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ADVANCING REGENERATIVE MEDICINE IN PEDIATRIC GASTROENTEROLOGY: THE ROLE OF ENTERAL OXYGEN THERAPY IN CHRONIC GASTRODUODENAL DISEASE

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Abstract

Aims: The objective of this investigation was to assess the clinical effectiveness of enteral oxygen therapy (EOT) in promoting mucosal healing within the gastrointestinal tract of children diagnosed with chronic gastroduodenal pathology (CGDP).
Methods and Materials: A total of 286 pediatric patients with established CGDP were included in a randomized clinical study. Diagnostic procedures encompassed fibrogastroduodenoscopy and comprehensive screening for Helicobacter pylori infection using both breath and stool antigen tests.
Results: Based on FGDS findings, a novel Scoring Scale for Regeneration Processes (SSRP) was developed to quantify mucosal healing without the need for invasive biopsy. Following standard inpatient treatment, patients with inflammatory lesions demonstrated a Grade 3 regeneration response, while those with ulcerative pathology reached Grade 4. After a single course of rehabilitation incorporating EOT, a marked improvement to Grade 1 regeneration was observed (mean score: 6.6 ± 0.77), compared to Grade 2 in the non-EOT group (mean score: 10.9 ± 1.23). These findings reflect a statistically significant enhancement—over 63%—in reparative-regenerative activity associated with EOT. Concurrently, H. pylori carriage rates declined by up to 2.5-fold in the EOT group.
Conclusions: Enteral oxygen therapy substantially accelerates mucosal regeneration in children with CGDP, demonstrating up to a 63% increase in reparative capacity. Moreover, its integration into a comprehensive rehabilitation protocol contributes to a significant reduction in Helicobacter pylori colonization, with prevalence decreasing to 9.5%.
Keywords: Pediatric gastroenterology; Enteral oxygen therapy; Mucosal regeneration; *Helicobacter pylori* infection; Gastrointestinal mucosa.

Annotatsiya

Maqsad: Ushbu tadqiqotning maqsadi — surunkali gastroduodenal patologiyaga (SGDP) chalingan bolalarda enteral oksigen terapiyasining (EOT) me'da-ichak shilliq qavatining regeneratsiya jarayoniga terapevtik ta'sirini baholashdan iborat.
Materiallar va usullar: Tasodifiy klinik tadqiqot doirasida SGDP tashxisi qo'yilgan 286 nafar bola da tekshiruv olib borildi. Diagnostika usullari sifatida fibrogastroduodenoskopiya (FGDS) hamda

Helicobacter pylori infeksiyasini aniqlash uchun nafas testi va immunoxromatografik najas antigen testi qo‘llanildi.
Natijalar: FGDS natijalariga asoslanib, morfologik biopsiyasiz regeneratsiya darajasini baholash uchun yangi ballik baholash tizimi — Regeneratsiya Jarayonini Baholash Shkalasi (RJBS) ishlab chiqildi. Standart statsionar davolashdan so‘ng yallig‘lanishli holatlarda 3-daraja, yara holatlarida esa 4-daraja regeneratsiya qayd etildi. EOT qo‘llanilgan reabilitatsiya kursidan so‘ng regeneratsiya 1-darajagacha yaxshilandi (o‘rtacha ball: 6.6 ± 0.77), EOT qo‘llanilmagan guruhda esa 2-daraja (o‘rtacha ball: 10.9 ± 1.23) qayd etildi. Bu natijalar EOT yordamida regeneratsion-reparativ jarayonlarning 63% dan ortiq kuchayishini ko‘rsatdi. Shu fonda *H.pylori* tashuvchilik darajasi 2.5 barobargacha kamaydi.
Xulosa: Enteral kislorod terapiyasi SGDP bilan kasallangan bolalarda me’da shilliq qavatining regeneratsiya jarayonlarini sezilarli darajada tezlashtiradi, bu esa reparativ faollikning 63% gacha oshishini ta’minlaydi. EOTni kompleks reabilitatsiya dasturiga kiritish *Helicobacter pylori* kolonizatsiyasini sezilarli darajada kamaytirishga xizmat qiladi — 9.5% gacha.
Kalit so‘zlar*:* Pediatrik gastroenterologiya; Enteral kislorod terapiyasi; Shilliq qavat regeneratsiyasi; *Helicobacter pylori* infeksiyasi; Me’da-ichak shilliq qavati.

