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Journal of the Neurological Sciences 250 (2006) 20–26

Journal of the Neurological Sciences

www.elsevier.com/locate/jns

Normal anatomy of the developing fetal brain. Ex vivo anatomical–magnetic resonance imaging correlation

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Received 10 November 2005; received in revised form 20 June 2006; accepted 21 June 2006
Available online 14 August 2006

Abstract

Fetal brain Magnetic Resonance Imaging (MRI) is a new technique of growing interest, with a high potential to detect prenatal central nervous system abnormalities. This requires an accurate knowledge of the normal morphological sequence of brain development. In this paper we studied the cortical development of post-mortem normal fetal brains, correlating MRI estimations of fetal age with *in vitro* anatomical and anthropometric measurements.

Ten post-mortem fetal heads were submitted to MRI. Maturational state of sulci and gyri and gray-white matter differentiation were analysed in the MRIs and by dissection of the brains. The findings were correlated with the previously estimated ages of the fetuses, which varied between 17 and 38 weeks. Consistency between methods was assessed employing intraclass correlation coefficient and Bland–Altman plots, with a 95% confidence interval. Estimations of fetal age obtained by MRI were very similar to those achieved by anthropometric measurements or by considering anatomical parameters. Gyral development proved to be more precise than gray-white matter differentiation for this purpose.

Fetal MRI proved to be as reliable as the macroscopic anatomical examination for depicting normal cortical developmental sequence and age, suggesting that this technique may be a suitable option for achieving precise information about the morphology of human brains along the gestational period.

Keywords: Fetal brain; Cerebral cortex; Development; Anatomy; Magnetic resonance imaging

1. Introduction

Ultrasonography is currently considered the first choice imaging method for routine examination of the fetal brain. However, in-utero fetal brain Magnetic Resonance Imaging (MRI) may show more accurately the morphological changes occurring within the developing brain. Brain abnormalities may, as well, be diagnosed prenatally through careful analysis of morphology and changes in the signal intensities of the different central nervous system (CNS) structures [1].

During the previous 10 years, MRI has largely improved its diagnostic possibilities due to the development of ultra-quick sequences techniques, which enable to obtain quite well defined images in less than 20 s [1]. This procedure proved to be reliable enough for individualising different types of cortices within the normal adult brain [2,3].

These techniques make the sedation of the fetus in utero unnecessary, adding further safety when controlling pregnant women. By using this method, fetuses of only 13 weeks have

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doi:10.1016/j.jns.2006.06.020

been studied with no side effects even in the long term outcome [1].

Fetal MRI may be used when there are suspicions of destructive brain lesions or malformations. Examples of these pathologies are a possible damage of the CNS due to maternal infection with toxoplasmosis, a family history of CNS malformations or genetic defects involving the CNS, or the confirmation of a malformation previously detected by ultrasonography [1].

Obtaining an accurate diagnosis of a fetal brain developmental abnormality undoubtedly requires the knowledge of the normal morphological sequence of brain development.

Previous works have described MRI images of normal fetal brains, correlating their findings with the "gestational" or "post-conceptional age". Some authors have estimated this period considering the number of weeks of maternal amenorrhea [1,4–6], while others have calculated it based upon ultrasonographic measurements [1,4,7,10]. Nevertheless,

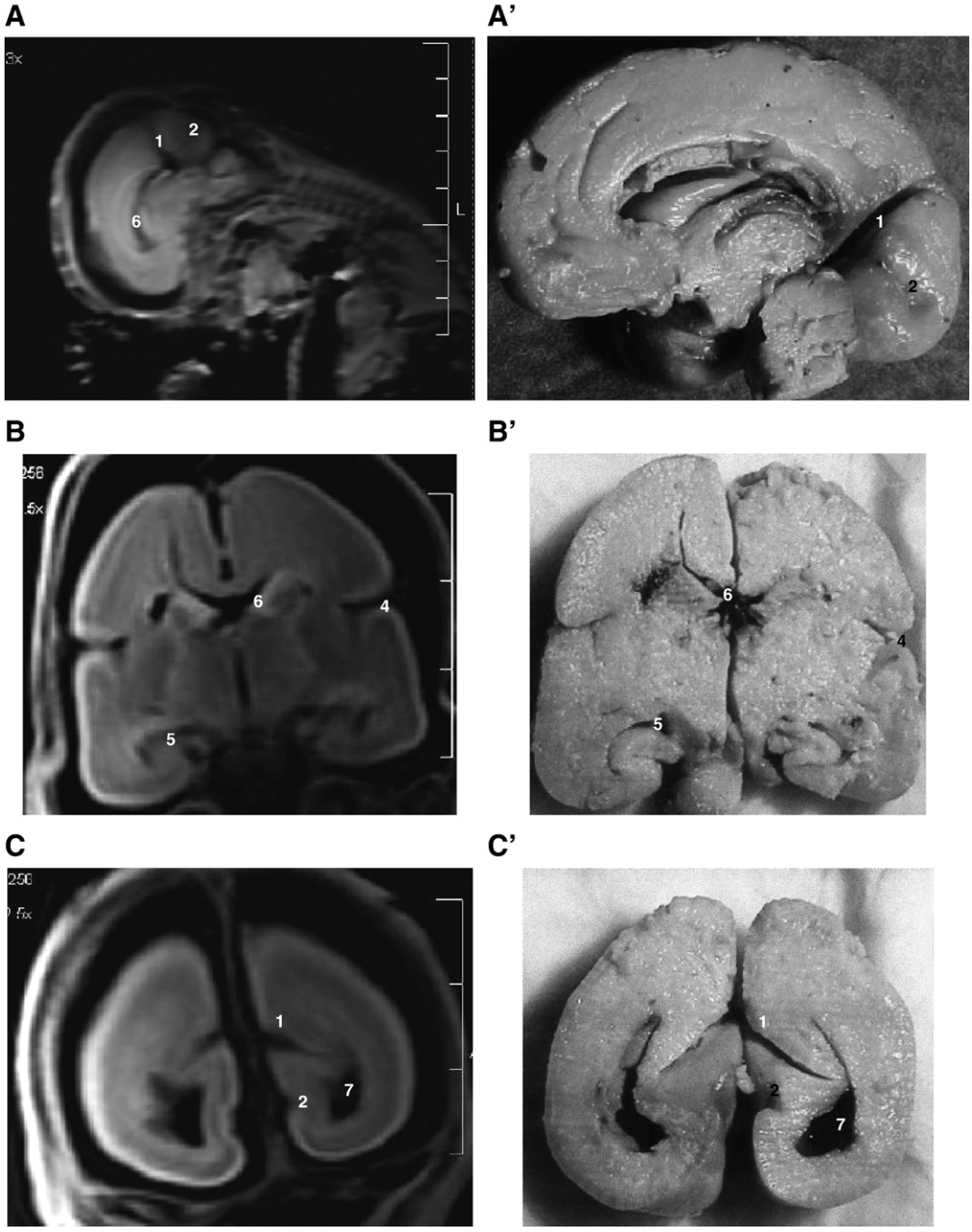

Fig. 1. Magnetic resonance images and anatomical preparations from fetus number 5, post-conceptional age: about 23–25 weeks. A and A': Sagital slice, B and B': coronal geniculocapsular slice, C and C': coronal parietooccipital slice. 1: Parietooccipital fissure, 2: calcarine fissure, 3: cingulate sulcus, 4: sylvian fissure, 5: hippocampic fissure, 6: lateral ventricle, frontal horn, 7: lateral ventricle, occipital horn.