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Assessment of Diagnostics of Rhinogenic Complications of the Orbit and Eyelids in Children Based on Clinical and Laboratory Data

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Abstract Currently, rhinosinusitis is the most common nosology in otorhinolaryngological pathology in children. Timely diagnosis of complicated rhinosinusitis is highly relevant. Among the main causes of the frequent development of inflammatory diseases of the nasal cavity and their complications are the effects of various infectious agents, allergens, a decrease in the general specific and nonspecific resistance of the body, as well as a violation of the barrier function of the nasal mucosa.

Keywords Rhinogenic complications, Diagnosis of complicated rhinosinusitis, Infectious agents, Allergens, A decrease in the general specific

1. Introduction

Anatomical features of the paranasal sinuses and their direct connection with the orbit contribute to the rapid development of severe septic complications. Among all the severe complications of acute sinusitis, orbital ones occupy the first place. Thus, inflammatory diseases of the orbit have a rhinosinusogenic origin in 40-80% of cases in adults and in 43% of cases in children. In children, especially younger ones, diagnosis is often difficult, based on objective data and the results of additional research methods. Despite the improvement of the diagnostic level, not all medical institutions can perform an in-depth study of the immunological status of patients or apply imaging techniques to identify complicated otorhinolaryngological pathology in children. The heavy workload of specialists in the field does not always allow us to determine the likelihood of complications in time. At the same time, the use of simple and affordable diagnostic methods integrated with IT technologies allows the doctor to diagnose and diagnose the disease in the shortest possible time. One of the convenient, simple and accessible markers for determining the activity of the inflammatory process and impaired immunological reactivity of the body is the integral blood index of the leukocyte shift index (ISL) [2,4,6,8,10,12,13].

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The aim of the study is to investigate the features of clinical and laboratory parameters of RCO and eyelids in children using the LSI indicator. To study the features of clinical and laboratory parameters of rhinogenic complications of the orbit (RCO) and eyelids depending on the blood leukocyte shift index (LSI) to create a predictive model in pediatric patients.

2. Material and Methods

The study included 50 patients who were treated at the Regional Clinical Hospital of Bukhara with inflammatory pathology of the paranasal sinuses. Group I with RCO –reactive edema of the eyelids and orbital tissue included 29 (58.0%) patients (of which 16 (32.0%) were boys, 13 (26.0%) were girls). In group 2 with ROC, purulent-septic complications of the eyelids and orbit included 21 (42.0%) patients (of which 10 (20.0%) were boys, 11 (22.0%) were girls). were examined, who were treated in the pediatric otorhinolaryngology department of the Bukhara region "Regional Children's Multidisciplinary Clinical Hospital" during the period from 2023 to 2024, including 26 (52.0%) boys and 24 (48.0%) girls. The average age of the patients was 6.66±0.63 years. Group 1 included 29 (58.0%) patients with reactive edema of the eyelids and orbital tissue (including 16 (32.0%) boys and 13 (26.0%) girls). Group 2 included 21 (42.0%) patients with purulent-septic complications of the eyelids and orbit (including 10 (20.0%) boys and 11 (22.0%) girls). The formula for calculating the indicator based on complete blood count data: LSI = (eosinophils + basophils + myelocytes + metamyelocytes +

band neutrophils + segmented neutrophils) / (monocytes + lymphocytes) Normally, the LSI is 1.96±0.56 [7,8,10]. The data were processed using descriptive statistical methods with the application of the software Statistic 10 ("StatSoft Inc.", USA). The analysis of the statistical significance of differences was carried out using Student's t-test; differences were considered statistically significant at $p<0.05$.

