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CLINICAL, ENDOSCOPIC, AND MICROBIOLOGICAL FEATURES OF CHRONIC RHINOSINUSITIS IN CHILDREN WITH CYSTIC FIBROSIS

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Abstract: This article analyzes the clinical, endoscopic, and microbiological characteristics of chronic rhinosinusitis in children with cystic fibrosis. The major clinical manifestations, the diagnostic value of modern nasal endoscopy, and the predominant microorganisms isolated from sinonasal secretions are discussed. The role of microbiological investigations in guiding targeted

antimicrobial therapy and the effectiveness of comprehensive treatment strategies are also evaluated. The findings suggest that early diagnosis and individualized management significantly improve disease control, reduce sinonasal inflammation, and contribute to better respiratory outcomes in children with cystic fibrosis.

Keywords: Cystic fibrosis, chronic rhinosinusitis, children, nasal endoscopy, microbiology, paranasal sinuses, bacterial colonization, early diagnosis, antimicrobial therapy, comprehensive treatment.

КЛИНИКО-ЭНДОСКОПИЧЕСКИЕ И МИКРОБИОЛОГИЧЕСКИЕ ОСОБЕННОСТИ ХРОНИЧЕСКОГО РИНОСИНУСИТА У ДЕТЕЙ С МУКОВИСЦИДОЗОМ

Аннотация: В данной статье проанализированы клинические, эндоскопические и микробиологические особенности хронического риносинусита у детей с муковисцидозом. Рассмотрены основные клинические проявления заболевания, диагностическая ценность современных эндоскопических методов исследования и спектр наиболее часто выявляемых микроорганизмов в содержимом околоносовых пазух. Особое внимание уделено роли микробиологического исследования в выборе рациональной антибактериальной терапии и эффективности комплексного лечения. Полученные результаты свидетельствуют о том, что ранняя диагностика и индивидуализированный подход к лечению способствуют улучшению течения заболевания, уменьшению воспалительных изменений и снижению риска респираторных осложнений у детей с муковисцидозом.

Ключевые слова: Муковисцидоз, хронический риносинусит, дети, эндоскопия, микробиология, околоносовые пазухи, бактериальная колонизация, ранняя диагностика, антибактериальная терапия, комплексное лечение.

MUKOVISSIDOZ BILAN KASALLANGAN BOLALARDA SURUNKALI RINOSINUSITNING KLINIK, ENDOSKOPIK VA MIKROBIOLOGIK XUSUSIYATLARI

Annotatsiya: Ushbu maqolada mukovissidoz bilan kasallangan bolalarda surunkali rinosinusitning klinik, endoskopik va mikrobiologik xususiyatlari tahlil qilingan. Kasallikning asosiy klinik belgilari, zamonaviy endoskopik diagnostika usullarining ahamiyati hamda sinonazal sekretsiyalarda uchraydigan asosiy mikroorganizmlar yoritilgan. Shuningdek, mikrobiologik tekshiruvlarning maqsadli antibakterial terapiyani tanlashdagi o‘rni va kompleks davolashning samaradorligi baholangan. Tadqiqot natijalari kasallikni erta tashxislash va individual davolash yondashuvlari bolalarda surunkali rinosinusitning kechishini yaxshilash hamda nafas yo‘llari asoratlarini kamaytirishda muhim ahamiyatga ega ekanligini ko‘rsatadi.

Kalit so‘zlar: Mukovissidoz, surunkali rinosinusit, bolalar, endoskopiya, mikrobiologiya, burun bo‘shlig‘i, paranasal sinuslar, bakterial kolonizatsiya, erta tashxis, kompleks davolash.

Introduction

Chronic rhinosinusitis is one of the most common chronic inflammatory diseases of the upper respiratory tract in children and represents a significant clinical problem, particularly among patients with cystic fibrosis. Cystic fibrosis is an autosomal recessive genetic disorder characterized by impaired function of the cystic fibrosis transmembrane conductance regulator protein, leading to the production of abnormally viscous secretions in the respiratory tract. The accumulation of thick mucus disrupts mucociliary clearance, promotes persistent bacterial colonization, and predisposes patients to chronic inflammation of the paranasal sinuses. The prevalence of chronic rhinosinusitis in children with cystic fibrosis is considerably higher than in the general pediatric population. Although radiological and endoscopic signs of sinonasal disease are observed in the majority of patients,

clinical manifestations may vary from mild nasal obstruction to severe chronic infection accompanied by recurrent exacerbations and deterioration of pulmonary function. Because the upper and lower airways constitute a unified respiratory system, chronic sinonasal infection may serve as a reservoir for pathogenic microorganisms, contributing to recurrent lower respiratory tract infections and progressive pulmonary disease.

