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Low-dose CT and inflammatory disease of the paranasal sinuses

B. Duvoisin[1], M. Landry[1], L. Chapuis[1], M. Krayenbuhl[2], and P. Schnyder[1]

Departments of [1] Radiology and [2] Otorhinolaryngology, University Hospital CHUV, Lausanne, Switzerland

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Summary. Computed tomography (CT) is the gold standard for exact delineation of inflammatory sinus disease, especially before endoscopic surgical treatment, and in cases of postoperative recurrences. In routine CT studies, the radiation dose to the patient is not negligible. Therefore, the authors evaluated prospectively the CT scans of 44 patients with inflammatory disease of the paranasal sinuses, to define the imaging ability of low-dose CT (i.e. 60 mA – 3 s, 30 mA – 3 s, and 30 mA – 2 s), comparatively with the standard mAs settings (130 mA – 3 s). In all cases, the exact extent of the disease was correctly assessed on each of the low-dose settings, with no false negative study. The increasing graininess of low mAs sections did not induce errors of interpretation, despite a less pleasant appearance to the eyes. In cases of extensive sinus disease, the thickness and integrity of the ethmoid septa were sometimes more difficult to evaluate on low-dose CT sections. The authors recommend the use of low mAs settings in the evaluation of inflammatory disease of the sinuses, complemented, if necessary, in cases of extensive abnormalities, by one or two sections obtained with standard mAs settings, focused on questionably abnormal bone septa.

Key words: Computed tomography, low dose – Paranasal sinuses – Inflammation

Computed tomography (CT) has proven to be the best test for quantifying the extent of abnormalities in chronic sinusitis [1–3]. Its impact in the preoperative work-up has been reemphasized recently, following the development of new endoscopic surgical treatments [4–6]. A recent paper stressed the importance of CT in sinus revision surgery, since surgical treatment of chronic hyperplastic rhinosinusitis is characterized by a high rate of recurrence [7]. As surgery is often necessary for adequate management of these recurrences, CT is then mandatory. These various reasons imply a broad and repetitive use of CT. Routine CT examinations of the paranasal sinuses are usually performed with 2- to 5-mm-thick sections at 120 kVp, and 300–400 mAs, in the coronal and/or axial planes, or in planes determined by the axis of the nasofrontal duct (NFD) [1–8]. With these techniques, the patient radiation dose is in the order of a few rads (centigrays), and is somewhat higher than entrance skin doses for standard sinus views (Waters, Caldwell, lateral, and Hirtz, unpublished data).

To obtain full benefit from the advantages of CT, without the shortcoming of higher patient doses, particularly to the lens and the thyroid, it is mandatory to reduce the patient dose by diminishing the milliampere-second (mAs) value. Because the spatial resolution of CT is not dependent on a high dose of radiation for high-contrast objects [9], it is known that a low mAs setting is acceptable, when evaluating abnormalities that do not include subtle soft tissue discrimination. Furthermore a recent paper reported the usefulness of low-dose CT in lung studies, this technique presenting particular potentials in the pediatric population, and for screening purposes [10].

For the above-mentioned reasons, we decided to evaluate prospectively the value of low-dose CT in the work-up of chronic sinusitis or rhinosinusal polyposis.

Patients and methods

During a 4-month period, from August to November 1990, 44 patients (male: 24; female: 20), aged from 17 to 76 years (mean: 39 years) underwent CT studies of the paranasal sinuses. The indications for CT examination included chronic hyperplastic rhinosinusitis, polyposis, and recurrent frontal or maxillary sinusitis. Thirty-four patients were examined with a protocol decribed elsewhere, including sections perpendicular and parallel to the NFD axis [8]. In 10 cases the sinuses were examined in the axial plane. In all cases, 2-mm-thick sections were obtained, with an interslice gap of 4–6 mm, without IV contrast injection. Routine imaging parameters included use of 120 kVp, 130 mA, 3-s scan time, and a standard reconstruction algorithm. The sections were imaged at a wide window width (1600 HU), centered at

