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CT-scan study of the incidence of sinus involvement and nasal anatomic variations in 196 children

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SUMMARY

CT-scan was used to examine rhinosinusitis in the developing sinuses; 196 children aged from 3 to 14 years were selected on the base of their chronic rhinorrhea, nasal congestion and cough. The patients were subdivided into six age groups (3-4, 5-6, 7-8, 9-10, 11-12 and 13-14 years). In the youngest age group, the authors noted maxillary involvement in 63%, ethmoidal involvement in 58%, and even sphenoidal sinus involvement in 29% of the children.

Involvement decreased gradually with age, with 10% of ethmoidal and 0% of sphenoidal involvement in the 13-14 years age group.

Maxillary sinusitis, however, persisted very frequently in the oldest age group (65%).

Frontal involvement seems to become significant at the age of 7-8 years (7%) but it never exceeds 15% (11-12 age group).

Septal deviations occurred in 16% of the youngest up to 72% in the oldest age group.

The prevalence of bullous conchae increased with age too, although less prominently.

INTRODUCTION

During childhood, the nose and the paranasal sinuses undergo a tremendous development (Wald, 1981; Pirsig, 1986); starting from virtually a single structure, a complex labyrinth is formed as the sinuses develop, each at different times. As well as anatomy, both physiology and immunology are subjected to chronological changes in the growing child. All these lifetime specific processes have to lead to a lifetime specific, relative risk of involvement of each sinus (Flock, 1957; Albegger, 1980; Jazbi, 1980; Wald, 1981).

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In the literature of the past decade, articles on the prevalence of rhinosinusitis in children especially deal with the maxillary sinuses. This is particularly due to a lack of (accurate and) non-invasive examinations, capable of giving concrete information about the condition of all the sinuses. In this respect, the value of standard X-rays to judge the developing sinuses has extensively been discussed (Caffey, 1980; Shurin, 1983; Kovatch 1984). To be visible on standard X-rays, the sinus mucosa has to thicken with a factor 10 or more (Unger).

New techniques, such as tomography and CT-scans are able to provide much more information (Messerklinger, 1987).

On the other hand, the atypical manifestation of rhinosinusitis in children also led to several misunderstandings about the frequency of this condition.

Terms such as "occult sinusitis" are used (Müller, 1970; Hesselinck, 1978; Münzel, 1980; Schmoldt, 1983); in contrast with adults, the difference between (acute) rhinitis and recurrent sinusitis is not as clear (Shurin, 1983). Mostly, there is no facial pain, no sinus tenderness, no headache. Complaints such as chronic asthenia, anemia, retardation in growth or irritability may mask the usually present purulent rhinorrhea, nasal obstruction and/or cough (at bedtime) (Münzel, 1980; Maes, 1987). The latter three conditions were used as criteria to enter the study.

To study the nose and paranasal sinuses, CT is ideal because of its unique ability to make detailed images of both bony and soft tissue structures, especially if high resolution techniques are used (Hesselinck, 1978). But there are disadvantages, too. First of all, the total investigation takes more time than a session of standard X-rays. Nowadays, the scanning time to obtain one slide is short indeed, but patient motion still affects the quality of the image, or it may disturb the good sequence of the images. For the younger child (mostly below three years of age), this would mean the necessity of a major premedication. Striking artefacts caused by any metal (e.g. dental fillings) may lessen the quality of the picture, but this is rarely an obstacle to the diagnosis. Evalution of the adenoids mostly has to be made on the scout view.

As to radiation, exact dosimetric studies are lacking, but the total dose is assumed to be equal to or slightly higher than the dose of four standard pictures.

Finally, the costs are about three times as high as for standard X-days.

MATERIALS AND METHODS

A. Patient group

During a six-month period (end of October 1986 - beginning of May 1987), CT-scans were taken of the sinuses of children who were suspected of having rhinosinusitis (Table 1).