Early recognition of chronic rhinosinusitis is therefore essential for improving both sinonasal and pulmonary outcomes. Modern nasal endoscopy provides direct visualization of the nasal cavity and paranasal sinus drainage pathways, allowing accurate assessment of mucosal edema, nasal polyps, purulent secretions, and anatomical abnormalities. In addition, microbiological examination of nasal and sinus secretions enables identification of predominant bacterial pathogens and determination of their antimicrobial susceptibility, thereby facilitating targeted antimicrobial therapy. Recent advances in pediatric otorhinolaryngology have emphasized the importance of integrating clinical evaluation, endoscopic examination, microbiological investigation, and imaging techniques for comprehensive assessment of children with cystic fibrosis. A multidisciplinary approach involving pediatricians, otorhinolaryngologists, microbiologists, and pulmonologists contributes to earlier diagnosis, individualized treatment planning, and improved long-term prognosis.

Relevance

Chronic rhinosinusitis is one of the most frequent upper respiratory tract complications in children with cystic fibrosis and significantly affects their quality of life and long-term respiratory prognosis. Impaired mucociliary clearance, accumulation of highly viscous secretions, and persistent bacterial colonization create favorable conditions for chronic inflammation of the nasal cavity and paranasal sinuses. Untreated sinonasal infection may become a continuous source of pathogenic microorganisms for the lower respiratory tract, contributing to recurrent pulmonary infections and progressive deterioration of lung function. Therefore, comprehensive evaluation of the clinical manifestations, endoscopic findings, and microbiological characteristics of chronic rhinosinusitis in children with cystic fibrosis remains an important and highly relevant issue in modern pediatric otorhinolaryngology.

Aim

The aim of this study is to investigate the clinical, endoscopic, and microbiological characteristics of chronic rhinosinusitis in children with cystic fibrosis, evaluate the diagnostic significance of modern examination methods, and identify the predominant microbial pathogens in order to improve early diagnosis and optimize therapeutic management.

Main part

Cystic fibrosis is one of the most common life-threatening autosomal recessive genetic disorders affecting children. The disease is caused by mutations in the cystic fibrosis transmembrane conductance regulator (CFTR) gene, resulting in abnormal chloride and sodium transport across epithelial cell membranes. Consequently, secretions produced by exocrine glands become highly viscous and difficult to eliminate from the respiratory tract. The impaired hydration of airway secretions significantly reduces mucociliary clearance and predisposes patients to persistent bacterial colonization and chronic inflammation. Chronic rhinosinusitis represents one of the earliest and most prevalent manifestations of upper airway involvement in children with cystic fibrosis. Nearly all patients demonstrate radiological abnormalities of the paranasal sinuses, while a substantial proportion develop clinically significant sinonasal disease. Persistent accumulation of thick mucus within the nasal cavity and paranasal sinuses obstructs the natural drainage pathways, creating an ideal environment for bacterial proliferation and biofilm formation. As a result, chronic inflammation gradually develops, leading to mucosal edema, polyp formation, and structural remodeling of the sinonasal mucosa.

The pathogenesis of chronic rhinosinusitis in cystic fibrosis is multifactorial. Defective mucociliary transport is considered the principal mechanism responsible for impaired clearance of

inhaled microorganisms and inflammatory debris. Persistent retention of secretions promotes colonization by opportunistic pathogens such as *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Haemophilus influenzae*, and other Gram-negative bacteria. Chronic microbial persistence stimulates continuous activation of the innate immune response, resulting in excessive neutrophilic inflammation and progressive tissue damage. Genetic factors also influence disease severity. Different CFTR mutations produce variable degrees of chloride channel dysfunction, explaining the heterogeneity of clinical manifestations among affected children. Patients carrying severe genetic variants frequently develop earlier and more extensive sinonasal involvement compared with individuals possessing milder mutations.

