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**DIAGNOSTIC SIGNIFICANCE OF 3D RADIOLOGICAL VISUALIZATION OF THE
PARANASAL SINUSES IN CHILDREN WITH CYSTIC FIBROSIS**



Makhmudova Saodat Kurbonbekovna

First-Year Basic Doctoral (PhD) Student, Department of Otorhinolaryngology No. 1, Samarkand State Medical University.

<https://orcid.org/0000-0003-4073-1898>

xamrakulova82@mail.ru



Khushvakova Nilyufar Juraqulova

Head of the Department of Otorhinolaryngology No. 1, Samarkand State Medical University, Doctor of Medical Sciences, Professor.

<https://orcid.org/0009-0000-6717-2067>

nilumedlor@mail.ru



Khamrakulova Nargiza Orzuyevna

Associate Professor, Department of Otorhinolaryngology No. 1, Samarkand State Medical University, Doctor of Medical Sciences.

<https://orcid.org/0009-0000-5783-3570>

xamrakulova82@mail.ru

Abstract: This article discusses the diagnostic assessment of pathological changes in the nasal cavity and paranasal sinuses in children with cystic fibrosis using modern radiological imaging techniques. Impaired mucociliary clearance, accumulation of thick secretions, and chronic inflammatory processes associated with cystic fibrosis may contribute to various structural



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abnormalities of the sinonasal system. The article focuses on the diagnostic capabilities of three-dimensional radiological visualization in assessing the anatomy of the paranasal sinuses, mucosal changes, sinus opacification, hypoplasia, polypoid changes, and sinus drainage pathways. Three-dimensional reconstruction provides additional diagnostic information regarding the localization and extent of pathological processes, spatial relationships between anatomical structures, and treatment planning. The integration of three-dimensional radiological visualization with clinical and endoscopic examinations may improve the comprehensive assessment of sinonasal pathology in children with cystic fibrosis.

Keywords: Cystic fibrosis, children, paranasal sinuses, three-dimensional visualization, radiological diagnosis, computed tomography, sinonasal pathology.

ДИАГНОСТИЧЕСКАЯ ЗНАЧИМОСТЬ 3 D РЕНТГЕНОВСКОЙ ВИЗУАЛИЗАЦИЙ ОКОЛОНОСОВЫХ ПАЗУХ ПРИ МУКОВИСЦИДОЗЕ У ДЕТЕЙ

Аннотация: В статье рассматриваются вопросы диагностики патологических изменений полости носа и околоносовых пазух у детей с муковисцидозом с использованием современных методов радиологической визуализации. Нарушение мукоцилиарного клиренса, накопление вязкого секрета и хронические воспалительные процессы при муковисцидозе могут приводить к развитию различных структурных изменений синоназальной системы. Особое внимание уделено диагностическим возможностям трехмерной радиологической визуализации при оценке анатомического строения околоносовых пазух, состояния слизистой оболочки, опакфикации пазух, гипоплазии, полипозных изменений и состояния дренажных путей. Трехмерная реконструкция позволяет получить дополнительную диагностическую информацию о локализации и распространенности патологического процесса, пространственных взаимоотношениях анатомических структур и возможностях планирования лечения. Комплексное использование трехмерной радиологической визуализации совместно с клиническими и эндоскопическими методами может повысить эффективность оценки синоназальной патологии у детей с муковисцидозом.

Ключевые слова: Муковисцидоз, дети, околоносовые пазухи, трехмерная визуализация, радиологическая диагностика, компьютерная томография, синоназальная патология.

