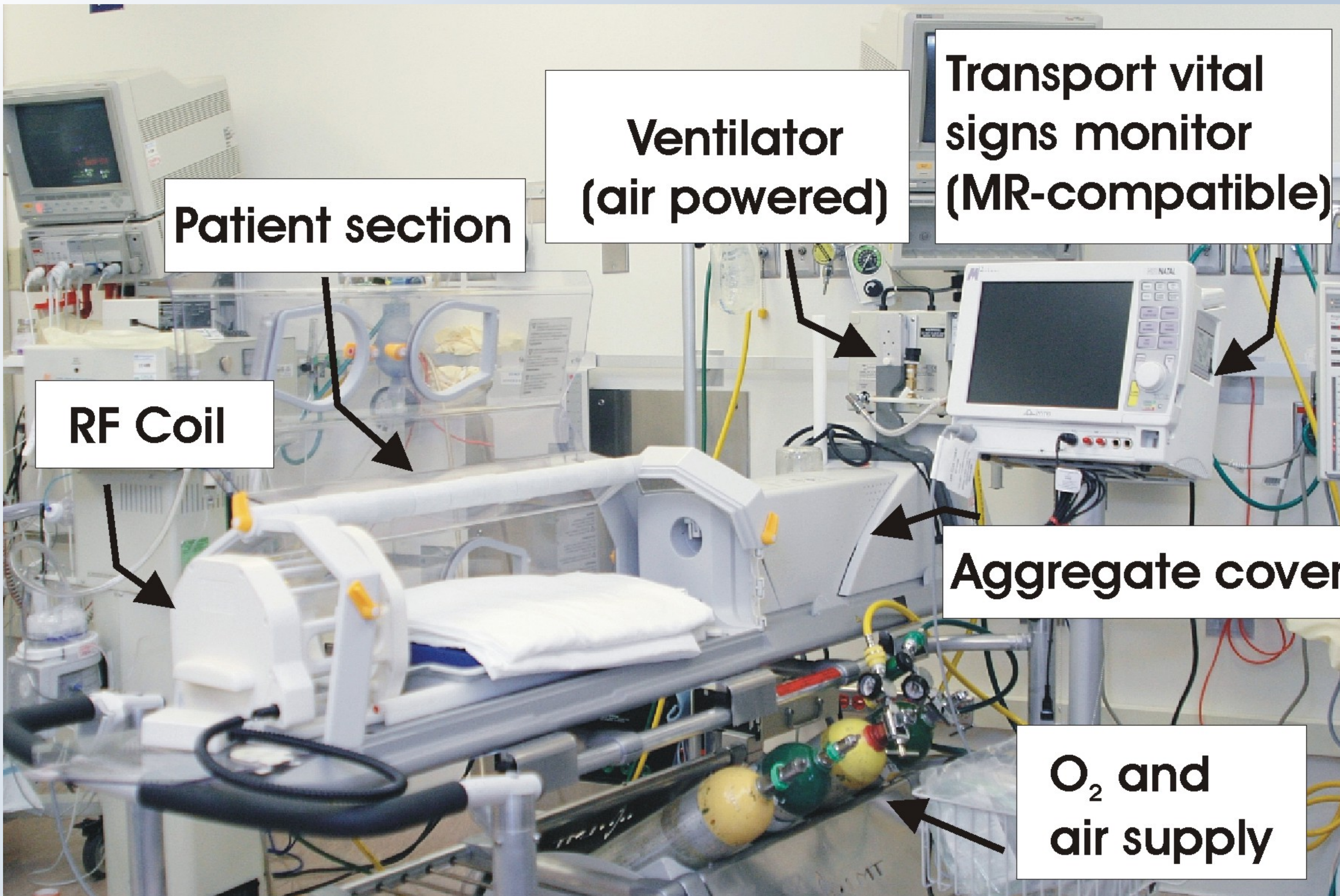
MR IMAGING OF THE TERM INFANT

Ashok Panigrahy, M.D.
Radiologist-in-Chief
Childrens Hospital of Pittsburgh of UPMC
Associate Professor

Children's Hospital of Pittsburgh of UPMC

Presentation Outline

- Technology
- HIE- cooling
- Diffusion imaging /MR spectroscopy
- Perfusion imaging
- Metabolic Disorders
- Infection
- Vascular lesions/tumors
- Malformations



Bluml et al., Radiology *2004 May; 231(2):594-601*

Future Trend- Hammersmith Neonatal Group, Imperial Group were the first!

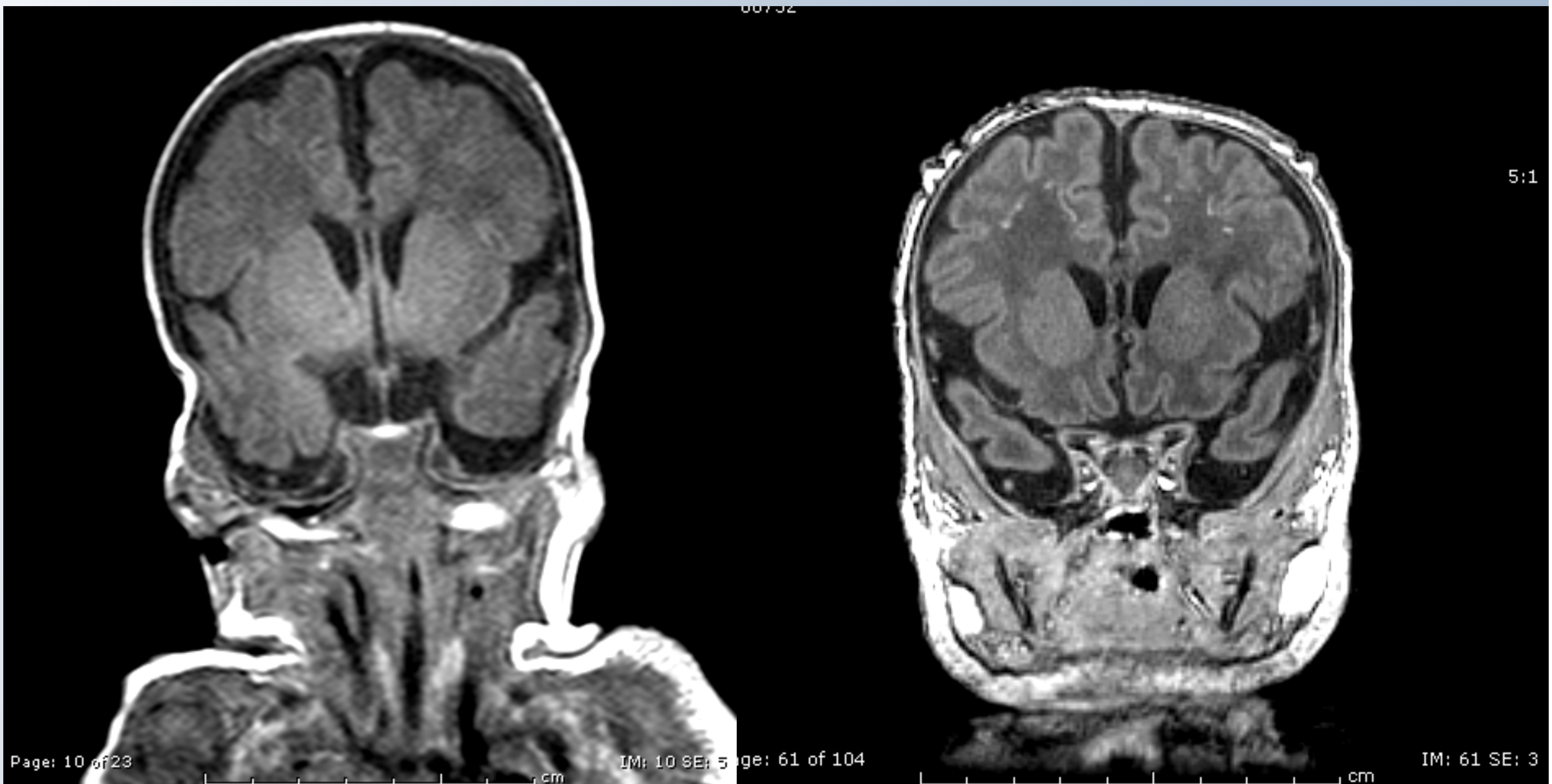
http://www.european-hospital.com/en/article/523-Neonatal_MRI_of_premature_babies.html

MRI scanner in the NICU

- Novel radiofrequency (RF) Coils for ^{1}H **<u>and</u>** for ^{31}P MRS

Standard head coil for MRI and ^{1}H MRS[1]	**Dual-tuned coil for MRI, ^{1}H MRS, and ^{31}P MRS[2]**	**Dual-tuned coil for MRI, ^{1}H MRS, and ^{31}P MRS optimized for children[2]**	**Newborn head coil for MRI and ^{1}H MRS with MR-compatible incubator[2]**

[1]General Electric, [2]Advanced Imaging Research Inc. (AIRI)


5:1
Page: 10 of 23
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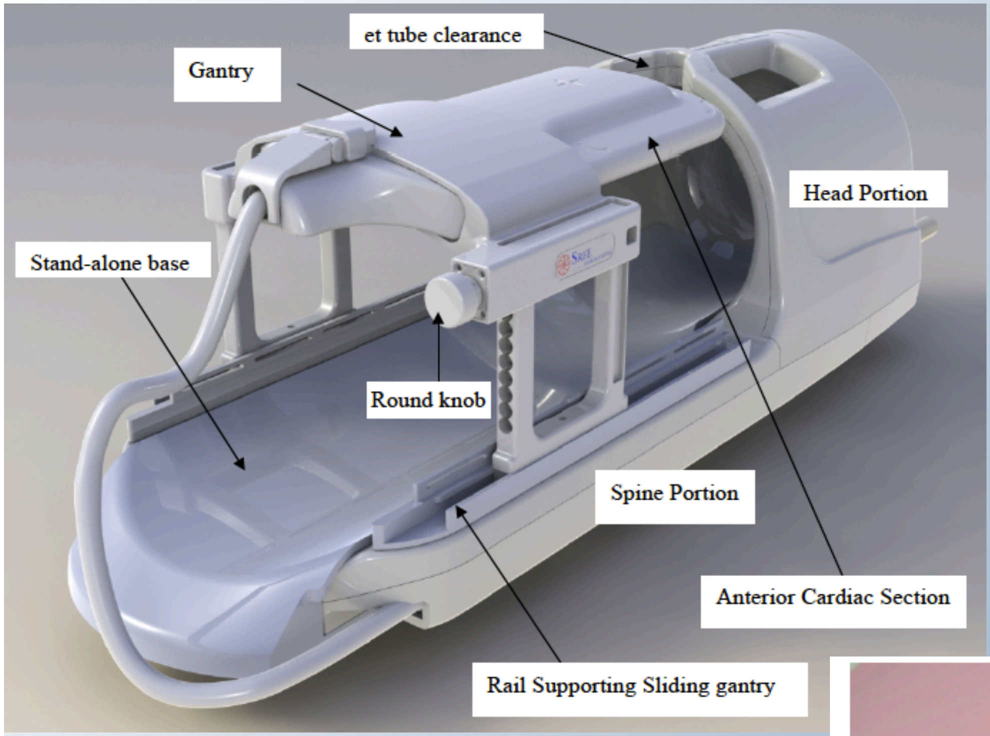
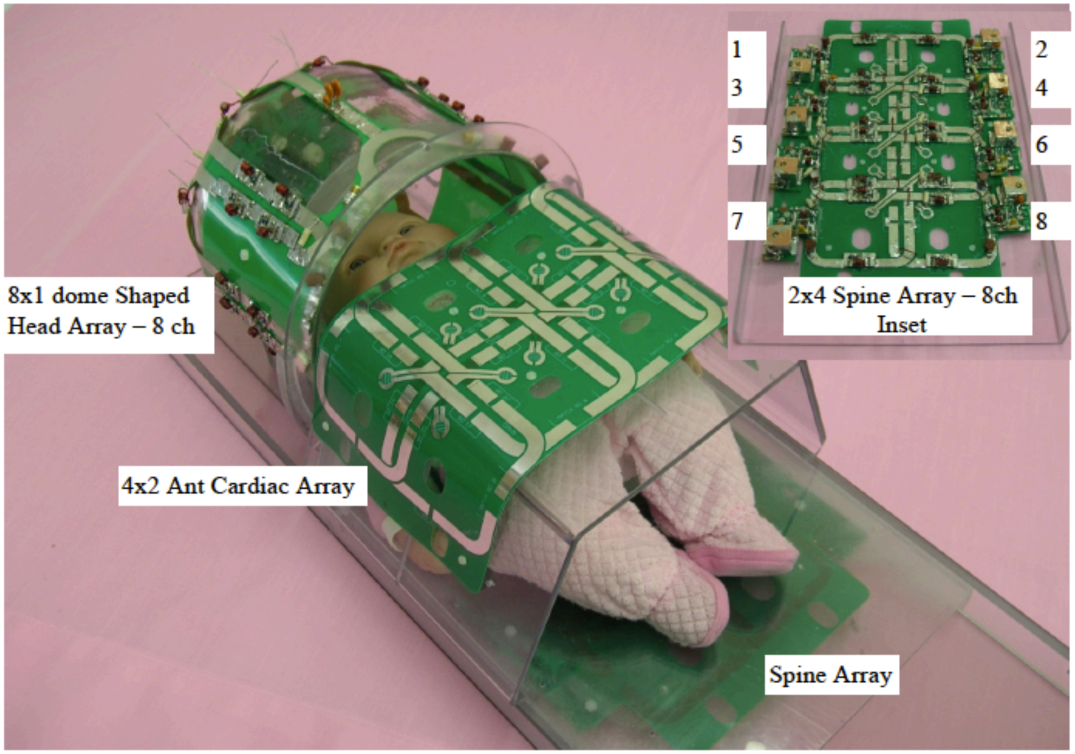
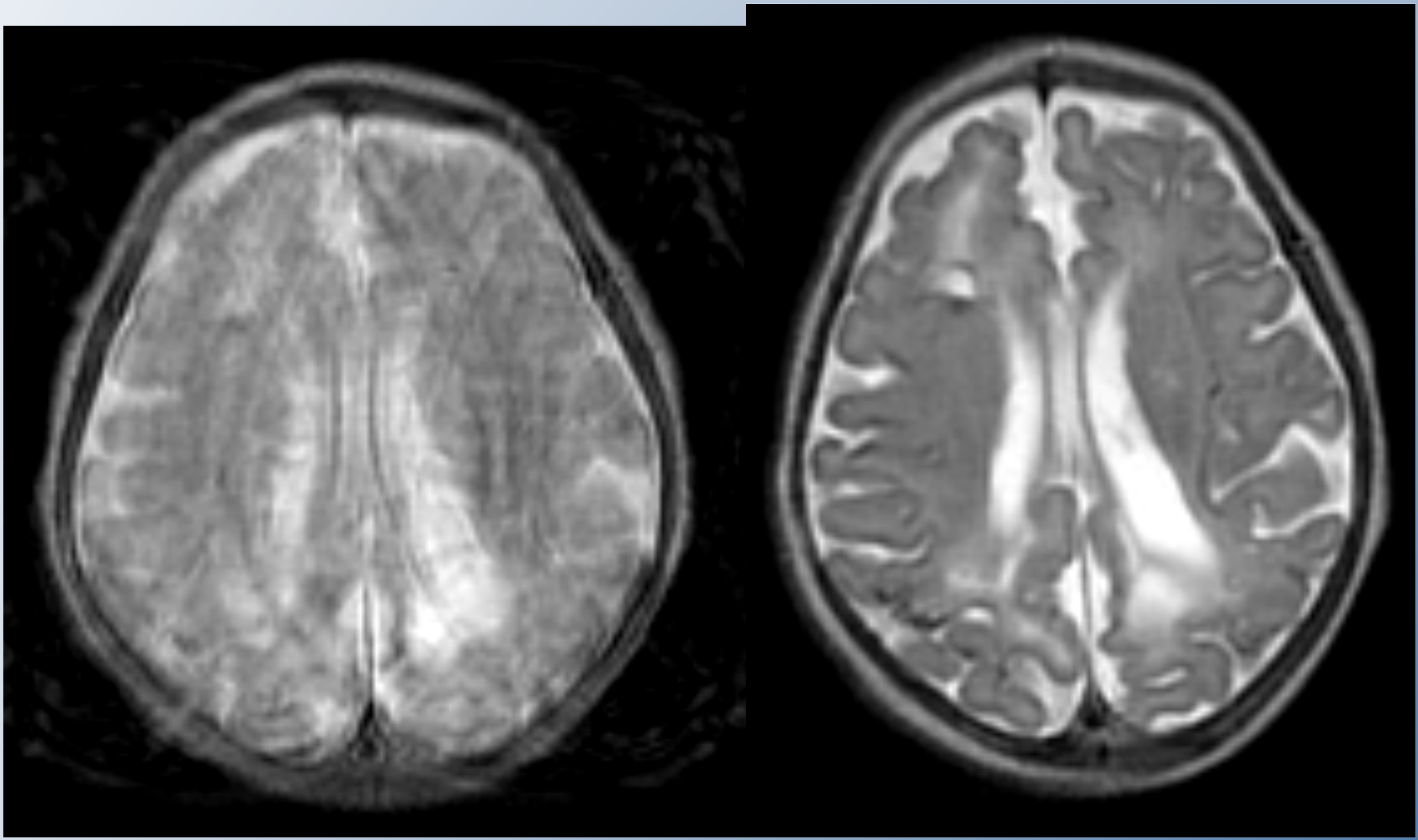


Dr. Ravi Srinivasin
Advanced Imaging



PROPELLER IMAGING
Motion Correction Sequence



Clinical Trials to Evaluate Cooling

- Cool Cap Trial (International)

– Lancet 2005; 365:663-70

- NICHD Whole Body Cooling Trial (US)

–NEJM 2005; 353:1574-84

- TOBY Trial (UK/Europe/Israel)
- ICE Trial (Australia)

Effect of Hypothermia on cMR TOBY TRIAL

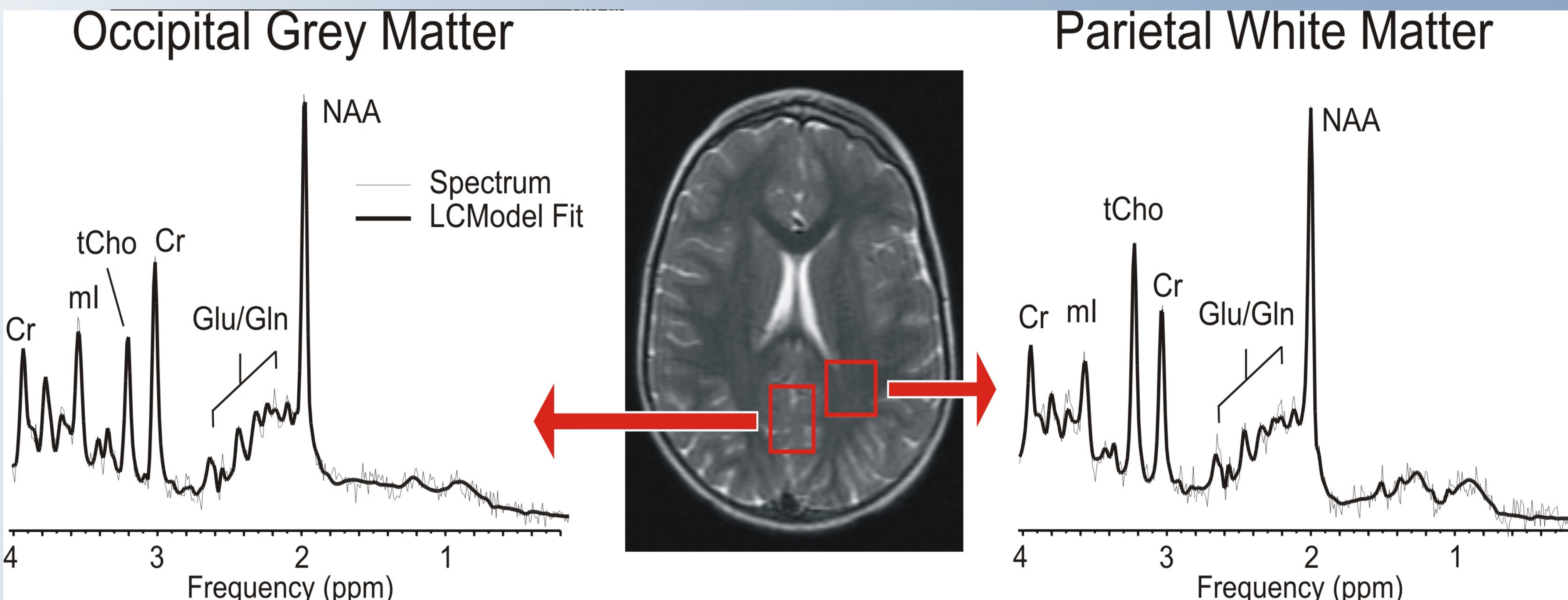
- Images available from 131 infants
- HYP- decreased lesions in basal ganglia/ thalamus;white matter; PLIC
- The predictive value of MRI for subsequent neurological impairment is not affected by HYP

Effect of Hypothermia on cMR NICHD study

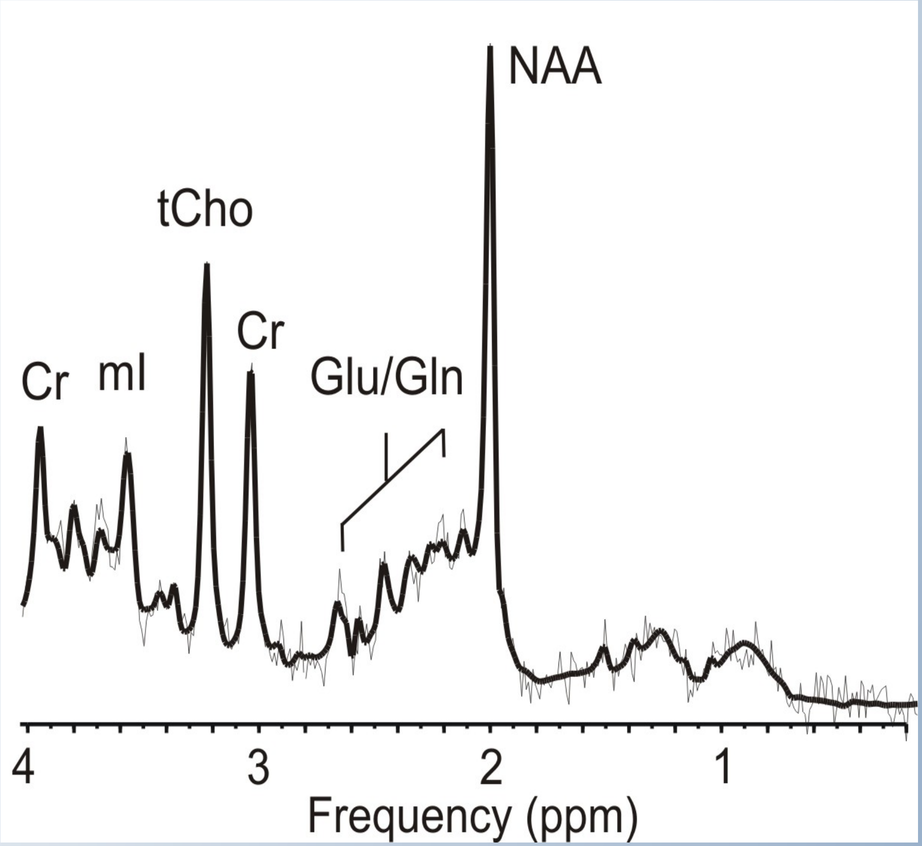
- 151 infants with MRI
- Three scales: Rutherford;Barkovich;NICHD
- Fewer watershed infarcts, less abnormalities in the ALIC and PLIC
- The predictive value of the injury was not altered by hypothermia
- The reduction of areas of brain injury in both groups shows whole body cooling in neuroprotective
- S. Shankaran et al, 2012

MRI and proton (^1H) MRS

- **MRI** uses the signal from hydrogen protons of water to reconstruct an image
- **^1H MRS** uses the signal from the protons of <u>chemicals</u> to generate a spectrum

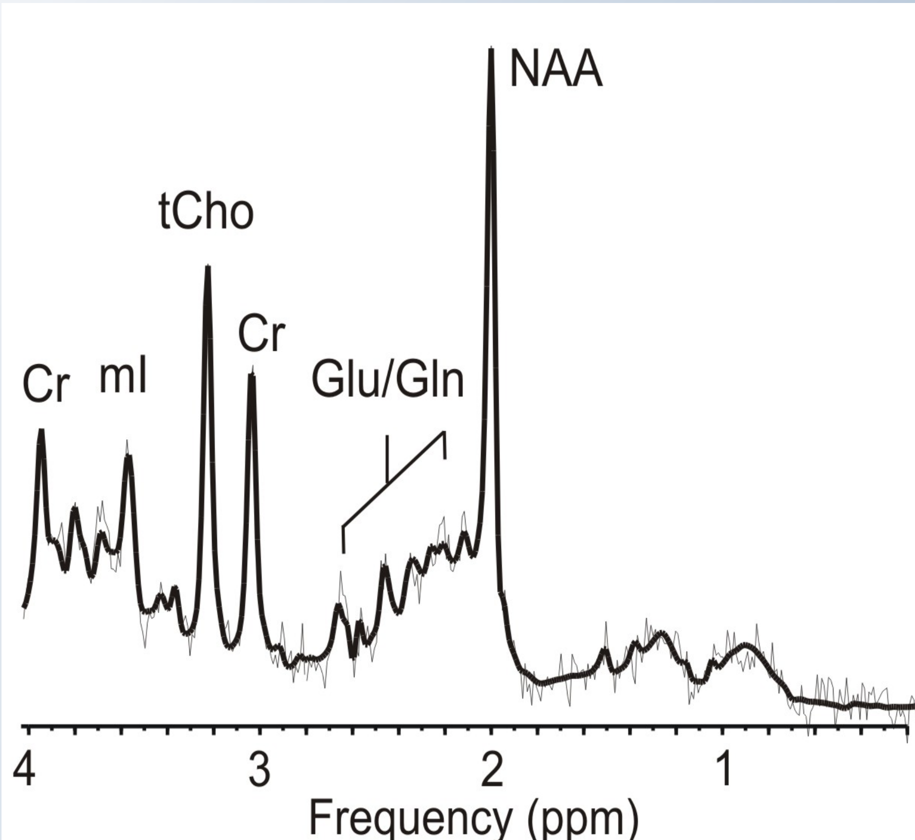


“Normal” proton (^1H) MRS



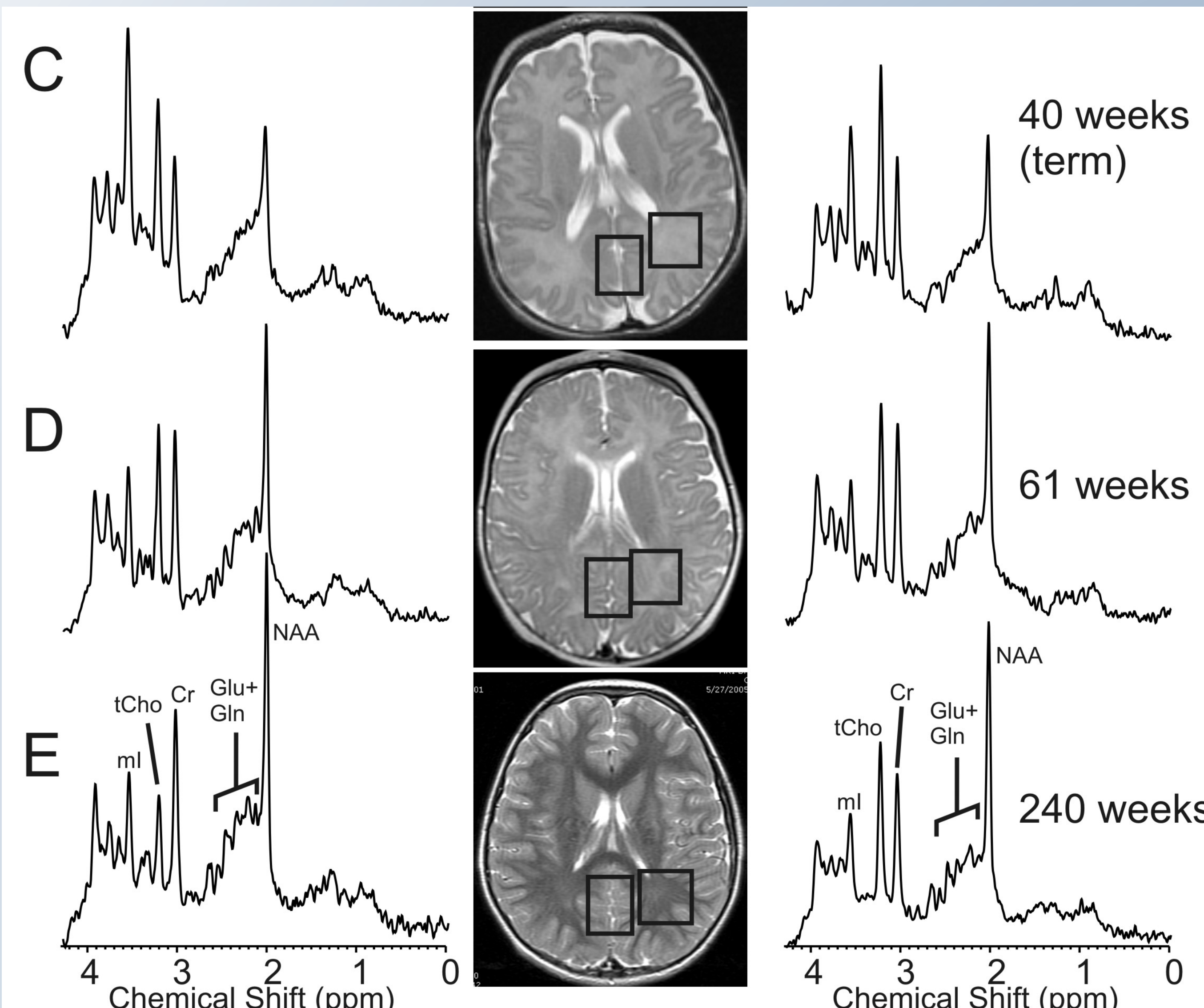
- Position on x-axis relative to a standard (measured in ppm = parts per million) identifies chemicals
- Peak height is proportional to concentration
- MRS is inherently quantitative (mmol/kg tissue)