The clinical presentation of chronic rhinosinusitis in children with cystic fibrosis varies depending on the severity of sinonasal inflammation, age of the patient, and degree of pulmonary involvement. Although radiological abnormalities are present in the majority of patients, many children initially exhibit only mild or nonspecific symptoms, making early diagnosis particularly challenging. Persistent nasal obstruction is considered the most common clinical manifestation and is frequently accompanied by thick mucopurulent nasal discharge, mouth breathing, chronic cough, reduced olfactory function, facial pressure, recurrent headaches, and postnasal drip. In younger children, feeding difficulties, sleep disturbances, irritability, and impaired quality of life may also be observed. Comprehensive clinical evaluation begins with detailed history taking, emphasizing the duration of symptoms, frequency of respiratory infections, previous surgical interventions, and current pulmonary status. Physical examination includes anterior rhinoscopy and assessment of nasal airflow; however, these methods often fail to visualize pathology located in the middle meatus or deeper regions of the nasal cavity.

Nasal endoscopy has become the gold standard for evaluating sinonasal disease in children with cystic fibrosis. Endoscopic examination enables direct visualization of mucosal edema, nasal polyps, purulent secretions, crust formation, obstruction of the osteomeatal complex, and anatomical variations that contribute to impaired sinus drainage. Endoscopy also allows collection of microbiological specimens from infected sites, thereby improving diagnostic accuracy and guiding antimicrobial therapy. Computed tomography remains the preferred imaging modality for assessing the extent of sinonasal disease. It accurately demonstrates mucosal thickening, sinus opacification, obstruction of sinus ostia, bone remodeling, and hypoplasia of the paranasal sinuses frequently observed in cystic fibrosis. Imaging findings are particularly valuable for surgical planning and long-term disease monitoring.

The microbiological profile of chronic rhinosinusitis in children with cystic fibrosis differs considerably from that observed in otherwise healthy pediatric patients. Due to impaired mucociliary clearance and accumulation of highly viscous mucus, the sinonasal cavity provides an ideal environment for persistent bacterial colonization and chronic infection. The microorganisms most frequently isolated from sinonasal secretions include *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Haemophilus influenzae*, *Streptococcus pneumoniae*, *Moraxella catarrhalis*, and several Gram-negative opportunistic pathogens. Among these organisms, *Pseudomonas aeruginosa* is considered one of the most clinically significant pathogens because of its ability to establish chronic infection through biofilm formation and its high level of antimicrobial resistance.

Biofilm formation represents one of the principal mechanisms responsible for treatment failure and recurrent disease. Bacteria embedded within biofilms demonstrate increased resistance to host immune defenses and antimicrobial agents, allowing persistent colonization despite repeated antibiotic therapy. Consequently, microbiological culture and antimicrobial susceptibility testing play an essential role in selecting targeted antimicrobial treatment.Recent advances in molecular microbiology have considerably improved pathogen detection. Polymerase chain reaction, next-generation sequencing, and metagenomic analysis allow rapid identification of microorganisms that may not be detected using conventional culture methods. These technologies provide a more

comprehensive understanding of the sinonasal microbiome and facilitate personalized therapeutic approaches.

The management of chronic rhinosinusitis in children with cystic fibrosis requires a comprehensive multidisciplinary approach aimed at controlling chronic inflammation, improving sinonasal drainage, reducing microbial colonization, and preserving respiratory function. Because cystic fibrosis is a lifelong multisystem disease, treatment should be individualized according to disease severity, microbiological findings, pulmonary status, and the presence of sinonasal complications. Medical therapy represents the first-line treatment for most pediatric patients. Regular nasal saline irrigation is recommended to remove thick secretions, improve mucociliary clearance, and reduce the concentration of inflammatory mediators within the nasal cavity. Hypertonic saline solutions are particularly beneficial because they increase airway surface hydration and facilitate mucus clearance. Intranasal corticosteroids are widely used to reduce mucosal inflammation, decrease nasal obstruction, and control nasal polyps in selected patients.

Antimicrobial therapy should be guided by microbiological culture and antimicrobial susceptibility testing whenever possible. Systemic antibiotics are indicated during acute bacterial exacerbations, whereas topical antibiotic irrigation may be considered in patients with persistent sinonasal colonization by resistant microorganisms. Careful antibiotic selection is essential to minimize antimicrobial resistance and improve therapeutic efficacy. Mucolytic therapy also plays an important role in reducing mucus viscosity and facilitating sinus drainage. In selected patients, recombinant human deoxyribonuclease may improve secretion clearance and decrease chronic bacterial colonization. Recent advances in cystic fibrosis transmembrane conductance regulator modulator therapy have demonstrated beneficial effects on respiratory secretions and may also contribute to improved sinonasal health in eligible patients.

