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Fungal Sinusitis: Diagnosis with C. T. and M. R. Imaging

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Abstract

Fifteen patients with surgically proven diagnosis of fungal sinusitis were examined by plain film, CT and MRI. Plain films revealed calcifications within the sinuses in 8 cases while CT showed calcifications either in the form of a cast or of focal calcifications in 11 cases. The remaining 4 cases were false negative by CT. The attenuation of the calcifications was always above 120 HU. MR showed a characteristic signal pattern in the form of a central signal void within the sinus representing the fungal ball surrounded by a hyperintense rim on the T2-weighted images representing the inflamed mucosa. Following contrast media injection there was a strong enhancement of the inflamed mucosa but not of the central void or mycetoma. The void caused by the mycetoma ball may either be due to the calcifications or the presence of trace amounts of manganese and magnesium, as well as by the decreased water content of the mycetoma balls and the high concentration of its protein content, being above 40%. MRI gave us important information about the content of the sinuses allowing the differentiation of lesions which are otherwise indistinguishable by CT. Still MR seems to be not specific as the above-mentioned characteristic signal pattern could be seen in patients with mucocele, acute intrasinus hemorrhage, partially aerated and inflamed paranasal sinuses, dentigerous cysts of the maxillary sinuses and postoperative sinuses with fibrosis. To differentiate between these different entities, one has to resort to CT.

Introduction

FUNGAL sinusitis affecting the paranasal sinuses appears early as a circumferential mucosal inflammation forming a central ball and later extending into the surrounding structures such as the nose, orbit and intracranially [1]. Clinically, fungal sinusitis can not be differentiated from chronic polypoidal hypertrophic sinusitis. Both are manifested by a triad of nasal discharge, pain and tenderness related to the inflamed sinus and nasal obstruction [2]. Plain film may show a mucosal thickening or opacification of the paranasal sinuses, but can only suggest a fungal sinusitis in the presence of dense concretions which are due to the calcium deposition within the necrotic material of the fungal balls [3]. This is seen in approximately 50% of patients [4]. They vary in size from 2-10 mm, but may reach up to 20 mm. Most are solitary concretions and they result in a gritty appearance on the plain and CT images. On CT the densities may range from 120 till 800 HU. Other radiological findings seen on plain films and CT are concentric or polypoidal thickening or complete opacification of the sinuses or intracranial extension in the form of destruction of the bony boundaries. The most common sinuses involved are the maxillary sinuses followed by the ethmoid, frontal and sphenoid sinuses [5]. Histochemical analysis such as kossa stain and Dahl method for calcium analysis proved that the concretions consisted of tertiary calcium phosphate deposited in necrotic areas of mycelium [6]. MRI appeared to show some characteristic findings in fungal sinusitis [7].

We attempted to analyze the signal pattern of fungal sinusitis on MR and to see if it has specific appearance and compared the sensitivity of plain films and CT to MR in diagnosing fungal sinusitis.

Patients and Methods

The study population included 15 patients. 9 were females and 6 were males. Their age ranged from 22 till 58 years, with the mean age of 42.

The most common complaints were those of chronic sinusitis which included headache, nasal obstruction, nasal discharge, characteristic pain radiating to the upper molar teeth and tenderness of the involved sinuses. All patients were examined by plain films which included a sinus view, direct PA and lateral view.

All patients were examined also by CT and by MRI. Some patients had CT before MRI while others had MRI before CT. The CT examination was performed on a Philips scanner as well as on a Somatom ART (Siemens, Iselin). The patients were scanned first in the coronal view with a slice thickness of 3.0 mm in the osteomeatal complex region and 4.0 mm in the rest of the paranasal sinuses. We started anteriorly at the level of the fronal sinuses and extended the examination till the sphenoid

sinus. Other parameters included 5-sec. scan time, 450 mAs and 125 Kvp. This was followed by an intravenous contrast study and was finalized by axial views of the paranasal sinuses with the same parameters mentioned above.