"Normal" proton (^1H) MRS

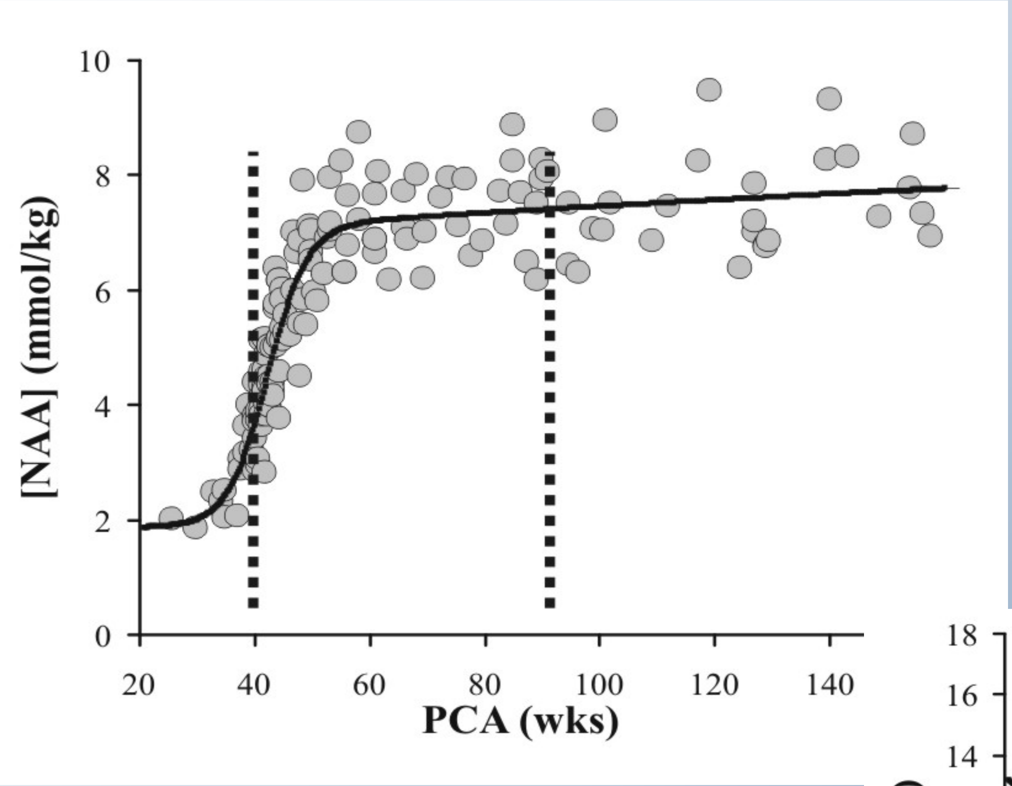


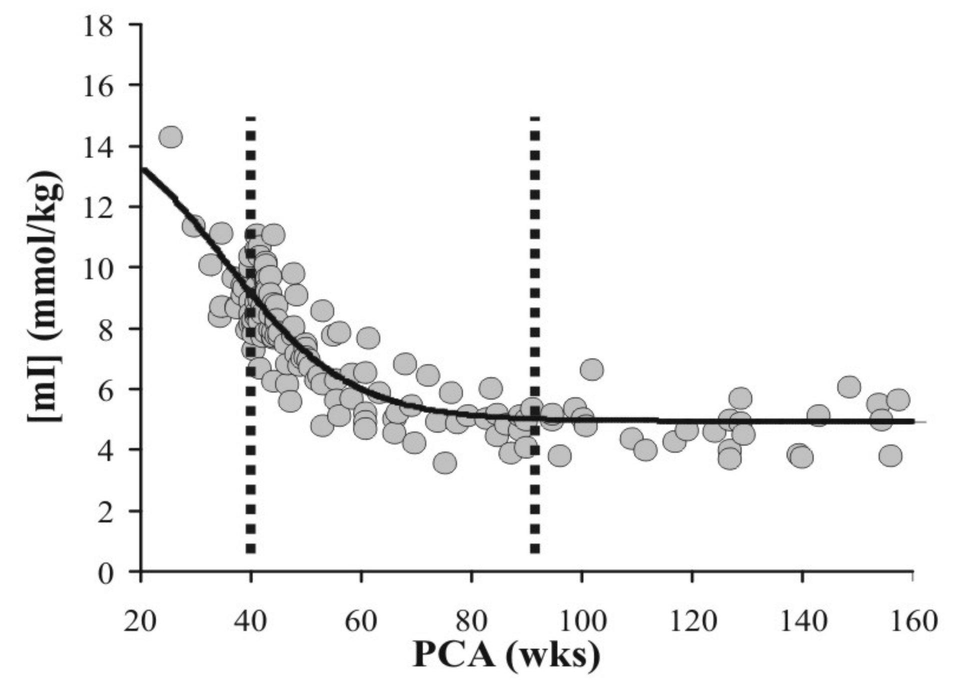
- **NAA (N-acetyl-aspartate):** Marker for mature neurons and axons.
- **Cr (creatine):** Free creatine and phosphocreatine. Replenishes ATP via PCr + ADP -> Cr + ATP
- **tCho (choline containg metabolites):** Group of choline containing metabolites involved in synthesis and breakdown of membrane phospholipids (phosphatidylcholine = lecitine)
- **mI (myo-inositol):** Sugar-like molecule, osmolyte, astrocyte marker, involved in membrane metabolism, detoxification
- **Glu (glutamate):** Neurotransmitter, high in neurons
- **Gln (glutamine):** Glutamate detoxification, osmolyte, astrocyte marker

Normal age-dependent changes

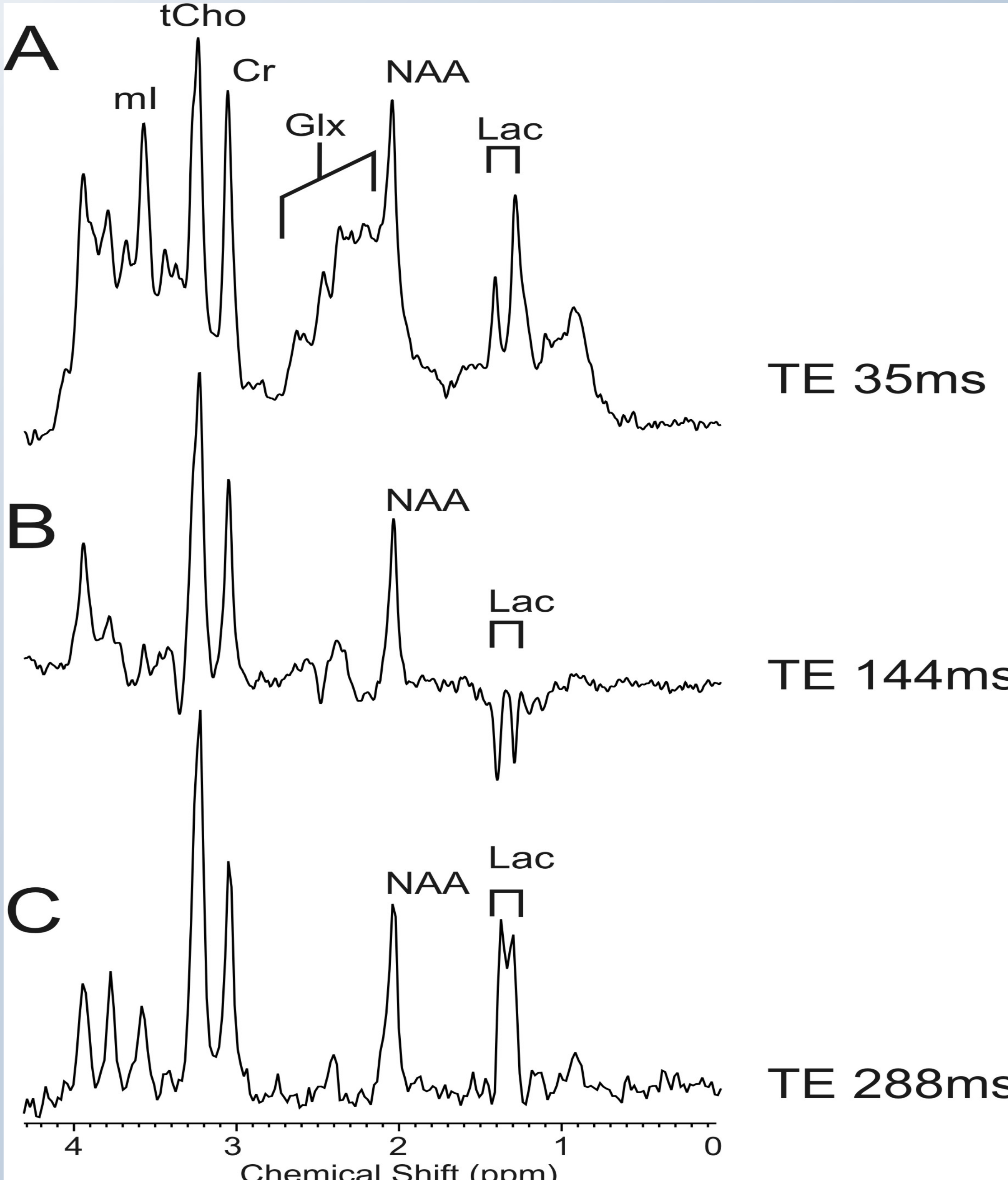


Normal age-dependent changes

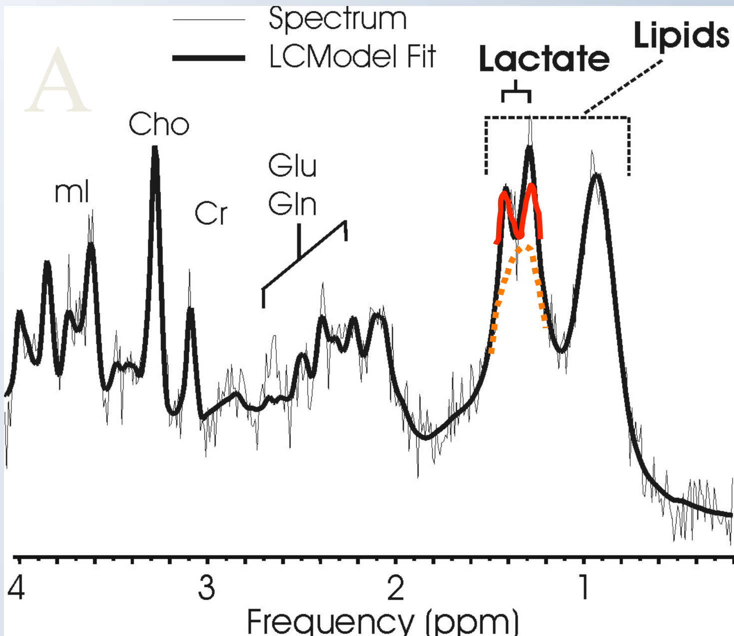


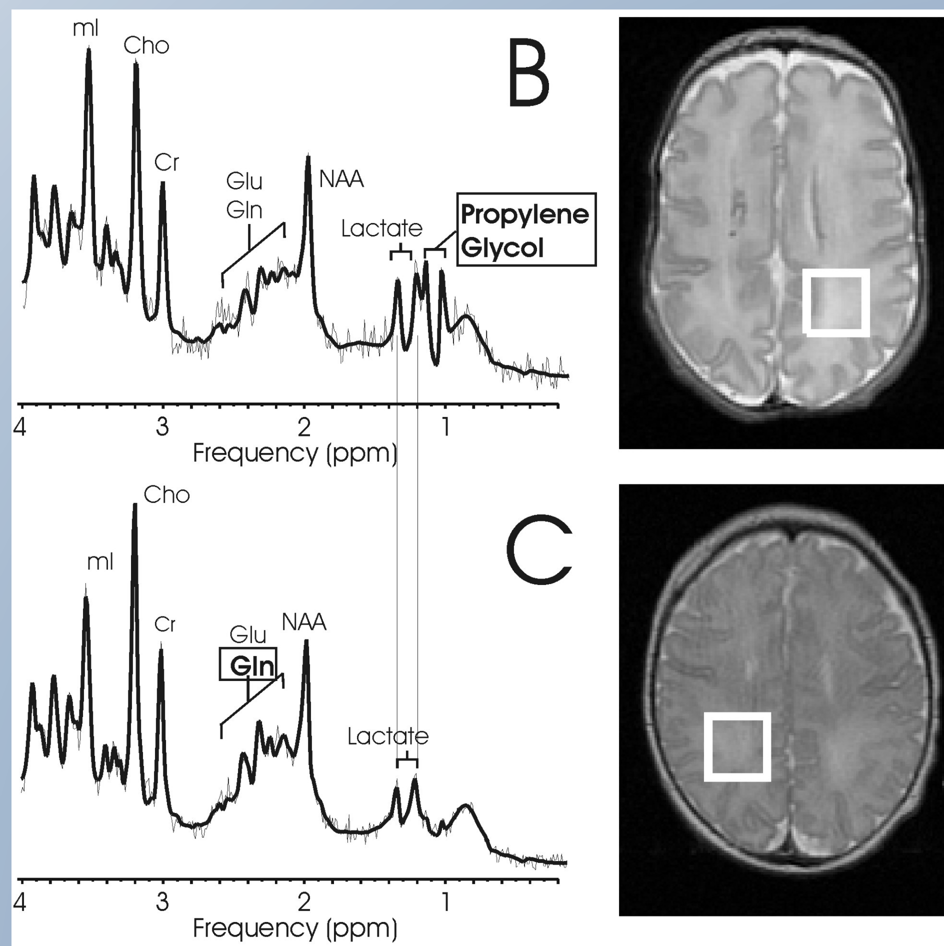


Bluml et al. Cerebral Cortex, 2012

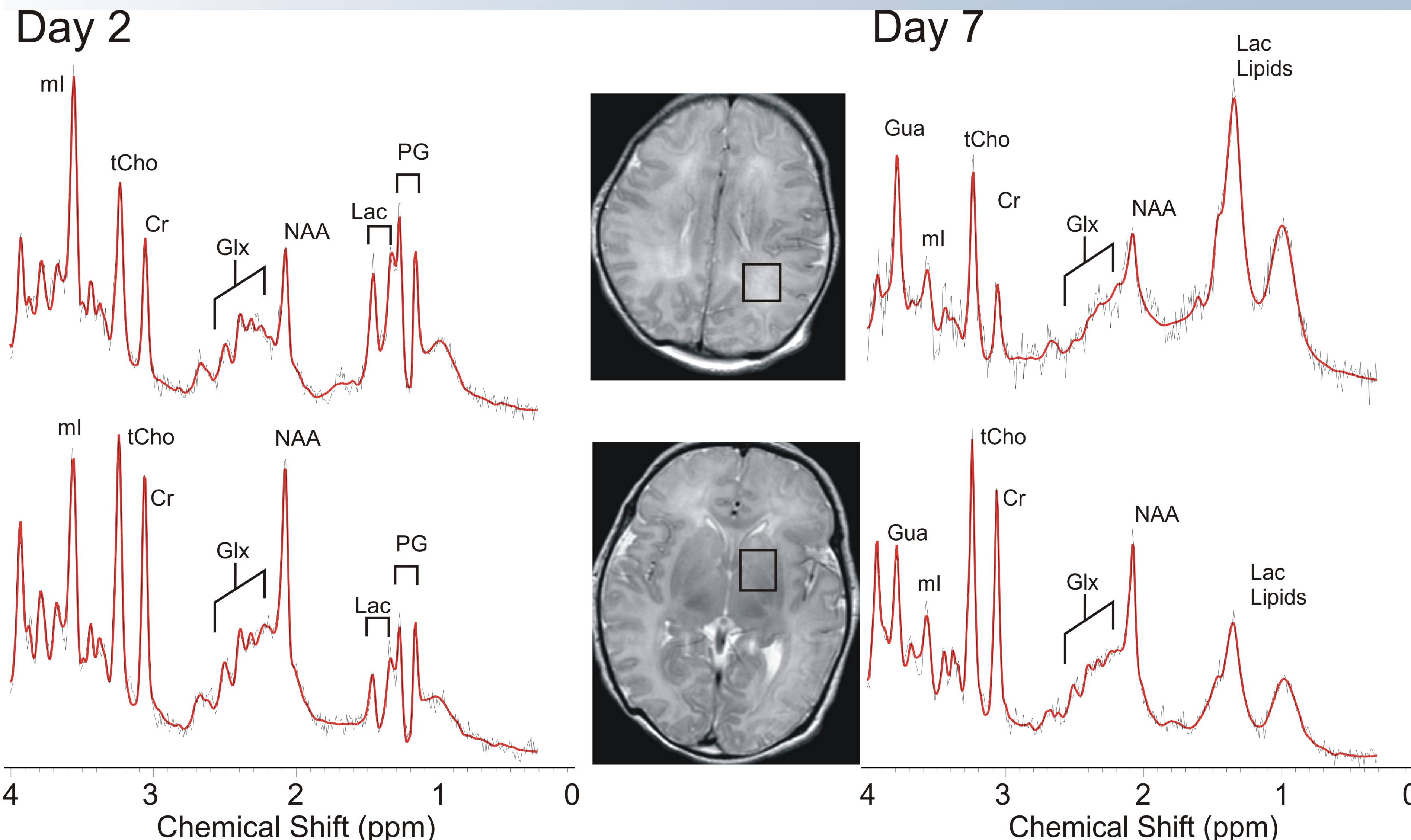

A
tCho
mI
Cr
Glx
NAA
Lac
TE 35ms
B
NAA
Lac
TE 144ms
C
NAA
Lac
TE 288ms
4
3
2
1
0
Chemical Shift (ppm)

Differentiation of lactate, lipids, and propylene glycol





- Lac: Characteristic doublet of narrow lines at 1.33 ppm
- PG: Characteristic doublet of narrow at 1.2 ppm
- Lipids (macromolecules): Broad peaks at 0.9 and 1.3 ppm


Day 2
Day 7
mI
tCho
Cr
Glx
NAA
Lac
PG
Gua
Lac
Lipids
4
3
2
1
0
Chemical Shift (ppm)

Cerebral Magnetic Resonance Biomarkers in Neonatal Encephalopathy: A Meta-analysis

WHAT'S KNOWN ON THIS SUBJECT: MRI of the brain is often used for prediction of long-term neurodevelopmental outcome after NE; however, there is no consensus with regard to which particular MR biomarker and at which age are most accurate for predicting adverse outcome.

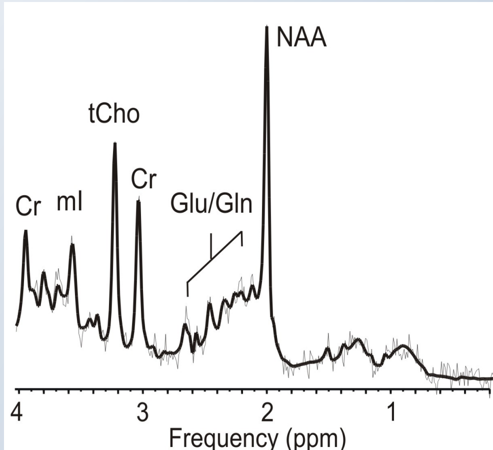
WHAT THIS STUDY ADDS: Meta-analysis of the published data suggests that deep gray matter Lac/NAA and Lac/Cr are the most accurate quantitative MR biomarker for prediction of neurodevelopmental outcome after NE. This biomarker may be useful as a surrogate end point and as a bridging biomarker.

AUTHORS: Sudhin Thayyil, MBBS, MD, DCH, MRCPCH,[a] Manigandan Chandrasekaran, MBBS, DCH,[a] Andrew Taylor, MD,[b] Alan Bainbridge, PhD,[c] Ernest B. Cady, FInstP, BSc,[c] W. K. Kling Chong, MD,[d] Shahed Murad, PhD,[e,f†] Rumana Z. Omar, PhD,[e] and Nicola J. Robertson, PhD[a]

[a]University College London Institute of Women's Health, London, UK; [b]Centre for Cardiovascular Imaging, Great Ormond Street Hospital for Children, London, England; [c]Department of Medical Physics and Bioengineering, University College London Hospitals NHS Trust, London, England; [d]Department of Pediatric Neuroradiology, Great Ormond Street Hospital for Children, London, England; [e]Department of Statistical Science, University College London, Biomedical Research Unit, London, England; [f]Biostatistics Group, UCLH/UCL Biomedical Research Unit, University College London, London, England

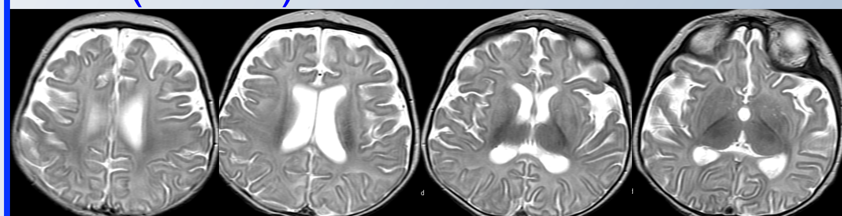
Fully Automated Processing and Documentation of SV-MRS - MRS Database

Spectrum +
H_2O +
T2-fit



1

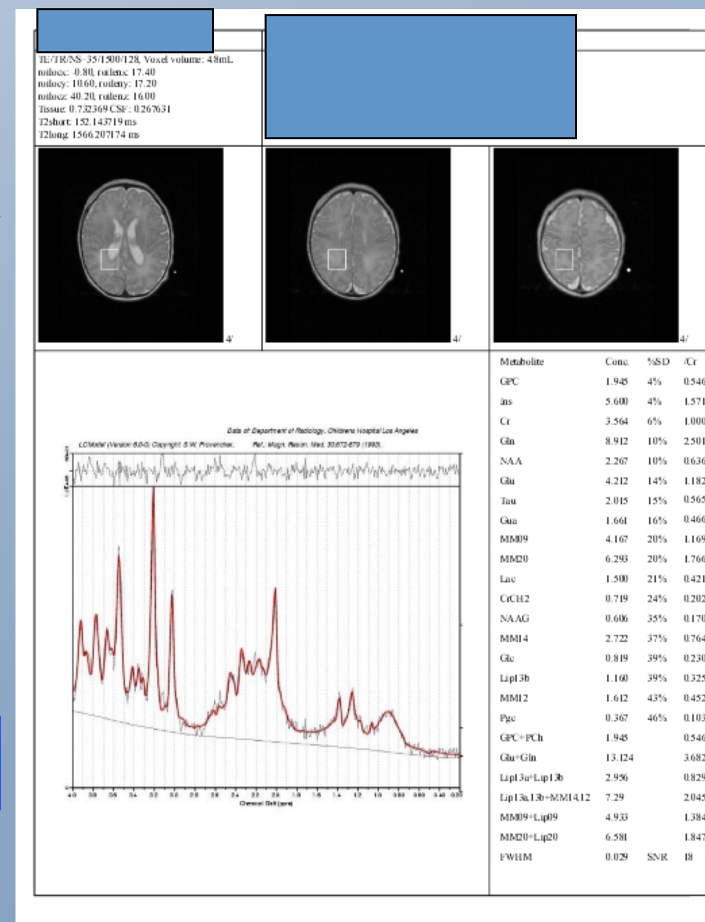
MRI (Dicom)



Processing Workstation

2

- ➢ **"Query/retrieve"**
- ➢ **LCModel, MatLab, Perl**
- ➢ **"Raw results"**



TE/TR/NS=35/1500/128, Voxel volume: 4.8mL
roilocx: -0.80, roilenx: 17.40
roilocy: 10.60, roileny: 17.20
roilocz: 40.20, roilenz: 16.00
Tissue: 0.732369 CSF: 0.267631
T2short: 152.143719 ms
T2long: 1566.207174 ms

Metabolite	Conc.	%SD	/Cr
GPC	1.945	4%	0.546
Ins	5.600	4%	1.571
Cr	3.564	6%	1.000
Gln	8.912	10%	2.501
NAA	2.267	10%	0.636
Glu	4.212	14%	1.182
Tau	2.015	15%	0.565
Gua	1.661	16%	0.466
MM09	4.167	20%	1.169
MM20	6.293	20%	1.766
Lac	1.500	21%	0.421
CrCH2	0.719	24%	0.202
NAAG	0.606	35%	0.170
MM14	2.722	37%	0.764
Glc	0.819	39%	0.230
Lip13b	1.160	39%	0.325
MM12	1.612	43%	0.452
Pgc	0.367	46%	0.103
GPC+PCh	1.945		0.546
Glu+Gln	13.124		3.682
Lip13a+Lip13b	2.956		0.829
Lip13a,13b+MM14,12	7.29		2.045
MM09+Lip09	4.933		1.384
MM20+Lip20	6.581		1.847
FWHM	0.029	SNR	18

3

- **MRS Database**

Additional Information:

(ROI, patient history, pathology, etc.)

MULTI-SITE HYPOTHERMIA ECMO STUDY

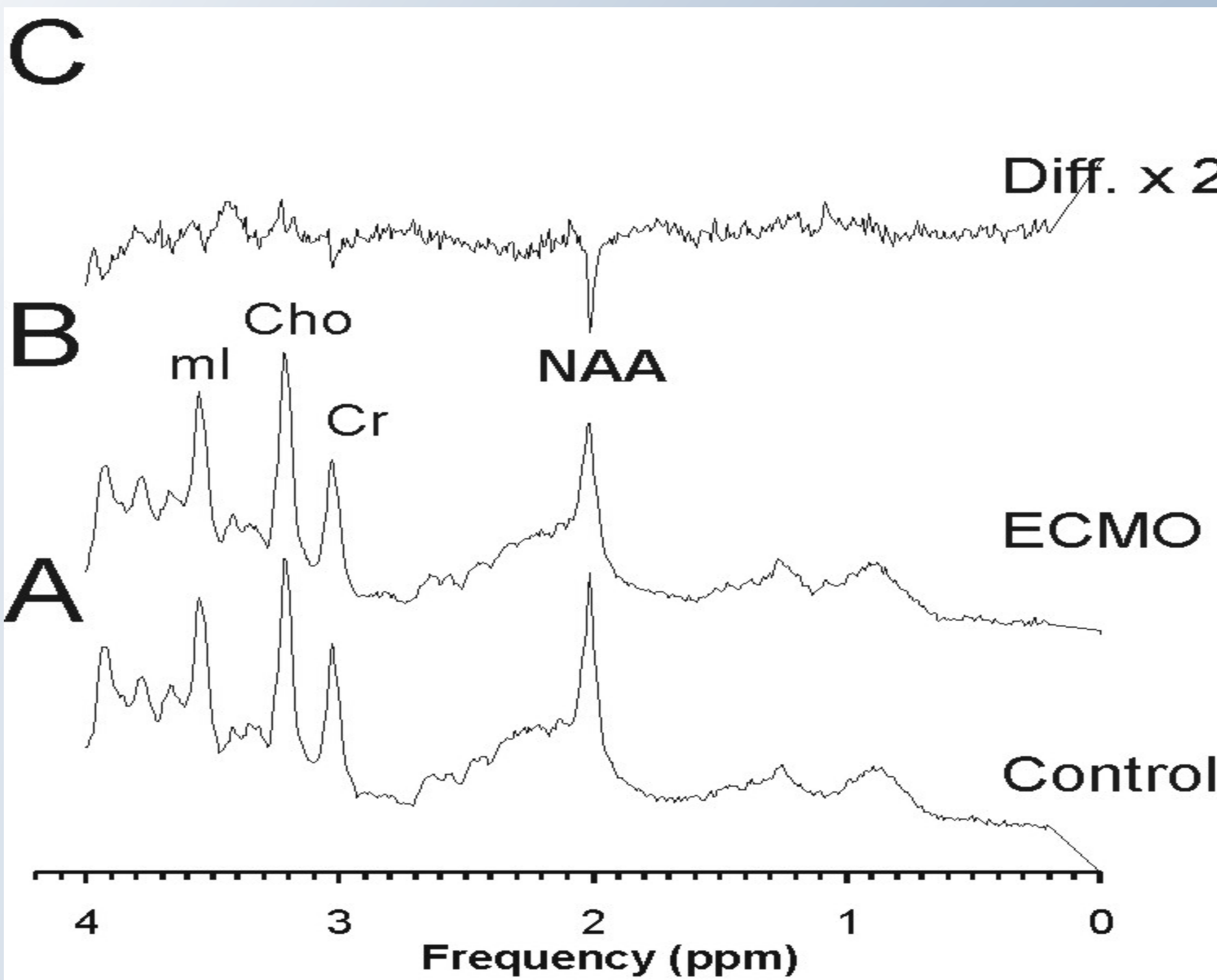
Table: There were no apparent differences when the quality of spectra obtained at multiple sites was compared with spectra acquired at CHLA.

