

早期産児の頭部MRI DEHSI、PWMLについて

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岩手県立釜石病院





3月末



仮設住宅



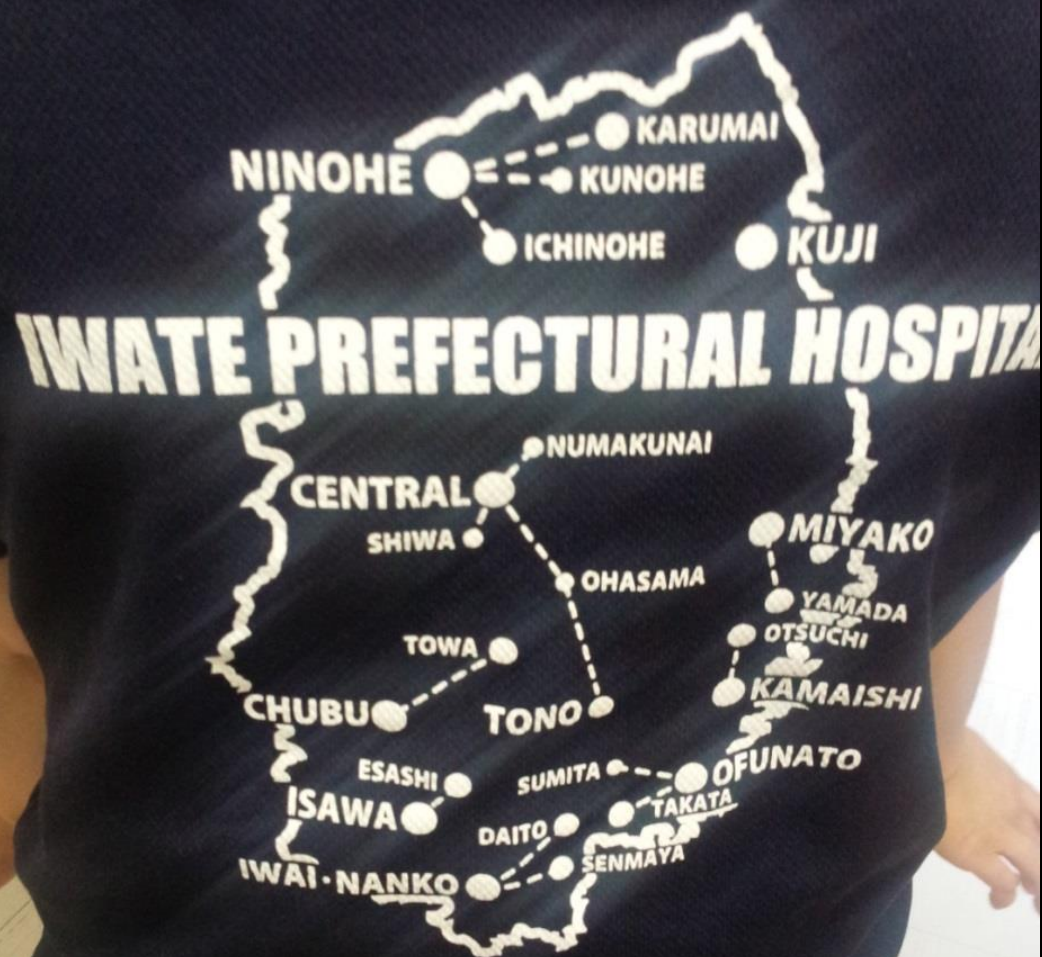


仮設住宅



震災時のがれきの残骸

岩手の臨床研修病院(いわてイーハトーヴ臨床研修病院群)



T- shirt

岩手の臨床研修病院 (いわてイーハトーヴ臨床研修病院群)



white matter injury of very preterm infant

- 背景には早期産児・超低出生体重児の生存率の新生児医療の発達により著明な改善
- 一方にて脳性麻痺の罹患率は低下していない
- また、cognitive impairment, behavioral impairment, learning disabilityの問題が大きくなってきている。
- major lesion; GMH-IVH, cystic PVLについてはUSにて十分に診断可能ではあるが、USにて評価しづらいsubtle white matter injuryについては、MRIが有効であり、予後評価に有効であるとの報告が増加

周産期死亡率の国際比較

一番低いのは、高いのは？(対1000出生)

•スウェーデン	• 5.2
•スペイン	• 3.6
•アメリカ	• 13.5
•日本	• 2.9
•ドイツ	• 6.8
•フランス	• 5.5

周産期死亡率の国際比較

一番低いのは,高いのは(対1000出生)

•日本	•2.9
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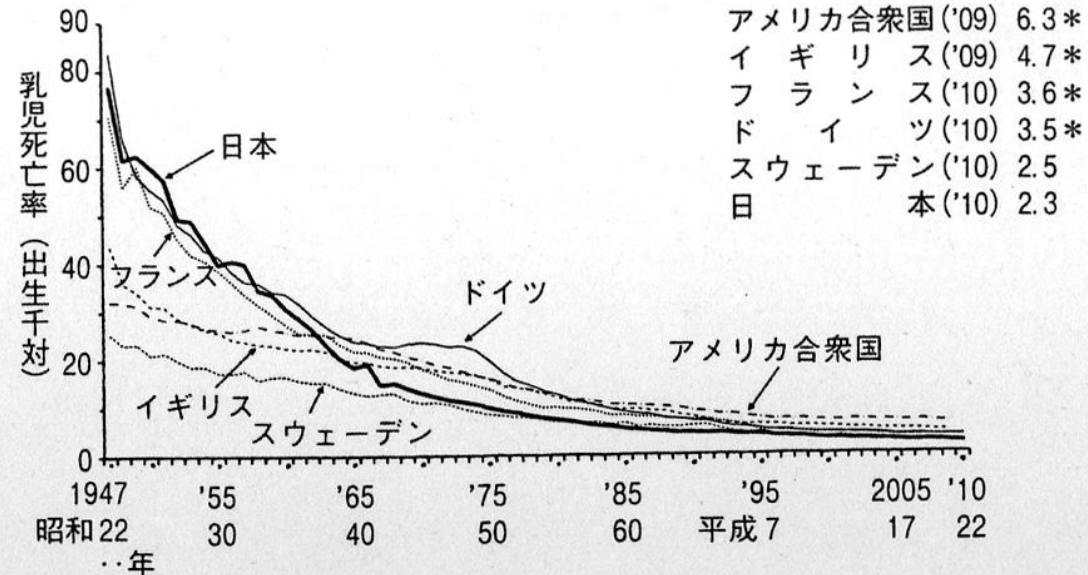
周産期死亡率・乳児死亡率の国際比較

表34 周産期死亡率(変更前の定義：出生千対)の国際比較

	1970	'80	'90	'95	2000	'10		
						周産期死亡率	妊娠満28週以後死産比 ¹⁾	早期新生児死亡率
日本 ¹⁾	21.7	11.7	5.7	4.7	3.8	2.9	2.0	0.8
アメリカ合衆国	22.0	10.9	7.7	7.0	6.2	(06) 6.1	3.0	3.1
フランス	27.8	14.2	9.3	7.6	7.1	(03) 6.8	3.1	3.7
ドイツ	18.0	9.0	8.3	7.5	'01) 6.8	(06) 8.0	5.3	2.6
スイス	20.7	13.0	8.3	6.6	'99) 6.6	(09) 13.5	11.8	1.7
イタリア	26.7	11.6	6.0	6.9	'99) 6.2	(07) 5.5	3.5	2.1
ハンガリー	34.5	23.1	14.3	9.0	10.1	(09) 7.7	5.4	2.3
オランダ	31.7	17.4	10.4	8.9	'97) 6.8	(07) 4.5	2.8	1.7
スペイン	18.8	11.1	9.7	8.9	'98) 7.9	(08) 5.4	3.3	2.1
スウェーデン	⁷⁵⁾ 21.1	14.6	7.6	6.0	'99) 5.2	(09) 3.6	2.2	1.4
イギリス	16.5	8.7	6.5	5.3	'02) 5.3	(09) 5.2	4.0	1.2
オーストラリア	23.8	13.4	8.2	7.5	8.2	(03) 8.5	5.7	2.8
ニュージーランド	21.5	13.5	8.5	6.9	6.0	(05) 5.9	2.9	2.9
	19.8	11.8	7.2	'97) 5.7	5.8	(09) 4.9	2.8	2.1

周産期死亡率・乳児死亡率い
ずれも日本が世界一低い

図21 乳児死亡率(出生千対)の国際比較



乳児死亡率・新生児死亡率の国際比較

表39 乳児死亡率・新生児死亡率(出生千対)の国際比較

	乳児死亡率						新生児死亡率			
	'60年	'70	'80	'90	2000	'10	'80年	'90	2000	'10
日本	30.7	13.1	7.5	4.6	3.2	2.3	4.9	2.6	1.8	1.1
カナダ	27.3	18.8	10.4	6.8	5.3	'06) 5.0	6.7	4.6	3.6	'06) 3.7
アメリカ合衆国	26.0	20.1	12.6	9.2	6.9	'08) *6.6	8.4	5.8	4.6	'08) 4.3
オーストラリア	37.5	25.9	14.3	'91) 7.5	4.8	'09) 3.8	9.3	'91) 4.4	3.2	'09) 2.5
デンマーク	21.5	14.2	8.4	'91) 7.2	'01) 4.9	'09) 3.1	5.6	'91) 4.2	'01) 3.5	'09) 2.3
フランス	27.4	15.1	10.0	7.3	'03) 4.0	'09) 3.7	5.6	3.6	'03) 2.7	'09) 2.4
ドイツ	33.8	23.6	12.6	7.0	4.4	'07) 3.9	7.8	3.5	2.7	'07) 2.7
ハンガリー	47.6	35.9	23.2	'91) 15.6	9.2	'09) 5.1	17.8	'91) 11.4	6.2	'09) 3.4
イタリア	43.9	29.6	24.5	8.0	'03) 4.7	'07) 3.5	11.2	6.2	'03) 3.4	'07) 2.4
オランダ	16.5	12.7	8.6	7.1	5.1	'08) 3.8	5.7	5.7	3.9	'08) 2.8
ポーランド	56.8	33.2	21.3	'91) 15.0	8.1	'09) 5.6	13.3	'91) 10.8	5.6	'09) 4.0
スウェーデン	16.6	11.0	6.9	6.0	'01) 3.7	'09) 2.5	4.9	4.9	'01) 2.5	'09) 1.6
スイス	21.1	15.1	9.1	'91) 6.2	4.9	'09) 4.3	5.9	'91) 3.6	3.6	'09) 3.5
イギリス	22.5	18.5	12.1	'92) 6.6	5.6	'07) 4.8	7.7	'92) 4.3	3.9	'07) 3.3
オーストラリア	20.2	17.9	10.7	'92) 6.7	5.2	'09) 4.3	7.1	'92) 4.3	3.5	'09) 3.0
ニュージーランド	25.6	16.7	13.0	'91) 8.4	6.1	'09) 4.9	5.8	'91) 4.4	3.6	'09) 2.8

資料 厚生労働省「人口動態統計」
 WHO「World Health Statistics Annual」
 UN「Demographic Yearbook」
 UN「Population and Vital Statistics Report」

乳児死亡率・新生児死亡率も世界一低い

Magnetic resonance imaging of white matter diseases of prematurity

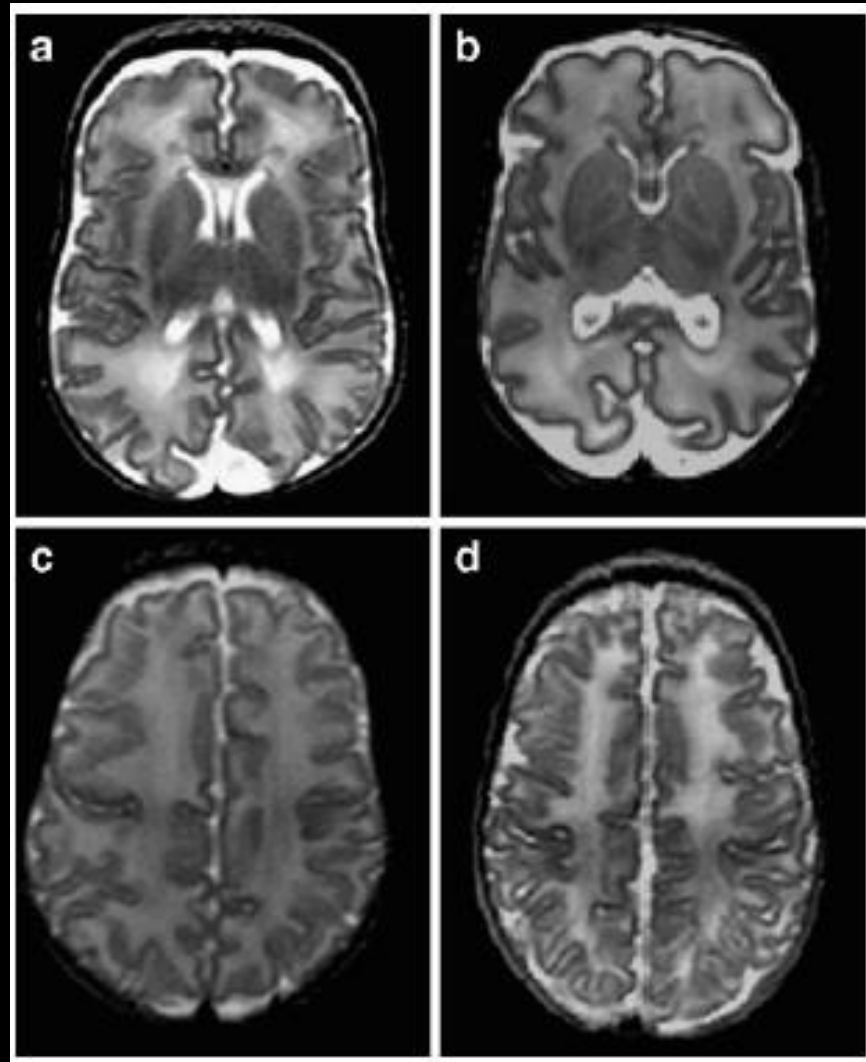
**Mary A. Rutherford • Veena Supramaniam • Ashraf Ederies • Andrew Chew •
Laura Bassi • Michela Groppo • Mustafa Anjari • Serena Counsell • Luca A. Ramenghi**

Neuroradiology 2010; 52: 505-21

white matter injury of prematurity

- Germinal matrix hemorrhage/intraventricular hemorrhage (GMH/IVH)
- Periventricular Leucomalacia (PVL)
 - most well recognized acquired causes of motor impairment in infants born preterm
- new abnormality on MRI
 - punctate white matter lesion (PWML)
 - diffuse excessive high signal intensity (DEHSI)
 - milder forms of PVL
 - spectrum of white matter injury of prematurity

DEHSI



diffuse excessive high signal intensity (DEHSI)

- diffuse high signal lesion in the white matter on T2-WI and low signal on T1-WI
- very common in extremely preterm infants
- diagnosed at term equivalent age (TEA)
- unclear neurobiological bases
- increased ADC
- significant developmental impairment but no motor abnormality at 2 years of age

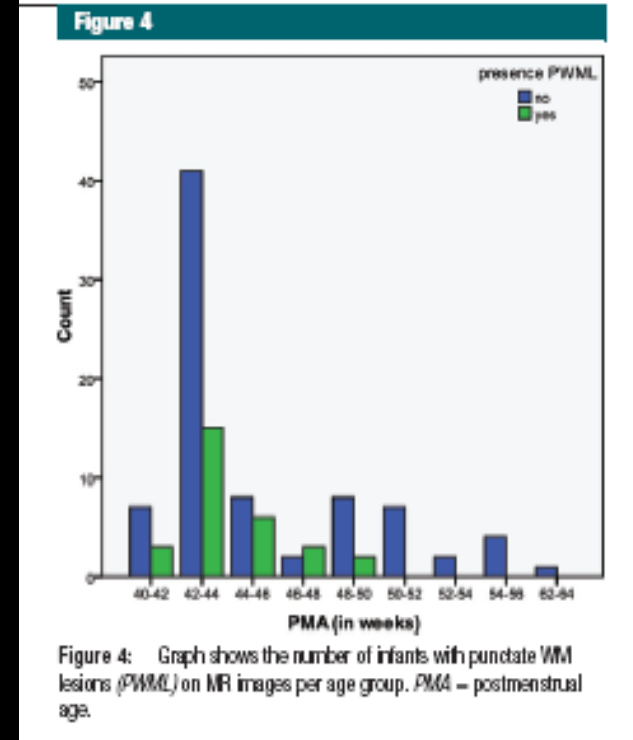
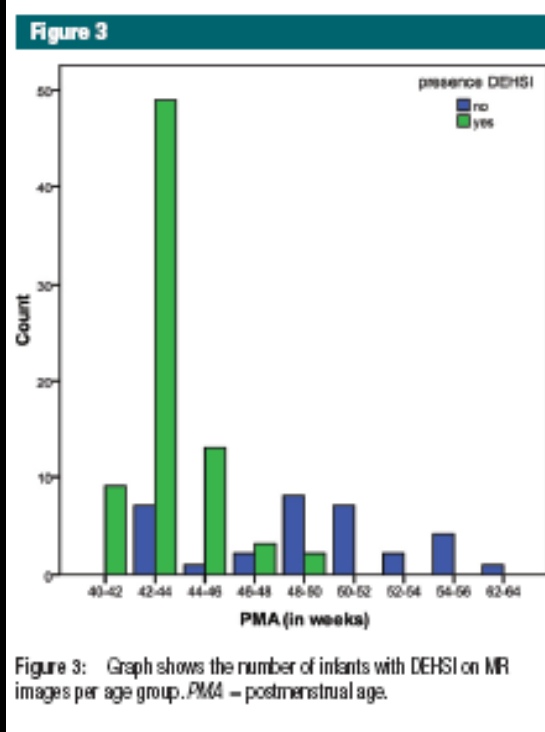
Clinical Implications of MR Imaging Findings in the White Matter in Very Preterm Infants: A 2-year Follow-up Study¹

de Bruine FT, van den Berg-Huysmans AA, Leijser LM et al. Clinical implications of MR imaging findings in the white matter in very preterm infants: A 2-year follow-up study. *Radiology* 2011; 261: 899-906

110 preterm infants < 32 weeks

MRI at term equivalent age

2 year clinical follow-up



- DEHSI present in 89%
 - before 50 weeks
 - no association with neuro-developmental outcome
- PWML and ventricular dilatation
 - mental and psychomotor developmental delay, motor delay and cerebral palsy

Table 3

Presence of DEHSI, Punctate WM Lesions, and Ventricular Dilatation on MR Images and Neurodevelopmental Outcome at a Corrected Age of 2 Years (n = 86)

Outcome Measure	DEHSI			Punctate WM Lesions			Ventricular Dilatation			
	No (n = 26)	Yes (n = 59)	PValue	None or ≤ 6 (n = 67)	> 6 (n = 8)	PValue	Normal/Mild (n = 21)	Moderate (n = 45)	Severe (n = 18)	PValue
MDI score	93.7 ± 10.6*	97.2 ± 13.0*	.23	97.5 ± 12.1*	89.3 ± 11.1*	.02†	97.2 ± 7.6*	96.1 ± 14.3*	94.4 ± 12.5*	.79
Any mental delay	2 (7.7)	3 (5.5)	.65	3 (3.5)	2 (14.3)	.20	0 (0)	3 (7.1)	2 (12.5)	.12
Moderate mental delay	1 (3.8)	1 (1.8)	.54	1 (1.5)	1 (7.1)	.32	0 (0)	1 (2.4)	1 (6.2)	.24
Severe mental delay	1 (3.8)	2 (3.6)	>.99	2 (3.0)	1 (7.1)	.44	0 (0)	2 (4.8)	1 (6.2)	.31
PDI score	94.8 ± 12.9*	93.1 ± 16.3*	.66	97.2 ± 11.2*	78.9 ± 0.5*	<.001†	95.2 ± 9.5*	96.7 ± 13.0*	85.2 ± 21.3*	.03†
Any motor delay	1 (4.3)	6 (12.2)	.42	2 (3.4)	5 (35.7)	.002†	0 (0)	3 (8.3)	4 (23.8)	.02†
Moderate motor delay	0 (0)	2 (4.2)	>.99	1 (1.7)	1 (7.1)	.35	0 (0)	2 (5.6)	0 (0)	.98
Severe motor delay	1 (4.3)	4 (8.2)	>.99	1 (1.7)	4 (28.6)	.004†	0 (0)	1 (2.8)	4 (23.8)	.008†
Cerebral palsy	1 (3.8)	5 (8.8)	.66	2 (3.0)	4 (25.0)	.01†	1 (4.8)	1 (2.2)	4 (25.0)	.03†
Severe cerebral palsy	1 (3.8)	0 (0)	.31	0 (0)	1 (6.3)	.19	0 (0)	0 (0)	1 (6.2)	.11
Internalizing problems‡	48.2 ± 10.2*	48.1 ± 9.5*	.96	47.0 ± 8.8*	53.5 ± 1.8*	.05	45.5 ± 8.6*	50.1 ± 9.8*	49.4 ± 9.9*	.22
Externalizing problems‡	50.1 ± 9.9*	50.6 ± 9.4*	.84	49.2 ± 9.2*	56.5 ± 9.1*	.01†	49.4 ± 9.9*	51.4 ± 0.1*	50.1 ± 9.6*	.75
Total problems‡	49.0 ± 10.1*	49.1 ± 8.8*	.98	47.6 ± 8.5*	56.4 ± 9.3*	.003†	47.3 ± 8.3*	50.7 ± 9.6*	48.7 ± 8.7*	.37

Note.—Unless otherwise indicated, data are number of infants and data in parentheses are percentages.

* Data are means ± standard deviation.

† Significant P value.

‡ Based on child behavior checklist (31).

Jeon TY, Kim JH, Yoo S-Y, et al. Neurodevelopmental outcomes in preterm infants: Comparison of infants with and without diffuse excessive high signal intensity on MR images at near-term-equivalent age. *Radiology* 2012; 263: 518-526.

- 126 high risk preterm infants with <32 weeks or <1500g
 - MRI at near-term-equivalent age
 - neurodevelopmental outcomes at 18-24 months of age
- DEHSI
 - 75%
 - no differences on neurodevelopmental outcomes between with DEHSI and without DEHSI
- cystic encephalomalacia and PWML
 - significant predictors of cerebral palsy

Table 3**Neurodevelopmental Outcomes at a Corrected Age of 18 Months to 2 Years**

Outcome Measure	With DEHSI (<i>n</i> = 95)	Without DEHSI (<i>n</i> = 31)	<i>P</i> Value
MDI score*	97 (105, 86)	97 (104, 85)	.749 [†]
Severe cognitive delay [‡]	9 (9)	1 (3)	.483 [§]
PDI score*	93 (103, 84)	97 (103, 85)	.634 [†]
Severe psychomotor delay [‡]	11 (12)	2 (6)	.665 [§]
Cerebral palsy [†]	7 (7)	2 (6)	> .99 [§]
Neurosensory impairment [‡]	11 (12)	9 (29)	.054 [§]

* Data are medians except as otherwise specified. Numbers in parentheses are the 75th and 25th percentiles, respectively.

[†] Determined with the Wilcoxon two-sample test.

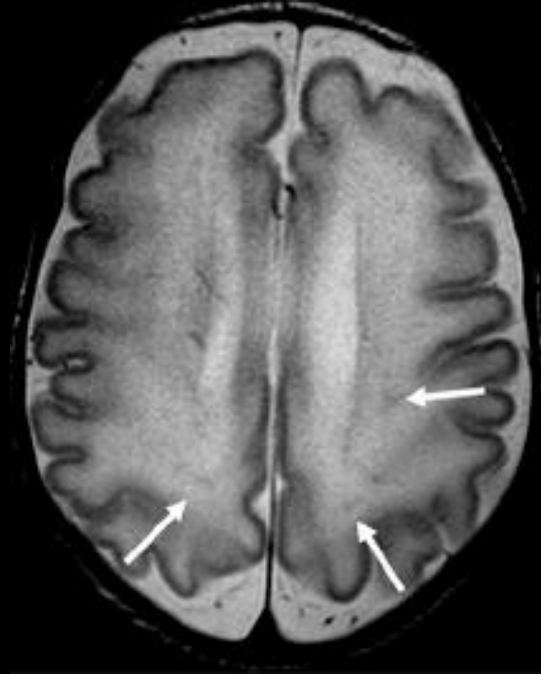
[‡] Data are numbers of patients except as otherwise specified, and numbers in parentheses are percentages.

[§] Determined with exact logistic regression analysis.

Radiology 2012; 263: 518-526.