To evaluate the presence of calcifications or fungal concretions, all examinations were performed initially without administration of contrast media. The CT scans were analyzed for the presence and extent of soft tissue masses in the paranasal sinuses and extension into the nasal cavities, into the orbit or intracranially, areas of increased attenuation in the soft tissue masses in the form of casts or concretions, and extent of bone erosion. For optimal evaluation of paranasal soft tissue masses and simultaneous demonstration of calcifications, a window width of approximately 2000 and a level of -200 were used [3]. The attenuation of paranasal sinuses soft tissue masses is similar to those of orbital rectae muscles. Fungal concretions were suspected if areas of increased attenuation in the sinus masses appeared denser than the intraorbital musculature. In those cases with calcifications the window seems to maximally enhance the contrast between the increased attenuation, a suspected fungal concretion and the surrounding inflammatory tissue (window width of 300 and level of 30) [1].

All patients underwent MRI study and were studied by a Philips 1.5 Tesla superconductive magnet or by a Siemens 1.0 Tesla superconductive magnet with a head coil. The T1 weighted images were obtained with a short repetition time (TR) 200-800 msec. and a short echo time (TE) 20-40 msec. The T-2 weighted images were obtained with a long TR and a long TE (2000-2500/60-80). Images were reconstructed with a 256 x 256 data matrix. The slice thickness was 5 mm. After the acquisition of the T1 and T2-weighted images, intravenous gadolinium was injected and TR weighted images were performed again in the axial, sagittal and coronal views. The signal intensities of the nasal cavity and paranasal sinuses on T1 and T2-weighted images were compared with those of the normal turbinates mucosa.

The first 4 patients were originally diagnosed by CT and MRI as chronic polypoidal hypertrophic sinusitis, but this diagnosis was revised after we received the operative report. All other ten patients were immediately diagnosed by the radiological methods as fungal sinusitis. The patients were examined in the Radiology Department of the Cairo University Hospital, Egypt, and in Dr. Erfan Hospital, Jeddah, Saudi Arabia. The patients were examined over a period of approximately three years. The criteria used for diagnosing a fungal disease on plain films and CT was the presence of foci of increased attenuation within the sinuses associated with mucosal thickening, complete opacification of the paranasal sinuses, possible bone

destruction or bone sclerosis of the walls of the paranasal sinuses and partial or complete obstruction of one or both nasal cavities. The criteria used in MRI were the presence of hypointense signal within the sinus, most pronounced on the T2-weighted with the other above-mentioned findings. All patients underwent surgery in the form of evacuation of the involved paranasal sinuses.

Histopathological examination of the tissue removed at surgery included the search for the presence of fungal disease, calcifications and hemosiderin deposition by Prussian blue stain.

Results

Fungal sinusitis was diagnosed in 15 patients. The diagnosis was based on the presence of fungal balls or mud during surgery and after histopathological examination of the tissues removed during surgery.

Plain film suggested the diagnosis of fungal sinusitis in 8 patients. The maxillary sinuses were involved in 14 cases, 8 were bilateral. The ethmoid sinuses were involved in 12 cases, while the frontal sinuses were involved as frequent as the sphenoid sinuses in 7 cases. Unilateral disease was seen only in 2 patients, while all the other patients had bilateral disease involving the various sinuses.

Clinically, there were no specific symptoms that would suggest the diagnosis of fungal sinusitis.

The plain film and CT findings were: Complete opacification of at least one of the paranasal sinuses and it was this sinus that showed dense concretions within. These dense concretions which suggested the diagnosis of fungal sinusitis were seen in 8 patients on plain films and in 12 patients on CT (Fig. 1, 2 and 4). CT, being more sensitive in detecting calcifications especially in such a complex anatomic area where there is a large superimposition between the various bony structures of the paranasal sinuses and the skull bones. The most persistent and characteristic finding was the presence of decreased signal intensity on the MR images mainly on the T2-weighted MR images (Fig. 4). Thus, plain film was false-negative in 7 patients, while CT was false-negative in 4 patients and MR suggested the correct diagnosis in all cases. The calcification being an important diagnostic criterion in the diagnosis of fungal sinusitis was further analyzed. The lowest CT number was 120 HU, while the highest was 800 HU, and the mean was 422 HU. These areas of focal hyperattenuation varied in size. The smallest measured 4 mm in diameter, while the largest nearly formed a cast of the maxillary sinuses and measured 22 mm at the greatest width (Figs. 1 and 2).

As regards the intracranial and intraorbital extension, MR was as sensitive as CT in demonstrating intraorbital (4 cases) (Fig. 4) and intracranial (3 cases) extension (Figs. 4 and 5).

