Restricting Indications for Sinonasal Computed Tomography in Children With Cystic Fibrosis

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Objectives: To evaluate whether a low rate of exposure to sinonasal computed tomographic (CT) scans can be achieved when strict criteria are applied for their use in children with cystic fibrosis (CF) and to emphasize the importance of limiting radiation exposure in the context of the current longer life expectancy in this group of patients.

Design: Retrospective chart review.

Setting: Tertiary care children’s hospital.

Patients: The study included 277 children who were regularly followed up in the CF clinic in the last 11 years (mean duration of follow up, 7.87 years), 33 of whom underwent sinonasal CT.

Main Outcome Measures: Indications used for scanning, health professional (ear, nose, and throat specialist or pulmonologist) ordering the test, eventual modifications of ongoing treatment according to CT results, and time lapse between CT scanning and surgery.

Results: Of 277 children with CF, 33 (12%) underwent a total of 39 sinonasal CT scans during the follow-up period (0.018 scans per patient per year of follow-up). Twenty-nine of the CT scans (74% of all cases, 90% of CT scans ordered by the ear, nose, and throat surgeon) were performed in the preoperative context and demonstrated the extent of the polypoid disease whenever present (26 cases [90%]) and the cause of nasal obstruction (20 cases [69%]). The mean period between the scanning and the surgery was 57 days (range, 0.10-173 days). Computed tomographic scans that were not meant for preoperative planning were performed in 10 cases (26%). The indications were disease evaluation (10%), ruling out a mucocele (5%); pre–lung transplantation status (5%), ruling out an intraorbital complication (3%); and headache investigation (3%). The results of the scans did not modify the management of the disease in those patients.

Conclusions: With the use of stringent criteria, it is possible to achieve a low rate of exposure to sinonasal CT scans in the population of children with CF. The main indication should be the preoperative planning regarding anatomy, extent of disease, and sites of nasal obstruction. The use of CT scans for disease evaluation does not seem to appreciably modify the treatment course and could be avoided.


Chronic rhinosinusitis is nearly a universal finding in patients with CF and is complicated by nasal polyposis in 6% to 48% of cases. Therefore, mucosal thickening, partial opacification, sinus hypoplasia, polyposis, and maxillary mucocele-like formations are typically present in any computed tomographic (CT) scans of the area, whether intentionally for sinusitis evaluation or as an incidental finding on CT of the head. Chronic rhinosinusitis can often be considered a radiologic disease, as patients do not tend to complain. Some patients report nasal obstruction, anosmia, rhinorrhea, and, less frequently, headaches, but only when specifically questioned. The discrepancy between the symptoms, signs, and imaging findings led authors to question the clinical utility of CT scans in the evaluation of sinonasal disease in CF.

Concern about exposure to ionizing radiation is particularly relevant in the pediatric population, considering the tissue vulnerability and cumulative lifetime dose in repeated examinations. Radiation damage can affect organ function, such as eye lens opacification, or theoretically, and in the light of an increased life expectancy in CF, induce malignant transformation. Current ear, nose, and throat (ENT) or radiology practice guidelines in non–CF-related sinusitis do not recommend the use of CT in simple acute sinusitis. On the other hand, its use in chronic disease is supported by most expert panels, either as an aid for establishing the diagnosis or as part of a more
advanced investigation. In children with CF, in whom sinonasal disease is of the chronic type, there are no guidelines to detail the indications for CT scans.

The prevalence of CF is higher among the French Canadian population in Quebec compared with other Western societies because of regional founder effects, and follow-up for this population is mainly assured in our institution. For the last decade, we have adopted a conservative approach regarding treatment for chronic rhinosinusitis, focusing on intensive nasal hygiene and the local application of steroids, whose effectiveness has been proved only in the non-CF population. Also, our approach includes restricting indications for the use of CT to the preoperative context. Therefore, we aimed to evaluate whether a low rate of exposure to sinonasal CT scans was achieved with the use of these indications.

METHODS

The study population included all patients who were followed up in the pulmonary CF clinic at Sainte-Justine University Pediatric Hospital in Montreal, Quebec, Canada, from 2001 to 2011. We performed a retrospective chart review to retrieve demographic data, the attending ENT physician, the number and date of CT scans performed, the signs and symptoms at the time of the CT scan, the clinical indication for ordering the CT scan, and the examination’s findings as well as the number and dates of the sinonasal procedures that the patients underwent. Six cases that were managed outside the framework of the CF clinic were excluded from the study.