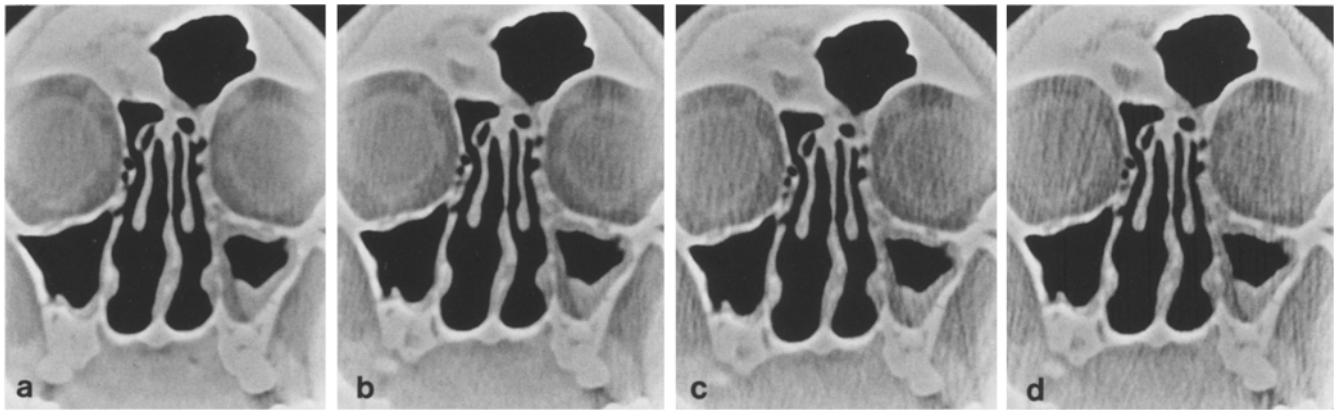

Fig. 1. Left maxillary chronic sinusitis; note also slight mucosal thickening at the base of the left frontal sinus, and right maxillary sinus. Section parallel to the nasofrontal duct axis at four different milliampere (mA) and second (s) settings: **a** 130 mA – 3 s, **b** 60 mA – 3 s, **c** 30 mA – 3 s, and **d** 30 mA – 2 s. All abnormalities are clearly identified, whatever the mAs setting. Despite an increasing graininess, and more apparent artifacts, lower mAs settings (**c**, **d**) sections are quite sufficient for analysis of normal and abnormal structures

– 100 HU to enable the best detection of mucosal abnormalities. The studies were obtained on a Pace CT scanner (General Electrics, Milwaukee, Wis.). This unit uses a continuous radiation; for this reason the mAs product can be calculated by multiplying the mA settings by the scan time.

In each plane of study, one section of interest was selected, and reimaged with the same slice thickness and 120 kVp setting, but with three different settings for the mA and the time, i.e. 60 mA – 3 s, 30 mA – 3 s, and 30 mA – 2 s. Thus for each section selected, four separate images were available for comparison. Each image was evaluated independently by two of us (B.D., M.L.), comparing: (a) the identification and delineation of normal anatomic structures of the sinuses, (b) the detection and assessment of abnormalities (defined as complete opacification of the sinus cavity, mucoperiostal thickening, and/or fluid layering), (c) the analysis of bone septa, and (d) the ease of interpretation, considering the presence of artifacts and amount of graininess.

In the present study we did not try to measure the actual patient dose. However, dose is proportional to the mAs value when the other factors are constant; thus it can be assumed that the dose reduction between the routine scan and the three different settings is respectively of an approximate factor of 2, 4 and 6.

Results

In 9 cases the standard CT examination did not disclose any abnormality in all paranasal cavities. For these cases, the correct diagnosis was established at all dose settings. Due to their high contrast with air, the sinusal walls and septa were clearly identified at every mAs value.

