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Computerized Medical Imaging and Graphics 29 (2005) 279–285

Computerized Medical Imaging and Graphics

www.elsevier.com/locate/compmedimag

Fluid-attenuated inversion-recovery MR imaging in assessment of intracranial oligodendrogliomas

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Received 5 April 2004; revised 25 October 2004; accepted 25 October 2004

Abstract

This retrospective study consisted of 17 consecutive patients with oligodendrogliomas. We qualitatively and quantitatively assessed the diagnostic value of fluid-attenuated inversion-recovery (FLAIR) images compared with T2-weighted fast spin-echo (FSE) images for evaluating intracranial oligodendrogliomas. Qualitative evaluations of signal intensity, tumor conspicuity, definition of tumor margin, distinction between solid and cystic-like parts within tumor, and calcification were performed. Quantitative criteria comparing FLAIR to T2-weighted FSE images included tumor-to-background contrast and contrast-to-noise ratio (CNR) and tumor-to-cerebrospinal fluid (CSF) contrast and CNR. Our results demonstrate that the FLAIR sequence can replace the T2-weighted FSE sequence for evaluating oligodendrogliomas.

Keywords: Brain neoplasms; Oligodendroglioma; Magnetic resonance (MR); T2-weighted sequence; FLAIR sequence

1. Introduction

Oligodendrogliomas, one of the three major types of gliomas, are uncommon primary intracranial tumors [1]. They are generally classified as low-grade or anaplastic, corresponding to the World Health Organization (WHO) grade II and grade III, respectively. Most oligodendrogliomas are usually infiltrating neoplasms regardless of the histological grade [2,3]. Treatment of oligodendrogliomas is typically surgical resection followed by radiotherapy and/or chemotherapy. It has been demonstrated that the extent of surgery correlates with survival for oligodendrogliomas [4–7]. Therefore, accurate imaging is critical for assessment of these tumors because exact tumor depiction facilitates, not only diagnosis, but also planning of tumor resection and post surgical radiotherapy.

T2-weighted magnetic resonance (MR) spin-echo (SE) images were originally found to be the most sensitive sequence for detecting intracranial tumors. The fluid-attenuated-inversion-recovery (FLAIR) sequence yields heavily T2-weighted MR images of the brain with almost complete suppression of cerebrospinal fluid (CSF) signal. Many studies have been performed to evaluate the usefulness of FLAIR for imaging intracranial tumors, such as astrocytomas, glioblastoma multiforme, metastases, meningiomas, etc. FLAIR images are usually used as a complementary examination to T2-weighted SE or fast SE (FSE) images in the diagnosis and delineation of these brain tumors [8–11]. The findings from these studies may not extrapolate to imaging oligodendrogliomas in part related to the underlying different pathological processes of these entities. Even astrocytomas, another primary brain tumor, are considerably different pathologically from oligodendrogliomas being comprised of spindle cells with processes instead of the round cells lacking cellular processes found in oligodendrogliomas [12]. Differences in MR imaging

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doi:10.1016/j.compmedimag.2004.10.005

characteristics between oligodendrogliomas and astrocytomas have already been described for MR sequences other than FLAIR [1,4,13,14]. Furthermore, to our knowledge, there are few descriptions concerning the use of FLAIR imaging in the evaluation of oligodendrogliomas. Thus, we have retrospectively reviewed patients with oligodendrogliomas.

Oligodendrogliomas may preferentially involve the cortical gray matter [12]. Moreover, foci of cystic degeneration are relatively common [1]. We, therefore, hypothesized that FLAIR should be superior to T2-Weighted MR imaging for the assessment of oligodendrogliomas. The aim of this study was to qualitatively and quantitatively assess the diagnostic value of FLAIR imaging of oligodendrogliomas compared with T2-weighted FSE imaging.

2. Materials and methods

Seventeen consecutive patients (8 males and 9 females; age range, 15–72 years, mean age, 41.9 years) with oligodendrogliomas and pre-treatment MR studies including both T2-weighted FSE and FLAIR imaging were included. Pre-treatment computed tomography (CT) scans were also available in nine of these patients. The institutional review board at our hospital approved this retrospective study.