In most cases, the use of CT scan was restricted to preoperative planning, only after the indication for surgery had been set. Various multidetector CT (MDCT) scan machines were used during the study period, and the radiation dose data are incomplete, mainly for tests performed before 2007. Considering all the available information, the 75th percentile of the effective radiation dose, calculated using the region- and age-specific coefficients proposed by Shrimpton et al24 was 0.31 mSv. In 2010 and 2011, the intention to use low-dose protocols yielded a decrease in exposure to radiation, with an effective radiation dose ranging between 0.12 and 0.19 mSv. Bismuth shielding was used for protection of eyes and thyroid glands whenever possible, considering child size and level of cooperation. Images were reviewed and compared with the formal interpretation by the radiologist at the time of testing. All patients, regardless of the use of the CT scan, were treated according to a conservative approach adopted by our institution, including intensive nasal hygiene, drug therapy, and endoscopic sinus surgery (ESS) (only in medically resistant cases).

Patients were treated on a regular basis with 2 or more daily saline-based solutions for nasal irrigation and twice-daily corticosteroid nasal spray. A nasal decongestant (oxymetazoline hydrochloride) was added for 5 consecutive days during exacerbations. As compliance cannot be taken for granted, we insist on continuous education of the patients and their families by a dedicated team starting at an early age. Each follow-up visit is used to reconfirm proper high-volume saline irrigation, nose blowing, and steroid application techniques. Systemic antibiotics (eg, oral first-generation cephalosporin) are administered immediately at the first signs of an upper respiratory tract infection. Treatment is augmented if rhinosinusitis is suspected.

Indications for ESS in our series were confined to unbearable nasal obstruction or purulent rhinorrhea that was resistant to maximal conservative therapy as perceived by the patients or their parents. The presence of polyposis without significant symptoms was not used as an indication for surgery.

RESULTS

The study included 277 patients aged 1 to 18 years (mean age, 13.7 years at the end of follow-up); 127 were female and 150 were male. The mean duration of follow-up was 7.85 years (range, 1-11 years). Thirty-three patients underwent a sinonasal CT scan (12% of the total cohort cases) over the study period (Figure). The total number of CT scans was 39, yielding 0.018 scans per patient per year of follow-up. The symptoms and signs at the time of the CT scan were nasal congestion or obstruction in 29 patients (74%), nasal polyposis in 25 patients (64%), purulent rhinorrhea in 12 patients (31%), mucocle in 3 patients (8%), and headache in 2 patients (5%) (Table 1).

The CT scan was performed in the context of presurgical planning in 29 patients (74%). Nineteen of the 19 CT scans performed before a primary surgery showed a maxillary mucocle; 17 of them showed polyposis (89%) and demonstrated its extent; and 2 (10%) showed hypertrophic inferior turbinates (Table 2). When performed before a revision surgery, the CT scan revealed
an unsuspected maxillary mucocele in 1 case (10%) and polypsis in 9 cases (90%). In 10 cases, a CT scan was performed outside the preoperative context (26% of the scans). Six of these scans (60%) showed a maxillary mucocele, including partial obstruction in 5 of 6 cases of complete obstruction of the nasal lumen, and 4 of the scans demonstrated the extent of polypsis, with partial obstruction of the lumen in 75% of cases.

A total of 29 endoscopic sinonasal procedures were performed, including 19 primary endoscopic sinonasal procedures and 10 revision procedures. In 4 of the revision cases, the first operation was performed during the study period, and in the other 6 revision procedures, the previous operations were performed before the beginning of the study. The mean time from CT to surgery was 56 days (range, 10-173 days). All primary procedures in–tons were performed before the beginning of the study. The mean time from CT to surgery was 57 days (range, 10-173 days). All primary procedures included middle meatal antrostomy, anterior and posterior ethmoidectomy, and polypectomy. Inferior turbinectomy, sphenoidectomy, middle turbinoplasty, and adenoidectomy were added in 3, 1, 1, and 1 cases, respectively (Table 3).

Ten of the CT scans were not followed by an operation (Table 4). Two of these scans were ordered by the ENT surgeon to rule out a mucocele and 1 for disease evaluation in an uncooperative autistic child. The other 7 scans were ordered by the pulmonologist for disease evaluation (3 cases) as part of the pre–lung transplantation protocol (2 cases) or for the workup of headache or peri-