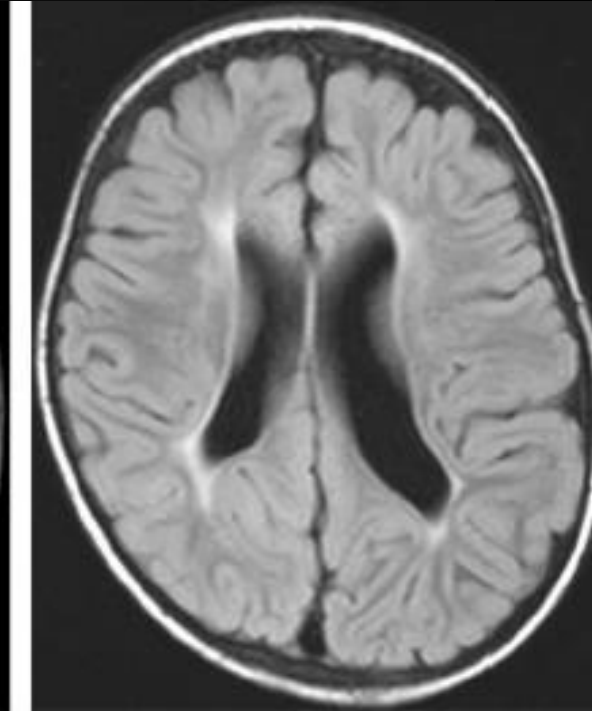
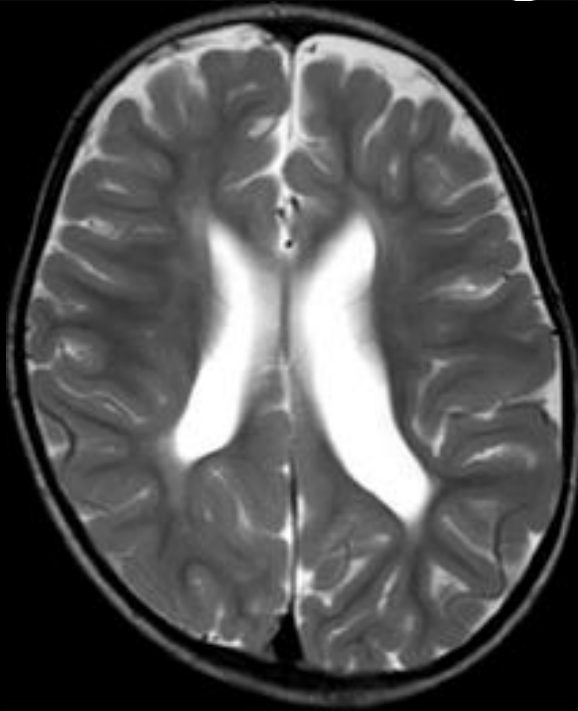
DEHSIの現時点での考え方

- DEHSI of the white matter represents a prematurity-related developmental phenomenon rather than white matter injury.



27 weeks infant with
MRI at 35 weeks

DEHSI and PWML



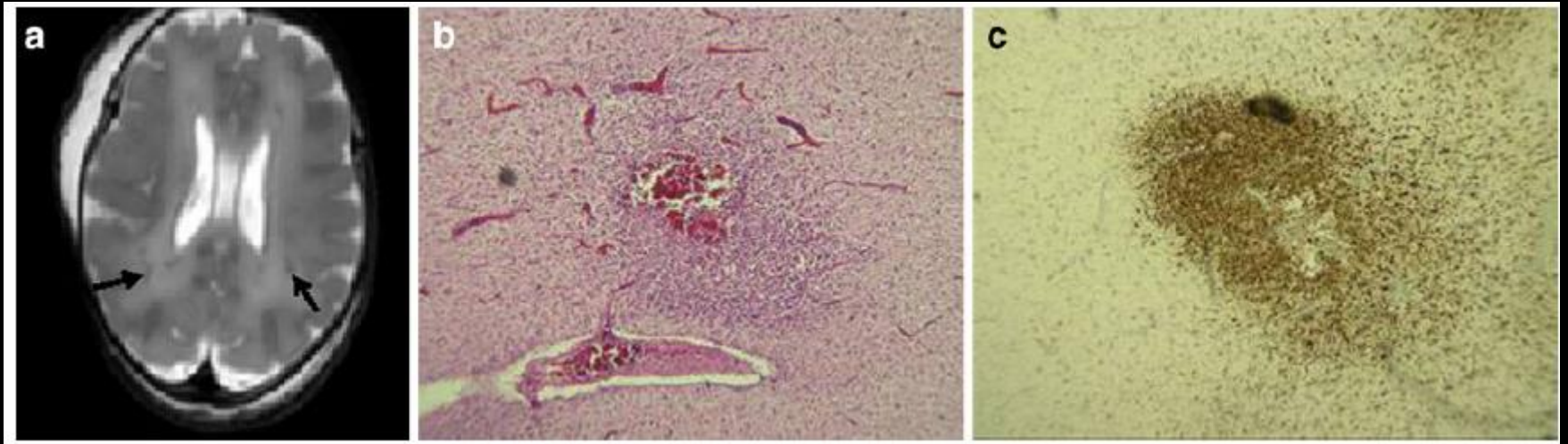
MRI at 24 months

c/w PVL

outcome: Cerebral palsy

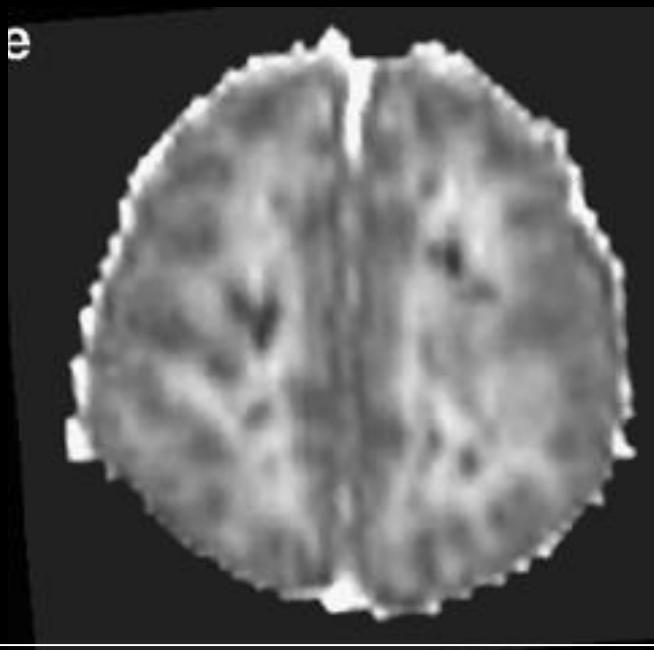
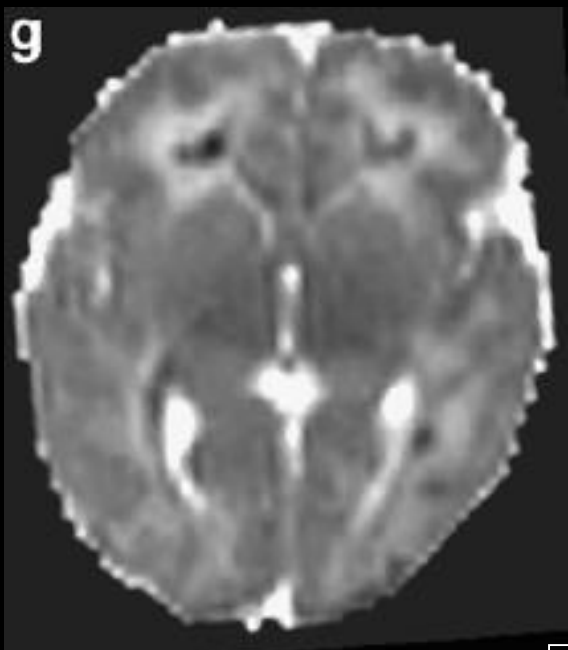
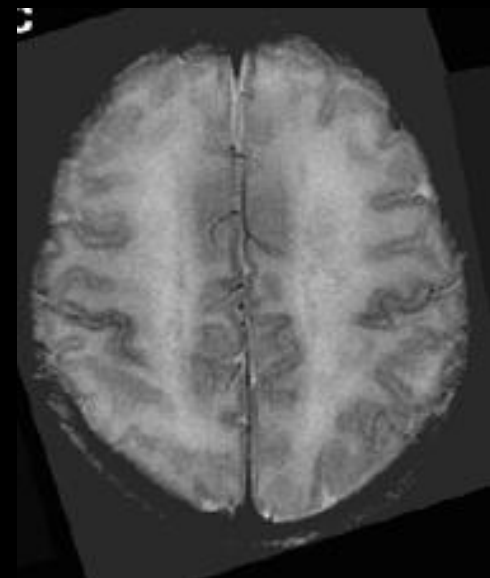
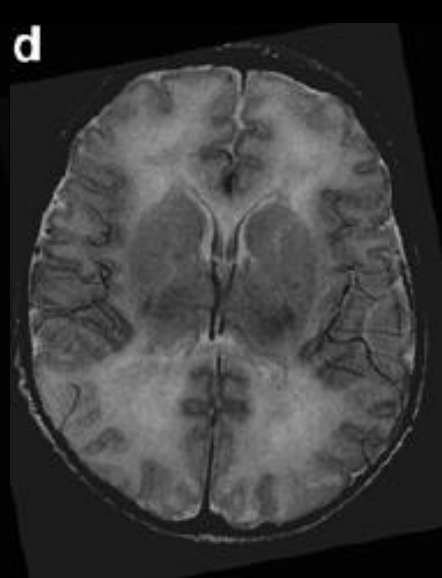
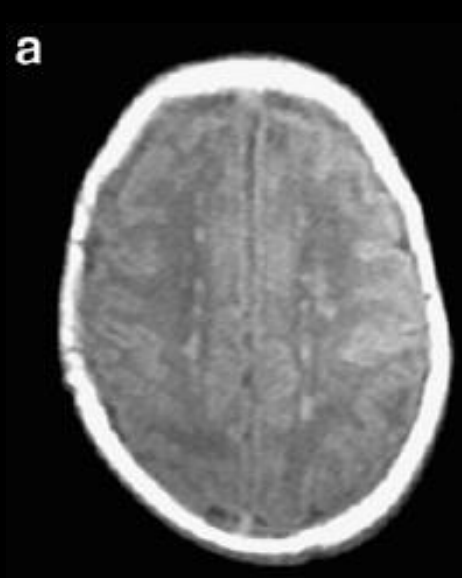
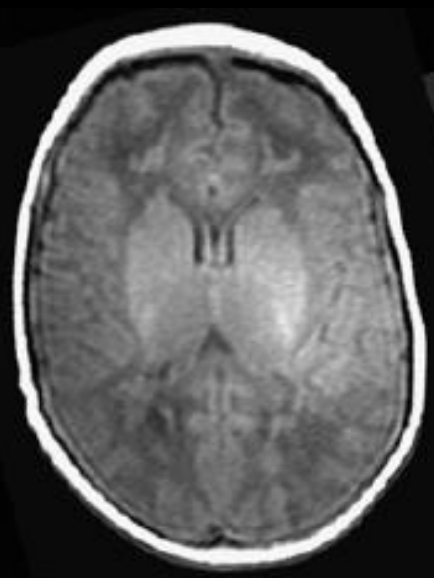
punctate white matter lesion (PWML)

- spotty high signal intensity on T1-WI and low signal on T2-WI
 - along the corona radiata and optic radiation, in the posterior periventricular white matter
 - no microhemorrhage on SWI
 - decrease number by term
 - similar to PVL
 - pathologically, cluster of activated microglia
 - the increased risk of motor impairment
 - PWML in corticospinal tract, wide-spread PWML

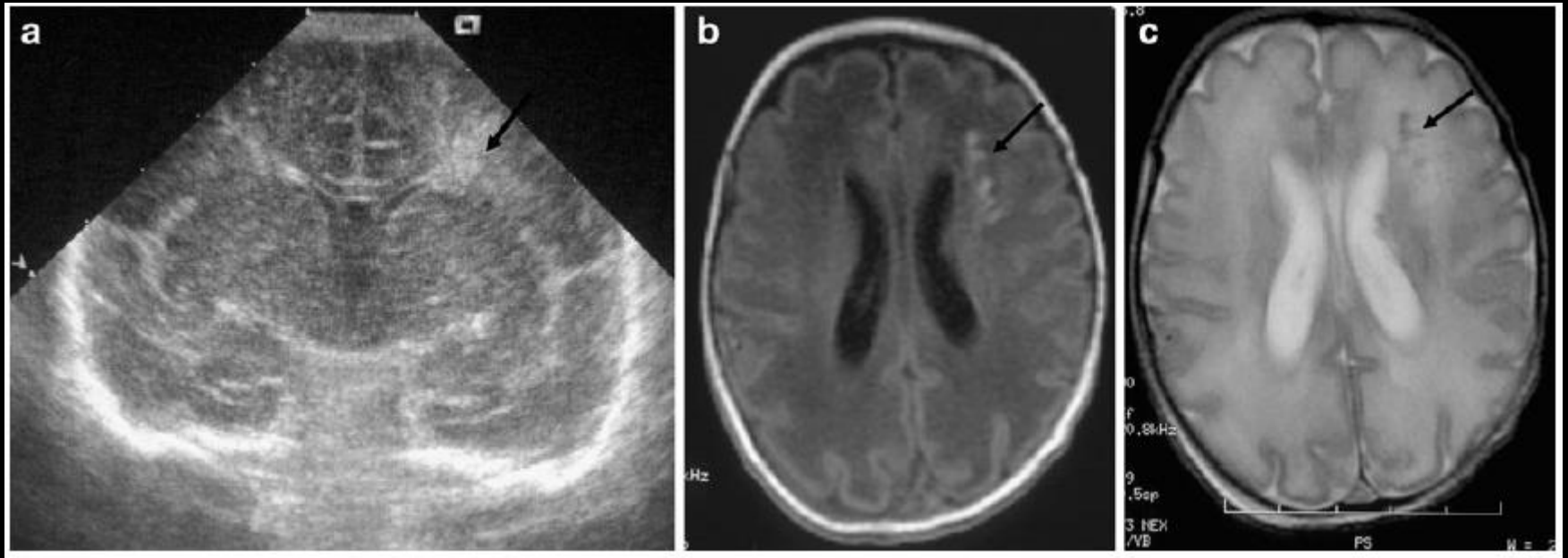


vascular congestion and activated microglia

Neuroradiology 2010;52: 505-521



Neuroradiology 2010;52: 505-521



Neuroradiology 2011; 53: 669-679

- SWIを用いてPWMLに2種類あることを報告
 - hemorrhagic PWML and non-hemorrhagic PWML
- hemorrhagic PWML more associated with GMH and IVH
- non-hemorrhagic PWML with white matter injury
- mixed pattern
- histologically,
 - early gliosis and necrosis

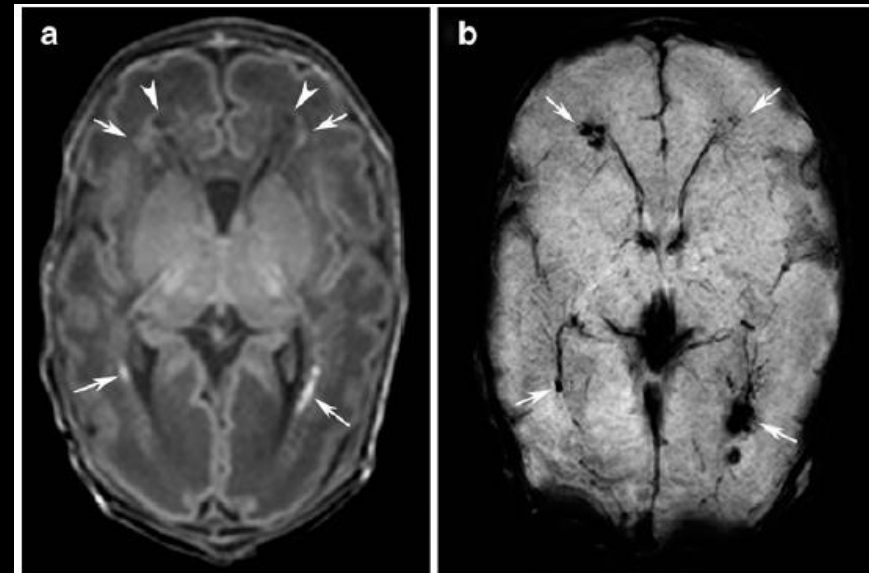
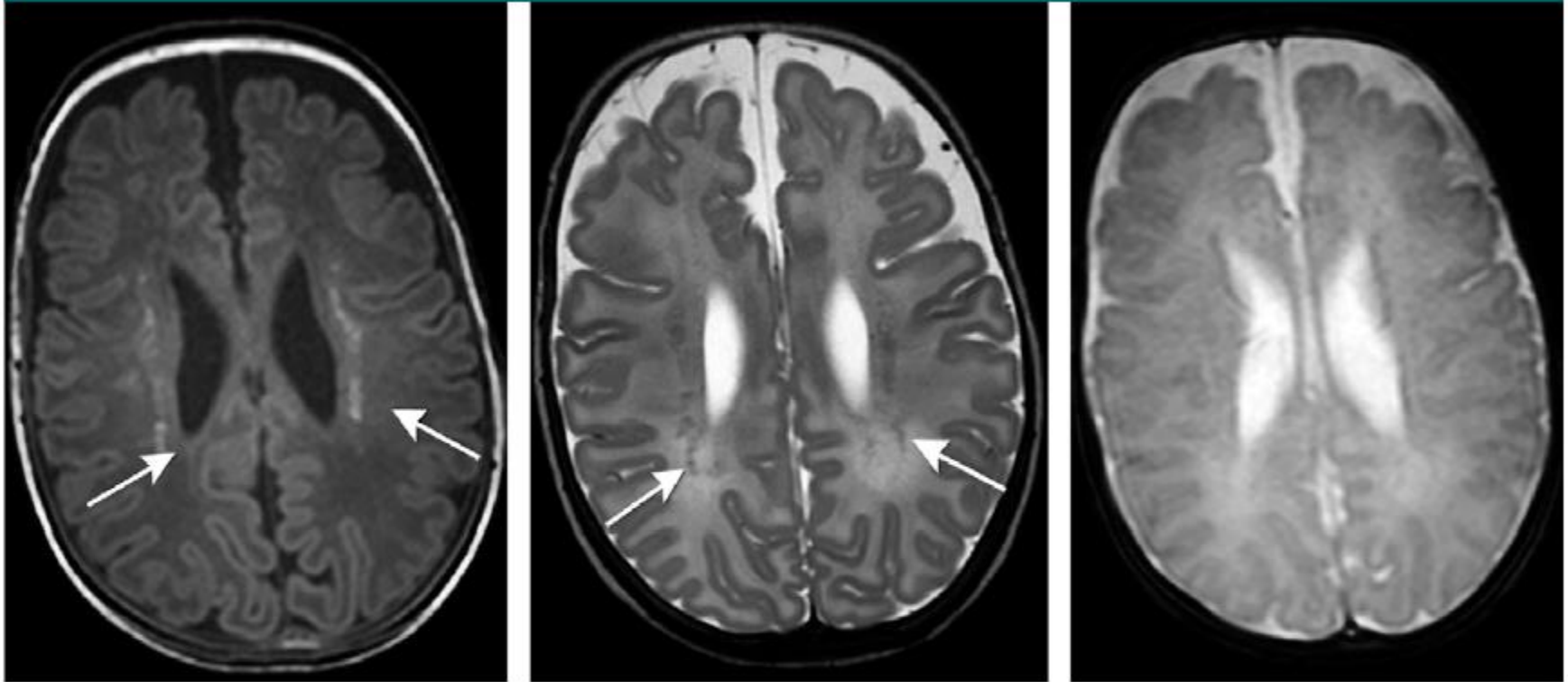


Figure 2



a.

b.

c.

Figure 2: Punctate WM lesions (arrows) appear as high-signal-intensity lesions on (a) T1-weighted MR image and as less pronounced low-signal-intensity lesions on (b) T2-weighted MR image, but are not visible on (c) T2*-weighted gradient-echo MR image, which is susceptible to hemorrhages or calcification.

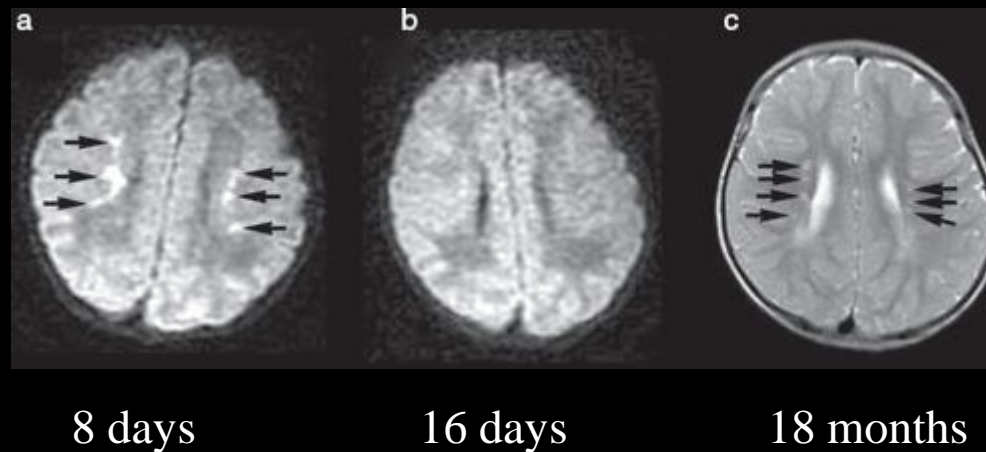
Radiology 2011;261: 899-906

Punctate white matter lesions in a late preterm-born infant with hypoxic ischaemic encephalopathy: chronological change in magnetic resonance imaging

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Accepted for publication 22nd November 2011.



punctate white matter lesion (PWML)

予後との関係

- PWML may imply a good prognosis, a normal neurodevelopmental outcome
 - Cornette LG et al. Arch Dis Fetal Neonatal Ed 2002;86:F171-F177
- reduced brain maturation: delayed myelination and reduced cortical infolding
 - Ramenghi et al. Neuroradiology 2007; 49:161–167
- Useful for predict motor prognosis in preterm infants with PVL
 - Nanba Y et.al. Pediatrics 2007; 120: e10-e19
- the increased risk of motor impairment
 - Rutherford MA, et al. Neuroradiology 2010; 52: 505-21
- FA significantly lower in PLIC at term equivalent age
 - Pediatr Res 2011; 69: 561-566

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MDI score	93.7 ± 10.6*	97.2 ± 13.0*	.23	97.5 ± 12.1*	89.3 ± 11.1*	.02†	97.2 ± 7.6*	96.1 ± 14.3*	94.4 ± 12.5*	.79
Any mental delay	2 (7.7)	3 (5.5)	.65	3 (3.5)	2 (14.3)	.20	0 (0)	3 (7.1)	2 (12.5)	.12
Moderate mental delay	1 (3.8)	1 (1.8)	.54	1 (1.5)	1 (7.1)	.32	0 (0)	1 (2.4)	1 (6.2)	.24
Severe mental delay	1 (3.8)	2 (3.6)	>.99	2 (3.0)	1 (7.1)	.44	0 (0)	2 (4.8)	1 (6.2)	.31
PDI score	94.8 ± 12.9*	93.1 ± 16.3*	.66	97.2 ± 11.2*	78.9 ± 0.5*	<.001†	95.2 ± 9.5*	96.7 ± 13.0*	85.2 ± 21.3*	.03†
Any motor delay	1 (4.3)	6 (12.2)	.42	2 (3.4)	5 (35.7)	.002†	0 (0)	3 (8.3)	4 (23.8)	.02†
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Cerebral palsy	1 (3.8)	5 (8.8)	.66	2 (3.0)	4 (25.0)	.01†	1 (4.8)	1 (2.2)	4 (25.0)	.03†
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† Significant P value.

‡ Based on child behavior checklist (31).

T1WIと拡散強調像に注目

新生児の低酸素性虚血性脳症（早期産児）

早期産児の低酸素性虚血性脳症にて運動予後不良を示唆するMRI所見

修正term前後に撮影したMRIにて、

Magnetic Resonance Imaging Regional T1 Abnormalities at Term Accurately Predict Motor Outcome in Preterm Infants

Yukiko Nanba, MD^{a,b}, Kiyoshi Matsui, MD^a, Noriko Aida, MD^c, Yoshiaki Sato, MD^a, Katsuaki Toyoshima, MD^a, Motoyoshi Kawataki, MD^a, Rikuo Hoshino, MD^a, Makiko Ohyama, MD^a, Yasufumi Itani, MD^a, Akiko Goto, MD^a, Akira Oka, MD^d

Departments of ^aNeonatology and ^bRadiology, Kanagawa Children's Medical Center, Yokohama, Japan; ^cDivision of Perinatology, Department of Perinatal Medicine and Maternal Care, and ^dDivision of Child Neurology, Department of Medical Subspecialties, National Center for Child Health and Development, Tokyo, Japan

The authors have indicated they have no financial relationships relevant to this article to disclose.

