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Functional MRI in neonates using neonatal head coil and MR compatible incubator

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Abstract

Structural and functional magnetic resonance imaging of the newborn brain is a complex and challenging task. Term and preterm neonates require a controlled microenvironment and close monitoring during the MRI study to maintain respiratory and cardiovascular functions, body temperature, and fluid and electrolyte homeostasis. In addition, to minimize motion artifacts, most neonates also need to be sedated, which carries the risk of respiratory depression compromising the neonate's ability to maintain appropriate ventilation and oxygenation during the procedure. Finally, because of their small head size, the use of the standard MR head coils results in suboptimal picture quality in the neonate. Thus, these limitations affect our ability to obtain both high quality structural and functional MRI studies. To overcome these difficulties, we have utilized an MR compatible incubator with a built-in radiofrequency head coil optimized for the neonatal brain volume. In this study we demonstrate that functional MRI and high-resolution structural MRI of the newborn brain can be achieved with this novel design. The use of this equipment offers potential for studying the development of the preterm and term neonatal brain and obtaining state-of-the-art, high-resolution structural and functional imaging in this most vulnerable patient population.

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Introduction

Neuroimaging of the adult human brain functions have been intensively investigated in recent years (Moonen and Bandettini, 1999). Positron emission tomography (PET) using a radioactive marker to trace metabolic activity in the brain (Roland, 1993) and functional MRI (Ogawa et al., 1992) detecting the oxygen uptake-induced changes in hemoglobin have become the standard adult functional neuroimaging methods. Despite the intensive investigation of

adults and older children with these techniques, little is known about children (<6 years of age), and even less about infants and neonates. Performing neonatal functional MRI (fMRI) is challenging primarily because of the unique developmentally regulated physiologic status of the neonate that affects our ability to perform developmental neuroimaging.

The purpose of this study is to describe the use of an MR compatible incubator in combination with a neonatal volume head coil (NVHC) specifically scaled and tuned for premature and term neonates. We demonstrate the use of this device to acquiring high-resolution images of the neonatal brain and fMRI with superior signal-to-noise ratio (SNR), unmatched by standard adult head or knee coils.

The specific goals of this study were three-fold: (1) to provide a stable and safe microenvironment for neonates

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