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Screening Sinus CT: A Good Idea Gone Bad?

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Screening sinus computed tomography (SSCT) was a great idea. Functional endoscopic sinus surgery, popularized in the 1990s among head and neck surgeons throughout the United States, had become a commonly performed surgical procedure for sinusitis, and plain-film sinus radiography, a series none too glamorous for neuroradiologists or head and neck imagers alike, was recognized as insufficient for showing the surgeon the fine detail needed to proceed with this new surgical technique.

A new examination, SSCT was promoted as a means of inexpensively and accurately "screening" for the presence of inflammatory sinonasal disease, and if the patient went to surgery, the coronal images served as an intraoperative "roadmap" for the surgeon. The technique consists of obtaining only 3-mm noncontrast coronal views of the paranasal sinuses, zooming the images so that only the sinuses are included, and filming at a single window and level setting that is intermediate to those of bone and soft tissues (1). Thus, the advantages of this innovative approach included decreased cost, low radiation dose, and the fact that the images served as a surgical tool. Sinus computed tomography (CT) protocols before the advent of SSCT varied among institutions and radiologic practices, especially with respect to the use of intravenous contrast material and replacement of CT by magnetic resonance (MR) imaging; however, they generally included both the axial and coronal planes filmed at two window/level settings, one for bone and one for soft tissue/brain detail.

SSCT was embraced enthusiastically, because it is easy, involves imaging in one plane and one window only, requires no contrast material, and is fast and a "breeze" to interpret. Generally, the subjects are otherwise healthy outpatients who "probably" have inflammatory disease. We learned a few new words like concha bullosa, agger nasi, and fovea ethmoidalis, and we were off, applying this fantastic new study.

Unfortunately, SSCT has become a good test gone bad. Now that we're at least 5 years into our experience, the problems associated with this protocol have surfaced. The proponents of SSCT provide data suggesting that it is not only possible to determine whether disease is present but also that the disease can be classified into one of five common patterns (2, 3). Our aim is to comment upon the validity of these claims, primarily by reviewing them in relation to known characteristics that make the screening process efficacious. Moreover, we postulate on how SSCT might perform in the general clinical setting and provide

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anecdotal evidence of instances in which SSCT failed to provide adequate clinical insight.

Purpose of Screening

The concept of screening has evolved over the last century, and plays an important role in the public health arena and in the clinical management of cases (4, 5). In the field of public health, screening is useful for determining the incidence and prevalence of disease, and is a means of identifying populations and individuals at risk for disease. Moreover, screening of test populations is often used to validate a generalized program of screening. Finally, screening is used clinically as a means of determining whether definitive diagnostic evaluation need be performed to confirm disease, usually in an asymptomatic patient. This use of screening, of benefit primarily for the clinical treatment of the patient, is thought of as prescriptive screening. Obviously, prescriptive screening is most significant in patients with early or preclinical symptoms who have not yet received a formal diagnosis.

In medical terms, screening is important in that it provides data to support or not to support a presumed clinical diagnosis. It is a method of testing whether a disease is present or absent. When present, confirmatory examination or testing is required, which, if also positive for disease, leads to treatment. In economic terms, performing definitive testing for disease is usually not feasible given the financial constraints present in the modern clinical setting. Screening often provides a method of reducing the economic burden of diagnosis by reserving definitive (and often costly) diagnostic testing for those with the greatest likelihood of actually having disease (6).

To develop a successful screening program, the disease itself must be amenable to screening (7–9). There are several well-known characteristics that make screening efficacious. Screening works best if it is used to detect preclinical or early disease, thereby allowing for early intervention. Because repeat screening at short intervals is needed to detect acute diseases, chronic diseases with their longer clinical courses are more amenable to screening. Finally, diseases with higher prevalence (given the elevated pretest prevalence of disease) within the population are more easily screened than are rare diseases.

To be successful, a screening program must meet the criteria of acceptability, reliability, and validity (9). An assessment of the *acceptability* of a given test takes into account such issues as whether the test is readily available, the cost of conducting it, its invasiveness, and the complexity of administering it. *Reliability* refers to whether there is low intraobserver or instrumentational variability, reproducibility of test results, and little variation of test results due to subject variability. *Validity* is defined as concordance between the test results and the final clinical diagnosis. These subjective issues described above, combined with the familiar epidemiologic concepts of sensitivity, specificity, and preditive value, are used to judge the characteristics of a screening test.

Does SSCT Conform to the Screening Model?