T1WIにて、放線冠レベルの白質高信号に着目

脳室周囲のspotty hyperintensity 運動障害軽度 ↓

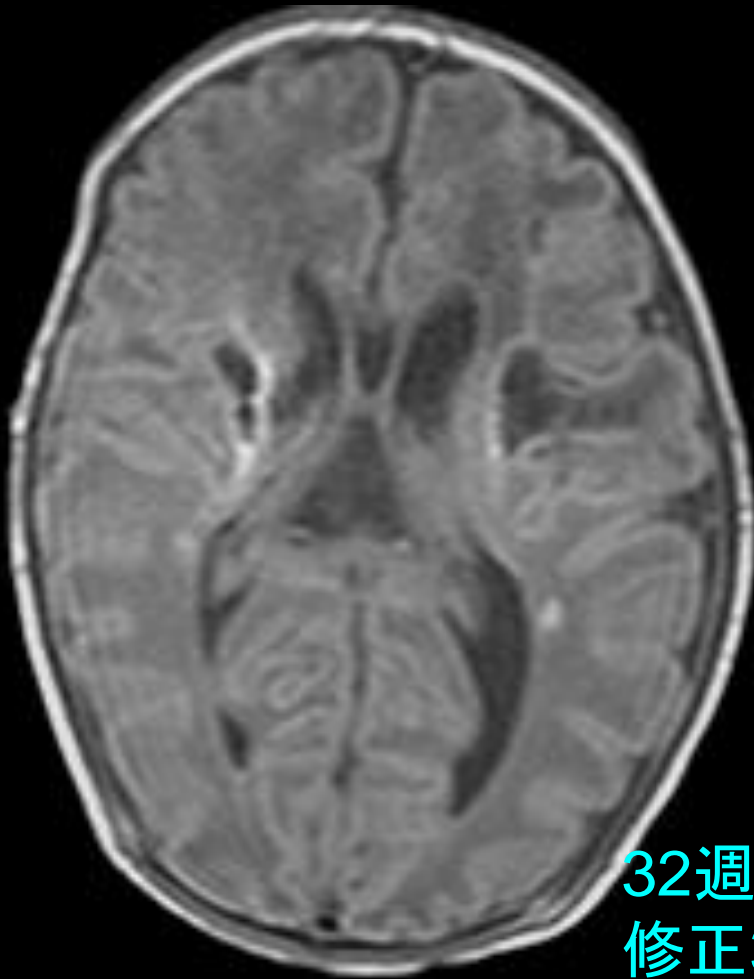
脳室周囲のband-like hyperintensity

脳室周囲のcystic formation (+T1 hyperintensity) 重度

Nanba Y, Matsui K, Aida N, et.al. Pediatrics 2007;120: e10-e19.

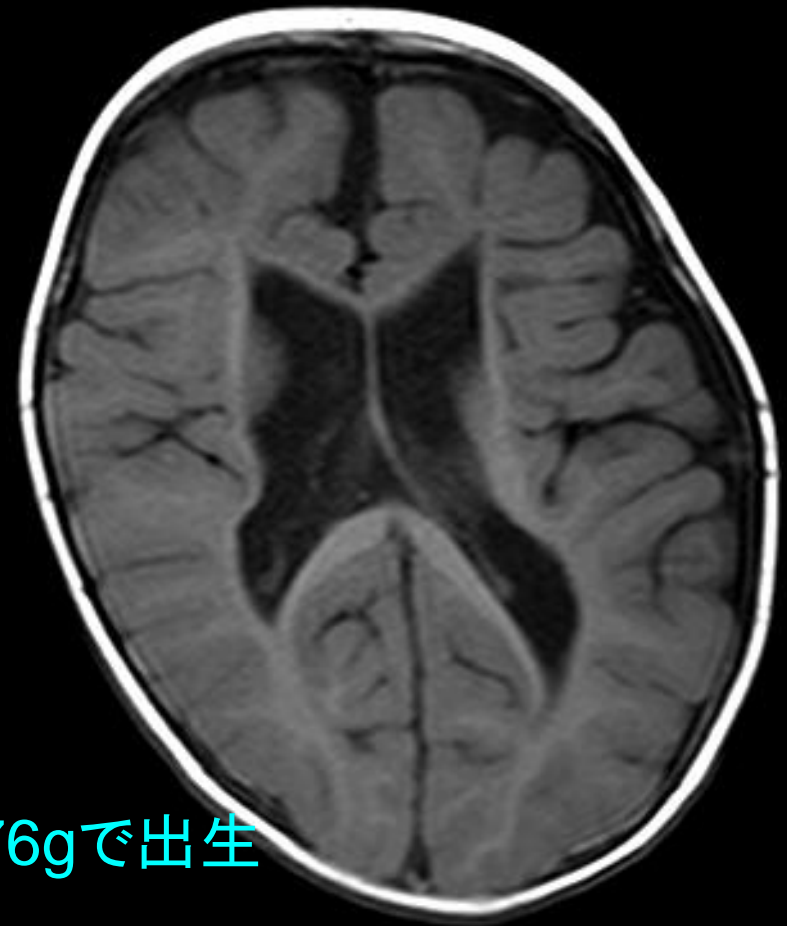
T1WIと拡散強調像に注目

新生児の低酸素性虚血性脳症（早期産児）



32週 1776gで出生
修正38週

- ・脳室周囲のcystic change
- ・脳室周囲のT1WI線状高信号

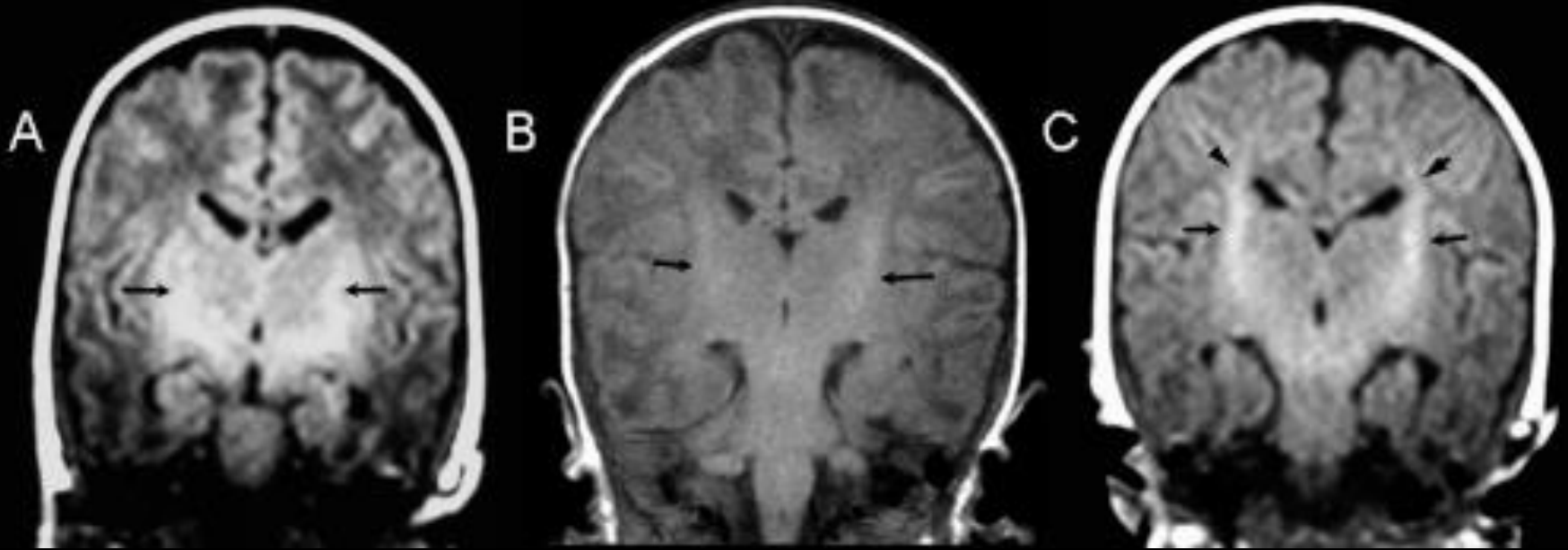


1年後
痙性麻痺、てんかん

重要なポイントとしては

- 修正43週までは放線冠レベルには髄鞘化が到達しない＝正常の髄鞘化による高信号は修正43週までは内包後脚よりは上方(放線冠)には認められない
- 白質損傷によるT1高信号と正常髄鞘化の高信号の鑑別には、横断像よりも冠状断像が有効である

正常の髄鞘化

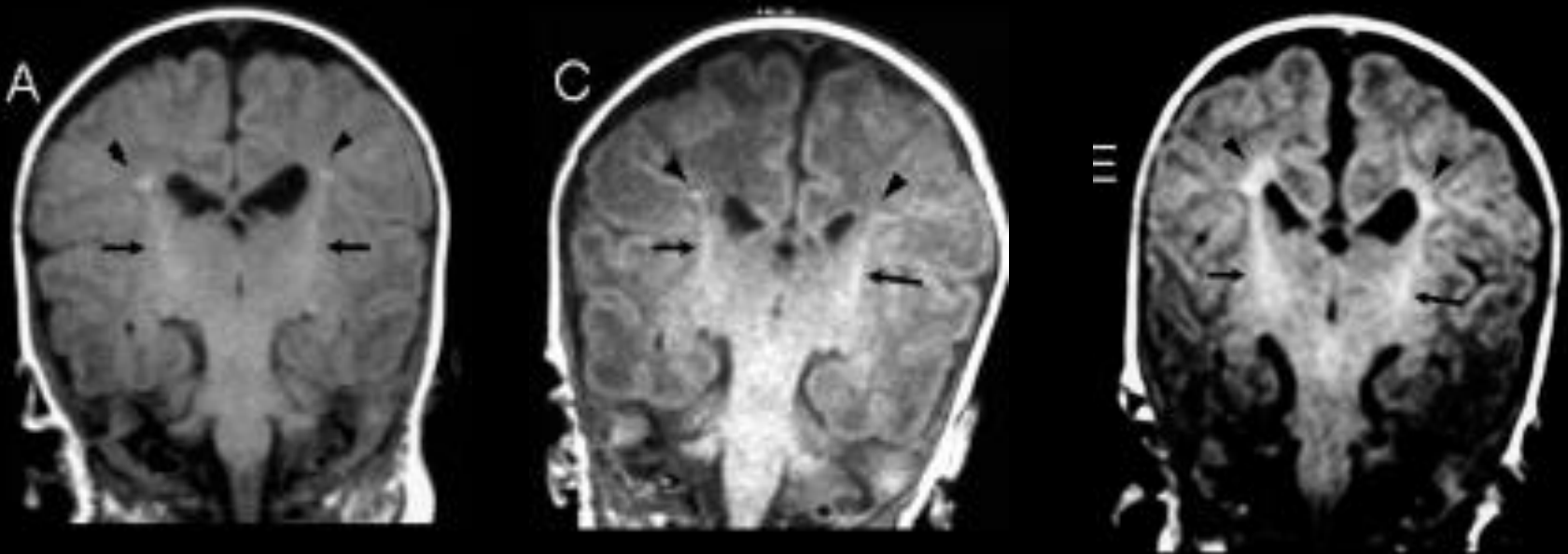


36 weeks

39 weeks

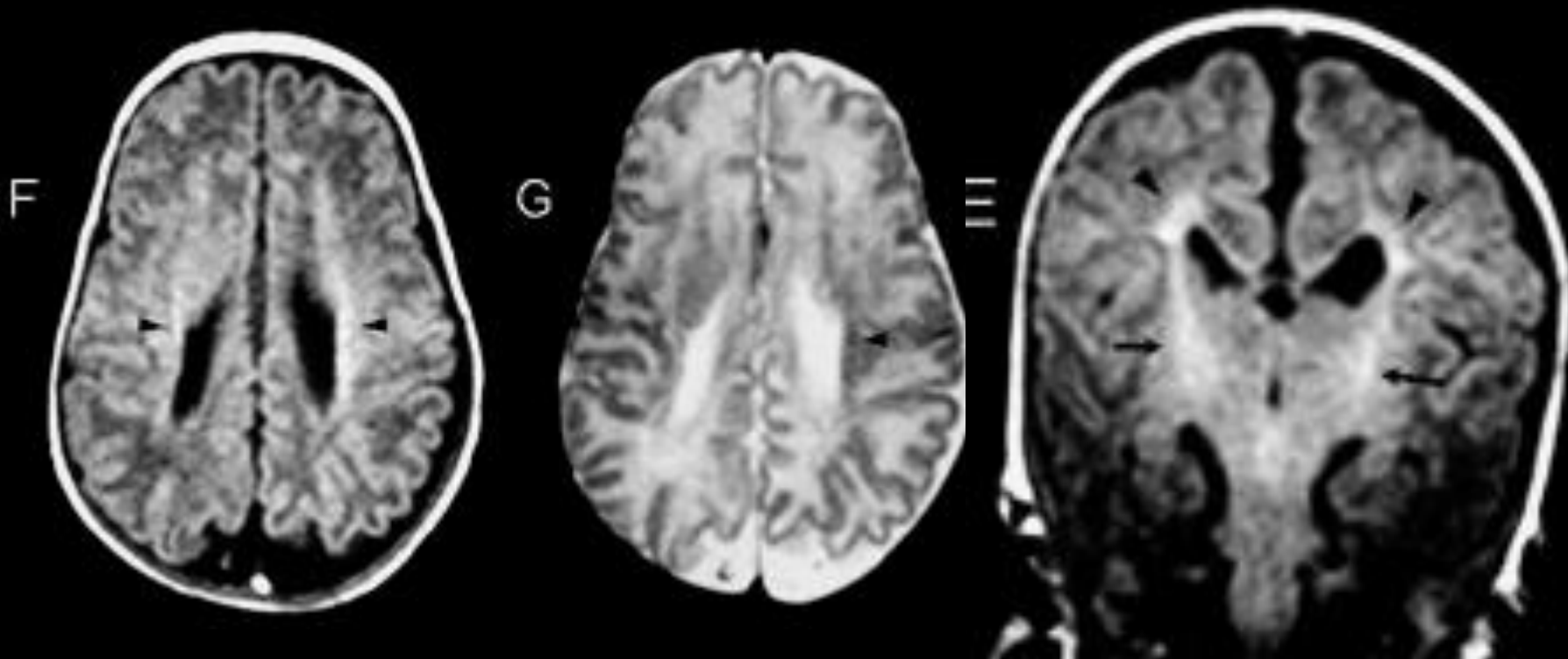
45 weeks

異常なT1高信号



もう一つのポイントとして、正常髄鞘化による高信号と異常高信号の鑑別、また異常T1高信号が錐体路を通過しているかどうか？ この判定には、横断像より冠状断像の方が有用である

Nanba Y, Matsui K, Aida N, et.al. Pediatrics 2007;120: e10-e19.

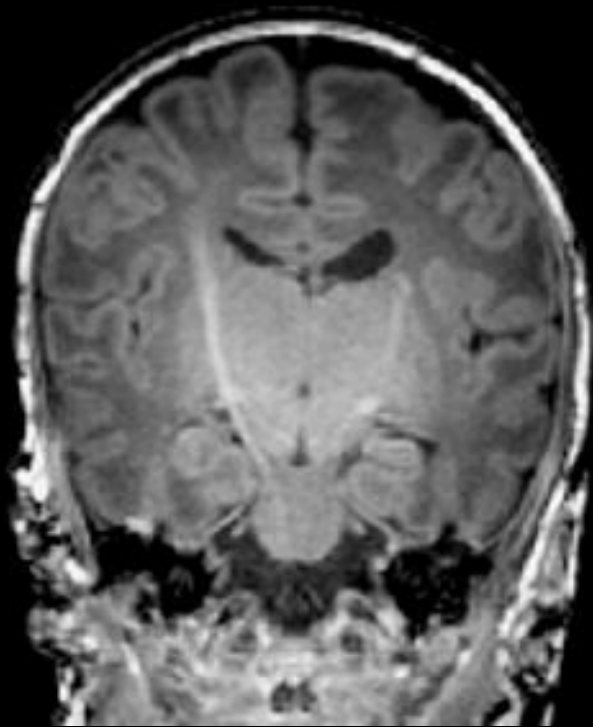


横断像では、正常髄鞘化か異常高信号かの判定困難 錐体路の通過の判定も困難：錐体路の異常高信号は予後不良

PWML の予後との関係

- Useful for predict motor prognosis in preterm infants with PVL
 - Nanba Y et.al. Pediatrics 2007; 120: e10-e19
- PWMLの数、大きさ、広がり、位置、錐体路との関係によってその臨床的意義が決まる
 - 脳室周囲の **spotty hyperintensity**
 - 脳室周囲の **band-like hyperintensity**
 - 脳室周囲の **cystic formation +T1 hyperintensity**

新生児期のMRIにはT1冠状断像 は必須である



錐体路の髄鞘による高信号の程度、量、対側との比較、PWMLとの関係

White matter injury in premature

The NEW ENGLAND JOURNAL of MEDICINE

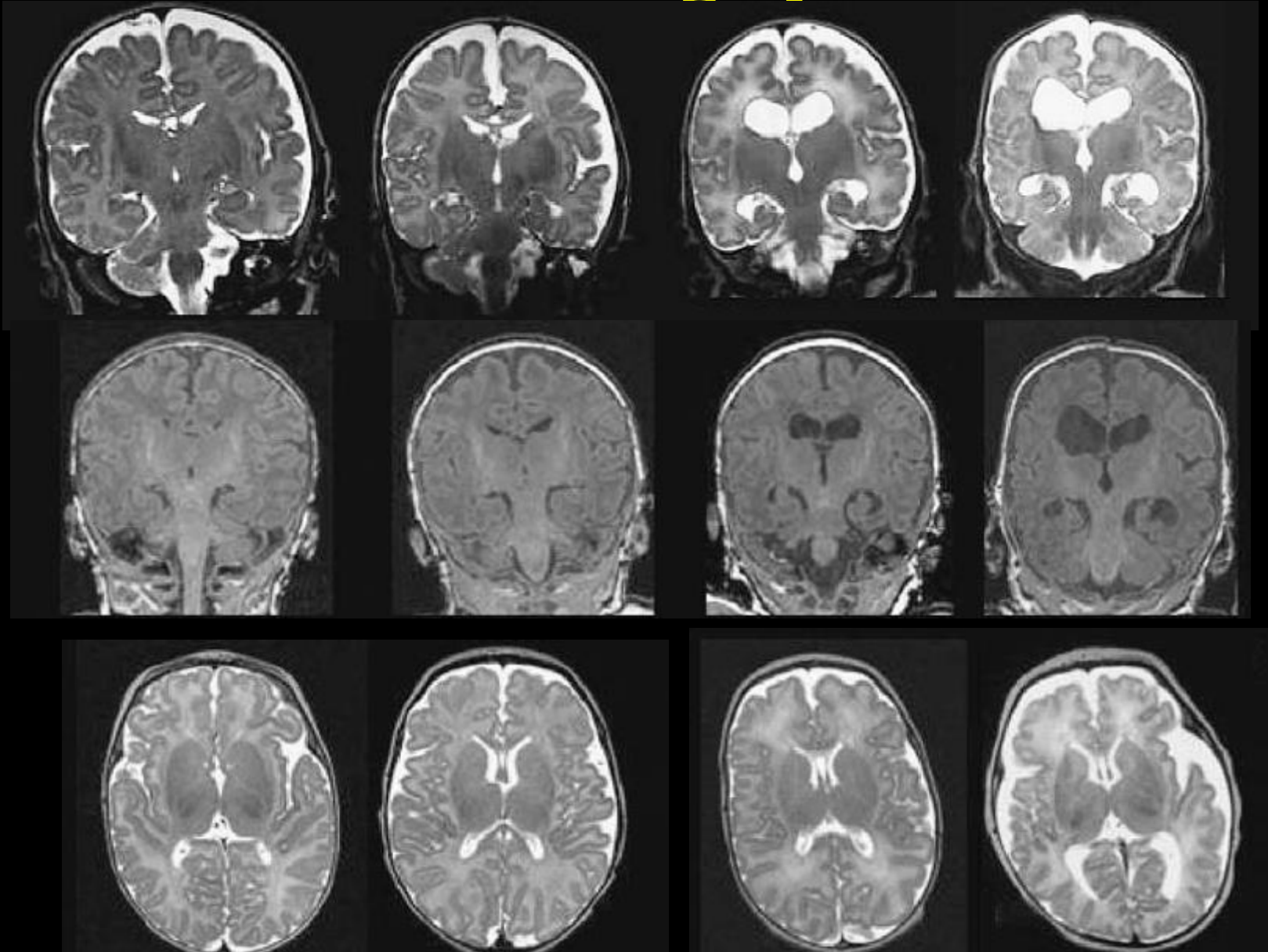
ORIGINAL ARTICLE

Neonatal MRI to Predict Neurodevelopmental Outcomes in Preterm Infants

Lianne J. Woodward, Ph.D., Peter J. Anderson, Ph.D., Nicola C. Austin, M.D.,
Kelly Howard, B.Sc., and Terrie E. Inder, M.D.

- N Engl J Med 2006; 355:685-694
- 167 very preterm infants < 30 weeks
- term equivalent MRI at 40 weeks
- severe cognitive delay, severe psychomotor delay, cerebral palsy, and neurosensory (hearing or visual) impairment at 2 years of age

MRI scoring system



MRI scoring system: white matter

- using five areas of assessment within the white matter with a score
 - 1 (normal)
 - 2 (mild abnormality)
 - 3 (moderate-severe abnormality)
 - for each area of assessment.
- The five areas of white matter abnormality that were scored included:

1. The nature and extent of white matter signal abnormality

- This was scored based on the T1- and T2-weighted signal abnormalities in the white matter best observed in the axial imaging.
- Grade 1: normal T1- and T2-weighted signal throughout the white matter.
- Grade 2: focal regions of high T1-or T2-weighted signal (2 or fewer regions per hemisphere).
- Grade 3: multiple regions of high T1- or T2-weighted signal (more than 2 regions per hemisphere).

2. Periventricular white matter volume loss

- This was also scored based on the combined T1- and T2-weighted imaging analyzing the ratio of periventricular white matter to ventricular volume in both the axial and sagittal imaging.
- Grade 1: normal periventricular white matter volume usually associated with small ventricles
- Grade 2: mild reduction in white matter volume with mild to moderate increased ventricular size.
- Grade 3: marked reduction in white matter volume often occurring with marked increase in the size of the ventricle and/or extra-axial space.

3. Cystic abnormalities

- This was easily assessed on any imaging view or modality but occurred rarely (only 5 percent or less of MR images).
- Grade 1: normal, with no cystic abnormality.
- Grade 2: less than 2mm single focal cyst.
- Grade 3: multiple cysts or a single larger (2mm or greater) single focal cyst which is rare.

4. Ventricular dilatation

- This was also scored based on the combined T1- and T2-weighted imaging in both the axial and sagittal imaging.
- Grade 1: normal with no evidence of ventricular dilatation.
- Grade 2: moderate enlargement resulting in mild rounding of the frontal horns, minimal enlargement of the temporal horns and moderate enlargement of the occipital horns.
- Grade 3: more global enlargement of a moderate to severe nature including significant enlargement of the frontal, temporal and occipital horns.

5. Thinning of the corpus callosum

- This was scored based on the sagittal and coronal T1-weighted MR imaging.
- Grade 1: normal, with thick corpus callosum visible in all views.
- Grade 2 :focal thinning in the corpus callosum often visible in the mid region of the body of the corpus on sagittal images.
- Grade 3 :global thinning across the entire corpus callosum.

an overall white matter abnormality score

- a) no abnormality - Total score 5 to 6
- b) mild abnormality – Total score 7 to 9
- c) moderate abnormality – Total score 10 to 12
- d) severe abnormality – Total score 13 to 15.

association between moderate-to-severe white-matter abnormalities on MRI and subsequent neurodevelopmental outcomes

- risks of severe motor delay odd ratio: 9.79 (2.56-37.47)
- risk of cerebral palsy odd ratio: 8.39 (2.28-30.89)
- more sensitive than US of IVH or cystic PVL
- White matter abnormalities more sensitive to predict than gray matter abnormality
- A substantial proportion of children with moderate-to-severe white-matter abnormalities were free of severe impairment at two years of age, worrisome MRI findings may not necessarily result in severe neurodevelopmental problems.

Iwata S, Nakamura T, Hizume E, et al.