In 4 patients an extensive nasosinusal polyposis was noted, with total opacification of all paranasal cavities. In 47 cases abnormalities of the large cavities were observed on standard CT studies (Fig. 1), including 14 sinuses with total opacification, 31 with mucosal thickening, and 8 polypoid lesions. All abnormalities were correctly identified on all mAs settings. The exact delineation of the disease was possible whatever the technique chosen, and the exact thickness of the sinusal walls was correctly quantified at all mAs value settings.

In 33 cases abnormalities of the ethmoid cells were noted on routine CT sections. Whatever the mAs value setting, all abnormalities were identified, and the anatomic definition of the lesions was not affected by reduction of the dose (Fig. 2). However, in cases with adjacent ethmoidal opacities, the analysis of the septa was at times more difficult with reduction of the dose, especially in the plane parallel to the NFD axis (Fig. 3).

With dose reduction, the ease of interpretation was not altered significantly on sections perpendicular to the NFD axis, and in the routine axial plane, despite an increasing graininess. However, in the plane parallel to the NFD axis, the ease of interpretation was slightly to moderately lowered, as the importance of artifacts increased with reduction of the dose.

Discussion

The impact of CT in detecting paranasal sinus disease is well known [1–3]. Due to the development of new endoscopic surgical procedures in cases of chronic sinusitis, and to the fairly high rate of postoperative recurrences, necessitating revision sinus surgery, CT has become mandatory to delineate accurately the extent of sinusal abnormalities [4–7].

Routine CT examinations of the paranasal sinuses are usually performed with use of 2- to 5-mm-thick sections at 120 kVp, and 300–400 mAs, performed in the coronal and/or axial planes, or in planes determined by the axis of the NFD [1–8]. With these techniques, the patient radiation dose is in the order of a few rads (centigrays), and is higher than entrance skin doses for standard sinus views (Waters, Caldwell, lateral, and Hirtz, personal unpublished data).

This shortcoming of fairly high radiation doses, comparatively to the routine X-ray views, should be obviated

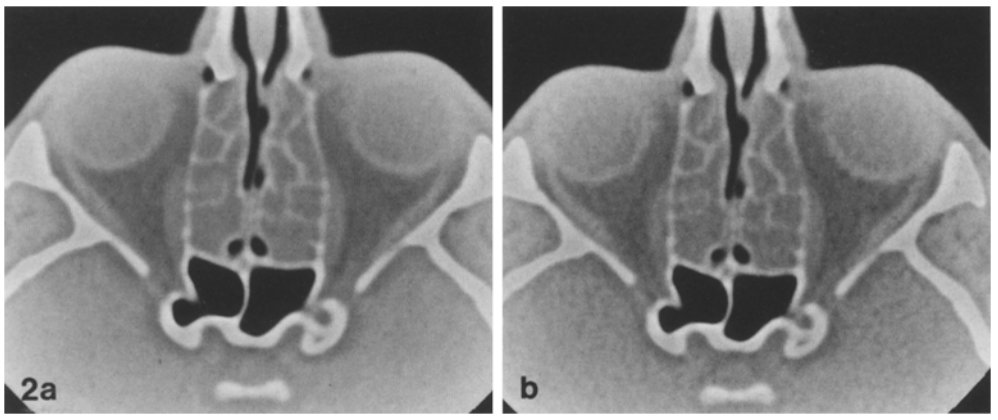

Fig. 2. Nasosinusal polyposis, with bilateral extensive ethmoid opacities; axial section: **a** 130 mA – 3 s, **b** 30 mA – 2 s. Despite increasing graininess, the septa are as clearly identified on low-dose setting (**b**) as on the routine section (**a**)