The MR images were all analyzed and the short TR/TE images demonstrated that the fungal mass was iso-to hypointense compared with the normal mucosal turbinates. On the long TR/TE images there was a greater decrease intensity being similar to air (Fig. 4), while the intensity of the adjacent mucosal thickening increased markedly. The signal pattern is shown in Table 1 and is compared to the signal pattern of other causes of sinus pathology, such as bacterial sinusitis or polyps. The appearance of bacterial sinusitis may sometimes be confused with fungal sinusitis as both conditions show a central void or decreased signal intensity on the T2-weighted images (which is caused by the fungal ball in fungal sinusitis and by air in the bacterial sinusitis) surrounded with a peripheral hyperdense

Table (I): MR Signal Pattern of Different Sinus Content.

Sinus Content	MR Signal Intensity		
	T 1-weighted	PD-weighted	T2-weighted
Chronic secretions pastelike consistency	Low	Lower than on T1 -weighted sequence	Lower than on PD-weighted sequences or signal void
Dessicated, rocklike	Signal	Signal void	Signal void
Mycetomas, cheesy consistency	Low	Lower than on T1 weighted sequence	Lower than on PD-weighted sequences or signal void
Dessicated, rocklike	Signal void	Signal void	Signal void
Hemorrhage (< 24 h)	Low	Lower than on T1 weighted sequence	Lower than on proton density-weighted sequence (n=2) or signal void (n=1)
Tooth in dentigerous cyst	Signal void	Signal void	Signal void
Fibrosis in postoperative sinus	Low	Low	Lower than on PD-weighted sequences

Fig. (1): Case 1: CT shows cast-like homogenous calcification best seen in the center of the right maxillary sinus representing the partially calcified fungal ball surrounded by a hypointense rim representing the inflamed and edematous mucosa.

Fig. (2): Case 2: Marked calcification representing a calcified fungal balls filling both maxillary and ethmoid sinus.

Fig. (3): Case 3: Coronal, post-Gadolinium T1 weighted MR images showing central hypointensity in both maxillary sinuses representing the fungal ball surrounded by an enhancing rim of inflamed mucosa.

signal due to the mucosal thickening. Paranasal neoplasms have a lower signal intensity than allergically or bacterially infected mucosa and usually shows intermediate signal intensity on the T2 weighted images. They should not be confused with fungal sinusitis because of the different signal patterns, but may be confused in cases where there is intraorbital or intracranial extension.

During the course of our work, we encountered 3 cases that showed decreased signal intensity in the central part of the sinus that were not proven to be fungal sinusitis. Two cases proved to be mucocele of the sinus containing a central inspissated or past-like or rock-hard material,