Аннотация

Цель исследования: оценить терапевтическую эффективность энтеральной оксигенотерапии (ЭОТ) в стимуляции процессов регенерации слизистой оболочки желудочно-кишечного тракта у детей с хронической гастродуоденальной патологией (ХГДП).
Материалы и методы: Проведено рандомизированное клиническое исследование с участием 286 детей и подростков с подтверждённым диагнозом ХГДП. Диагностические мероприятия включали фиброгастродуоденоскопию и тестирование на *Helicobacter pylori* с использованием дыхательного уреазного теста и иммунохроматографического анализа кала на антигены.
Результаты: на основе данных ФГДС была разработана оригинальная шкала оценки процессов регенерации (ШОПР), позволяющая количественно оценить степень восстановления слизистой без проведения морфологической биопсии. После стандартного стационарного лечения у пациентов с воспалительными изменениями наблюдалась регенерация III степени, при язвенных поражениях — IV степени. После одного курса реабилитации с применением ЭОТ отмечен переход к I степени регенерации (в среднем $6,6 \pm 0,77$ балла), тогда как в группе без ЭОТ — II степень (в среднем $10,9 \pm 1,23$ балла). Полученные данные свидетельствуют о статистически значимом усилении репаративно-регенеративных процессов — более чем на 63% при использовании ЭОТ. На этом фоне также зафиксировано снижение носительства *H.pylori* до 2,5 раз.
Выводы: Энтеральная оксигенотерапия существенно ускоряет процессы регенерации слизистой оболочки желудка у детей с ХГДП, обеспечивая увеличение репаративной активности до 63%. Включение ЭОТ в комплексную реабилитационную программу способствует значительному снижению уровня колонизации *Helicobacter pylori*, с уменьшением распространённости до 9,5%.
Ключевые слова: Педиатрическая гастроэнтерология; Энтеральная оксигенотерапия; Регенерация слизистой; Инфекция *Helicobacter pylori*; Слизистая желудочно-кишечного тракта.

Introduction. The health status of the pediatric population remains a critical focus within contemporary healthcare systems, with particular emphasis on gastrointestinal disorders in children [1,2]. Among the spectrum of digestive tract pathologies, chronic inflammatory conditions of the upper gastrointestinal

tract occupy a leading position in pediatric morbidity statistics. Despite ongoing efforts by healthcare administrators and clinical practitioners, the incidence of these disorders continues to rise, having increased several-fold over the past decade [3,4].

Notably, recent epidemiological data indicate a marked surge in the prevalence of chronic gastroduodenal pathology (CGDP) among children residing in South Asia, reaching 65.3%. This trend is mirrored in Central Asia, where CGDP is increasingly recognized as a regionally significant pathology affecting both pediatric and adult populations [5].

In response to the increasing prevalence of chronic gastrointestinal disorders in the pediatric population, there has been a clear shift toward the development and refinement of rehabilitative strategies aimed at improving clinical outcomes. Despite these advancements, the integration of innovative pharmacotherapeutic approaches into these protocols remains a complex and unresolved issue. Within the field of pediatric gastroenterology, particular attention is devoted to stimulating mucosal regeneration in the gastroduodenal region—a process frequently impaired under chronic inflammatory conditions and requiring targeted therapeutic support, [6].

While substantial scientific evidence supports the systemic effects of enteral oxygen therapy (EOT), particularly on hematopoietic function, its role in modulating regenerative processes within the gastrointestinal mucosa remains largely unexplored. This gap in knowledge is especially relevant given the etiopathogenetic significance of Helicobacter pylori (HP) infection in CGDP. Globally, HP prevalence varies widely—from 9.0% to 95%—depending on regional socioeconomic conditions [7,8].

HP is a well-established contributor to ulcerative lesions in the gastrointestinal mucosa, necessitating targeted regenerative interventions. However, current biomedical literature offers minimal insight into the potential therapeutic impact of EOT on mucosal healing in the stomach and intestines, underscoring the need for further translational and clinical research in this domain.

Subjects and methods.

Study design.

Clinical observation of patients was based on a randomized controlled scientific study. The test reports are by the CONSORT 2010 recommendations and are presented with their protocols on the website: ClinicalTrials.gov PRS ID: ID:NCT04702542.

