Single-Shot Fast Spin-Echo Diffusion MR Imaging of the Brainstem and Cerebellum in Premature Newborns

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Introduction

The utility of single-shot fast spin-echo (SSFSE) diffusion tensor imaging (DTI) for acquiring minimally distorted images has been established at 1.5T used for the study of adult and pediatric brain [1,2]. The purpose of this study was to improve diffusion tensor MR imaging of the brainstem and cerebellum of preterm newborns using the SSFSE sequence, and thereby accurately measure the rotationally-averaged apparent diffusion coefficient (Dav) values in these posterior fossa regions in infants with and without white matter injury.

Method

23 premature newborns were studied at 27-40 weeks of gestational age on a 1.5T Signa EchoSpeed System (GE Medical System, Milwaukee, WI) using an specialized MR compatible incubator and a custom-designed neonatal head coil [3]. 13 newborns had a second exam approximately 2-3 weeks after the initial scan. Conventional MRI (T1 weighted sagittal spin-echo, T2 weighted axial dual spin echo, 3D T1-weighted coronal SPGR) was performed to assess the severity of white matter injury using a previously established scoring system: 0 (normal) to 3 (severely abnormal) [4].

A tensor SSFSE sequence was written to include the acquisition of six gradient directions (1 0 1, -1 0 1, 0 1 1, 0 1 -1, 1 1 0, -1 1 0) enabling the calculation of the diffusion tensor. The neonatal DTI scans were acquired with a FOV of 18cm, thickness of 5mm, 128x128 FreqxPhase. The b value was 600 s/mm^2. A Dav-map was generated as the mean of the eigenvalues of the tensor. Dav was calculated in 10 regions: cerebral peduncles, superior colliculi (G1), inferior colliculi (G1), hippocampus (G3), ventral pons (G2), dorsal pons (G1), deep cerebellar WM, cerebellar cortex (G3), ventral medulla (G2), and dorsal medulla (G1). The hippocampus was included for comparison purposes. Due to insufficient signal-to-noise ratio, anisotropy values were not analyzed. The ROIs were further grouped into 3 regions: G1 dorsal group, G2 ventral group, and G3 gray matter group. Differences in Dav across regions, age, and the severity of white matter injury were analyzed using a mixed random effects model.

Results

Dav differed significantly between regions, as demonstrated in **Table 1**. Dav significantly decreased over this gestational age range for all regions except the cerebral peduncles, and the ventral and dorsal medulla. The Dav within the three groups of regions were also found to be significantly different; dorsal vs ventral with P<0.0001, dorsal vs GM with P<0.0001 and ventral vs GM with P=0.049, with dorsal 1145.8±14.0, ventral 1299.6±15.4, GM 1334.7±15.1. They were also found to be significantly correlate with gestational age at scan with dorsal group P=0.022, ventral group P=0.033, and gray matter group of P<0.0001. There was no statistically significant difference in Dav between the left and the right ROI in any structure (p=0.90). Also, Dav (x10^{-3} mm^2/s) did not show significant differences between white matter injury groups; 1244±17.8 (score=0), 1212±15.4 (score=1), 1211±21.4 (score=2), and 1278±31.9 (score=3) with p=0.064.

Conclusion

This study demonstrated the feasibility of using a SSFSE-DTI sequence to obtain DTI parameters in the brainstem and cerebellum of premature newborns. Significant regional and temporal variations in Dav were observed which agreed with known maturational changes. From early in life to term, there was a significant decrease in Dav in many brainstem regions with different rate of maturation as shown by the earlier maturation of dorsal group (lower Dav) and later maturation of ventral group (higher Dav).

Table 1. Dav (x10^{-3} mm^2/s) squares means*, standard errors** and p-values of differences between structures

	1	2	3	4	5	6	7	8	9	10
	1180* 18.5**	1114 18.5	1130 18.3	1317 18.3	1295 18.1	1129 18.1	1253 18.1	1350 18.1	1304 19.2	1198 18.8
cerebral peduncles (1)		**0.034**	0.25	**<.0001**	**<.0001**	0.22	**0.010**	**<.0001**	**<.0001**	1
superior colliculi (2)			1	**<.0001**	**<.0001**	1	**<.0001**	**<.0001**	**<.0001**	**0.002**
inferior colliculi.(3)				**<.0001**	**<.0001**	1	**<.0001**	**<.0001**	**<.0001**	**0.028**
hippocampus (4)					0.98	**<.0001**	**0.035**	0.80	1	**<.0001**
ventral pons (5)						**<.0001**	0.48	0.12	1	**<.0001**
dorsal pons (6)							**<.0001**	**<.0001**	**<.0001**	**0.022**
deep cerebellum (7)								**<.0001**	0.27	0.17
cerebellar cortex (8)									0.42	**<.0001**
ventral medulla (9)										**<.0001**
dorsal medulla (10)										

References

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