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Management of chronic rhinosinusitis in children

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ABSTRACT

Chronic rhinosinusitis (CRS) in children and adults appear to have different etiology and therefore different diagnostic and treatment strategies. Adult chronic rhinosinusitis has a relatively greater inflammatory component whereas childhood chronic rhinosinusitis has a relatively greater infectious component. This is secondary to immaturity of the pediatric immune system, increased incidence of viral upper respiratory tract infections, smaller ostia of the sinuses and adenoidal hypertrophy. Concentrations of eosinophils in adult mucosa are greater than those in children. There is a greater degree of collagen deposition and expansion of submucosal mucous glands in the adult sinus indicating more tissue remodeling and potentially greater irreversible scarring. Immune deficiencies, cystic fibrosis, and ciliary dyskinesia are more likely to occur in children. Being a multifactorial disease careful history and physical examination, together with appropriate investigations are essential for the correct diagnosis and treatment.

Key words: Chronic sinusitis in children, chronic rhinosinusitis in children, chronic cough in children, gastroesophageal reflux in children, cystic fibrosis, ciliary dyskinesia.

RESUMEN

Rinosinusitis crónica (CRS) suele manifiestarse de forma diferente en niños que en adultos. Presenta diferente etiología y nos obliga a estrategias diferentes diagnósticas y terapéuticas. Adultos con CRS presentan un mayor componente inflamatorio, mientras que en los niños predomina el componente infeccioso, quizá debido a inmadurez de su sistema inmune, una mayor incidencia de infecciones virales de la vía aérea superior. menor tamaño del ostium sinusal y mayor incidencia de hipertrofia adenoidea. La concentración de eosinófilos en la mucosa de los adultos es mayor que en la de los niños. Existe mayor grado de depósito de colágeno y expansión de glándulas mucosas en la submucosa en adultos, indicando mayor remodelación y potencialmente mayor daño irreversible. Inmunodeficiencias, fibrosis quística y diskinesia ciliar son más frecuentes en la infancia. Siendo la CRS un síndrome multifactorial, nos obliga obtener una historia clínica detallada, así como un examen fisico completo que incluya endoscopia de la via aérea superior y que evalúe integramente cada caso de forma individual.

Palabras clave: *Sinusitis crónica en niños, rinosinusitis crónica en niños, tos crónica en niños, reflujo gastroesofágico en niños, fibrosis quística, diskinesia ciliar.*

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Sinusitis means inflammation of at least 1 of the paranasal sinuses, often preceded by rhinitis. This has led to the use of the term rhinosinusitis (RS), which more accurately describes the extent of the inflammation.[1-4] Chronic rhinosinusitis (CRS) is a multifactorial disease *(Table I)*, making it difficult to accurately diagnose and treat. In the European Consensus on Rhinosinusitis (EP3OS),[1] CRS includes children who show 2 symptoms or more beyond 12 weeks. These symptoms could be nasal blockage or nasal discharge (anterior/posterior)± facial pain/pressure, ± reduction or loss of smell. Other authors define CRS in children as those symptoms persisting beyond 8 weeks.[4]

It is a common cause of chronic cough, affects quality of life, and represents a significant cause of morbidity.[1-6] Epidemiological studies in children are limited; the natural history reveals a decrease in the prevalence of rhinosinusitis after 6-8 years of age, probably due to the maturity of the immune system.[1,2,7-9]

In temperate climate there is an increase in CRS during fall and winter.[1,2,8] Young children and infants who attend day care or nursery, show a dramatic increase in the prevalence of CRS or recurrent rhinosinusitis compared with children who stay at home.[1,2]

During normal childhood development, the maxillary sinus is the first to form. At birth, the rudimentary aerated sinus is 6-8 cm^3 in volume, with its maximal dimension in the anteroposterior direction. When a child reaches the age of 7-8 years the floor of the maxillary sinus already occupies the same level as the nasal floor.[7]

Table I. CRS in children. Factors predisposing to recurrent or chronic rhinosinusitis.

