

European Course on
Pediatric Neuroradiology in
Latin America (ECPNR-LATAM)
3rd Cycle - Module 1

How to Manage Neonatal MRI: Tips and Tricks

Idealização:



Organização:



European Course on
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3rd Cycle - Module 1

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Idealização:



Organização:



How to Manage MRI: Tips and Tricks

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There is no conflict of interest in this presentation

How to Manage MRI: Tips and Tricks

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Contents

- Preparation
- Imaging Acquisition
- Advanced techniques
- Appropriate GBCA

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Preparation and Environment

Feed & Wrap

MR Compatible Incubator (Lammers)

Clinical monitoring with presence of neonatologist and/or neonatal nurse



Feed and Wrap

- **Feed:** to induce sleep
- **Wrap:** swaddling them snugly in a blanket or a vacuum mattress
- Newborns < 3 to 6 months old
- Avoid sedation or general anesthesia



Appropriate Coils

Size-optimized 32-Channel Brain Arrays for 3 T Pediatric Imaging

Boris Keil,^{1,2*} Vijay Alagappan,^{1,2} Azma Mareyam,¹ Jennifer A. McNab,^{1,2}
Kyoko Fujimoto,¹ Veneta Tountcheva,¹ Christina Triantafyllou,¹⁻³ Daniel D. Dilks,³
Nancy Kanwisher,³ Weili Lin,⁴ P. Ellen Grant,^{1,2,5,6} and Lawrence L. Wald^{1,2,7}



	Neonate	6 months old	1 year old	4 years old	7 years old	Adult
Dia. (mm)	60	65	72	80	85	90

Appropriate Coils

Specifically designed
neonatal coils

Suitable for small head



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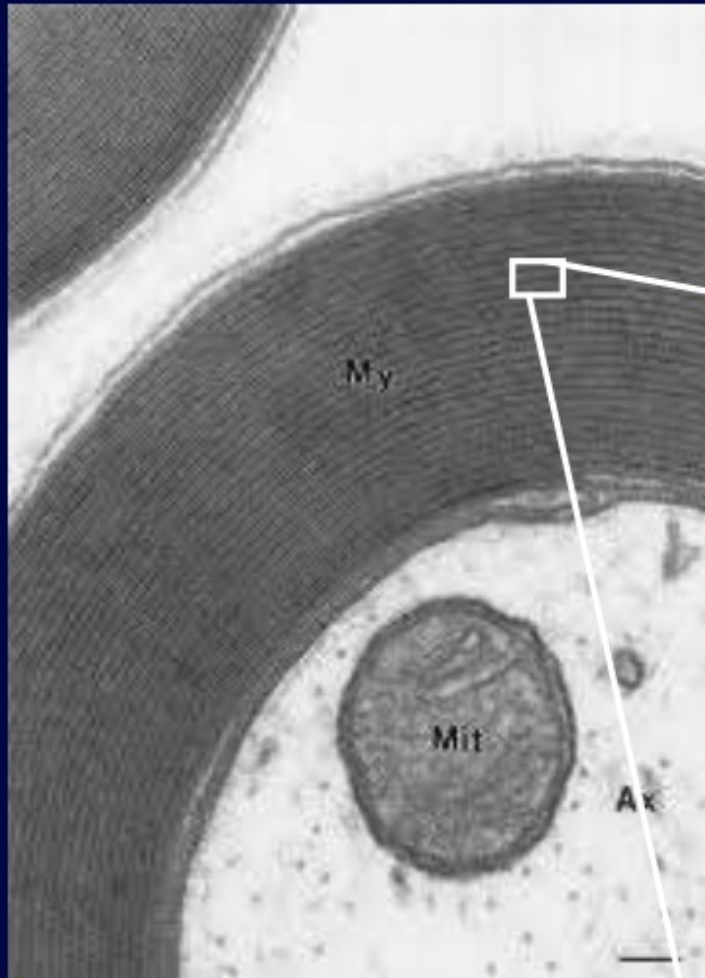
Contents

- Preparation
- **Imaging Acquisition**
- Advanced techniques
- Appropriate GBCA

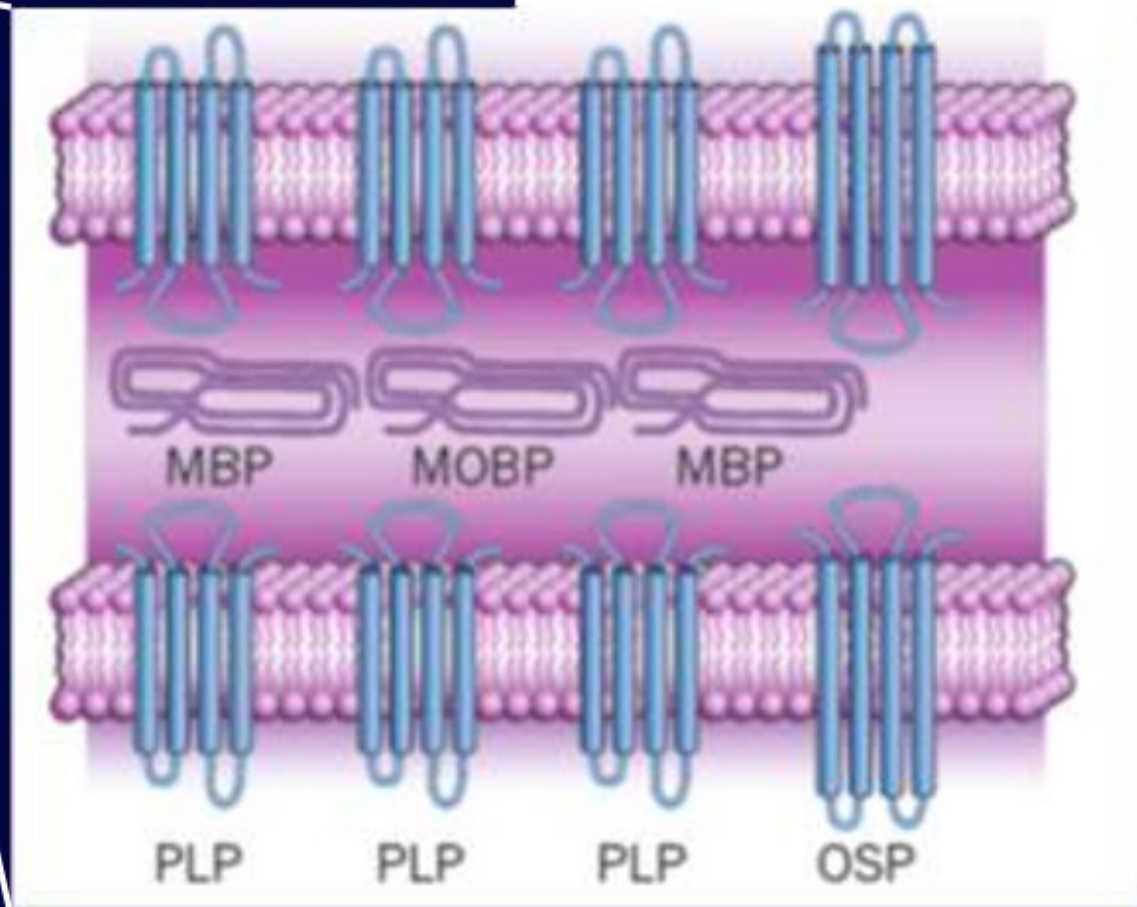


COMPACT MYELIN

*Multiple double-layer of OL cell membrane
extroflexions compacted by two main proteins*