Table 1. Patient population.

age group (in years)	total	male	female
03 to 04	38	24	14
05 to 06	46	30	16
07 to 08	42	24	28
09 to 10	21	14	07
11 to 12	20	09	11
13 to 14	29	17	12
total	196	118	78

Selection criteria were as follows:

1. The child should have a chronic purulent rhinorrhea, nasal obstruction and cough (day- and/or nighttime cough), as these complaints were found to be very frequently present in rhinosinusitis, (Kaiser-Meinhardt, 1955; Münzel, 1980; Daele, 1984; Maes, 1987) as was seen in retrospective studies. Other symptoms such as fever, sinus tenderness, headache and fetor ex ore naturally did not act as exclusion criteria.
2. The child had to be able to undergo the examination without premedication. For this reason there are no patients below three years of age in our study. Almost all the children aged four years and more satisfied this condition.
3. Permission from the parents.

B. C.T.-study

High resolution technique was used. The number of sections was restricted as much as possible, especially in the younger child, in order to cut down the radiation dose. Normally, the sections were taken at 6 mm intervals. Scan time per section was 5 sec. Total scan time was about 15 min. One total CT-study consisted of 6 to 12 sections and one scout view.

Whenever the patient was able to lie in ventral decubitus with the head in hyperextension, coronal sections were taken. These give better information about the lateral nasal walls, and make it much easier to differentiate between anterior and posterior ethmoid cells than do transversal sections.

C. Protocols

Protocols were separately made by a radiologist and by two otolaryngologists; the results were discussed afterwards. Items that were looked for included:

a. Frontal sinus and frontal recess, maxillary sinus, infundibulum, anterior ethmoidal sinus, posterior ethmoidal sinus, sphenoidal sinus (in every case, both left and right). To specify the degree of involvement, we used the following scale for the frontal, the maxillary and the sphenoidal sinuses (Figure 1):

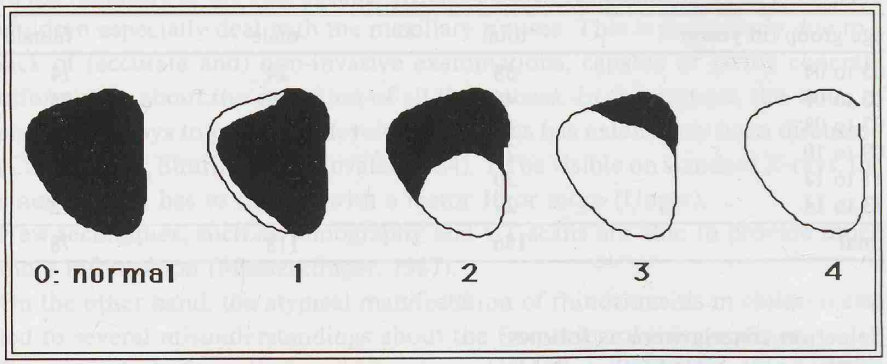

Figure 1. Level system used to describe the degree of sinus involvement.

0: normal sinus
1: mucosal thickening of max. 2 millimeters
2: partial opacification up to a maximum of 50%
3: more than 50%
4: totally clouded sinus

For the ethmoidal sinuses, we used a 0-1-2 scale:
0: normal
1: partially clouded cells
2: totally clouded cells

For the frontal recess and the infundibulum:
0: normal
1: affected

b. We also looked for septal deviations, conchae bullosae and Haller cells.
All data were correlated to the age of the patients and prepared for statistical processing.