The study design was structured into three sequential phases: preparatory, investigative, and analytical. During the preparatory phase, inclusion criteria for patient selection were developed, and formal agreements were established with urban and rural family polyclinics to facilitate clinical, laboratory, and instrumental assessments. The second phase involved direct engagement with patients as part of the research process. Clinical and laboratory evaluations were conducted on an outpatient basis in collaboration with pediatric subspecialists, including pediatric gastroenterologists, allergists, surgeons, and infectious disease specialists. The final phase encompassed the systematization of clinical data, followed by statistical analysis and interpretation of the study results. The data were evaluated using current methodologies biostatistical methods to ensure the validity and scientific rigor of the conclusions drawn.

Ethical review. Prior to the initiation of clinical and laboratory investigations involving pediatric patients in an outpatient setting, formal ethical approval was obtained from the Ethics Committee operating under the Ministry of Health of the Republic of Uzbekistan (Pr. No. 3, 20/04/2017). The research strictly conformed to established ethical guidelines to internationally recognized standards, including the principles outlined in the CPCSEA Declaration of Helsinki and the ethical guidelines of the World Medical Association governing biomedical research involving human subjects. The study was prospectively registered on the ClinicalTrials.gov Protocol Registration (NCT04702542). In accordance with ethical requirements, written informed consent was

secured from the legal representatives—parents or guardians—of all participating children prior to enrollment in the study. All clinical procedures and research outcomes were systematically documented in the patients' official outpatient medical records, ensuring traceability and compliance with regulatory standards.

Eligibility criteria.

We examined 286 children aged 6 to 15 years with chronic gastroduodenal pathology (CGDP), of whom 156 were boys and 130 were girls. Among those surveyed, chronic gastroduodenitis (CGD) was diagnosed in 174 (60.8%); chronic gastritis (CG) of various forms, in 43 (15.03%); chronic duodenitis (CD), in 22 (7.7%); gastric ulcer (PUD), in 8 (2.8%); and duodenal ulcer (DU), in 39 (13.6%) patients. Initially, all patients, depending on the age category, based on the WHO recommendation (2013), were divided into two age groups: the 1st age group, comprising ill children from 6 to 11 years old (N= 145-50.7%), and the 2nd age group comprising ill adolescents from 12 to 15 years old (N= 141-49.3%). In accordance with the study objective—to evaluate the efficacy of the proposed rehabilitation protocol for children with chronic gastroduodenal pathology (CGDP)—the patient cohort was stratified into two rehabilitation groups: Group 1-RG (n = 147) and Group 2-RG (n = 139). Both groups were matched by age and clinical presentation of the underlying condition to ensure comparability. For control purposes, 110 healthy children and adolescents of comparable age and gender distribution, with no history of somatic disorders, were recruited. Participants in the control group were selected from individuals undergoing routine annual health screenings at a family outpatient clinic.

Research methods.

Research methods included the following:

• Instrumental research: fibrogastroduodenoscopy (FGDS) of the upper parts of the digestive system.

• Determination of *Helicobacter pylori* (HP) infection.

Qualitative assessment of Helicobacter pylori (HP) infection was performed using two independent diagnostic techniques: a breath test utilizing the HELIK® system with an indicator tube, and an immunochromatographic assay of stool samples. Quantitative analysis of the pathogen was not conducted. A patient was classified as HP-positive only if both tests yielded positive results. In cases where only one test was positive, confirmation of infection status was established through an invasive diagnostic procedure—specifically, an enzyme-linked immunosorbent assay (ELISA). The extent of HP colonization was also used as a key marker for evaluating the effectiveness of the rehabilitation protocol. Accordingly, all enrolled patients (N = 286) underwent HP testing at three stages: prior to treatment, following standard therapy, and after completion of the initial rehabilitation phase.

5. Rehabilitation method.

The rehabilitation program developed by us functioned according to the principle - an individual approach to each patient, taking into account the combined pathology and age characteristics. The duration of the rehabilitation program depended on the clinical stage and the severity of the underlying and combined pathology. At the same time, the nature of inflammatory processes (chronic gastritis, chronic duodenitis, chronic gastroduodenitis) was taken into account: at least 6 months, with necrotic ulcers (peptic ulcer of the stomach and/or duodenal ulcer) or at least 1 year, after the endoscopic picture of scarring. The program we developed for the rehabilitation of children with CGDP had the following differences from similar rehabilitation measures:

✓ Recommendations on nutrition (introduction of an individual food diary);
✓ Nondrug recovery (a combination of physical therapy and physiotherapy, depending on the clinical picture of the disease);
✓ Administration of a repeated preventive course of eradication therapy (every

6 months, during the entire rehabilitation period), etc.