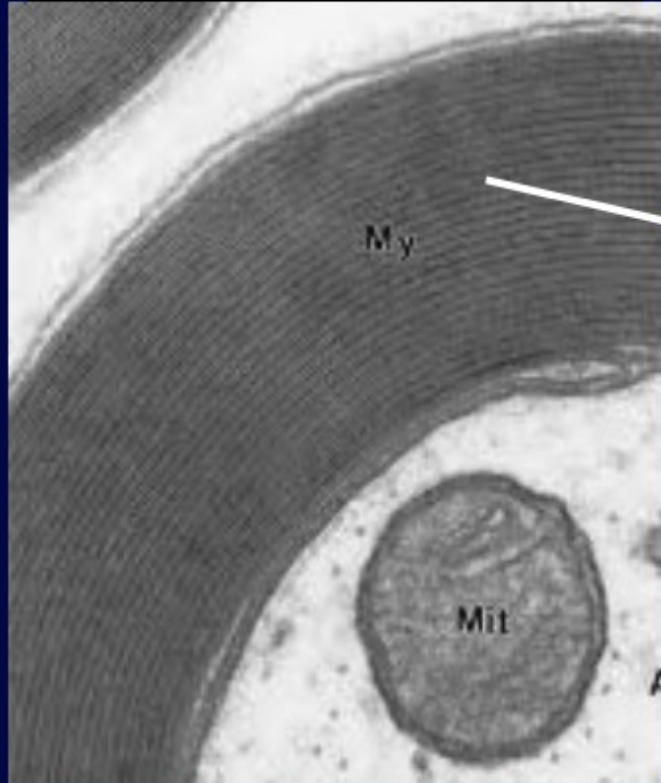


PLP – proteolipid protein
MBP – myelin basic protein

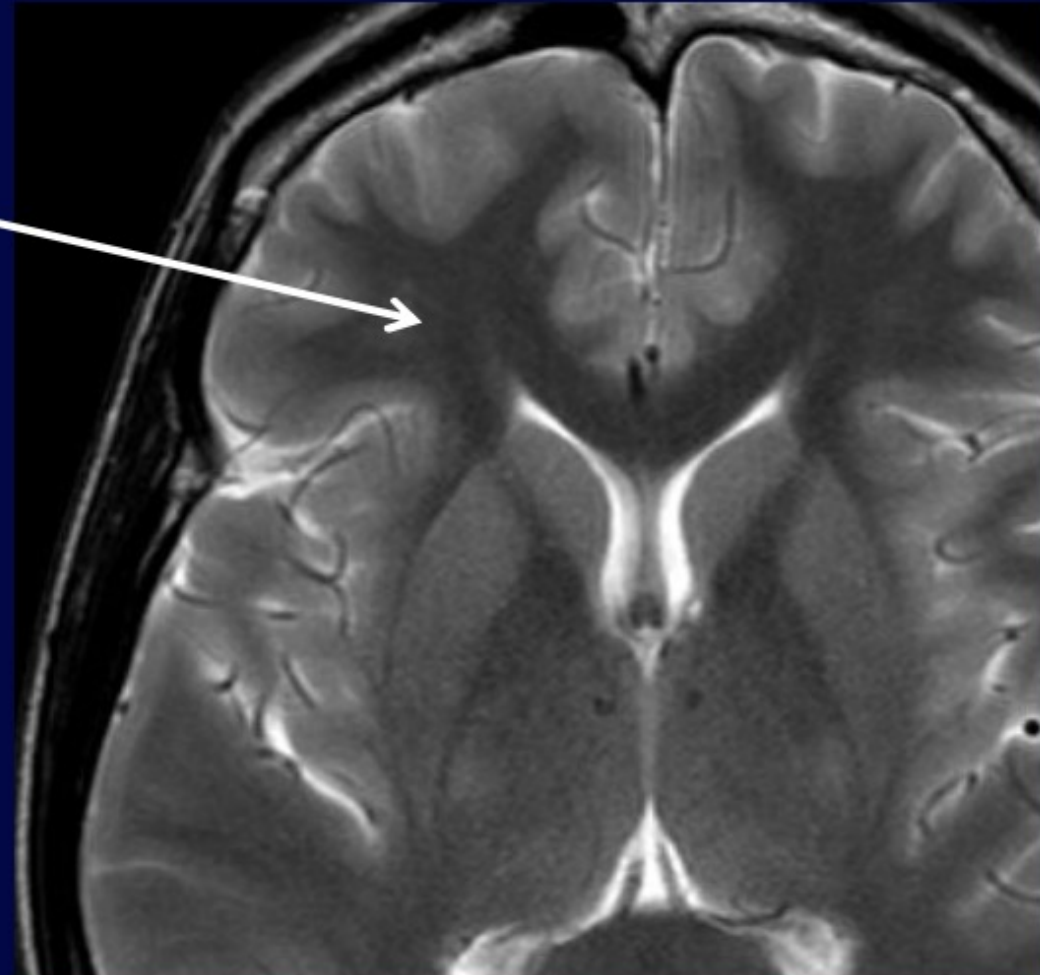


Adult

COMPACT MYELIN



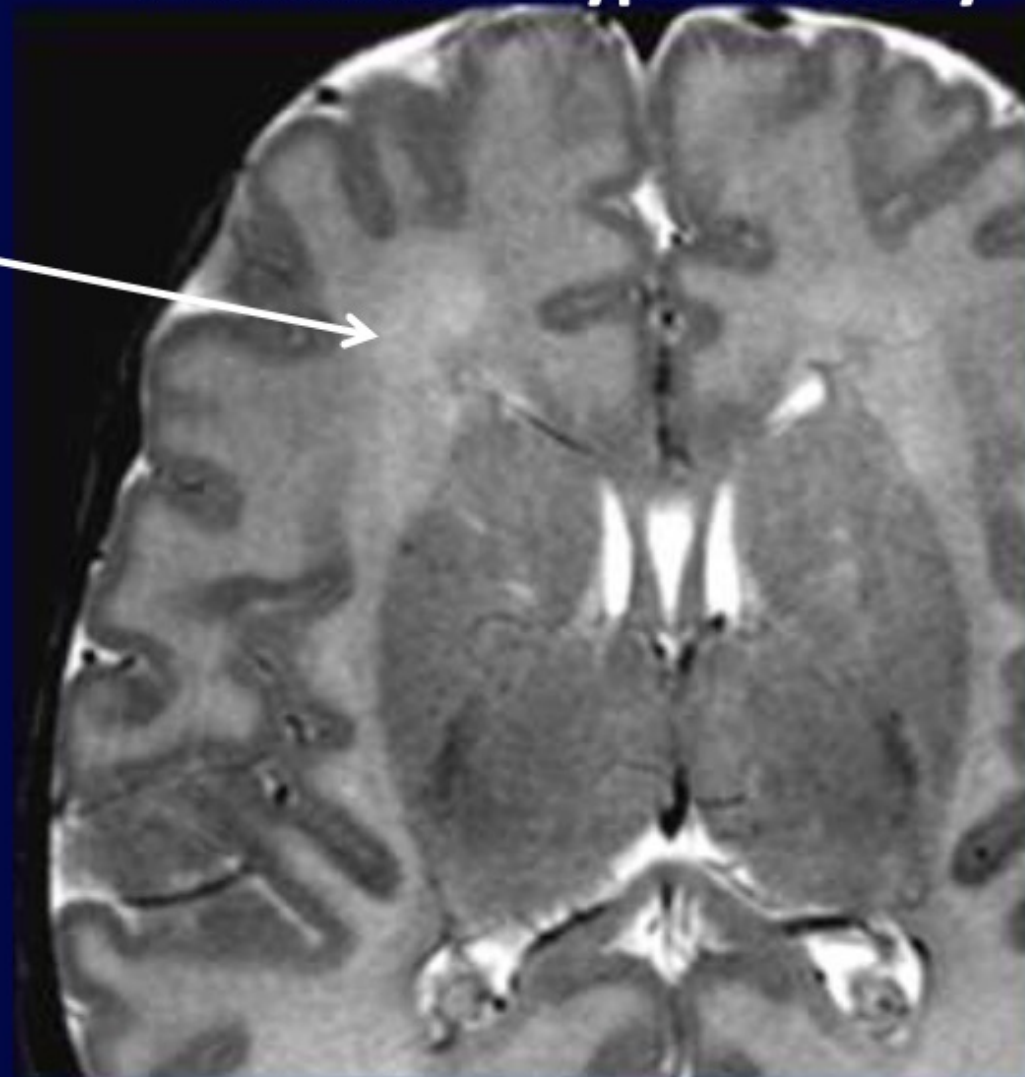
Reduction of extracellular free water
results in
T2 shortening - hypointensity



Newborn

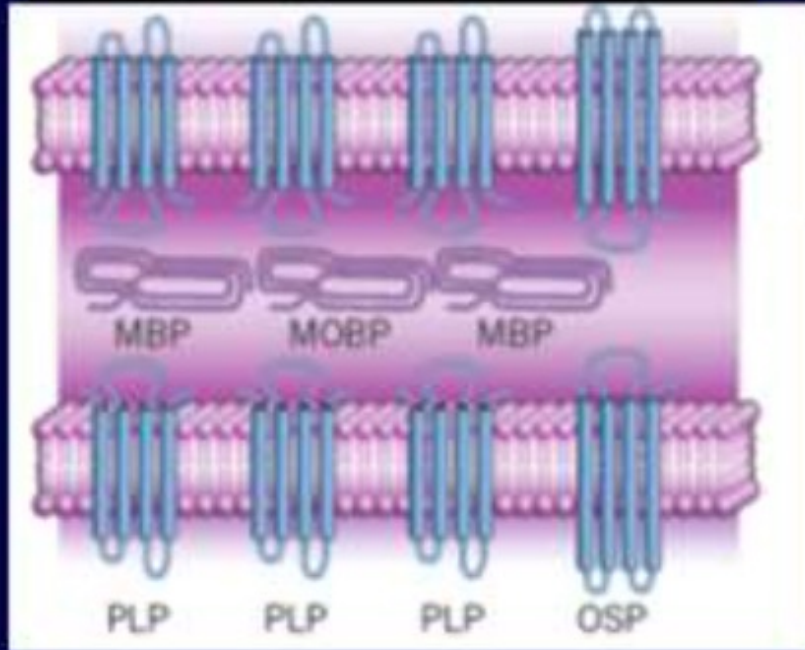
Increase of extracellular free water results in T2 increase – hyperintensity

MYELIN ABSENCE

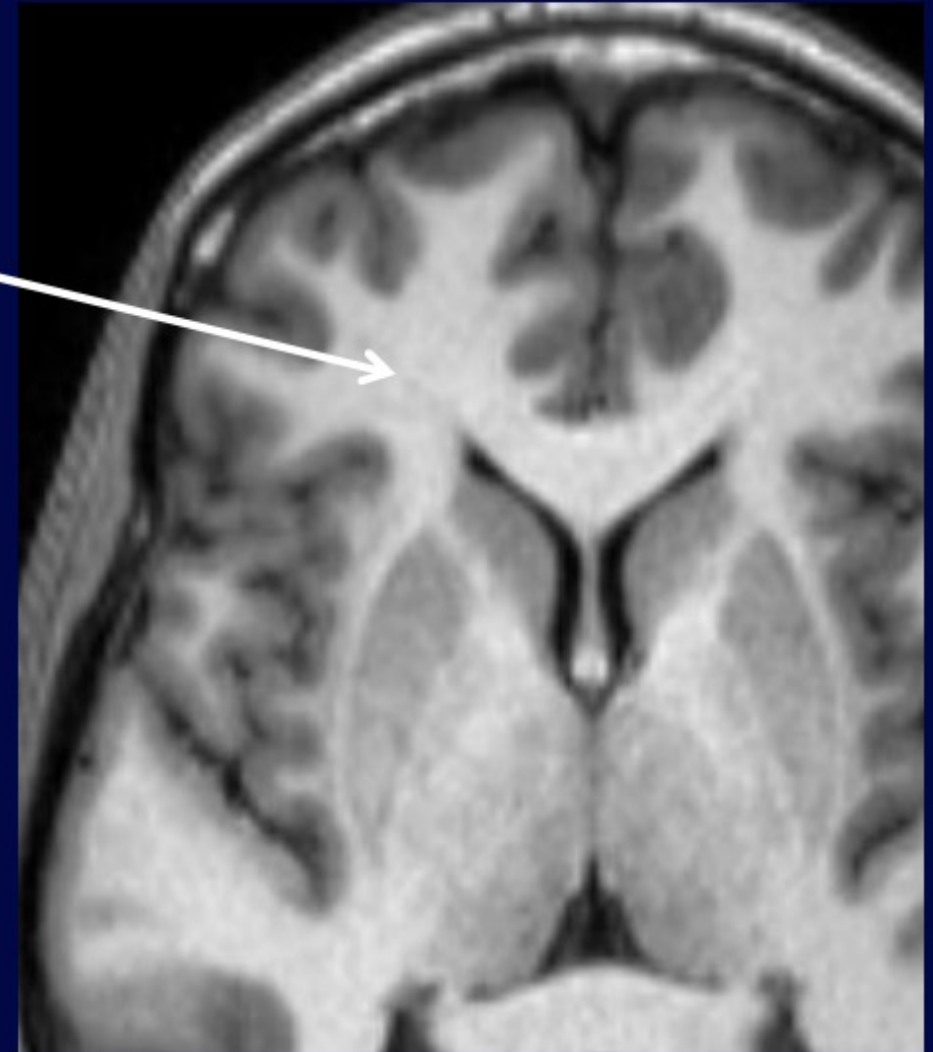


Adult

MYELIN PRODUCTION



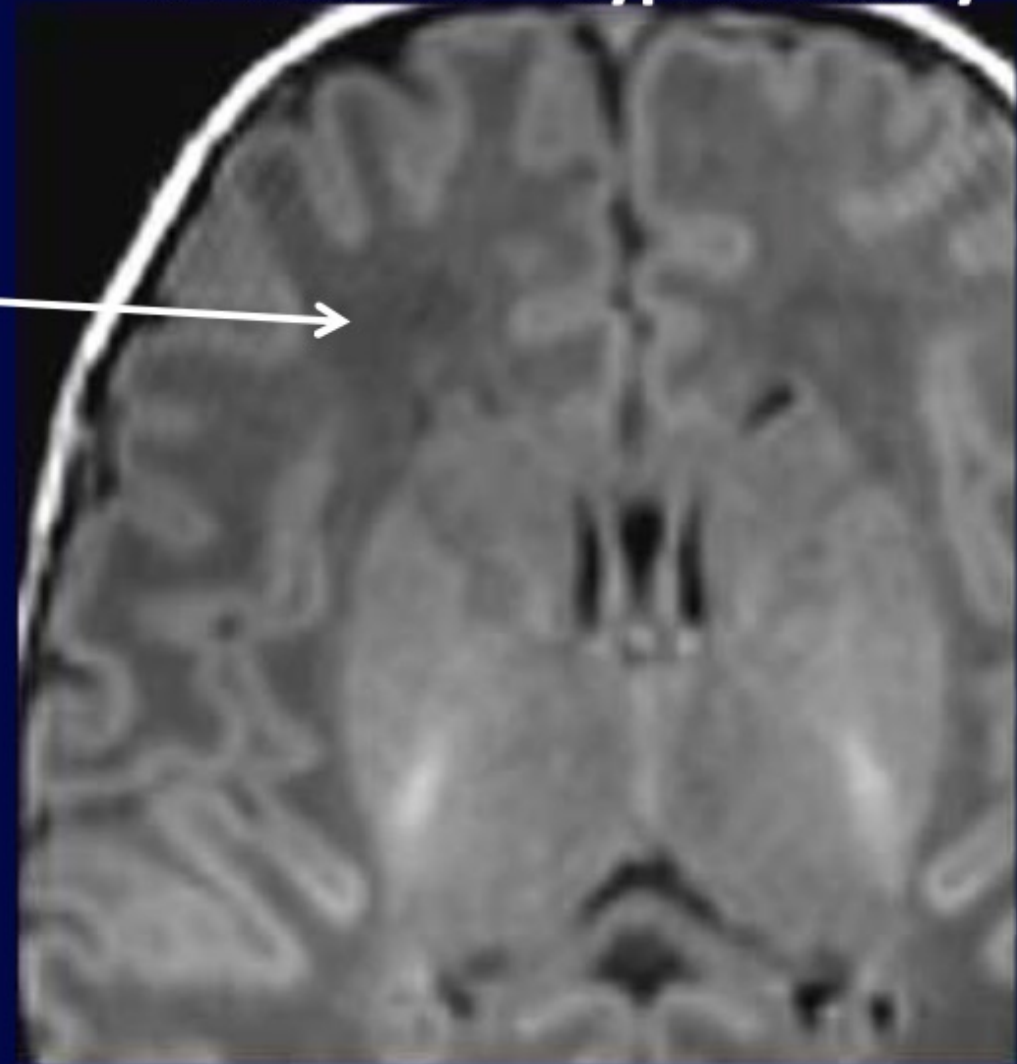
Increase of lipid concentration
results in
T1 shortening – hyperintensity