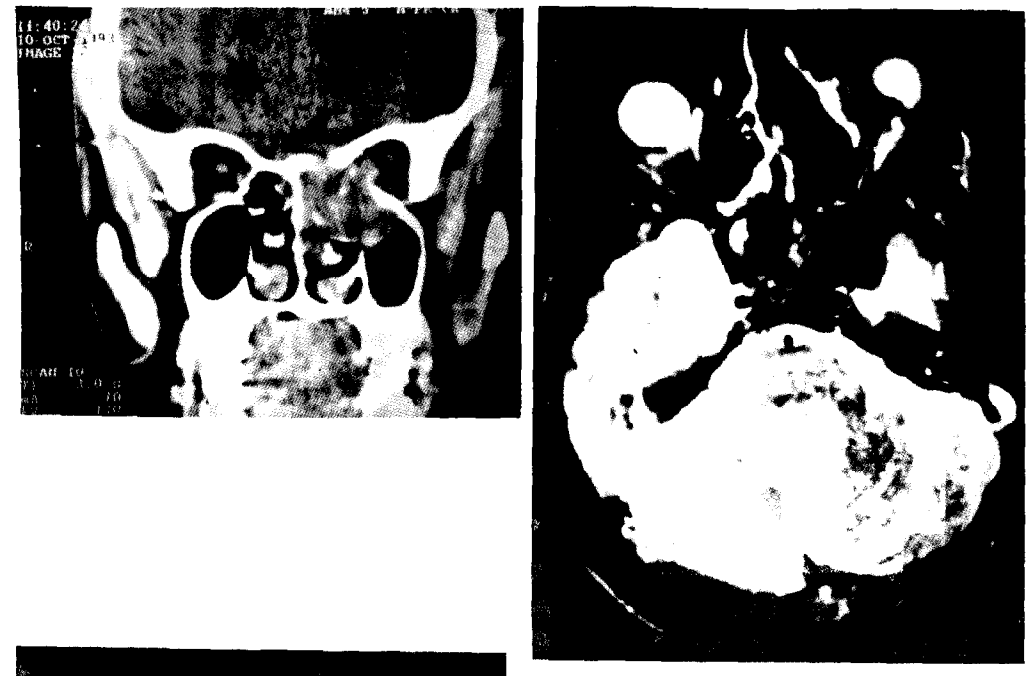

Fig. (4): Case 4: Coronal CT (A) showing fungal disease involving the left ethmoid and maxillary sinuses with foci of calcification within. Evidence of intraorbital and intracranial extension. The Axial T2 weighted MR images (B) show a signal void in the ethmoid sinus with invasion of the apex of the left orbit. Coronal Post-Gadolinium MR (C) showed a characteristic centrum hypointensity in the left ethmoid sinus surrounded by peripheral enhancement of inflamed mucosa.

Fig. (5): Case 5: Sagittal T1 weighted post-Gadolinium MR showing fungus sinusitiis with large sub-frontal intracranial extension. The intracranial component shows a central hypodensity suggestive of the fungal ball surrounded by peripheral enhancement representing inflamed mucosa and dura.

while the third case proved to be acute hemorrhage into the sinuses as already mentioned. All 3 cases are not included in our study.

As regards the laboratory findings, the use of Von Kossa stain and Dahl method for calcium analysis revealed the presence of calcium in each of the fungal specimens.

Discussion

Fungal sinus disease may appear in two forms. A slowly progressing extramucosal fungus ball usually caused by Aspergillus species or in immunologically compromised patients, as a fulminant infection usually caused by mucomycosis. The extramucosal fungal sinusitis is more common in dusty, damp, tropical countries such as in Egypt and Saudi Arabia, and usually develops as a saprophytic growth in retained secretions in a sinus cavity.

The disease appears to be more frequent than previously recognized [5]. This may be related to increased recognition because of increased availability of sophisticated equipment in today's time. Since fungal sinusitis usually requires surgical intervention, accurate preoperative radiological diagnosis is important for the Clinician. The typical course of the disease is that it starts first as a chronic sinusitis that does not resolve with antibiotic therapy or normal saline sinus irrigation [6]. Typically, however, the true identity of disease is not recognized until surgery, where usually a brownish muddy substance is seen filling the sinus. The treatment usually involves removal of the fungal ball, the restoration of the mucociliary drainage and this should be followed by biopsy of the mucosa of the sinus to evaluate mucosal invasion [7].

Plain film and tomography usually shows in the early cases circumferential mucosal thickening with characteristic absence of air fluid level followed by complete opacification of the sinus, wall destruction and rarely wall sclerosis and a somewhat characteristic increased attenuation within the fungal ball which is usually seen in 50% of cases [8]. These focal hyperattenuations may appear as focal concretions or may form a diffuse increased density of a cast of the sinus and were extensively studied by Stammberger at al [9] and were found to represent calcium phosphate and calcium sulfate deposits within necrotic areas of the mycelium. These characteristics, however, are insufficiently nonspecific so that distinction between chronic sinusitis and neoplasms or other sinus pathology remains difficult [10]. On CT study, the abovementioned changes, as well as the calcifications were better seen because of the multiplanner direction of CT and because of its ability to visualize lesions in thin cuts without any overlap. Plain film or CT could measure the density of the concretions. Our results correlate well with those of Stammberger et al [11] as regards the incidence of calcifications within the sinus which is the most specific finding as regards the plain film and the CT. The only differential diagnosis of a hyperintense structure in the sinus is a dentigerous cyst or the presence of a foreign body in the sinus (sinolith) [12].

Unfortunately, plain films show calcifications (the only characteristic finding) in only 50% of cases. CT proved to be slightly more specific but also not conclusive as shown in our results, as only 11 patients were shown to have calcifications within the sinus. Furthermore, osteoma, osteoblastoma, as well as osteogenic sarcoma may sometimes give a similar appearance to an invasive fungal disease on CT [12].