• Allergy
• Frequent viral upper respiratory infections
• Day-care «itis», school attendance
• Enlarged adenoids
• Enlarged adenoids w/wo harboring bacteria («biofilms»)
• Biofilm formation in sinus tissue
• Tabacco smoke
• Irritants/pollutants
• GERD
• Immaturity of the pediatric immune system
• Primary
• Secondary (frequent)
• Small sinus ostia
• Anatomical abnormalities
• Variants affecting/blocking ostiomeatal complex (ex. concha bullosa)
• Defects in mucociliary clearance
• Primary (rare)
• Secondary (frequent)
• Cystic fibrosis
• Inmotilia cilia syndrome

Ethmoidal air cells are present at birth, two to three ethmoid cells are found bilaterally and continue to grow until late puberty or until the sinus walls reach compact bone.[1,7]

Pneumatization progresses in a posterior direction, enlarging the posterior air cells until the lateral and medial walls of the ethmoidal sinuses are parallel in the anterior to posterior direction.[7]

High-resolution computed tomography (CT) may show pneumatization of the sphenoidal sinuses as early as age 2. Pneumatization progresses in an inferior posterolateral direction. The sinus attains its mature size by the age of 14.[7]

The frontal sinuses are present at 8 years and developed by 12 years of age. The frontal sinuses gradually develop from the anterior ethmoid cells into the cranium. The earliest pneumatization of the frontal sinus occurs at or shortly after 2 years of age.[7]

The exact etiology of chronic rhinosinusitis is not completely understood but derives from interactions among local host factors, environmental factors and systemic host factors.[8] Local host factors, such as anatomic abnormalities, are uncommon in children.[1,7,8] However, if endoscopic evaluation and radiology suggest structural abnormalities such as severe septal deviation, concha bullosa o Haller cells, this information could be relevant in a specific case. Obstruction of the nasal drainage by enlarged adenoids was thought as an important causative factor in CRS, but recent studies have shown no relation between large adenoids and increased incidence of CRS.[8-10] Nevertheless, the adenoid itself may play a role in CRS as a reservoir of pathogenic bacteria. When mucociliary clearance is compromised during URI (upper respiratory infection) or in allergic rhinitis, the bacteria may have access to the sinuses and provoke sinusitis. Studies have demonstrated that sinonasal symptoms correlate with the quantity of bacterial colonization in the adenoids.[8,11] Bacterial cultures taken from the lateral nasal wall and the adenoids in individual patients with CRS demonstrate identical strains of bacteria, supporting the idea that the adenoids may act as a source of bacteria that become pathogenic in CRS.[12] The presence of «biofilms» in the adenoids has been demonstrated;[8,13,14] and are resistant to antibiotics. The adenoids of children CRS showed greater surface covered by biofilms than the adenoids removed for obstructive sleep apnea.[13] In a mixed population of adults and children surgically treated due to CRS, 80% of the patients showed evidence of biofilms in the sinus tissue *versus* none of the controls.[15]

Environmental factors such as infectious microorganisms, noxious inhalants and pollutants may contribute in the development of CRS. They irritate the upper aerodigestive tract, including the nose and sinus cavities. The most common and significant is tobacco smoke, which is a predictor of poor long term prognosis in CRS, impairing mucociliary clearance[16] and respiratory epithelial ciliogenesis.[17]

Although viruses are not isolated frequently in sinus aspirates[18] most of the authors[1,19,20] agree that viral infections cause rhinosinusitis. Computed tomography abnormalities of the paranasal sinuses are observed for several weeks after upper airway infections. It is assumed that only 5 to 10% of acute upper airway infections in early childhood are complicated by acute rhinosinusitis.[1,14]

The most prevalent organisms found in children with acute rhinosinusitis are *Streptococcus pneumoniae* (35-42%), *Haemophilus influenzae* (21-28%), *Moraxella catarrhalis* (21-28%), *Streptococcus pyogenes* (3-7%) and anaerobes (3-7%).[1,2,14]

Sinus contents during endoscopic sinus surgery of patients who have failed medical treatment have recovered alpha-hemolytic streptococci and *Staphylococcus aureus* followed by *S. pneumoniae*, *H. influenzae* and *M. Catarrhalis*, anaerobic organisms grown only in 6% of the samples.[21]