		FWHM[a]	S/N[b]	Cr[c]	Cr SD[d]	Cho[c]	Cho SD[d]
multi-site (n=13)	mean	0.033	0.31	5.00	4%	2.22	4%
	stdev	0.009	0.10	1.66	2%	0.50	1%
CHLA (n=15)	mean	0.031	0.34	5.22	4%	2.35	3%
	stdev	0.007	0.07	0.55	0%	0.24	1%

[a] *FWHM = full width of half maximum of the unsuppressed water peak, an objective and quantitative measurement of the field homogeneity within the the selected region of interest for MRS*
[b] *S/N = signal-to-noise-ratio, determined from signal amplitude of the water peak and the random noise signal of spectra*
[c] *absolute concentrations of creatine (Cr) and choline (Cho)*
[d] *SD = standard deviation, these are the Cramer-Rao lower bounds (CRLB). CRLB are objective indicators for the reliability of a measurement taking into consideration the noise level of the MR signal.*

Panigrahy, Sood, Bluml et al, work in progress, 2011

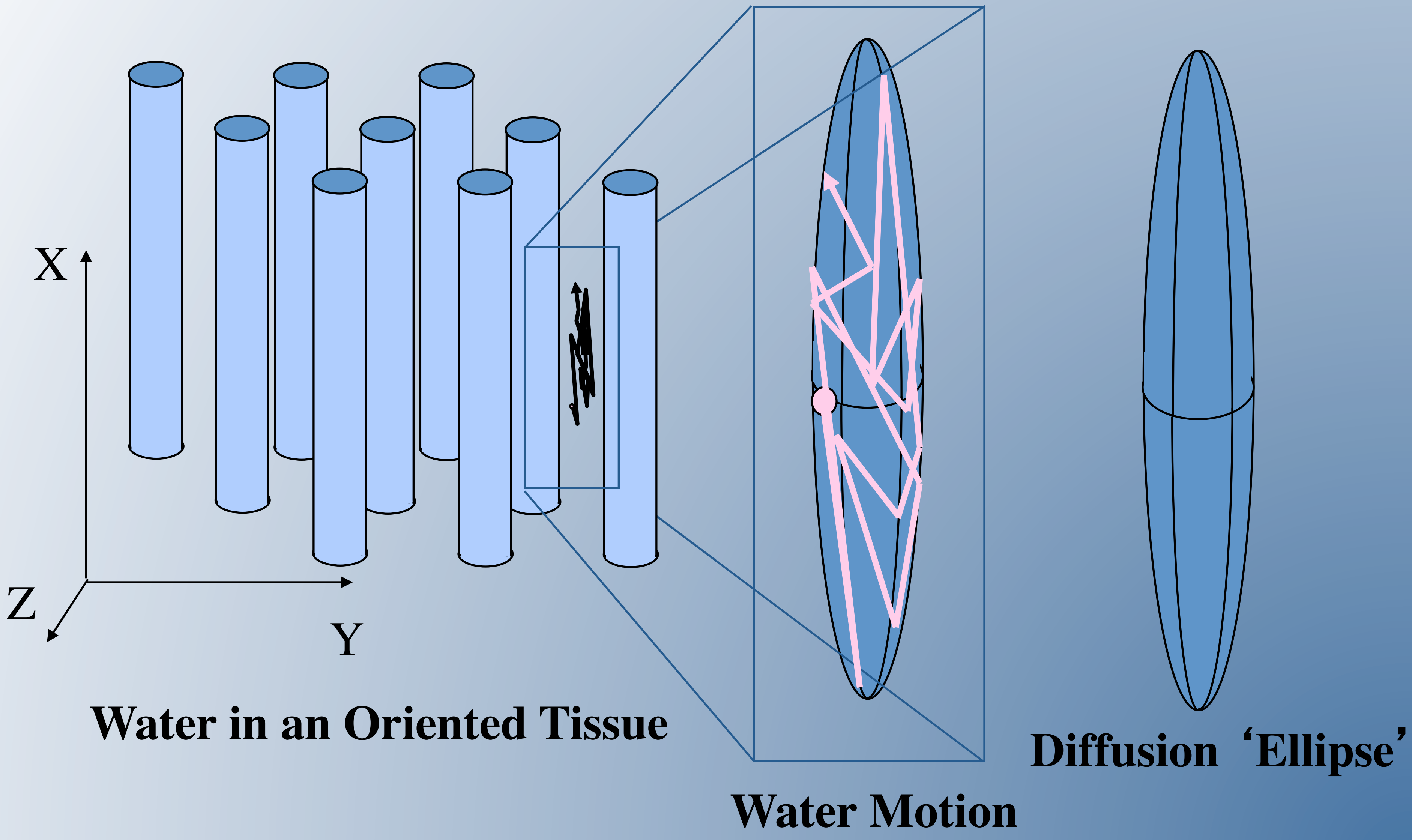
MRS- ECMO RELATED BRAIN INJURY



DIFFUSION TENSOR IMAGING

- By manipulating magnetic field gradients MR images can be sensitized to diffusion- the random thermally driven motion of water molecules in tissue
- Water motion: isotropic or anisotropic

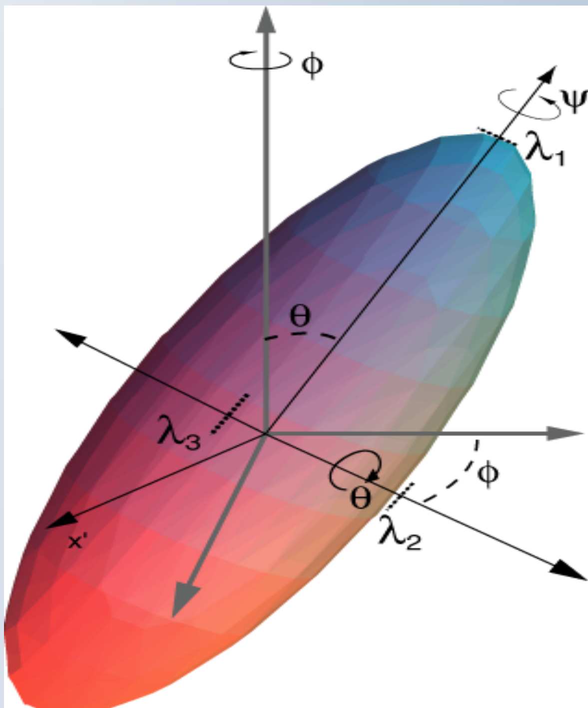
Diffusion in 3-D: White Matter



Eigen-system Analysis of Diffusion Tensor

$$\vec{\mathbf{D}} = \begin{pmatrix} D_{xx} & D_{xy} & D_{xz} \\ D_{xy} & D_{yy} & D_{yz} \\ D_{xz} & D_{yz} & D_{zz} \end{pmatrix} = \begin{pmatrix} V_{1x} & V_{1y} & V_{1z} \\ V_{2x} & V_{2y} & V_{2z} \\ V_{3x} & V_{3y} & V_{3z} \end{pmatrix} \bullet \begin{pmatrix} \lambda_1 & & \\ & \lambda_2 & \\ & & \lambda_3 \end{pmatrix} \bullet \begin{pmatrix} V_{1x} & V_{2x} & V_{3x} \\ V_{1y} & V_{2y} & V_{3y} \\ V_{1z} & V_{2z} & V_{3z} \end{pmatrix}$$

$$\lambda_1 \geq \lambda_2 \geq \lambda_3$$

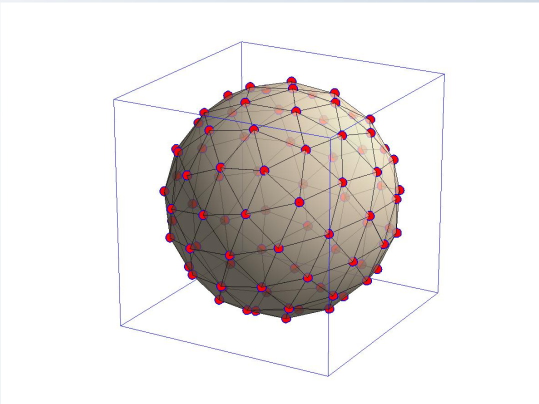


- Major Eigen-Value : λ_1
- Major Eigen-Vector: $\begin{bmatrix} V_{1x} & V_{1y} & V_{1z} \end{bmatrix}^T$

$$FA = \sqrt{\frac{3 \bullet \sum_{i=1,2,3} \left(\lambda_i - \bar{\lambda}\right)^2}{2 \bullet \sum_{i=1,2,3} \lambda_i^2}}$$

$$\bar{D} = \frac{\lambda_1 + \lambda_2 + \lambda_3}{3}$$

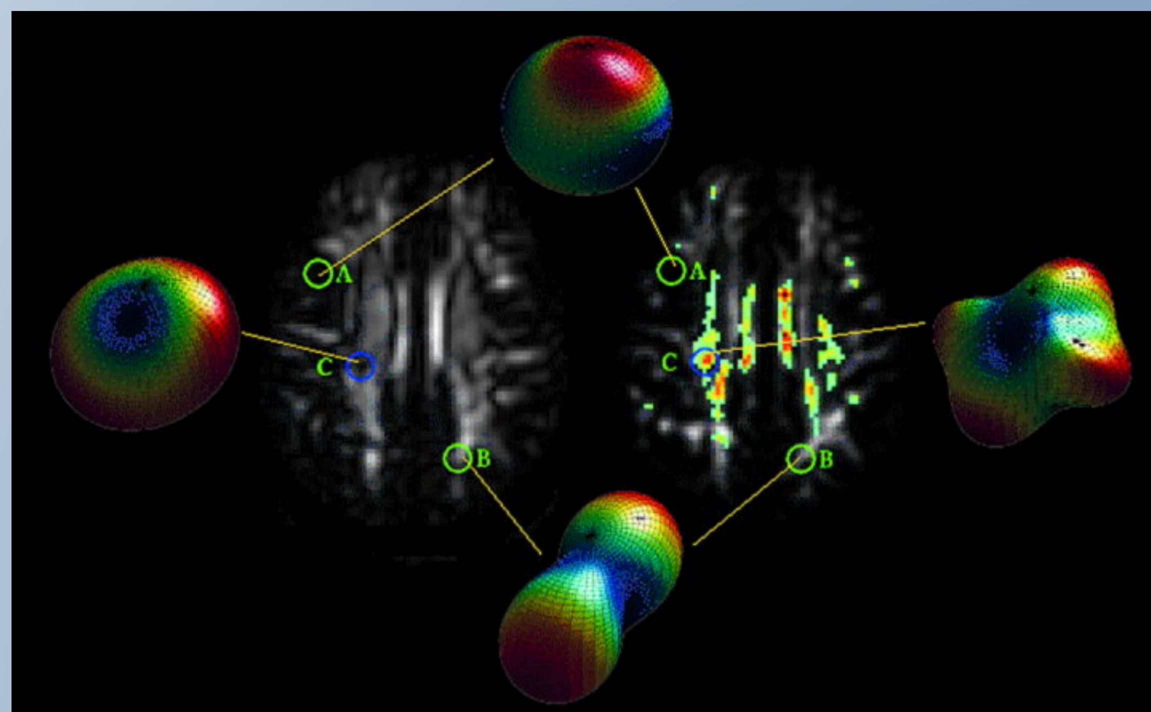
High Angular Resolution Diffusion (HARDI)



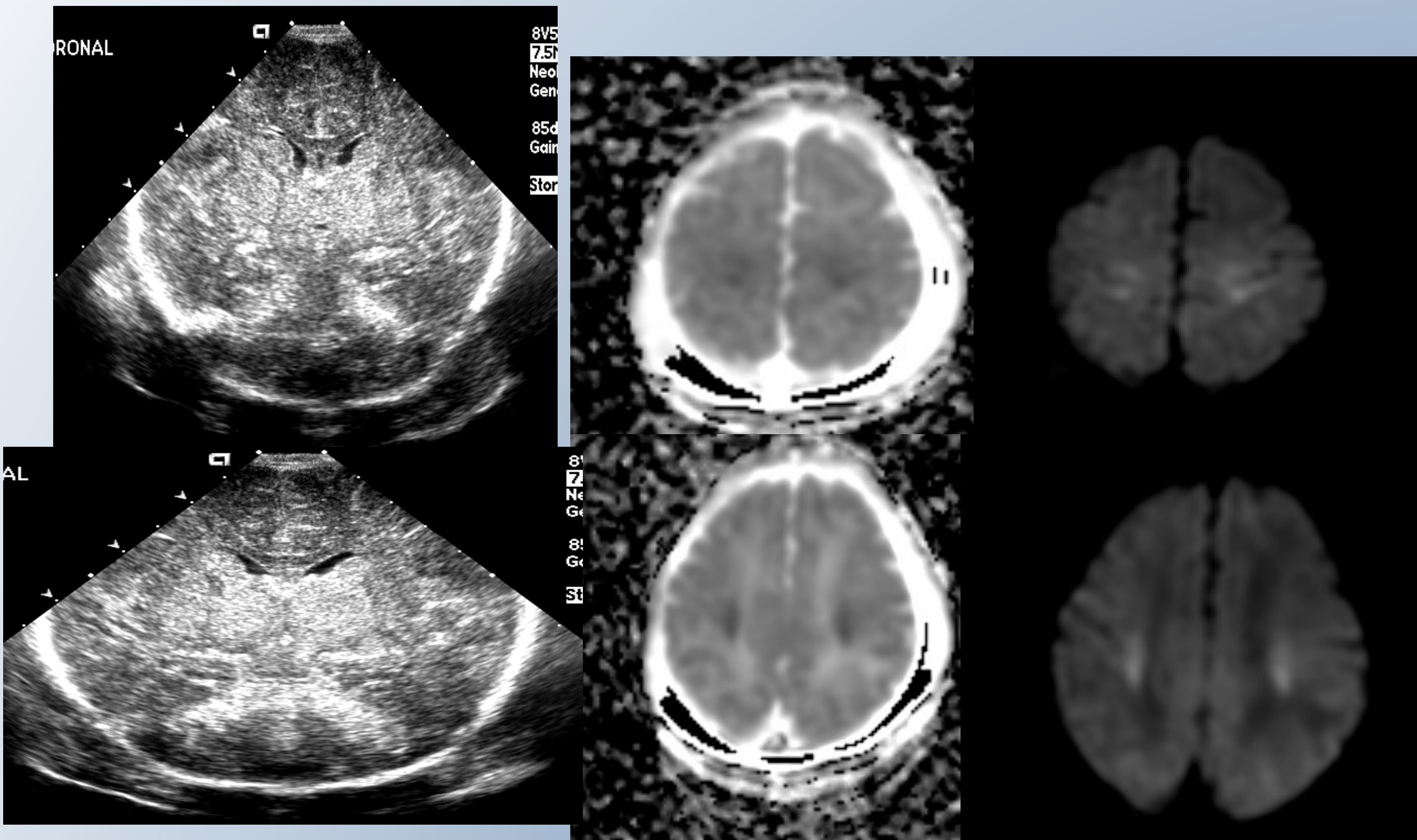
HARDI Encoding

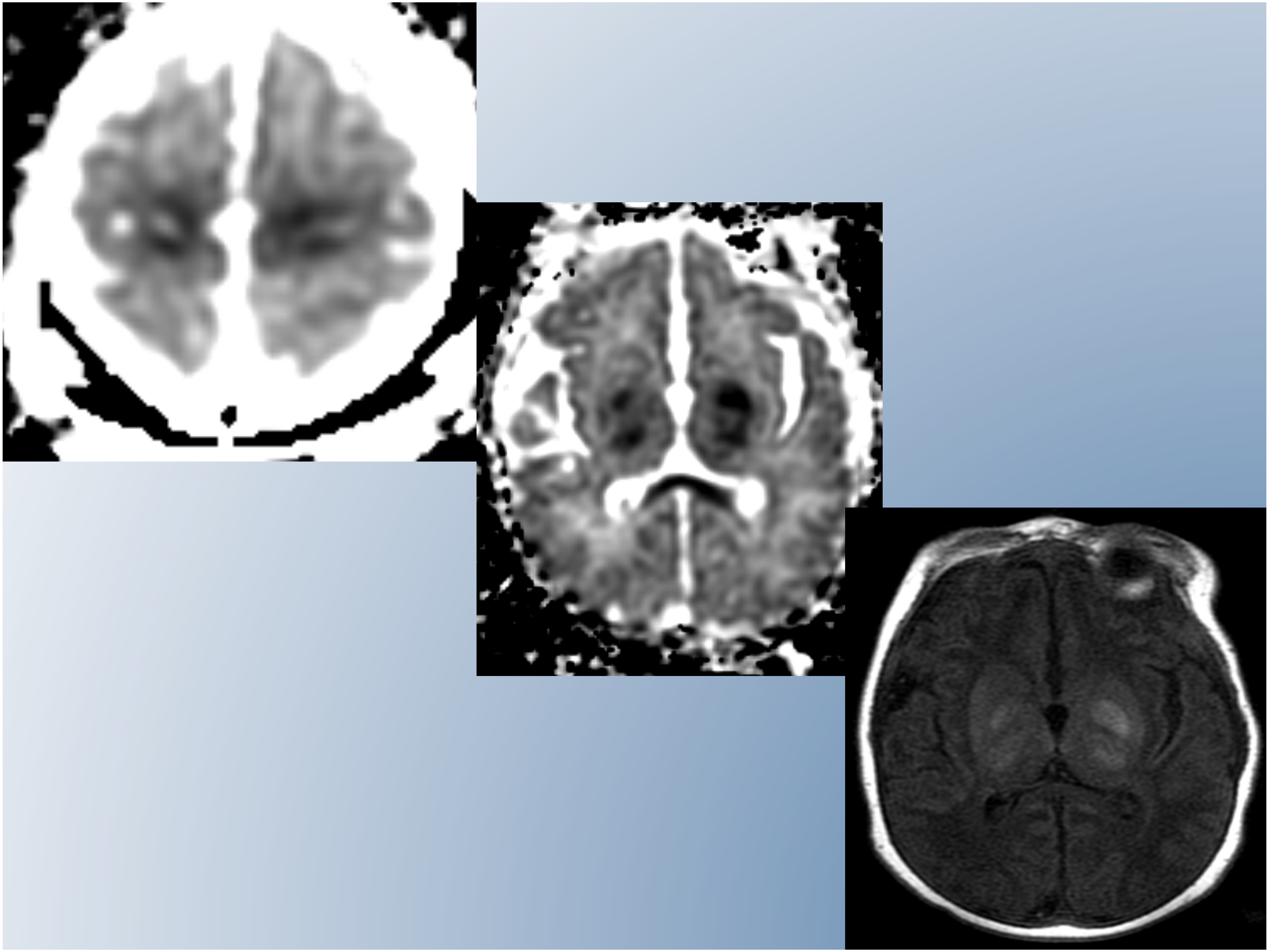
Frank, MRM 2002

- Identify complex white matter structures
- Improve diffusion MRI based tractography
- Increase number of directions