Newborn

Decrease of lipid concentration
results in
T1 increase – hypointensity

MYELIN ABSENCE

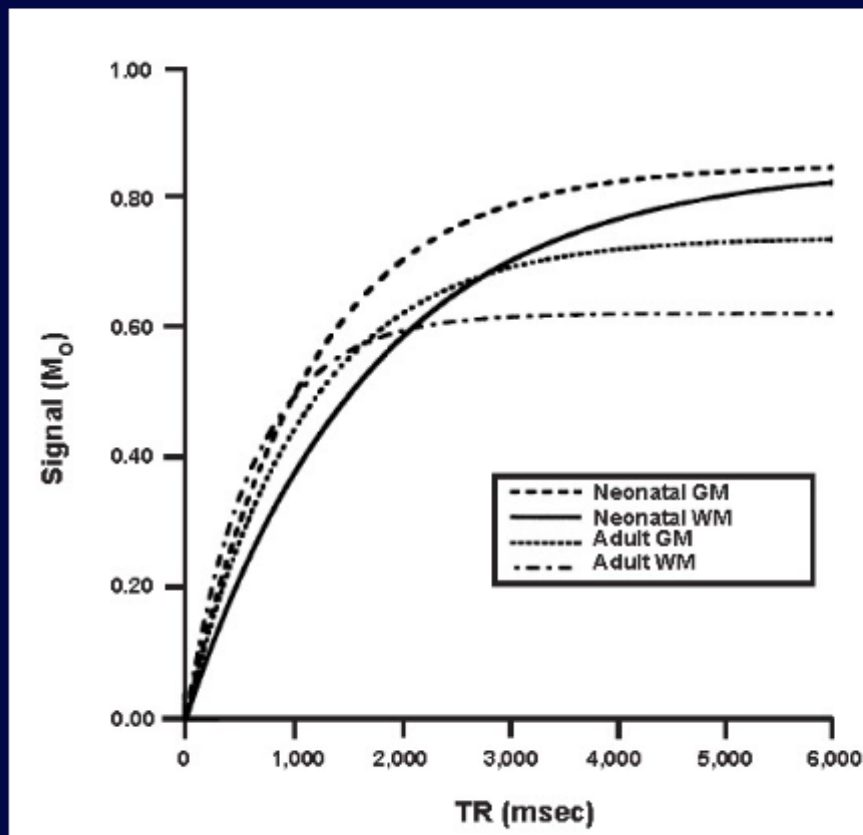


MRI of the Neonatal Brain: Optimization of Spin-Echo Parameters

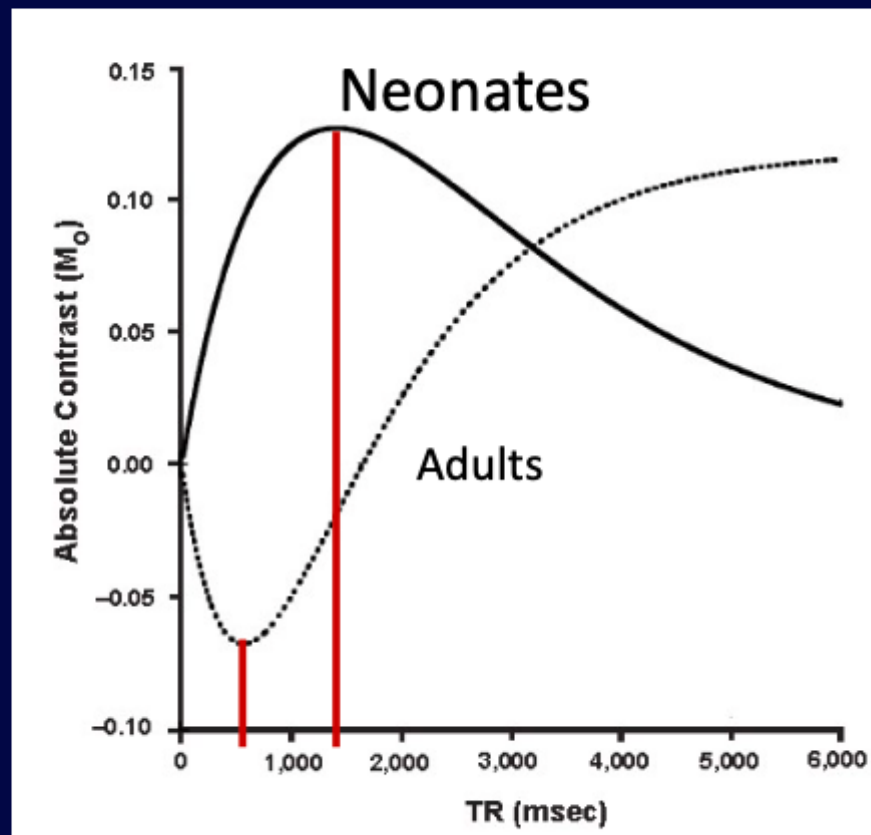
Richard A. Jones^{1,2}
Susan Palasis
J. Damien Grattan-Smith

AJR 2004;182:367-372

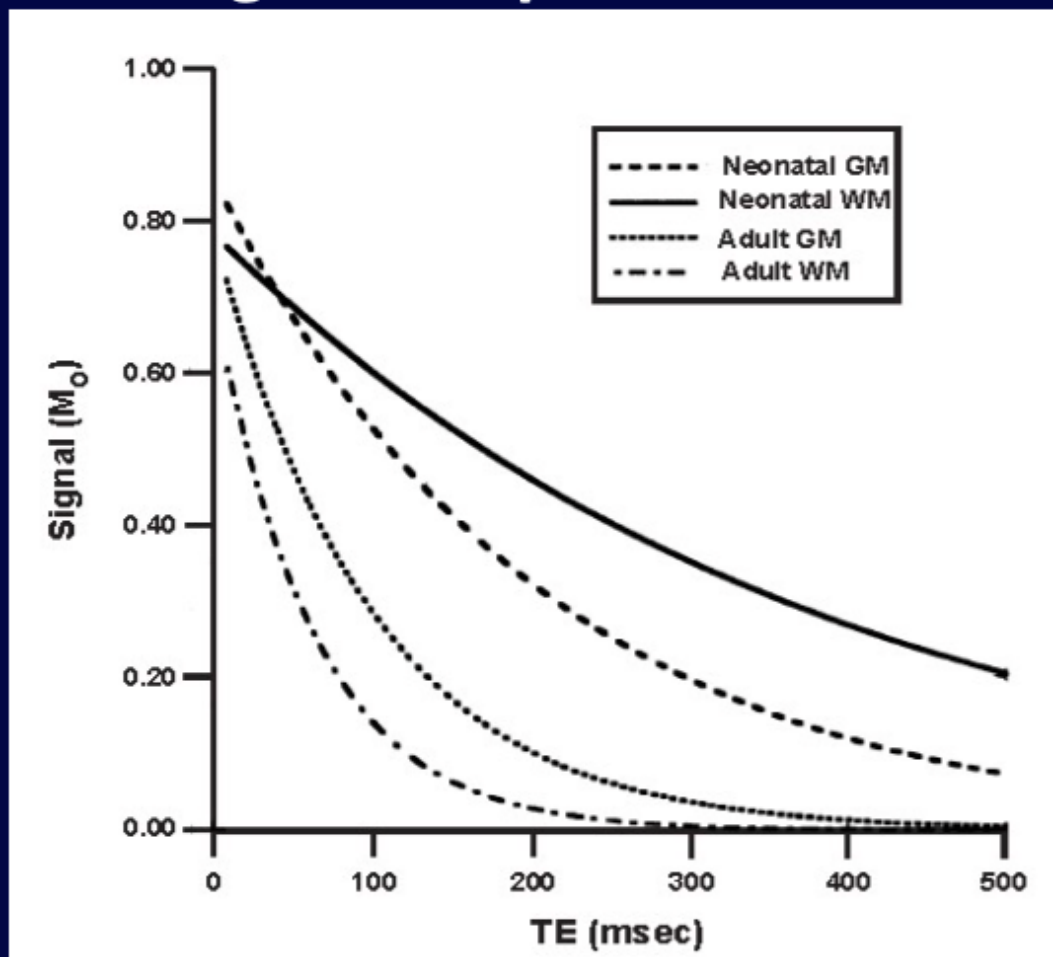
T1 weighted sequence



Gray-white matter contrast



T2 weighted sequence



Gray-white matter contrast

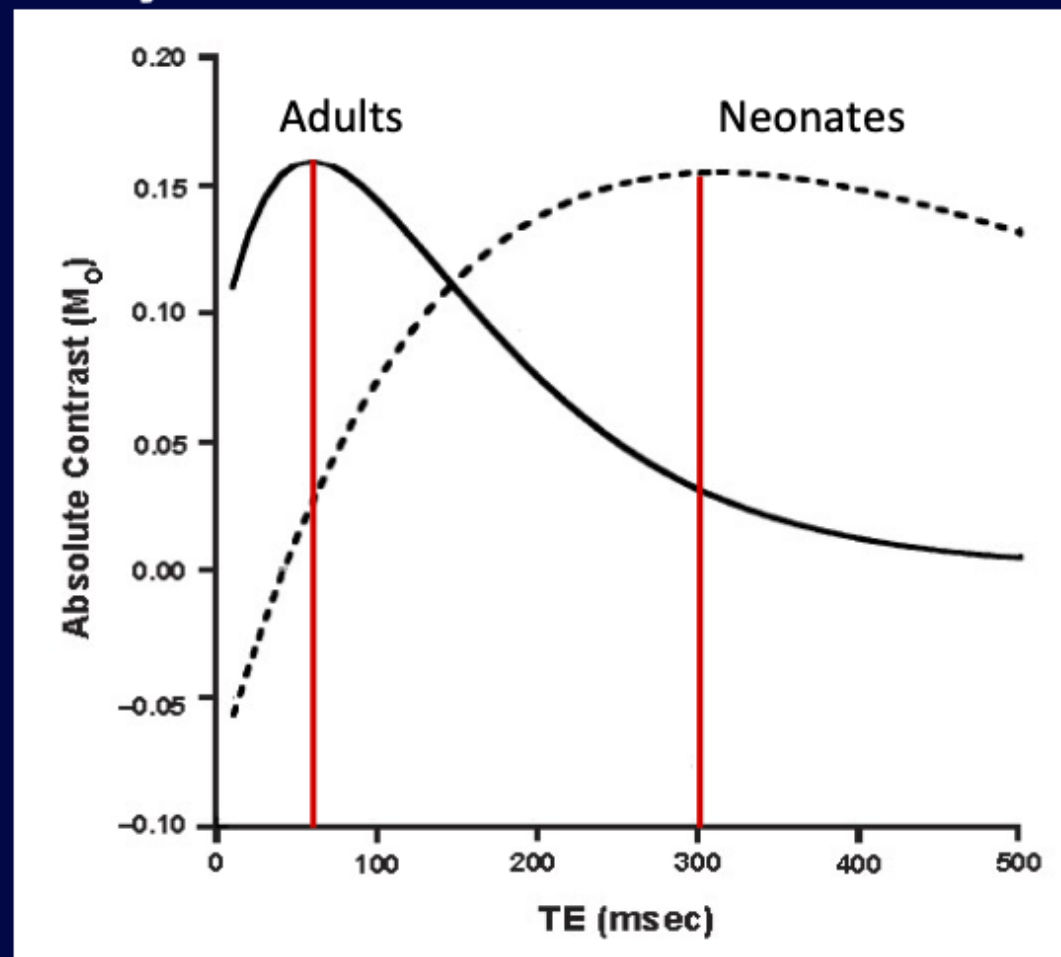


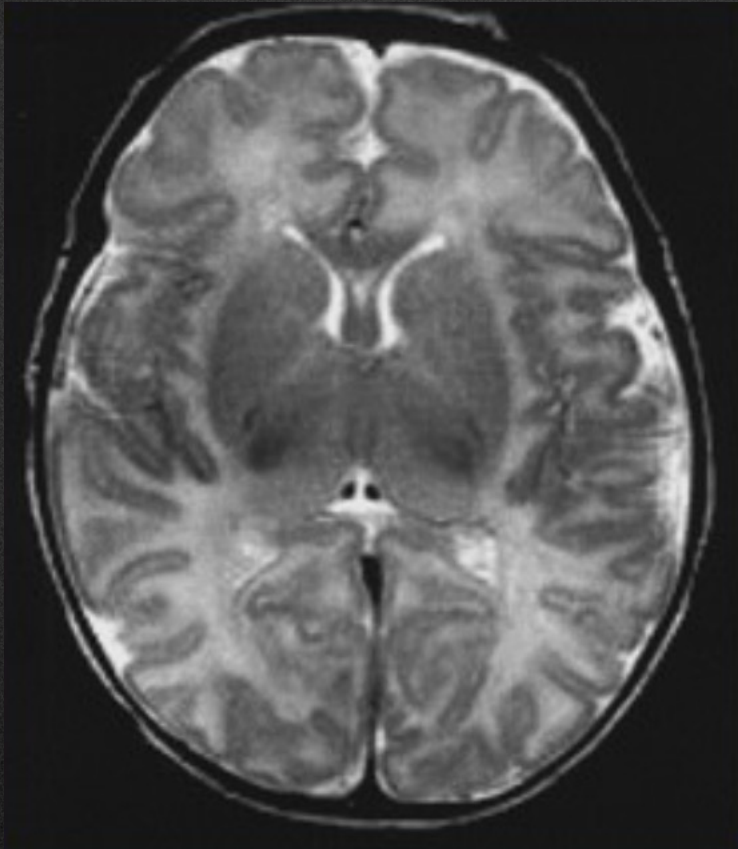
TABLE 2 Parameters Used for Comparison of Standard and Optimized Sequences