The rationale for the creation of the rehabilitation program was the WHO recommendation "Strategic directions for improving the health and development of children " WHO/FCH/CAH/02.21 (2013), and guidelines for the diagnosis and treatment of HP infection in children formulated by the ESPGHAN and NASPGHAN (2016), [8].

6. Enteral oxygen therapy technique.

For enteral oxygen therapy, oxygen cocktails that were prepared in a pharmacy from the products of pharmacological companies approved by the Pharmaceutical Committee under the Ministry of Health of the Republic of Uzbekistan were used. EOT was prescribed to patients once a day in a volume of 200 ml as a second breakfast for 10-14 days. The cocktail was consumed with a spoon slowly over 8-10 minutes. In the course of treatment with enteral oxygen therapy, no allergic or adverse reactions were noted in some patients.

7. Statistical Analyses.

Quantitative data analysis was performed using Microsoft Excel 7.0 (Windows XP platform), applying standard statistical procedures including calculation of the arithmetic mean (M) and standard deviation (s). The outcomes derived from the clinical assessment of pediatric patients with chronic gastroduodenal pathology (CGDP) were evaluated for statistical significance at a confidence threshold of $p < 0.05$. Comparative analysis was conducted between subgroups of patients stratified by Helicobacter pylori infection status—infected versus non-infected cohorts.

Results

The evaluation of mucosal regeneration was conducted based on endoscopic findings, complemented by concurrent analysis of hematological parameters. In alignment with the primary objective of the study, and guided by the visual characteristics of gastric mucosal alterations observed during endoscopy, we developed a non-invasive Scoring Scale for the Regeneration Process (SSRP). This tool enabled the assessment of reparative dynamics without the need for morphological biopsy. To validate the diagnostic accuracy of the SSRP, we employed the 11-item QUADAS (Quality Assessment of Diagnostic Accuracy Studies) tool, as recommended by the Cochrane Collaboration. The evaluation yielded favorable results, supporting the reliability of the scale. Given the pediatric nature of the study population, the use of invasive procedures such as biopsy was deliberately minimized in accordance with the 2016 guidelines of ESPGHAN and NASPGHAN, which emphasize the prioritization of non-invasive diagnostic strategies in children, [8].

Biopsy procedures were reserved exclusively for cases in which metaplastic transformation of the gastric mucosa was identified. The developed scoring system enabled a non-invasive evaluation of reparative and regenerative dynamics within the gastrointestinal mucosal layer in the context of therapeutic interventions for chronic gastroduodenal pathology (CGDP).

Using the Scoring Scale for the Regeneration Process (SSRP), the degree of mucosal recovery in the upper gastrointestinal tract was assessed at two distinct time points: following standard inpatient treatment and after completion of a targeted rehabilitation program. Analysis of regeneration outcomes revealed that, among patients presenting with inflammatory lesions, Grades 2 and 3 regenerations were predominantly observed after conventional inpatient therapy, with a mean SSRP score of 16.6 ± 1.14 ($P = 0.038$), indicating moderate mucosal recovery.

At the same time, in patients with ulcerative forms of CGDP, the 4th degree of regeneration was mainly observed (22.6 ± 0.81, $P=0.047$), indicating subjective improvements in the condition of patients after the course of

treatment against the background of the initial stage of proliferation.

After a single rehabilitation course, in patients from 1-RG with inflammatory forms of CGDP disease, when using EOT, a transition to 1-degree regeneration was noted (6.6 ± 0.77 points, *P=0.032*), while in patients from 2-RG, this indicator corresponded to the 2nd degree of regeneration according to SSRP (10.9 ± 1.23, *P=0.041*).

When analysing the ulcerative forms of CGDP, we noted a similar picture; in particular, in patients from 1-RG, this indicator averaged 9.4 ± 0.81 points, which indicated a transition from the 4th degree to the 2nd degree of regeneration (*P=0.038*).

In patients from 2-RG, this indicator was 14.2 ± 0.47 points, which corresponded to the border between 2 and 3 degrees of regeneration (*P=0.044*). Consequently, these children needed a longer course of rehabilitation.