Given the model described above, the SSCT examination should meet the following criteria in order to be a viable screening test: (*a*) the disease is amenable to screening; (*b*) a screening test of acceptability, reliability, and validity is available; (*c*) a confirmation test of high specificity is available; and (*d*) there is an efficacious means of intervention. Each of these issues is discussed below.

Is the Disease Amenable to Screening?—The criteria that make a disease most amenable to screening are that the disease is preclinical or early in course, chronic, and prevalent within the population. In the case of sinusitis, the disease is usually manifest; however, it may be chronic and it is certainly prevalent within the population. From first principles, one would predict that screening would be useful in ascertaining the presence of sinusitis. Amenability to screening, however, is a complex question that cannot be viewed in isolation.

This discussion relates primarily to recurrent acute sinusitis, or chronic sinusitis, defined as persistent symptoms despite 4 to 6 weeks of antibiotics, decongestants, and topical steroids. Except in very specific situations, when there is sclerosis of the sinus walls, small sinus volume, or polyposis, the SSCT results are too nonspecific to diagnose "chronic sinusitis" confidently without correlation with clinical history (10). Therefore, the results of the test (SSCT) must take into account the clinical setting. In the proper clinical setting, mucosal thickening in a sinus could represent viral rhinitis, allergic rhinitis, resolving bacterial sinusitis, developing bacterial sinusitis, or chronic sinusitis; or it may be a normal finding in an asymptomatic patient (11). It is unlikely, therefore, that a single examination will answer the simple question, Does this patient have recurrent acute or chronic sinusitis? It is definitely not a "yes or no" test; instead, the answer is almost always a resounding "maybe."

Is SSCT an Acceptable, Reliable, and Valid Screening Test?—The greatest strength of SSCT is the wide acceptability it has gained over the past half decade. The acceptability has come largely from the fact that SSCT is simple and inexpensive to administer, well tolerated by the patient, and noninvasive.

The reliability of SSCT is more suspect. As conceived originally, SSCT was to be performed on a patient who had already been treated with antibiotics, decongestants, and steroids, and who was either unresponsive to that clinical regimen or was clinically well but had a history of recurrent acute sinusitis. Some authors even advocated treating the patient immediately before the scan with topical vasoconstrictors so that reversible mucosal disease would not be misinterpreted as an obstructing lesion (1). Unfortunately, this careful protocol has not routinely been followed in many practices, and a significant complicating factor is the medical status of the patient at the time the test is performed. Some patients are scanned when they are acutely or subacutely ill, some are treated with antibiotics

and decongestants before scanning, and others may be clinically well at the time SSCT is performed. Obviously, the reliability of results are expected to suffer.

The greatest contention regarding SSCT concerns the question of validity. The very premise that SSCT can accurately depict disease has itself not been satisfactorily defended in the literature in the subgroup of patients who were studied. Indeed, there are significant data to indicate that SSCT can be used to determine whether a given patient has anatomy consistent with one of five well-described CT patterns. Proponents contend that classification according to these patterns allows diagnosis of the specific type of sinonasal disease pattern from which a specific patient suffers (2). Although intuitively appealing, little convincing data supporting this notion are found in the literature. Most important, data that directly correlate clinical outcome with SSCT findings are preliminary at best. From a formal perspective, this is borne out by the fact that there are no widely accepted figures for the sensitivity and specificity of SSCT.

One final confounding issue concerning validity is the population examined in the initial study. The study cohort consisted of patients who were reportedly all candidates for endoscopic sinus surgery as determined by otolaryngologists (1–3). It would be ill advised to extend findings from that study group to all persons with purported sinonasal disease. Even when the referral for SSCT came from the appropriate specialists, approximately 3% to 5% of the patients were determined to have significant disease that was outside the realm of inflammatory sinonasal disease (1–3).

Is a Highly Specific Confirmation Test Available?—No, not really. In fact there are competing standards of reference: the resolution of symptoms versus the resolution of disease at imaging. Correlation with both reported symptoms and findings at nasal endoscopy is currently the best standard of measurement. Most head and neck physicians do not perform maxillary antrum puncture, aspiration, and culture, which would be the ideal confirmatory test. The lack of these data makes validation of SSCT more difficult from an epidemiological basis. Moreover, the data offered as evidence of validity, the assignment of patients into groups on the basis of established categories of abnormal anatomy, are suspect because the degree of concordance of anatomic variations or ostiomeatal unit opacification is known only for highly selected patient populations (12, 13). Informed scientific decisions, therefore, are educated guesses at best, especially for "all comers," or those patients not thoroughly screened or treated by clinicians experienced with complicated sinusitis. Given that the subgroup for which data are available is highly selected, application of these results to the general clinical setting may not be prudent.

