

Disclosure



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Neuroimaging Infants Requiring Cardiovascular Devices

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Our Questions

- What type of condition, injuries or abnormalities is the focus of our study?
- What is the age group of focus for neuroimaging?
- What question(s) is neuroimaging supposed to provide answers?
- What type of neuroimaging and how many will we need to answer the above question(s).

Question #1

- What types of conditions are in need of cardiovascular devices?
 - Complex congenital heart disease
 - Dilated cardiomyopathy
 - Failed Fontan procedures
 - Others?

- What types of brain injuries accompany either cardiac pathology or cardiovascular devices?
 - Arterial thromboembolic events (strokes)
 - Venous thrombosis
 - Hemorrhage
 - Hypoxic/ischemic events
 - White matter injury
 - Delayed maturation of white matter
 - Hydrocephalus

Increased Risk of Cerebral Injury in Congenital Heart Disease Infants

- In Utero
 - Microcephaly
 - Under-development of the brain
 - Term newborns with congenital heart disease may have brains more similar to premature newborns due to immaturity or underdevelopment (Miller et al 2007; Licht et al 2009)
 - Cerebral dysgenesis in up to 30% of hypoplastic left heart syndromes*
- Preoperative injury commonly noted
 - PVL (16%), strokes (8%), intracranial hemorrhages (4%)*
 - Seen in 39% of patients, most commonly strokes, associated with balloon atrial septostomy**
- Post-operative injury
 - Seizures are most common complication (9-32% reported)
 - PVL (48%), new infarcts (19%), new ICH (33%), new or worsened lesions (67%)*
 - Seen in 35% of patients, most commonly white matter injury**

* Mahle et al 2002; ** McQuillen et al 2007

Question # 2

- What is the age group of focus for neuroimaging?
 - Newborns?
 - Infants (probably)
 - Toddlers?
 - Young children?

Increased Risk of Cerebral Injury in Newborns and Infants

- Developmentally, newborns and infants are at increased risk of cerebral injury
 - Selective vulnerability of the immature brain
 - Increased thromboembolic risk
 - Increased risk for seizures
- Cerebral injury can occur in utero
 - Periventricular leukomalacia (PVL)
 - Prenatal strokes
 - Cerebral dysgenesis or malformations
- Newborns
 - Presence of patent foramen ovale allowing for right to left shunting of blood
- Prevalence of cerebral palsy is 1.0-2.4 per 1000 live births in the U.S.
 - ~8000 children with CP are born annually in the U.S.

Question #3

- What question(s) is neuroimaging supposed to provide answers to?
 - Is the cardiovascular device safe for the immature brain?
 - What are the potential brain injuries, their incidence and time of occurrence in infants with these cardiovascular devices?


Conclusions from Questions #1-3

- Our patient population is at high risk of brain injury from
 - their pre-existing cardiac condition,
 - their acute state prior to requiring a cardiovascular device, and
 - predisposition due to their immature brain
- *Therefore, neuroimaging is essential to determine safety by distinguishing new from pre-existing brain injury and serial images will be required.*



QUESTION #4

What type of neuroimaging and how many will we need to answer Questions #1-3?



What types of neuroimaging are available?

- Ultrasounds (US)
- CT scans
- MR imaging

Potential Diagnostic Rate

Injury	US (%)	CT (%)	MRI (%)
Stroke	50	90	100
Venous thrombosis	<50	90	100
Hemorrhage	70	100	100
Hypoxic/ischemic events	<50	90	90
White matter injury	10	40	100
Delayed maturation of white matter	0	0	100
Hydrocephalus	100	100	100

Is the cardiovascular device MR compatible?

- If the device is MR incompatible, then neuroimaging will be restricted to US and CT scans.
- Head US is only an option if the anterior fontanelle is open (< 9 months of age).
- US may be performed at the bedside. CT scans will require transportation unless a portable CT is available.
- Both US and CT have limitations in identifying certain types of injury.



