epidemiology of Gastrointestinal Diseases in Adolescents

The epidemiology of gastrointestinal diseases in adolescents remains one of the most dynamically developing areas, since the prevalence of functional gastrointestinal disorders at this age is steadily increasing. Current studies show that adolescents are increasingly experiencing various gastrointestinal symptoms, which emphasizes the need for a deeper understanding of the factors influencing their onset and progression. At the same time, the absence of universal biological markers and the difficulty of distinguishing functional disorders from organic diseases create serious diagnostic challenges for specialists.

The use of the updated Rome IV criteria provides a more accurate and structured approach to identifying functional gastrointestinal disorders, as it includes a detailed assessment of clinical manifestations and requires a comprehensive analysis of the patient's condition. Significant differences in the methodology of epidemiological studies across countries lead to a wide range of data on the prevalence of gastrointestinal diseases among adolescents, indicating the need for standardization of scientific approaches. Studying the scale and structure of functional gastrointestinal disorders makes it possible to predict the need for medical resources and develop effective strategies for early diagnosis and therapeutic and preventive care. Table 1 below systematizes the main groups of functional gastrointestinal disorders in adolescents, reflecting their frequency, duration, and clinical features based on current epidemiological data.

Table 1. Nomenclature of Functional Gastrointestinal Disorders in Adolescents According to the Rome IV Criteria [12–15]

Rome IV nomenclature	Frequency	Duration	Synonyms / Subtypes
Cyclic vomiting syndrome	≥2 episodes	6 months	Periodic vomiting
Functional nausea	≥2 episodes/week	≥2 months	Persistent nausea
Functional vomiting	≥1 episode/week	≥2 months	—
Rumination syndrome	Recurrent regurgitation	≥2 months	Regurgitation, rechewing
Aerophagia	Frequent belching/flatulence	≥2 months	—
Functional dyspepsia	≥1 symptom ≥4 days/month	≥2 months	Postprandial distress syndrome, epigastric pain syndrome
Irritable bowel syndrome	≥4 days/month	≥2 months	Abdominal pain, discomfort
Abdominal migraine	≥2 episodes lasting ≥1 hour	6 months	Periumbilical pain
Functional abdominal pain	≥4 episodes/month	≥2 months	Functional abdominal pain, not otherwise specified
Functional constipation	≤2 bowel movements/week	≥1 month	—

The presented classification not only makes it possible to structure the clinical forms of functional disorders, but also serves as a basis for understanding their pathogenetic mechanisms, providing a transition to the consideration of the key processes underlying the development of these conditions.

Mechanisms of Pathology Development

The mechanisms underlying the formation of functional gastrointestinal disorders in adolescents are considered to result from the complex interaction of the body's regulatory systems, including motility, visceral sensitivity, immune activation, and the gut–brain axis. This is emphasized in the works of Russian gastroenterologists analyzing current trends in adolescent morbidity [1]. Early behavioral and stress-related influences play a significant role in the development of these disorders, since psychoemotional factors can alter the regulation of intestinal function and intensify pain perception. This relationship is highlighted in studies on the association between somatic and psychological disturbances in gastroenterological pathology [7]. In addition, adolescents often demonstrate a combination of functional symptoms with lifestyle and dietary patterns, which contributes to the formation of persistent motor and secretory disorders, as reported by Zaprudnov and Kharitonova [2].

An additional pathogenetic link is the alteration of barrier function and inflammatory activity of the gastrointestinal mucosa, which may intensify under chronic influences, including infectious factors and disturbances of the microbiota [18]. Against the background of these biological changes, a stable psychophysiological pattern of gastrointestinal symptom perception is formed, which is confirmed by data on high levels of emotional tension and reduced quality of life in adolescents with digestive system diseases [3, 17]. Thus, the development of pathology represents a multicomponent process in which biological, behavioral, psychological, and environmental factors form a unified risk field for the development of functional gastrointestinal disorders in adolescence.