### Table 2. Scan Findings

<table>
<thead>
<tr>
<th>Variable</th>
<th>Scan Before First Operation</th>
<th>Scan Before Revision Surgery</th>
<th>Not Preoperative Scan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maxillary mucocele</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Partial obstruction</td>
<td>6 (32)</td>
<td>1</td>
<td>5 (50)</td>
</tr>
<tr>
<td>Reaching septum</td>
<td>13 (68)</td>
<td>0</td>
<td>1 (10)</td>
</tr>
<tr>
<td>Polyposis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Partial obstruction</td>
<td>11 (58)</td>
<td>6 (32)</td>
<td>3 (30)</td>
</tr>
<tr>
<td>Reaching nasal floor</td>
<td>6 (32)</td>
<td>3 (15)</td>
<td>1 (10)</td>
</tr>
<tr>
<td>Hypertrophic inferior turbinates</td>
<td>2 (10)</td>
<td>0</td>
<td>2 (20)</td>
</tr>
<tr>
<td>Sinus hypoplasia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frontal</td>
<td>17 (89)</td>
<td>NA</td>
<td>7</td>
</tr>
<tr>
<td>Sphenoid</td>
<td>8 (42)</td>
<td>NA</td>
<td>4</td>
</tr>
</tbody>
</table>

Abbreviation: NA, not applicable.

### Table 3. Procedures Included in the Operation in Addition to Middle Meatal Antrostomy Plus Anterior and Posterior Ethmoidectomy

<table>
<thead>
<tr>
<th>Variable</th>
<th>First Surgery (n = 19)</th>
<th>Revision Surgery (n = 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inferior turbinectomy</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Sphenoidectomy</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Middle turbinoplasty</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Adenoidectomy</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Unilateral surgery</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Posterior ethmoidectomy not performed</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

### Table 4. Indications for Computed Tomography (Not Preoperative Cases)

<table>
<thead>
<tr>
<th>Variable</th>
<th>No. of Cases</th>
<th>Ordering Physician</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre–lung transplant</td>
<td>2</td>
<td>Pulmonologist</td>
</tr>
<tr>
<td>Rule out mucocele</td>
<td>2</td>
<td>ENT surgeon</td>
</tr>
<tr>
<td>Disease evaluation</td>
<td>4</td>
<td>3 Pulmonologists</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and 1 ENT surgeon</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(autistic child)</td>
</tr>
<tr>
<td>Headache</td>
<td>1</td>
<td>Pulmonologist</td>
</tr>
<tr>
<td>Periorbital cellulitis</td>
<td>1</td>
<td>Pulmonologist</td>
</tr>
<tr>
<td>Total</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

This study was intended to evaluate whether a low rate of exposure to CT scan radiation in children with CF can be achieved by applying conservative management and restricting the indications for scanning to the preoperative context. Indeed, with 7.6 years of mean follow-up time and 277 patients, we found that the rate of using the CT scan was 12%, or 0.018 scans per patient per year of follow-up. A direct comparison to the usage rate of the CT scan without applying these criteria was not possible, because in the numerous studies treating sinonasal disease in CF, the actual usage rate is not mentioned, nor are detailed criteria according to which patients were imaged. In the past, sinonasal CT scans were considered part of the routine sinus assessment of children with CF in some centers. We find it reasonable to estimate, based on the large number of CT scans performed in short periods of time in several series and on our previous experience, that this rate varied between 15% and 40%.

The preoperative CT scan was of therapeutic value because it provided information concerning both the patients’ anatomy and the extent of their polypoid disease, serving to guide surgery. In our series, 26 of the preoperative scans (90%) showed polyps, including 9 cases of complete obstruction by polyps reaching the nasal floor. Because CT scans are capable of demonstrating both bone and mucosal disease, it is normal for the scan images to reflect variations seen on endoscopic examination, as shown in the non-CF population, and to serve as the reference for navigation-assisted surgery. However, in the CF population, CT scan findings should not be relied on for clinical interpretation, as demonstrated by Sakano et al, who looked for correlations between surgical endoscopic findings, CT scans, and genotype in 50 patients over a period of 8 months. The authors noticed that in 49 of 50 patients CT scans demonstrated findings compatible with sinus disease and that there was no association between those findings and disease severity.
The second advantage of the preoperative CT scan is that it was used to establish the diagnosis in cases in which the medically resistant nasal obstruction was unexplained by the physical examination findings. The scan can reveal the site of obstruction, again assisting operative decision making. Of the 19 CT scans performed in our series before a primary ESS, 19 (100%) showed medializedation of the lateral nasal wall, with demineralization of the uncinate process and formation of a maxillary mucocelelike lesion. In 6 patients (32%), the mucocele caused partial obstruction, and in 13 patients (68%), the resulting obstruction was complete, often along with displacement of the nasal septum. This rate seems comparable to the 82% medial bulging of the lateral nasal wall in advanced maxillary disease among patients with CF who were not yet operated on, as described by Eggesbo et al.17 The presence of an anatomical obstruction, accompanied by subjective congestion or obstruction, is an accepted indication for considering surgery,2,24 hence the importance of the imaging in these cases.