Qualitative brain MRI at term and cognitive outcomes at 9 years after very preterm birth. *Pediatrics* 2012; 129:e1138-e1177

76 very preterm infants
BW<1500g or GA<32 weeks

TABLE 2 Neurodevelopmental Outcome at 9 Years in Subjects With or Without Abnormal MRI Findings: Composite Assessment of White Matter

	Normal (n = 37)	Abnormal (n = 23)	P
IQ			
Verbal	100.8 ± 12.9	88.7 ± 17.0	<.005
Performance	93.5 ± 12.4	78.6 ± 17.5	<.001
Full scale	97.0 ± 11.2	82.3 ± 16.6	<.001
Incidence of cerebral palsy (%)	1 (3)	5 (22)	<.05
Requirement for special assistance at school (%)	15 (41)	19 (83)	<.005

TABLE 3 Neurodevelopmental Outcome at 9 Years in Subjects With or Without Abnormal MRI Findings: Composite Assessment of Gray Matter

	Normal (n = 46)	abnormal (n = 14)
IQ		
Verbal	96.4 ± 15.4	95.1 ± 17.0
Performance	88.3 ± 16.0	86.1 ± 17.3
Full scale	91.8 ± 15.0	90.1 ± 16.4
Incidence of cerebral palsy (%)	4 (9)	2 (14)
Requirement for special assistance at school (%)	26 (57)	8 (57)

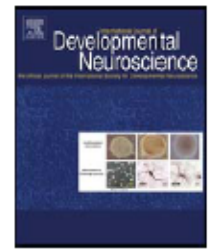


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Review

The developing oligodendrocyte: key cellular target in brain injury in the premature infant

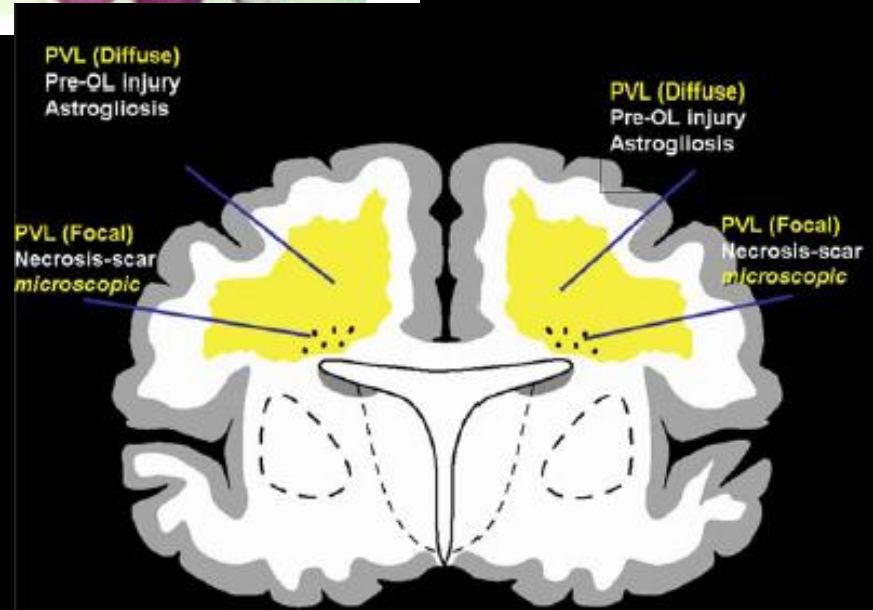
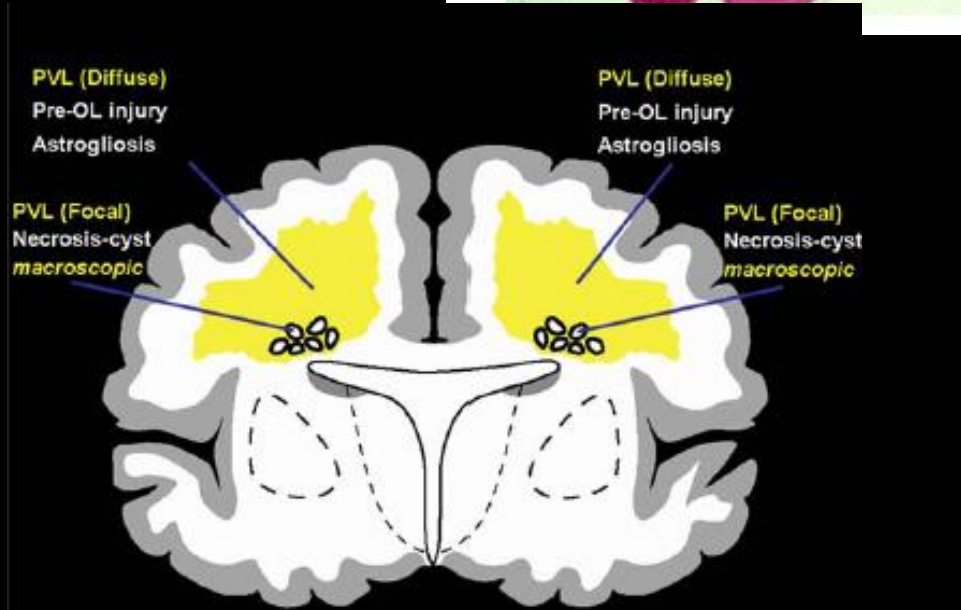
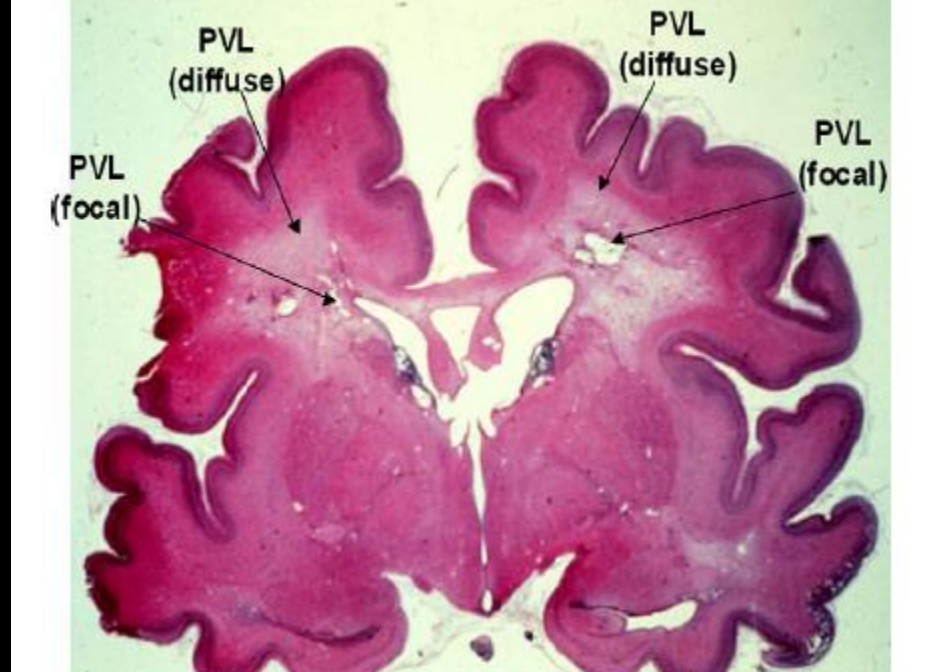
Joseph J. Volpe^{a,*}, Hannah C. Kinney^b, Frances E. Jensen^a, Paul A. Rosenberg^a

^a Department of Neurology, Children's Hospital and Harvard Medical School, Boston, MA 02115, USA

^b Department of Pathology, Children's Hospital and Harvard Medical School, Boston, MA 02115, USA

Two component of PVL- focal and diffuse

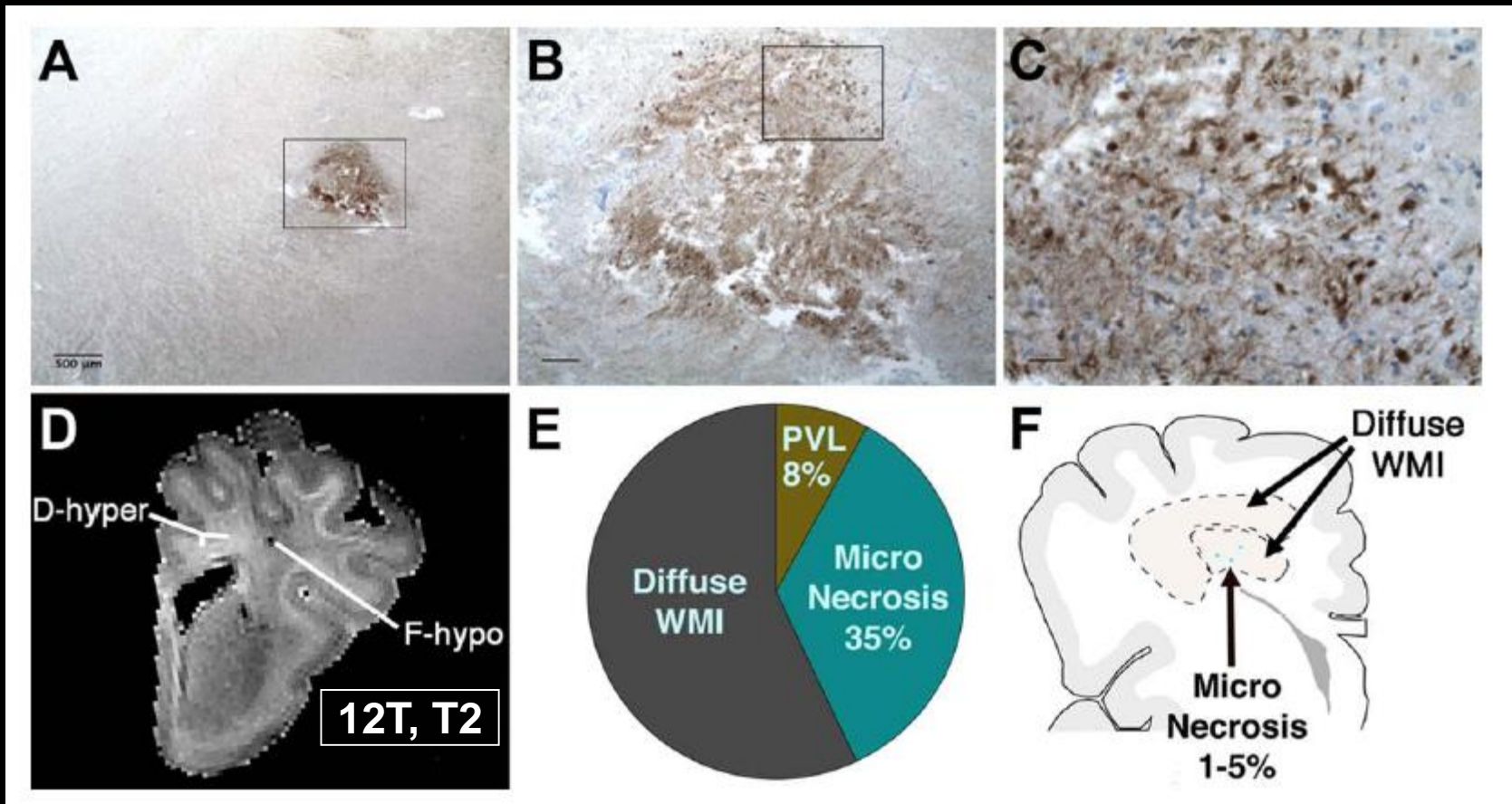
JJ Volpe et al. Int J. Devl Neuroscience 2011; 29: 423-440



Brain Injury in Premature Neonates: A Primary Cerebral Dysmaturation Disorder?

Stephen A. Back, MD, PhD^{1,2} and Steven P. Miller, MDCM, MAS^{3,4}

Annals of Neurology 2014; 75: 469-486



staining for β -amyloid precursor protein, a marker of axonal degeneration

Barkovich の教科書に立ち返ると

- white matter injury of prematurity
 - prior PVL
 - frequently accompanied by neuronal and axonal disease affecting thalami, basal ganglia, cerebral cortex, brain stem and cerebellum
 - term: encephalopathy of prematurity
 - etiology; hypoxic-ischemic injury, infection, metabolic disease, hydrocephalus, congenital heart disease

white matter injury of prematurity

- focal/multifocal cavitory white matter injury
 - severe clinical manifestation
 - decreasing, much less common < 5%
 - AJNR 2003; 24: 1661-69, AJNR 2003; 24: 805-9、
 - Acta Paediatr 2010; 99: 354-8
- focal/multifocal noncavitory white matter injury
 - intermediate clinical severity
 - increasing, 50% of premature neonate
- diffuse white matter injury:
 - mildest clinical manifestation

それに対応するMRI画像とは？

- focal/multifocal cavitary white matter injury
 - **cystic PVL**:これはもともと従来から狭義のPVLとされていたMRI画像
 - USではPVE higher grade → cystic change
 - motor impairment; cerebral palsy
- focal/multifocal noncavitary white matter injury
 - **non-cystic PVL**と言われていた概念(広義のPVLに含む)
 - micronecrosis
 - punctate white matter lesion (PWML)
- diffuse white matter injury
 - conventional MRIでは異常として認識できない
 - advanced MRI, DTI, connectivity studyで認識できる
 - いわゆる発達障害(cognitive, behavioral and learning impairment)と関連

現在求められている課題

MRI and advanced MRIによる

- diffuse white matter injury (mildest clinical manifestation) の解明
- 発達障害 (cognitive, behavioral and learning impairment) の解明
- preterm risk baby の正確な予後予測
- Hypoxic-ischemic encephalopathy の予後予測

この分野の研究に関しては、DTI, MRS 共に今盛んに研究されている分野であり、
どんどん新たな知見が生まれつつあります。
すぐに現在の知見も陳腐化すると
考えられます。どうか、皆様の奮闘で日
本からも新たな論文が出ることを期待し
ております。

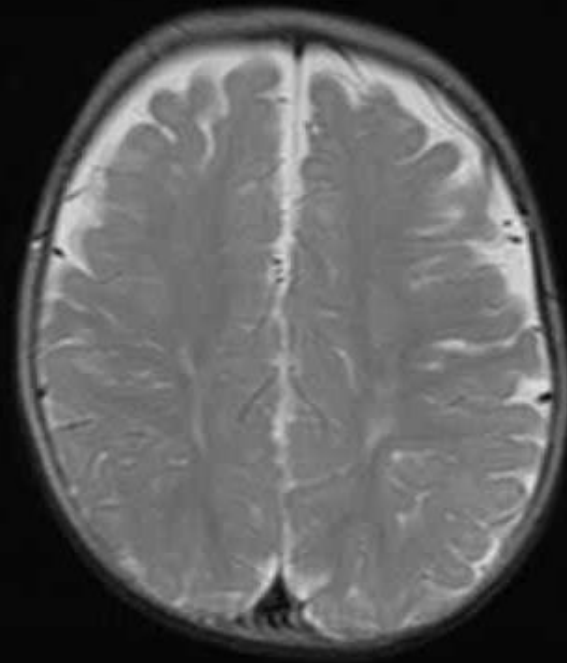
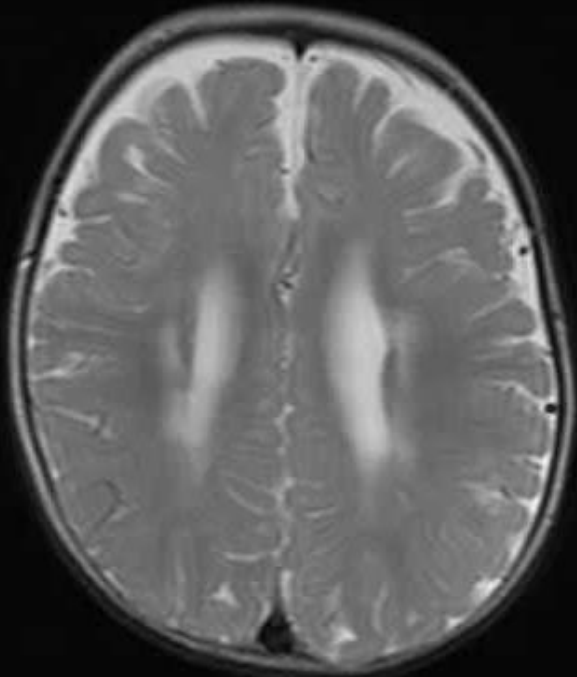
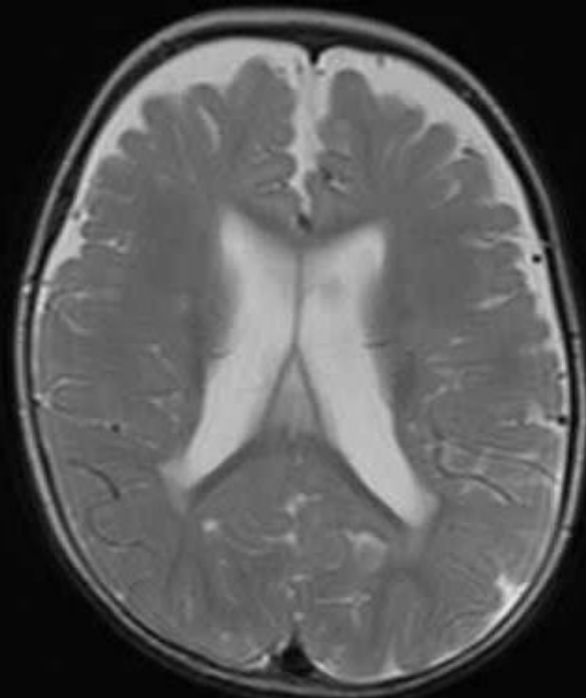
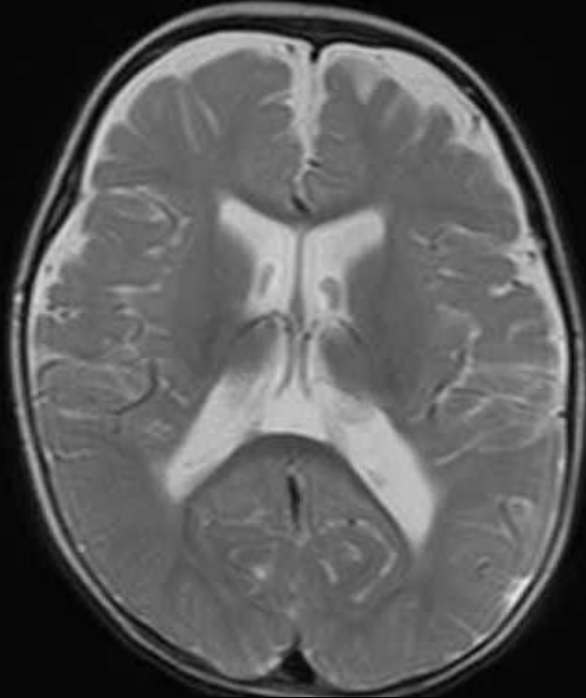
御静聴ありがとうございました

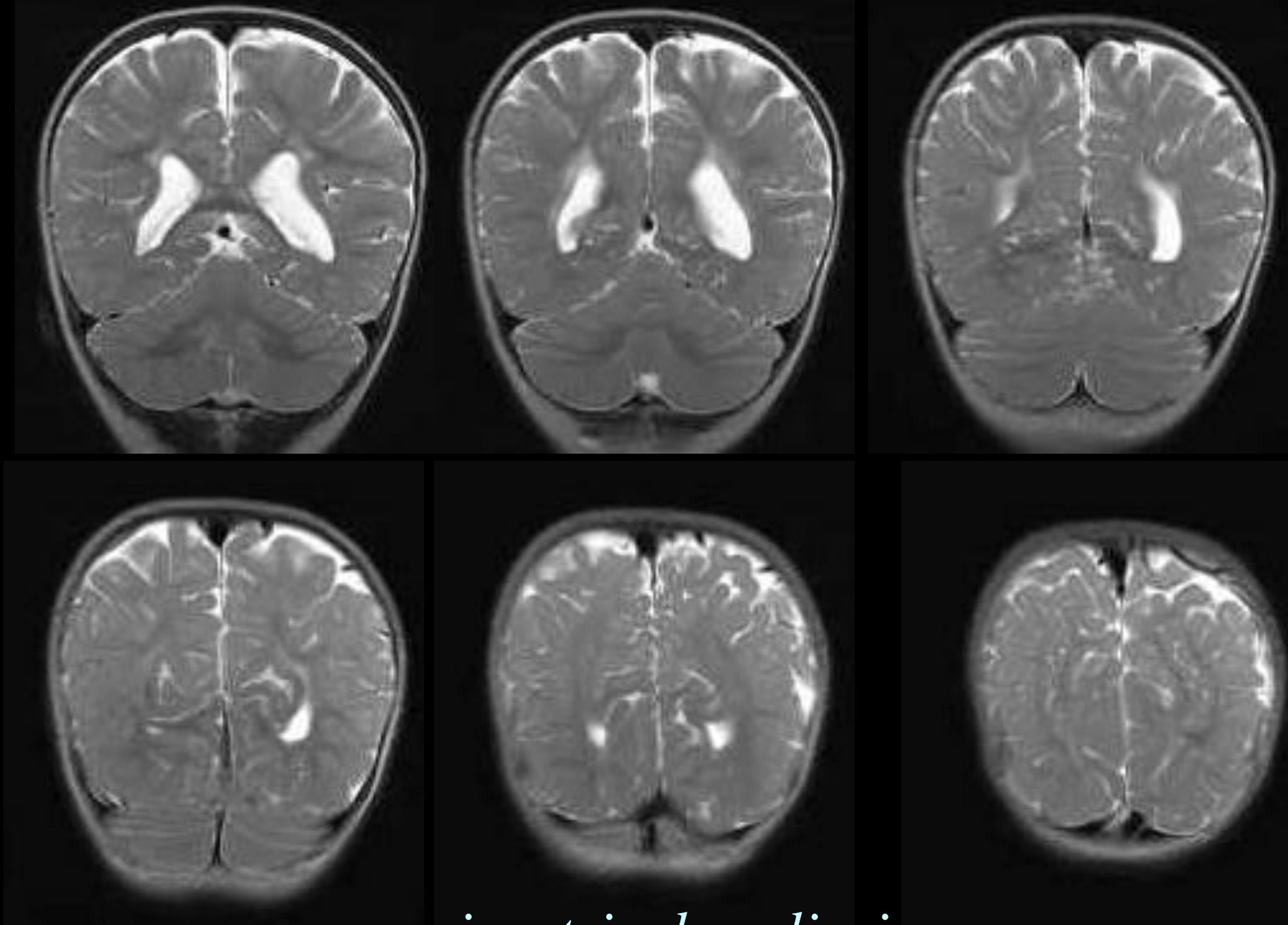
第9回小児神経放射線研究会 2014. 10. 25. (土) メルパルク京都
当番世話人: 相田典子先生 神奈川県立こども医療センター 放射線科

one pitfall on MRI

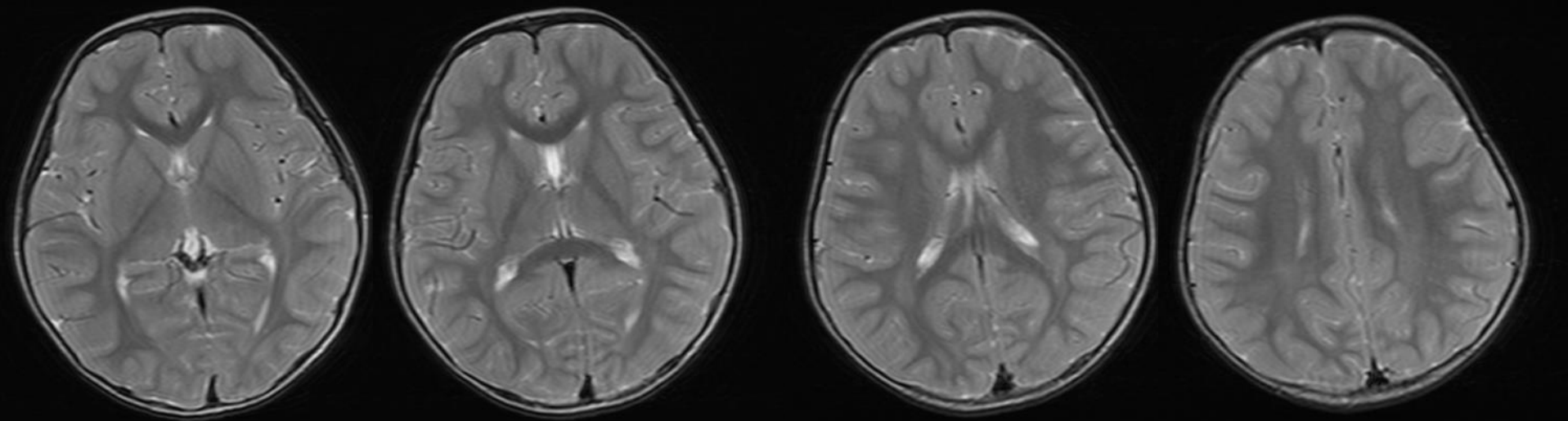
frequently asked question

- so-called terminal zone vs periventricular gliosis
- terminal zone: normal areas of slow myelination dorsal and superior to the trigones
- separated by thin band of myelinated WM vs directly abuts the ventricular wall
- loss of myelinated WM volume
- irregular ventricular wall