MR studies were performed at 1.5 or 1.0 T. T2-weighted FSE images were obtained with TR = 2000–5266 ms; TE = 80–104 ms; and imaging matrix of 256–512 × 160–308. FLAIR images were obtained with TR = 6000–9002 ms; TE = 105–165 ms; inversion time of 1766–2700 ms; and imaging matrix of 256 × 160–192. Both T2-weighted FSE images and FLAIR images were acquired with a section thickness of 5 mm, an intersection gap of 2 mm, and a field of view of 180 × 240 mm. Twenty slices were acquired in each study. All patients also underwent pre- and post-contrast T1-weighted imaging.

All 17 tumors were pathologically confirmed by either resection ($n = 12$) or biopsy ($n = 5$). All of the pathologic specimens were reviewed by a board-certified neuropathologist. Ten oligodendrogliomas were low-grade and seven were anaplastic according to the WHO classification system. Low-grade oligodendrogliomas (WHO II) have even cellularity and little nuclear pleomorphism. There is no necrosis, endothelial proliferation or mitotic activity. They may show microcystic areas. Anaplastic oligodendrogliomas (WHO III) are defined by increased cellular density and pleomorphism with endothelial proliferation, vascular proliferation, mitotic activity, and necrosis [2,3].

FLAIR images were compared with T2-weighted FSE images qualitatively and quantitatively. Qualitative evaluation was performed independently by four neuroradiologists (Y.Z., W.S., M.H., W.S.). The evaluation included: (1) signal intensity; (2) tumor conspicuity; (3) definition of tumor margin; (4) distinction between solid and cystic-like parts within tumor; (5) and calcification. It was then subjectively determined whether the FLAIR images were superior to, equal to or inferior to T2-weighted FSE images.

The tumor signal intensity and signal heterogeneity (homogeneous or inhomogeneous) on FLAIR images were compared with those on T2-weighted FSE images. For assessment of tumor conspicuity and definition of tumor margin, the following three-point scale was used: +1, FLAIR images were superior to T2-weighted FSE images; 0, FLAIR and T2-weighted FSE images were equal; and −1, FLAIR images were inferior to T2-weighted FSE images. Statistical significance was determined with sign test. A bonferroni correction was applied and a significant difference was accepted if the P-value was less than 0.01. In addition, Cohen's κ was used to assess inter-reader agreement.

In assessing the definition of tumor margin, apart from overall impression, interface distinction between the tumor and nearby anatomic structures (ventricle, white matter, and gray matter) were also evaluated separately. Oligodendrogliomas are not typically associated with vasogenic edema and the tumor–edema interface, even though it exists, cannot be easily depicted due to the high signal of tumor and lack of obvious contrast enhancement [1,13,14]. Therefore, the tumor margin was defined as the outermost boundary of the tumoral area demonstrating high signal intensity on T2-weighted FSE or FLAIR images.

The tumoral cystic-like part was defined as that area within the tumor that had signal intensity close to CSF on T1-weighted images, and demonstrated no enhancement on contrast-enhanced T1-weighted image. The evaluation for tumor calcifications on the MR images utilized CT scans as the gold standard for the presence or absence of calcifications.

In 14 oligodendrogliomas for which images were available digitally, the quantitative assessment was performed by two neuroradiologists (M.W., Y.Z.). Tumor-to-background contrast, tumor-to-background contrast-to-noise ratio (CNR), tumor-to-CSF contrast, and tumor-to-CSF CNR were calculated according to the following formula:

$$\text{Contrast} = (S_{\text{tumor}} - S_{\text{B or CSF}})/S_{\text{B or CSF}} \quad \text{and}$$

$$\text{CNR} = (S_{\text{tumor}} - S_{\text{B or CSF}})/\text{SD}_{\text{noise}}.$$

S_{tumor} is the signal intensity of the solid part within tumor. S_{B} is the signal intensity of the background as measured in normal-appearing white matter adjacent to tumor. S_{CSF} is the signal intensity of ventricular CSF. SD_{noise} is the standard deviation of the image noise measured on the image along the phase-encoding direction in an area outside the head. The statistical significance of these quantitative data was determined with the paired t-test. A bonferroni correction was applied and a significant difference was accepted if the P-value was less than 0.01.