BOLALARDA MUKOVISSIDOZDA BURUN YON BO'SHLIQLARINING 3D RENTGENOLOGIK VIZUALIZATSIYASINING DIAGNOSTIK AHAMIYATI

Annotatsiya: Ushbu maqolada mukovissidoz bilan kasallangan bolalarda burun va burun yon bo'shliqlarining patologik o'zgarishlarini zamonaviy radiologik usullar yordamida aniqlash masalalari yoritilgan. Mukovissidozda mukotsiliar klirensning buzilishi, quyuq sekretning to'planishi va surunkali yallig'lanish jarayonlari sinonazal tizimda turli strukturaviy o'zgarishlarning rivojlanishiga olib kelishi mumkin. Maqolada uch o'lchamli radiologik vizualizatsiyaning burun yon bo'shliqlari anatomiyasi, shilliq qavat holati, sinuslarning opakifikatsiyasi, gipoplaziya, polipoz o'zgarishlar va drenaj yo'llarini baholashdagi imkoniyatlari ko'rib chiqiladi. Uch o'lchamli rekonstruksiya patologik jarayonning joylashuvi va tarqalishini batafsil aniqlash, anatomik tuzilmalar o'rtasidagi fazoviy munosabatlarni baholash hamda davolash taktikasini rejalashtirish uchun qo'shimcha diagnostik ma'lumot beradi. Ushbu yondashuvni klinik va endoskopik tekshiruvlar bilan birgalikda qo'llash mukovissidozli bolalarda sinonazal patologiyani kompleks baholash imkonini beradi.

Kalit so'zlar: Mukovissidoz, bolalar, burun yon bo'shliqlari, uch o'lchamli vizualizatsiya, radiologik diagnostika, kompyuter tomografiyasi, sinonazal patologiya.



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Introduction

Cystic fibrosis is a hereditary multisystem disease characterized by impaired chloride transport, increased secretion viscosity, and dysfunction of mucociliary clearance. Although the disease predominantly affects the lower respiratory tract, the upper respiratory tract and paranasal sinuses are also frequently involved. In children with cystic fibrosis, impaired mucociliary clearance and the accumulation of thick secretions may contribute to chronic inflammation, recurrent infection, mucosal thickening, and structural abnormalities of the paranasal sinuses. Sinonasal manifestations may develop at an early age and can remain clinically underestimated because their symptoms may overlap with those of other respiratory manifestations of cystic fibrosis. Therefore, objective imaging assessment of the paranasal sinuses is important for detecting structural changes, determining the extent of sinonasal involvement, and selecting an appropriate management strategy.

Conventional radiographic examination provides limited information about the complex three-dimensional anatomy of the paranasal sinuses. Three-dimensional radiological visualization allows the anatomical structures of the maxillary, ethmoid, frontal, and sphenoid sinuses to be assessed from different spatial projections. It may also facilitate the identification of mucosal thickening, partial or complete sinus opacification, anatomical variations, and other pathological changes associated with chronic sinonasal disease. The use of three-dimensional imaging is particularly relevant in pediatric patients because diagnostic accuracy must be balanced against radiation exposure. Modern imaging technologies aim to provide sufficient anatomical information while maintaining radiation doses as low as reasonably achievable. Therefore, assessment of the diagnostic potential of three-dimensional visualization of the paranasal sinuses may contribute to improving the diagnosis and monitoring of sinonasal manifestations in children with cystic fibrosis. Despite the increasing availability of advanced radiological imaging, the diagnostic role of three-dimensional visualization in pediatric patients with cystic fibrosis requires further evaluation. Determining the frequency and characteristics of sinonasal abnormalities and assessing the diagnostic capabilities of three-dimensional imaging may contribute to more accurate and individualized management of these patients.

Relevance

Cystic fibrosis in children can cause chronic pathological changes in the nose and paranasal sinuses in addition to affecting the lower respiratory tract. Impaired mucociliary clearance, accumulation of thick secretions, chronic mucosal inflammation, and recurrent infections can negatively affect the anatomical and functional condition of the paranasal sinuses. Therefore, early detection and assessment of sinonasal changes in children with cystic fibrosis are important for comprehensive disease management. Three-dimensional radiological visualization of the paranasal sinuses enables detailed spatial assessment of pathological changes, anatomical structures, and the extent of inflammatory processes. In pediatric patients, it is particularly important to obtain sufficient diagnostic information while minimizing radiation exposure. Therefore, investigating the diagnostic capabilities of three-dimensional imaging of the paranasal sinuses is a relevant issue in modern pediatric radiology and otorhinolaryngology.

Aim

To evaluate the diagnostic capabilities of three-dimensional radiological visualization of the paranasal sinuses in children with cystic fibrosis, assess the detected sinonasal pathological changes, and determine the diagnostic significance of this imaging method.

Main part

Cystic fibrosis is an inherited disease that alters the physical and chemical properties of secretions throughout the body. Defective chloride ion transport leads to the production of thick and viscous mucus. This process affects not only the bronchopulmonary system but also the nasal cavity and paranasal sinuses. Accumulation of thick secretions contributes to impaired mucociliary clearance. As a result, drainage of the nasal passages and paranasal sinuses becomes impaired.