When comparing the assessment results between the two rehabilitation groups, the results are as follows: 1-RG : 2-RG = 7.66 ± 0.721: 12.15 ± 1.295 (*P=0.039*) or 1: 1.6.

The data indicate a more than 63% increase in reparative-regenerative processes when using enteral oxygen therapy. When comparing the results of haematological analyses, after a course of standard treatment in patients with CGDP, haematological parameters of peripheral blood changed in a positive direction. In particular, the average haemoglobin level after treatment, namely, 113.6 g/L, rose to 120.4 g/l, which was 6% higher than the primary indicator but 5.6% lower than that in the control group (*P=0.029*), (*Table 1.*).

Table 1. Results of the assessment using the Scoring Scale of the Regeneration Process (SSRP) in patients with CGDP (N= 286).

		after treatment	age group I		age group II		Total	
			1-RG	2-RG	1-RG	2- RG	1-RG	2- RG
CGD (N=174)	M	16.47	6.30*,**	10.22*,**	6.78*	11.13*	6.53*	10.65*
	±	1.607	0.700	0.914	2.152	0.906	0.864	1.003
CG (N=43)	M	17.13	6.75*,**	12.25*,**	7.00*	12.25*	6.89*	12.25*
	±	1.375	0.875	0.875	0.800	1.750	0.840	1.313
CD (N=22)	M	16.33	6.25**	9.00**	6.33*	10.67*	6.29*	9.75*
	±	0.444	0.750	2.000	0.444	0.444	0.612	1.375
PUD (N=8)	M	23.50	9.50**	13.33*	9.67*	15.67*	9.60*	14.80*
	±	0.500	0.500	0.444	0.444	1.111	0.480	1.360
DU (N=39)	M	21.60	9.33*,**	12.50*,**	9.00*	13.67*	9.13*	13.50*
	±	1.111	1.111	1.500	0.400	1.111	0.688	0.833

CGDP (N=286)	M	19.28	7.58*,**	11.54*,**	7.76*	12.68*	7.66*	12.15*
	±	1.082	0.812	1.183	0.848	1.065	0.721	1.295

Note: reliability * *P=0.031-0.044* of the indicator of the total number of patients, as well as age groups I and II in relation to the indicator after treatment; ** *P=0.032-0.047* age group I in relation to age group II with respect to the indicator after treatment.

At the same time, the lowest rate was noted among patients with PU (119.1 g/L) and duodenal ulcers (119.9 g/L), and higher rates were noted among patients with CGD (120.9 g/L) and CD (121, 5 g/L) (*P=0.037*). However, at the same time, the clinical signs of anaemia, noted in 165 (57.7%) patients before treatment, despite the complex standard treatment, remained in 16.4% (N= 47) of the observed cases, albeit only 1-degree anaemia and mainly in children from the older age group. In particular, as studies have revealed, in patients from the 1st rehabilitation group (1-RG), all indicators of peripheral blood exceeded those of patients from 2-RG on average, as follows: haemoglobin, up to 3%; erythrocytes (red blood cells - RBC), up to 2.4%; blood colour index (BCI), up to 3.8%; and mean corpuscular haemoglobin concentration (MCHC), up to 4%, (*P=0.038*). Consequently, the implementation of comprehensive preventive rehabilitation of schoolchildren with CGDP helps to remove the picture of chronic hypoxia from the haematological parameters of peripheral blood. During the study, at the same time, an increase in regenerative processes in the mucous membrane of the stomach and intestines was noted, as was also reported in our previous publication [7].

Discussion

In the clinical practice of gastroenterologists, it is often necessary to influence the reparative-regenerative processes in inflammatory diseases of the gastroduodenal zone. In recent years, there has been an increase in the number of publications devoted to the problem of the regenerative effects of oxygen in the body, [9]. In patients with various pathologies, the pathway of the oxygen-sensitive factor induced by hypoxia, which plays a central role in the control of erythropoiesis and metabolism in internal organs, is more thoroughly studied, [10]. Oxygen, as the most abundant of the essential elements involved in metabolism, is a critical factor in the regulation of organic development. The oxygen concentration plays a vital role in determining cell fate and maintaining cellular homeostasis, [11]. At the same time, under normal conditions, aerobic metabolism is supported by a sufficient supply of oxygen, [12]. Hypoxia is the driver of cell function. The effects of hypoxia on cells and tissues are numerous, including embryonic development, maintenance of stem cell pluripotency, [13], induction of cell-type differentiation, and multiple signalling cascades, e.g., those involving blood vessels and endothelial tissue, [14].

