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Review

Magnetic resonance imaging based functional imaging in paediatric oncology

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Abstract Imaging is central to management of solid tumours in children. Conventional magnetic resonance imaging (MRI) is the standard imaging modality for tumours of the central nervous system (CNS) and limbs and is increasingly used in the abdomen. It provides excellent structural detail, but imparts limited information about tumour type, aggressiveness, metastatic potential or early treatment response. MRI based functional imaging techniques, such as magnetic resonance spectroscopy, diffusion and perfusion weighted imaging, probe tissue properties to provide clinically important information about metabolites, structure and blood flow. This review describes the role of and evidence behind these functional imaging techniques in paediatric oncology and implications for integrating them into routine clinical practice.
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1. Introduction

Functional imaging examines tissue properties relevant to the underlying biology of tumours. Techniques include diffusion weighted imaging and perfusion weighted imaging (DWI and PWI), assessing tissue structure and blood flow, and magnetic resonance spectroscopy (MRS), measuring metabolite profiles.

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These complimentary modalities provide important information about tumour characteristics, allowing derivation of a more complete biological picture.

2. Main techniques in functional imaging

2.1. Diffusion weighted imaging

DWI is based on microscopic water diffusion in tissue. Images acquired with high- and low-diffusion weighting (b-values) are used to develop apparent diffusion coefficient (ADC) maps [1]. ADC values are a quantitative measure of diffusion with an inverse relationship with cellularity [2] that may be useful for tumour characterisation.

DWI requires no intravenous (i.v.) access, contrast injection or compliance with breath-hold techniques. It can be performed on all modern magnetic resonance scanners and standard central nervous system (CNS) protocols have short acquisition times. Protocols used in the body may be longer, particularly if DWI is acquired using several b-values to allow for capillary blood flow. Additional scanning time is typically 30 s for CNS and 2–5 min for body protocols; additional general anaesthesia is not usually required.

2.2. Diffusion tensor imaging

Diffusion tensor imaging (DTI) provides quantitative orientation-specific information about water diffusion expressed by the term 'fractional anisotropy' (FA) [3]. This technique can be used to track nerve fibres in the brain, as diffusion coefficients are higher when measured parallel than perpendicular to myelinated neurones [4]. White matter tracts are visualised through 3-dimensional mathematical models (tractography) or colour coded maps [3] (Fig. 1). Standard acquisition time is 6 min, but may be longer if imaging complex regions with intersecting tracts. Additional i.v. access is not required.

2.3. Magnetic resonance spectroscopy

1H-Magnetic resonance spectroscopy (MRS) enables non-invasive discrimination between different types and grades of brain tumour. Information is provided about intermediary metabolites such as choline (involved in membrane synthesis), mobile lipids (apoptosis and necrosis) and N-acetylaspartate (NAA; neuronal marker) [5]. The relative amounts of the various metabolites are presented graphically in the form of a spectrum (Fig. 2).

MRS can be performed following routine magnetic resonance imaging (MRI) without the need for additional i.v. access or general anaesthesia. Single voxel spectroscopy where data is acquired from a single predefined volume typically adds 5 min to the examination time and is relatively easy to acquire and process. Acquisition and analysis of multivoxel magnetic

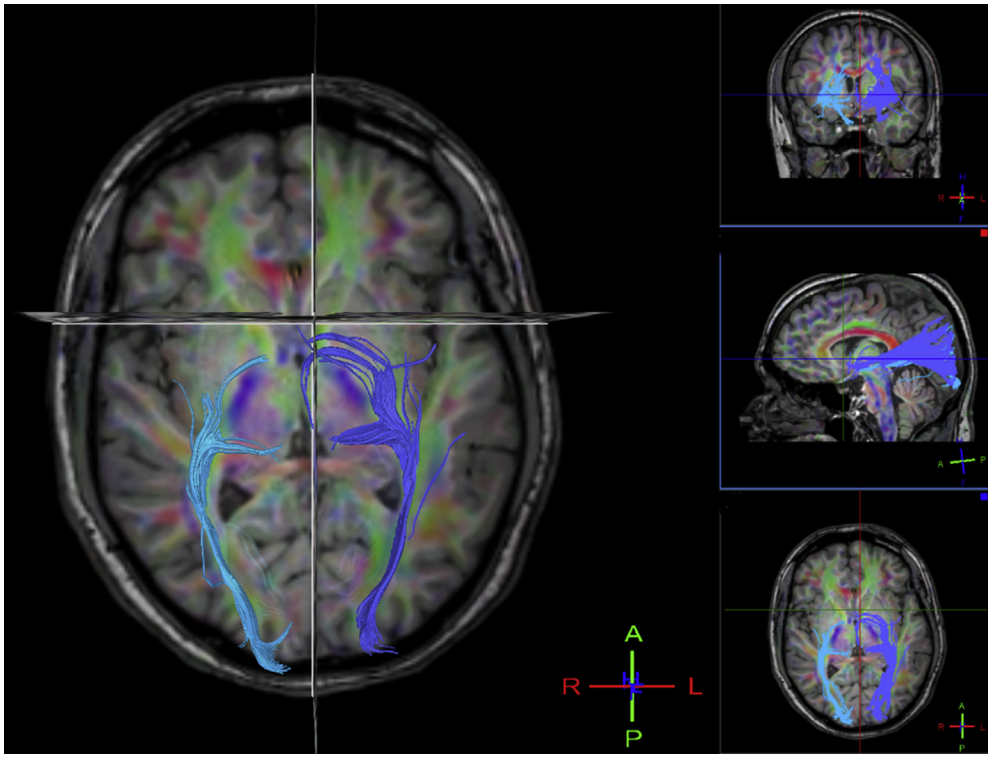

Fig. 1. Diffusion tensor imaging (DTI) demonstrating the optic radiations.

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