Long-term prevention and regular follow-up are fundamental components of chronic rhinosinusitis management in children with cystic fibrosis. Early identification of sinonasal disease allows timely therapeutic intervention before irreversible structural changes develop. Routine otorhinolaryngological assessment should therefore become an integral part of comprehensive cystic fibrosis care. Periodic nasal endoscopic examination enables early detection of mucosal edema, nasal polyps, recurrent infection, and postoperative anatomical changes. Regular microbiological monitoring facilitates identification of persistent bacterial colonization and guides appropriate antimicrobial therapy before pulmonary exacerbations occur.

Daily nasal irrigation, appropriate medication adherence, maintenance of adequate hydration, respiratory physiotherapy, and optimization of nutritional status significantly reduce disease progression. Education of patients and caregivers regarding proper nasal hygiene techniques and recognition of early clinical symptoms is essential for improving long-term treatment compliance. The prognosis of chronic rhinosinusitis largely depends on early diagnosis, adequate medical management, control of pulmonary disease, and continuous multidisciplinary follow-up. Although complete eradication of chronic sinonasal inflammation may not always be achievable, appropriate long-term treatment substantially improves sinonasal function, reduces infection frequency, enhances quality of life, and contributes to better preservation of pulmonary health.

Rapid advances in pediatric otorhinolaryngology and molecular medicine have introduced new opportunities for improving the diagnosis and treatment of chronic rhinosinusitis in children with cystic fibrosis. Future research is increasingly directed toward precision medicine, molecular microbiology, artificial intelligence, and individualized therapeutic strategies. Modern molecular diagnostic techniques, including polymerase chain reaction, next-generation sequencing, and metagenomic analysis, enable rapid identification of pathogenic microorganisms and characterization of the sinonasal microbiome. These technologies improve diagnostic sensitivity and facilitate targeted antimicrobial therapy. Artificial intelligence has demonstrated promising applications in the interpretation of computed tomography images and nasal endoscopic findings. Automated image

analysis systems may assist clinicians in detecting early inflammatory changes, evaluating disease severity, and predicting treatment outcomes with greater diagnostic consistency.

Biomarker research is another rapidly developing field. Identification of inflammatory mediators, cytokines, and microbial biomarkers within nasal secretions may provide non-invasive methods for early diagnosis, disease monitoring, and assessment of therapeutic response. The development of novel cystic fibrosis transmembrane conductance regulator modulators has significantly improved respiratory outcomes in many patients and may reduce the severity of chronic sinonasal disease by restoring epithelial ion transport and improving mucociliary clearance. Personalized medicine based on genetic mutation profiles is expected to become an increasingly important component of future cystic fibrosis management. Overall, integration of advanced diagnostic technologies, molecular microbiology, precision medicine, and multidisciplinary care is expected to improve early detection, optimize therapeutic decision-making, reduce pulmonary complications, and enhance the long-term quality of life of children with cystic fibrosis.

Results

A total of 30 children diagnosed with cystic fibrosis and chronic rhinosinusitis were included in this study. The patients were randomly divided into two equal groups. Group I (n = 15) received conventional medical management, including saline nasal irrigation, topical corticosteroids, and systemic antibiotic therapy when clinically indicated. Group II (n = 15) received comprehensive treatment consisting of conventional medical therapy combined with regular nasal endoscopic follow-up, culture-guided antimicrobial therapy, intensive mucolytic treatment, and individualized multidisciplinary care.

Clinical, endoscopic, and microbiological assessments were performed before treatment and after a six-month follow-up period. At baseline, no statistically significant differences were observed between the two groups regarding symptom severity, endoscopic findings, or microbiological profile ($p > 0.05$).

Following treatment, children in the comprehensive treatment group demonstrated significantly greater clinical improvement. Persistent nasal obstruction decreased from 93.3% to 20.0%, while mucopurulent nasal discharge decreased from 86.7% to 13.3%. In the conventional treatment group, these symptoms decreased to 46.7% and 40.0%, respectively.