RESULTS

In 196 children the authors were able to evaluate the degree of involvement of the different sinuses (Table 2).

a. Norm: Percentage of children, selected for the study, but having a normal CT. The amount of 50% in the 5-6 years age group might be due to the high incidence of adenoid hypertrophy in these children.

b. Max: Percentages of children with affected maxillary sinus: there seems to be no clear change of frequency of sinus affection during growth, but looking at the severity of the involvement, we can see that it is worse in younger children. The

Table 2. Percentage of children without sinusitis („norm") or with affection of the given anatomical structures. „n" stands for the absolute number of children per age group.

age (years)	n	norm	max	inf	front	reces	eth A	eth P	eth	sphen
	abs	%								
3/ 4	38	28	63	40	0	25	53	34	58	29
5/ 6	46	50	39	27	0	12	24	24	35	13
7/ 8	42	30	52	37	7	30	38	26	40	26
9/10	21	38	33	14	5	10	14	14	23	19
11/12	20	35	45	37	15	20	20	5	20	10
13/14	29	34	65	21	0	12	10	3	10	0
all	196	36	50	30	9	8	27	18	31	16

rates of involvement of degree 2, 3 and 4 are as follows: age group (3–4): 53% ; age group (13–14): 28%.

In younger children, we also find a higher rate of bilateral involvement.

c. Inf: (infundibulum): Percentages of children with involvement of the infundibulum (Figure 2) are calculated without missing values (on some CT-scans, the infundibulum could not be clearly indentified or evaluated – these CT's were not taken into account for the statistics). There is a statistical significance between the rates of involvement of the infundibulum and of

1. the maxillary sinus ($p < 0.00$, $\chi 2 = 149$, $N = 354$)
2. the anterior ethmoidal cells ($p < 0.00$, $\chi 2 = 94$, $N = 354$).

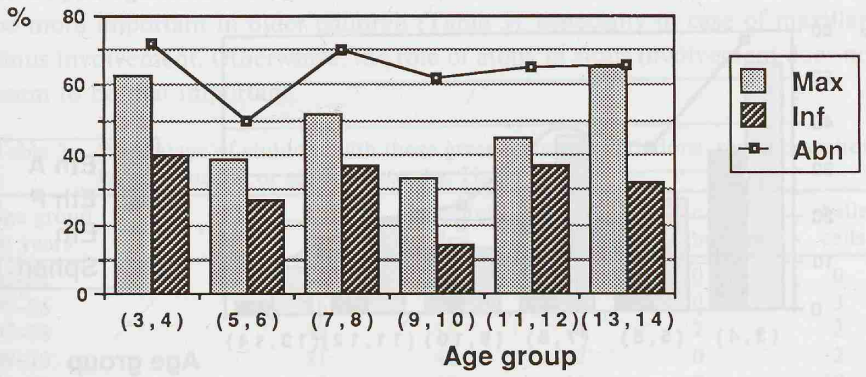

Figure 2. Percentages of children with sinusitis per age group (Abn), of children with maxillary sinusitis (Max) and infundibular affection (Inf).

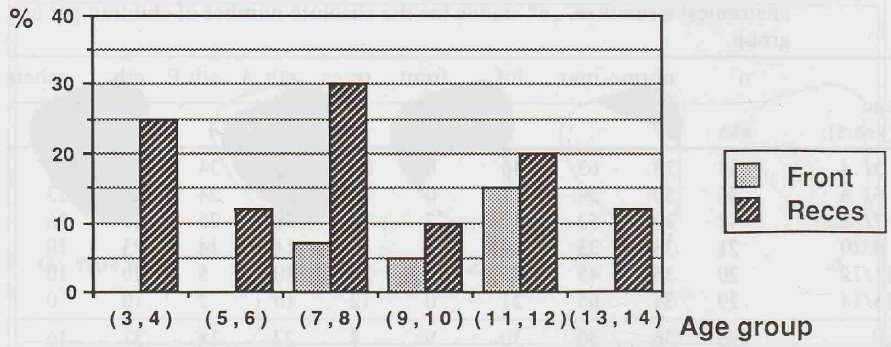

Figure 3. Percentages of children with frontal sinusitis or frontal recess involvement.

d. Front: Percentages of children with affected frontal sinus (Figure 3): this term ("frontal sinus") was used when pneumatisation reached above the orbital roof; 11% of the children of group (5–6) and 38% of group (7–8) fitted in this definition. Only seven children older than seven were found to have a frontal sinusitis. However, the number of cases in this series was considered to be too small to be of statistical significance.

e. Reces: Percentages of children with affected frontal recess (Figure 3): percentages are calculated without missing values (for calculating the frequencies, the CT-scans which could not clearly demonstrate an infundibulum were not taken into consideration).

f. Eth A. Eth P. Eth: Percentages of children with affection of anterior, posterior ethmoidal sinuses, and of the ethmoid in toto (Figure 4) (considered as affected if anterior or posterior cells were affected). The anterior ethmoidal sinuses were most frequently involved, but the total ethmoidal region tends to be less affected with age.