Because most pediatric sinus infections begin with an upper respiratory tract viral infection and progress to a bacterial sinus infection, administration of oral antibiotics is thought to be the cornerstone of treatment of the disease. Abundant evidence, however, has shown that this treatment in many cases, does not cure the disease.[8] The complex pathogenesis of pediatric rhinosinusitis may be a primary reason for treatment failure. Another may be the significant increase in antibiotic resistance for the past decades, a problem that is more relevant in the pediatric population because of the use of broad-spectrum antibiotics, recurrent infections, and increased day-care attendance.[22]

Chung and collaborators[22] studied the bacteriology and antimicrobial susceptibility of pediatric chronic rhinosinusitis for 6 years; they performed a total of 295 cultures obtained from 165 children yielded 399 isolates. The most common isolates were α-hemolytic streptococcus (20.8%), *Haemophilus influenzae* (19.5%), *Streptococcus pneumoniae* (14.0%), coagulase-negative staphylococcus (13.0%), and *Staphylococcus aureus* (9.3%). Anaerobes accounted for 8.0% of all isolates. Susceptibility rates of *H. influenzae* for ampicillin and cotrimoxazole were 44.7% and 42.1%, respectively, in the first 3 years of the study and 25% and 40%, respectively, in the next 3 years. Susceptibility rates of *S. pneumoniae* were 83.3% for penicillin, 0% for erythromycin, and 33.3% for clindamycin in the first 3 years and 73.7%, 5.3% and 28.9%, respectively, in the latter 3 years. This study showed a different pattern of antibiotic resistance in pediatric chronic rhinosinusitis as compared with previous studies in both children and adults, suggesting that the resistance rate of *H. influenzae* for ampicillin appears to be a growing problem in pediatric rhinosinusitis in some parts of the world.

Baroody[23] demonstrated in children CRS who underwent surgery, a greater number of eosinophils compared to the control group regardless of the allergic status. Chan and collaborators compared the maxillary sinus biopsies of children with CRS (median age 3.9 years) with tissue from adults with CRS without nasal polyposis,[24] and showed that children had a lower number of eosinophils, more lymphocytic inflammation, more neutrophils and less morphological deterioration than adults.[24]

Systemic host factors, such as allergic rhinitis, asthma, gastroesophageal reflux disease (GERD) and mucociliary dysfunction, also may predispose a patient to CRS.[1,4,8,14]

Early reports suggested that up to 70% of children with CRS also have allergic rhinitis, a higher incidence than in the general population.[1,8,14] In a prospective study of 70 children with allergic rhinitis, Rachelefsky showed that 53% of them had an abnormal sinus radiograph.[25] The Children's Respiratory Study, from Tucson, USA, reported that having allergic rhinitis and being sensitized to grass pollen at the age of 8, are independent risk factors for sinusitis, and having rhinitis and sinusitis were a concomitant risk factor for presenting asthma (OR 6.5).[26] It is proved that blowing your nose propels intranasal fluid into the maxillary sinus.[27]

Baroody and collaborators[28] showed that allergen challenge of the nose in allergic rhinitis patients, leads to a significant increase in maxillary sinus eosinophils, albumin, eosinophil cationic protein, and histamine levels. This study confirms that nasal inflammation precede sinus inflammation.

Regarding the interaction of CRS with asthma, several studies in children have shown significant improvement in their asthma (improvement in lung function, decreased use of b2 agonists) when sinusitis is treated medically.[1,4,28,29]

Despite the challenging dilemma relating the causal relationship between allergy, asthma and CRS, it has become commonly accepted the «united airway concept» and the «nose-lung» interaction where allergic rhinitis, asthma and CRS are all manifestations of inflammation of a continuous airway.