Parameter	T1-Weighted		T2-Weighted	
	Standard	Optimized	Standard	Optimized
Sequence	Spin-echo	Turbo spin-echo	Turbo spin-echo	Turbo spin-echo
Field of view (mm)	170 × 170	170 × 170	160 × 120	160 × 120
Matrix	256 × 218	256 × 218	256 × 173	256 × 173
TR (msec)	420	850	5,000	10,000
TE (msec)	12	11	105	270
Echo-train length	1	3	13	27
No. of excitations	3	3	2	2
Bandwidth (Hz/pixel)	130	148	130	130
Maximal no. of slices	20	20	24	24
Scanning time (min:sec)	3:05	3:07	2:14	2:19

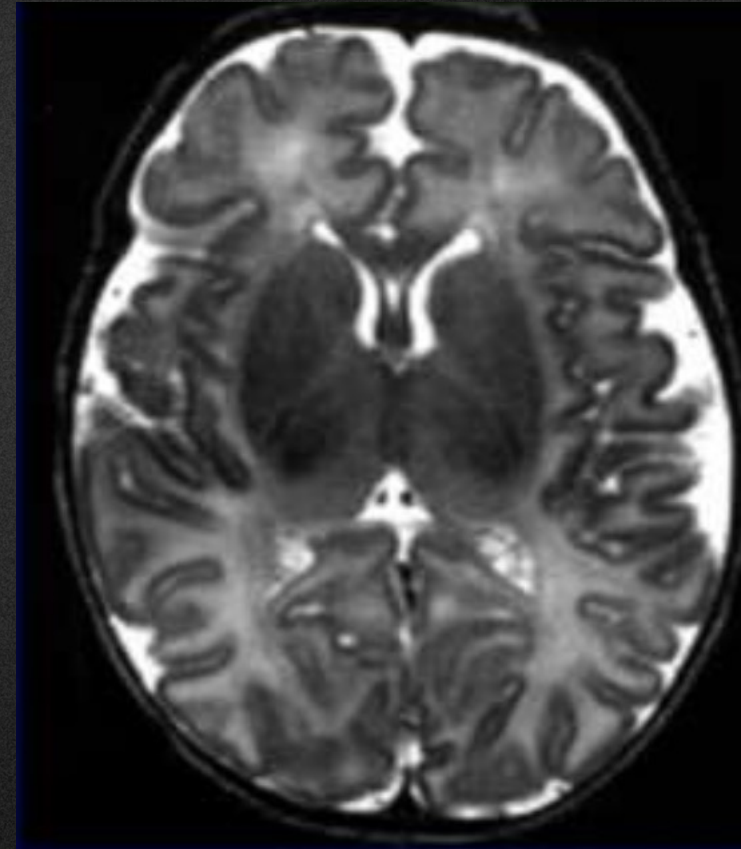
Optimised Protocol

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TR 5.000, TE 105



TR 10.000, TE 270



3T - *Why high resolution?*

The evolution of radiology is based on the continuous improvement of the 3 faces of imaging resolution:

- ✓ Space
- ✓ Contrast
- ✓ Time

This is especially important in Neonatal and Paediatric Brain

- ✓ Small
- ✓ Different contrast between G/W matter
- ✓ Time sensitive

3T x 1.5T

**S/N**

MORE NOISE

Same parameters, more artefacts

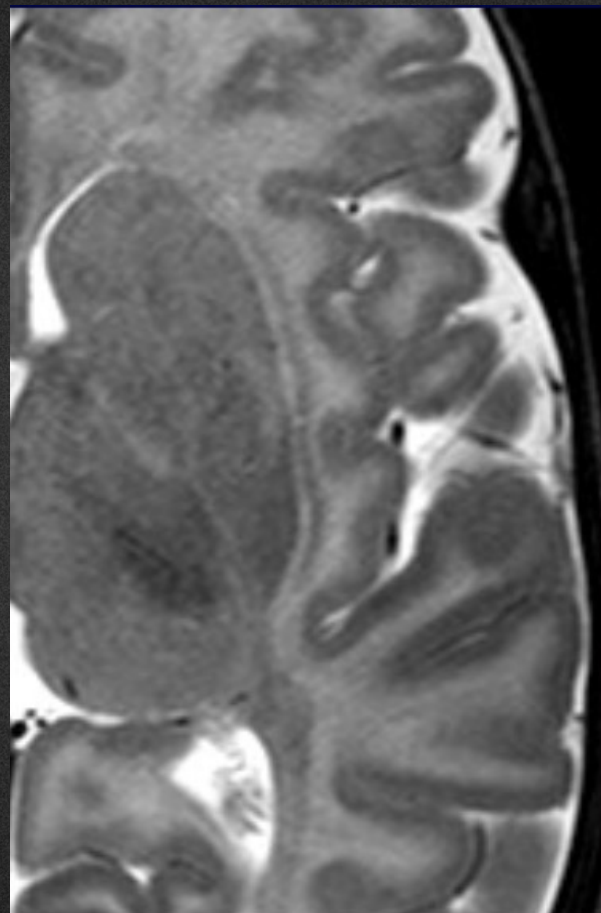
MORE SIGNAL

Less time, equal spatial resolution
Equal time, more spatial resolution

3T x 1.5T

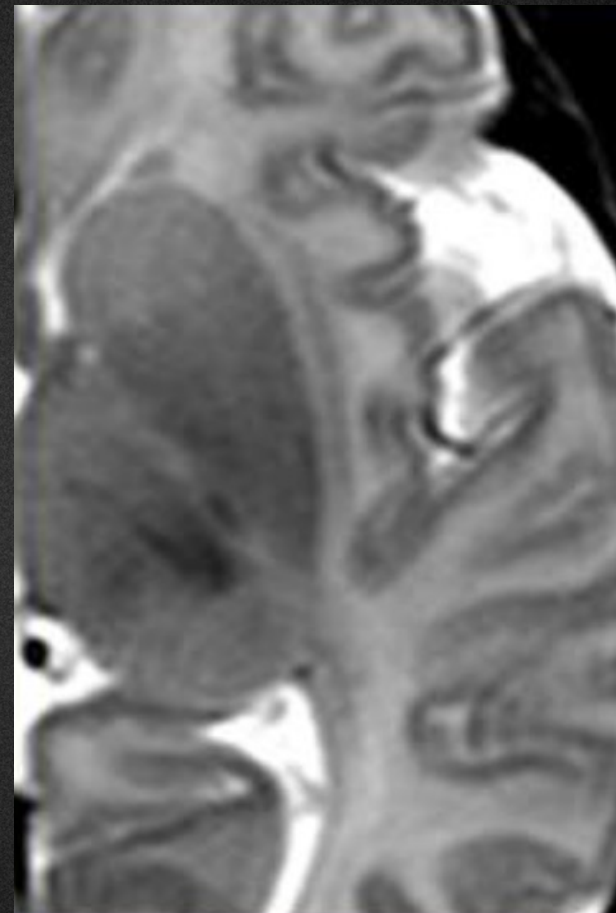
3T

0.38 ml imaging



1.5 T

1.7 ml imaging

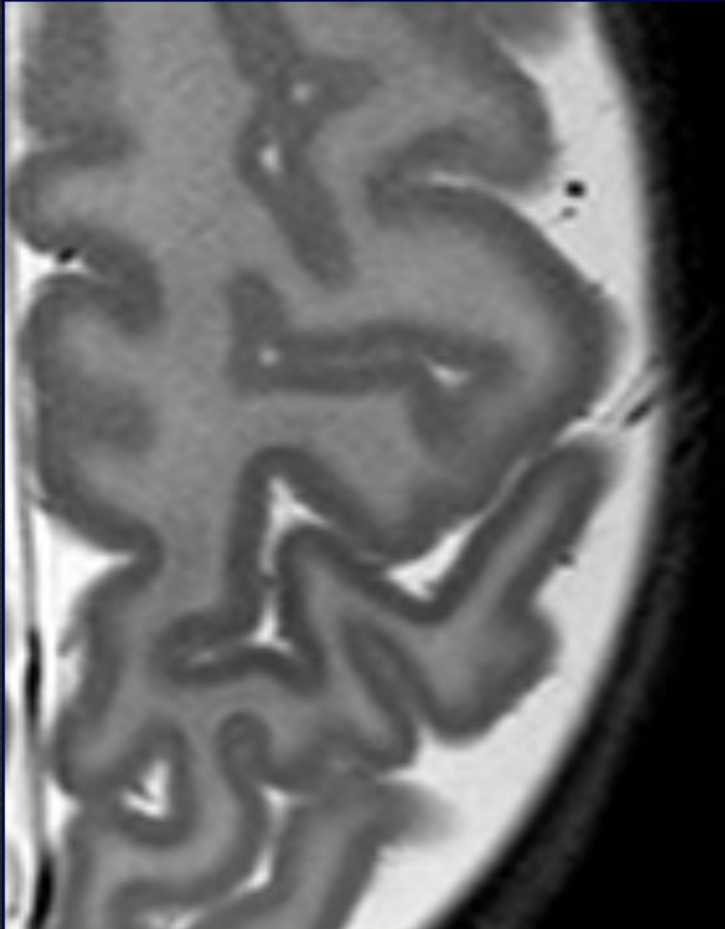


Look at the contrast !

