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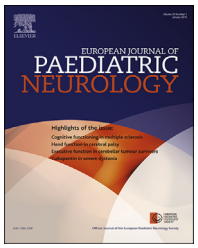

Original article

Analysis of T2 signal intensity helps in the differentiation between high and low-grade brain tumours in paediatric patients

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ABSTRACT

Purpose: Previous studies hypothesized that the analysis of magnetic resonance intensity of the solid portion in paediatric tumours can provide pre-surgical information about the histopathology. Classically, high signal-intensity in T2weighted (T2w) images identifies low-grade tumours, while anaplasia is characterized by T2 hypointensity. We aimed to investigate if T2w signal intensities can pre-operatively distinguish between low-grade and high-grade brain tumours in paediatric patients.

Methods: Two raters, blinded to the histological diagnosis, rated the signal intensity of MR images (T2w) from 36 children with newly diagnosed brain tumours, 17 children with low-grade brain tumours and 19 children with high-grade brain tumours were included in this study. Relative T2 values were obtained by dividing the T2w values of the solid portion of the tumour by the T2w values of the vitreous humour.

Results: The best cut-off point to distinguish low and high-grade paediatric brain tumours was 0.8. If the signal intensity was less than or equal to 0.8 the tumour was expected to be a high-grade tumour with a sensitivity of 100%. Prediction of a low-grade tumour was more uncertain with a sensitivity of 70.5%. Overall, 86% of the tumours would have been predicted correctly.

Conclusion: Our data suggest that T2w signal intensities of the solid portion of brain tumours in paediatrics can pre-operatively differentiate between low-grade and high-grade tumours. In addition, T2 hypointensity may be helpful in targeting stereotactic biopsy.

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1. Introduction

Brain tumours in children are rare, but show a large histopathologic spectrum. Knowledge of the likelihood of histopathology therefore has the potential to influence many aspects of care, especially helping to determine the need of pre-operative staging of the central nervous system in children with an elevated risk of leptomeningeal dissemination, such as patients with medulloblastoma.

Until now, there has been no established method able to reliably identify the most likely histopathology in cerebral neoplasms in childhood with MRI alone. Histopathologic evaluation of brain biopsies still is the gold standard for definitive diagnosis and any MR sequence can only predict histopathology.

Paediatric brain tumours include not only a wide range of histologies, but also sometimes show surprising morphology. However, in general the solid tumour structure tend to be more homogenous in magnetic resonance imaging (MRI) when compared to brain tumour in the adult population, i.e. paediatric brain tumours are less necrotic. This aspect probably explains the use of diffusion in the pre-operative diagnostic in paediatric brain tumours.

Previous studies have demonstrated that diffusion-weighted imaging (DWI) can provide information that complements conventional MRI in brain tumours.[1–4] The authors reported that DWI hyperintensity is suggestive of medulloblastoma,[1–3,5–7] and that the ADC value is prognostic for the survival in patients with brain tumours.[8]

Recently studies have proved the reliability of correlating signal changes in T2weighted (w) image with the histopathological findings in children with cerebellar neoplasms.[7,9] Forbes et al.[9] placed the region of interest (ROI) in cerebellar neoplasms in order to calculate the relative diffusion weighted signal intensity and relative T2 signal intensity of each neoplasm. Their results showed that the measurement of the relative diffusion and T2w signal intensities can be used to predict histopathology in paediatric patients with cerebellar neoplasms.

The aim of our study was to determine whether using relative T2w signal intensities can allow us to distinguish between high and low-grade brain tumours in children.

2. Patients and methods

The study was approved by the local ethics committee.

2.1. Patients

We retrospectively analysed the pre-operative MRI scans of 36 children (20 male, 16 female, mean age 9.5 years, range from 4 months to 17 years) with cerebral neoplasms WHO grade underwent neurosurgery for tumour resection or stereotaxis between February 2007 and January 2014. Inclusion criteria for subsequent analysis were the final histopathological diagnosis of tumour according to the World Health Organization (WHO GRADE) 2007,[10] the availability of initial MR images before any treatment, and T2w images. Only lesions measuring more than 1 cm in diameter were included.

17 children had low-grade brain tumours (10 WHO grade I astrocytomas, 1 WHO grade II astroblastoma, 1 pilomyxoid astrocytoma, 4 WHO grade II astrocytomas, 1 ganglioglioma) and 19 children had high-grade tumours (7 medulloblastomas, 4 WHO grade III ependymomas, 1 PNET, 1 WHO grade III astrocytoma, 2 WHO grade IV astrocytoma, 1 rhabdomyosarcoma metastasis, 1 atypical teratoid rhabdoid tumour, 2 germinomas).

2.2. Analysis of pre-operative MRI findings and data assessment

Pre-operative MRI scans were obtained at 3 T (Magnetom Verio, Siemens Medical Solutions, Erlangen, Germany) with an 8-channel phased array head coil using a standard protocol consisting of axial T2-and diffusion weighted images as well as T1w pre and post contrast images.

Using a dedicated PACS workstation, two neuroradiologists, one with more than ten years' experience in paediatric imaging, analysed the anonymous pre-operative MRI scans.

2.3. Placing of the ROIs

The observers placed ROI in the solid portion of the cerebral neoplasms, and in the vitreous humour for normalization purposes. The core of the tumour was defined based on contrast-enhanced T1w images (cystic, necrotic and calcified areas were excluded). Evaluation was only performed on the solid enhancing area of the tumour; these regions were correlated with on-axial T2w images respectively. In the case of non-enhancing tumours, measurements were based on T2w images (the homogeneous solid area was selected). As a control, T2w measurements were made of the normal vitreous humour.

It was important to confidently identify the more homogeneous area of the tumour. Theoretically, T2-hypointensity may be caused by bleeding; this has to be ruled out with gradient-echo imaging (T2*). For purposes of normalization a ROI was located on the vitreous humour to measure the signal intensity in this site.

Placing of the ROIs is illustrated in Fig. 1.

T2w signal intensity was quantitatively measured using the dedicated standard software of the PACS (Picture Archiving and Communication System). We used a similar measurement to that used by Forbes et al.[9] in the evaluation of cerebellar neoplasms in paediatric patients, but we also included supra- and infratentorial neoplasms.

The relative coefficient values were calculated dividing the T2w values of the solid tumour portion by the T2w values of the vitreous humour. The vitreous humour's T2 signal intensity was used as a reference. The quotient obtained was thus defined as the relative T2w signal intensities of solid component of the tumour. To prove the validity of the measurements of the relative signal intensity for both groups, a ROI was also placed in the normal appearing periventricular white matter.

The scores assigned by the two neuroradiologists were taken for further statistical analysis. The results of these