The possible mechanisms by which sinusitis can worsen asthma[30] includes sinobronchial reflex involving activation of trigeminal afferent pathways via stimulation of sinonasal neuroreceptors, which causes bronchospasm through the vagal nerve. CRS patients experiment extrathoracic hyperresponsiveness, bronchial hyperresponsivenes and pharyngitis that improve with the treatment of their sinusitis.[31] Pharyngeal receptors may contribute to this phenomenon. It has been demonstrated in CRS an increased number of eosinophils inversely proportional with epithelial thickening ($p < 0.05$) and directly proportional with a larger area of nerve fibers in the pharyngeal submucosa.[32] The damage of pharyngeal epithelium contributes to the airway hyperresponsiveness seen.[32]

Gastroesophageal reflux disease has been implicated as a cause of local inflammation and as predisposing factor in CRS.[1,8,14] Incidence of GERD may be higher in infants than in the adult population. The nasopharynx and nasal cavity are exposed to gastric contents either acid or non acid, which may cause the mucosa to undergo chronic inflammatory changes, resulting in CRS.[1,8,33]

El-Serag looking at the extraesophageal associations of GERD in children without neurologic defects, found GERD as a significant risk factor for sinusitis (OR 2.3, 95% CI; p <0.0001).[34] Phipps[35] demonstrated a high prevalence of GERD (63%) in pediatric patients with medically refractory CRS based on upper esophageal and nasopharyngeal pH probes. Barbero and collaborators recommend that children with chronic sinusitis refractory to usual medical treatment should be evaluated for the possibility GERD and treated properly before considering the surgical option.[36]

GERD in children may be associated to chronic rhinorrhea, nasal obstruction, chronic cough, hoarseness, dysphonia and wheezing. Endoscopic evaluation of the pharynx and larynx help to determine the relationship of GERD with symptoms of the upper airway. The diagnosis of GERD can be confirmed by 24 h pH monitoring, although if the refluxate is not acid, the pH monitoring will not be able to detect it. Bingol Boz and collaborators have documented the usefulness of scintigraphy, a fast (less than 1 hour) noninvasive, and less costly study for the diagnosis of pediatric acid or non acid GERD.[37,38]

A recent review discusses the existence of an esophageal-nasal reflex, particularly in regard to mucous hypersecretion and symptoms of postnasal drip in GERD patients. Thus, the use of PPI (proton pump inhibitors) therapy would decrease the frequency of postnasal drip.[39]

CHILDREN WITH SPECIFIC DISEASES AND CRS

a) Cystic fibrosis (CF)

In children with cystic fibrosis the prevalence of nasal disease exceeds 50%.[1,40] In a prospective study of 84 children with CF, Brihaye and collaborators[41] found polyps in 45% of them (mean age 15 years) and medial bulging of the lateral nasal wall in 12% (mean age 5 years). The computed tomography scan showed a 100% opacification of the anterior complex (anterior ethmoid, maxillary and if developed, frontal sinuses) and 57% opacification of the posterior complex (posterior ethmoid and sphenoid). Recent data suggest that CF heterozygotes are present in the pediatric population with CRS.[1,42]

b) Primary ciliary dyskinesia (PCD)

Genetic disease characterized by abnormalities in ciliary structure or function. Chronic rhinitis-sinusitis (100%), recurrent otitis media (95%), neonatal respiratory symptoms (73%) and *situs inversus* (55%) are strong phenotypic markers of the disease. Nasal nitric oxide production is very low in PCD (usually less than 100 ppb). Values exceeding 250 ppb have a sensitivity of 95 % for excluding the diagnosis of PCD.[1,43,44] The saccharine test is an easy procedure to screen older children and adults. Electron microscopy of cilia may confirm the diagnosis, although PCD with normal ultrastructure, sometimes with primary ciliary disorientation, is well described. There may be a temporary and secondary ciliary dyskinesia, which is an acquired form (after infection, inflammation or toxic inhalants).[45,46]

DIAGNOSTIC APPROACH

Diagnosing chronic rhinosinusitis in children is more difficult and the symptoms may be different and age dependent than in adults.[8,14,47] We must determine whether the pediatric patient truly has CRS or merely has frequent upper respiratory infections or persistent allergic rhinitis. Facial pain in an infant may only manifest itself as irritability. Chronic cough, however, does seem to be a very common problem and a sole presenting symptom.[37] Symptoms referred by their parents such as cough, nasal discharge, nasal obstruction, halitosis, may be more reliable in younger children. Older children and adolescents are able to describe more localized symptoms, such as nasal congestion, otalgia, facial pressure/pain or hyposmia.[8]

It is a safe practice not to assume an acute exacerbation of CRS unless symptoms of a viral upper respiratory tract infection (URTI) fail to resolve within 7-10 days of onset or get gradually worse over that time period as opposed to the expected slow improvement seen with a viral illness.[48] A history must stress the symptoms and their duration. Chronic upper airway obstruction should prompt further questioning to rule out adenotonsillar hypertrophy. Past medical history should inquire about the seasonal pattern of symptoms to determine whether allergy may play a role; other sinopulmonary or recurrent infections as well as the possibility of extraesophageal symptoms of GERD.[37] A thorough family history is also important to assess the risk of atopy, cystic fibrosis, and immunodeficiency.