3T x 1.5T

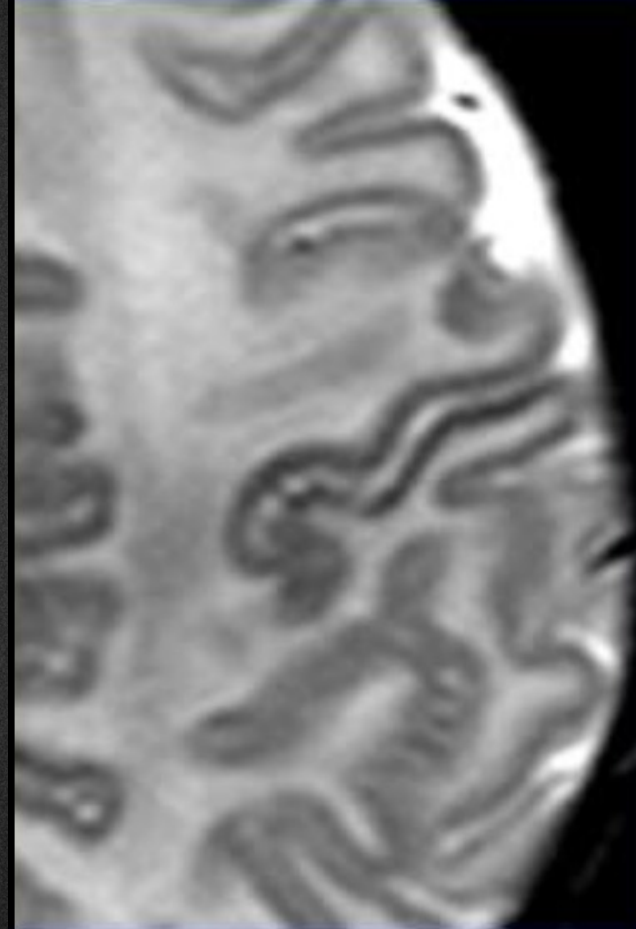
3T

0.38 ml imaging



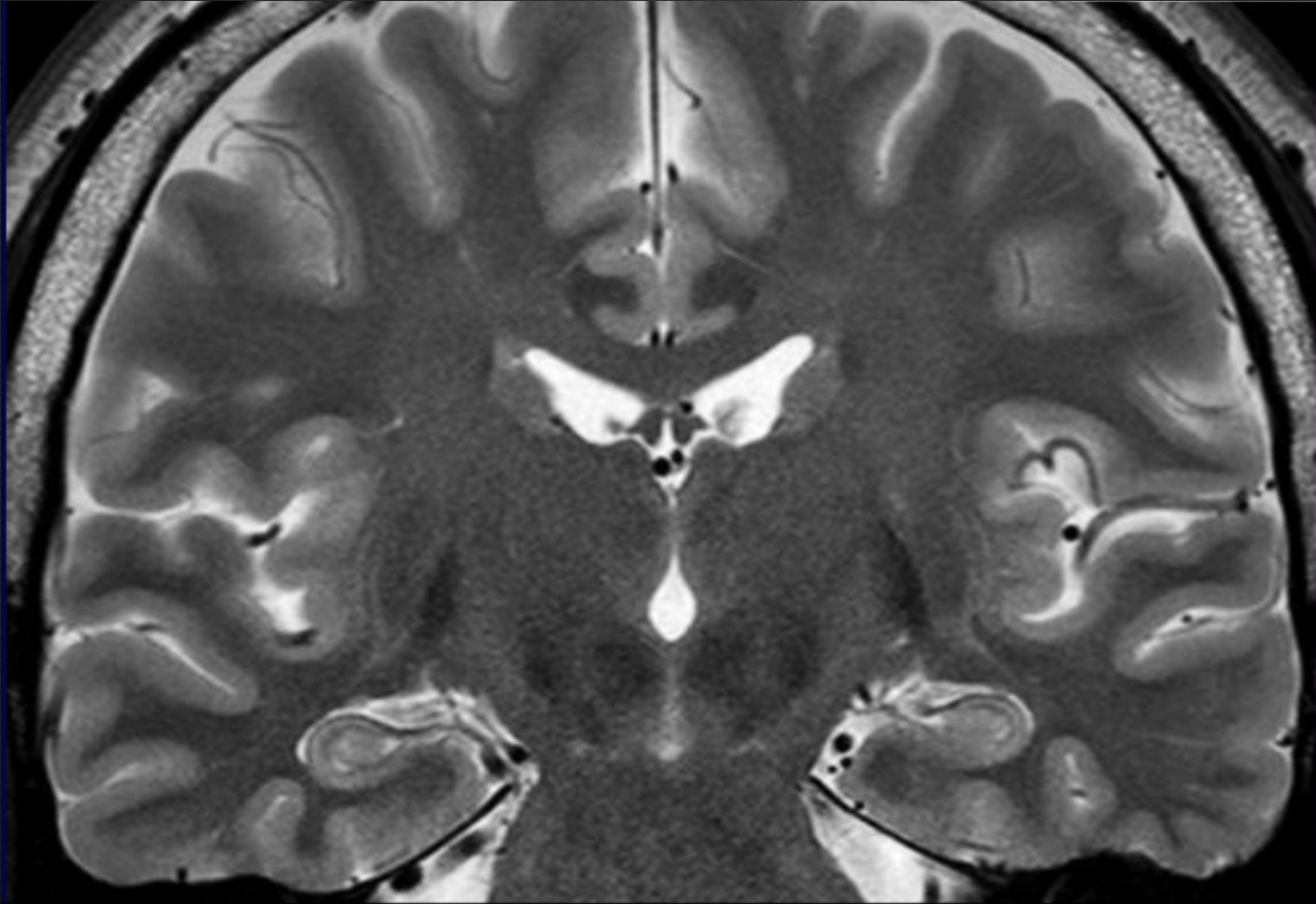
1.5 T

1.7 ml imaging



Look at the contrast !

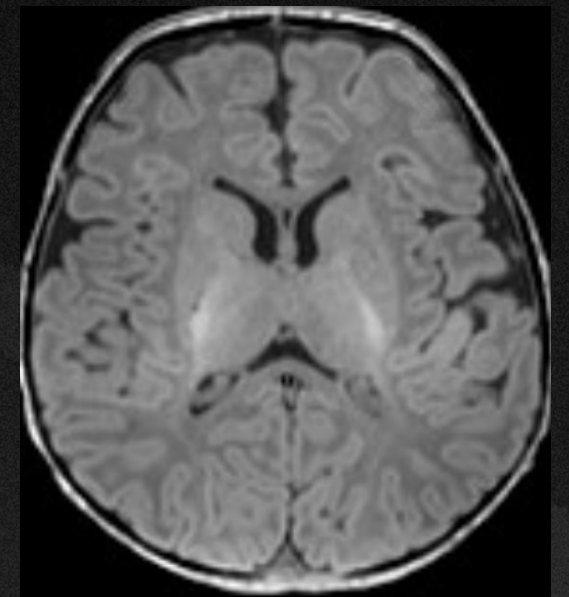
3T – The standard



0.45 x 0.57 x 3.0 mm = 0,769 ml

Time: ~ 4 min

T1 MPRAGE

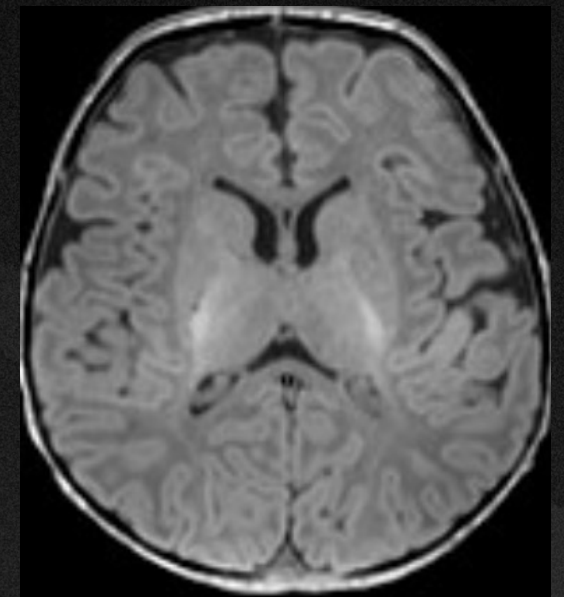



Neonates have long T1 times, low WM–GM contrast

Standard 3D MP-RAGE protocols → long (~9 min), motion-prone, lower diagnostic yield

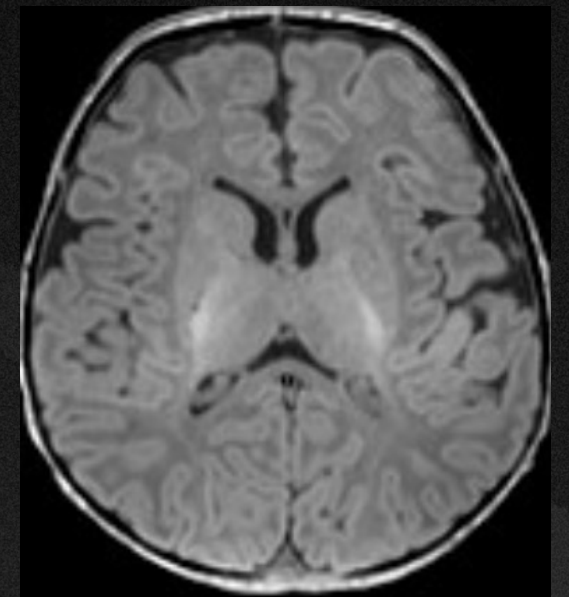
Optimised MP-RAGE provides fast, high-quality 3D T1 imaging in neonates, with better SNR/CNR and clinical usability.

MPRAGE



Feature 	Adult Brain	Neonatal Brain
T1 Relaxation Time	WM has a shorter T1 time than GM.	WM has a longer T1 time than GM because it is not yet fully myelinated.
White-Gray Matter Contrast	WM appears brighter than GM on T1-weighted scans.	GM appears brighter than WM, a phenomenon known as "reversed contrast".
Optimal Inversion Time (TI)	The optimal TI for maximal WM-GM contrast is shorter, around 1,300 ms at 3T.	The optimal TI is longer, around 1,600 to 2,000 ms at 3T, to maximize the more limited WM-GM contrast.
Contrast-to-Noise Ratio (CNR)	Relatively high.	Significantly lower (approximately one-third) than in adults.
Motion Susceptibility	Less prone to motion.	Highly susceptible to motion artifacts, necessitating shorter scan times and specialized techniques.

T1 MPRAGE



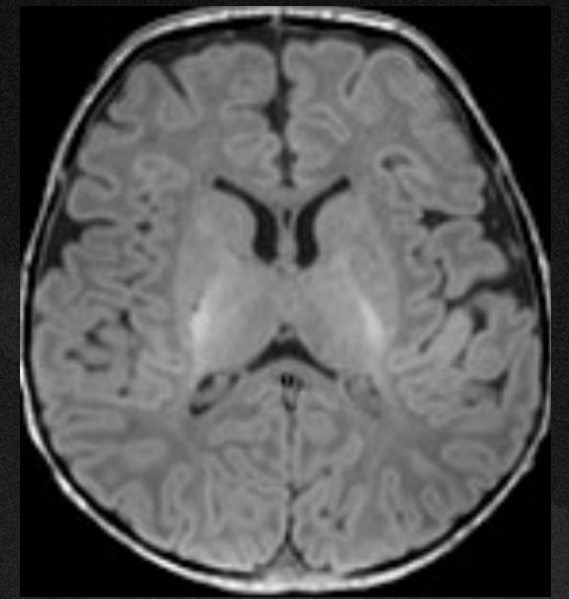
Optimization strategy

↓ Receiver bandwidth → reduces noise

↓ Acquisition train length (via partial Fourier 6/8) → boosts contrast

Bloch equation simulations with neonatal tissue properties → tuned flip angle, TI