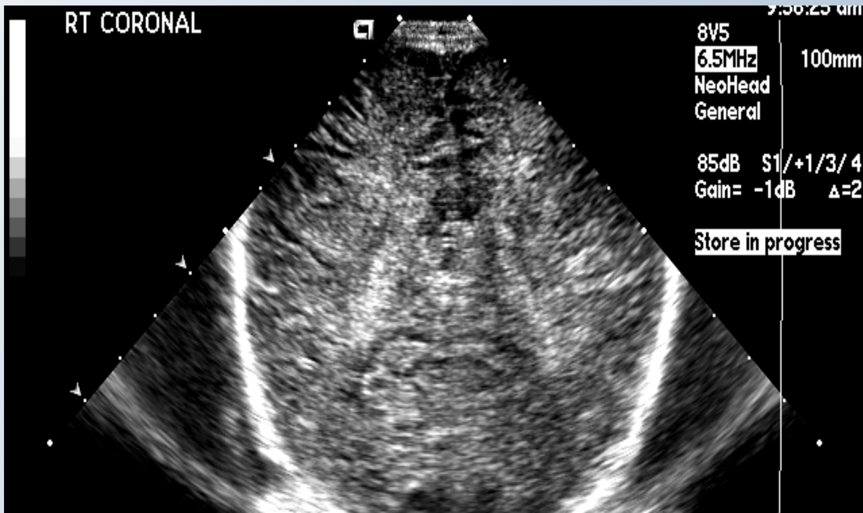


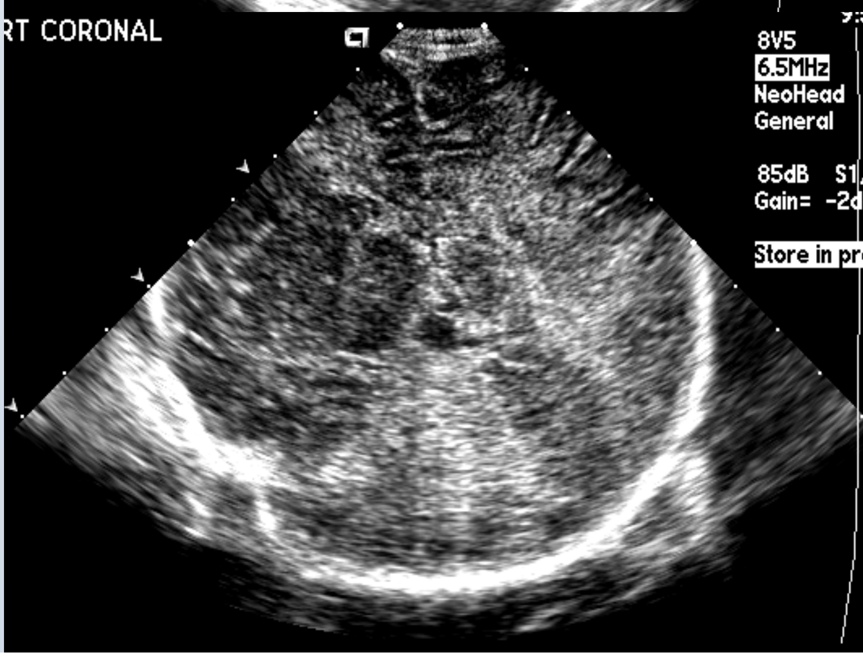
Central Pattern of Injury

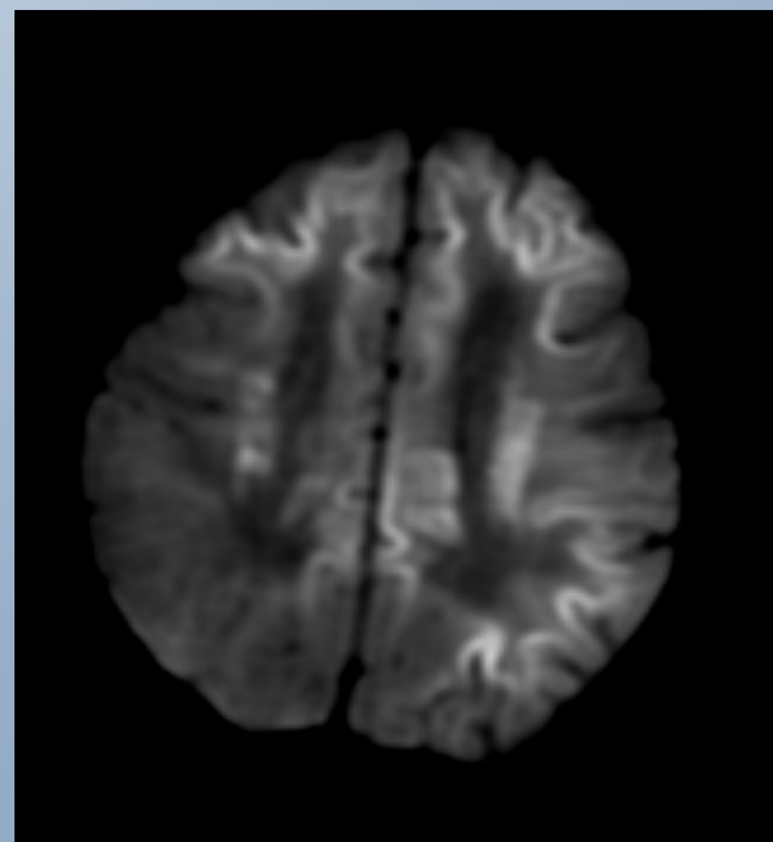


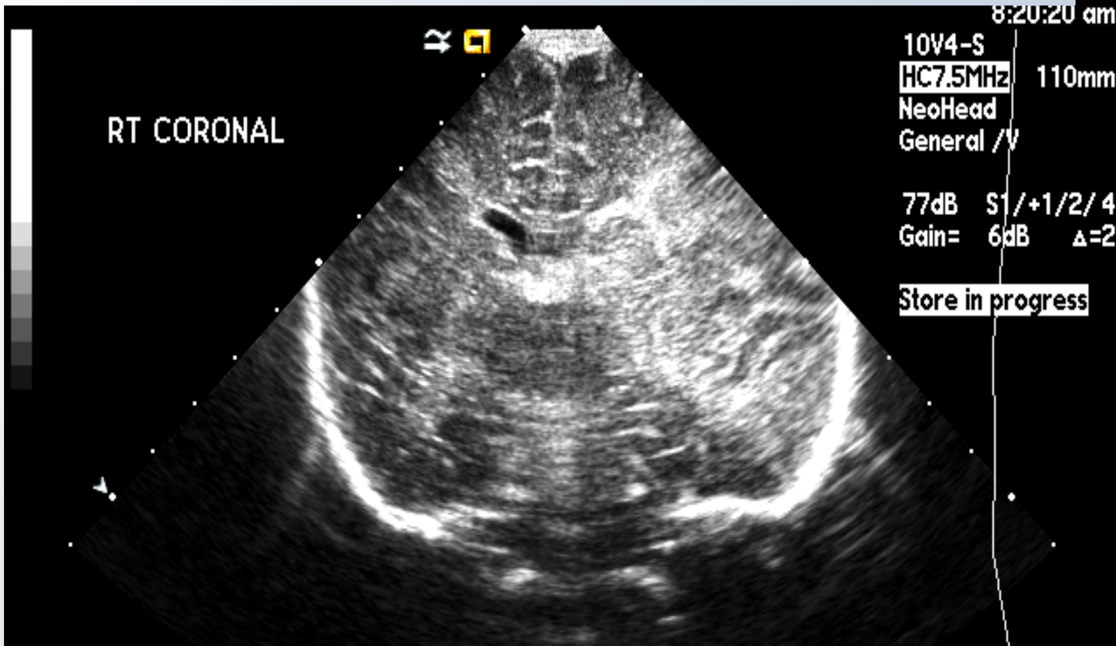


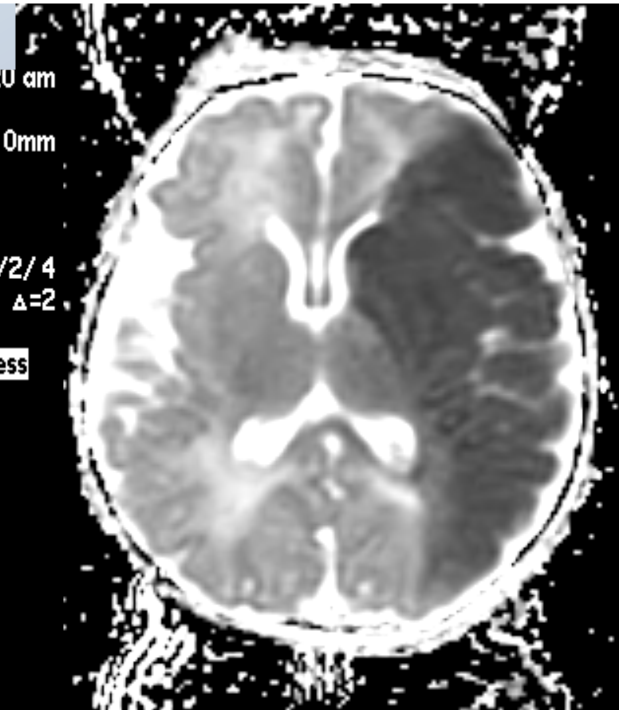
Peripheral Pattern of Injury

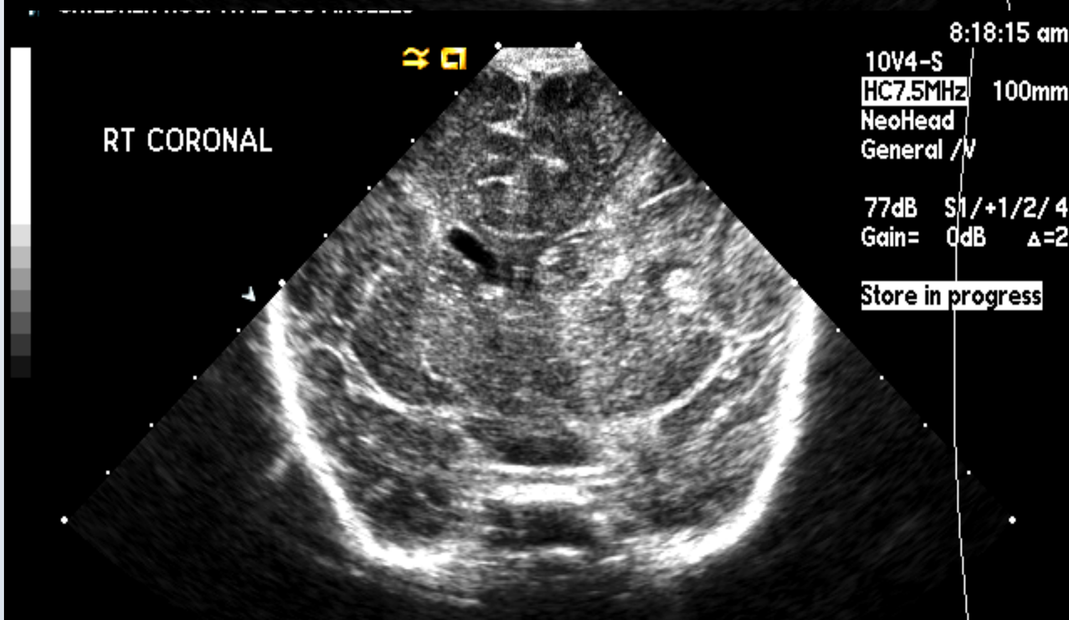




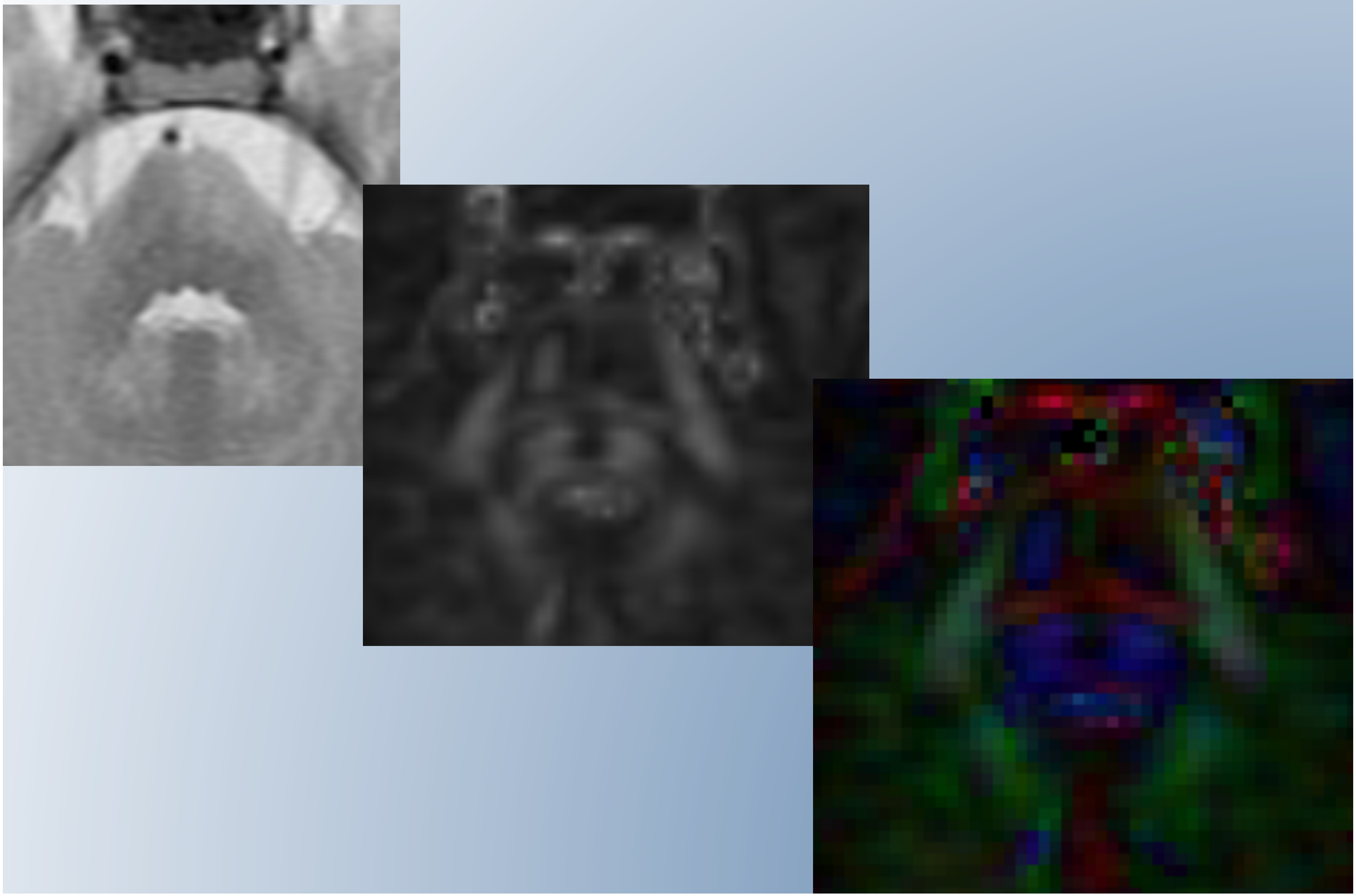


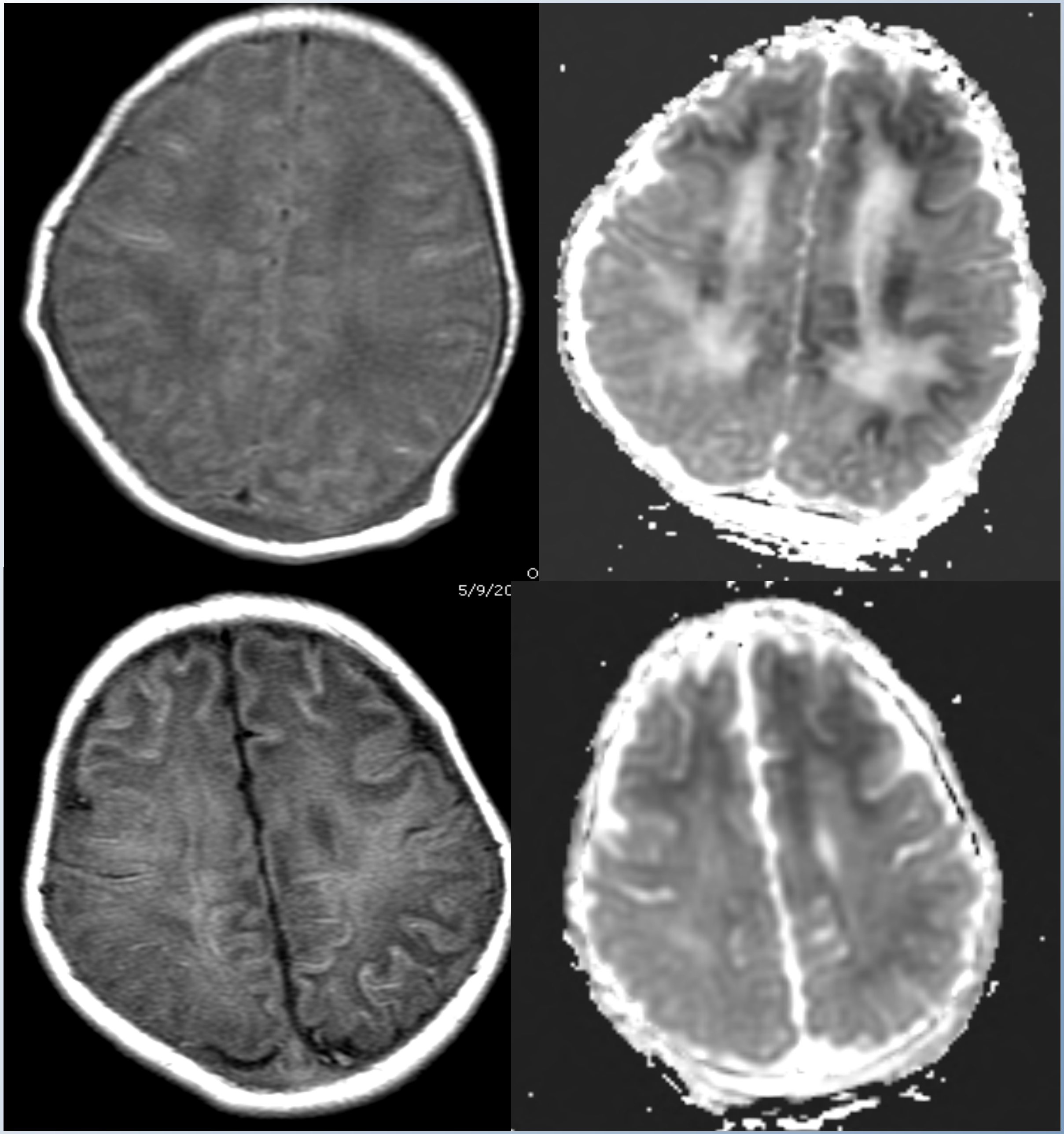

8:20:20 am
RT CORONAL
10V4-S
HC7.5MHz 110mm
NeoHead
General /V
77dB S1/+1/2/4
Gain= 6dB Δ=2
Store in progress




8:18:15 am
RT CORONAL
10V4-S
HC7.5MHz 100mm
NeoHead
General /V
77dB S1/+1/2/4
Gain= 0dB Δ=2
Store in progress

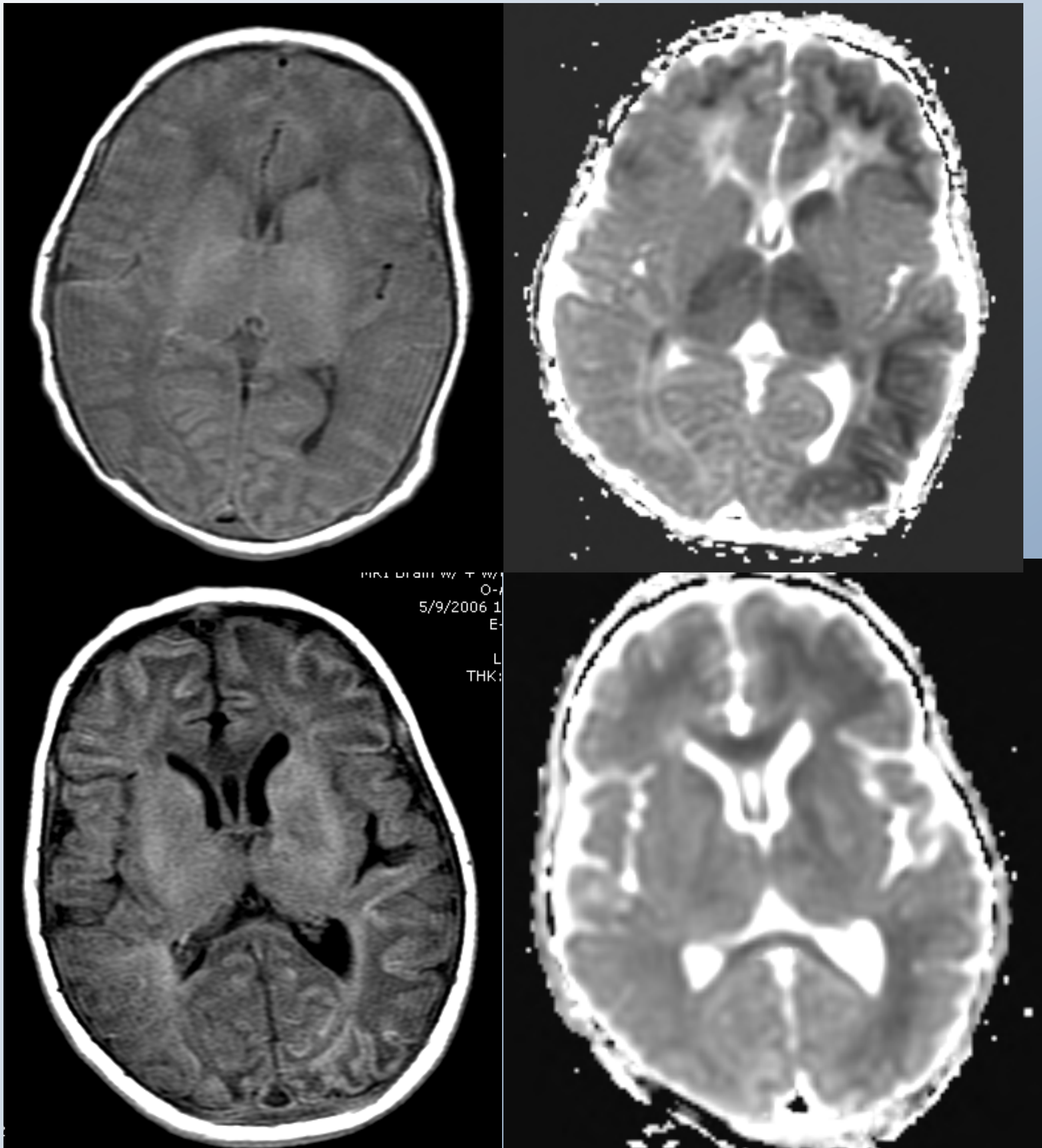
Acute Wallerian Degeneration





2 Days

7 Days



2 Days

7 Days

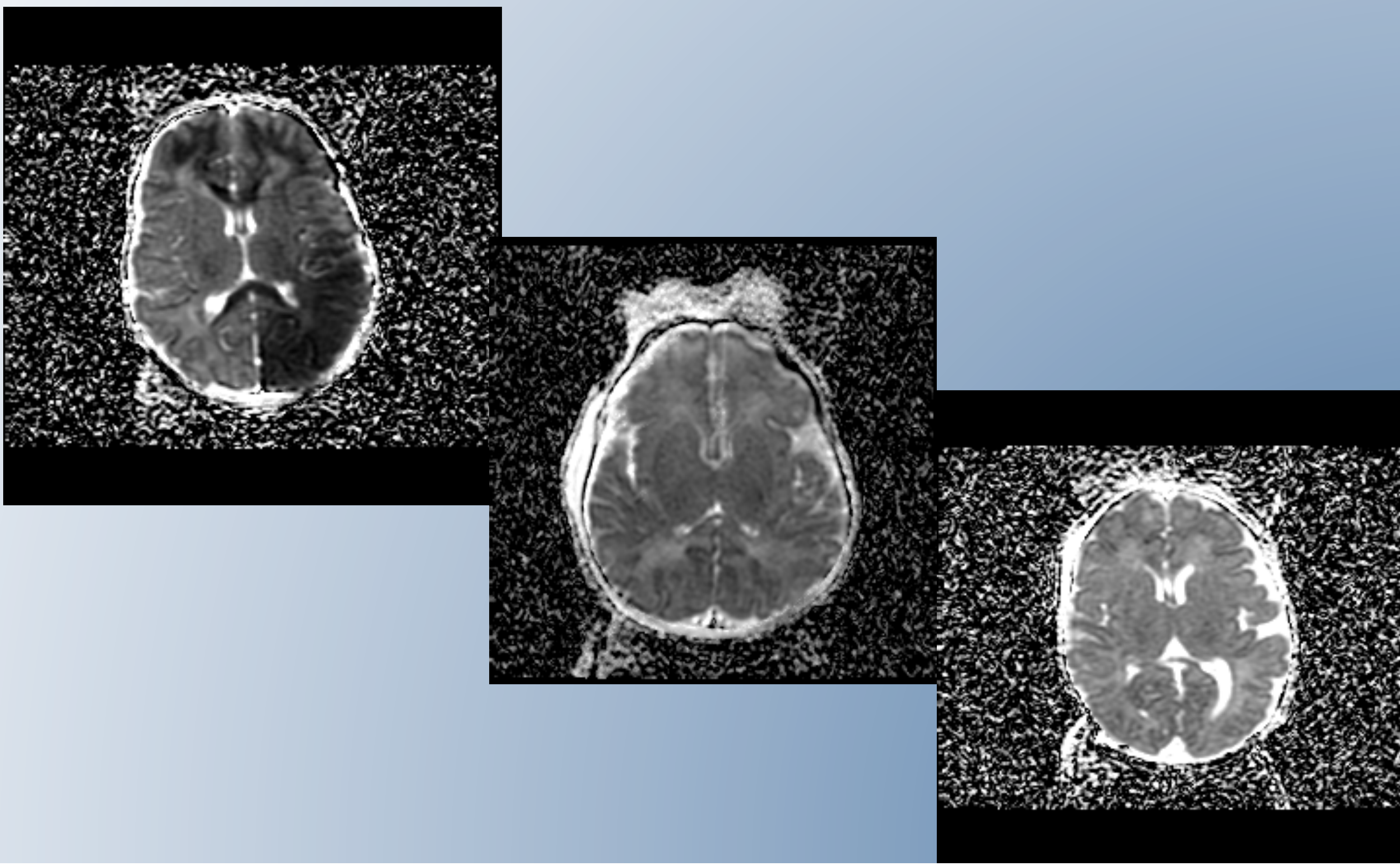
Diffuse Pattern of Hypoxic-Ischemic Injury-CENTRAL

- Central pattern: dorsal brainstem tegmentum, the posterior putamen, the lateral thalamus, the cortical spinal tract and peri-rolandic cortex
- Profound hypoxia/hypotension
- Poor neurological prognosis
- May be fatal depending on brainstem involvement

Diffuse Pattern of Hypoxic-Ischemic Injury-PERIPHERAL

- Periperal pattern:parasagittal cortex in the borderzone/watershed regions
- Mild to moderate hypoxia/hypotension
- Better prognosis compared to central
- Both central and peripheral patterns can occur together

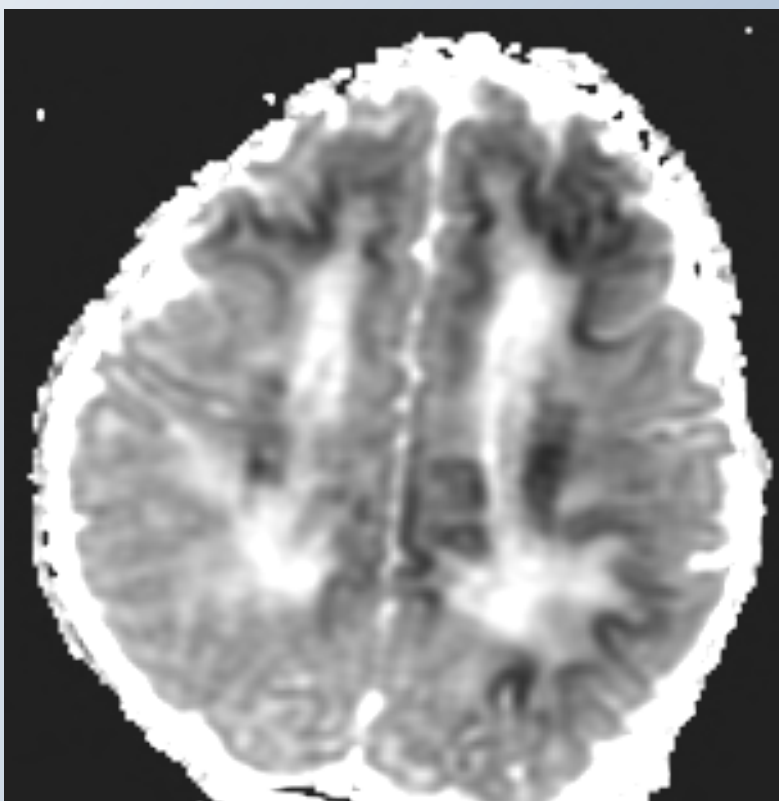
How does cooling effect microstructure and metabolism?

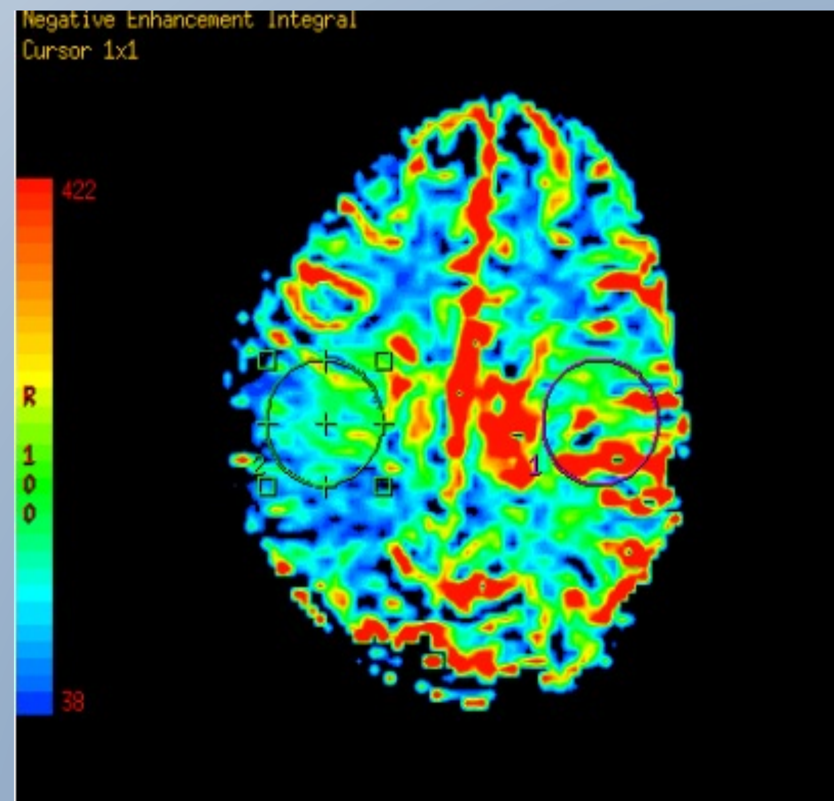


Hypothermia-MRS/DTI

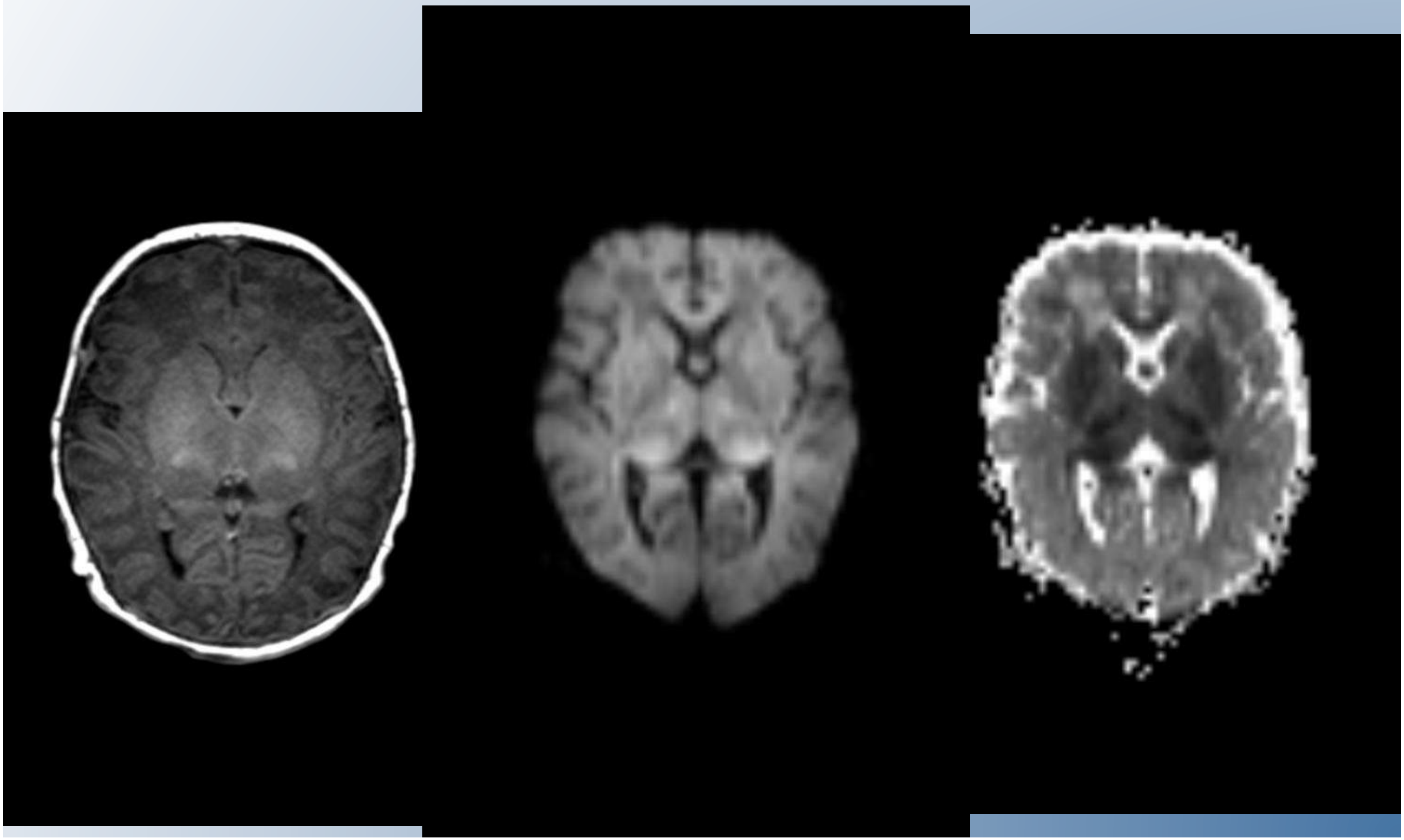
- Slower recovery of ADC to pseudo-normalization
- Hypothermia may extend the window in which HIE lesions are visible on DWI sequences
- Reduction in lactate levels

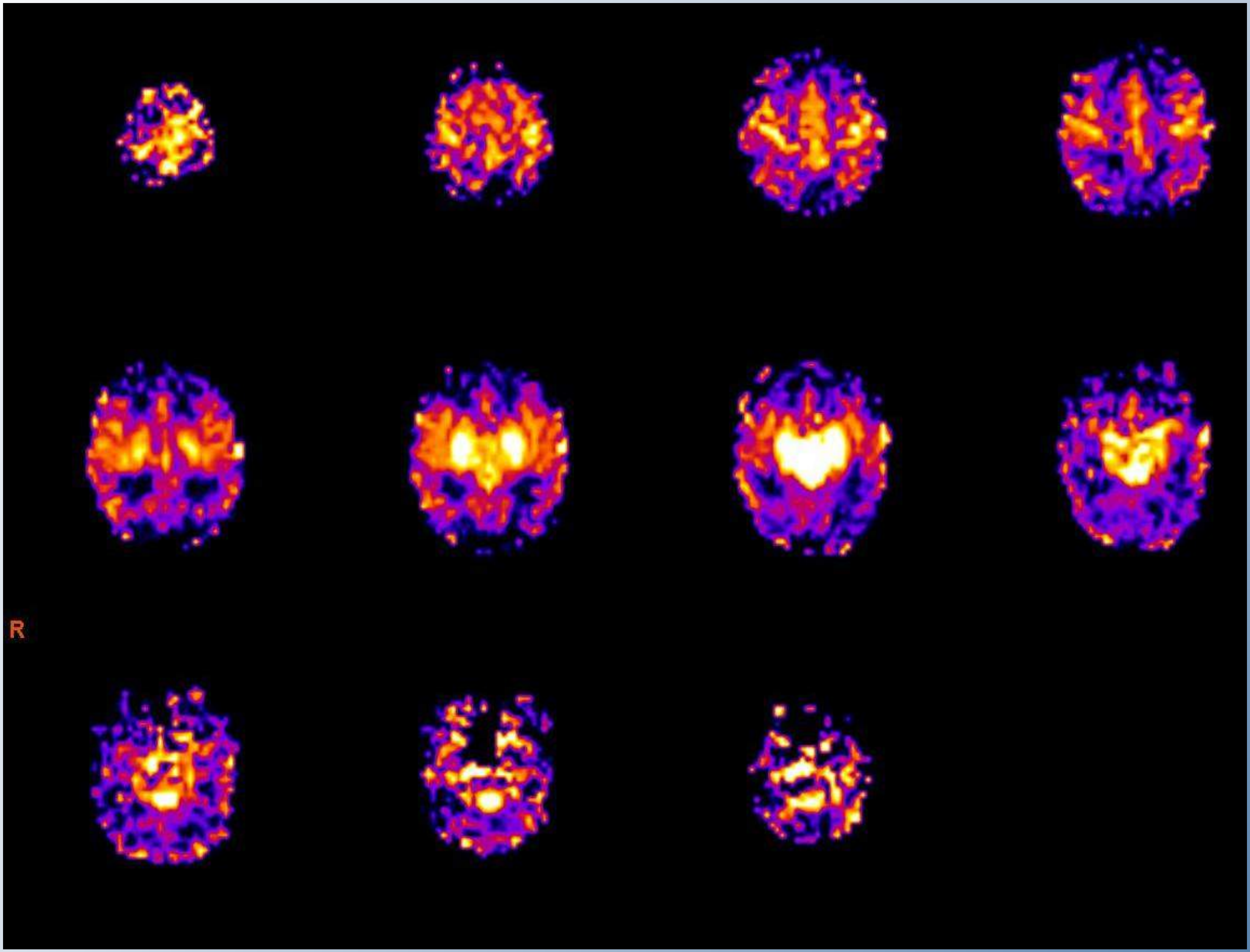
Hyper-perfusion in HIE





2 day old - History of umbilical cord prolapse and emergent C-section





Courtesy of Dr. A. Vassough , CHOP

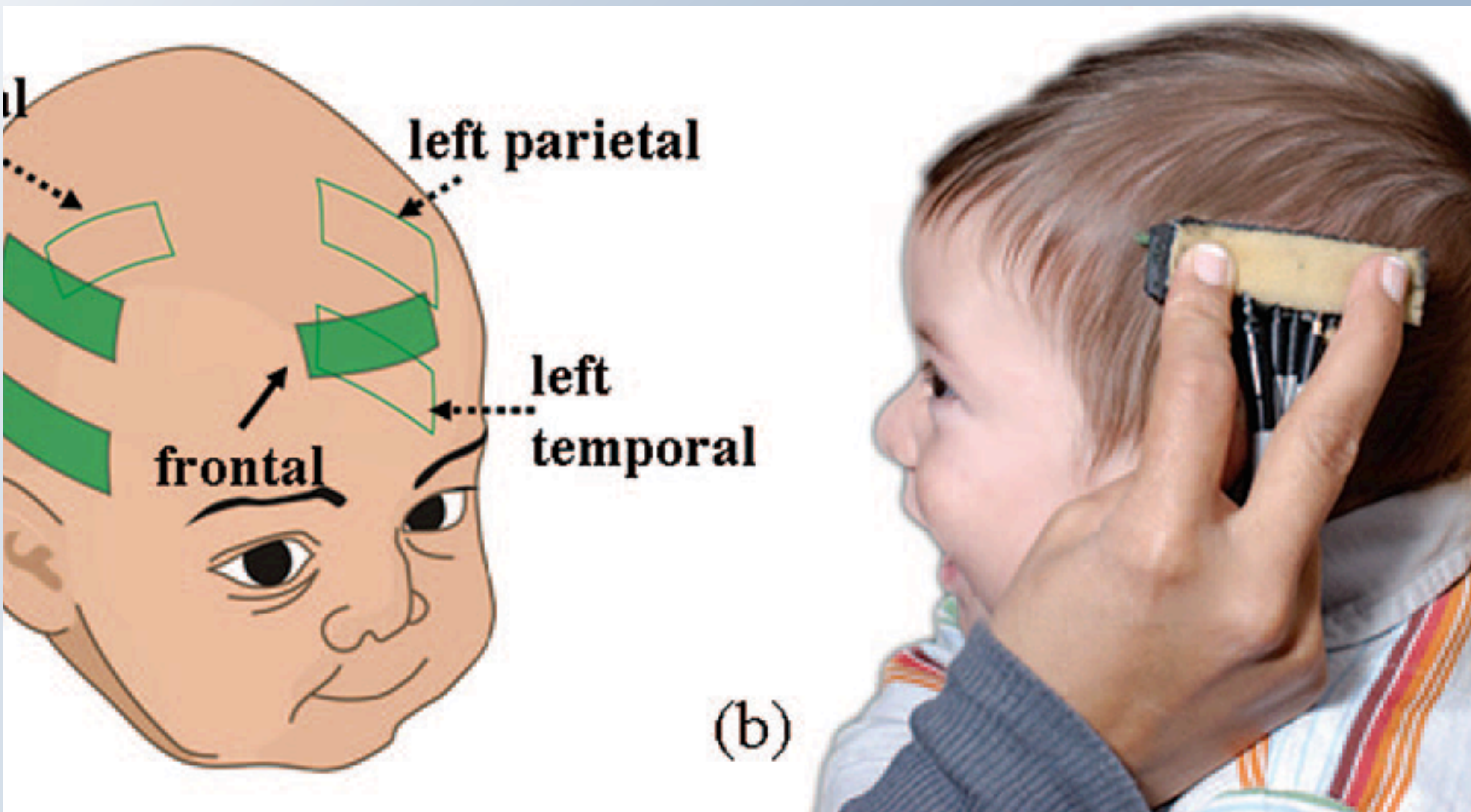
Hyper-perfusion?