The physical exam includes a full evaluation in the child with concomitant disease such as asthma, ear infections and atopic dermatitis. The nasal exam in young children is usually restricted to anterior rhinoscopy using the otoscope with the largest possible speculum. Attempting to see the middle meatal area is useful and might show purulent drainage, which is highly suggestive of a sinus infection. Rarely, polyps can be seen and if so, then testing to rule out cystic fibrosis is strongly recommended. Topical decongestion will allow a better view further into the nose. The mouth and throat exam should evaluate postnasal drainage as well as the size of the tonsils.

Upper airway endoscopic examination, using appropriately sized flexible endoscopes and reassurance to the parents about the benefits of the procedure, will add critical information regarding the inflammatory status of the nasal cavity; asses the middle meatus, sphenoetmoidal recess, opening of the Eustaquian tube, adenoids, tonsils, nasopharynx, oropharynx, postnasal drip, anatomical and functional evaluation of the larynx.[49-52] Although the lateral neck radiograph often suggests the size of adenoids, the nasopharynx is a three-dimensional space and therefore frequent errors in the actual evaluation of adenoid size are made. Ideally, we should use flexible nasopharyngoscopy to assess the real status of adenoids, its size, appearance and its relationship to the nasopharynx and the eustachian tube opening.[49-51] Using tympanometry with ipsilateral reflex will give information of the middle ear status and the child hearing.[52]

Regarding imaging in CRS, computed tomography (CT) scanning is «the imaging modality of choice confirming the extent of pathology and the anatomy».[1] However, a study performing Waters' view radiography, and high resolution CT, in the same day in 134 patients, and using CT findings as the gold standard, plain radiography had a sensitivity of 68% and a specificity of 87% and in a survey on 91 children with clinically significant chronic sinusitis, a sensitivity and a specificity against CT of 76% and 81%, respectively, were observed; and was suggested as the first step to achieve a diagnosis by imaging in subjects with clinical symptoms suggesting CRS.[53] However, it has to be noted that plain radiography is inadequate to assess the anterior ethmoid, and the infundibular, middle meatus and frontal recess air passages.[54]

Computed tomography scanning is considered the gold standard of CRS diagnosis by imaging, because it provides superior resolution of bone and soft tissue and removes superimposed overlapping structures that are present in conventional radiography.[54] Sinus obstruction, opacification, mucoperiosteal thickening, and osteitis can be easily seen. CT imaging is of particular importance when endoscopic sinus surgery is planned, because it accurately assesses the anatomic variants and the key structures of the ostiomeatal complex.[8,54] Unlike adults, where a normal Lund-McKay score should be 0, in children without CRS is about 3, and the diagnostic cutoff for an abnormal CT is a score of 5 or above.[8,54] While CT scans are more accurate, they also expose the pediatric patient to anesthesia, and more radiation,[55] which may increase the risk of developing future malignancies. This risk should be well considered before ordering a CT scan if diagnosis can be achieved without radiologic confirmation.

Magnetic resonance imaging (MRI) is commonly considered as the best anatomic imaging technology available. When indicated, MRI with contrast gadolinium-based agents may better characterize the local disease extension or its diffusion beyond paranasal and nasal cavities.[54] MR is useful in chronic fungal sinusitis. Another advantage of MR over CT is the capacity to differentiate sinus opacification caused by inflammation or neoplasms by distinguishing soft tissue from dense secretions.[54]

Other diagnostic tests include a workup for allergies, and if indicated, immune deficiency and cystic fibrosis. Allergy skin testing should be considered if the child has a personal or family history of atopy. The use of nasal cytology with the technique described by Alfredo Jalowayski using rhinoprobe mr. with bilateral sampling, display the predominant cellular infiltrate regarding the inflammatory process been developed.[50-52]