T1 MPRAGE



SNR efficiency ↑ 160%

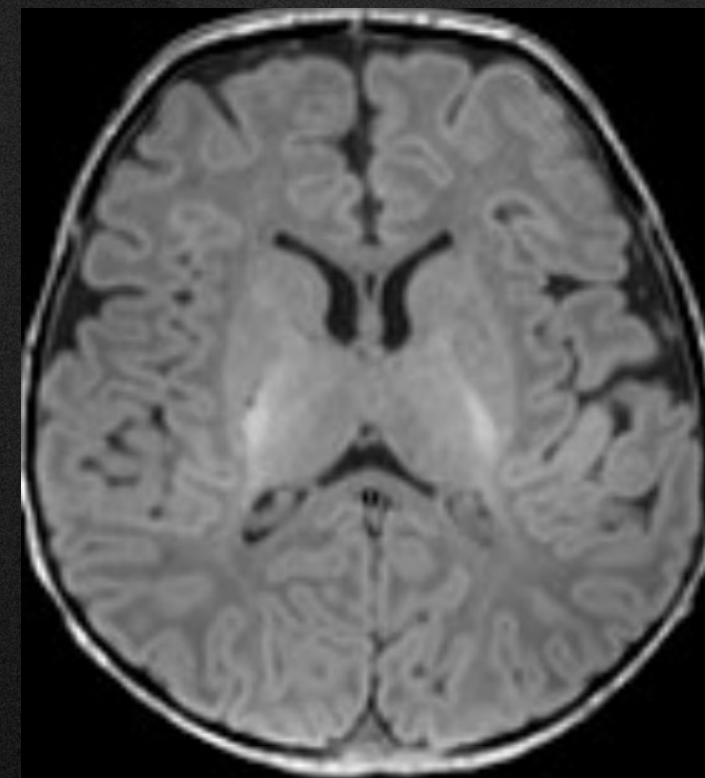
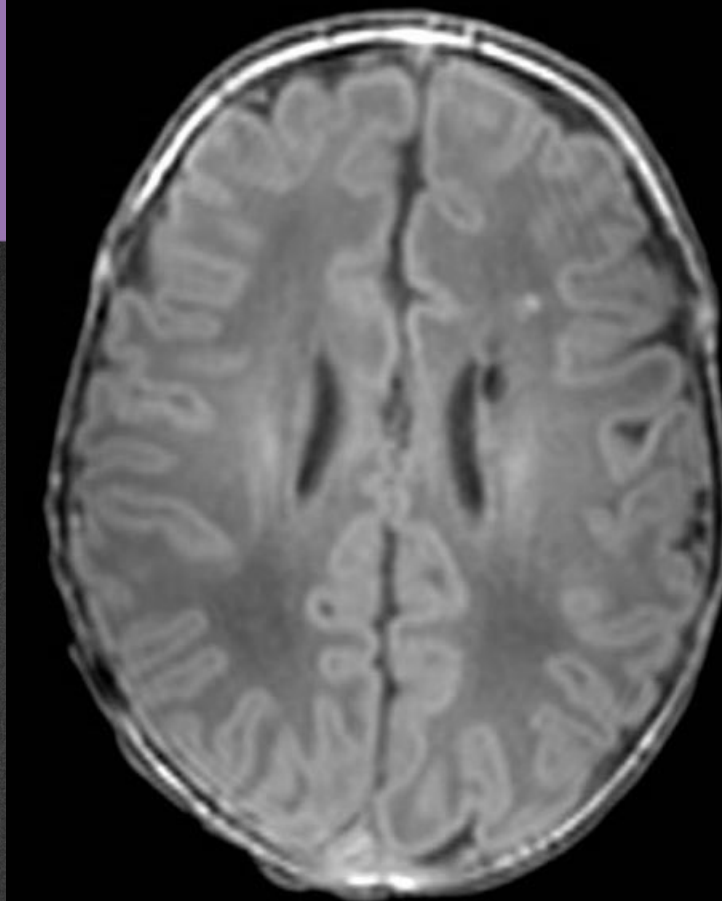
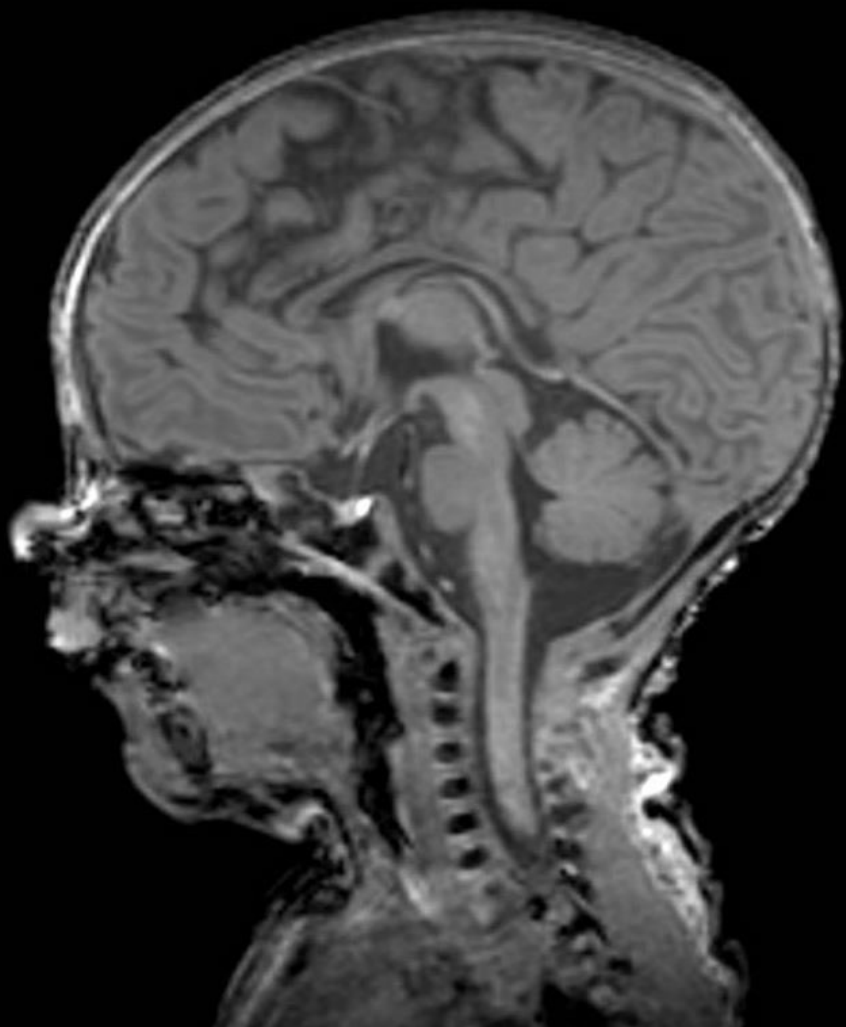
CNR efficiency ↑ 26%

Scan time ↓ 60%

Higher image quality, fewer motion failures

T1 MPRAGE

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DWI

Higher water content → higher ADC values in neonates

Motion sensitivity → echo-planar imaging (EPI) is fast but prone to motion and susceptibility artifacts

Timing after HIE → DWI is most pronounced at 1–4 days of life; pseudonormalization can occur around 7–10 days

1.5T: Lower SNR – reduce B value to gain some signal (B800 instead of B1000)

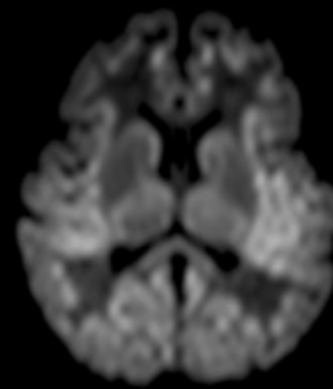
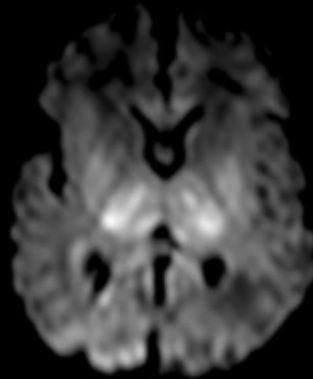
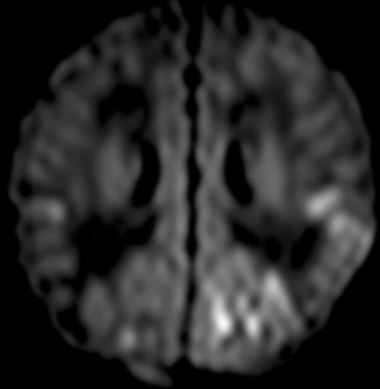
Patterns of HIE

WATERSHED
(peripheral)

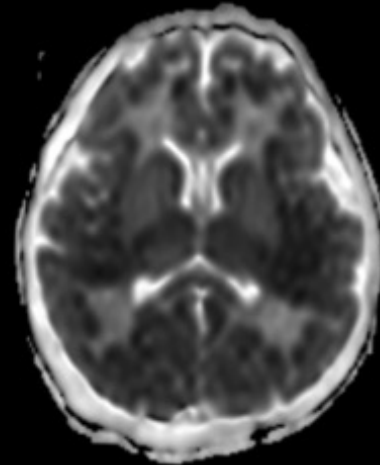
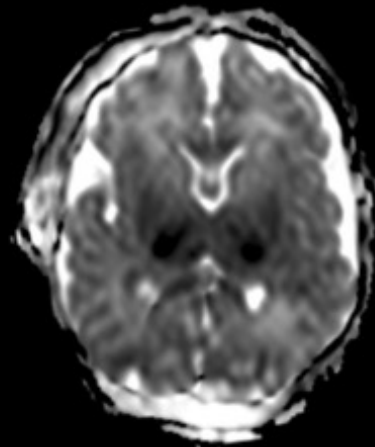
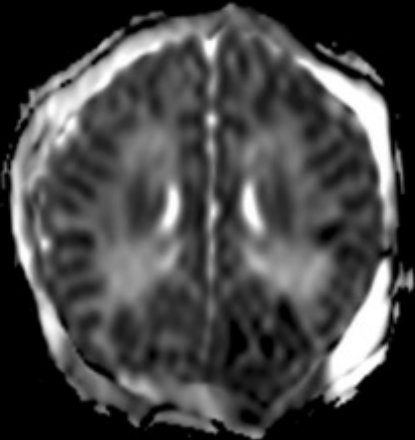
BG-TH
(central)

GLOBAL

DWI



ADC



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Lakatos A et al (2019). Neurodevelopmental effect of intracranial hemorrhage observed in hypoxic ischemic brain injury in hypothermia-treated asphyxiated neonates - an MRI study. BMC Pediatrics. 19. 10.1186/s12887-019-1777-z.

SWI

Haemorrhage:

germinal matrix, intraventricular, parenchymal, subdural

Venous anatomy and thrombosis

Characterizing HIE

venous prominence, microbleeds

Calcifications (e.g., congenital infections)

Vascular malformations and stroke sequelae

SWI

“Brush sign”

Conspicuous medullary veins

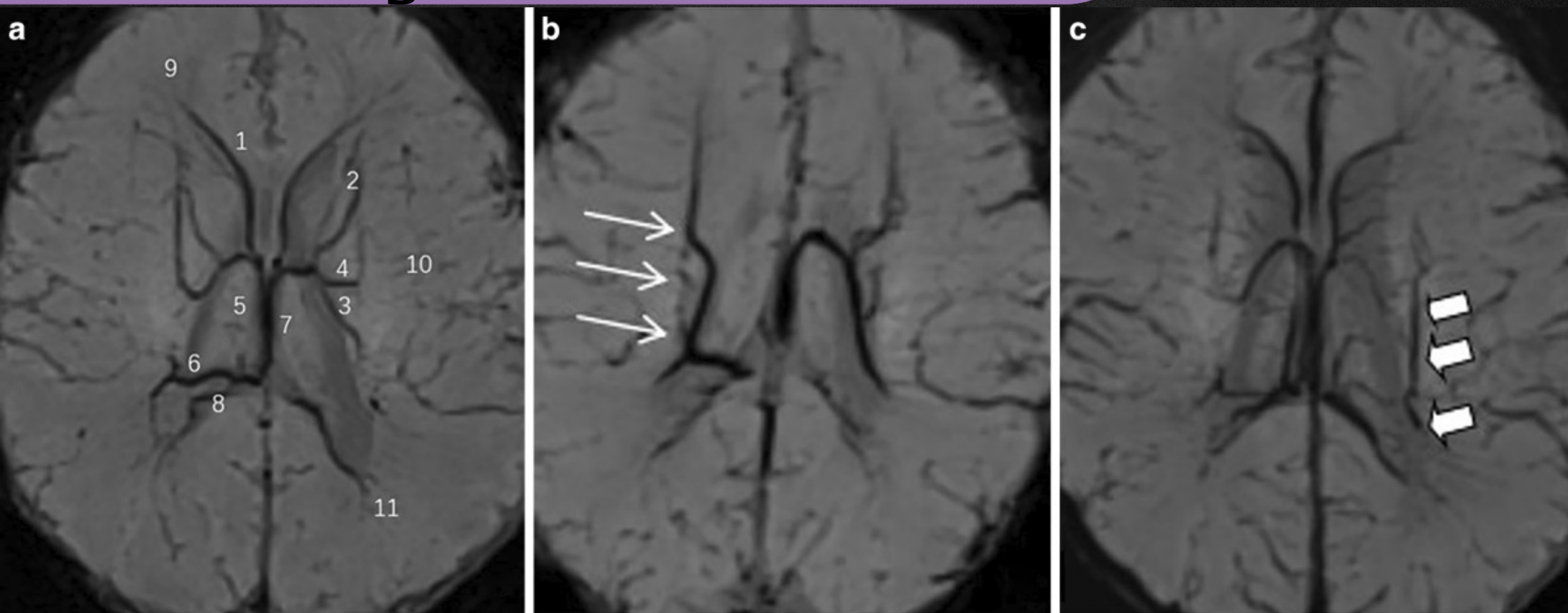
venous congestion

increased deoxyhemoglobin

impaired superficial venous drainage



Brush Sign



FLAIR



Incomplete myelination + high water content → leads to high signal intensity, can mimic lesions

Low sensitivity in very young neonates (<1 month) → often less useful than T1, T2, and DWI at this age

Longer acquisition time → increases risk of motion

Poor SNR in small brains → requires optimized coils and careful parameter selection

FLAIR post gad

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Useful when detecting abnormalities in the subarachnoid spaces or dural layers