Is There an Efficacious Means of Intervention?—The answer to this question is Yes. One of the largest studies in which the results of endoscopic sinus surgery were evaluated in carefully and appropriately selected patients suggests a long-term benefit (14).

SSCT in the Real Medical World

The precise role of SSCT is not widely understood. The most clearly defined role in the literature is that the scope of the test is to identify the presence or absence of anatomic variants that predispose people to inflammatory sinonasal disease. Unfortunately, to many referring clinicians, the role has been broadened simply to diagnose the presence or absence of sinusitis—something that is difficult to do, as there are no findings considered pathognomonic for sinusitis. An even greater danger is when more generalized clinical findings, such as headache and facial pain, are attributed to "sinusitis" and that the SSCT will be ordered inappropriately.

Although SSCT may be performed at significant cost savings over that of a full study performed with contrast material, the savings potential is reduced when contrast material is eliminated. As a general rule, in the absence of known malignancy, contrast material is not administered at our institution; therefore, the cost benefit claimed is most likely overstated. The greatest difficulty with cost arguments is that this test, which is incompletely validated, may become the standard of care for all patients. This may be a significant, albeit unwarranted, end result of the SSCT protocol. Although its proponents do state limits to the SSCT method, they do so only as subtext to the greater argument that they believe the method works.

Clinical Problems

Here are the problems that none of us anticipated. First, the symptoms of sinusitis are nonspecific. Is there a more unenlightening and nonspecific complaint than headache, a symptom that may result from something as benign as a stressful day in a busy radiology department to a subarachnoid hemorrhage from a ruptured intracranial aneurysm? Or nasal stuffiness and facial pain—again, nonspecific findings. Either could portend anything from garden-variety bacterial sinusitis to invasive fungal sinusitis, adenoid cystic carcinoma with perineural extension up the vidian canal, or a melanoma of the nasal mucosa.

In the "real medical world," referral sources may include nurse practitioners, physician assistants, and physicians ranging from generalists to head and neck surgeons. Our level of confidence in an SSCT ordered by an internist, regardless or how proficient a physician, should be different from that in one requested by a head and neck surgeon (keeping in mind, of course, argument number one, that malignant disease of the paranasal sinuses may have a fairly benign presentation). A wider range of clinical presentations constituting "inflammatory sinonasal disease" should be expected from the non–head and neck surgeon, which may result in a higher proportion of patients with symptom origins that are beyond the limits of SSCT to depict. Once again, data concerning this point are not found in the literature.

The number of aggressive infectious or neoplastic lesions we've seen on SSCT studies is astounding. But even more dramatic has been the fact that "malignant" radio-

logic characteristics were overlooked by radiologists interpreting the films. Maybe even the radiologist has been lulled into assuming that patients referred for SSCT just have "inflammatory disease." Perhaps the most incredible example we've seen is the young patient with acute headache referred from a local emergency department for an SSCT to "rule out sinusitis" as a cause of the headache. Although the sinuses were normal, the radiologist missed the subarachnoid hemorrhage. Figure 1 shows a young man scanned for "headaches, rule out sinusitis." With zoomed coronal images only, it is likely that the colloid cyst and mild hydrocephalus would have been missed. We've seen two patients in the past 12 months referred for SSCT to evaluate facial pain in whom the initial interpretation was "normal sinuses," despite the obvious widening of the vidian canal and perineural extension from adenoid cystic carcinoma of the palate (Fig 2). Numerous cases of squamous cell carcinoma, melanoma, metastases, and invasive fungal disease have been evaluated initially with SSCT, despite rather impressive clinical symptoms, because when the referring physician ordered a sinus CT, it was assumed to mean an SSCT (Fig 3). Although we agree that presentation of anecdotal evidence is less compelling than is solid prospective clinical data, the former are more readily available at this time. Moreover, the nature of several of these cases provides an opportunity for reflection upon the application of the test in the real world.

Are these problems with SSCT regional? We doubt it. Given the lack of appropriate consultation before imaging (often the lack of consultation is the norm as opposed to the exception), combined with the confusion surrounding SSCT, it is certainly prudent to gather more data than less on all persons imaged.

What Do We Recommend and Why?

