Prematurity and Developmental Plasticity in the Brain

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Introduction

Developmental plasticity may be defined as the ability of cells or tissue to develop in response to their environment. The transition from fetal to postnatal life constitutes a major change in environment, and if this occurs prematurely, then in response it can be expected that there may be a different developmental trajectory from that associated with term birth. It is becoming more widely appreciated that such differences may have a strong influence on long-term health - into childhood and beyond (1). With the advent of modern imaging techniques, neurodevelopmental changes and responses can be investigated in much more detail than was previously possible. This presentation focuses in particular on the effects of premature birth and the role that MRI can play in understanding how prematurity impacts on brain structure and function.

Brain structure and function in children born very prematurely

Advances in perinatal care have led to the survival of increasing numbers of children born very prematurely. However, about 10-15% of children born very preterm (<32 weeks of gestation) or of very low birth weight (<1500g) will develop major neurological impairments, and many others (~20-30% or more) will go on to develop cognitive impairments and/or behavioural problems, often in conjunction with minor neurological signs. Modern MR techniques enable us to examine the neural basis of these impairments, and can provide a key link in relating a wide variety of prenatal and perinatal variables to neurodevelopmental outcome.

MR techniques in the preterm population

Initial MRI studies were usually based on conventional neuroradiological assessment of T1- or T2-weighted images, with a much greater emphasis on the detection of frank lesions than of the more subtle abnormalities that might also be associated with differing developmental trajectories and outcomes. However, more quantitative MR tools and additional contrast mechanisms and methods of analysis are now available. As a result, there is an increasing focus on the identification of relatively subtle brain abnormalities and on their relationships to neurological, neuropsychiatric and cognitive outcome. Approaches that are attracting particular interest in this respect include diffusion tensor imaging for the investigation of white matter integrity and connectivity, and voxel- or deformation-based morphometry for the identification of subtle structural abnormalities. MRS can also play an important role, particularly in the early neonatal period, for example through the detection of increased lactate.

Many MR studies have been performed in the neonatal period, and others have been carried out in early or late childhood, though clearly it would of greatest interest if the full developmental trajectory could be followed in individuals from birth through childhood and beyond. While this poses many challenges, both technical and logistic, it is apparent that MRI will play a critical role in establishing and understanding links between environmental factors experienced early in life and the subsequent development of brain disease and dysfunction. This in turn could contribute substantially to the design of early interventional strategies aimed at improving long-term outcome.

1. Bateson et al (2004). Developmental plasticity and human health. Nature 430:419-421.