3. Results

LSI values in the general age group (n=50) from 1 to 17 years old were: 1.61 in patients of group 1; 3.45 in patients of group 2 ($p\leq0.05$). With an index of LSI from 1.36 to 1.96, the development of reactive edema of the eyelids and orbital tissue is predicted, from 3.14 to 4.72 the development of purulent-septic complications of the eyelids and orbit in patients of preschool and primary school age. All children were admitted on an emergency basis with complaints of nasal obstruction, redness and swelling of the eyelid skin, narrowing of the palpebral fissure, headache, pain in the sinus projection, hyperthermia, anxiety, and sleep disturbance. In 100% of cases, examination by an otorhinolaryngologist, pediatrician, and ophthalmologist was performed; when indicated, consultation with a neurologist, anesthesiologist, and neurosurgeon was conducted. Upon admission, clinical and laboratory diagnostics, radiography (RG), computed tomography (CT), and, when indicated, magnetic resonance imaging (MRI) of the paranasal sinuses (PNS), orbit, and brain were performed. In cases of suspected orbital and intracranial complications, CT or MRI with contrast enhancement was performed. In edema of the orbital tissue, moderate exophthalmos with displacement of the eyeball, diplopia, and chemosis are observed. According to CT data of the PNS, in children of Group 1, opacification of the cells of the ethmoidal labyrinth and maxillary sinus was detected. When inflammation spreads from the bone walls to the periosteum, periostitis of the orbital walls occurs, and in such cases CT scans may reveal purulent inflammation of the ethmoid bone cells, periostitis of the medial orbital wall, and infiltration of adjacent soft tissues. Subperiosteal abscess and eyelid abscess are consequences of purulent periostitis and develop very rapidly, often on the 2nd–3rd day of the course of sinusitis.

Orbital phlegmon is the most severe and dangerous purulent-septic complication that occurs when pus spreads from the paranasal sinuses through the veins or by contact into the orbit and with the development of cavernous sinus thrombosis. According to CT data of the PNS, in children of Group 2, purulent exudate was detected in the maxillary and frontal sinuses, as well as in the cells of the ethmoidal labyrinth. Exophthalmos, displacement of the eye, and a defect of the bony medial wall of the orbit at the junction with the cells of the ethmoidal labyrinth were noted. The presence of pus and infiltration of orbital tissues was detected. In children of Group 1, in the presence of purulent exudate, surgical treatment was performed in the form of drainage and irrigation of the PNS. In children of Group 2, surgical treatment was performed in the form of endoscopic maxillary sinusotomy, polysinusotomy, and orbitotomy with evacuation of pus. Verification of the diagnosis of non-purulent orbital complications was carried out at LSI values from 1.36 to 1.96, and there were no indications for surgical treatment. At LSI values from 1.96 to 3.14, drainage of the maxillary and frontal sinuses was performed, and purulent discharge was obtained. The diagnosis of purulent complications of the eyelids or orbit was confirmed by LSI values in the range from 3.14 to 4.72. The LSI value correlated with the detection of purulent exudate during surgery on the PNS and orbit, as well as with CT data.

With the development of reactive edema of the eyelids and orbital tissue, antimicrobial therapy was carried out using recommended protected aminopenicillins (ampicillin + sulbactam at a daily dose of 150–200 mg per 1 kg of body weight, 3 or 4 intravenous administrations; amoxicillin + clavulanic acid at a dose of 120 mg per 1 kg of body weight per day, 3 intravenous administrations) or third-generation cephalosporins (cefotaxime at a daily dose of 100–150 mg per 1 kg of body weight, 2–3 administrations; ceftriaxone at a dose of 50–80 mg per 1 kg of body weight per day, 1 administration). The listed drugs are characterized by high activity against the main typical pathogens of purulent-inflammatory diseases of the paranasal sinuses and their complications (Streptococcus pneumoniae, Haemophilus influenzae, Moraxella catarrhalis, Staphylococcus aureus) [1,3,5,7,9,11,13].