There is cross-talk between these transcription factors in response to hypoxia, and *hypoxia-induced factors* (HIF) play a central role in regulating the cellular response to hypoxia, [15]. Consequently, the regenerative process is impossible without the participation of oxygen, [16].

Differentiation of the cells being restored is also an important factor. Stem cell migration, proliferation, and differentiation are essential for the regeneration of tissues and organs. Many factors involved in this process have not yet been fully understood, and this problem remains open. At the same time, *reactive oxygen species* (ROS) play an important role in the regeneration process; however, the interaction between oxygen (O2), ROS, and HIF has been proven, [17].

In recent years, interest has grown in the mechanism of action of ROS as well as in reactions with their participation. Interest in this issue

grew after a discovery by Professor Enrique Amaya and his group. They identified genes that are activated during tail regeneration in certain reptiles. According to the authors, the decrease in ROS levels was accompanied by the suppression of tissue growth and regeneration, [18].

Research has shown that ROS are required to maintain the regenerative response. In addition, the formation of ROS is involved in almost all the studied regenerative systems, including those in the human body, [19]. Regenerative medicine itself is a new and promising medical direction for the treatment of patients with defective, or dysfunctional tissues by maintaining or increasing the biological activity of cells, [20].

Additionally, the high therapeutic properties of oxidants such as hydrogen peroxide and ozone remain unclear, [21]. It should be noted that the distortion of the regenerative process in the form of excessive or insufficient regeneration can lead to the development of metaplasia, [22], indicating a pathological reparative-regenerative process. The basis of this process is the violation of the mechanisms responsible for regulating the formation of cells, and this type of regeneration should be attributed to one of the stages of the process of oncogenesis, [23].

The formation of ROS occurs during the transfer of electrons (catalysed by oxidases) from the respiratory chain to mitochondria, [23,24]. It should be noted that all living organisms produce reactive oxygen species in the course of their normal life, and HP is no exception. Pathogenic microorganisms generate ROS to destroy host tissues, [24,25].

In the course of the inflammatory process, when there is an increase in redox processes, due to insufficient functioning of the antioxidant defence system, "oxidative stress" develops, which is one of the main mechanisms of damage to biological membranes, in this case, the gastric mucosa, [26]. Regenerative processes in acute injuries of the colon and duodenum are implemented as restitution with the restoration of function. According to some scientists, HP can lead to an increase in the proliferation of damaged cells in the mucous layer of the stomach and intestines, but this effect is due to an increase in gastrin production, [27], and apoptosis is enhanced, which is more clearly observed in HP associated gastritis, [28].

Based on the above data, we can conclude that free oxygen shows both regenerative properties in the body. At the same time, free oxygen has a bactericidal effect. In particular, ROS provide an alternative bactericidal mechanism for clinically traditional antibiotics, [29].

Considering the action of ROS, involving treatments that include bactericidal antibiotics, photodynamic therapy, photocatalysis of titanium dioxide [30], the use of oxygen cocktails as a therapeutic measure is relevant. As our studies showed, in patients who, against the background of conventional treatment, received enteral oxygen therapy, the HP infection rate was 2.5 times less than that in patients from the second group (9.5% versus 23.8%). But we should not exclude other factors affecting the intestinal microbiota, in particular, taking medications and poor nutrition of children, [31].

Based on the above results, it can be concluded that patients with CGDP need rehabilitation therapy after a course of standard treatment. Consequently, the study of the regenerative effects of oxygen in peptic ulcer diseases in young patients remains a topical area of modern medicine.

Conclusion.

The integration of enteral oxygen therapy (EOT) into clinical protocols significantly accelerates reparative and regenerative processes on the damaged gastric mucosal surface—up to 63.0% improvement compared to baseline. Simultaneously, the implementation of a comprehensive rehabilitation strategy incorporating EOT leads to a marked reduction in Helicobacter pylori carriage—by approximately 2.5-fold (from 23.8% to 9.5%). This therapeutic approach also contributes to measurable improvements in peripheral blood hematological parameters among pediatric patients with

chronic gastroduodenal pathology, indicating a systemic restorative effect.

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