Sturge Weber

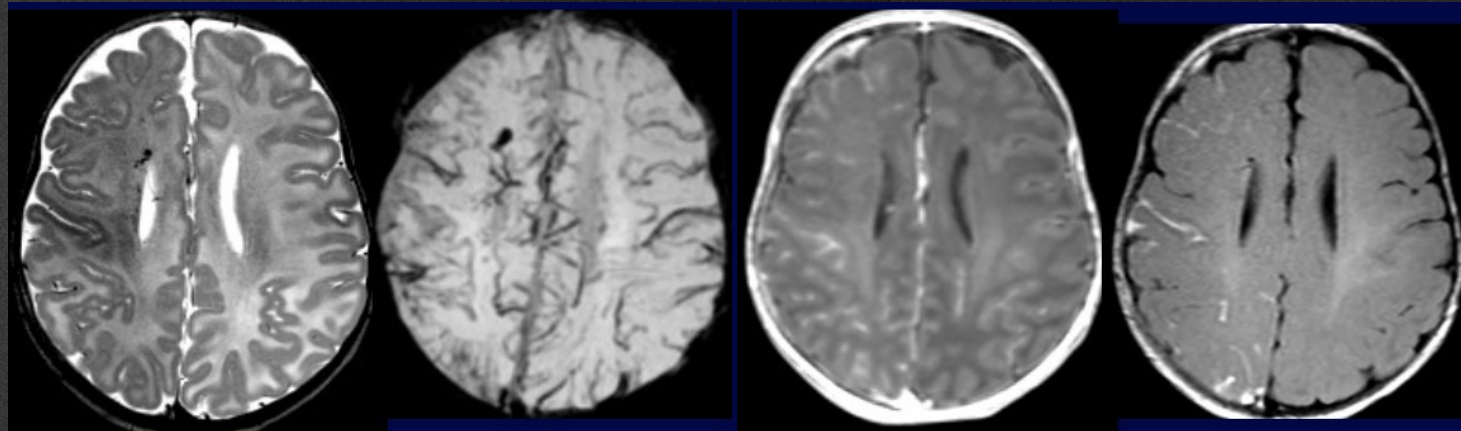
Newborn

T2W

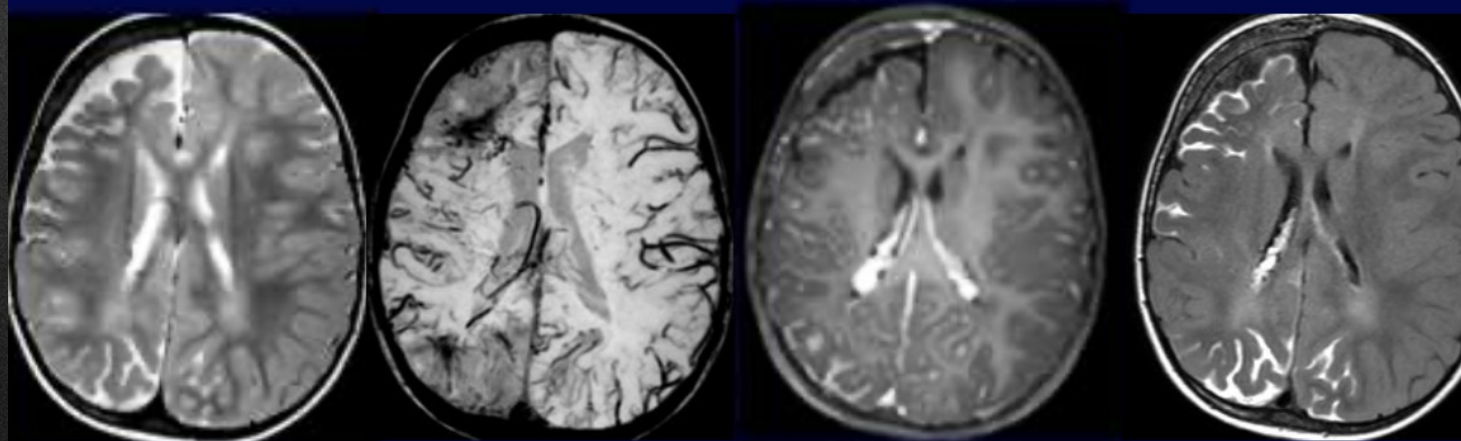
SWI

T1W post cont

FLAIR post cont



2y old



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- **Advanced techniques**
- Appropriate GBCA



Compressed SENSE (CS)

Advanced MRI acceleration technique that combines:

SENSE (Sensitivity Encoding): parallel imaging technique
uses the spatial sensitivity of multiple coil elements to
reduce scan time

Compressed Sensing (CS): reconstruction method
allows accurate image reconstruction from undersampled
k-space data.

Compressed SENSE (CS)

- Key idea:

By combining Sensitivity Encoding and Compressed Sensing, CS MRI can **significantly shorten scan times** while **maintaining image quality**, which is especially crucial in neonates who are prone to motion.

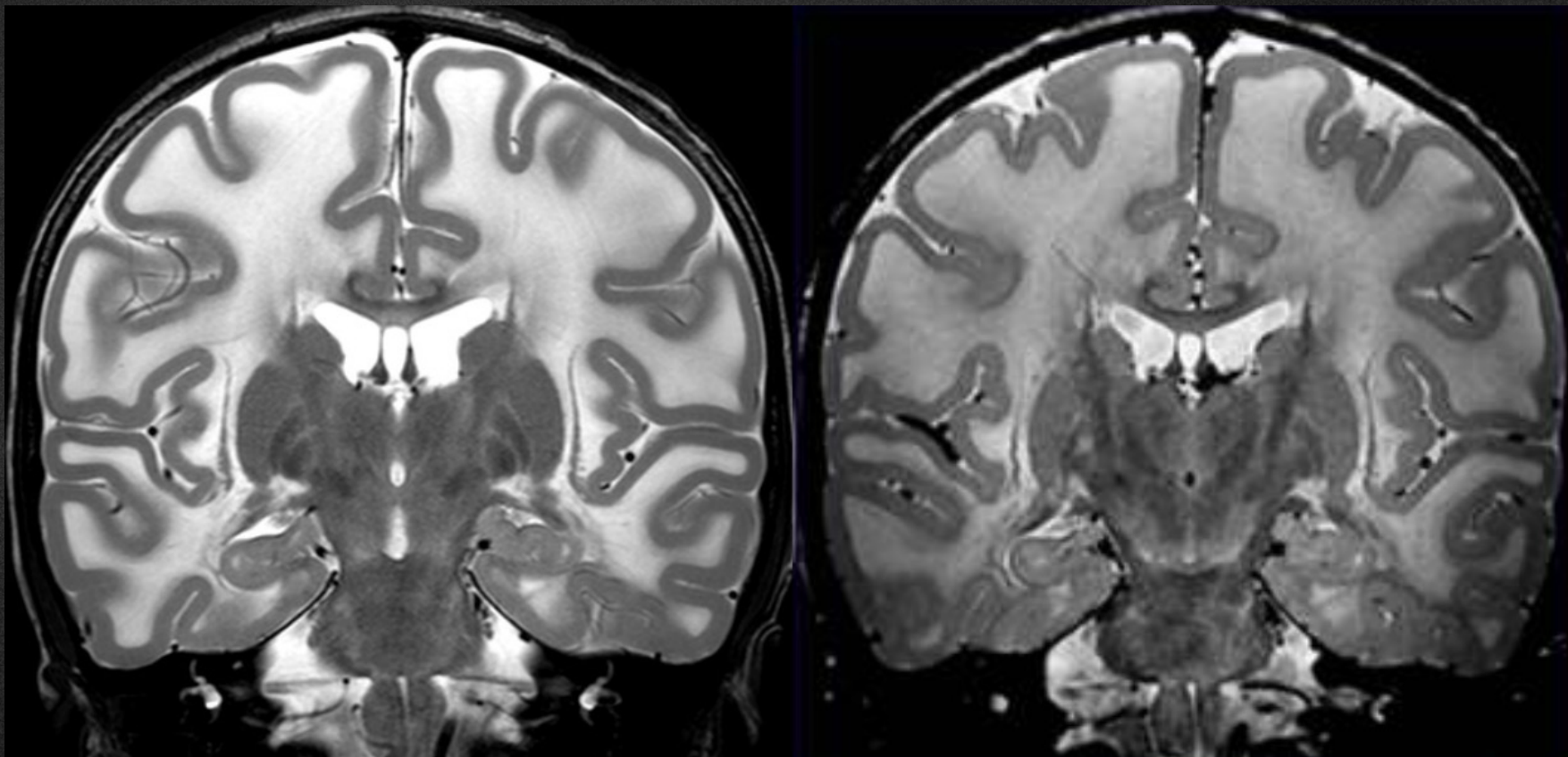
Compressed Sense

Benefit	Explanation
Shorter scan time	Reduces total examination time by 30–50% or more.
Reduced motion artifacts	Faster acquisition reduces blurring from involuntary movements.
High-resolution imaging	Maintains fine anatomical detail despite undersampling.
Lower sedation	Minimizing scanning time reduces the need for sedation.
Flexible protocol design	Enables more sequences in the same session (DWI, SWI, FLAIR, T1, T2).

Compressed Sense

$0.45 \times 0.57 \times 3.0 \text{ mm} = 0,769 \text{ ml}$

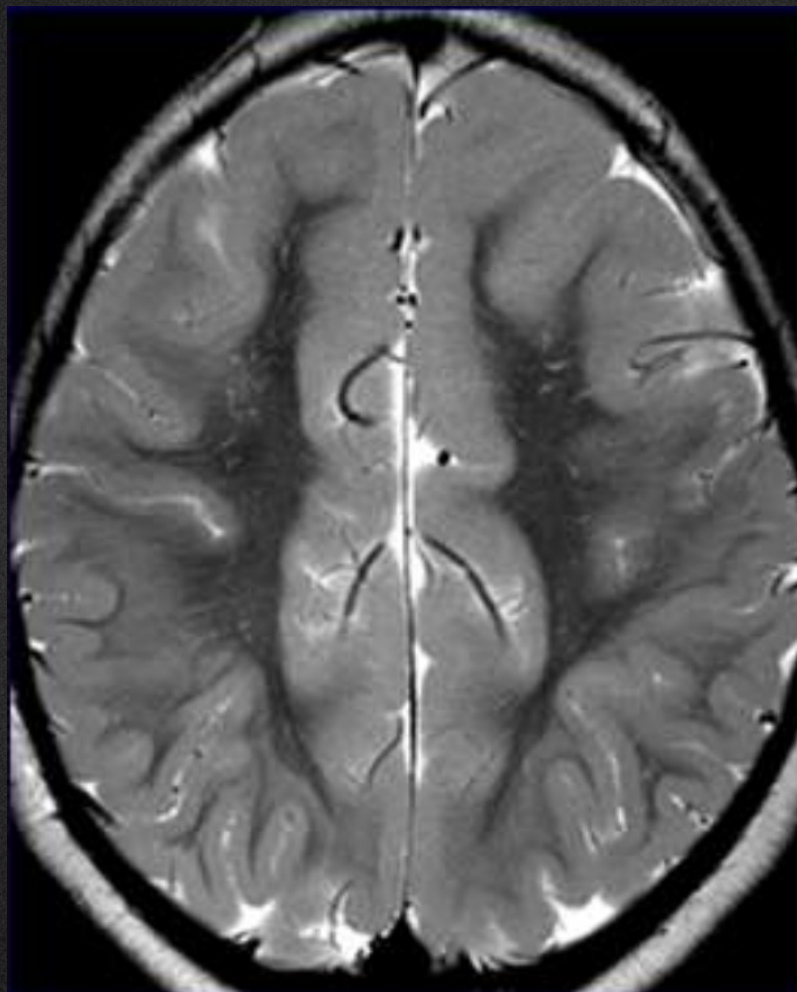
$0.3 \times 0.3 \times 1.1 \text{ mm} = 0,099 \text{ ml (99nl)}$