- Decreased ADC- associated with increased cerebral blood flow
- Hyperfusion/perfusion- contributing to injury or secondary phenomenon to the development of injury
- biomarker of outcome predicting?
- Treatment effect- hypothermia?

NIRS- Near-infrared spectroscopy

- Light to measure blood volume and oxygenation- frequency domain
- Low quantitative accuracy to measure absolute cerebral hemoglobin
- Grant et al- increased CBV and relative cerebral oxygen consumption in HIE patients compared to control (not cerebral tissue oxygenation)- JCBFM 2009
- Increased perfusion-increased neuronal activity?

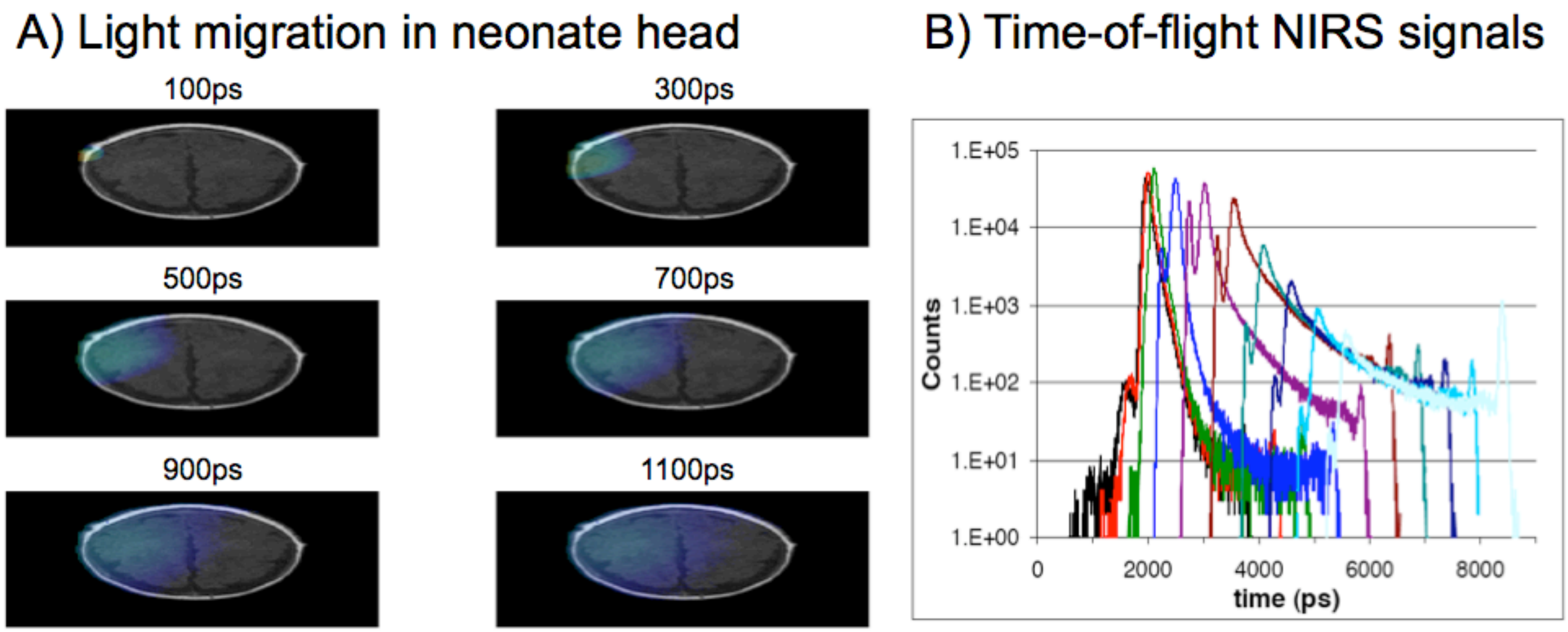
NIRS- Frequency Domain
Continuous wave



Issue with FD- NIRS

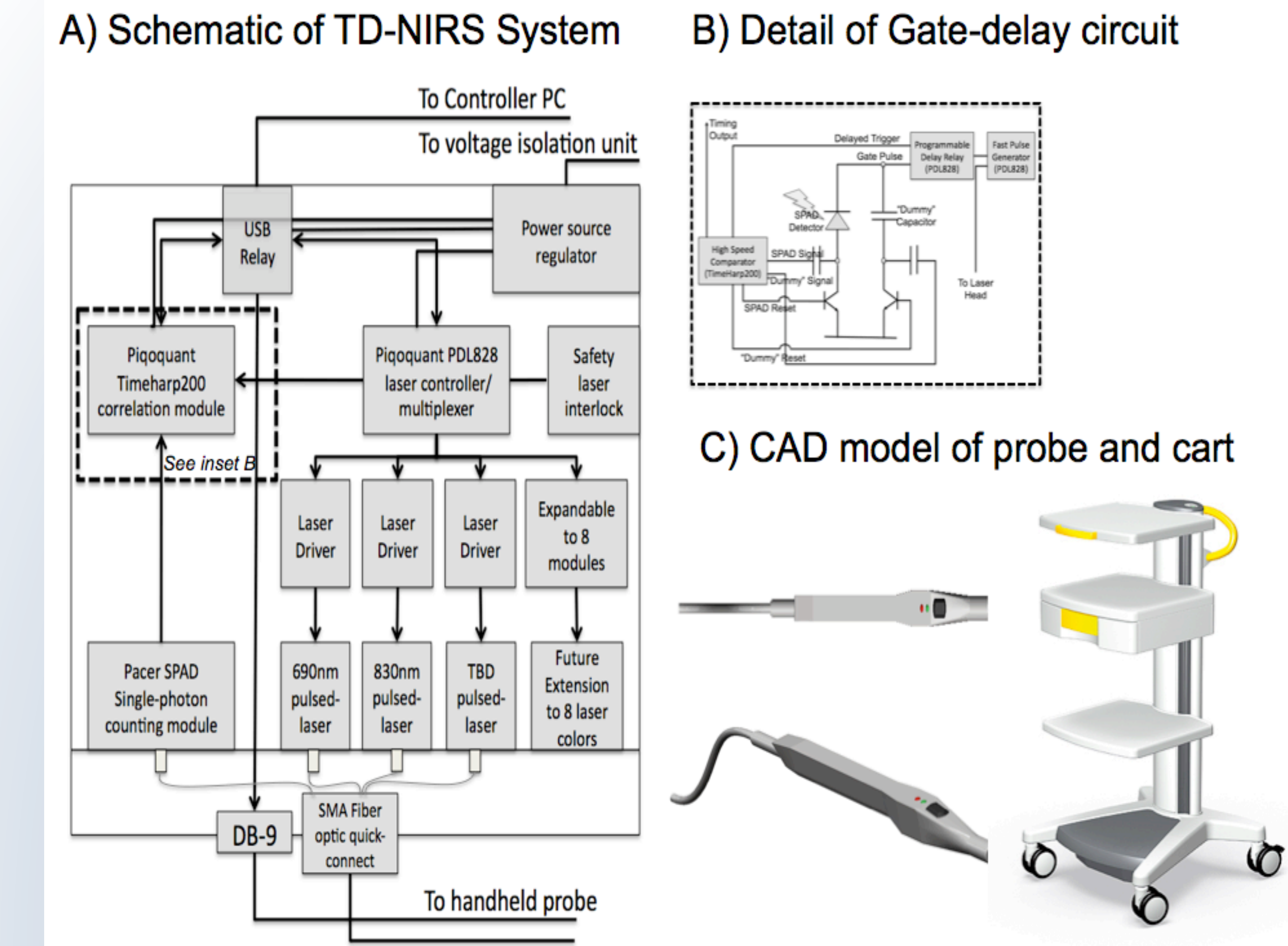
- Only able to measure changes in optical absorption of tissue – relay on look-up tables for correction factors for quantitative results
- Consensus from clinical trials is that FD-NIRS may not have quantitative accuracy for on-demand measurements

Development of Time Domain NIRS



2nd generation NIRS pulsed-laser light source allow time of flight information about light transmission – directly measure optical pathway information- more accurate baseline measurements

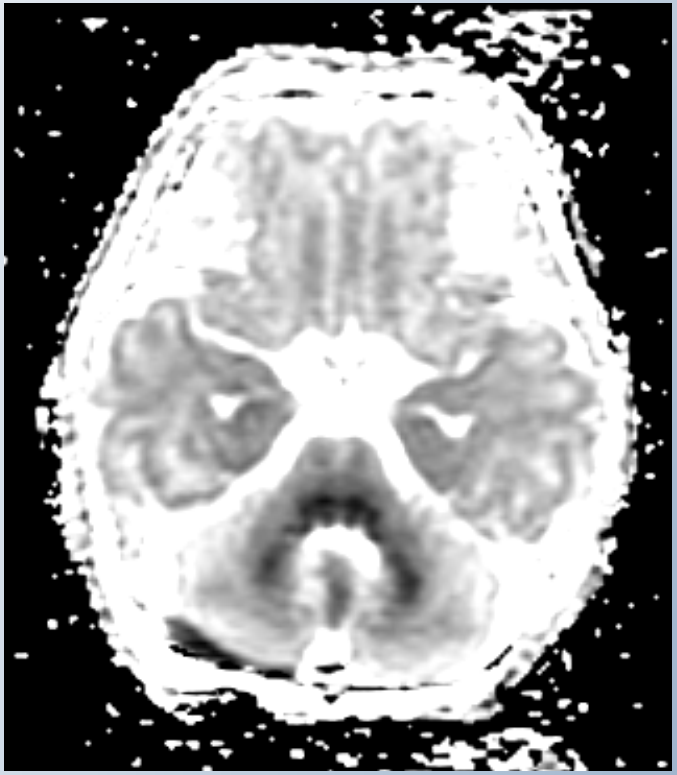
Ted Huppert et al. University of Pittsburgh

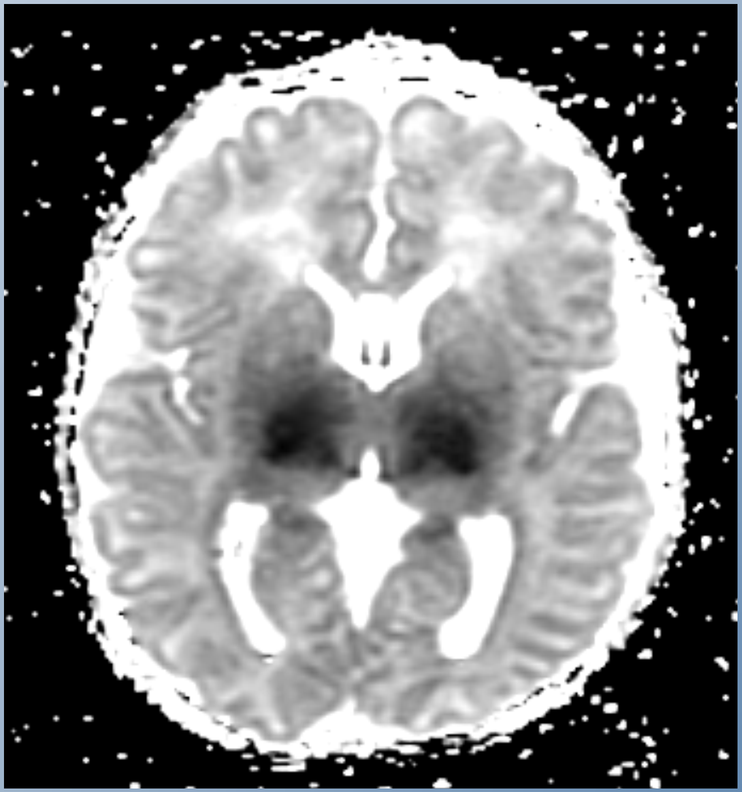

A) Schematic of TD-NIRS System
To Controller PC
To voltage isolation unit
USB Relay
Power source regulator
Piqoquant Timeharp200 correlation module
See inset B
Piqoquant PDL828 laser controller/ multiplexer
Safety laser interlock
Laser Driver
Laser Driver
Laser Driver
Expandable to 8 modules
Pacer SPAD Single-photon counting module
690nm pulsed-laser
830nm pulsed-laser
TBD pulsed-laser
Future Extension to 8 laser colors
DB-9
SMA Fiber optic quick-connect
To handheld probe
B) Detail of Gate-delay circuit
Timing Output
Delayed Trigger
Gate Pulse
Programmable Delay Relay (PDL828)
Fast Pulse Generator (PDL828)
SPAD Detector
"Dummy" Capacitor
High Speed Comparator (TimeHarp200)
SPAD Signal
"Dummy" Signal
SPAD Reset
"Dummy" Reset
To Laser Head
C) CAD model of probe and cart

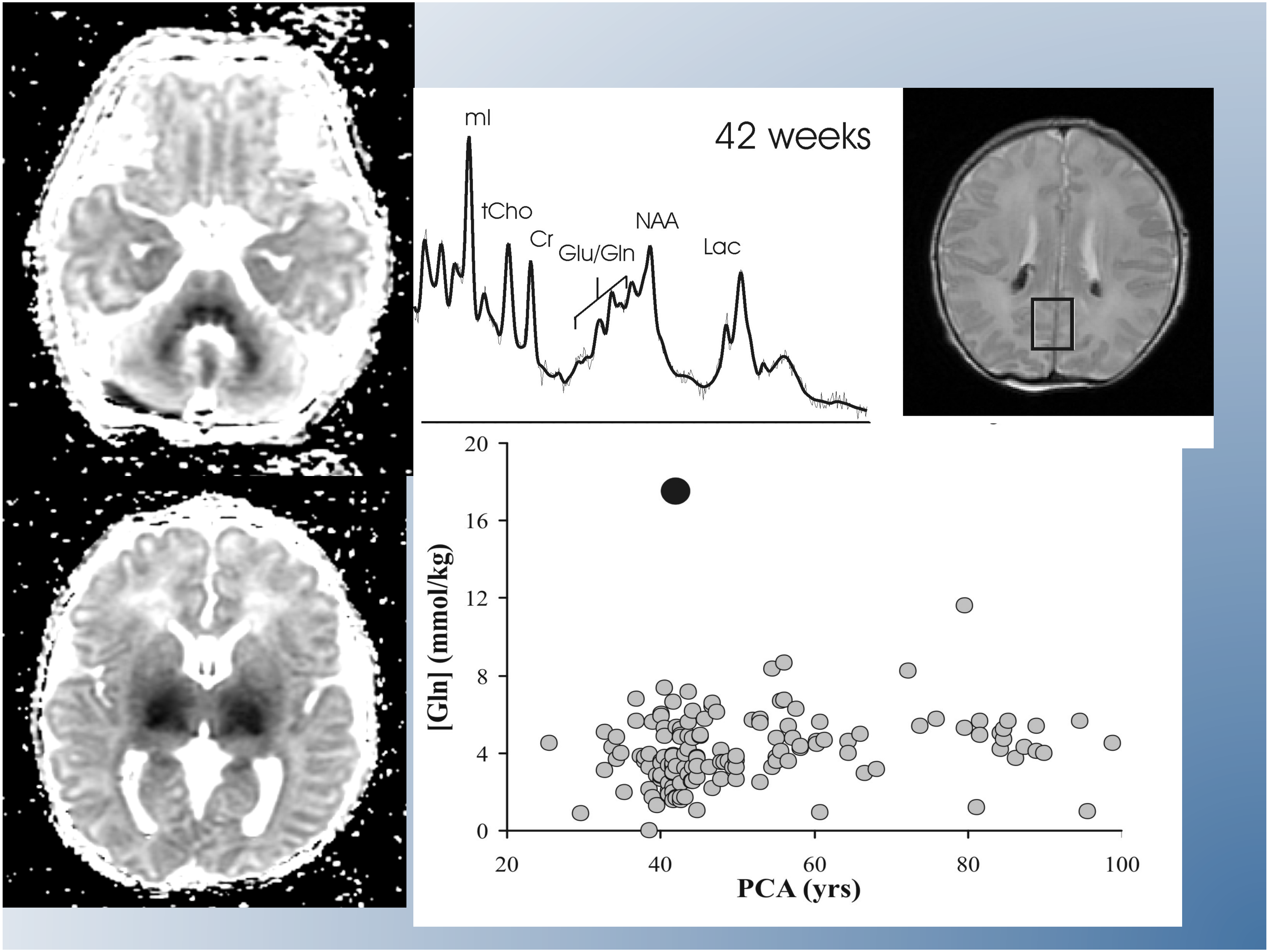
Metabolic Disease Can “Mimick” Patterns of Perinatal Hypoxic-Ischemic brain Injury

- Maple syrup urine disease
- Urea cycle disorders
- Organic aciduria
- Isolated sulfite oxidase deficiency
- Mitochondrial disorders
- Peroxisomal disorders

Mean Diffusivity/ADC:Mimic Central Hypoxic-ischemic Injury







mI
tCho
Cr
Glu/Gln
NAA
Lac
42 weeks
[Gln] (mmol/kg)
PCA (yrs)

Classification of Hydrocephalus

Entity involved	Parameter	Subtypes
Patient	Onset	Congenital/acquired Fetal/neonatal/infantile/child/adult/geriatric Acute/subacute/chronic
	Causes	Primary/secondary/idiopathic
	Underlying lesions	Dysgenetic/posthemorrhagic/post-SAH//post-IVH/postmeningitic/post-traumatic/ with brain tumor/spinal cord tumor/brain abscess/arachnoid cyst/cysticercosis, etc.
	Symptomatology	Macrocephalic/normocephalic/microcephalic Occult/symptomatic/overt Coma/stupr/dementia Hydrocephalus/parkinsonism complex, etc.
Hydrocephalus	Pathophysiology: -CSF ciculation	Communicating/noncommunicating Nonobstructive/obstructive External/internal/interstitial Isolated compartments: UH/IFV/IRV/ICCD/DCH/DLFV, etc.
	-ICP dynamics	High/normal
	-Chronology	Slowness progressive/progressive/long-standing/arrested
Treatment	Postshunt	Shunt-dependent/shunt-independent slit-like ventricle/slit ventricle syndrome, etc.

SAH, subarachnoid hemorrhage; *IVH*, Intraventricular hemorrhage; *UH*, unilateral hydrocephalus; *IFV*, isolated fourth ventricle; *IRV*, isolated rombencephalic ventricle; *ICCD*, isolated central canal dilatation; *DCH*, double-compartment hydrocephalus; *DLFV*, disp

Volpe, JJ, **Neurology of the Newborn**, 4th Ed., 2001

Representative subgroups in the classification of hydrocephalus

Congenital hydrocephalus	Acquired hydrocephalus
Simple hydrocephalus	*Acquired hydrocephalus*
(hydrocephalus with congenital change limited in the CSF pathway)	(hydrocephalus secondary to underlying lesion in the postnatal period)
Atresia of foramen of Monro	Tumor
Aqueductal stenosis	Posthemorrhagic
Maldevelopment of arachnoid granulation	Postinfectious
Others	Post-traumatic
	Others
Dysgenetic hydrocephalus	*Postshunt hydrocephalus*
(hydrocephalus associated with CNS dysgenesis)	(hydrocephalus after shunt placement)
Hydranencephaly	Shunt-dependent
Holoprosencephaly	Unilateral hydrocephalus
Dandy-Walker syndrome	Isolated fourth ventricle
Dysraphism	Isolated rhombencephalic ventricle
Chiari malformation	Isolated central canal dilatation
Syringobulbia-myelia	
Lissencephaly	
Arachnoid cyst,etc.	
Others	
Secondary congenital hydrocephalus	
(hydrocephalus secondary to underlying lesion in the fetal period)	
Tumor	
Posthemorrhagic	
Postinfectious	
Others	

Adapted from [Oi S, 2003], Volpe, JJ, **Neurology of the Newborn**, 4th Ed., 2001

Genetics of Hydrocephalus (malformation)

- X-linked hydrocephalus
- Dandy-Walker malformation
- Holoprosencephaly
- Neural Tubes Defects
- Tuberous Sclerosis
- Agenesis of Corpus Callosum
- Interhemispheric Cysts
- Migration Abnormality

Neonatal Hydrocephalus (other causes)

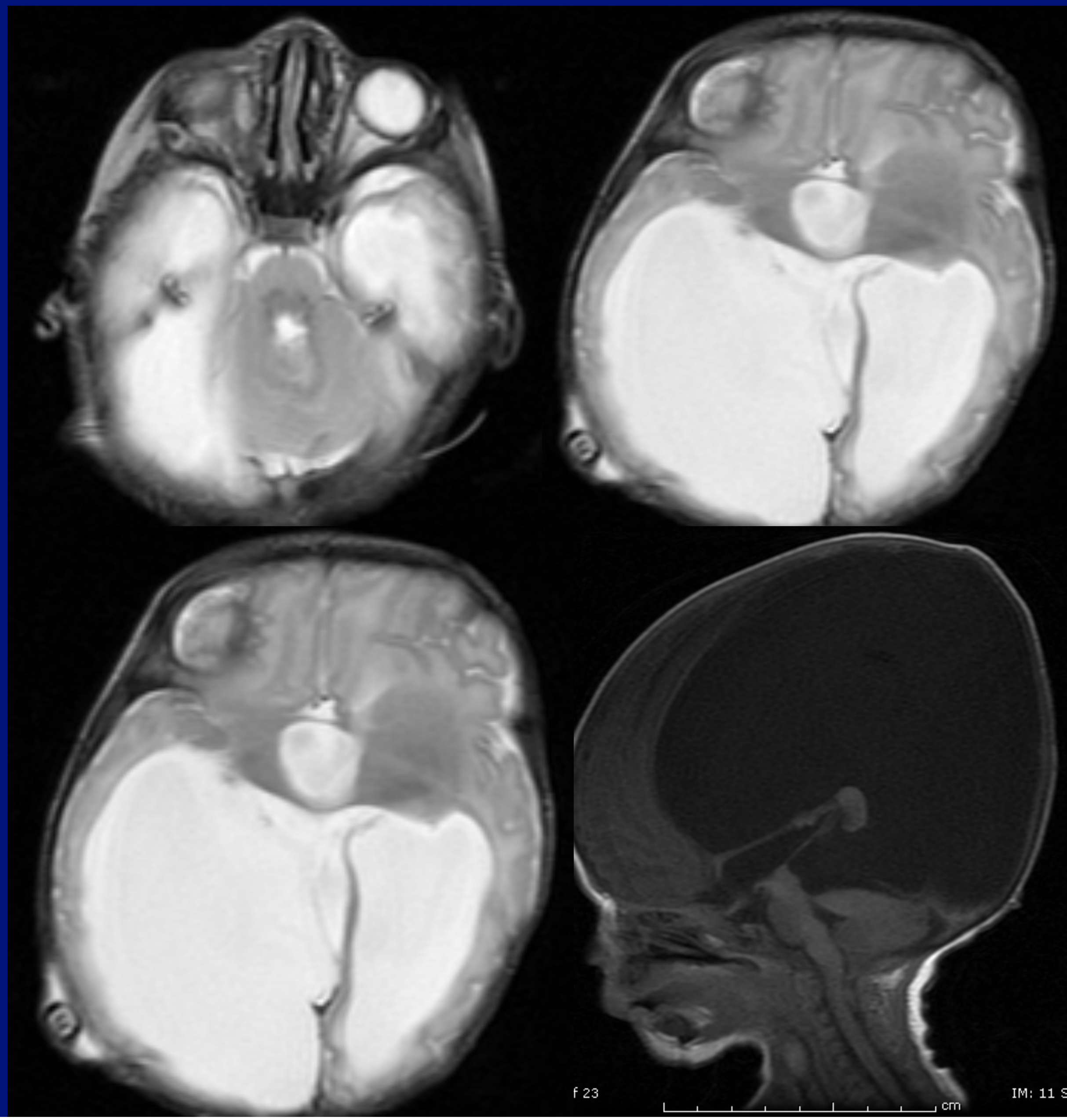
- Hemorrhage
- Infection
- Tumors

NEONATAL CONGENITAL MALFORMATIONS

X-linked Hydrocephalus

- Aqueductal Stenosis
- 1:30,000 male births
- Chromosome Xq28
- L1 CAM gene (neural cell surface adhesion molecule)
- CRASH syndrome (corpus callosal hypoplasia, mental retardation, adducted thumbs, spastic paraplegia and hydrocephalus)

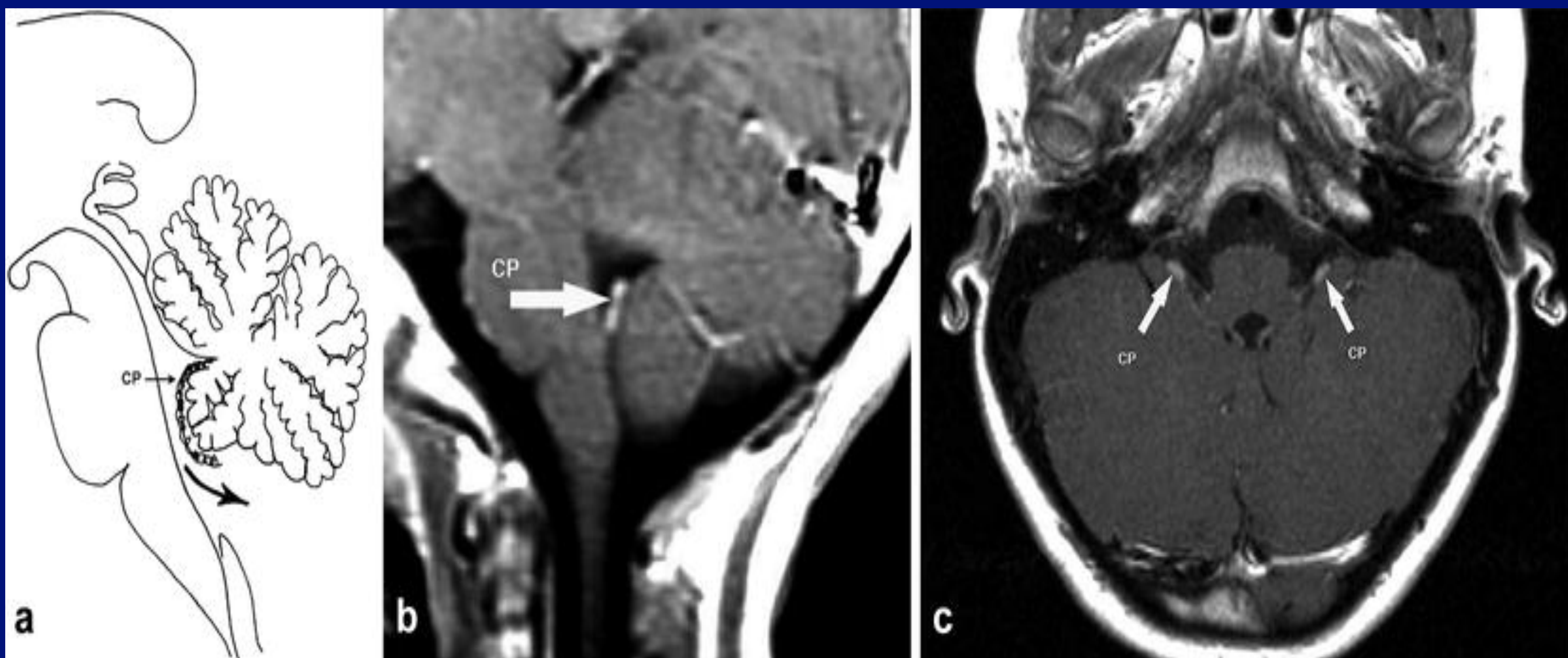
Aqueductal Stenosis



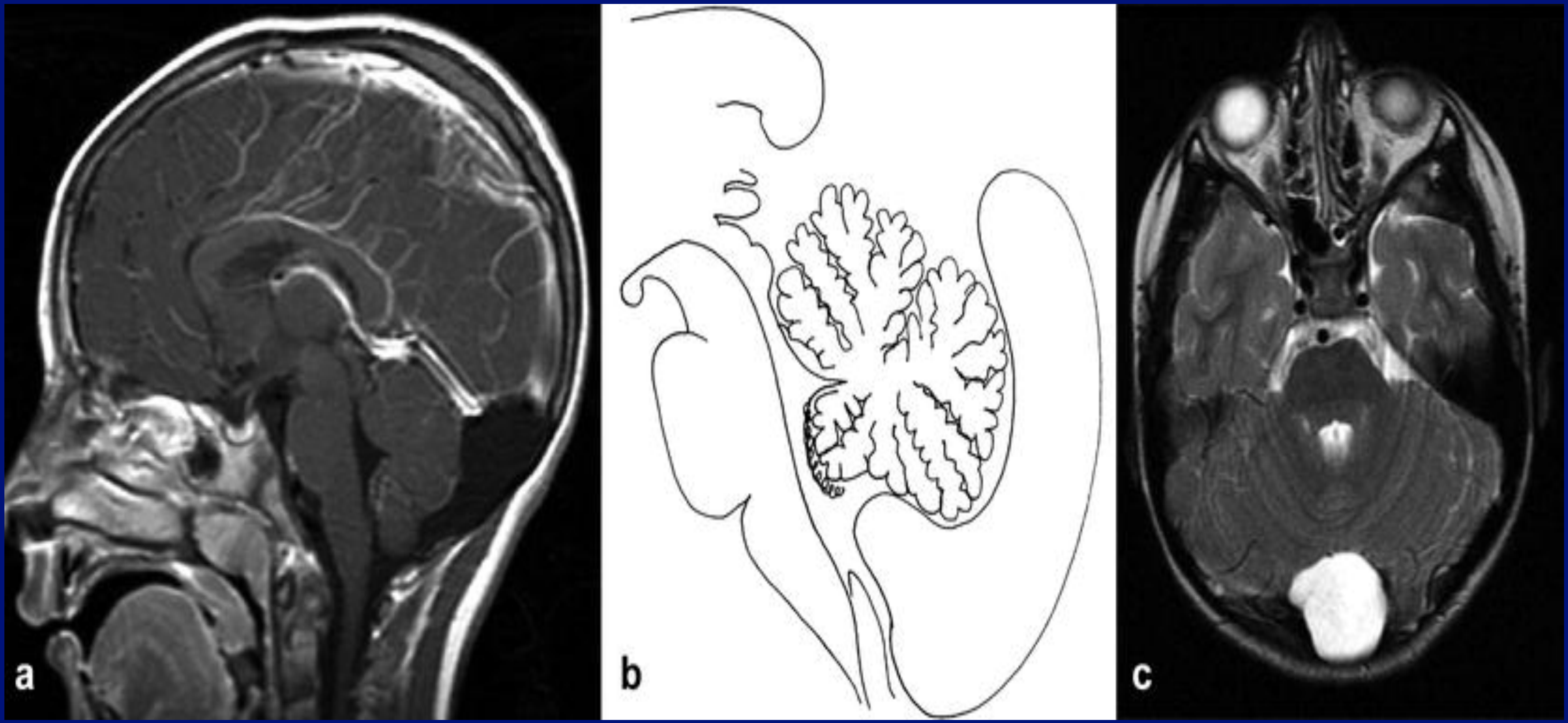
Posterior Fossa Cyst Differential: Role of Choroid Plexus

