INTRODUCTION Diffusion tensor imaging (DTI) is a sensitive and early indicator of brain injury. Studies of both animals and adult humans demonstrate that the directionally-averaged water apparent diffusion coefficient (\(D\)) decreases within minutes of injury. Following stroke in rat (1), \(D\) values are reduced initially, return to normal approximately three days later ("pseudonormalization"), and are higher than normal thereafter. In adult humans with stroke (2), the changes in \(D\) follow a similar pattern except that pseudonormalization takes place later—approximately seven days after injury. In this preliminary study, we assessed the timing of \(D\) changes following brain injury in newborn human infants. We also measured diffusion anisotropy \(A_v\) values to evaluate the sensitivity of this method to disruption in white matter.

METHODS Three patients who sustained brain injury at birth were studied. All infants were born at term and were the products of unremarkable pregnancies. Two of the three infants had tight nuchal cords at birth and evidence of asphyxia in the newborn period (lethargy, reduced urine output, seizures in one). This condition is associated with spastic cerebral palsy later in life (3). The third infant sustained a skull fracture and cerebral contusion as a consequence of a failed forceps delivery. Conventional MRI (FLAIR and T1-weighted images) as well as diffusion tensor images were obtained; as soon as practical after birth, on day of life (DOL) #3, and on DOL #7. Infants were not sedated for the study.

Maps of brain water \(D\) and \(A_v\) were generated using a single-shot, multi-slice, spin echo, echo planar imaging sequence (4). DTI sequence parameters were TE = 106 ms, TR = 3 s, flip angle = 90°, FOV = 180 × 240 mm, raw data matrix = 96 × 200. Diffusion measurements were made using seven diffusion gradient axis orientations with \(b\) values of 0 and 800 mm/s. Imaging parameters for FLAIR images were: TI = 2350 ms, TR = 6500 ms, TE = 105 ms, FOV = 113×180 mm. Imaging parameters for T1-weighted images were: TR = 500 ms, TE = 12 ms, FOV = 113×180 mm.

RESULTS

![Figure 1](image1.png)

Figure 1 A series of axial images taken from a seven-day-old infant who had a tight nuchal cord at birth. Images A and B are FLAIR images showing regions of periventricular injury as bright areas. Image C is the \(A_v\) map corresponding to image B. Image D, shown for comparison, is an \(A_v\) map taken from a normal term infant from the same brain region as images B and C. Note that anisotropy is markedly reduced in the infant with periventricular white matter injury.

![Figure 2](image2.png)

Figure 2 A series of axial images from three infants who sustained brain injury near birth. The first column consists of \(D\) maps in which increased signal intensity represents reduced diffusion coefficient and indicates cerebral injury. FLAIR images are shown in the second and third columns. The images obtained "at birth" were, from top to bottom, taken at 28, 17, and 18 hours of life. The images in the far right column were taken on DOL #7. In each instance, injury is visible on the \(D\) map, but not the FLAIR image, at birth. Note also that the injuries detected on the \(D\) maps at birth were confirmed at one week of age on FLAIR images. Areas of injury are marked by white arrows.

\(D\) values were reduced maximally (~40%) soon after the injury and on DOL #3. By DOL #7 \(D\) values were rising, though they were still less than normal in two of three infants. Injury was not visible on conventional MRI until the scans obtained on DOL #7.

CONCLUSION DTI shows injury in newborn brain much earlier than conventional MRI. The timing of \(D\) changes in newborns more closely parallel those of adult humans than those of rodents. \(A_v\) maps appear sensitive to injury and show evidence of more widespread injury than detected on conventional MRI. DTI, in conjunction with FLAIR, may be useful for estimating the age of injury in newborns.

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