Endoscopic examination demonstrated a marked reduction in mucosal edema, nasal polyps, and purulent secretions in Group II. The average endoscopic inflammation score decreased from 7.2 ± 1.1 to 2.6 ± 0.8, whereas Group I demonstrated a reduction from 7.0 ± 1.0 to 4.5 ± 0.9.

Microbiological analysis revealed that Pseudomonas aeruginosa and Staphylococcus aureus were the most frequently isolated microorganisms before treatment. After six months, bacterial eradication or significant reduction was achieved in 73.3% of patients in Group II compared with 46.7% in Group I. Culture-guided antimicrobial therapy significantly improved microbiological outcomes and reduced recurrent bacterial colonization. Children receiving comprehensive management experienced fewer episodes of recurrent respiratory infections and demonstrated improved nasal breathing, sleep quality, and overall quality of life during follow-up. No severe treatment-related complications or serious adverse events were recorded throughout the study period. Overall, the findings indicate that comprehensive management integrating modern endoscopic assessment, microbiological monitoring, individualized antimicrobial therapy, and multidisciplinary follow-up provides significantly better clinical, endoscopic, and microbiological outcomes than conventional treatment alone in children with cystic fibrosis and chronic rhinosinusitis.

Discussion

The present study demonstrated that children with cystic fibrosis frequently develop chronic rhinosinusitis characterized by persistent sinonasal inflammation, significant endoscopic abnormalities, and chronic bacterial colonization. The findings indicate that impaired mucociliary clearance associated with cystic fibrosis creates favorable conditions for the accumulation of viscous

secretions, prolonged microbial persistence, and recurrent inflammation of the nasal cavity and paranasal sinuses. These pathophysiological mechanisms explain the high prevalence of chronic rhinosinusitis observed in this patient population. The results also revealed that comprehensive management combining clinical assessment, nasal endoscopy, microbiological investigation, and individualized antimicrobial therapy produced significantly better outcomes than conventional treatment alone. Patients receiving multidisciplinary care demonstrated greater improvement in nasal obstruction, reduction of mucosal edema, decreased purulent secretions, and better microbiological eradication of pathogenic bacteria. These findings support the growing evidence that successful management of chronic rhinosinusitis in children with cystic fibrosis requires accurate identification of causative microorganisms together with regular endoscopic monitoring.

Microbiological analysis confirmed that *Pseudomonas aeruginosa* and *Staphylococcus aureus* remained the predominant bacterial pathogens responsible for persistent sinonasal infection. Their ability to produce biofilms contributes to chronic colonization, antimicrobial resistance, and recurrent disease. Therefore, microbiological culture with antimicrobial susceptibility testing remains essential for selecting appropriate targeted antibiotic therapy and minimizing treatment failure. The study further demonstrated that regular follow-up and individualized treatment strategies contribute to better disease control and improved quality of life. Early diagnosis combined with timely therapeutic intervention not only reduces sinonasal symptoms but may also decrease the risk of recurrent lower respiratory tract infections by eliminating potential bacterial reservoirs within the upper airways. Although the study showed encouraging clinical results, certain limitations should be acknowledged. The relatively small sample size and short follow-up period may limit the generalizability of the findings. Future multicenter investigations involving larger pediatric populations and longer observation periods are recommended to evaluate the long-term effectiveness of modern diagnostic technologies, molecular microbiological methods, and personalized therapeutic approaches in children with cystic fibrosis.

Conclusion

Chronic rhinosinusitis is one of the most common upper airway complications in children with cystic fibrosis and has a significant impact on respiratory health and overall quality of life. Early diagnosis based on comprehensive clinical evaluation, nasal endoscopy, microbiological investigation, and radiological assessment enables timely identification of sinonasal disease and facilitates individualized treatment planning. The findings of this study indicate that comprehensive management incorporating endoscopic monitoring, microbiological culture-guided antimicrobial therapy, regular nasal irrigation, and multidisciplinary follow-up provides superior clinical and microbiological outcomes compared with conventional treatment alone. Such an approach effectively reduces sinonasal inflammation, improves nasal function, decreases bacterial colonization, and contributes to better long-term respiratory health. The integration of modern diagnostic techniques with individualized evidence-based treatment should be considered an essential component of routine care for children with cystic fibrosis. Further large-scale prospective studies are warranted to optimize therapeutic strategies and improve long-term clinical outcomes in this vulnerable pediatric population.

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