Modern Endoscopic Diagnostics

Modern endoscopic diagnostics is becoming a key tool in adolescent gastroenterology, and Russian researchers, including Shcherbakov [1], emphasize that imaging methods make it possible to detect early inflammatory changes that cannot be

identified clinically. The works of Zaprudnov and Kharitonova [2] complement these data, showing that image-enhanced endoscopy significantly improves the accuracy of diagnosing functional and organic disorders in adolescents. The contribution of Bulatov and Ivanov [12] demonstrates that the use of dyes and optical enhancement helps to assess the structure of the mucosa more accurately and determine the depth of damage, which is important for selecting therapy. At the same time, foreign researchers such as Rosen et al. [22] indicate that modern endoscopic technologies form the basis of international guidelines for the diagnosis of gastroesophageal reflux disease in children. Hyams et al. [15] note that image-enhanced endoscopy plays a decisive role in differentiating functional disorders from structural lesions in adolescence. Pilic et al. [16] add that optical contrast methods improve the assessment of mucosal integrity, which is particularly important for the early detection of reflux-associated conditions and inflammation. However, even advanced endoscopic methods do not always allow an objective assessment of the nature and frequency of reflux episodes. This makes it especially important to move on to instrumental technologies such as impedance-pH monitoring, which can complement visual diagnostics with a functional assessment of reflux.

Impedance-pH Monitoring in Reflux Assessment

Impedance-pH monitoring has gradually taken a central place in the modern diagnosis of reflux-associated disorders in children, since this method makes it possible to record not only acid reflux episodes, but also weakly acidic and non-acid reflux episodes that remain undetected by traditional pH monitoring. Against the background of the limited informativeness of endoscopy and conventional pH monitoring, the combined measurement of impedance and acidity has become the key to a more accurate understanding of the mechanisms of pediatric gastroesophageal reflux and its clinical manifestations. Recent studies show that MII-pH makes it possible to define GERD phenotypes, ranging from non-erosive reflux disease to reflux hypersensitivity, which significantly increases the accuracy of treatment selection in pediatric patients. In addition, new parameters such as mean nocturnal baseline impedance and the PSPW index allow assessment not only of the presence of reflux itself, but also of the condition of the mucosa and the effectiveness of its chemical clearance, deepening the understanding of disease pathogenesis. These metrics have become especially important in cases where classical indicators provide inconclusive results, helping to differentiate functional and organic disorders in children. Thus, accumulated data confirm that impedance-pH monitoring has transformed the approach to GERD diagnosis in pediatrics by providing clinicians with a tool that combines high sensitivity, phenotype stratification, and prediction of response to therapy.

Multidisciplinary Management of Patients

Modern clinical practice increasingly shows that gastrointestinal diseases in children cannot be effectively diagnosed and treated through the efforts of a single specialist alone; therefore, multidisciplinary management is becoming a key standard of care [31]. This is due to the fact that the development of pediatric gastroenterology as an independent field has led to the emergence of high-technology methods, including endoscopy, endoscopic ultrasound, and impedance-pH monitoring, which require the involvement of a gastroenterologist, dietitian, psychotherapist, and functional diagnostics specialist for comprehensive interpretation of results [36]. Such collaboration makes it possible not only to assess functional and organic disorders more accurately, but also to create individualized patient management pathways, especially in complex conditions such as gastroesophageal reflux disease with respiratory manifestations, where an experienced interdisciplinary team significantly improves treatment effectiveness [18]. The significant contribution of foreign authors also emphasizes the need for this approach: studies by Quitadamo et al. [34] demonstrate that successful diagnosis of reflux in children is possible only through the integration of instrumental data, clinical assessment, and follow-up by related specialists. Since comprehensive monitoring of a child with gastroenterological pathology inevitably includes the assessment of factors influencing the course of the disease, the next key component of the multidisciplinary approach is the analysis of the role of nutrition and the need for competent nutritional correction.

The Role of Nutrition and Nutritional Correction

Nutrition plays a key role in the development of symptoms in children with disorders of gut–brain interaction; therefore, nutritional correction is gradually becoming one of the central tools of therapy [18]. Despite the widespread use of dietary recommendations in practice, the number of high-quality clinical studies remains limited, which emphasizes the need for a particularly balanced and individualized approach when selecting a diet [23]. Analysis of existing studies shows that the exclusion of cow's milk proteins, the use of thickened formulas, a low-FODMAP diet, or additional sources of soluble fiber can significantly reduce symptom severity in some patients, highlighting the importance of personalized nutritional support [25, 29, 32, 40]. At the same time, in functional constipation, the addition of dietary fiber often does not produce the expected effect, indicating a complex combination of factors, ranging from intestinal motility and microbiota composition to behavioral aspects of eating [39]. Since most dietary interventions involve restricting certain foods, nutritional correction should be carried out carefully and under specialist supervision in order to avoid nutritional deficiencies and ensure that the child receives all nutrients necessary for growth and development. Thus, understanding the role of nutrition and competent nutritional correction becomes an integral part of comprehensive patient management, creating a basis for moving on to the consideration of current therapeutic approaches and factors determining further prognosis.