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Persistent retention of secretions creates favorable conditions for microbial colonization and infection. At the same time, activation of the local immune response may contribute to chronic inflammation. Children with cystic fibrosis may experience nasal obstruction, difficulty breathing through the nose, and persistent nasal discharge. Chronic inflammation can lead to thickening of the sinonasal mucosa. Continued inflammation may also narrow the natural drainage pathways of the sinuses. Nasal polyps may develop in some patients. Radiological examination can demonstrate partial or complete opacification of the paranasal sinuses. Hypoplasia of individual sinuses and other developmental abnormalities may also be observed. Therefore, assessment of the sinonasal system is an important component of comprehensive evaluation in children with cystic fibrosis. Clinical symptoms do not always accurately reflect the severity of radiological abnormalities.

Three-dimensional radiological imaging provides an opportunity to examine the anatomical structure of the paranasal sinuses in greater detail. In children with cystic fibrosis, this method can be used to assess the shape, size, and internal structure of the sinuses. One of the important radiological findings is mucosal thickening. Partial or complete opacification of the sinus cavity may also be detected. These changes may be associated with retained secretions and chronic inflammatory processes within the sinuses. Some patients may demonstrate developmental abnormalities of the maxillary, ethmoid, frontal, and sphenoid sinuses. Sinus hypoplasia has been described as an important radiological feature in cystic fibrosis. Nasal polyps can also be identified using three-dimensional imaging. The condition of the nasal passages and natural sinus drainage pathways can be assessed as well. Three-dimensional reconstruction provides a clearer representation of the spatial relationships between anatomical structures. This is particularly useful when complex anatomical abnormalities are present. The condition of the bony structures can also be evaluated in detail. Previous studies have described medial displacement of the lateral nasal wall and changes in the region of the uncinate process. Such findings may provide additional information when differentiating cystic fibrosis-related sinonasal disease from ordinary chronic rhinosinusitis. Three-dimensional images can help determine the extent of sinonasal pathology. They also allow assessment of which sinuses are predominantly affected. The obtained radiological findings should be interpreted together with clinical and endoscopic examination results.

Three-dimensional radiological visualization enables spatial assessment of the complex anatomy of the paranasal sinuses. This technique provides detailed information about both the internal and external anatomical structures of the sinuses. Three-dimensional reconstruction is particularly useful for evaluating the spatial relationships between individual sinuses and the nasal passages. Mucosal thickening, sinus opacification, and polypoid changes can be identified using this imaging approach. It also allows assessment of sinus hypoplasia and other developmental anatomical features. Three-dimensional images may provide a clearer representation of the anatomical extent of pathological processes. This information is particularly important when surgical treatment is being considered. Combining radiological findings with endoscopic examination may improve the overall diagnostic assessment. Because sinonasal changes in cystic fibrosis are often chronic, their monitoring over time may also be clinically relevant. However, radiation exposure must be carefully considered when computed tomography is used in children. When repeated examinations are required, low-dose imaging protocols should be considered whenever clinically appropriate. Modern cone-beam computed tomography is being investigated as a potential alternative for evaluating sinonasal anatomy. One of its potential advantages is the possibility of reducing radiation exposure in selected clinical situations. At the same time, image quality must remain sufficient for the specific diagnostic purpose. Three-dimensional visualization can provide detailed anatomical information that facilitates clinical decision-making. The method may contribute to assessment of disease severity, selection of treatment strategies, and preoperative planning.

Sinonasal abnormalities in children with cystic fibrosis may resemble those observed in other forms of chronic rhinosinusitis. Therefore, radiological assessment should include not only



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inflammatory changes but also structural features that may be associated with cystic fibrosis. Three-dimensional imaging allows detailed evaluation of the paranasal sinuses and nasal cavity. Mucosal thickening and partial or complete sinus opacification are among the most frequently assessed findings. Sinus hypoplasia may also be identified during radiological examination. Changes involving the lateral nasal wall and uncinate process can provide additional anatomical information. Nasal polyposis is another important finding that may be detected in patients with cystic fibrosis. Evaluation of the ostiomeatal complex is particularly important because obstruction of natural drainage pathways can contribute to persistent sinonasal inflammation. Three-dimensional reconstruction makes it possible to assess these structures from different spatial perspectives. This can help distinguish anatomical abnormalities from secondary inflammatory changes. Radiological findings should be interpreted together with clinical symptoms, nasal endoscopy, and microbiological data. Such an integrated approach provides a more comprehensive assessment of sinonasal involvement. Imaging may also help determine the extent of disease when clinical symptoms are nonspecific. This is particularly relevant in pediatric patients, in whom sinonasal manifestations may be underestimated clinically.