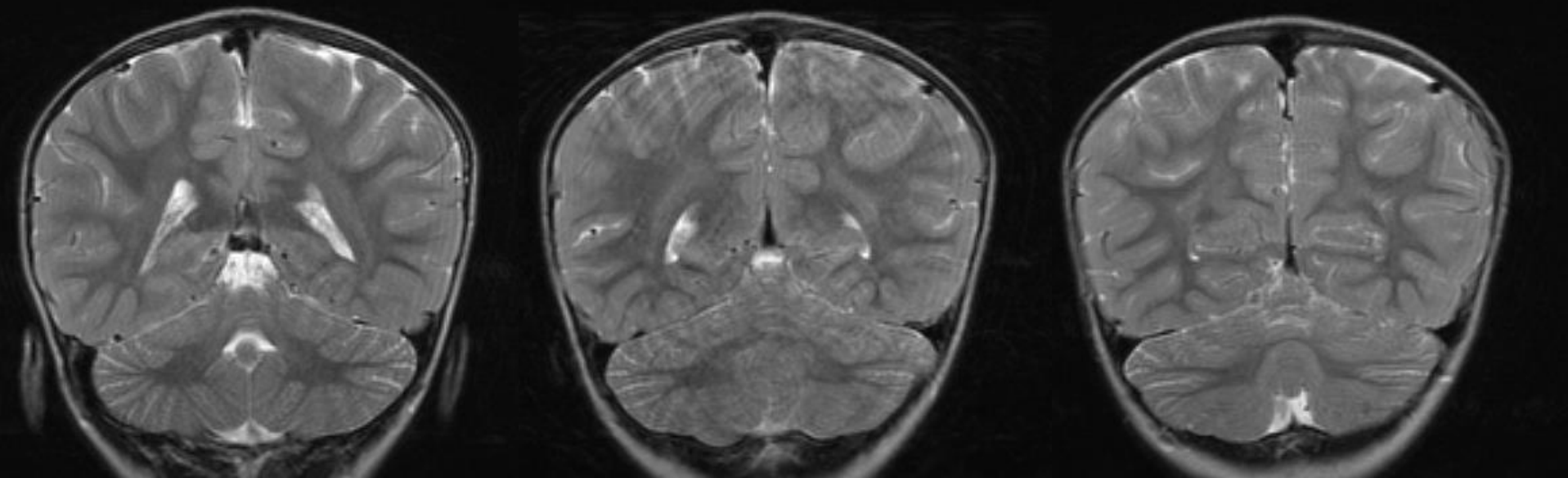




periventricular gliosis



of 18 of 18 IM of 18 of 18 of 18



Terminal zone

鑑別点の復習

- terminal zone: normal areas of slow myelination dorsal and superior to the trigones
- separated by thin band of myelinated WM vs directly abuts the ventricular wall
- loss of myelinated WM volume
- irregular ventricular wall in periventricular gliosis

受傷早期のMRIでははっきりわかる
が あとでは認識しにくくなるもの

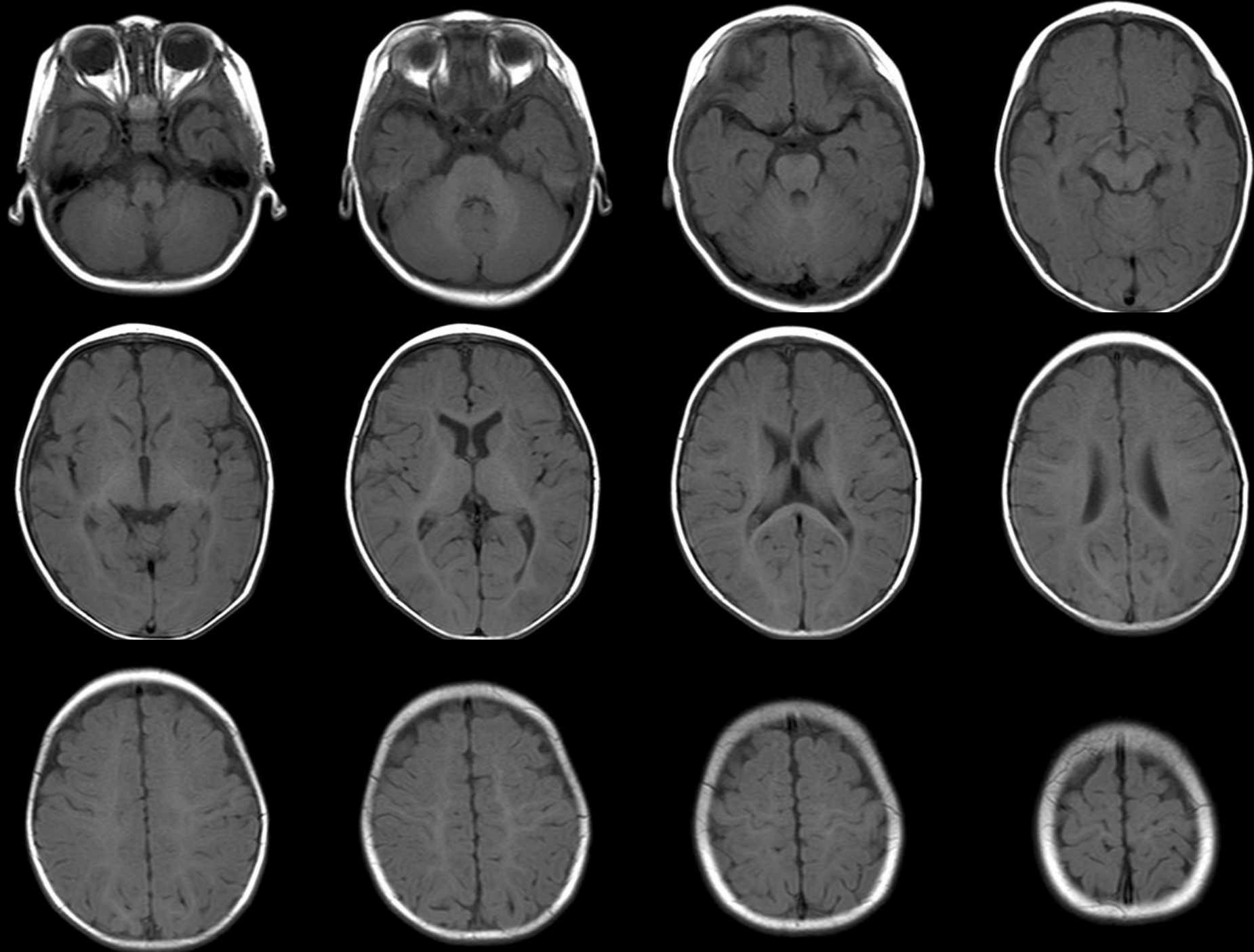
- HIE DWIでの信号変化
- HIE 基底核の信号異常

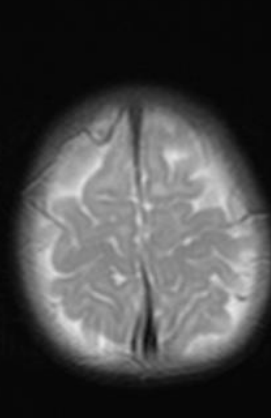
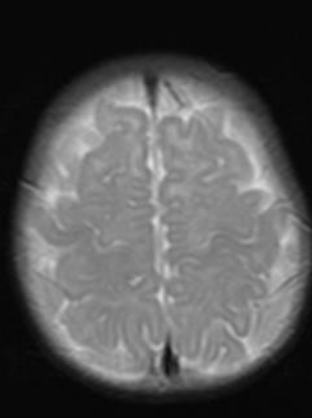
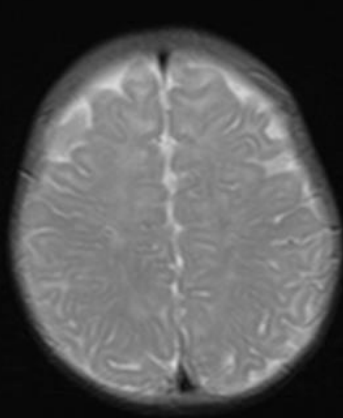
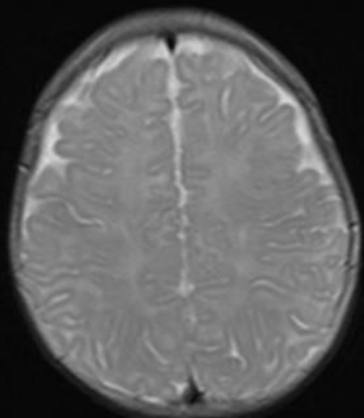
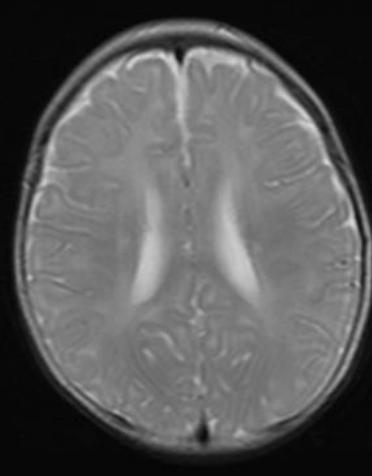
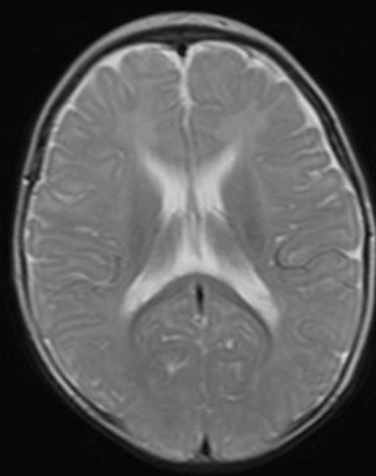
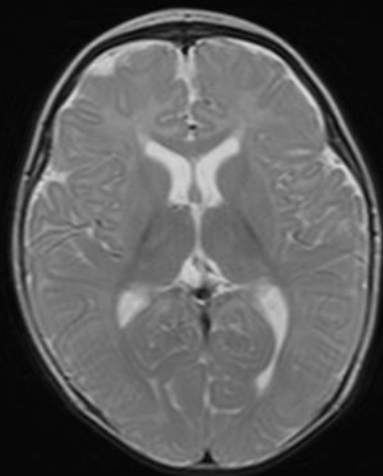
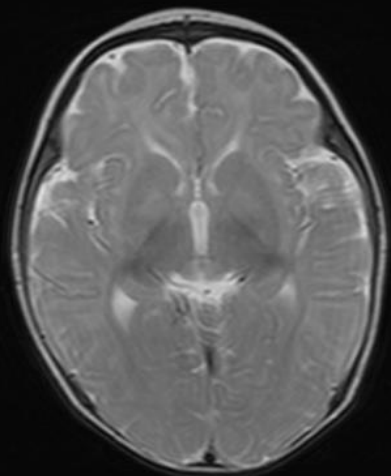
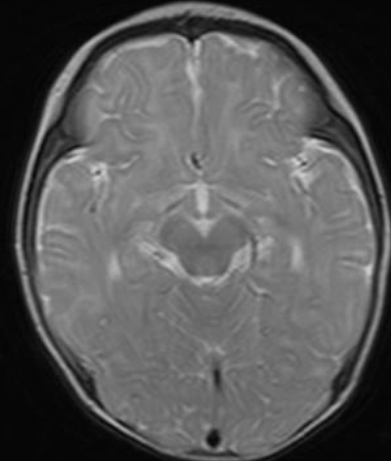
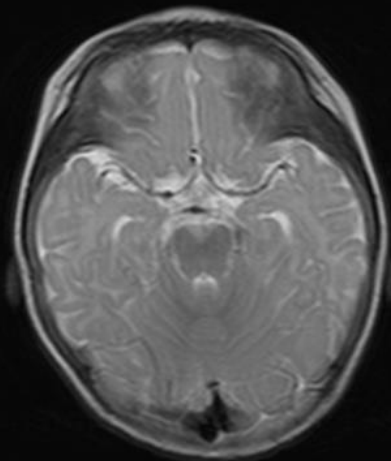
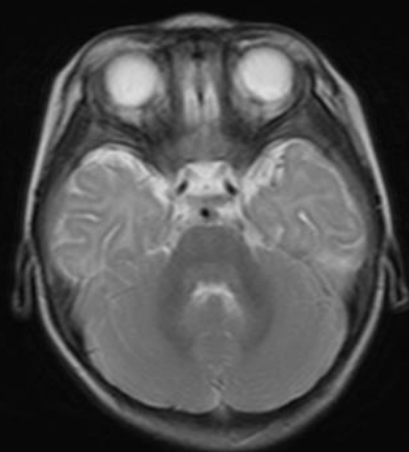
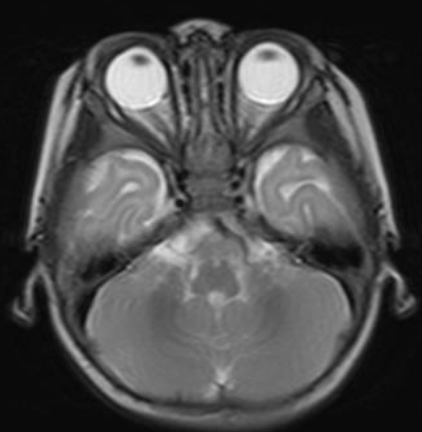
受傷早期のMRIで分かり難いが あとではっきり認識できるもの

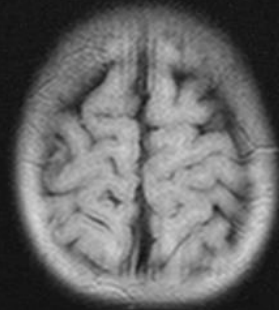
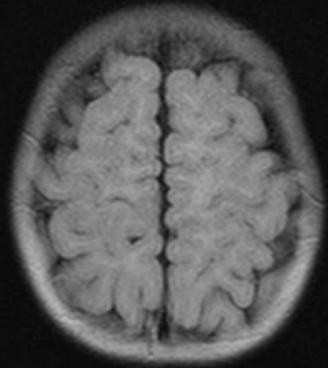
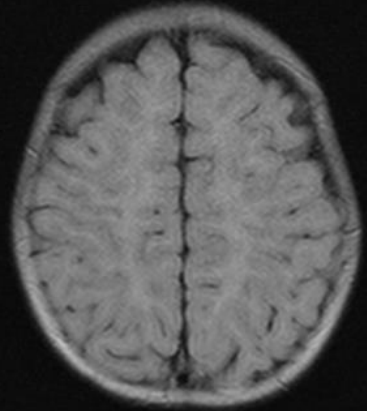
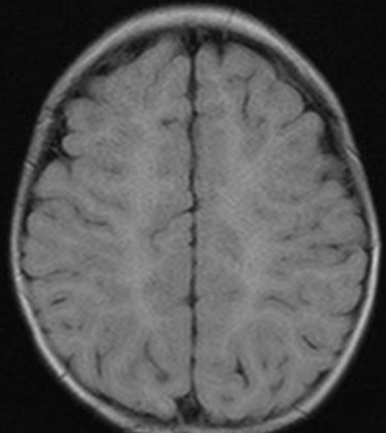
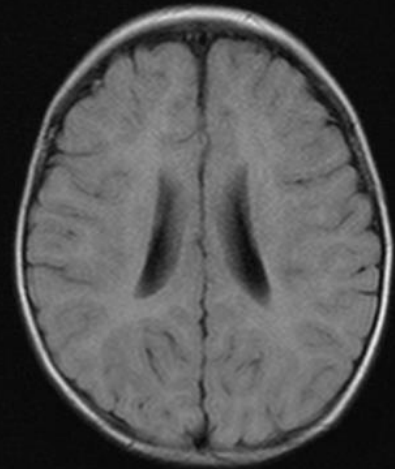
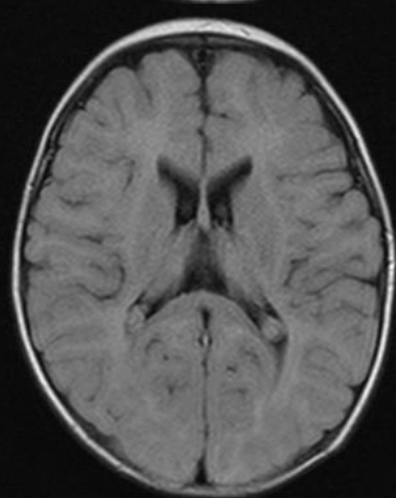
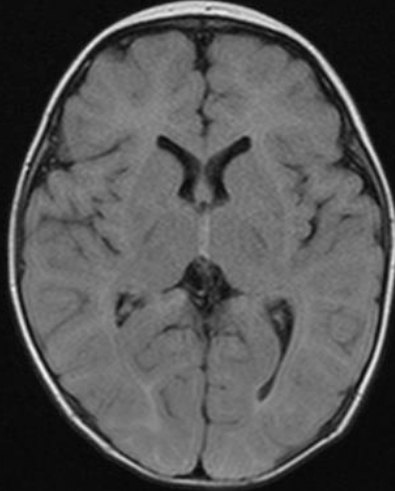
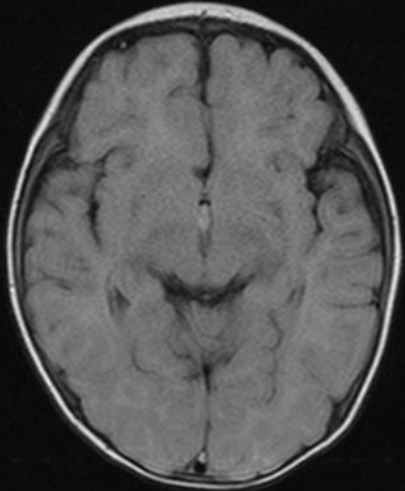
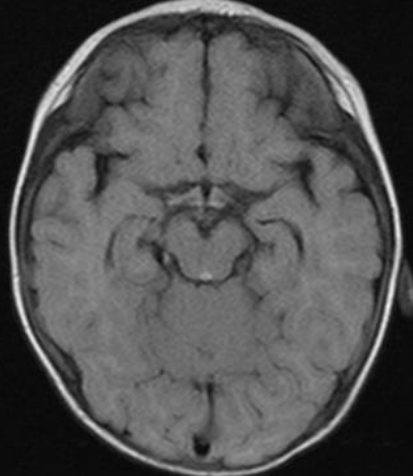
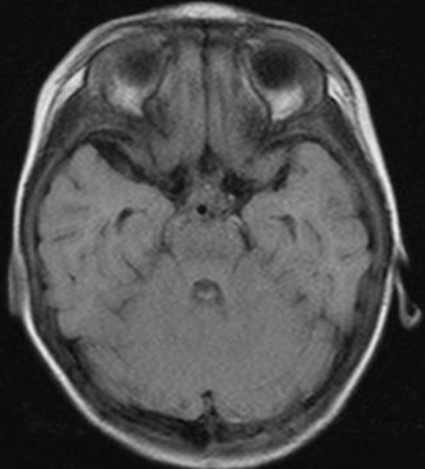
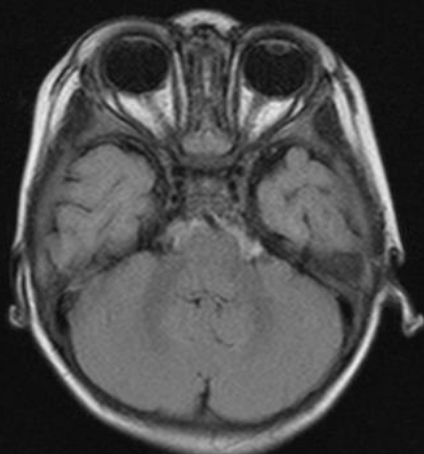
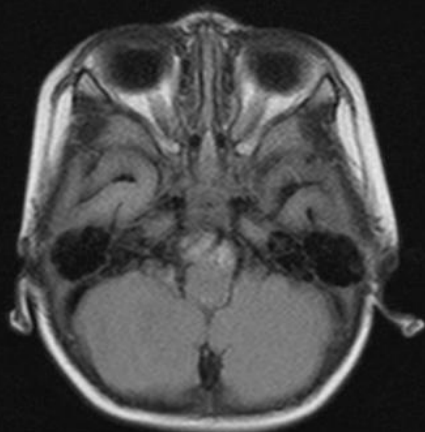
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- periventricular gliosis
- myelination delay

症例 修正6ヶ月男児

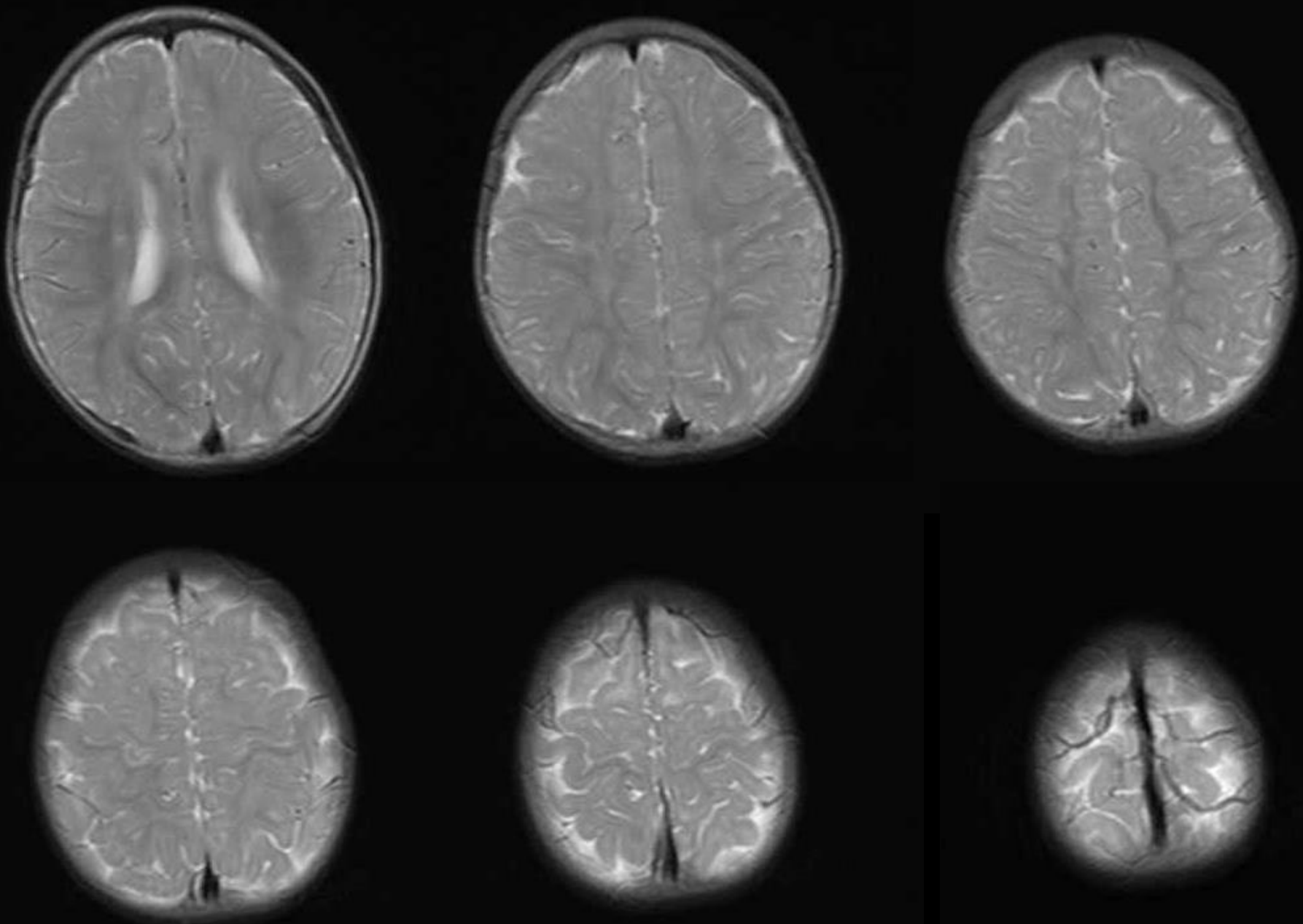
- 在胎36週、胎盤早期剥離の為、緊急帝王切開にて出生2426g。Apgar 4/5
- 自発呼吸無く、9分にて挿管、集中治療を受けた
- その後順調にて、生後4日にて抜管、1ヶ月にて、退院。
- 脳性麻痺危険児として、訓練中。