When verifying the diagnosis of a subperiosteal abscess or orbital phlegmon, immediate correction of antibacterial therapy was carried out — switching to reserve drugs that penetrate well through the blood-brain barrier, including for the prevention of intracranial complications. When selecting an antimicrobial agent, the results of microbiological examination of the material obtained during surgery were also taken into account (54.1% positive results, including 30.5% - Staphylococcus spp., 8.3% - gram-positive anaerobes, 5.6% - Enterococcus spp., 4.2% - Streptococcus pneumoniae, and 2.8% each - Escherichia coli and non-fermenting gram-negative microorganisms - Pseudomonas aeruginosa and Acinetobacter spp.). Patients with purulent-septic complications of the orbit were prescribed carbapenems (meropenem or imipenem + cilastatin at a dose of 60 mg per 1 kg of body weight per day), a fourth-generation cephalosporin (at a dose of 150 mg per 1 kg of body weight per day) in combination with the anti-anaerobic drug metronidazole (at a daily dose of 22.5 mg per 1 kg of body weight, 3 administrations); vancomycin — in the detection of vancomycin-sensitive staphylococci or enterococci (at a daily dose of 40 mg per 1 kg of body weight, divided into 4 administrations). To increase the effectiveness of antimicrobial therapy, all drugs were administered intravenously [13]. The average duration of antibacterial therapy was 12.4±0.74 days, with maximum values (21 days) in cases of abscess or orbital phlegmon, which does not contradict modern clinical recommendations [10].

In cases of facial vein phlebitis, to prevent thrombotic complications, the risk of fatal outcomes, and severe disability, unfractionated heparin (UFH) was prescribed, which is currently the drug of choice in children for short-term anticoagulant therapy, as well as in situations with a high risk of bleeding when controlled hypocoagulation is required using drugs with a short half-life and the availability of an antagonist (protamine sulfate) [18]. UFH was administered at a daily dose of 100 IU per 1 kg of body weight intravenously under the control of a coagulogram (activated partial thromboplastin time — APTT). The average duration of prophylactic use of UFH was 6.1±0.3 days. According to the results of the study, the mean LSI values (n=50) were 1.61±0.1 in patients of Group 1 and 3.45±0.49 in patients of Group 2. The value of Student's t-test was 3.71. The differences were statistically significant (p=0.001). However, a comparative analysis of LSI in patients of the studied groups by age did not show statistically significant differences (table) due to the small number of observations for individual age categories, revealing significant fluctuations of this indicator: from 0.76 to 2.27 in patients of Group 1 and from 1.21 to 6.82 in patients of Group 2.

In addition, in patients in the 1–2-year age category, this indicator proved to be uninformative for predicting the development of PNS complications: in cases of rhinogenic reactive edema of the eyelids and orbital tissue, LSI levels reached up to 1.77, while in septic complications of the eyelids and orbit, it ranged from 1.35. Particular attention should be paid to LSI values (5.94±0.48) in children aged 3 to 12 years — 60% of patients (30 out of 50, respectively). The obtained data indicate that children in this age group more frequently suffer from inflammatory diseases of the PNS and have RCO and eyelid involvement. Detailed analysis of LSI in patients revealed a statistically significant difference ($p \leq 0.05$) between the groups: in Group 1, it was 1.66±0.30, and in Group 2, 3.93±0.79 (Student's t-test value = 2.69, critical p-value = 2.048). The differences were statistically significant (p=0.01).

According to these results, changes in the activity of the inflammatory process and disturbances in immunological reactivity in patients can be assessed using LSI for predicting purulent-septic RCO and eyelid complications, as well as inflammatory PNS diseases in children aged 3 to 12 years. For this purpose, in patients with RCO aged 3 to 12 years, LSI is calculated based on the leukogram of a complete blood count. LSI values from 1.36 to 1.96 indicate the development of reactive eyelid and orbital tissue edema, while values from 3.14 to 4.72 indicate the development of purulent-septic complications — eyelid abscesses and orbital phlegmon.

The practical significance of LSI data lies in the fact that its level allows the physician to determine the need for early surgical intervention, its scope, and to select effective antimicrobial therapy.