Three-dimensional radiological visualization has an important role in determining the anatomical characteristics of sinonasal disease and supporting treatment planning. Detailed visualization of the paranasal sinuses allows physicians to assess the location and extent of pathological changes before selecting an appropriate therapeutic strategy. In children with cystic fibrosis, imaging can demonstrate sinus opacification, mucosal thickening, polyposis, and obstruction of the natural drainage pathways. These findings may be particularly useful when surgical treatment is being considered. Three-dimensional reconstruction provides information about the relationship between the paranasal sinuses, nasal cavity, orbit, and other adjacent anatomical structures. Such information can improve understanding of individual anatomical variations and potentially reduce the risk of surgical complications. However, radiological findings should not be considered an independent indication for surgery. The decision regarding treatment should be based on the patient's symptoms, endoscopic findings, disease severity, and response to conservative therapy. Radiological assessment can nevertheless provide important additional information for selecting and planning an intervention. It may also be useful for evaluating disease progression during long-term follow-up. In patients requiring repeated assessment, comparison of sequential imaging studies can help determine changes in sinonasal involvement.

Radiation safety is an important consideration when imaging children with cystic fibrosis because some patients may require repeated radiological examinations during long-term clinical follow-up. The objective of modern pediatric imaging is therefore to obtain sufficient diagnostic information while keeping radiation exposure as low as reasonably achievable. Three-dimensional computed tomography provides detailed anatomical information, but its use should be justified according to the clinical question. Low-dose imaging protocols can help reduce unnecessary radiation exposure while maintaining adequate image quality. Cone-beam computed tomography has also attracted attention as an alternative technique for selected sinonasal examinations. Its high spatial resolution may be useful for assessing bony structures and the anatomy of the paranasal sinuses. Recent research has investigated its potential to provide diagnostically useful images with lower radiation exposure than conventional computed tomography in selected pediatric patients with cystic fibrosis. However, the choice of imaging method should depend on the clinical indication, required anatomical information, equipment availability, and patient-specific factors. Three-dimensional visualization should therefore be used selectively rather than routinely. When appropriately indicated, it can provide detailed information about sinonasal anatomy, pathological changes, and treatment planning while modern dose-reduction strategies can help improve radiation safety.



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Results

The study included 60 children with cystic fibrosis, aged 6–17 years, who underwent three-dimensional radiological examination of the nasal cavity and paranasal sinuses. The obtained results demonstrated the presence of various structural and inflammatory changes in the sinonasal system. Overall, sinonasal pathological changes were identified in 52 patients (86.7%), indicating a high frequency of paranasal sinus involvement among the examined children with cystic fibrosis. One of the most frequently detected radiological abnormalities was mucosal thickening, which was observed in 43 patients (71.7%). This finding may reflect chronic inflammatory changes and impaired drainage within the paranasal sinuses. Three-dimensional visualization allowed the thickness and distribution of the mucosal changes to be assessed in greater detail. This provided additional information regarding whether the pathological process was localized or involved several sinus compartments.

Partial or complete sinus opacification was detected in 38 patients (63.3%). This radiological finding may be associated with accumulation of secretions, inflammatory changes of the mucosa, and impaired ventilation and drainage of the paranasal sinuses. Three-dimensional images made it possible to assess the extent of opacification and determine which anatomical regions were predominantly affected. The maxillary and ethmoid sinuses were the most frequently involved anatomical regions in the examined patients. Hypoplasia of one or more paranasal sinuses was identified in 27 patients (45.0%). Three-dimensional reconstruction provided an opportunity to evaluate the size, shape, and anatomical development of the sinuses, as well as their relationships with adjacent structures. This information was useful for assessing individual anatomical characteristics and identifying developmental abnormalities of the sinonasal system.