MRI proved to be more specific than CT a shown in our cases. The characteristic finding is the presence of a decreased signal intensity on the T1 and a signal void on the T2-weighted images which arise from the center of the sinus and represents the fungal ball surrounded by a characteristic thin rim of hyperintensity which represents the inflamed surrounding mucosa. The cause of the decreased signal intensity arising from the fungal ball was extensively studied and was suggested to he partly caused by the calcium in the calcification [10]. Still this would not explain the signal void in patients who do not show any calcification on the plain film or on the CT and Stammberger et al [11] after studying samples of the fungal balls by absorption spectrometry showed high concentration of magnesium and manganese within the fungal ball with higher concentration then seen in bacterially infected sinuses. The concentration of iron was also studied by them, as it is known that iron and hemosiderin cause a decreased signal

intensity on the T2-weighted images and this was found elevated only in patients with chronic hemorrhage [10]. Thus, after evaluating T1, proton density and T2weighted images, we showed a fairly characteristic appearance and a definite difference between fungal sinusitis and its differential diagnosis which is bacterial sinusitis or malignant neoplasms of the sinuses. Our study showed that MRI was correct in all patients. Towards the end of our study, we examined 3 other patients which showed an appearance similar to that of fungal sinusitis which is a signal void in the center surrounded by a hyperdense rim but was proven by surgery to be two cases of mucoceles containing paste-like and rock-like chronic secretions, and one patient with acute hemorrhage in a leukemic child.

After reviewing the literature, we realized that MRI usually gives us a plethora of information in the form of signal patterns which gives us important information about the content of the sinuses. The appearance of a central signal void surrounding a hyperdense rim which was thought to be specific for fungal sinusitis can be seen in five conditions [10]. The first condition is in patients with fungal sinusitis infected with aspergillus fungus and the cause of the decreased signal intensity is the presence of calcium and other minerals such as magnesium and manganese and because of the lack of hydration of fluid within these fungal balls or mycetomas which becomes thick, cheesy or may even have solid stony consistency. The second cause for this characteristic signal pattern is mucoceles and where the signal void represents chronic inspissated secretions and dried polyps in which the mucous protein concentration is greater than 35-40%. At this concentration at all the free water and some of the bound water have been eliminated resulting in a signal void on the T2-weighted images on MRI. This has been extensively studied and was shown that below this protein concentration, the secretions are liquid in nature while above this within the concentration the secretions rapidly progress towards a thick paste or dessicated solid rock-like substance [10].

The third cause of this signal pattern is seen in acute intrasinus hemorrhage where at least two major factors account for the low signal intensity. The first is the susceptibility effect of deoxyhemoglobin which causes a local field heterogenecity and thus T2 shortening. The second factor results from the formation of a fibrin clot which effectively squeezes the serum from the remaining protein complex, and thus the clot represents a poorly hydrated, semisolid, macromolecular protein mixture that causes a decreased signal intensity on the T2-weighted images [12]. The fourth cause is the presence of a dentigerous cyst within the sinus while the fifth cause is

the presence of air in a partially inflamed sinus. Air not containing any water molecules will again give a signal void.

The obvious problem realized by us and others [12] is that although MRI can give us a large amount of information about the nature of the sinus secretion and content, it may in specific cases not give us the final diagnosis and it is CT which may differentiate between the above-mentioned entities. CT will easily distinguish between the above five mentioned substances. CT will clearly show the air within a partially inflamed sinus. In patients with dentigerous cyst, the lesion will always be in the maxillary sinus and the sinus will be expanded and the tooth will always be in an eccentric location rather in a central location in patients with mucocele or fungal affection and CT will clearly show that we are dealing with enamel or with a tooth. Chronic secretions, mycetomas and hemorrhage will appear as a soft tissue on CT and can easily be differentiated from a dentigerous cyst or air within an inflamed sinus. In conclusion, we believe that MRI can give us a plethora of information about sinus disease and one should analyze this large amount of information before reaching a diagnosis. Although the characteristic appearance of fungal sinusitis has been shown in MRI, still this appearance may be seen in partially inflamed sinuses, acute intrasinusal hemorrhage, dentigerous cysts and rarely in postoperative sinuses with fibrosis and scar. Once this characteristic pattern of central signal void surrounded by a hyperdense rim is seen on the T2-weighted images, one should resort to CT in coronal view to differentiate those entities from each other.

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