Currently, rhinosinusitis is the most common nosological entity in otorhinolaryngological pathology in children. Timely diagnosis of complicated rhinosinusitis is highly relevant [1]. Among the main causes of the frequent development of inflammatory diseases of the nasal cavity and their complications, one can note the impact of various infectious agents, allergens, a decrease in the general specific and nonspecific resistance of the body, as well as impairment of the barrier function of the nasal mucosa [2,3]. The anatomical features of the paranasal sinuses and their direct connection with the orbit contribute to the rapid development of severe septic complications [4]. Among all severe complications of acute sinusitis, orbital ones rank first [1,4,5]. Thus, inflammatory diseases of the orbit have a rhinosinusogenic origin in 40–80% of cases in adults and in 43% of cases in children. The frequency of rhinosinusogenic orbital complications, according to the pediatric otorhinolaryngology department of the Bukhara region "Regional Children's Multidisciplinary Clinical Hospital," is 12%, which indicates the need for a multidisciplinary approach in the treatment strategy for pediatric patients [5]. In children, especially at a younger age, diagnosis is often difficult and is based on objective data and the results of additional research methods. Despite improvements in the level of diagnostics, not all medical institutions can perform an in-depth study of the immunological status of patients or apply imaging methods to detect complicated otorhinolaryngological pathology in children. The heavy workload of specialists in the field does not always allow timely determination of the likelihood of complications. At the same time, the use of simple and accessible diagnostic methods integrated with IT technologies allows the physician to carry out diagnosis and differential diagnosis of the disease in the shortest possible time. One of the convenient, simple, and accessible markers for determining the activity of the inflammatory process and disturbances in the immunological reactivity of the body is an integral blood indicator—the leukocyte shift index (LSI) [6–8].

Based on the accumulated experience in assessing and comparing the effectiveness of diagnostic and treatment methods in clinical practice, we decided to identify predictors of complication development that allow, with less time expenditure, the diagnosis and differentiation of the development of rhinogenic complications of the orbit (RCO) and eyelids in children. Such predictors can be applied for the development of clinical decision support systems [6,9].

4. Discussion

Our study demonstrates the diagnostic significance of LSI in determining the clinical course of RCO in inflammatory PNS pathology in patients aged 3–12 years. At the same time, the data allow us to highlight differences in the mean LSI values between patient groups with different forms of RCO. Analysis of LSI determined that reactive eyelid and orbital tissue edema is diagnosed when LSI is between 1.36 and 1.96, and purulent-septic lesions of the eyelids and orbital tissue are indicated when LSI is between 3.14 and 4.72. Several features should be noted: the integral LSI indicator is

used to diagnose the clinical course of RCO and eyelid involvement in inflammatory PNS pathology; no statistically significant differences in LSI were found between the study groups in the 1–2-year age category, which may be due to the small number of observations (n=9). Furthermore, it is very important that LSI allows the assessment of disease severity, timely prevention of septic infectious complications, and the determination of the timing, scope, and extent of both surgical and conservative treatment in patients with RCO.

5. Conclusions

The marker of clinical and laboratory parameters of the severity of the disease is the LSI indicator, taking into account the age of the child, which can be used in the early diagnosis of purulent-septic rhinogenic complications of the orbit and eye- lids in children. Thus, a marker of the clinical and laboratory parameters of disease severity is the leukocyte shift index (LSI), taking into account the child's age, which can be used as an additional method for in-depth diagnosis of purulent-septic rhinogenic complications of the orbit and eyelids in children. According to the results of our study, the LSI demonstrated high statistical significance in diagnosing non-purulent and purulent rhinogenic complications of the orbit and eyelids in patients aged 3–12 years. Reactive edema of the eyelids and orbital tissue is diagnosed at LSI values from 1.36 to 1.96, while purulent-septic complications of the eyelids or orbit correspond to LSI values from 3.14 to 4.72. The obtained data can be used to optimize algorithms for providing specialized medical care to children in this age group, as well as to determine the severity of the disease and indications for surgical treatment of rhinogenic orbital complications in patients with inflammatory paranasal sinus pathology. The use of an integral diagnostic index as a marker for the development of purulent-septic complications allows, in the future, the creation of a mathematically grounded clinical decision support system reflecting the state of the purulent-septic process.

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