Polypoid changes were observed in 16 patients (26.7%). Three-dimensional visualization allowed the location and extent of these changes to be evaluated from different spatial perspectives. Identification of polypoid changes is clinically relevant because such lesions may interfere with normal sinus drainage and contribute to persistent sinonasal inflammation. Changes in the ostiomeatal complex and impaired sinus drainage were detected in 31 patients (51.7%). The ostiomeatal complex plays an important role in normal ventilation and drainage of the paranasal sinuses. Narrowing or obstruction of this anatomical region may contribute to retention of thick secretions and persistence of inflammatory changes. Three-dimensional reconstruction provided clearer visualization of this region and helped to assess the anatomical factors potentially associated with impaired sinus drainage.

When the radiological findings were considered collectively, sinonasal pathological changes were present in 52 of the 60 examined patients (86.7%). The most frequent abnormality was mucosal thickening, observed in 43 patients (71.7%), followed by partial or complete sinus opacification in 38 patients (63.3%), changes in the ostiomeatal complex in 31 patients (51.7%), sinus hypoplasia in 27 patients (45.0%), and polypoid changes in 16 patients (26.7%). Assessment of three-dimensional reconstructions showed that the method was considered diagnostically informative for determining the localization and severity of sinonasal involvement in 47 patients (78.3%). This finding indicates that three-dimensional visualization can provide not only information about the presence of pathological changes but also about their anatomical distribution and severity.

Three-dimensional imaging also enabled detailed assessment of the spatial relationships between the nasal cavity and paranasal sinuses. This was particularly useful for evaluating complex anatomical structures, sinus drainage pathways, and the relationship of pathological changes to adjacent anatomical regions. Such information may be valuable when determining further diagnostic and therapeutic strategies. The results demonstrate that three-dimensional radiological visualization is a useful supplementary diagnostic method for assessing sinonasal pathological changes in children with cystic fibrosis. The technique allows detailed evaluation of mucosal thickening, sinus opacification, hypoplasia, polypoid changes, and abnormalities of the ostiomeatal complex. The obtained findings suggest that combining three-dimensional radiological visualization with clinical



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examination and other instrumental methods may improve comprehensive assessment of sinonasal involvement and support individualized treatment planning.

Discussion

Sinonasal involvement in children with cystic fibrosis is associated with increased mucus viscosity, impaired mucociliary clearance, and chronic inflammatory processes in the upper respiratory tract. These changes may lead to mucosal thickening, retention of secretions, sinus opacification, hypoplasia, and polypoid changes within the paranasal sinuses. Three-dimensional radiological visualization provides detailed information about the anatomical structure of the paranasal sinuses and the localization of pathological changes. This method is particularly useful for assessing the maxillary and ethmoid sinuses, the ostiomeatal complex, and the natural drainage pathways of the sinuses.

Three-dimensional reconstruction allows the size, shape, anatomical development, and spatial relationships of the paranasal sinuses with adjacent structures to be evaluated from different planes. These characteristics are important for determining the distribution of sinonasal pathological processes and describing individual anatomical features. In children with cystic fibrosis, radiological findings should be assessed together with clinical manifestations and endoscopic findings. Three-dimensional visualization provides additional diagnostic information, particularly in patients with complex anatomical abnormalities and pathological changes involving the sinus drainage pathways. Radiation exposure should also be considered when performing radiological examinations in children. Therefore, appropriate use of modern low-dose three-dimensional imaging technologies is important for obtaining adequate diagnostic information while maintaining radiation safety.

Conclusion

The study demonstrated a high frequency of sinonasal abnormalities among children with cystic fibrosis. Pathological changes were detected in 86.7% of the examined patients, with mucosal thickening (71.7%) and partial or complete sinus opacification (63.3%) being the most common findings. Sinus hypoplasia, ostiomeatal complex abnormalities, and polypoid changes were also frequently identified. Three-dimensional radiological visualization provided detailed assessment of the anatomical structure and pathological changes of the paranasal sinuses. In 78.3% of patients, the method was considered diagnostically informative for determining the localization and severity of sinonasal involvement. Therefore, three-dimensional radiological visualization can be considered a valuable supplementary diagnostic method for the assessment of paranasal sinus pathology in children with cystic fibrosis. Its combination with clinical and endoscopic evaluation may improve diagnostic assessment, facilitate determination of disease extent, and support individualized treatment planning.

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