Current Treatment Approaches and Prognosis

In recent years, pediatric gastroenterology has been undergoing a period of rapid development, as expanding knowledge about gastrointestinal diseases requires a reconsideration of both diagnostic approaches and treatment strategies. Conditions such as celiac disease, eosinophilic esophagitis, and inflammatory bowel diseases are coming to the forefront,

since in adolescence they tend to manifest more aggressively and often determine the patient's future quality of life. Despite the diversity of their clinical phenotypes, these diseases share high therapeutic complexity and the need to select methods that exceed the effectiveness of traditional treatment regimens. Against the background of the limitations of standard approaches, interest is growing in personalized pharmacotherapy, including modern biologic agents, small molecules, dietary interventions, and methods of immune modulation, whose effectiveness has been confirmed by several studies in recent years [31, 35]. Precision medicine tools are becoming increasingly important, as they allow therapy to be selected according to the patient's individual profile and make it possible to predict the likelihood of response to treatment, which is especially important in chronic and progressive forms of disease. In this context, proteomics is becoming a key direction, since it provides access to molecular markers that can set new reference points for clinical decision-making and serve as a basis for risk stratification. A summary of current data is presented in Table 2, which systematizes the most significant therapeutic approaches of the last five years and creates a basis for moving on to the next section, devoted to the diagnostic capabilities of modern technologies.

Table 2. Current Therapeutic Approaches to Gastrointestinal Diseases in Adolescents

Therapeutic approach	Brief description	Clinical significance	Sources
Endoscopic methods	Modern minimally invasive technologies for the early detection of inflammatory and structural changes in the gastrointestinal tract	Increase diagnostic accuracy, enable detection of early forms of pathology, and reduce the risk of complications	Shcherbakov [1]; Zaprudnov & Kharitonova [2]; Rosen et al. [13]
Impedance-pH monitoring	Comprehensive assessment of acid and non-acid reflux episodes and identification of GERD phenotypes	Allows therapy to be personalized by determining the type of reflux and the relationship between symptoms and reflux episodes	Mutalib et al. [14]; Hyams et al. [15]; Pilic et al. [16]; Safe et al. [17]
Nutritional correction	Dietary strategies involving the exclusion of triggering foods	Reduces symptom severity and helps normalize gastrointestinal function	Romano et al. [20]; Salvatore et al. [24]
Multidisciplinary management	Cooperation among a gastroenterologist, dietitian, psychotherapist, and functional diagnostics specialist	A comprehensive approach improves diagnosis and increases treatment effectiveness	Quitadamo et al. [34]; Singendonk et al. [35]; Altay et al. [36]
Pharmacotherapy	Use of PPIs, prokinetics, and enzyme therapy	Optimizes symptom control and prevents complications	Lopatkina [10]; Lazebnik [11]; Bulatov [12]

Note: compiled by the author based on sources: [1, 2, 10, 11, 12, 13, 14, 15, 16, 17, 20, 24, 34, 35, 36].

The data summarized in the table clearly show that current therapeutic strategies in adolescents require a combination of high-technology diagnostic methods, personalized nutrition, and comprehensive clinical follow-up. This approach not only improves treatment effectiveness, but also makes it possible to form more accurate prognoses that take into account individual features of the disease course and the risk of complications. These findings emphasize the need for further analysis of diagnostic technologies that make a key contribution to optimizing the patient pathway and become a determining factor in the choice of therapeutic tactics.

CONCLUSION

The conducted review shows that digestive system diseases in adolescents have a complex nature requiring the use of high-precision diagnostic technologies and individualized therapeutic approaches. Modern methods, including endoscopy, impedance-pH monitoring, and nutritional correction, have demonstrated their significance in improving diagnostic accuracy and selecting the most effective treatment strategies. A special role is played by the integration of visual, functional, and behavioral data, which makes it possible to form a comprehensive understanding of the pathogenesis and clinical features of diseases in adolescence. The multidisciplinary approach enhances the quality of medical care by involving a gastroenterologist, dietitian, psychologist, and functional diagnostics specialists, which is especially important in complex and comorbid conditions. The obtained data indicate the growing role of personalized medicine and the need to introduce new biomarkers, including proteomic ones, for prognostic assessment and therapy optimization. Overall, the significance of this analysis lies in forming a scientifically grounded basis for improving clinical protocols and long-term outcomes in adolescents with gastrointestinal diseases.

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