Immunologic evaluation should be considered in recurrent disease, poor response to antibiotics or rapid relapse, sinus culture of unusual microbes, and persistence of disease despite sinus surgery. Using these criteria, the following immune deficits were found by Sethi and collaborators:[56] IgA deficiency, low IgG with poor response to pneumococcal vaccine, low IgG and IgG1 with normal vaccine response and IgG1 deficiency with normal total IgG and vaccine response.[56] A reasonable approach would include assessment of quantitative and functional humoral immunity (CBC with differential, quantitative IGs, tetanus and diptheria titers, pre and post pneumococcal titers using the 23 valent Pneumovax®). The role of IgG subclass quantification is useful but still controversial, particularly in the setting of normal antibody responses to protein and polysaccharide antigens. Depending on the clinical setting HIV, Wiskott Aldrich syndrome, Hyper IgM and leukocyte adhesion deficiency should be rule out.

Pulmonary function tests may be considered in the child with chronic cough who is aged 4 or older.[37] Sometimes, the diagnosis of primary ciliary dyskinesia needs to be entertained and a biopsy for ciliary evaluation might be necessary.

MEDICAL TREATMENT

a) Nasal saline irrigations

A systematic review using various forms of irrigation and saline sprays (performed 1-4 times daily) found that nasal saline is an effective adjunctive treatment for CRS, although less effective as monotherapy than topical glucocorticoids. It is recommended in each of the recent rhinosinusitis consensus documents. Irrigation reduces postnasal drainage, removes secretions, rinses away allergens and irritants, and improves mucociliary clearance.[14,57]

b) Intranasal corticosteroids

Topical aqueous steroid nasal sprays are helpful in all types of CRS and are the cornerstone of maintenan-

ce treatment.[1,8,14,58-60] Intranasal glucocorticoids include budesonide, ciclesonide, fluticasone furoate, fluticasone propionate, mometasone furoate, and triamcinolone acetonide. Efficacy in CRS with NP is supported by a high level of evidence (grade A) from randomized trials in adults.[14] There are no data describing the efficacy of topical corticosteroids in pediatric CRS. There are studies showing that local corticosteroids are effective and safe in children with rhinitis[1,8,14,60] and one may assume that the same is true for CRS (level IV). It seems reasonable to use these agents in subjects with allergic rhinitis where a reduction in the nasal swelling by these agents is likely to be helpful in improving sinus drainage.[1,14,61] The newest intranasal corticosteroids are safer in children, due to their improved pharmacokinetics and less bioavailability.[60]

c) Systemic corticosteroids

Short courses of systemic steroids have been found useful to decrease mucosal swelling and inflammation in CRS. Recently, Ozturk[62] compared a 15-day course of methylprednisolone (MP) and 30-day course of amoxicillin/clavulanate (AC) *versus* 30-day course of AC and placebo in the treatment of children and adolescents with clinically and computed tomography documented CRS. Both groups demostrated significant improvement in symptoms and sinus CT scores *versus* baseline values. Methylprednisolone as an adjunct to amoxicillin/clavulanate was significantly more effective than AC alone in reducing CT scores (p.007) and cough (p.013). Also showed less clinical relapses in the MP group (25%) compared with AC group (43%).

d) Use of antibiotics

«Chronic rhinosinusitis in the young child does not have to be treated, as spontaneous resolution is the norm».[1,47] Van Buchem and collaborators followed 169 children with a runny nose for 6 months, treating them with decongestants or saline nose drops. They did not find a single child who developed a clinically serious complication.[47,48] In acute children CRS, a Cochrane meta-analysis[63] using antibiotics for persistent nasal discharge concluded that antibiotics given for 10 days reduced the probability of persistence in the short to medium term. The benefits were modest and for 8 children treated one additional child would be cured (NNT 8, 95% CI 5 to 29). No long-term benefits were documented.

Antibiotic use in children is also currently recommended for acute CRS exacerbations in the presence of purulent drainage on anterior rhinoscopy or nasal endoscopy.[1,8,14] The recent work by Ozturk[62] showed benefit in their CRS patients treated with 45/6.4 mg/kg/d (maximum, 2,000/285 mg/d) of amoxicillin/clavulanate for 30 days.