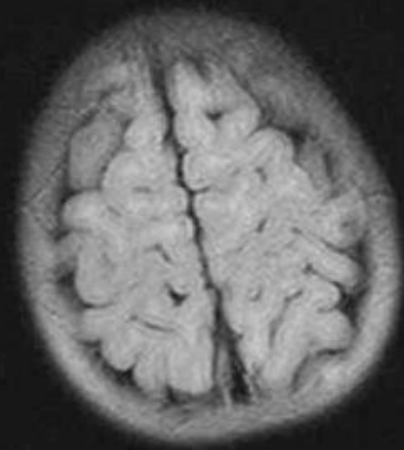
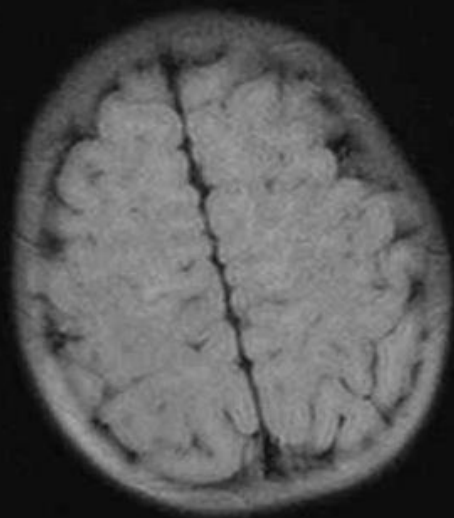
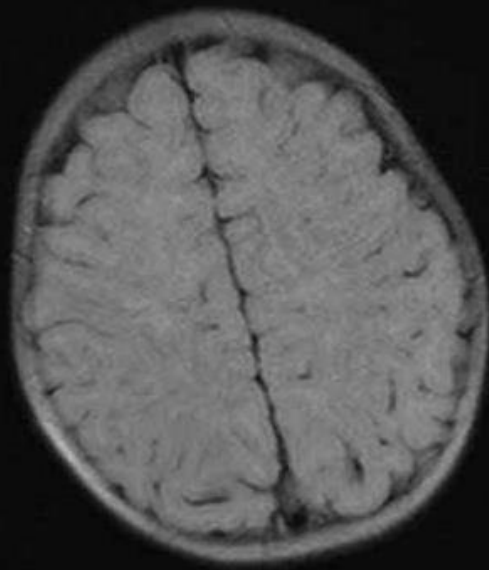
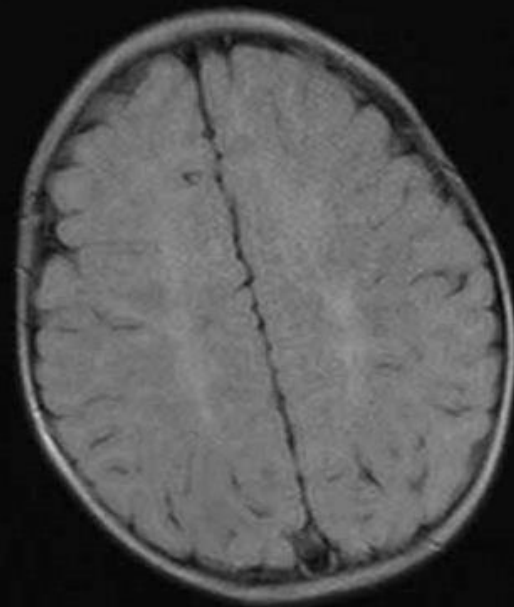
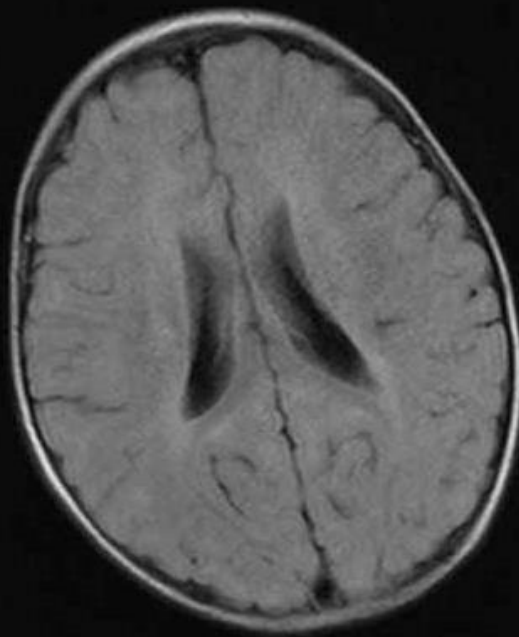
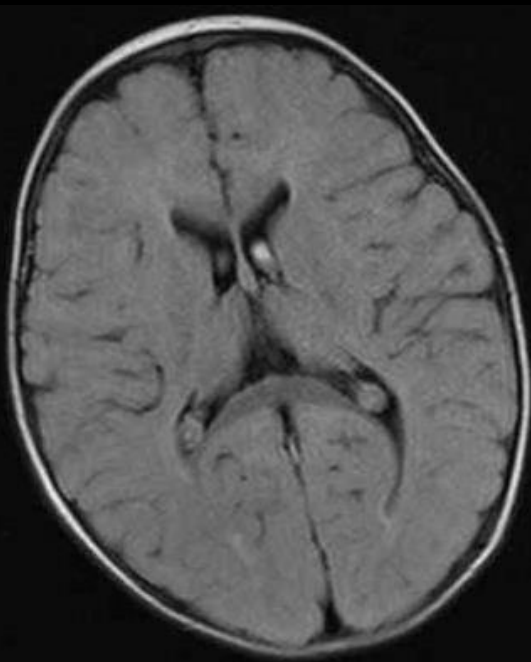




修正11ヶ月時のMRI.

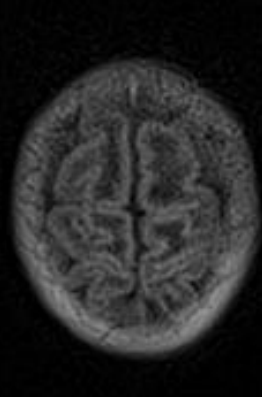
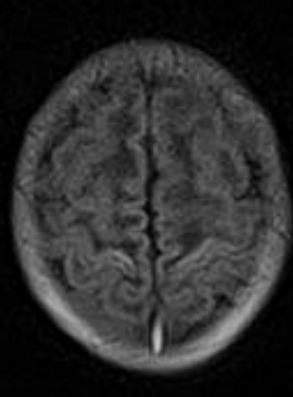
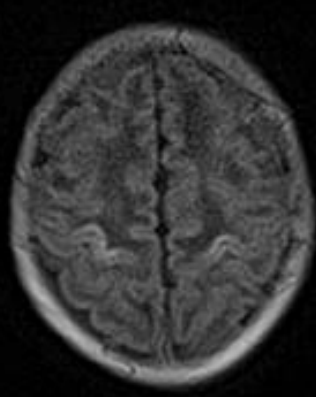
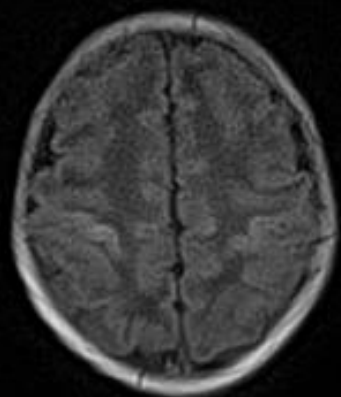
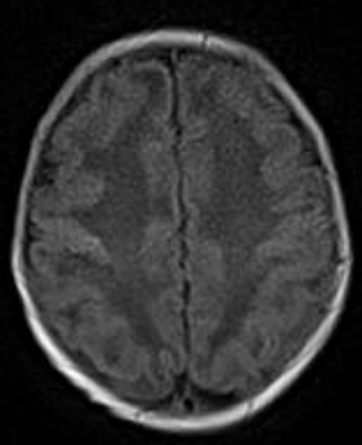
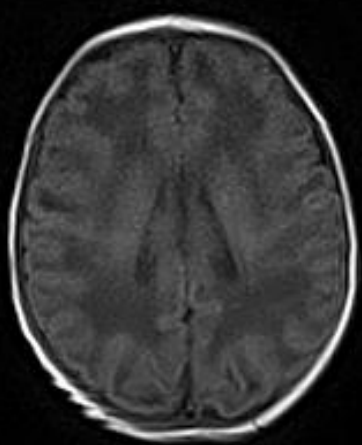
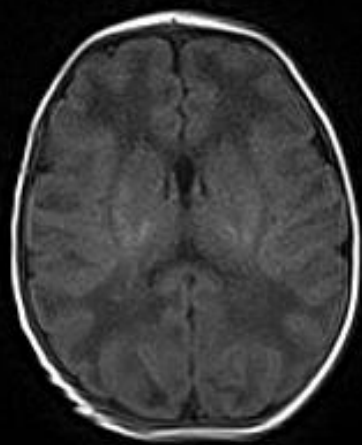
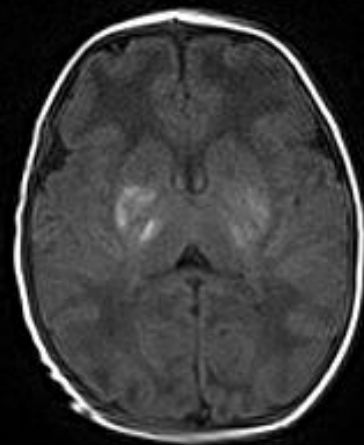
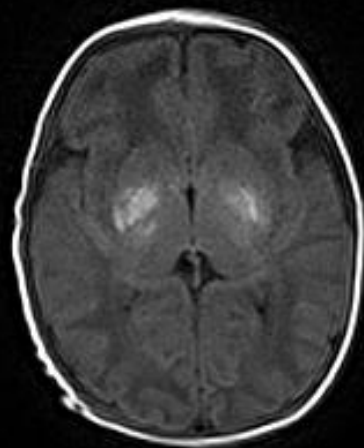
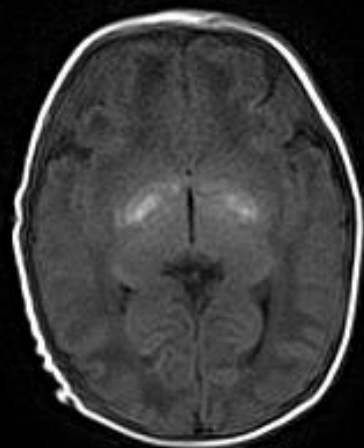
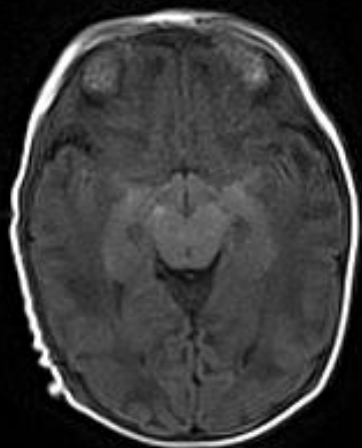
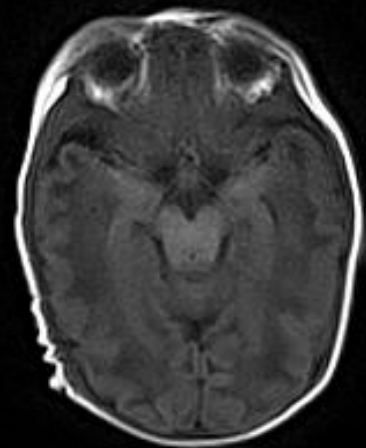


Rolandic type of cerebral palsy



FLAIRも時として万能ではない

新生児期のMRIに帰ると

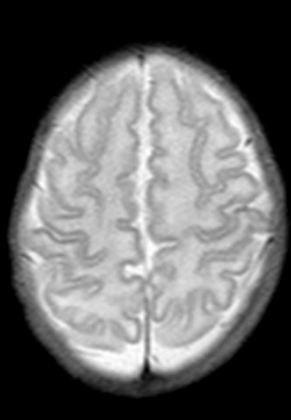
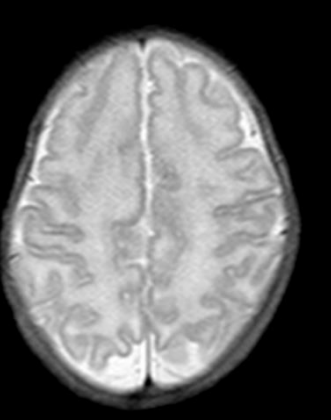
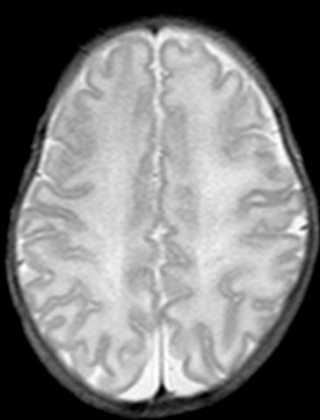
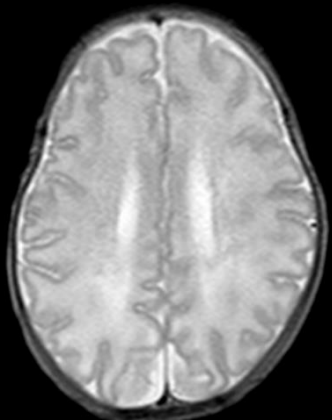
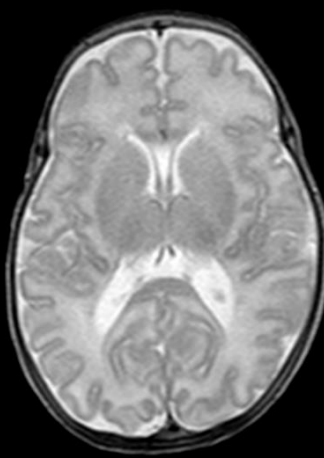
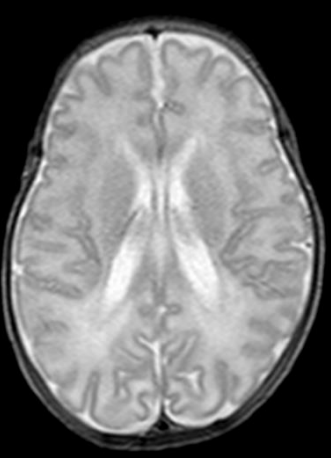
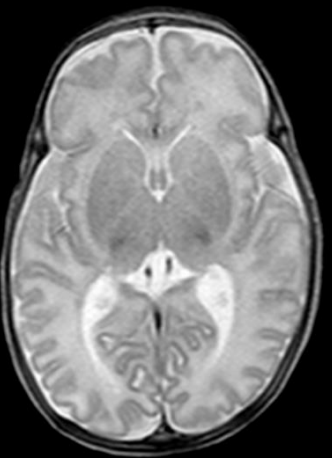
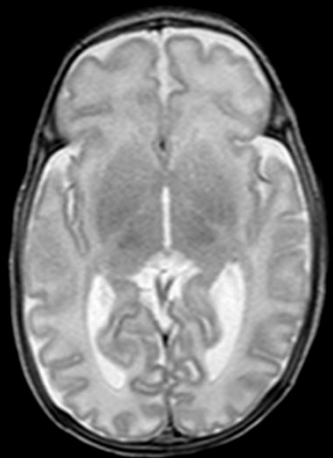
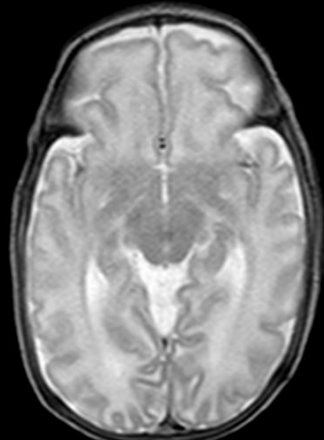
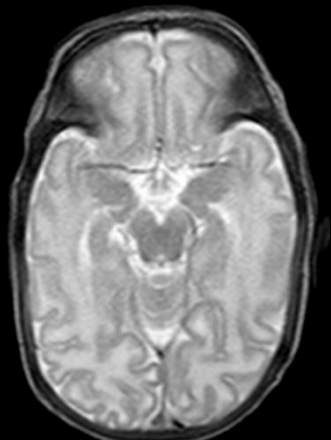
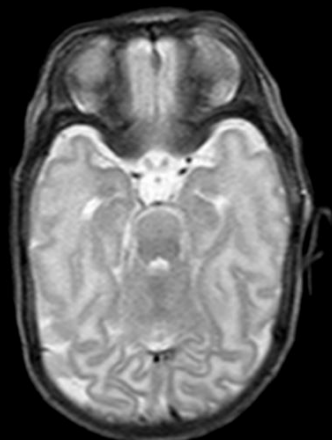
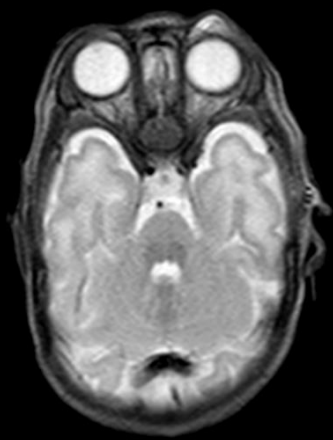


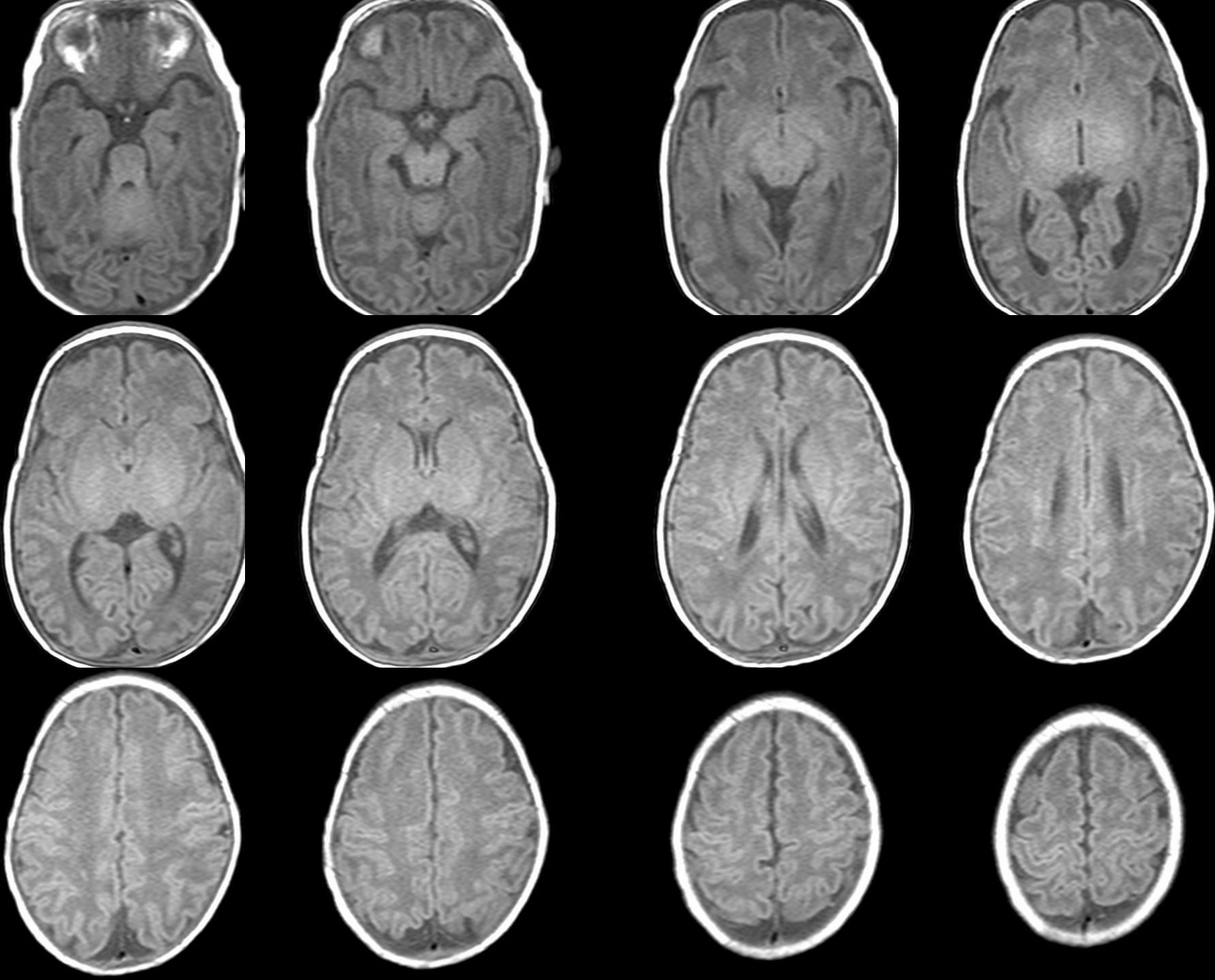
やはりはっきりと受傷部位が描出

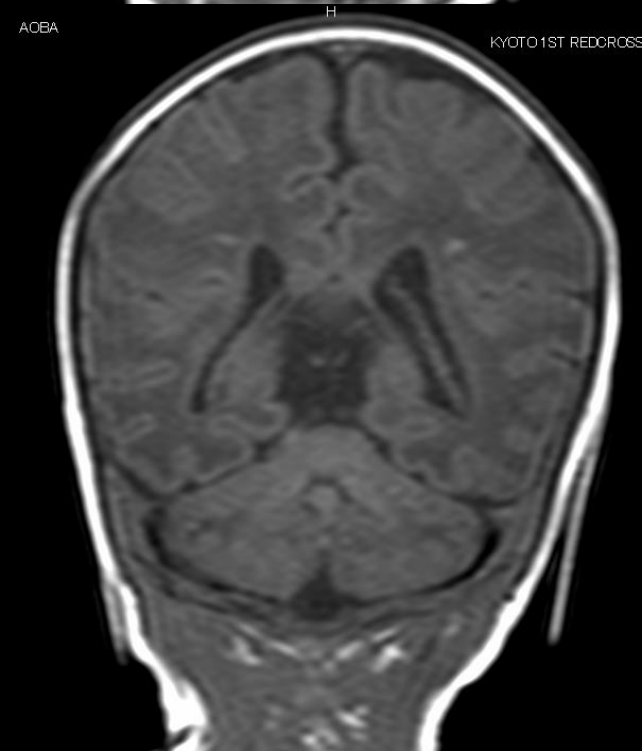
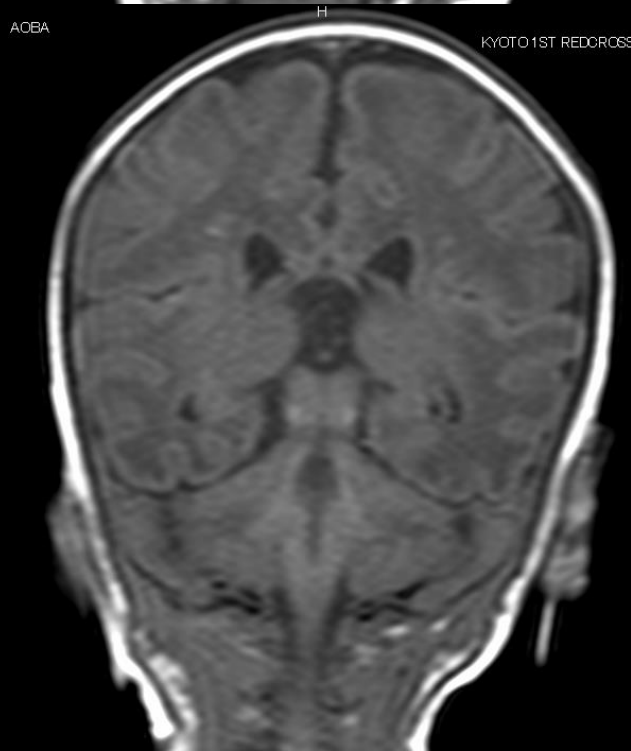
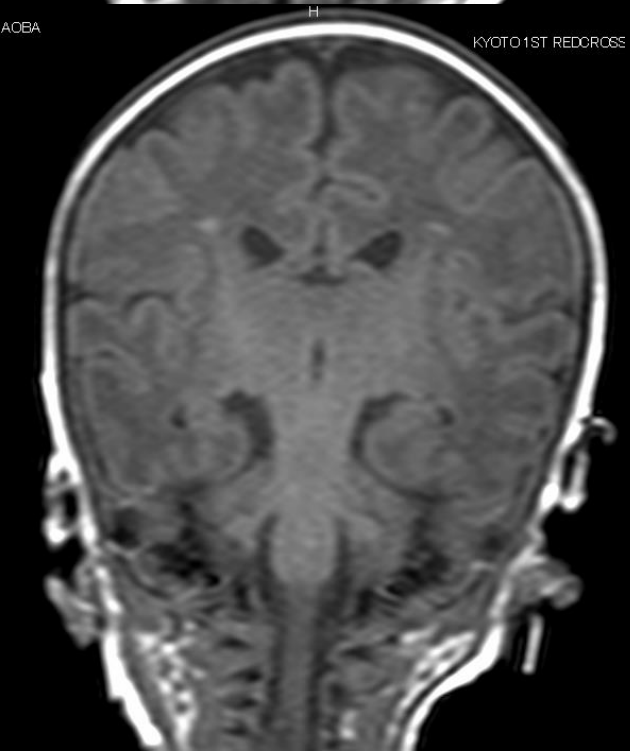
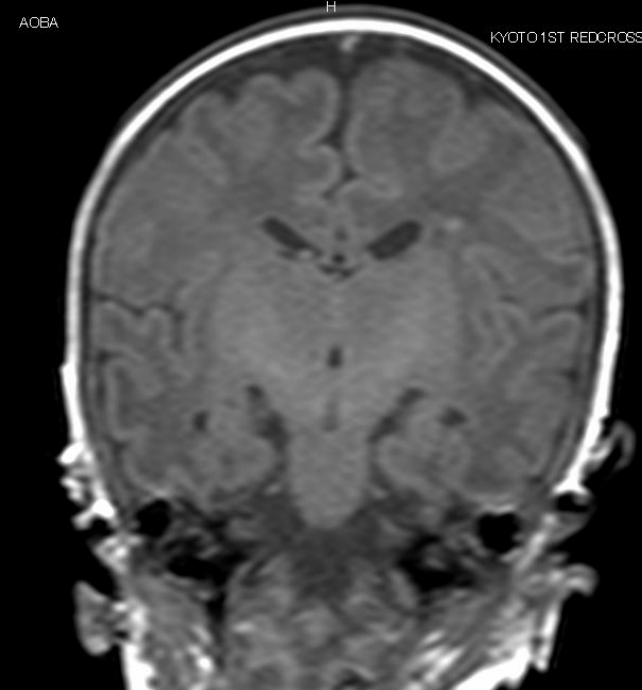
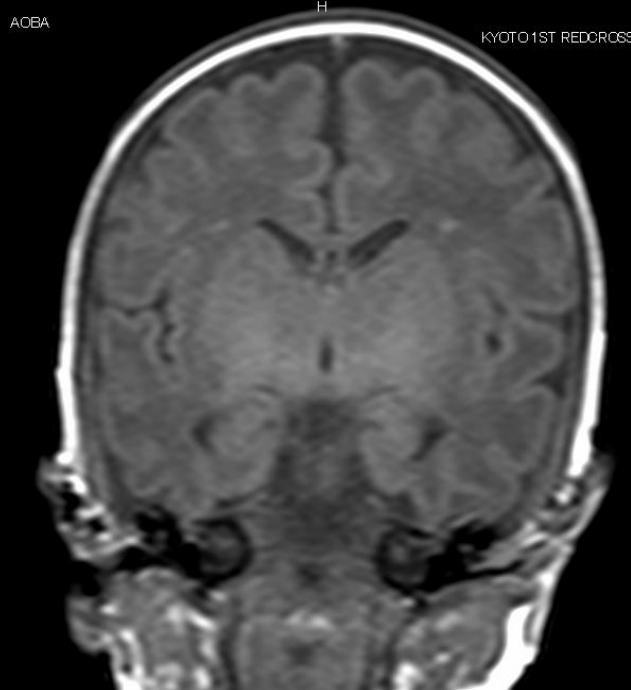
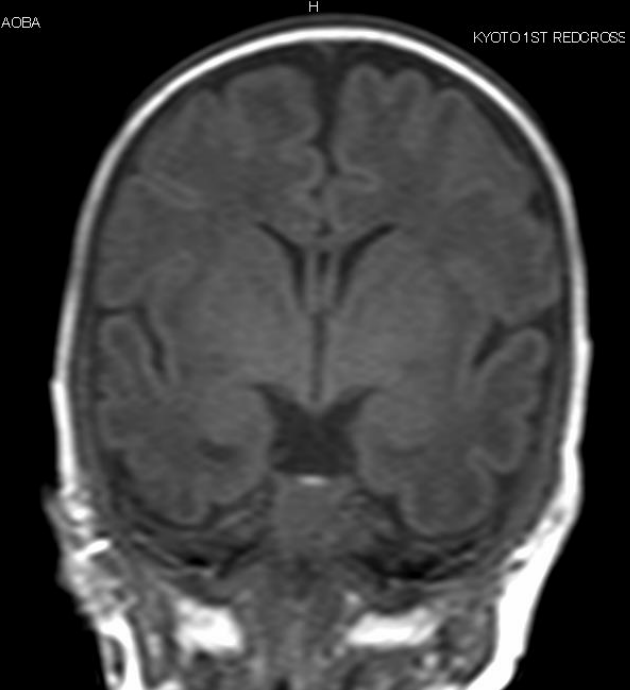
- 受傷早期のMRIではっきりわかるが あとでは認識しにくくなるもの
 - HIE DWIでの信号変化
 - HIE 基底核の信号異常
- 受傷早期のMRIで分かり難いが あとでははっきり認識できるもの
 - Rolandic injuryにおけるローランド皮質の信号変化
 - periventricular gliosis
 - myelination delay