The utility of the CT scans performed outside the preoperative context is questionable. Within the limits of our retrospective study, it seems as though none of the CT scans changed the treatment of the patients, but it cannot be ruled out that some of the nonobstructive CT scans contributed to the clinician’s action plan to remain conservative. The indications of these examinations (Table 4) were related to a general evaluation of the sinonasal disease in 80% of the cases, including 1 case of an uncooperative autistic child. In 7 of 10 cases, the indication was set by the pulmonologists rather than by the ENT surgeons. In only 20% of the cases was the CT scan performed to find the site of obstruction, revealing a partially obstructing mucocele in 1 case. Although the CT scan is an accepted tool to evaluate the severity of the disease in patients without CF, evidence is surfacing for a lack of correlation between images and symptoms, surgical findings, and treatment outcome in the CF population. McMurphy et al18 reviewed 290 CT scans of 134 patients performed over 6 years and found no difference between the preoperative and postoperative Lund-MacKay scores; Robertson et al2 stated that CT scans do not reflect clinical disease; and Ramussen et al23 found no correlation between CT scores, detection of pus and bacteria, and symptoms and concluded that the indication for surgery cannot be based on CT findings. These studies reinforce the fact that it is the clinical portrait that should determine the indication for surgery.

Endoscopic sinus surgery using CT-assisted navigation22 has been shown to be feasible and safe in patients with CF. Furthermore, as the recurrence of polyps occurs in 42% to 100% of cases,26 and accordingly the rate of revision ESS is considerably higher than in patients without CF (28%-60%15-19 vs 4%-18%27,28), CT-assisted navigation plays an important role as a guide to the surgeon facing the altered anatomy in such revision cases.

Owing to the good natural contrast between soft tissue, bone, and air in the sinus area, CT images of this region can be acquired using low energy levels and emitting a relatively low ionizing radiation. When a conventional MDCT is used and a low-dose protocol is applied, the radiation level should be in the range of 0.045 to 0.120 mSv,29,30 which is comparable to that of plain radiography (2 views yield approximately 0.06 mSv). Furthermore, effective doses for a standard protocol that is suitable for preoperative planning are evaluated in the range of 0.37 to 0.90 mSv.30,31 In recent years, the use of cone beam technology has been increasing, carrying the promise of decreased radiation doses, varying according to the time of exposure. Zoumalan et al32 studied flat-panel cone beam CT images acquired at 10, 20, and 40 seconds of exposure and generating effective radiation doses of 0.17, 0.08, and 0.04 mSv, respectively. They found improved image quality using a scan time of 20 seconds and above, but the study was limited by the small number of patients (n = 11) and lacked a comparison to MDCT. Of note, conventional dosimetry metrics cannot be directly adapted for cone beam CT imaging because of the altered beam geometry and scattered radiation profile of cone beam systems,33 which render the comparison of the 2 systems difficult.

The exposure levels above which the lens starts to be at risk of developing opacities and cataract formation (500 mGy)34 are far superior than those currently used. Nevertheless, CT scan use should always be conformed to the “as low as reasonably achievable” principle since the risk of long-term effect on tissues, including the risk of malignancy, can never be excluded. Also, the dose from each CT scan is cumulative over the life of an individual,3 and children with CF are expected to undergo a number of these examinations over the course of their lifetime.

Presently, there are no accepted guidelines for the use of the CT scan in patients with CF, and any indication should take into account the weak clinicoradiologic correlation as discussed herein as well as the potential risks of exposure to radiation. We propose that the use of the CT scan in children with CF be restricted to the preoperative context, where the main indications are to familiarize the surgeon with anatomy, to appreciate the extent of the polypoid disease, and to identify the main obstruction site (eg, maxillary mucocele). Using the CT scan for a general evaluation of the disease is not recommended, because CT images are unlikely to change the management, which in any case should concentrate on optimization of the local nasal hygiene and therapy. We showed that in the last 11 years the use of restricted indications for scanning, while placing emphasis on conservative treatment, yielded a low rate of exposure to ionizing radiation. Had we avoided the “nonsurgically indicated” 10 CT scans performed during the study period, the rate of exposure to radiation would have been even lower.

Submitted for Publication: May 22, 2012; final revision received August 26, 2012; accepted October 1, 2012. Correspondence: Oren Cavel, MD, Department of Otorhinolaryngology, Sainte-Justine University Hospital, 3175 Cote Sainte-Catherine, Montreal, QC H3T 1C5, Canada (oren.cavel@gmail.com).

Author Contributions: Drs Cavel and Froehlich had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Cavel, Quintal, Mar-
References