- Retrocerebellar arachnoid cyst
- Blake's pouch
- Dandy-Walker variant
- Dandy-Walker malformation (syndrome)

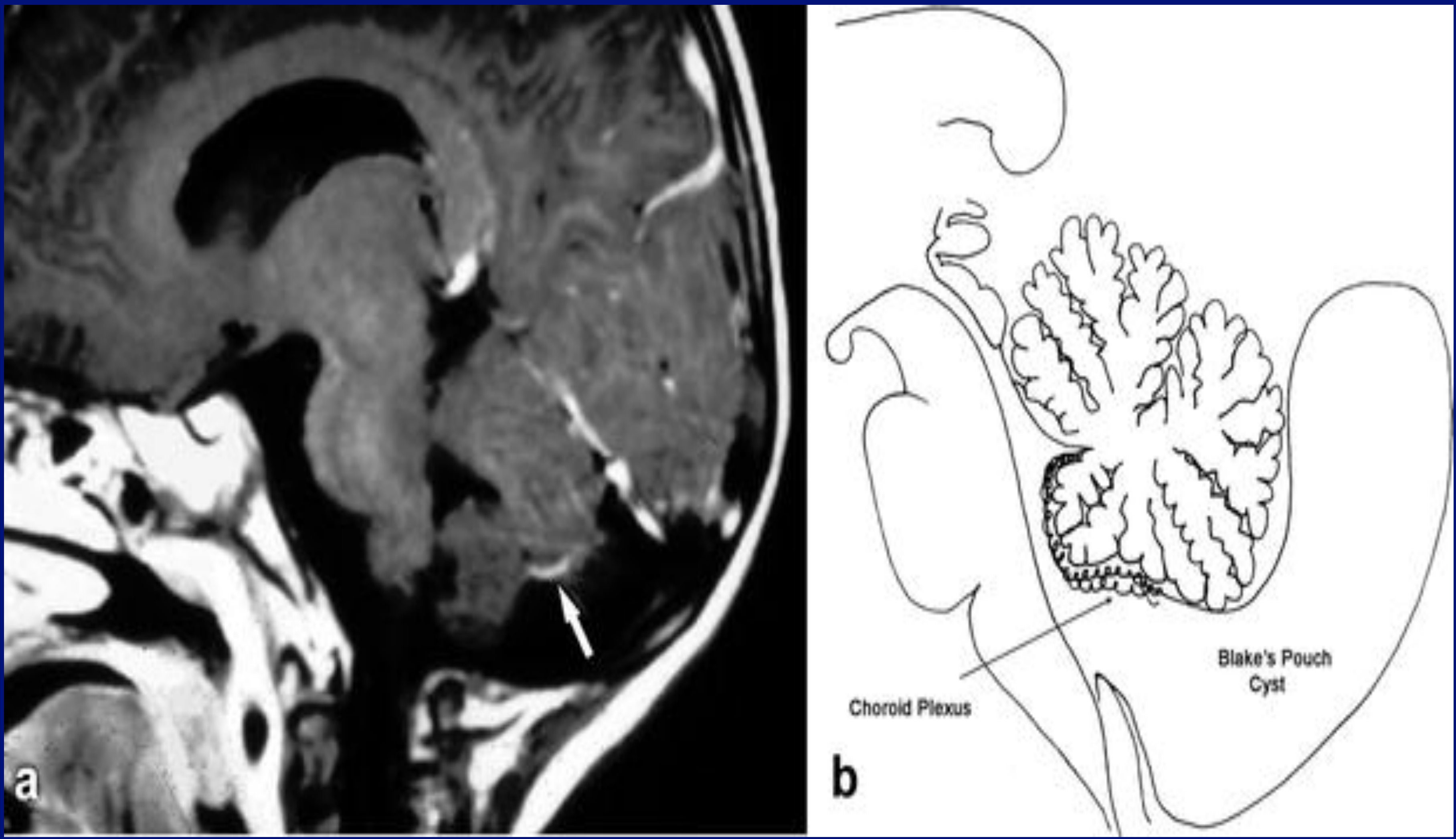
Normal Position of Choroid Plexus



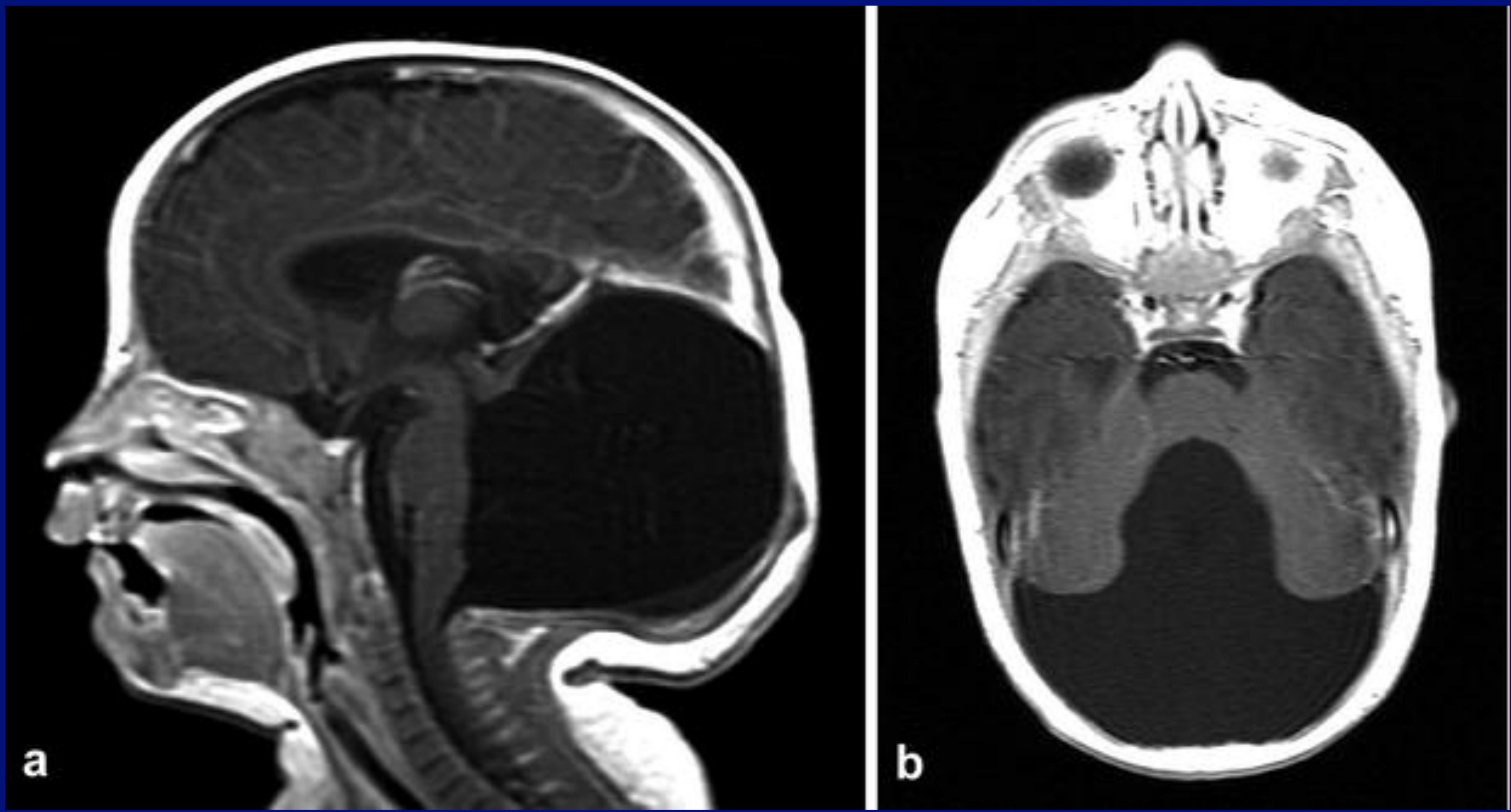
Retrocerebellar Arachnoid Cyst



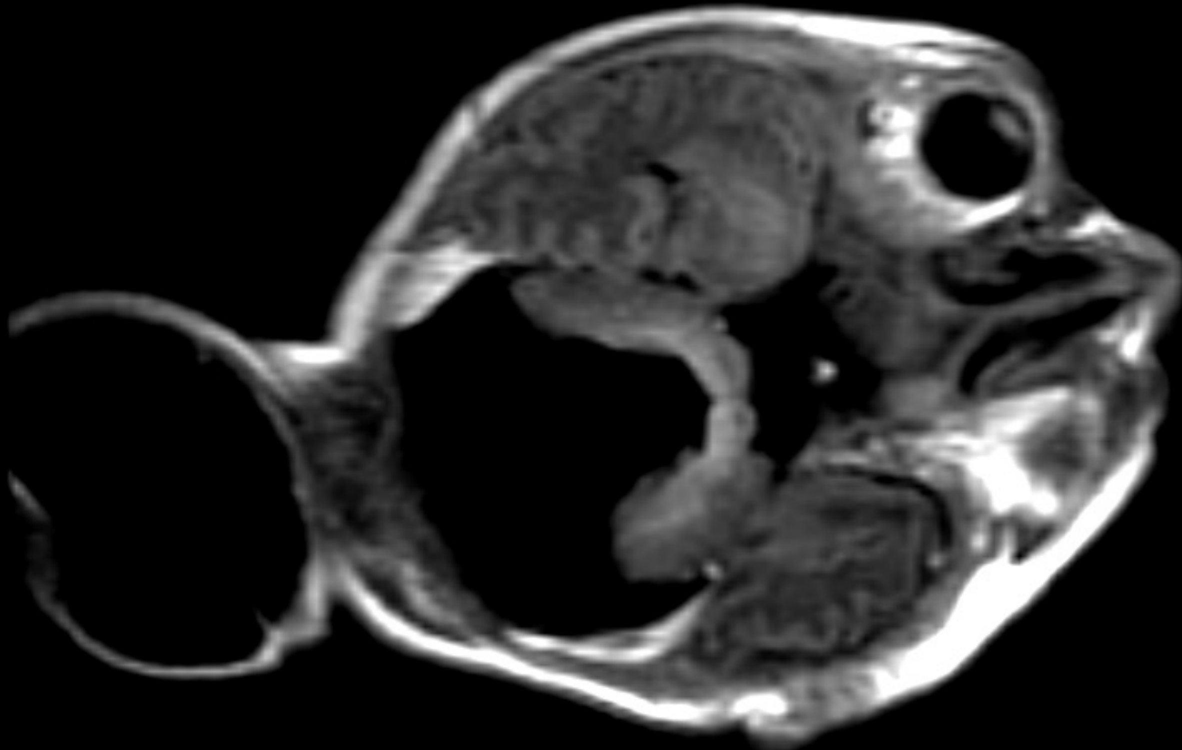
Blake's Pouch

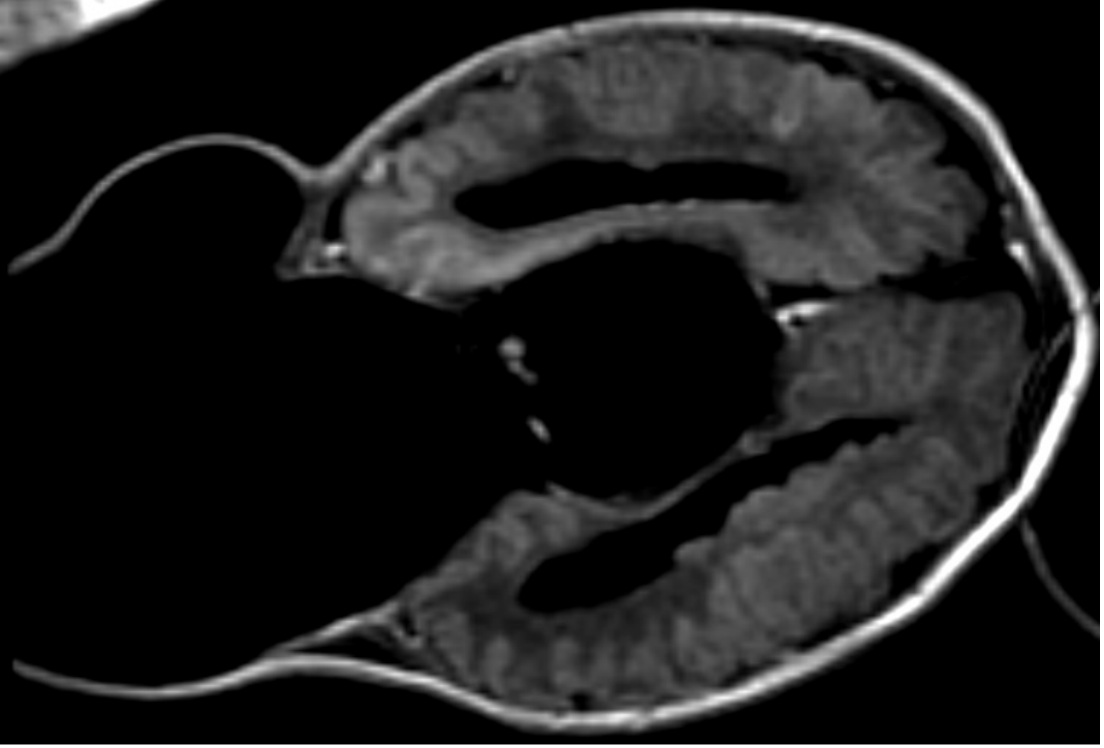


Dandy-Walker Malformation



Associated Abnormalities with Dandy-Walker Malformation

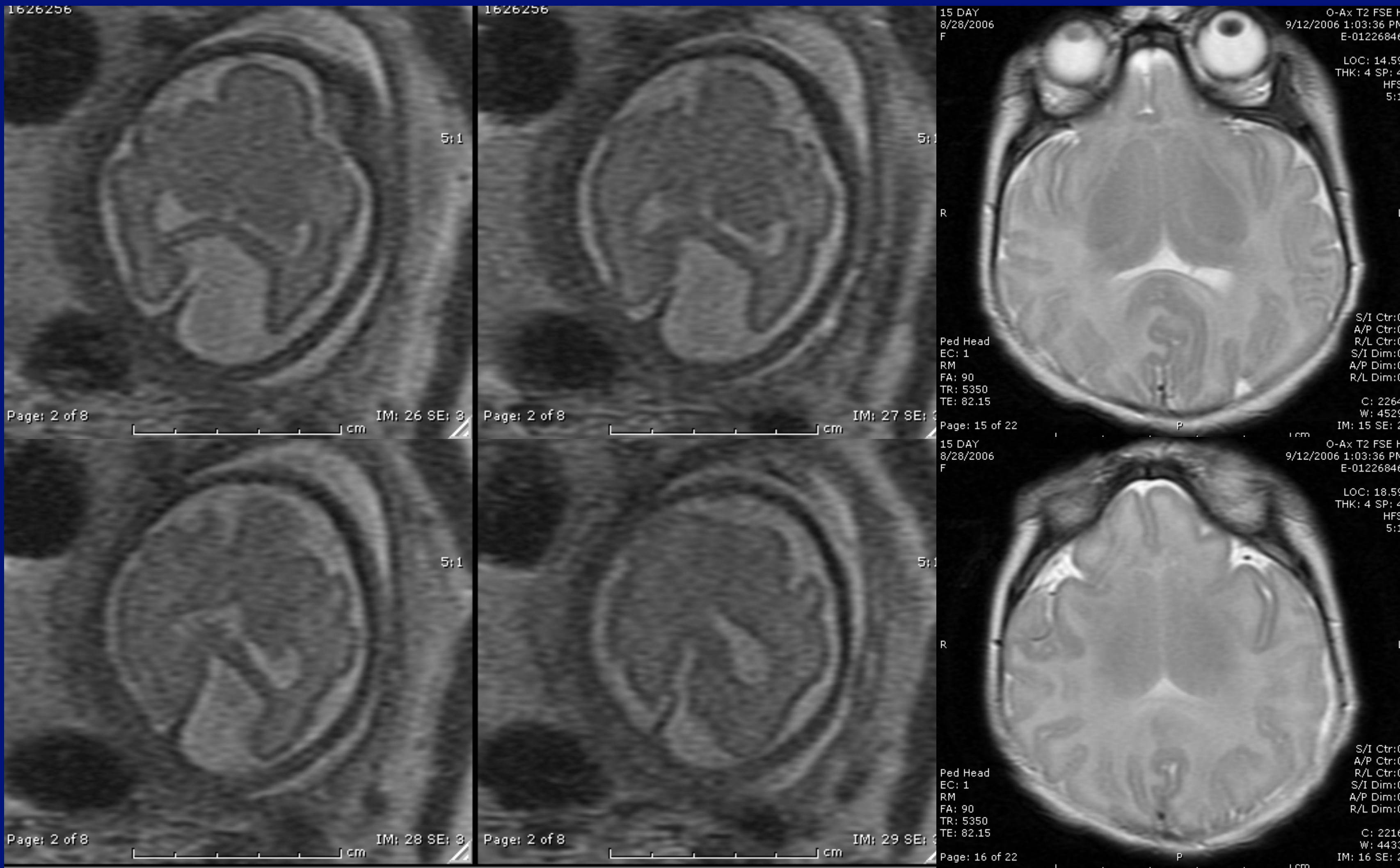


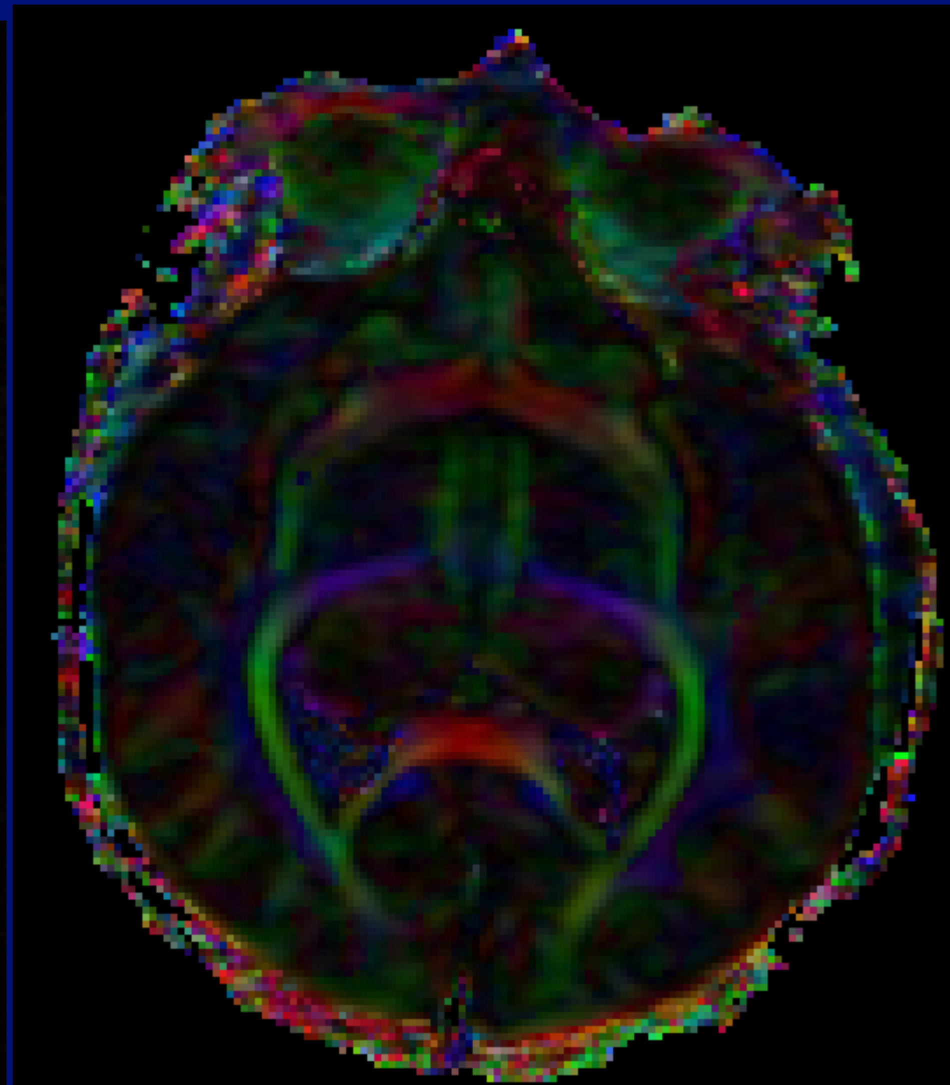


Holoprosencephaly

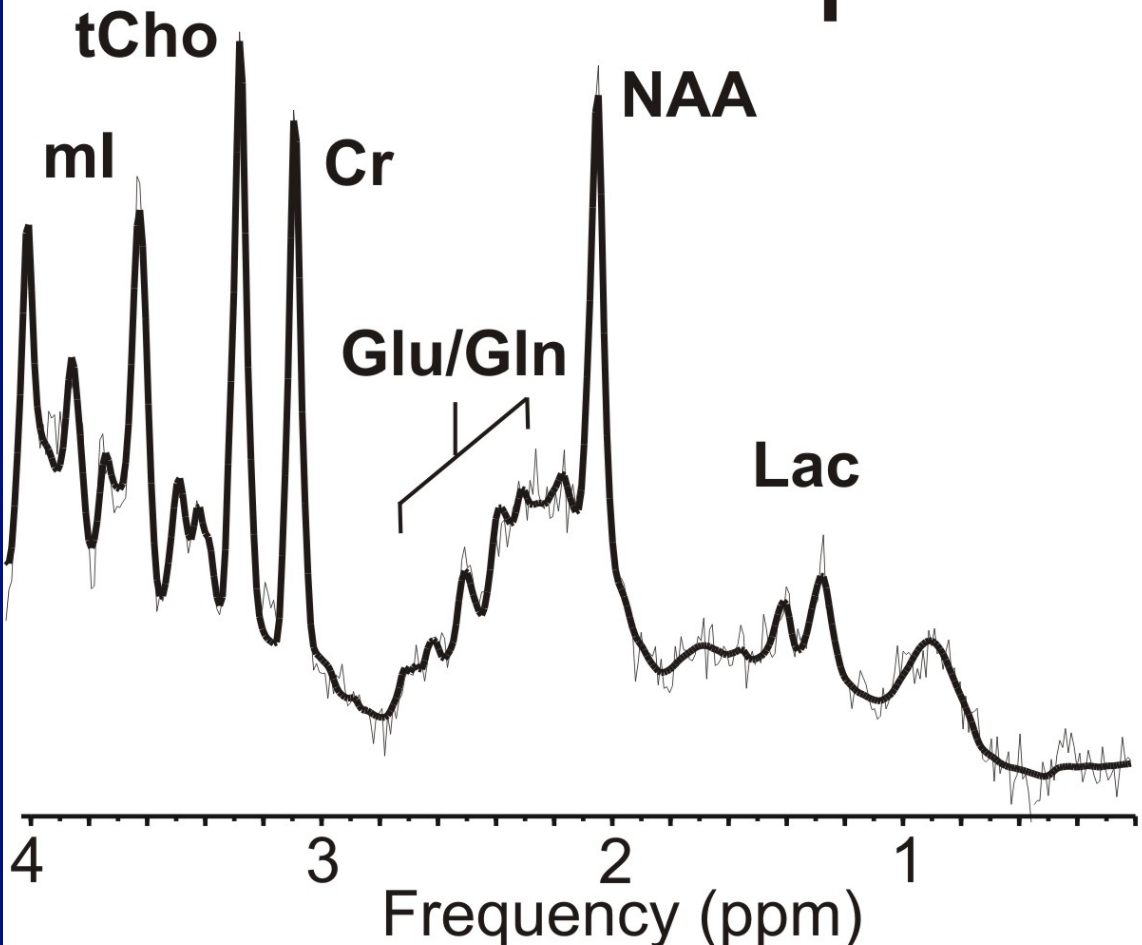
- Incomplete cleavage of the forebrain into two hemispheres
- Alobar, semi-lobar, lobar
- Wide spectrum of associated clinical abnormalities
- Sonic hedgehog (Shh) gene

Semi-Lobar Holoprosencephaly



Holoprosencephaly

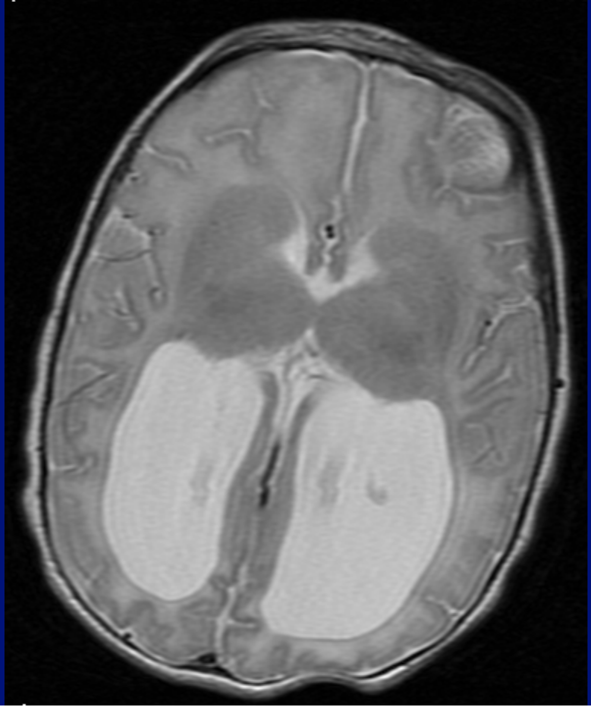


Neural Tube Defects

- 1:1000 live birth (common)
- Failure of anterior neuropore closure (anencephaly); failure of posterior neuropore closure (myelomeningocele); encephaloceles
- Gene mutations, chromosomal abnormalities, environmental factors
- Prevented by folic acid

Chiari II Malformation:

Prenatal Imaging

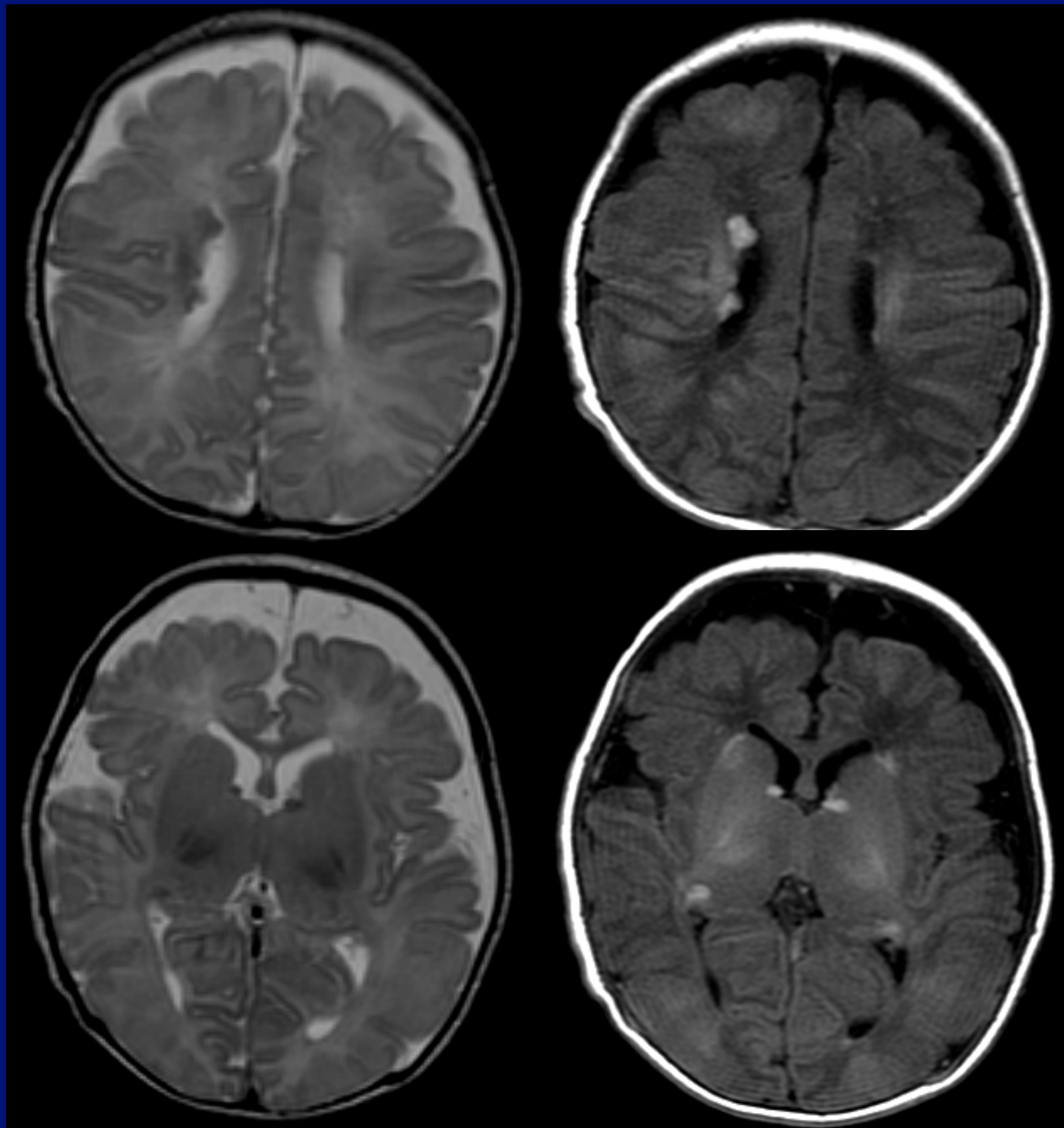


Chiari II Malformation:

Postnatal Imaging

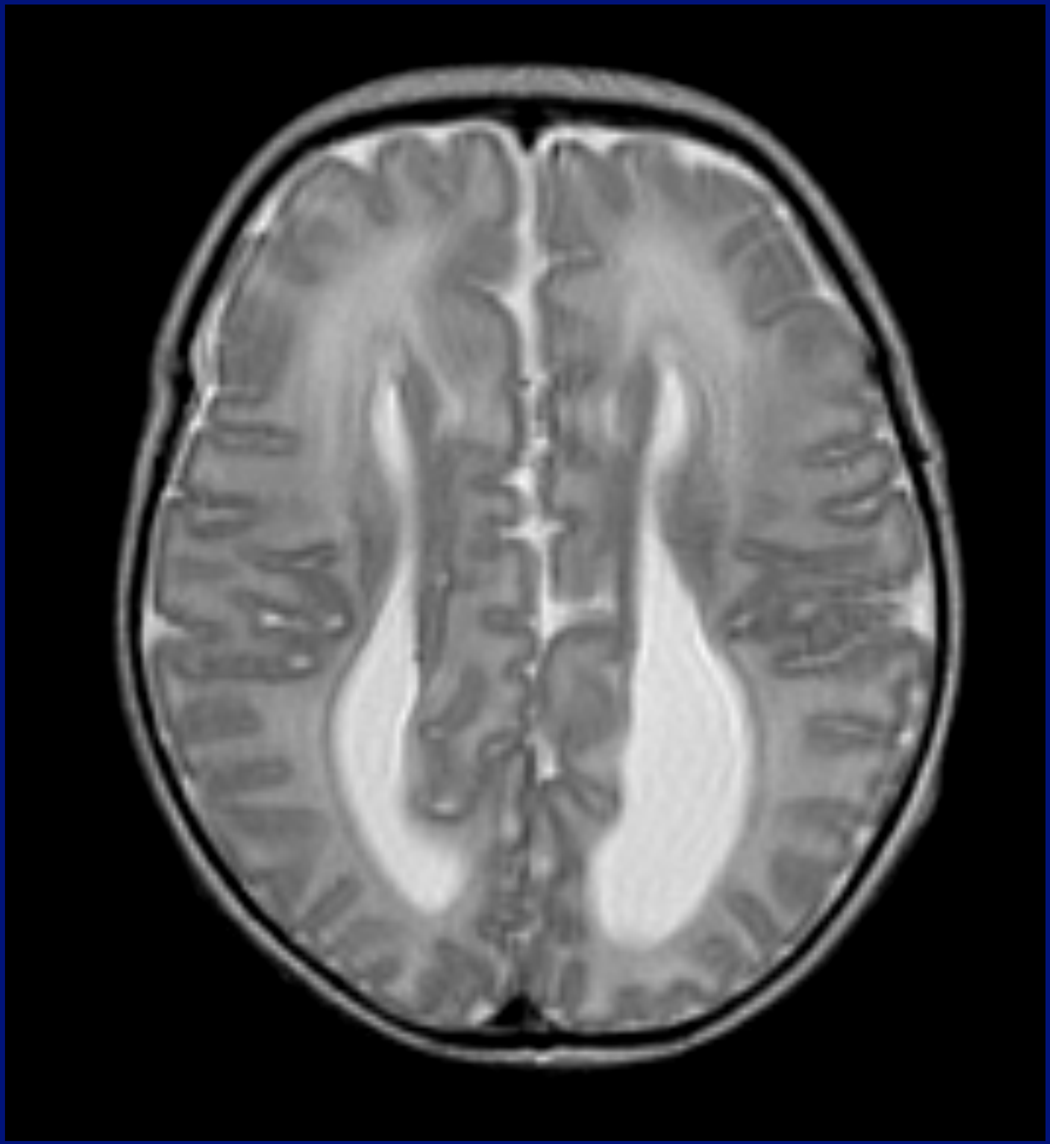
Neonatal Tuberous Sclerosis

- Autosomal Dominant syndrome:multi-system involvement including:brain eye,skin, kidneys, heart
- Hamartomas of all three germ layers:cortical tuber, subependymal nodules and subependymal giant cell astrocytomas
- TSC_1 and TSC_2 gene

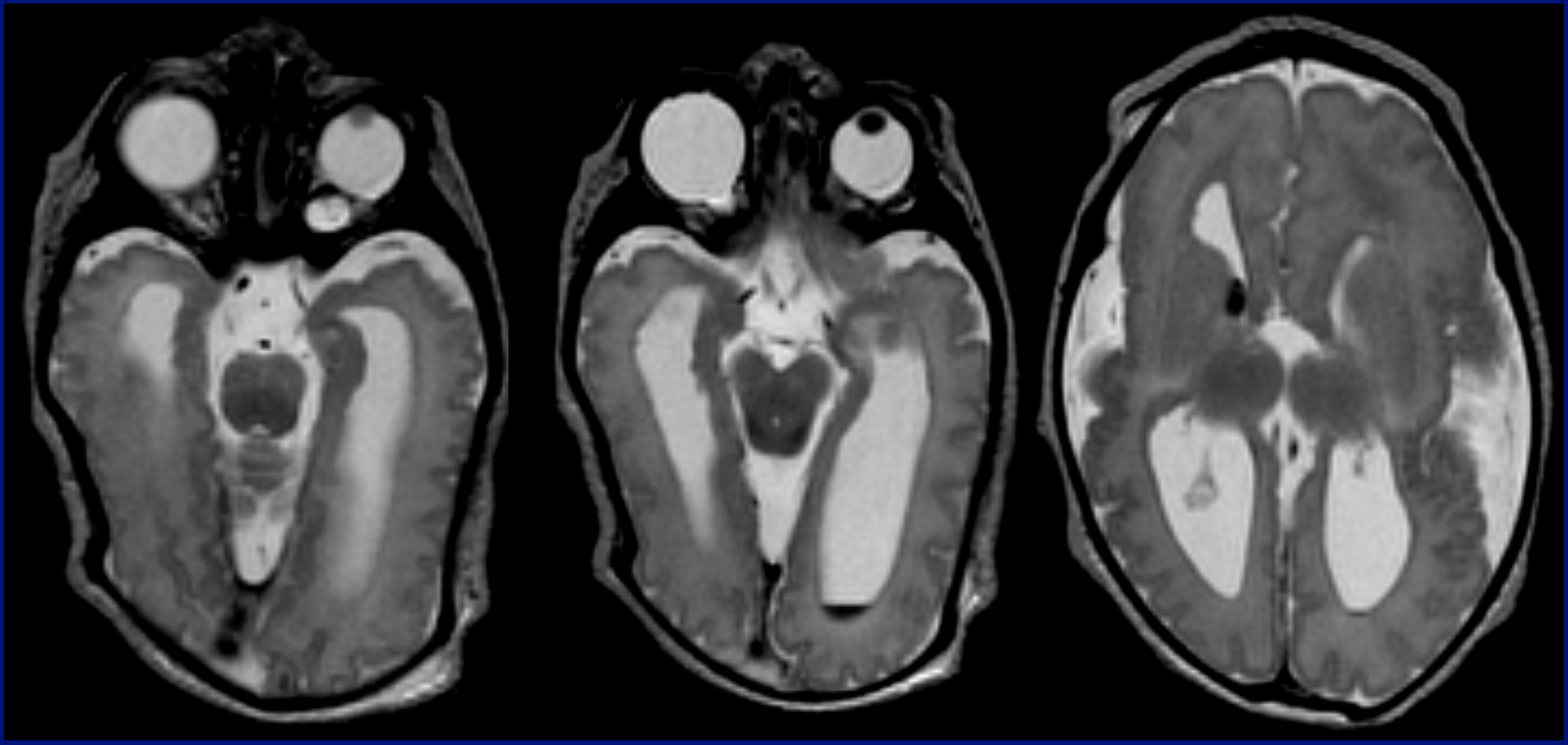


AGENESIS OF THE CORPUS CALLOSUM

Agenesis of the Corpus Callosum:Isolated



Agenesis of the Corpus Callosum: Associated with Other Abnormalities (syndromic)



Aicardi Syndrome

- Rare genetic disorder characterized by infantile spasm (jerking) and mental retardation
- Less than 500 cases in the world
- X-chromosome or random sporadic mutation
- Polymicrogyria, agenesis of CC, coloboma, heterotopia

Neonatal Hydrocephalus (other causes)

- Hemorrhage
- Infection
- Tumors

NEONATAL HEMORRHAGE

Neuropathology of Subdural Hemorrhage

SOURCE OF BLEEDING	LOCATION OF HEMATOMA
TENTORIAL LACERATION Straight sinus, vein of Galen, transverse sinus, and infratentorial veins	Infratentorial (posterior fossa), supratentorial
OCCIPITAL OSTEODIASTASIS Occipital sinus	Infratentorial (posterior fossa)
FALX LACERATION Inferior sagittal sinus	Longitudinal cerebral fissure
SUPERFICIAL CEREBRAL VEINS	Surface of cerebral convexity

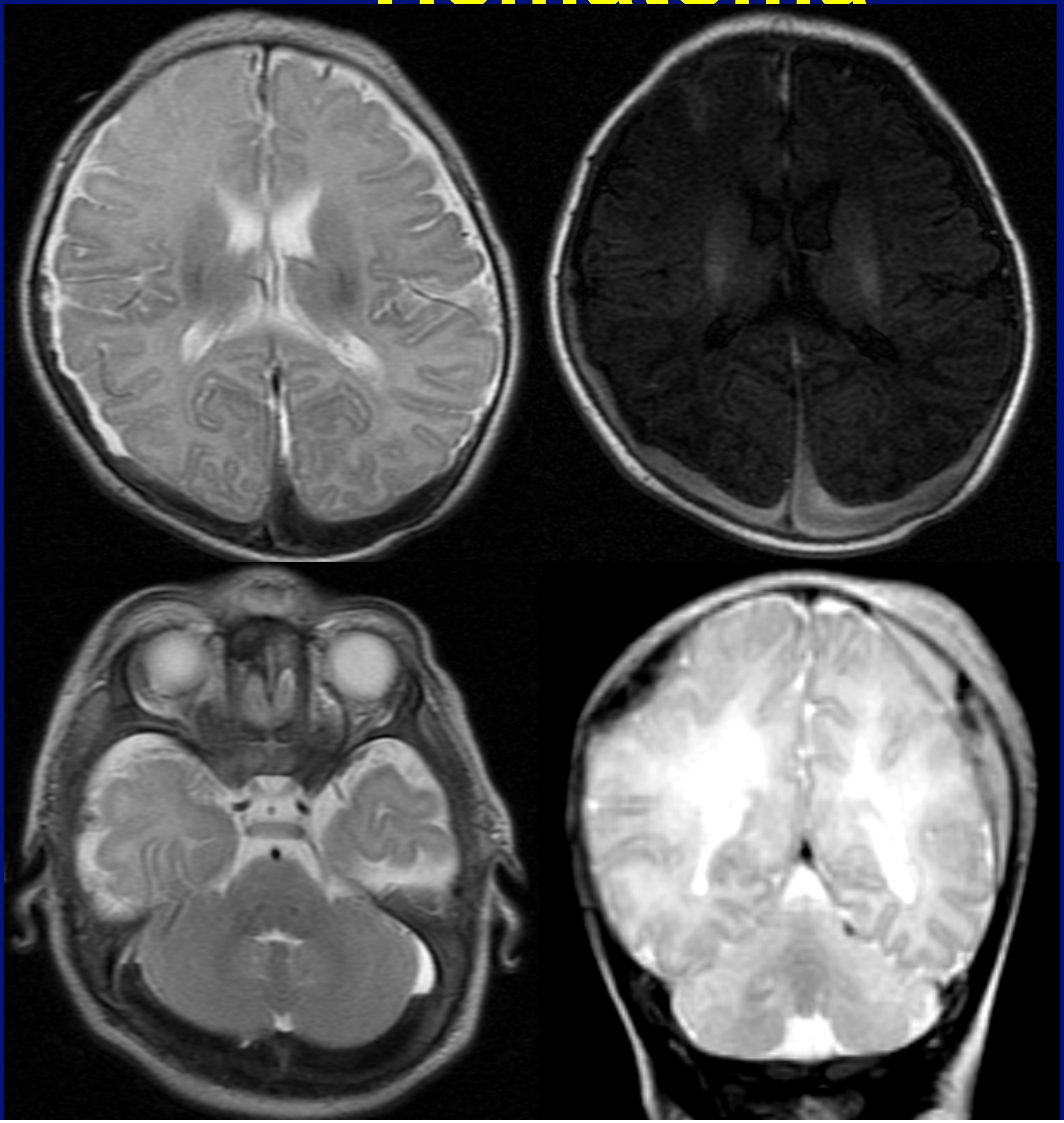
Adapted from Volpe, JJ, **Neurology of the Newborn**, 4th Ed., 2001

Pathogenesis of Neonatal Subdural Hemorrhage

AT RISK	PREDISPOSING FACTORS
Mother	Primiparous
	Older multiparous
	Small birth canal
Infant	Large full term
	Premature
Labor	Precipitous
	Prolonged
Delivery	Breech extraction
	Foot, face, brow presentation
	Difficult forceps or vacuum extraction
	Difficult rotation

Adapted from Volpe, JJ, **Neurology of the Newborn**, 4th Ed., 2001

Subdural vs Epidural Hematoma



Miscellanous Examples of Neonatal Intracranial Hemorrhage

TRAUMA
Epidural hemorrhage
Intracranial hemorrhage

HEMORRHAGIC INFRACTION
Embolus
Venous thrombosis
Arterial thrombosis

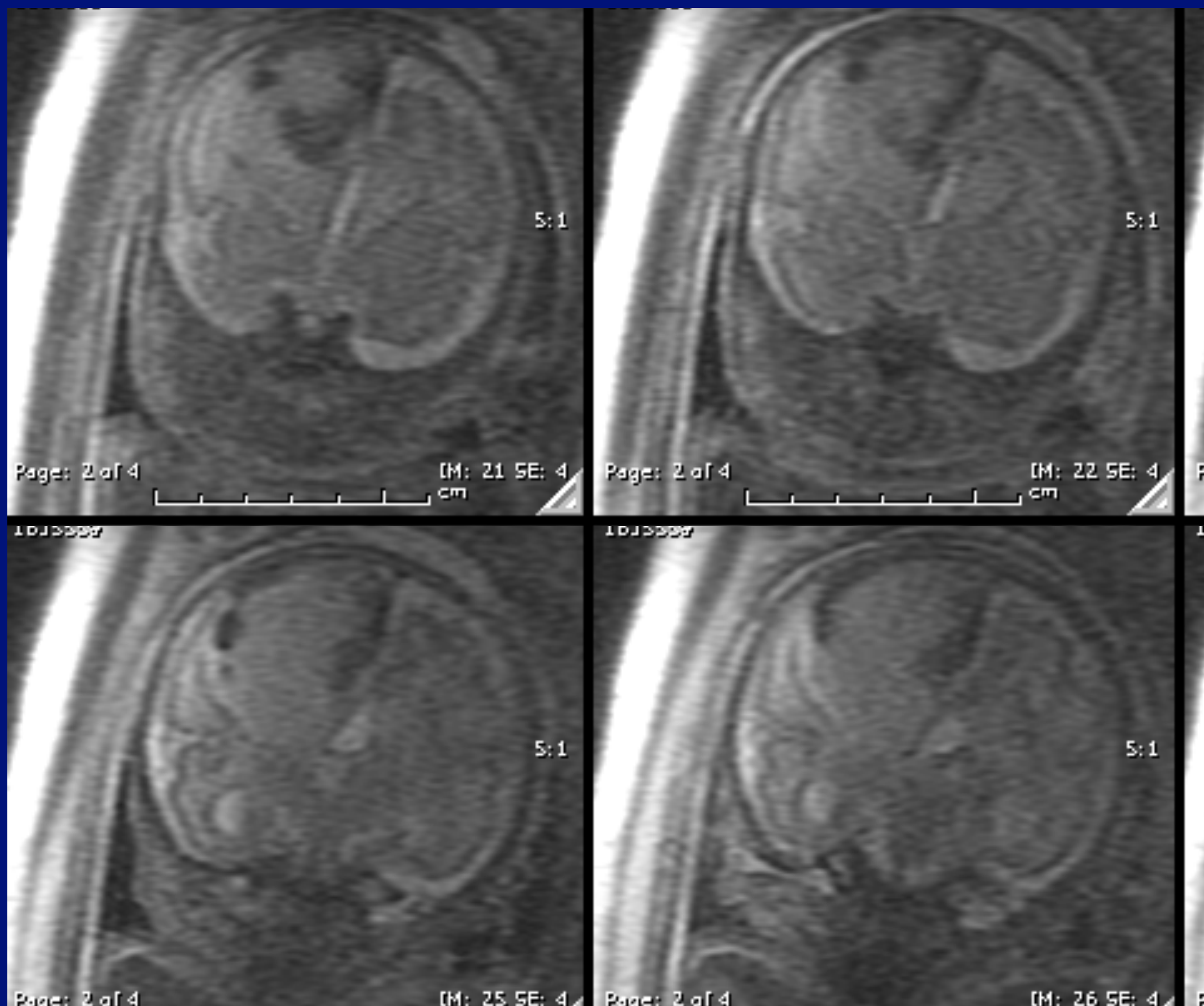
COAGULATION DISTURBANCE
Thrombocytopenia
Deficiency of coagulation factors