In the adult population, there is rarely a role for imaging in acute sinusitis, unless complications are suspected. Sinus CT is therefore reserved primarily for patients with recurrent or chronic sinusitis. In our department, we begin by asking all patients to fill out a comprehensive questionnaire to identify relevant clinical information (see Table). We prefer to image the patient after maximum medical treatment, so that any remaining disease is likely to be due to chronic infection/inflammation. Also, anatomic variants can be better appreciated when sinus and ostial opacification are reduced. The prone position is preferred, and we do not routinely pretreat with nasal vasoconstrictors. In most cases, imaging is then performed in both the transverse and coronal planes without contrast material. Axial images are obtained in both bone and soft tissue windows and are not zoomed, allowing visibility of the brain parenchyma. Coronal images are zoomed, and are photographed at bone windows only. The decision not to photograph soft-tissue contrast on coronal images was made because of the frequent presence of amalgam artifact on the coronal images, decreasing visibility of the intracranial contents. In this way, we are actually evaluating all the information that was obtained, and not "throwing away" part of it by casting a blind eye upon it. This approach casts the widest screening net that is within reason and practicality for the initial radiologic evaluation.

Fig 1. A 20-year-old man referred by a neurologist for SSCT. Request read, "Headaches, rule out sinusitis." On this axial image, note the small colloid cyst and mild hydrocephalus. The examination was acquired with prospective bone algorithm, which explains the "noise." The paranasal sinuses were normal.

Fig 2. Two patients, both with adenoid cystic carcinoma of the palate with perineural spread via the vidian canal. Both were referred for SSCT; requests read, "Rule out sinusitis, facial pain."

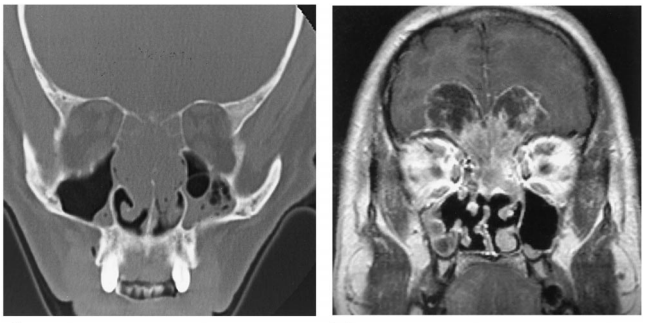
A, This scan in a 47-year-old woman was initially interpreted as "normal paranasal sinuses, no sinusitis." The perineural spread and widening of the greater palatine foramen (*arrow*) were not appreciated.

B, Different patient, same initial scan interpretation. The subtle destruction of the posterior maxillary sinus wall (*arrow*) was overlooked, as was the widening of the pterygopalatine fossa.

Once initial evaluation is complete, follow-up examination can be tailored specifically. The SSCT may indeed have a role to play in this regard, especially in persons who prove to have no disease outside the paranasal sinuses. Conversely, patients who do prove to have lesions suggestive of malignancy or gross and advanced inflammatory disease may actually benefit from follow-up contrast-enhanced MR imaging.

Summary

Given the lack of rigorous and formal validation, we believe that the use of SSCT as a single test for all persons with purported inflammatory sinonasal disease is a mis-



A B

Fig 3. A 70-year-old man with nasal obstruction and "chronic sinusitis."

A, Initial SSCT was interpreted as showing polyposis. Note subtle lytic changes of the skull base. These were not noticed by the radiologist, and the patient had endoscopic sinus surgery for resection of the "polyposis." The surgeon encountered massive blood loss during the procedure, which was terminated before complete resection of the nasal mass.

B, T1-weighted (500/20/1 [repetition time/echo time/excitations]) contrast-enhanced coronal MR image shows the postsurgical findings (right medial antrostomy, partial resection of nasal cavity mass) as well as the intracranial extension of the esthesioneuroblastoma.

Patient questionnaire administered before performing sinus CT

1. Who is your doctor?
2. Have you had this study before?
3. Describe your symptoms.
4. Specifically, do you have:
   - Sinusitis?
   - Allergies?
   - Hay fever?
   - Headaches?
   - Facial pain?
   - Toothache?
   - Visual problems?
   - Problems with your sense of smell?
   - Problems with your sense of taste?
5. How long have your symptoms persisted?
6. Please describe treatment and state whether it was medical or surgical.
7. Any other information that you feel would help in diagnosing your condition?

take. To evaluate this notion further, we have undertaken a prospective study at our institution to compare directly the CT findings obtained with our technique versus those obtained with SSCT. We encourage others to do the same. Until then, however, we must contemplate what we learn from the several anecdotal cases presented above. We have seen significant, serious pitfalls associated with the universal use of SSCT. Careful and meticulous imaging, done in a cost-effective manner, should be performed until all reasonable origins of symptomatic complaints are either identified or formally excluded. The final caveat remains that, although most sinus CT examinations will show benign inflammatory changes, an occasional patient will have malignant or aggressive disease; all scans should be carefully scrutinized for subtle findings, including bone destruction or atypical disease patterns.

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