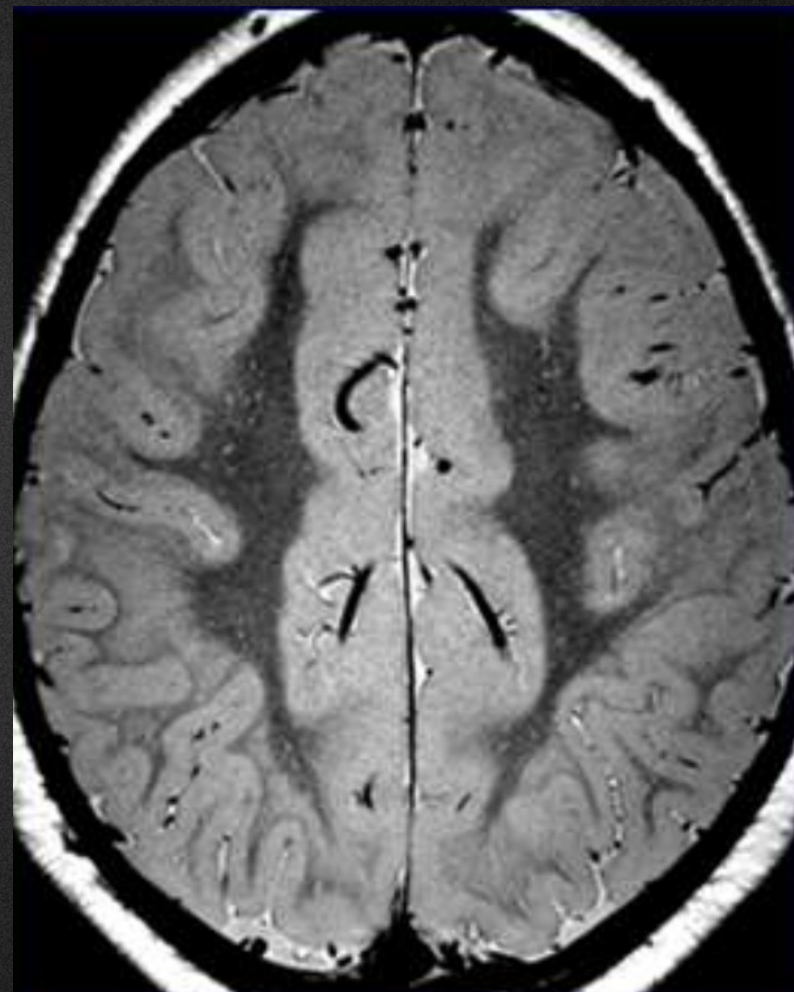
Possible to further reduce the spatial resolution below the limit of 0.1 ml (100 nl)

Compressed Sense

0,769 ml



0,099 ml (99nl)



Band Heterotopia

MR Spectroscopy

Lactate/N-acetylaspartate within 2 weeks of birth

Accurately predicts 2-year motor, cognitive and language outcomes in neonatal encephalopathy after therapeutic hypothermia

BGT Lac/NAA threshold of 0.39 sensitivity and specificity for 2-year:

- motor outcome 100% and 97%
- cognition 90% and 97%
- language 81% and 97%

MR Spectroscopy

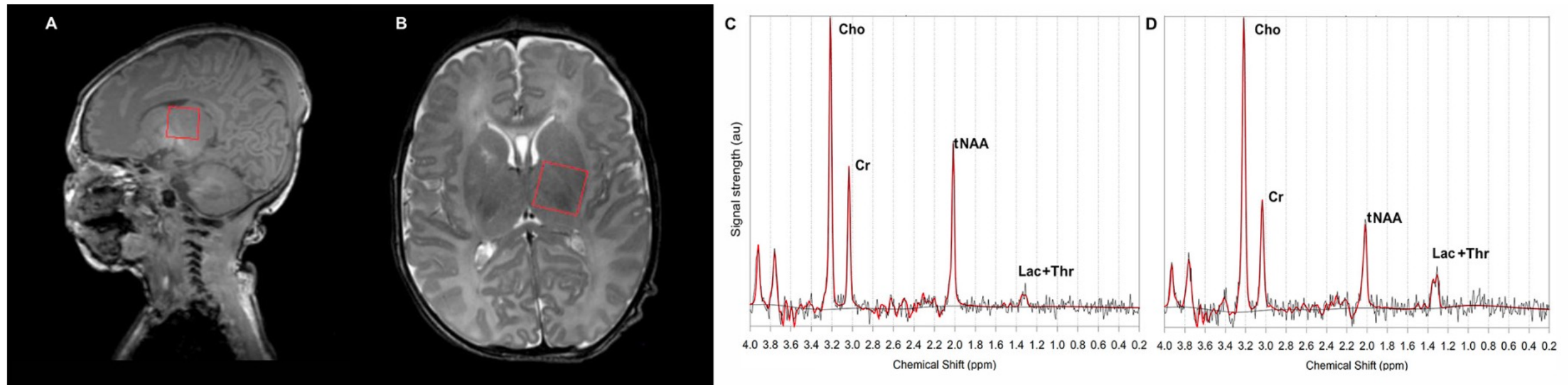


Figure 2 Position of the thalamic ^1H magnetic resonance spectroscopy voxel for spectral acquisition (sagittal A and axial B) from a neonate with normal outcome (Lac+Thr/tNAA 0.19) (C) and a neonate with poor outcome (Lac+Thr/tNAA 0.62) (D) after HT for NE. Cho, choline; Cr, creatine; HT, hypothermia; Lac, lactate; NE, neonatal encephalopathy; tNAA, total N-acetylaspartate; Thr, threonine.

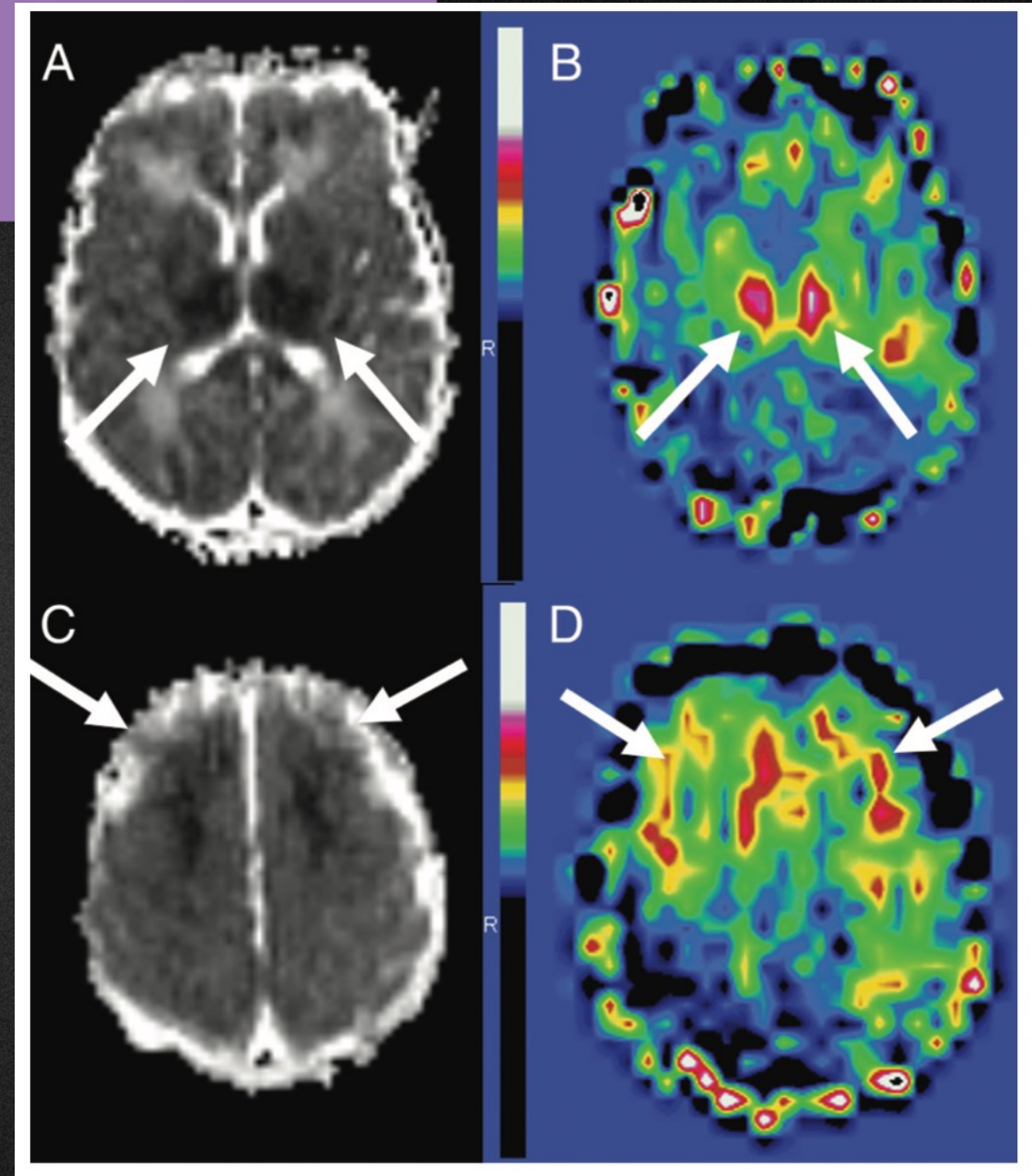
ASL

HIE neonate treated with hypothermia

Day 3

DWI: ischaemic injury in the thalami, lentiform nuclei and frontal watershed areas

ASL: higher perfusion in same areas



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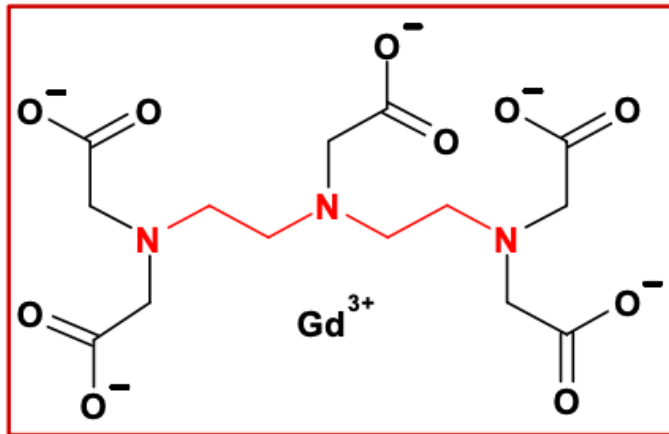
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Chemical structure GBCA

Linear

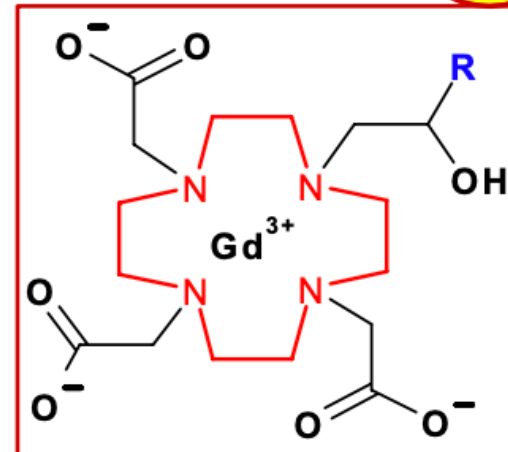
Gd³⁺



gadoversetamide (OptiMARK)
gadodiamide (Omniscan)
gadopentenic acid (Magnevist)
gadofosveset (Vasovist)
gadoxetic acid (Primovist)
gadobenic acid (MultiHance)

Macrocyclic

Gd³⁺



gadoteric acid (Dotarem)
gadoteridol (ProHance)
gadobutrol (Gadovist)

Chelate stability

- **Macrocyclic agents are more stable** and less prone to release gadolinium ions than linear
- **Nephrogenic systemic fibrosis (NSF):** stability of the chelate appears to have a role in the development of NSF in patients with renal impairment



EMA's final opinion confirms restrictions on use of linear gadolinium agents in body scans

Recommendations conclude EMA's scientific review of gadolinium deposition in brain and other tissues

Product	Type (formulation)	Recommendation
Artirem / Dotarem (<i>gadoteric acid</i>)	macrocytic (i.v.)	maintain
Artirem / Dotarem (<i>gadoteric acid</i>)	macrocytic (intra-articular)	maintain
Gadovist (<i>gadobutrol</i>)	macrocytic (i.v.)	maintain
Magnevist (<i>gadopentetic acid</i>)	linear (intra-articular)	maintain
Magnevist (<i>gadopentetic acid</i>)	linear (i.v.)	suspend
Multihance (<i>gadobenidic acid</i>)	linear (i.v.)	restrict use to liver scans
Omniscan (<i>gadodiamide</i>)	linear (i.v.)	suspend
Optimark (<i>gadoversetamide</i>)	linear (i.v.)	suspend
Primovist (<i>gadoxetic acid</i>)	linear (i.v.)	maintain
Prohance (<i>gadoteridol</i>)	macrocytic (i.v.)	maintain

Summary

- Preparation: coils, feed / wrap
- Tailored acquisition: correct parameters
- Magnet: high resolution, advanced techniques
- GBCA
 - has to be justified
 - macrocylic

Muito Obrigada!

- **NHNN Neuroradiology Team**
- **UCLH Neonatology Team**
- **Magda Sokolska (UCLH Clinical Scientist)**
- **Dr Fabio Triulzi - University of Milan**
- ***Patients and families***

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Contact

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