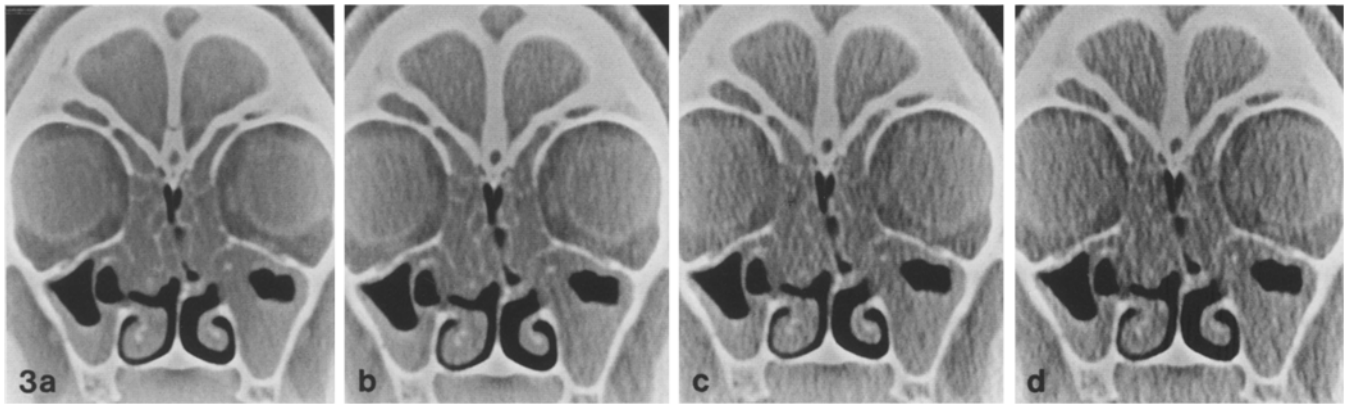

Fig. 3. Nasosinusal polyposis, with extensive ethmoid disease, fluid level, and hypertrophic mucosa in maxillary sinuses; section parallel to the nasofrontal duct axis: **a** 130 mA – 3 s, **b** 60 mA – 3 s, **c** 30 mA – 3 s, and **d** 30 mA – 2 s. The extent of abnormalities is clearly determined on each mAs setting. The ethmoid bone septa, which are faintly recognizable on the routine CT section (**a**), vanish progressively with lower mAs settings (**b–d**)

by reducing the dose for a CT study, mainly to allow repetition of CT examinations. As paranasal sinuses are air-filled cavities, contrast is high. In inflammatory disease, a subtle soft tissue discrimination is not necessary, and a low mAs setting is acceptable, because the spatial resolution of CT is not dependent on a high dose of radiation for high-contrast objects [9].

Our study was prompted by a recent paper of Naidich et al. [10], who described the impact of low-dose CT of the lungs, its potential in children, and for screening patients at risk for developing lung cancer. Following the good results of the preliminary observations reported in this paper, we studied prospectively 44 patients with chronic sinusitis, polyposis, or recurrent frontal and non-dental maxillary sinusitis.

Our observations indicate that reducing the mAs settings does not affect the detectability of inflammatory abnormalities of the paranasal sinuses. With our CT unit, which uses a continuous radiation, the normal sinusal walls are clearly delineated from the air, whatever the mAs setting. Each type of inflammatory abnormality (i.e. mucosal thickening, fluid level, and total opacification) is correctly diagnosed at all mAs settings, and the appreciation of the extent of the disease is not affected by dose reduction. Thus we may consider that the sensitivity of CT for detecting inflammatory changes in the sinuses is not dose-dependent. In cases of inflammatory sinus disease, we thus recommend that CT studies of the paranasal cavities be performed at low mAs settings.

The increasing graininess of the images obtained with lower mAs settings does not affect the detection of the abnormalities in sections obtained in the plane perpendicular to the NFD axis, and in routine axial sections. In sections parallel to the NFD axis, artifacts from bone structures of the scapular region are frequent, because as the neck of the patient is flexed, the shoulders and the facial structures are partially in the same section. In this plane, dose reduction lowers the ease of interpretation, due to a more difficult analysis of bone ethmoid septa, mainly in cases of extensive polyposis. In such cases we recommend performing one or two complementary sections with standard mAs settings, to better delineate the bone septa.

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B. Duvoisin, MD
Department of Radiology
University Hospital CHUV
CH-1011 Lausanne
Switzerland