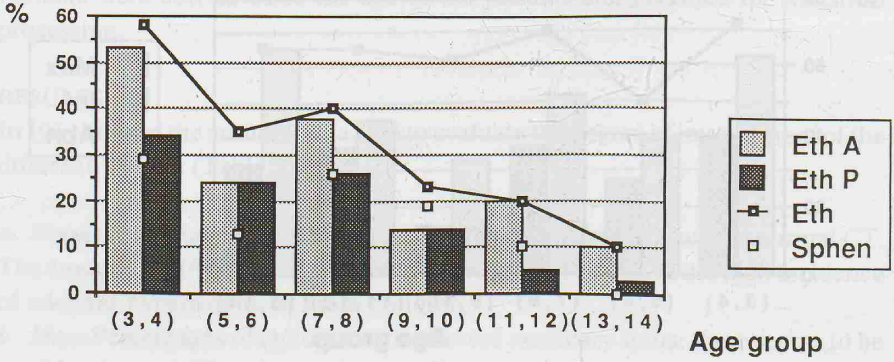

Figure 4. Percentages of children per age group with affection of anterior (Eth A) or posterior (Eth P) or one of both (Eth) ethmoidal sinuses, or of the sphenoidal sinuses.

g. Sphen: Percentages of children with affected sphenoidal sinus: a significant correlation between sphenoidal and both posterior ethmoid cell and maxillary sinus affection were found. In all children, the sphenoidal sinus was detected.

h. General findings:

- There was no significant difference between involvement of the left versus the right sinuses.
- Percentages of sinus involvement was higher in males for all the sinuses, with significance in both anterior and posterior ethmoidal sinuses.
- The mean age of the patients of the group in which the authors found involvement of maxillary, ethmoidal anterior or sphenoidal sinuses, was significantly lower than the mean age of the patients of the group in which these sinuses were normal (two-tailed t-test).
- If one compares the non-atopic with the atopic children, there seems to be no difference in the incidence of sinus involvement: of the 29 atopic children, 48% had a maxillary, 24% an ethmoidal and 10% a sphenoidal sinus involvement.
- Isolated maxillary sinusitis was found in 13% of the children (5% in the youngest age group to 31% in the oldest age group). Isolated ethmoidal sinusitis, however, was only found in 1,5% of the children, and for the frontal and sphenoidal sinuses, the incidences were respectively 0,5% and 1%.

DISCUSSION

If other selection criteria were used, this would probably result in different percentages of sinus involvement, but the study shows a manifest trend: rhinosinusitis is more prevalent and more extended than is generally recognized (e.g. high rate of involvement of sphenoidal and ethmoidal posterior sinuses in the youngest age group).

The fact that in younger children there is more bilateral and more severe involvement of the sinuses, pleads for the major role of the (immature) immune system in the pathogeneses of sinusitis. On the other hand, anatomic deviations seem to be more important in older children (Table 3), especially in case of maxillary sinus involvement. Otherwhise, the role of atopy in sinus involvement does not seem to be that important.

Table 3. Percentage of children with these given anatomic variations: septal deviation, bullous medial or superior concha, Haller cells.

age group in years	n	septal dev.	c. med. bullosa	c. sup. bullosa	haller cells
03-04	38	16	0	0	0
05-06	46	37	8	0	3
07-08	42	55	4	2	2
09-10	21	48	2	0	2
11-12	20	65	15	0	10
13-14	29	72	20	3	3

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