VASCULAR DEFECT
Aneurysm
Arteriovenous malformation
Coarctation of the aorta

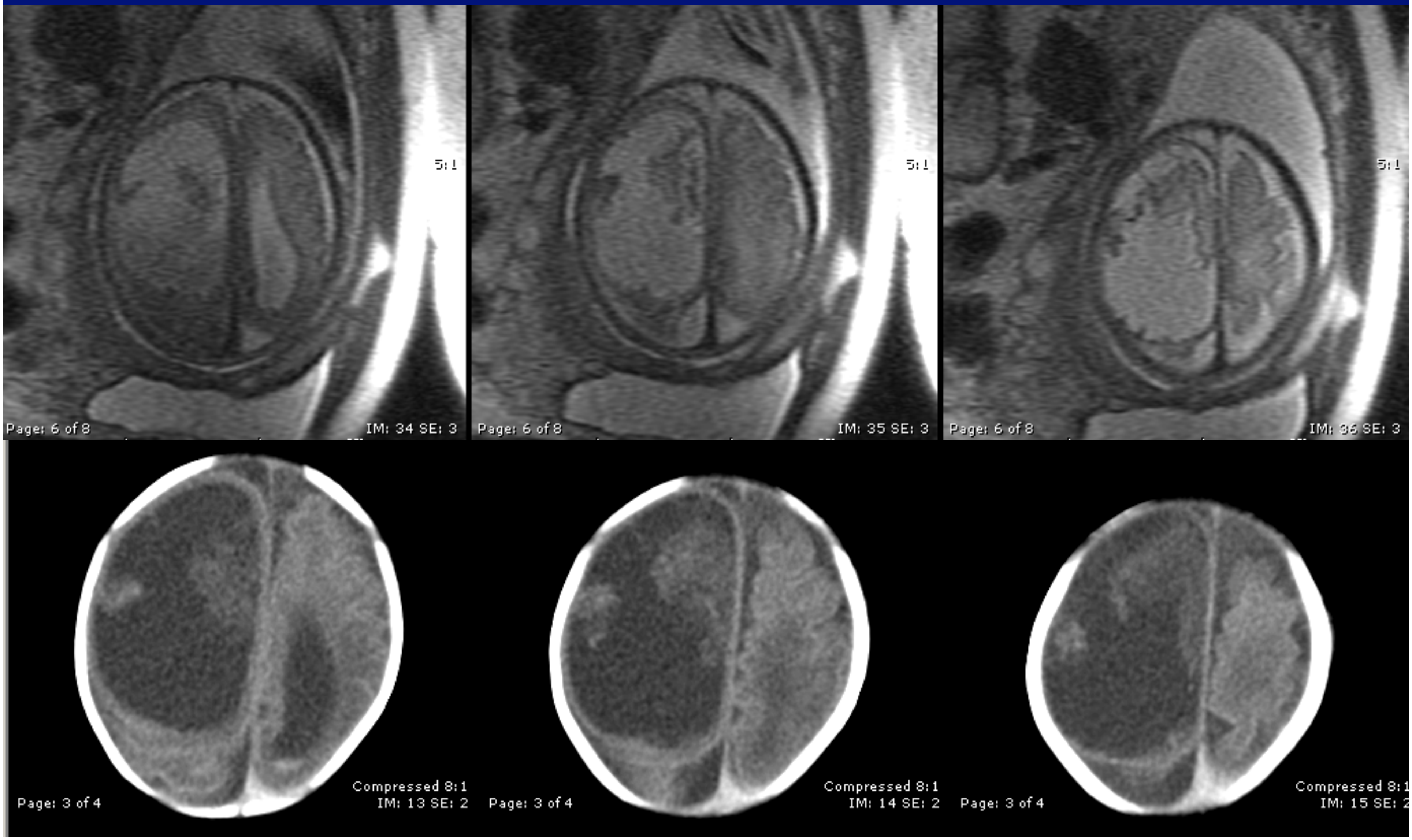
CEREBRAL TUMOR
UNKNOWN CAUSE
EXTRACORPOREAL MEMBRANE OXYGENATION

Adapted from Volpe, JJ, **Neurology of the Newborn**, 4th Ed., 2001

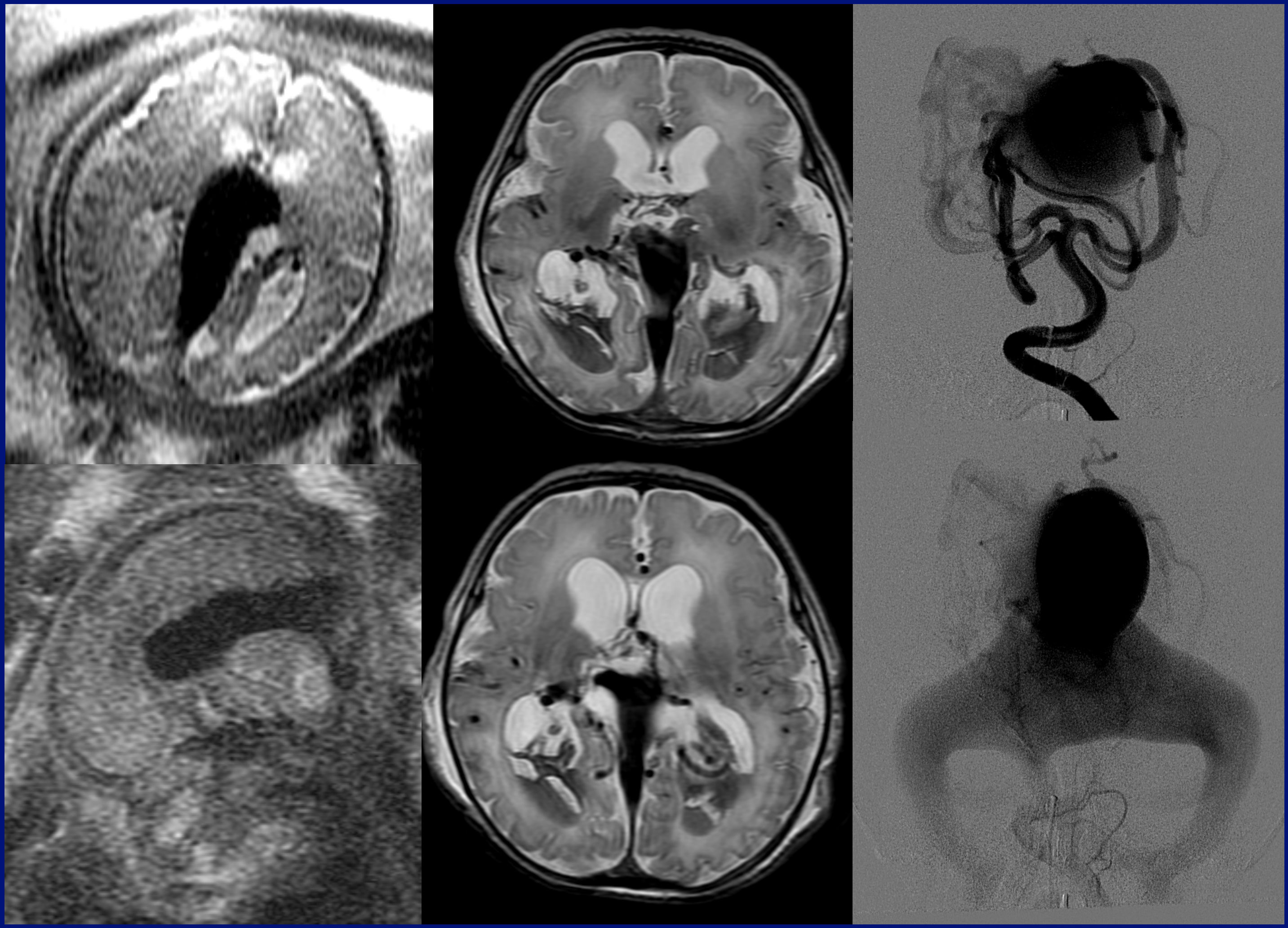
Alloimmune Thrombocytopenia



Alloimmune Thrombocytopenia



Vein of Galen AV Fistula

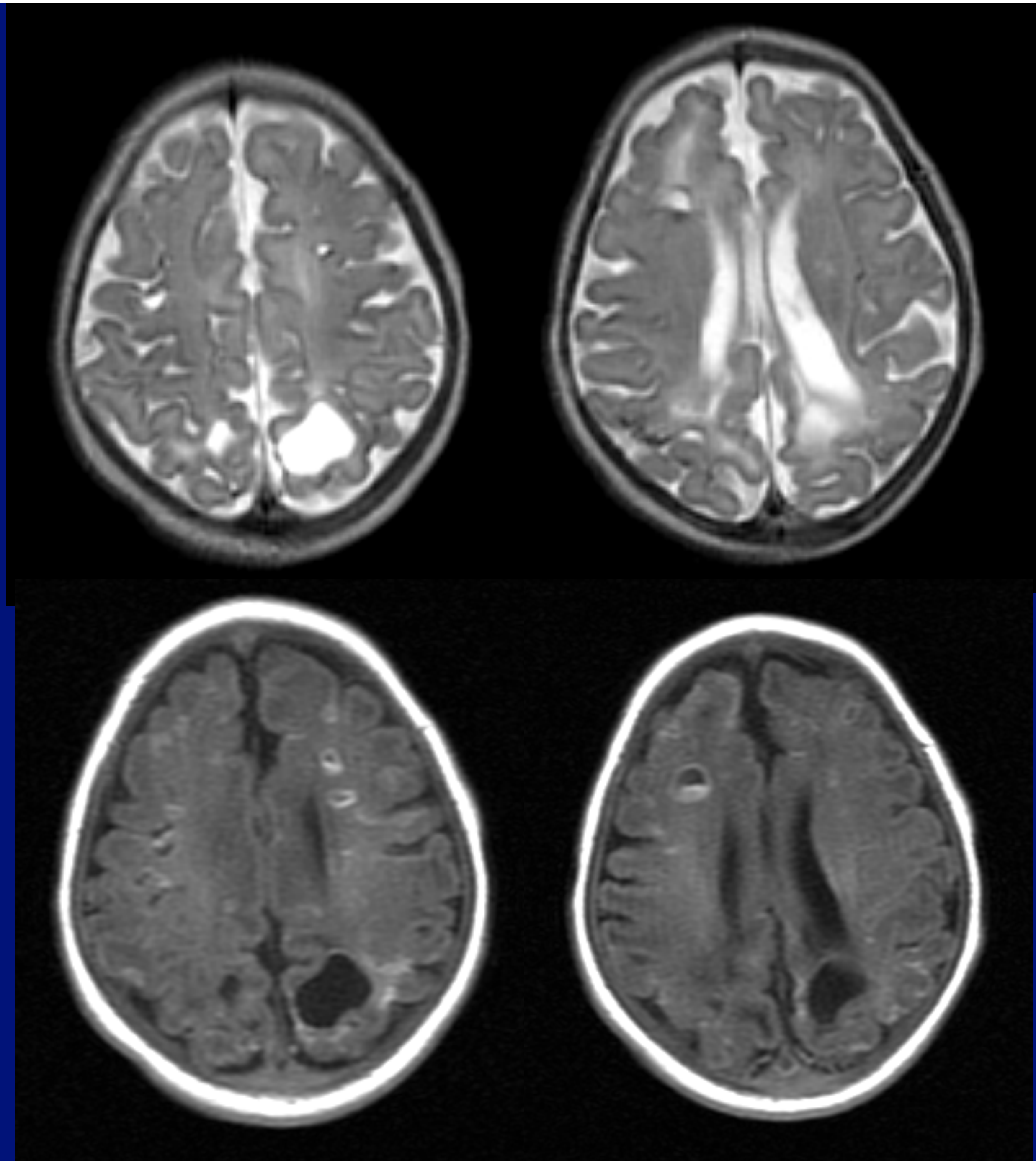


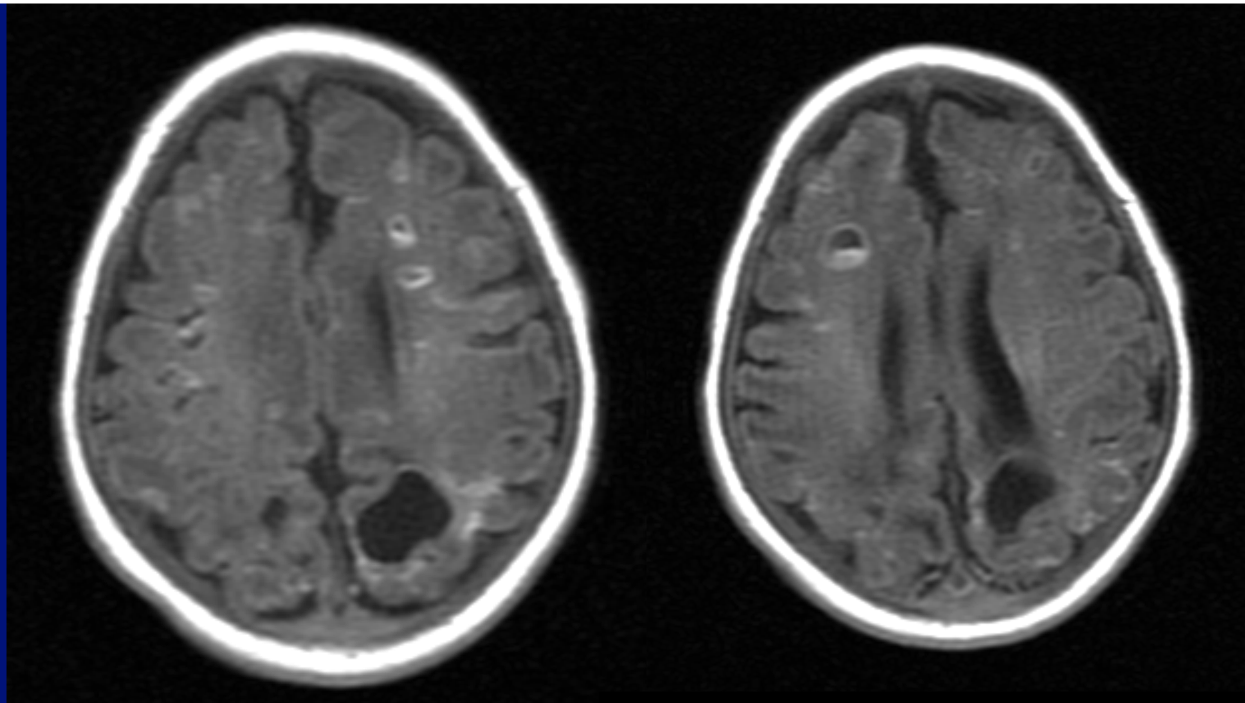
NEONATAL INFECTION

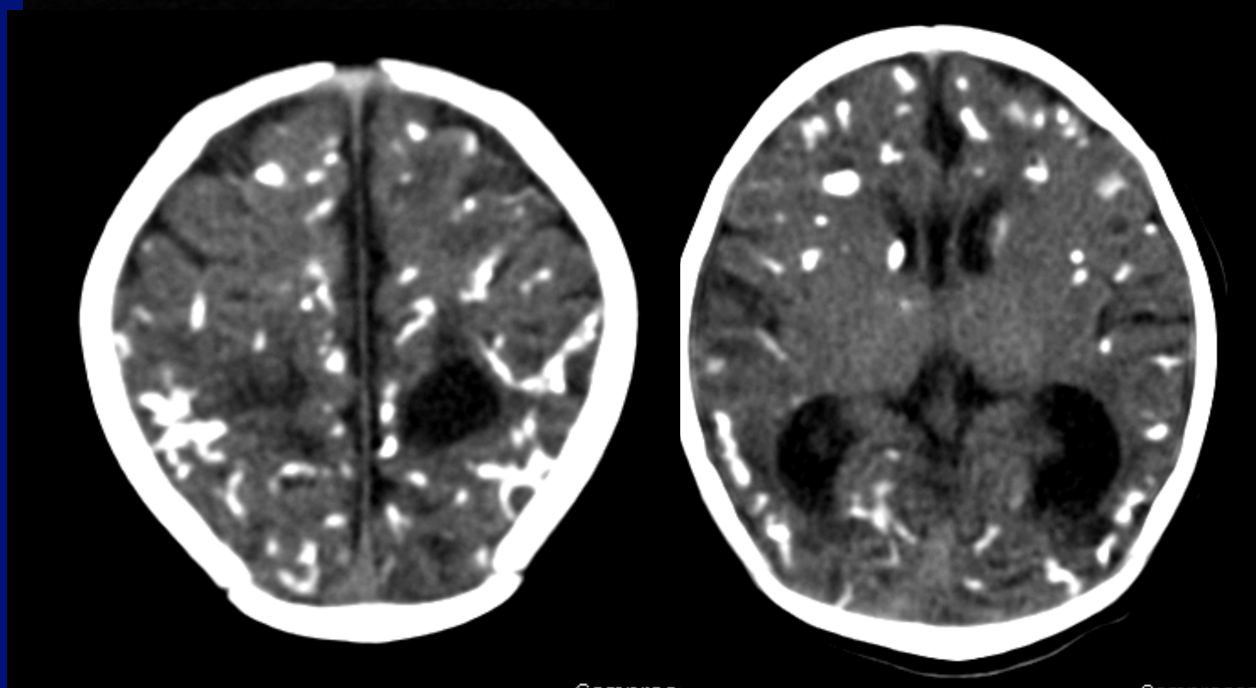
Central Nervous System Involvement by the TORCH Group

ORGANISM	MAJOR ROUTE OF INFECTION
Cytomegalovirus	Transplacental
Herpes simplex	Ascending and/or parturitional
Rubella	Transplacental
Toxoplasmosis	Transplacental
Syphilis	Transplacental
Human immunodefiency virus	Transplacental/parturitional

Volpe, JJ, **Neurology of the Newborn**, 4^{th} Ed., 2001







Bacterial Etiology of Neonatal Meningitis

BACTERIAL ETIOLOGY	PERCENT OF TOTAL
Group B *Streptococcus*	49
Other streptococci and staphylococci (includes groups D and E beta-hemolytic and alpha-hemolytic streptococci, *Streptococcus pneumoniae*, *Staphylococcus epidermidis*, and *Staphylococcus aureus*)	7
Escherichia Coli	20
Other gram-negative enterics (include *Pseudoomonas aeruginosa*, *Klebsiella* and *Enterobacter* species, *Procteus* species, *Citrobacter* species, *Serratia marcescens*, and so forth)	10
Listeria monocytogenes	7
Other (includes *Haemophilus influenzae*, *Salmonella* species, *Flavobacterium meningosepticum*, and so forth)	7

Adapted from Volpe, JJ, **Neurology of the Newborn**, 4th Ed., 2001

Neonatal Bacterial Meningitis

ACUTE

Arachnoiditis

Ventriculitis--choroid plexitis

Vasculitis

Cerebral edema

Infarction

Associated encephalopathy (cortical neuronal necrosis, periventricular leukomalacia)

CHRONIC

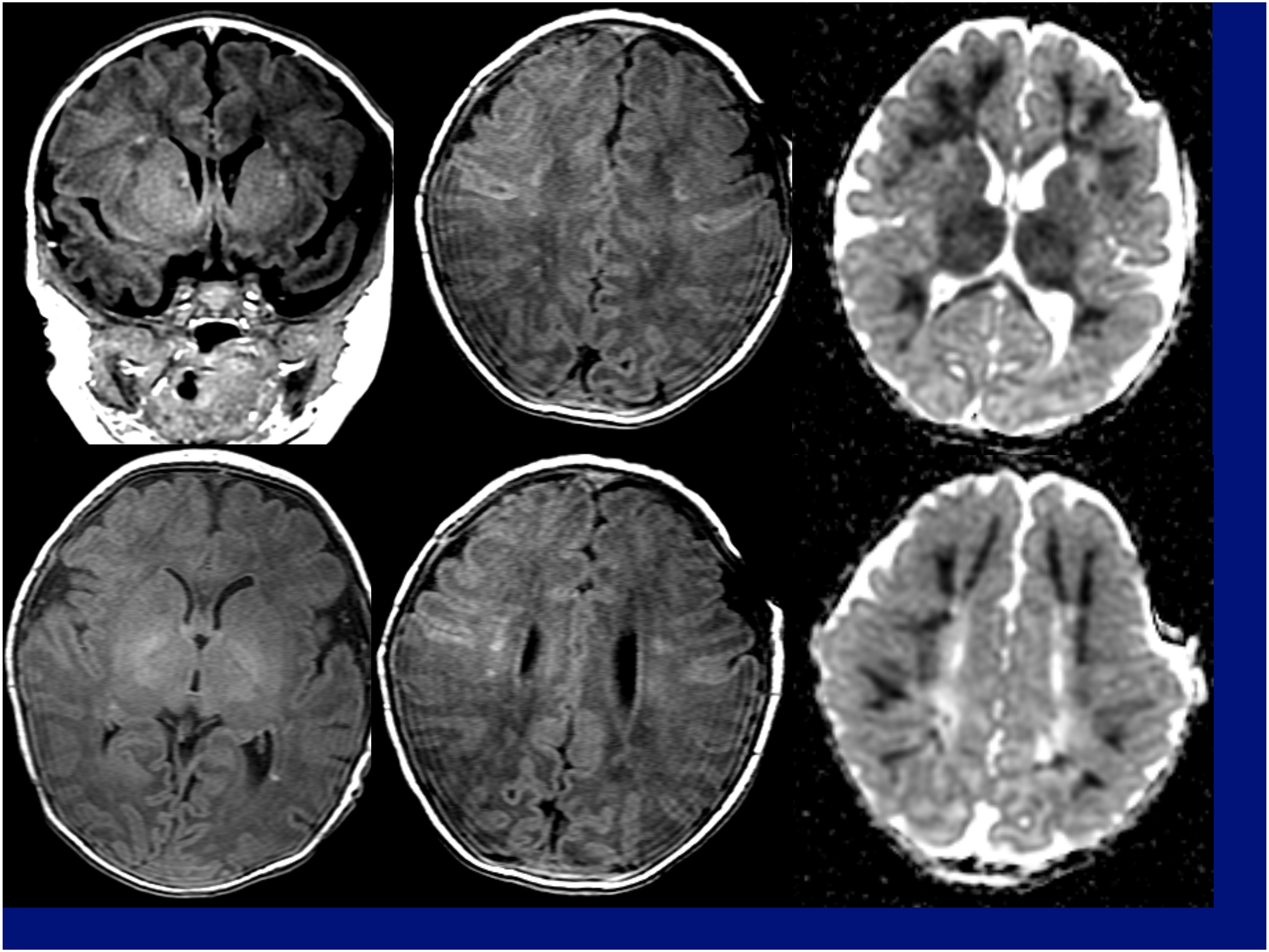
Hydrocephalus

Multicystic encephalomalacia--porencephaly

Cerebral cortical and white matter atrophy

Cerebral cortical developmental (organizational) defects (?)

Adapted from Volpe, JJ, **Neurology of the Newborn**, 4th Ed., 2001

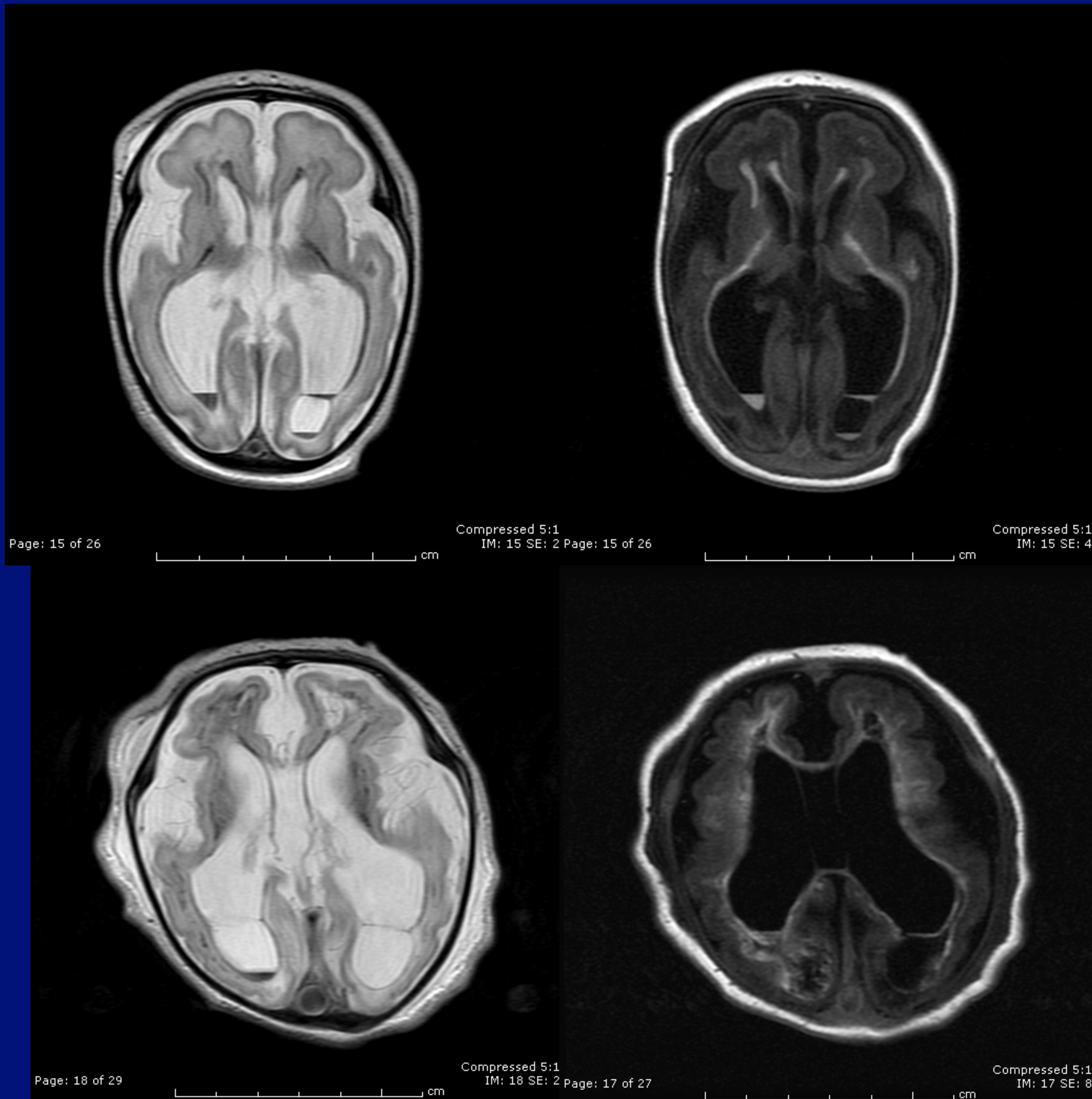


ORIGINAL ARTICLE

Human Parechovirus Causes Encephalitis with White Matter Injury in Neonates

Malgorzata A. Verboon-Maciolek, MD, PhD,[1] Floris Groenendaal, MD, PhD,[1] Cecil D. Hahn, MD, MPH,[2] Jonathan Hellmann, MBBCh,[3] Anton M. van Loon, PhD,[4] Guy Boivin, MD, PhD,[5] and Linda S. de Vries, MD, PhD[1]

Objective: To assess the role of human parechoviruses (HPeVs) as a cause of neonatal cerebral infection and to report neuroimaging findings of newborn infants with encephalitis caused by HPeVs.
Methods: Clinical presentation, cranial ultrasonography, magnetic resonance imaging (MRI) findings, and neurodevelopmental outcome of 10 infants admitted to a neonatal intensive care unit and diagnosed with encephalitis caused by HPeVs are reported.
Results: Nine of 10 infants, with a gestational age of 29 to 41 weeks, presented at 36 to 41 weeks postmenstrual age with clinical seizures. Seven had a fever and six had a rash. Clinical presentation was similar to that of infants with enterovirus infection. Cranial ultrasonography showed increased echogenicity in the periventricular white matter in all infants. Neonatal MRI confirmed white matter changes in nine infants, which changed to gliosis on later MRI. Outcome was variable with cerebral palsy in one, a suspect outcome at 18 months in one, learning disabilities at 7 years of age in one, epilepsy in one, and normal neurodevelopmental outcome in five children. Follow-up of one infant was only 9 months.
Interpretation: HPeVs should be added to the list of neurotropic viruses that may cause severe central nervous system infection in the neonatal period. White matter injury can be visualized with cranial ultrasonography, but more detailed information is obtained with MRI and especially diffusion-weighted imaging. Because clinical presentation of HPeV encephalitis is similar to that of enterovirus, real-time polymerase chain reaction for both viruses should be performed in atypical presentation of neonatal seizures. Ann Neurol 2008;64:266–273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NEONATAL BRAIN TUMORS

Neonatal Brain Tumors: Histological Types

	PERCENT OF TUMORS WITH PRESENTATION AT BIRTH	PERCENT OF TUMORS WITH PRESENTATION IN FIRST 2 MONTHS
Teratoma	48	26
Neuroepithelial	37	65
Other	17	9

Adapted from Volpe, JJ, **Neurology of the Newborn**, 4th Ed., 2001

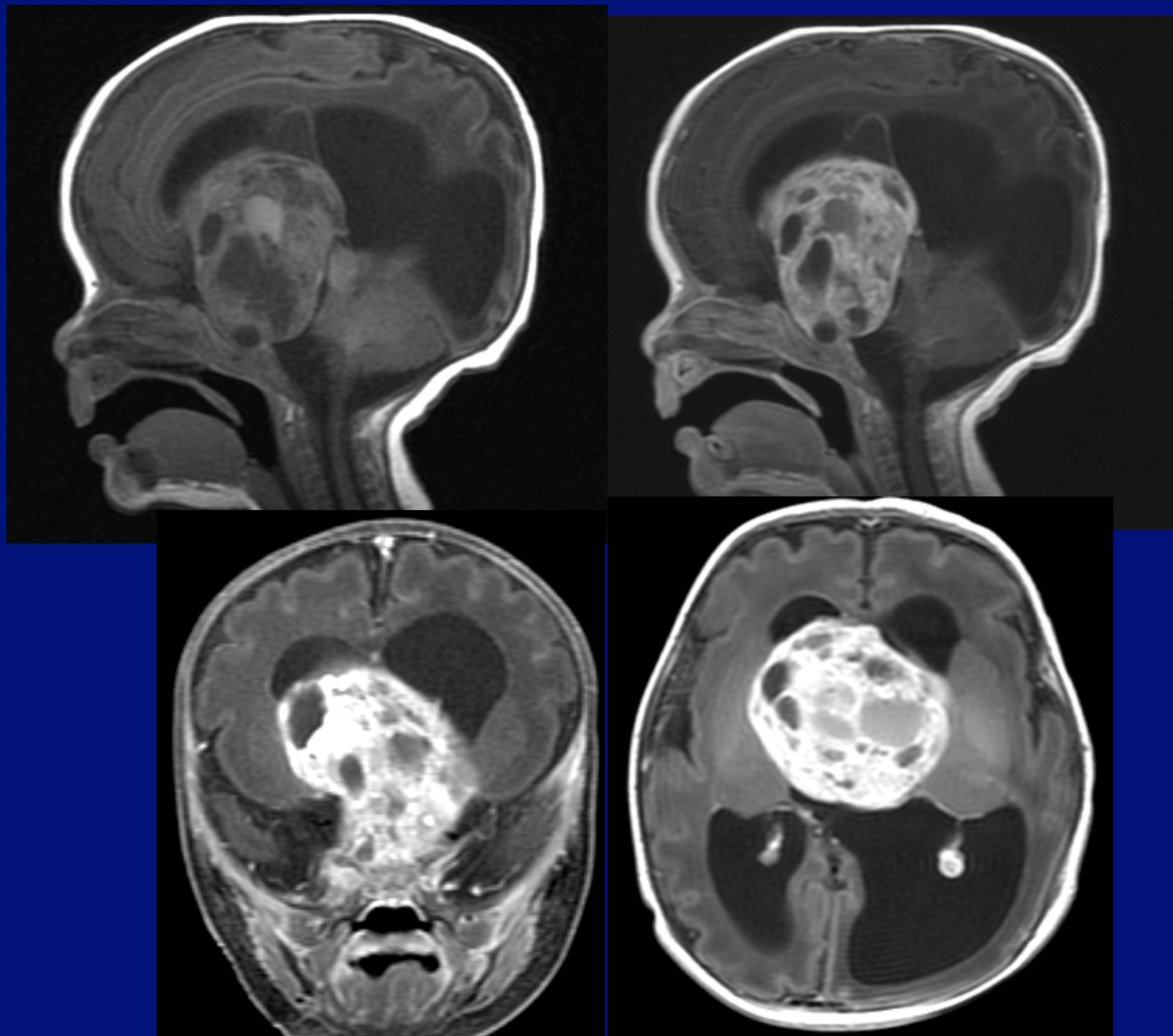
Types of Nonteratomatous Neonatal brain Tumors

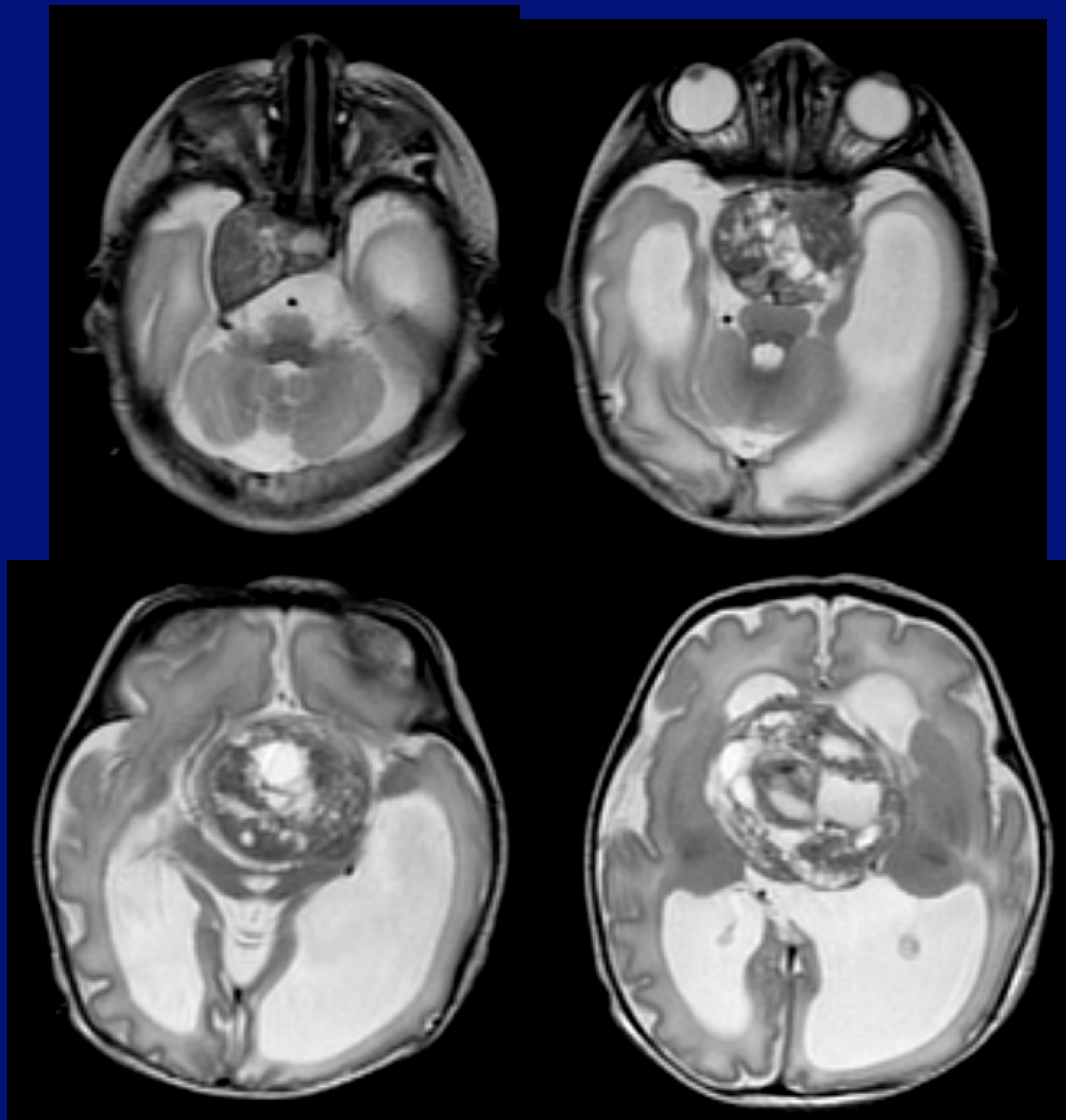
	PERCENT OF NONTERATOMA TUMORS
NEUROEPITHELIAL	
Medulloblastoma	18
Astrocytoma	15
Choroid plexus papilloma (and carcinoma)	13
Ependymoma, ependymoblastoma	11
Miscellaneous neuroepithelial	24
OTHER (MESENCHYMAL)	
Craniopharyngioma	7
Miscellaneous	12

Data from Wakai S, Araj T, Magai M: Surg Neurol 21:597-609, 1984

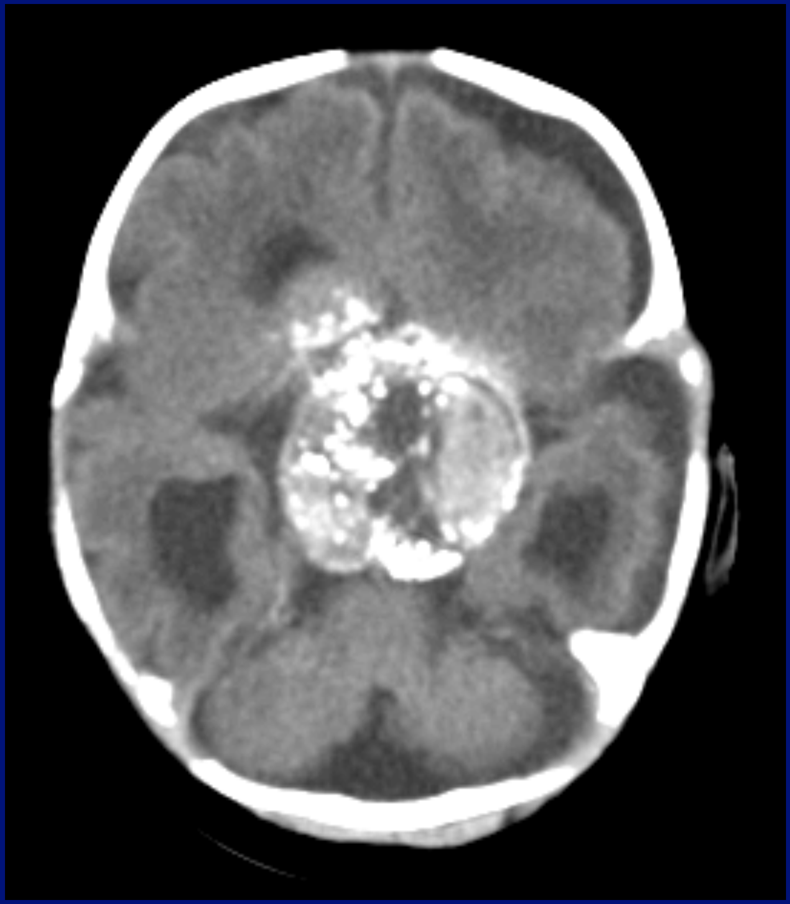
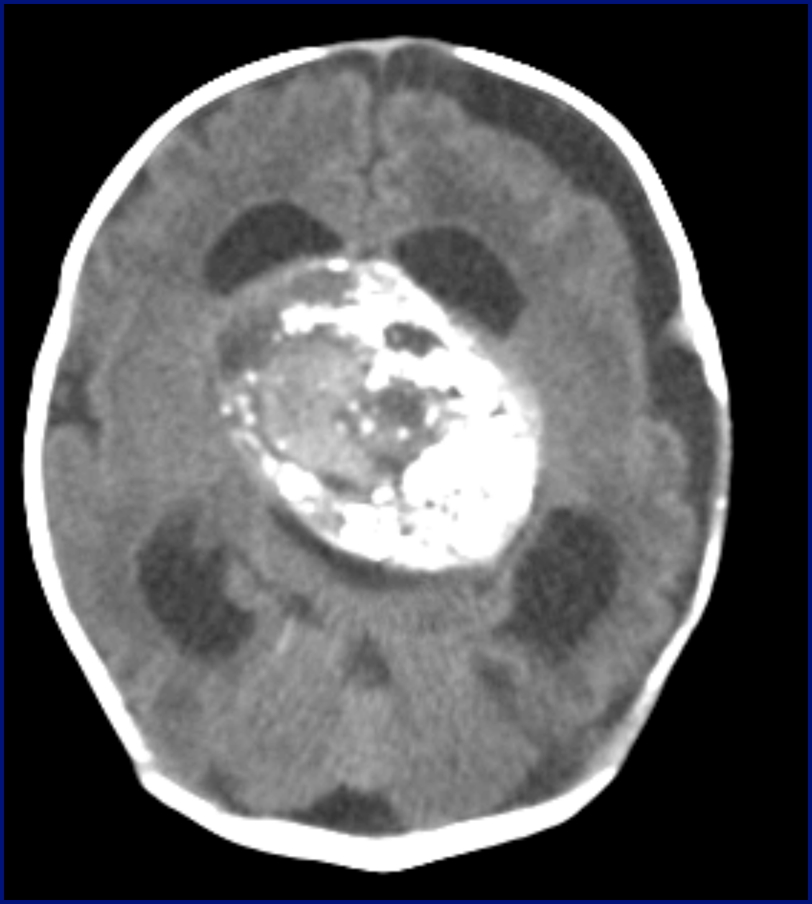
Adapted from Volpe, JJ, **Neurology of the Newborn**, 4th Ed., 2001

Suprasellar Mass





Congenital Craniopharyngioma (Differential:Teratoma)

Posterior Fossa Tumor: ADC Map

Posterior Fossa Tumor: MRS
PNET (teratoid features)