症例 早期産男児

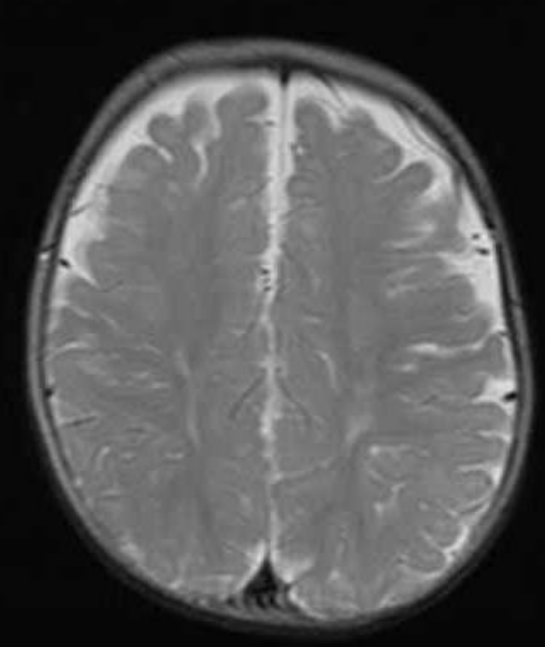
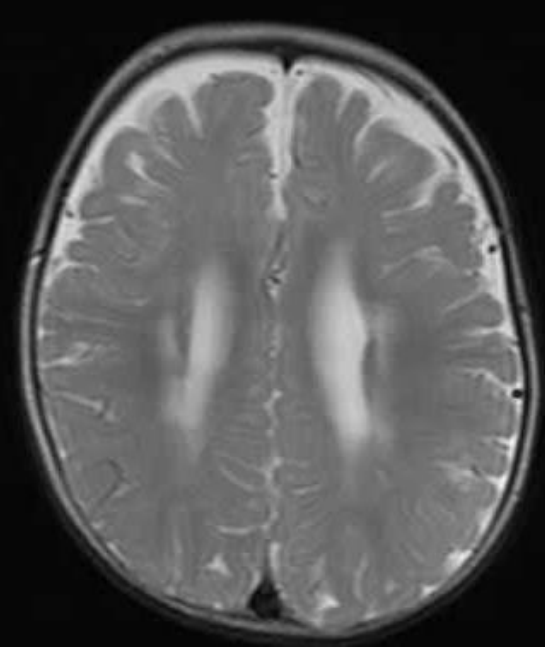
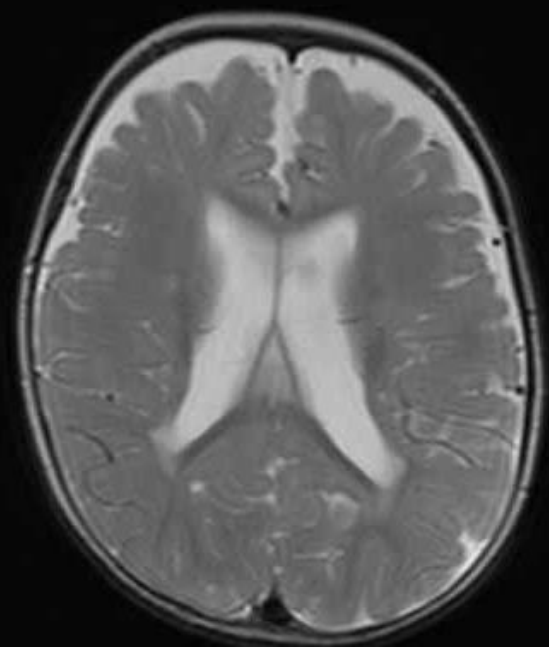
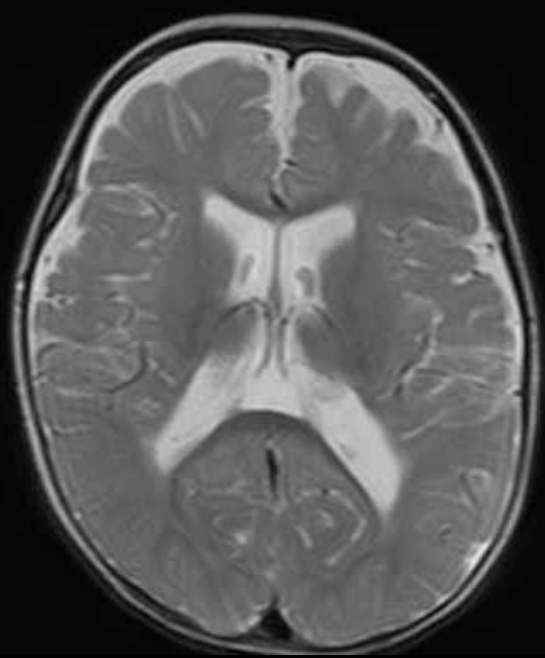
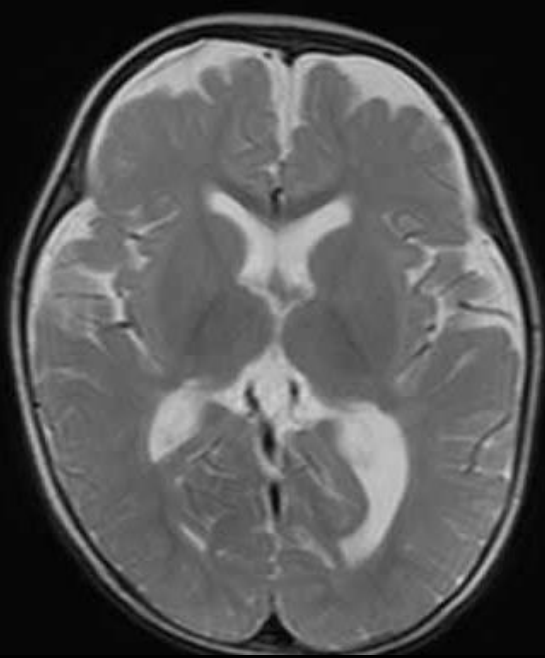
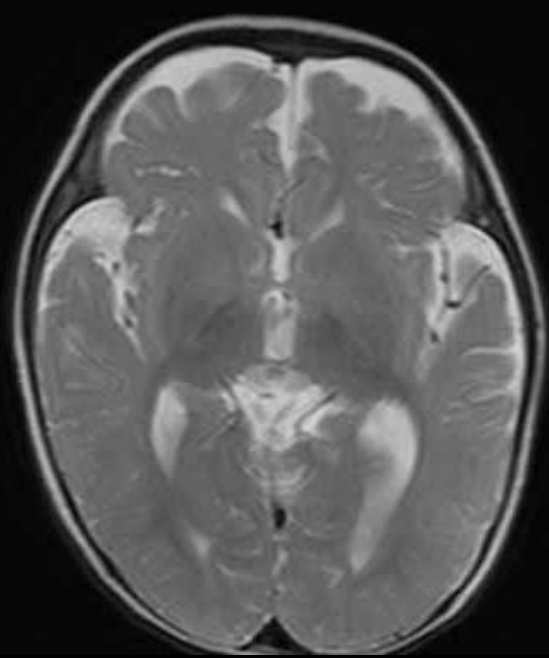
- 30週 1482gにて出生 NICU管理
- 退院前のMRIチェック;修正38週

