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The prognostic value of gadolinium-enhanced magnetic resonance imaging in acute invasive fungal rhinosinusitis

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KEYWORDS

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Summary Objectives: This study aimed to assess the prognostic value of gadolinium (Gd)-enhanced magnetic resonance imaging (MRI) in acute invasive fungal rhinosinusitis (AIFRS) and offer recommendations for determining surgical extent based on loss of contrast enhancement (LoCE), which reveals tissue ischemia from fungal invasion.

Methods: Preoperative and postoperative Gd-enhanced MRI was evaluated in 21 patients with confirmed AIFRS who underwent wide debridement and antifungal therapy. Patients were subdivided by AIFRS-specific survival. LoCE and contrast enhancement (CE) of intrasinonasal and extrasinonasal sites in preoperative and postoperative MRI were compared between the two groups.

Results: All patients had preoperative intrasinonasal LoCE and CE lesions, which did not differ between survivors and non-survivors. Bone destruction on CT was detected in 8 of 16 survivors (50%) and 4 of 5 non-survivors (80%). Intrasinonasal LoCE lesions were completely removed by surgery in all cases. Postoperative extrasinonasal LoCE lesions were found in all non-survivors but no survivors ($p < 0.001$). However, postoperative intrasinonasal and extrasinonasal CE lesions were detected in both survivors and non-survivors ($p = 0.119$ and $p = 0.111$, respectively). In addition, remission of hematologic diseases at the time of diagnosis of AIFRS and blood sugar control in diabetic patients were significantly associated with AIFRS-specific survival ($p = 0.028$ and $p = 0.023$, respectively).

Conclusions: LoCE lesions, which have to be surgically removed, should be screened using Gd-enhanced MRI for an earlier diagnosis of AIFRS, determination of surgical extent, and

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management of follow-up. Remnant LoCE lesions after surgery, active hematologic diseases, and poorly controlled blood sugar adversely affect the AIFRS-survival.

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Introduction

The rapidly progressive and destructive sinonasal pathology of acute invasive fungal rhinosinusitis (AIFRS), which most commonly affects immunocompromised patients, is caused by a fungal organism invading the sinonasal mucosa, submucosa, blood vessels, or bone.^{1,2} *Mucor*, *Rhizopus*, *Rhizomucor*, *Absidia*, and other *Mucorales* or *Aspergillus* species are the most common causes of AIFRS. Typical patients have impaired neutrophil function (hematologic malignancies, aplastic anemia, hemochromatosis, AIDS, and organ transplantation), poorly controlled diabetes mellitus, or are undergoing immunosuppression with systemic steroids or chemotherapeutic agents. AIFRS is rarely observed in individuals with normal immune systems.^{1–3}

The mortality of AIFRS remains high (approximately 10%–40%), in spite of improvements in medical and surgical treatment.^{4,5} Prognosis is primarily influenced by early diagnosis and treatment. Treatment includes aggressive and urgent surgical debridement, systemic antifungal therapy, and prompt correction of the underlying systemic disease.^{6,7} An advanced age, intracranial involvement, underlying disease, and surgical resection have been presented as independent prognostic factors in AIFRS.⁸ In particular, disease extent should be accurately assessed to determine the extent of surgical debridement required.

Imaging techniques are used to evaluate suspected AIFRS for early detection and to avoid unnecessary surgery in comorbid patients.⁵ Computed tomography (CT), usually performed in suspected AIFRS patients, typically reveals sinus involvement, bone destruction, and/or extension in the periorbital tissue, facial soft tissue, and retroantral fat pad thickening. Severe unilateral sinonasal mucosal thickening appears to be the most common CT finding of early-stage AIFRS, which means that this finding can be nonspecific, mimicking acute bacterial sinusitis.^{9,10} Thus, AIFRS cannot be detected until bone erosion and/or soft tissue infiltration appears on a CT scan.¹⁰ Groppo et al.⁵ have reported that magnetic resonance imaging (MRI) is more sensitive than CT imaging for detecting early AIFRS changes, with extrasinus invasion on MRI the most sensitive parameter. In particular, MRI is superior to CT for evaluating intracranial extension and providing intraoperative findings for this disease.^{10–12} Hence, MRI is useful for determining areas affected when an aggressive intervention is planned.^{3,5} Loss of contrast enhancement (LoCE) may be a characteristic gadolinium (Gd)-enhanced MRI finding of AIFRS, revealing tissue ischemia secondary to angiocentric invasion of fungal organisms.^{5,13} However, it is unclear whether the extent of debridement can be decided on MRI when a Gd-enhanced lesion is observed on MRI, especially if it is seen in the orbit or brain.

Accordingly, we aimed in our current study to investigate the prognostic value of Gd-enhanced MRI using preoperative

and postoperative MRI findings and to propose guidelines for determining surgical extent based on Gd-enhanced MRI findings in AIFRS.

Methods

Patients

We retrospectively reviewed the medical records and radiological images of 31 patients who were diagnosed with AIFRS by intraoperative histopathology between January 2003 and July 2013 at the Department of Otolaryngology, Asan Medical Center. Preoperatively, contrast-enhanced CT and/or Gd-enhanced MRI were performed. All patients underwent wide debridement via an endonasal and/or external approach to remove lesions. The diagnosis of AIFRS was confirmed by the histopathological features of intraoperative specimens, which were fungal invasion within the sinus mucosa, submucosa, blood vessels, or bone with a time course of less than 4 weeks duration.^{1–3} This study was approved by the institutional review board of the Asan Medical Center.

Twenty-one patients (11 men) who had both preoperative and postoperative Gd-enhanced MRI scans were included to evaluate the prognostic value of Gd-enhanced MRI. Ten patients who had not preoperative or postoperative Gd-enhanced MRI scans were excluded regardless of their clinical characteristics, surgical techniques, or etiology. We subdivided the two groups according to the AIFRS-specific survival.

Images

Twenty patients were examined by precontrast and post-contrast axial and coronal CT scans from the inferior maxilla to the clear frontal sinuses with 2- to 3-mm-thick slices. In all patients, MRI scans of the paranasal sinuses, orbit, and brain were obtained at 1.5 T ($n = 3$) or 3.0 T ($n = 18$). Precontrast T1-weighted images, T2-weighted images with or without fat suppression, and Gd-enhanced T1-weighted images with fat suppression were obtained. MR images were performed in axial, coronal, and sagittal planes with a 4-mm thickness. All CT and MR images read by a head and neck radiologist were retrospectively reviewed. LoCE and CE in preoperative and postoperative MR scans were assessed in the intrasinonasal and extrasinonasal sites. LoCE was defined as a focal lack of enhancement seen on MR imaging.^{5,13} Intrasinonasal lesions were confined to the sinonasal tract, whereas extrasinonasal lesions extended outside this tract.¹⁴ In addition, intrasinonasal and extrasinonasal bone destruction on preoperative CT scans were compared with LoCE on preoperative MR scans.

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