Because of increasing prevalence of beta-lactam–resistant bacteria in the community, administer antibiotics only for suspected infection as based on a careful history and physical examination. Antibiotics should account for bacterial resistance and should be safe in the pediatric population. For chronic sinusitis, a 4-week course of a broad-spectrum beta-lactam stable antibiotic should be administered. This should allow treatment for more than a week beyond symptom resolution and ensure restoration of mucociliary function and resolution of mucosal edema. Antibiotic prophylaxis as a strategy to prevent infection in patients who experience recurrent episodes of acute bacterial rhinosinusitis has not been systemically evaluated and is controversial. Antibiotics for treatment of chronic sinusitis are best-chosen based on culture results and sensitivities.[1,8,14,64]

The choice of antibiotics usually includes amoxicillin/clavulanate, high-dose amoxicillin/clavulanate, or second generation cephalosporins. In the case of allergies to these agents, then macrolides are utilized. If anaerobes are suspected, then clindamycin is a reasonable option.[14] Amoxicillin is not a first choice for treatment because of chronicity of the disease. Nebulized antibiotics have also been explored in adults as a potential treatment for acute infections in the setting of chronic sinusitis and in patients with cystic fibrosis and are a potential alternative for acute infections in patients with CRS.[65-67] No studies in children have been done.

Nasal topical antimicrobial agents, like Mupirocin have been used in the prophylaxis of recurrent sinusitis in adults. Nsouli reported a decrease in 70% in recurrent sinusitis treated patients *versus* 10% of their controls.[68] Recently, Uren and collaborators reported that nasal lavage with Mupirocin 0.05% in surgical recalcitrant CRS who presented positive guided cultures for *Staphylococcus aureus* showed an improvement (15 of 16 patients) in nasendoscopic findings after treatment, as well as improvement in overall symptom scores.[69]

The EP3OS document recommends long-term oral macrolide therapy based on a study by Ragab and collaborators[1,14,70] graded as level Ib evidence. No studies in children have been done.

SURGICAL TREATMENT

The vast majority of patients should be managed with medical therapy. When maximal and prolonged medical therapy has failed,[71-76] surgical intervention should be considered. Both adenoidectomy with or without antral lavage and functional endoscopic sinus surgery (FESS) have been shown to be safe and effective in the pediatric population. Adenoidectomy as an initial surgical option has a 50% success rate[71] and should be considered as the first-

line surgical treatment in all except those without significant adenoids, those with clear anatomical abnormalities causing CRS, or those with abnormal mucociliary clearance. For those children with asthma and a high computed tompography score, adenoidectomy with antral wash in the younger child or adenoidectomy with endoscopic sinus surgery in the older child seem to have a better outcome than adenoidectomy alone. Balloon catheter sinuplasty has been recently reported to be safe and feasible.[76]

CONCLUSIONS

The treatment of chronic rhinosinusitis in children relies on an understanding of the pathogenesis of the disease and proper diagnosis. Treatment is primarily medical with surgery reserved for medical failures or certain conditions *(Tables II and III).*

DISCLOSURE

The authors have no conflict of interest.

Table II. Management of chronic rhinosinusitis in children. Highlights.

CRS in heterogeneous:
1. Research on well characterized subgroups needed (phenotypes-endophenotypes)
2. Pediatric CRS likely to resolve with growth
3. Inflammation/Infection both relevant
4. Individualize each treatment
5. Surgery rarely needed in children
6. CT scan of the sinuses only if urgent investigation and intervention needed and in specific immunodeficient patients

Table III. CRS in children surgical indications.

Absolute indications for surgery in children include:
• Complete nasal obstruction in CF caused by massive polyposis or caused by medialization of the lateral nasal wall
• Orbital abscess
• Intracranial complications
• Antrochoanal polyp
• Mucoceles or Mucopyoceles
• Fungal sinusitis
Possible indications for surgery in children:
• CRS with frequent exacerbations persisting despite optimal medical tx and after exclusion of any systemic disease.
FESS (functional endoscopic sinus surgery) should be followed by medical management to control mucosal inflammation, or symptoms will invariably return.

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