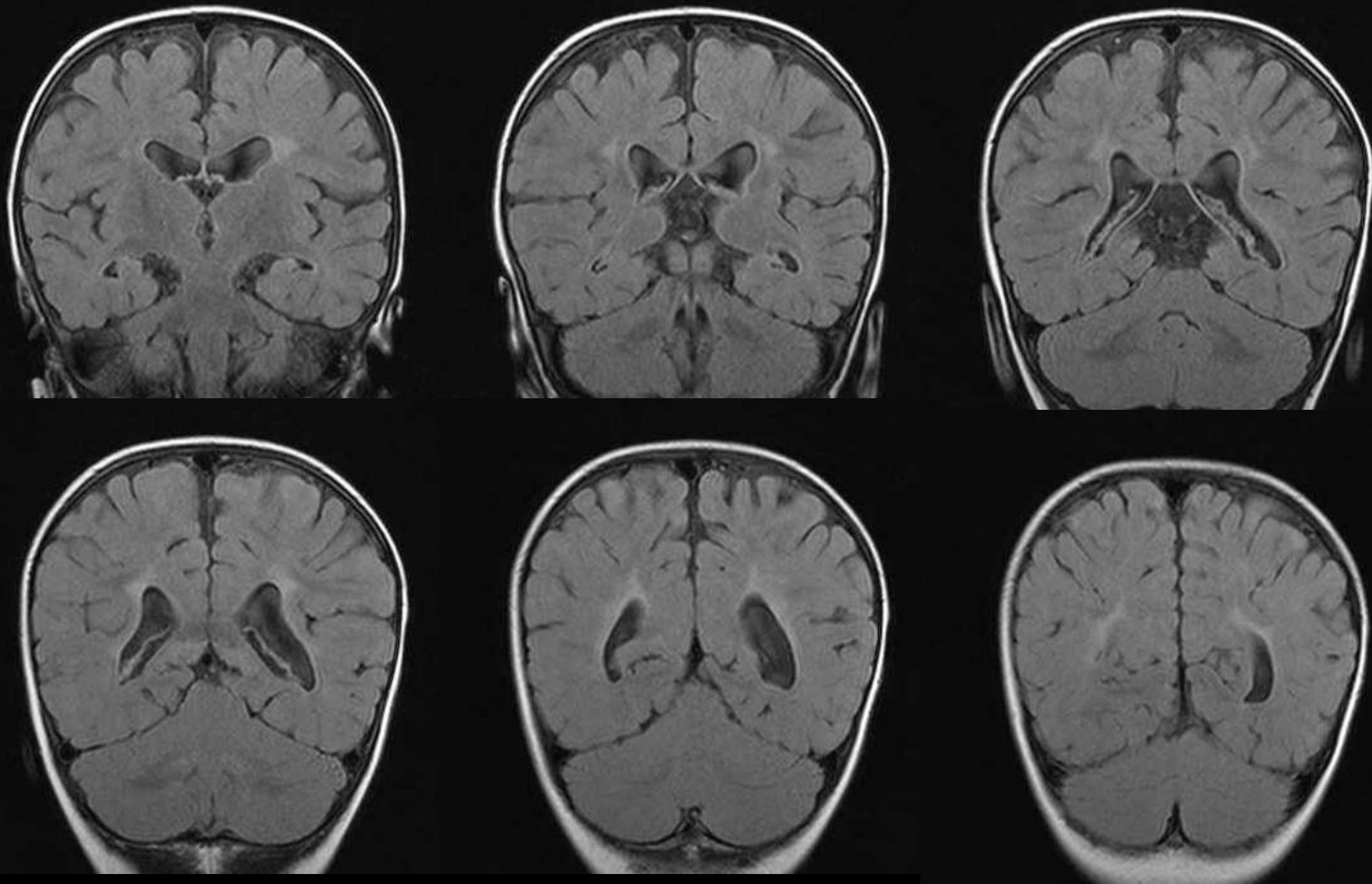






生後1才、修正11ヶ月時のMRI

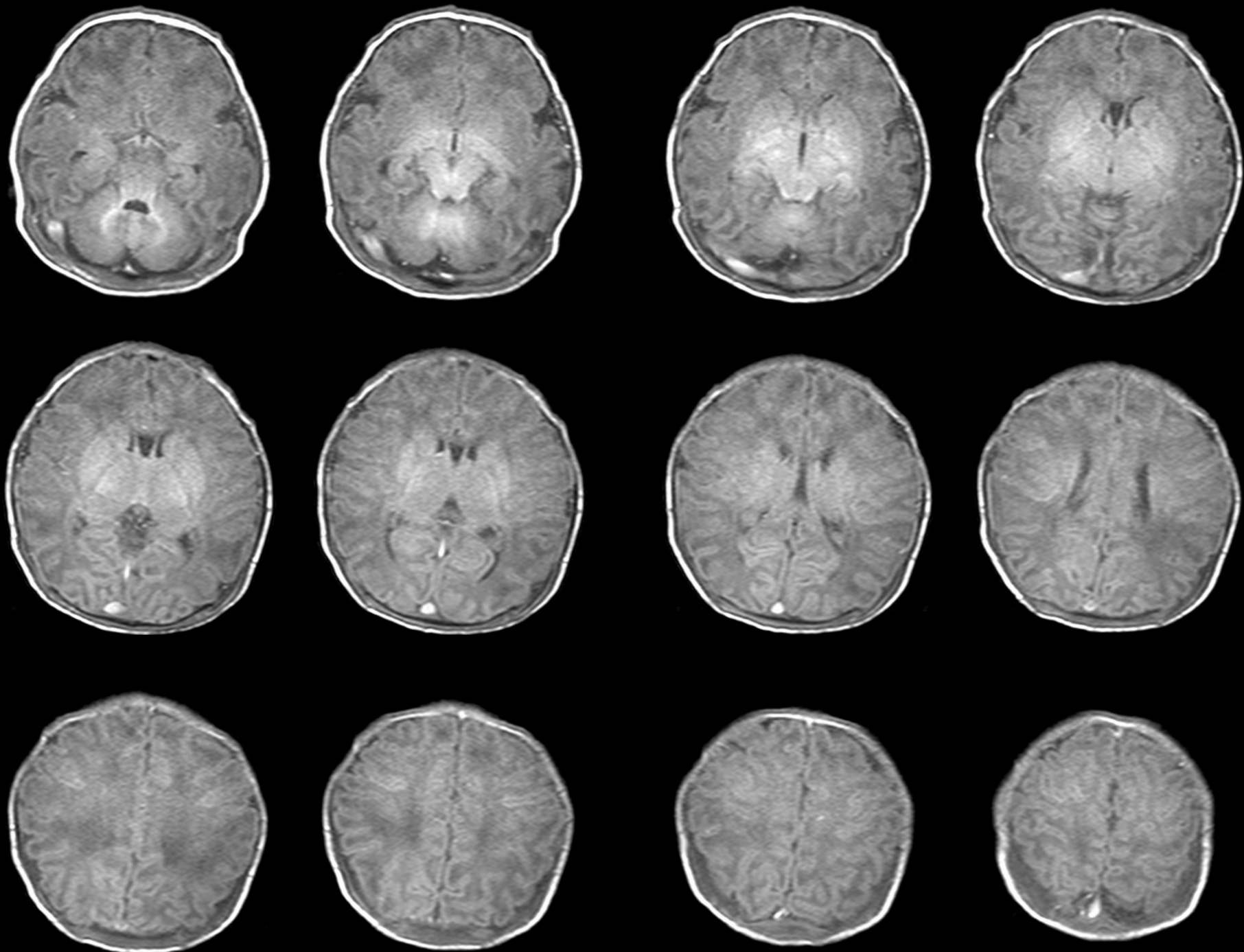


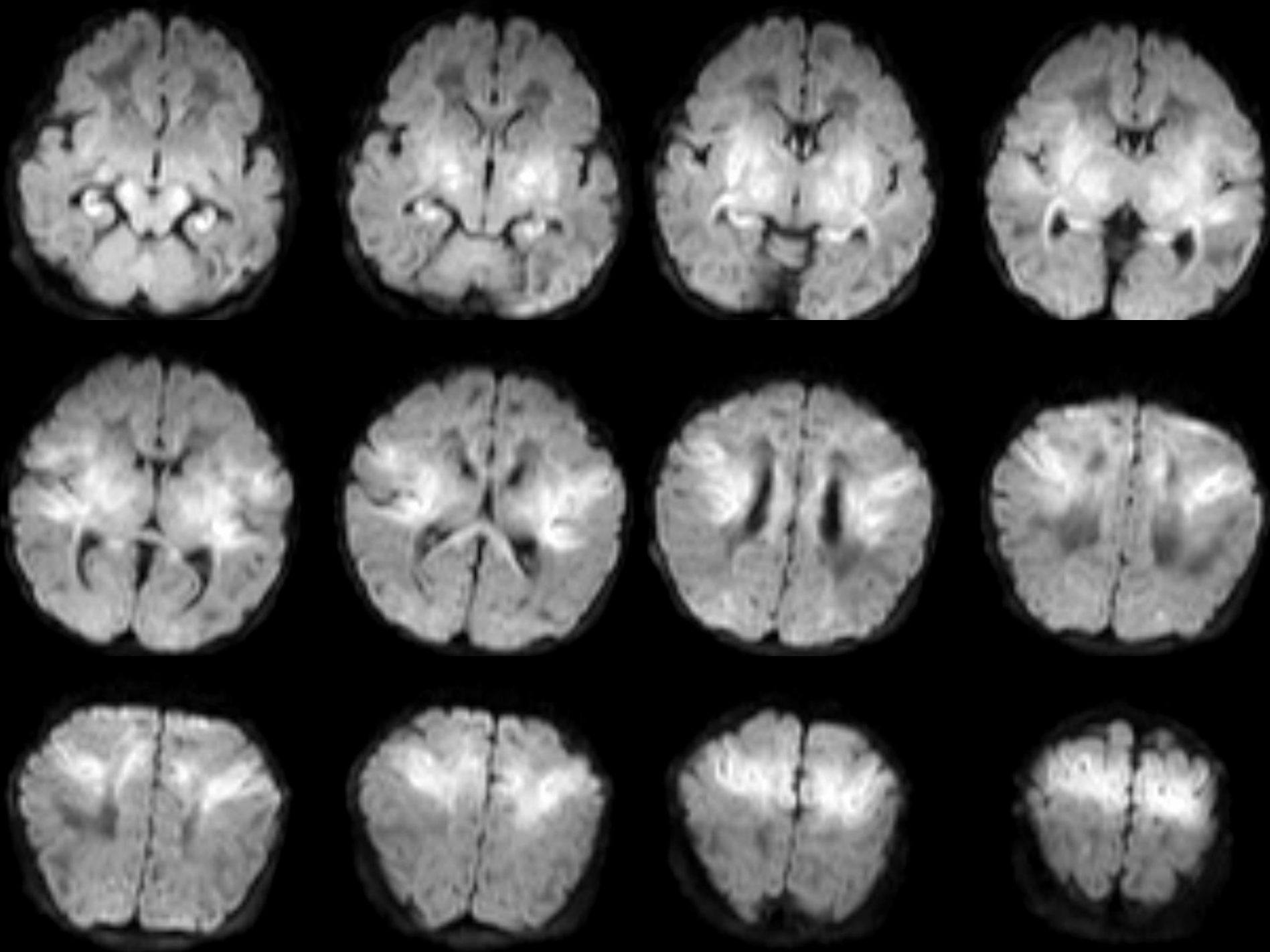


受傷早期のMRIで分かり難いが あとではっきり認識
できるもの periventricular gliosis, myelination delay

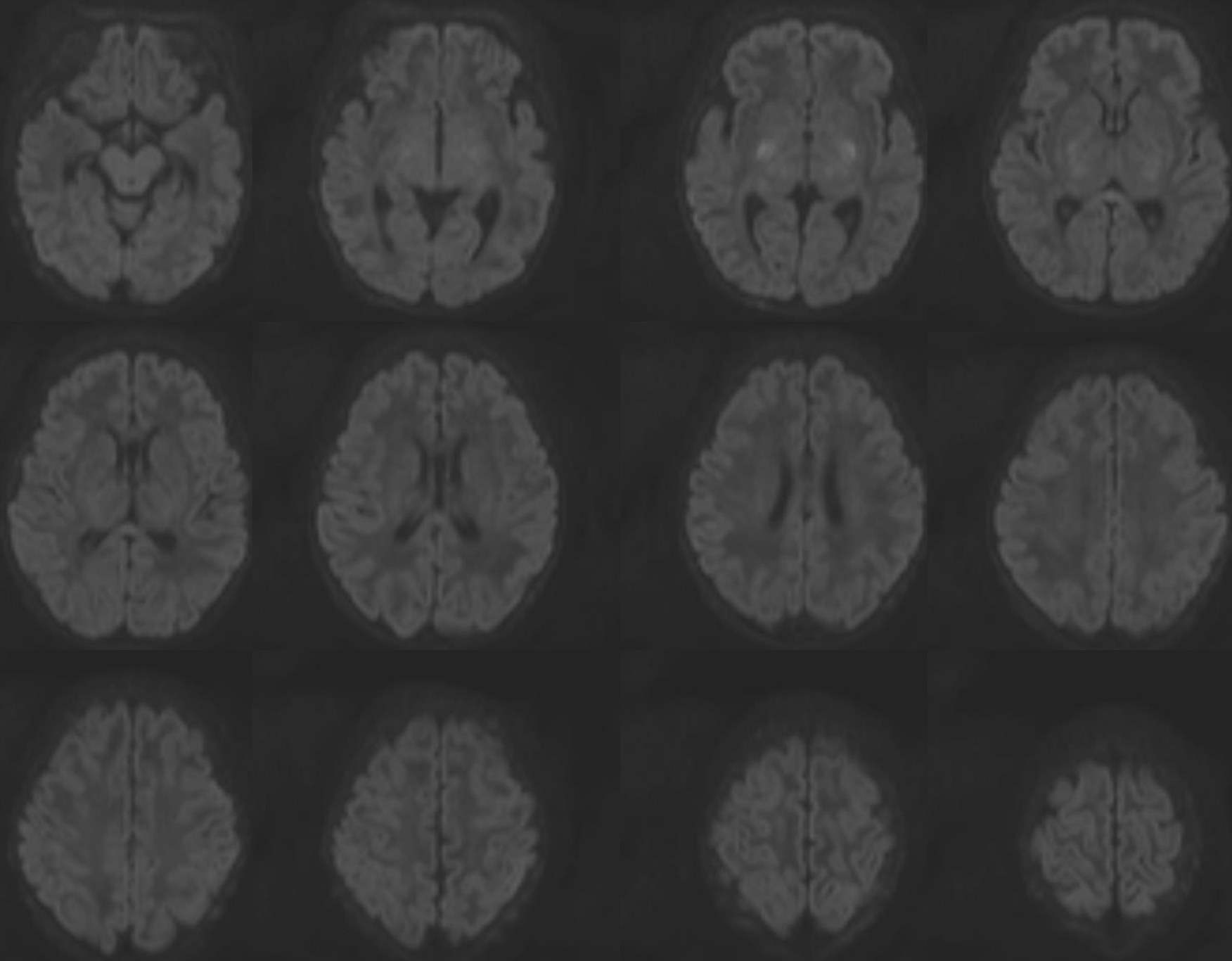
症例 West syndrome 男児

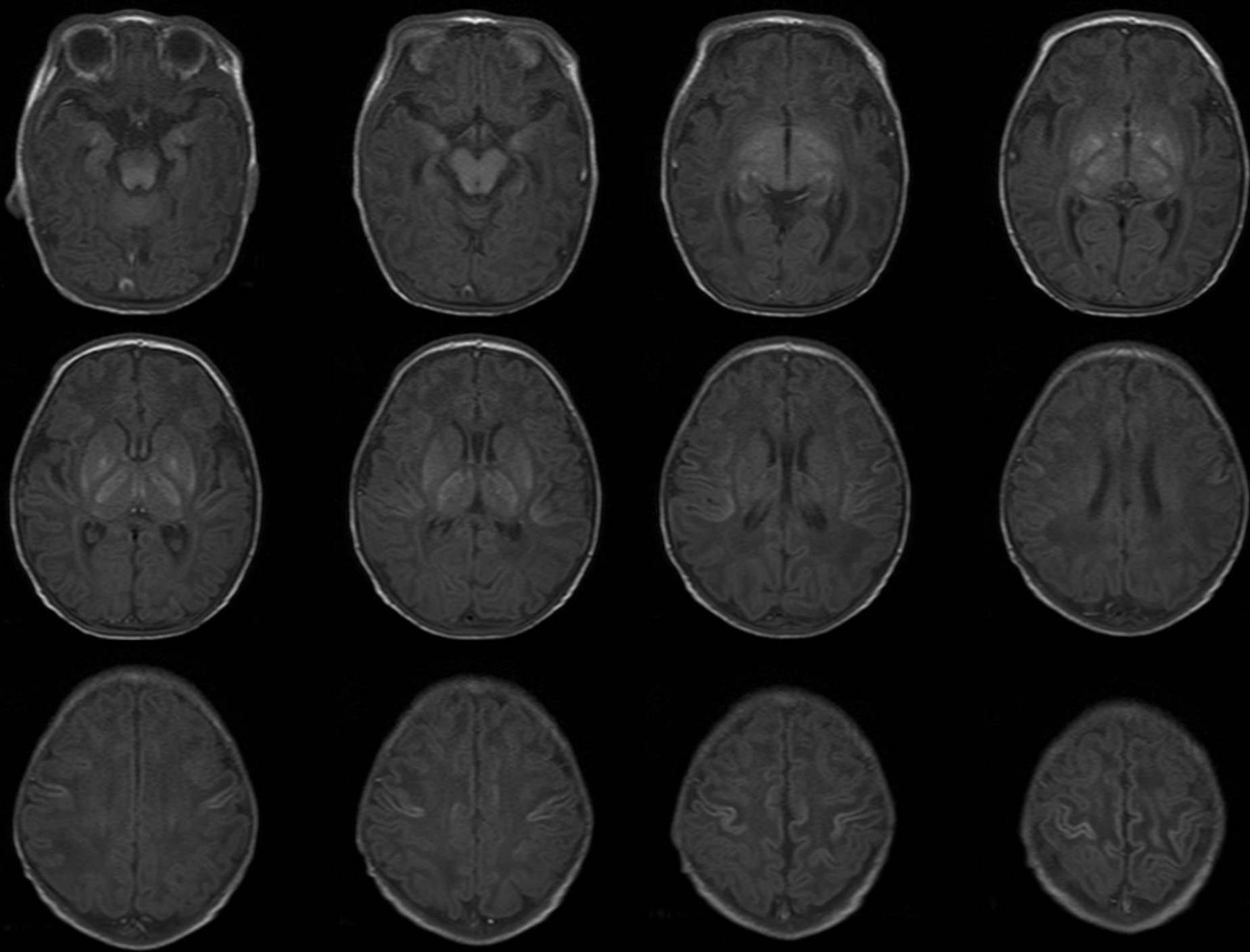
- 39週、Apgar 1/1 重症仮死にて2680gにて出生
- NICU管理
- 生後1日MRI



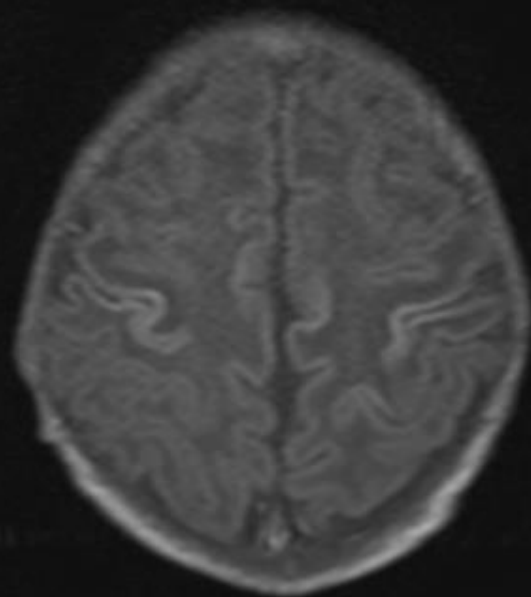
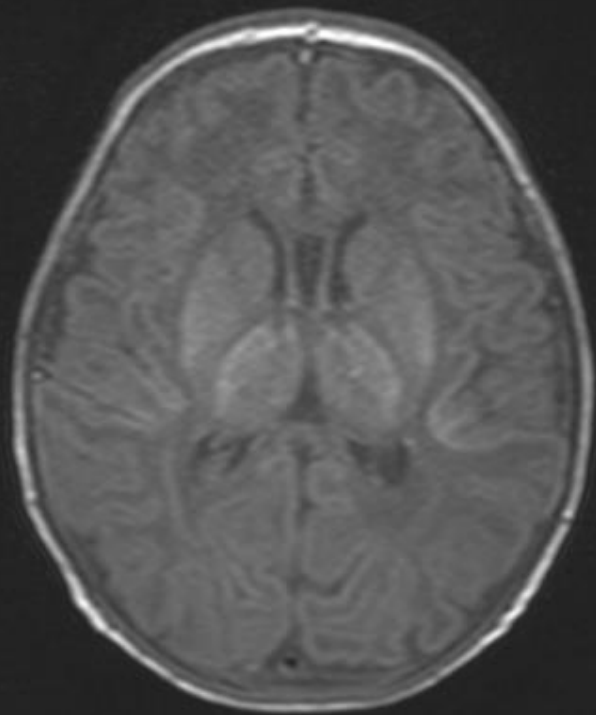
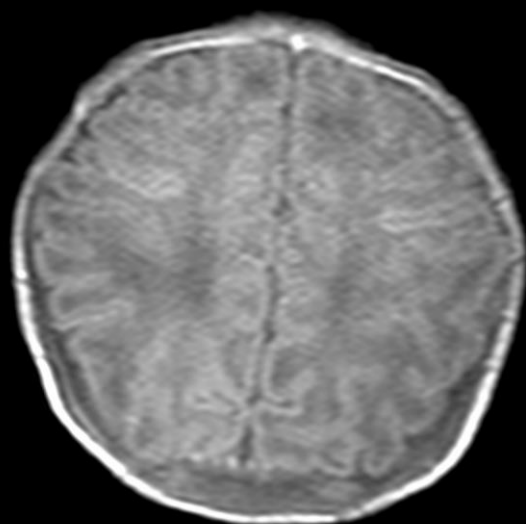
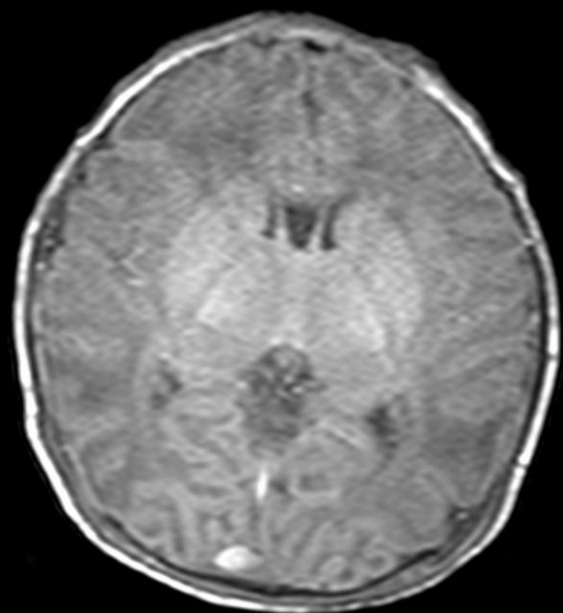


10日後のMRI(日令10日)





- 受傷早期のMRIではっきりわかるが あとでは認識しにくくなるもの
 - HIE DWIでの信号変化 pseudonormalization
 - HIE 基底核の信号異常
- “1-2-3-4 サイン”
 - T1WIにて**基底核**が高信号（特に被殻）
 - T1WIにて**視床**が高信号
 - 内包後脚の正常の高信号が消失
（“absent posterior limb sign”）
 - 拡散の低下 24時間～10日以内くらいまで
- 放線冠レベルでの錐体路（CR）と中心溝の皮質（PC）を比べる: PLIC > PP
 - CR > PC: OK
 - CR < PC: difficult to predict



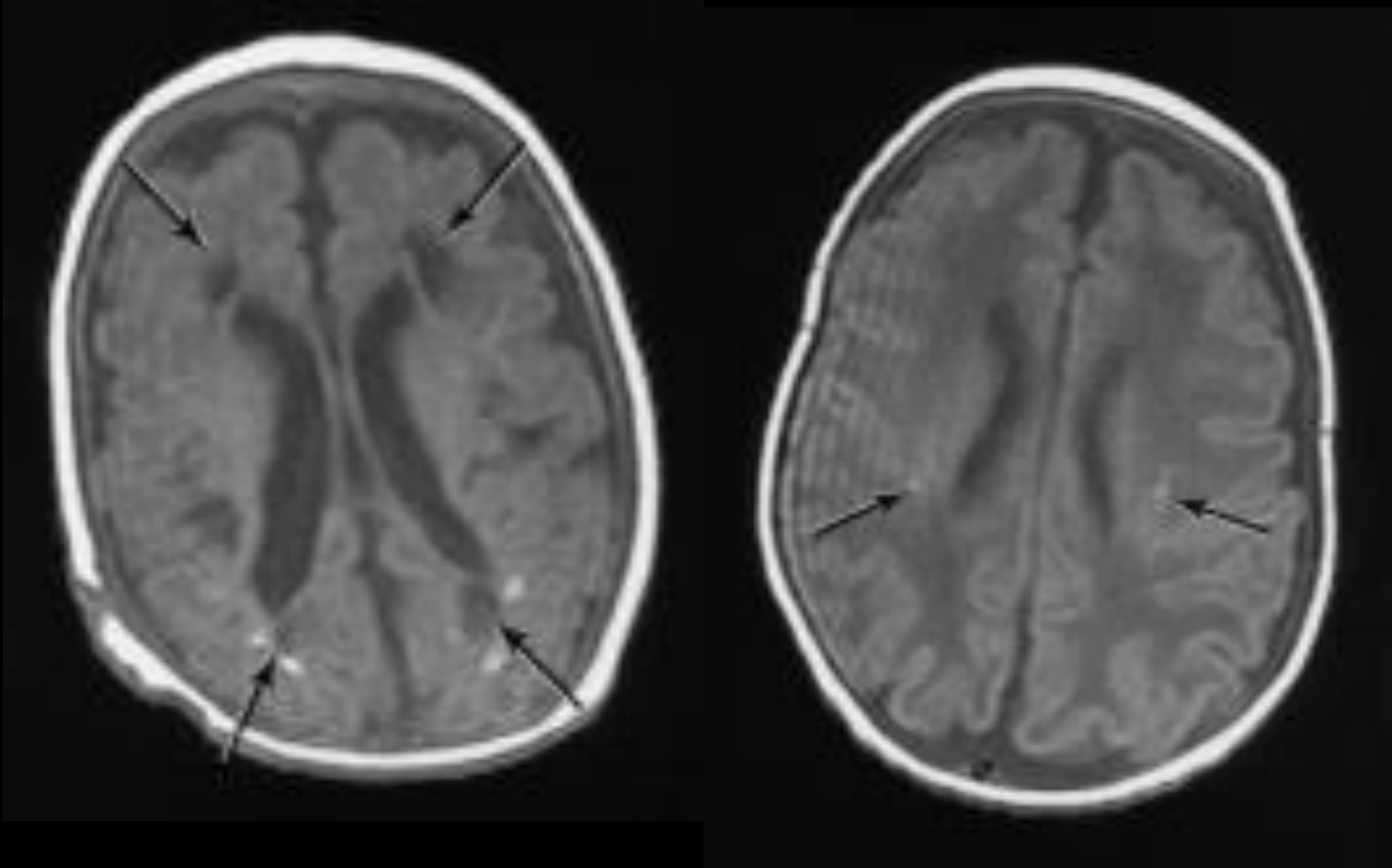
たとえタイムリーな時期にMRIが取れなくても

- 修正termの時期にMRIのT1強調画像を撮れば、その所見からある程度の予後予測が可能になりそう
- T1強調画像は横断像だけでなく、冠状断像もとりましょう
- 正期産児では
 - 内包後脚(PLIC)と被殻後部(PP)の信号を比べましょう
 - $PLIC > PP$: OK
 - $PLIC = \text{or} < PP$: predict to have HIE
 - 放線冠レベルでの錐体路(CR)と中心溝の皮質(PC)を比べる: $PLIC > PP$
 - $CR > PC$: OK
 - $CR < PC$: difficult to predict

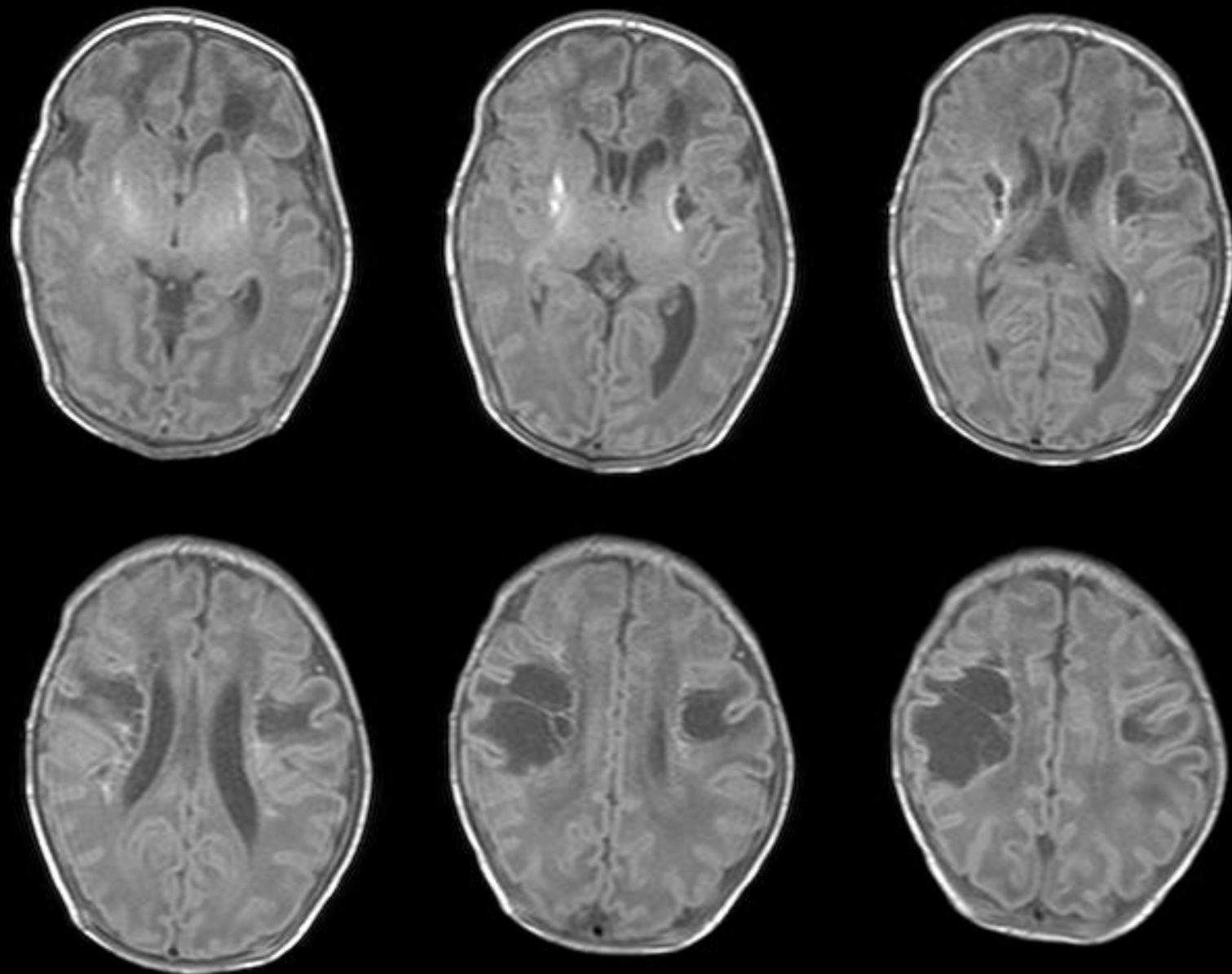
早期産児の低酸素虚血性脳症

- Profound asphyxia:
 - basal ganglia injury
- Partial asphyxia
 - germinal matrix hemorrhage (intraventricular hemorrhage)
 - periventricular white matter injury (periventricular leucomalacia (PVL))

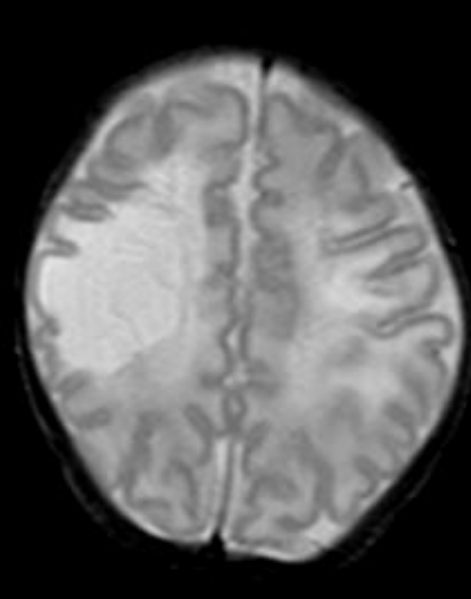
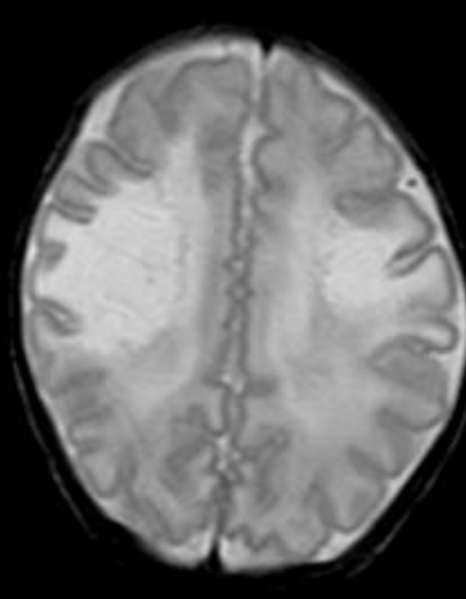
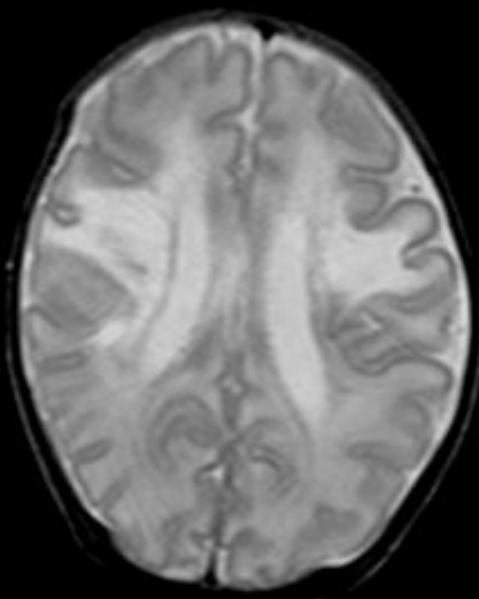
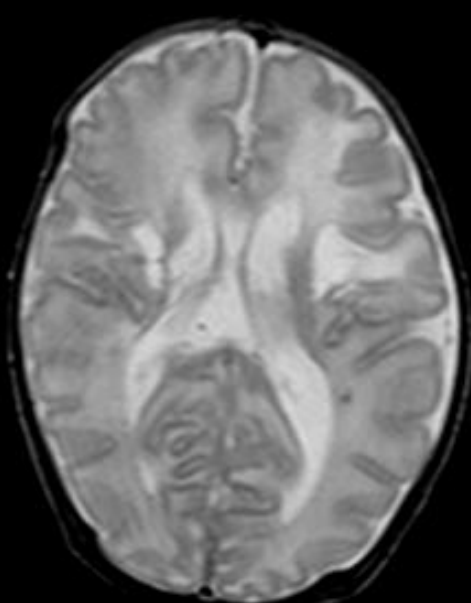
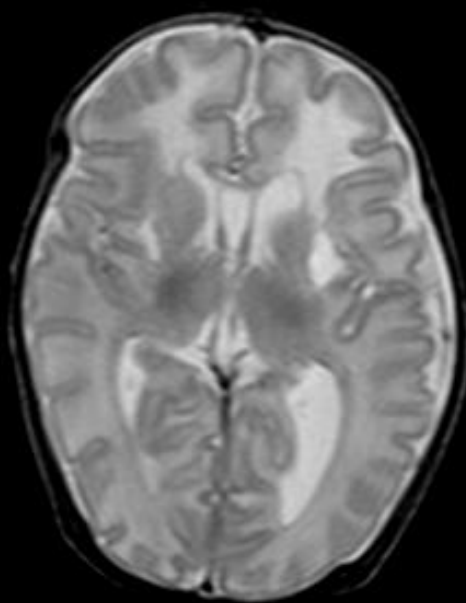
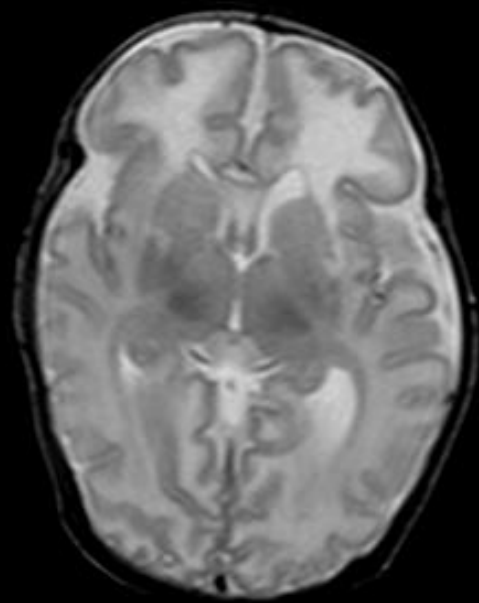
T1 hyperintensity at term



Pediatrics 2003;112: 1-7.



32W, 1776g Ap 4/8, MRI at 36w gestation



早期産児の修正term でのT1強調画像

- 修正43週までは放線冠レベルには髄鞘化が到達しない
- 放線冠レベルの高信号は異常
- 異常高信号の性質が予後予測に重要
 - 脳室周囲のspotty hyperintensity 運動障害軽度
 - 脳室周囲のband-like hyperintensity
 - 脳室周囲のcystic formation (+T1 hyperintensity) 重度
- 異常高信号の局在が予後予測に重要
 - 錐体路を通過する異常信号は予後不良