Recommendations for Timing of Neuroimaging

- Prior to placement of the cardiovascular device
- During the time period of cardiovascular device use
- After the cardiovascular device has been removed

Ideal Recommendations for Type of Neuroimaging

- Prior to placement of the cardiovascular device
 - MR imaging
- During the time period of cardiovascular device use
 - CT (portable or routine)
 - Serial US if patient cannot be moved and portable CT unavailable
- After the cardiovascular device has been removed
 - MR imaging

Suggested MR Imaging Recommendations

Scan Time = 45-60 minutes

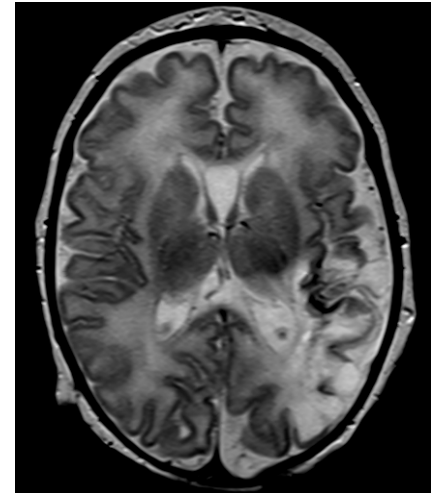
- 3DT1 for volumetric studies, including cortical folding
- TSE T2 and Diffusion imaging for visible brain injury
- DTI for estimation of FA & Dav., measures of white matter maturity
- MRS for metabolic ratios of white matter maturity
- SWI or Gradient Echo T2 for venous thrombosis or bleeds
- MRV of neck and intracranial venous flow

Minimum MR Imaging Recommendations

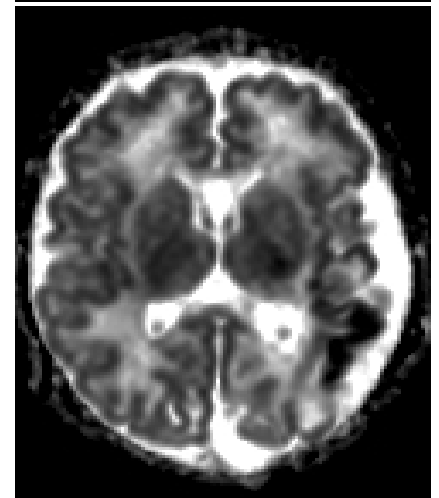
Scan Time = 4 minutes

- TSE T2 and Diffusion imaging for visible brain injury

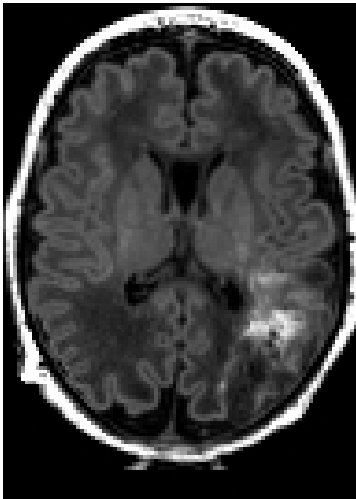
TSE T2 2.5 min.



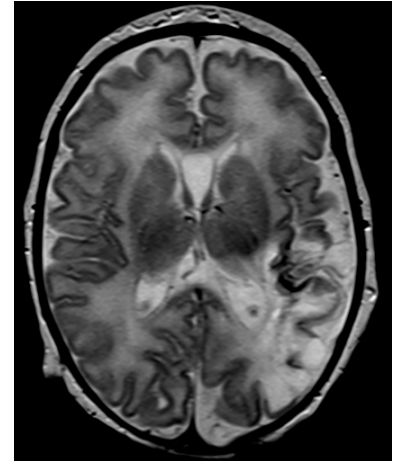
Diff 1.5 min.



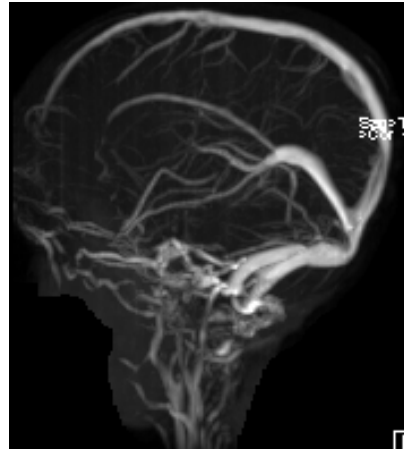
SHOW ME THE BRAIN



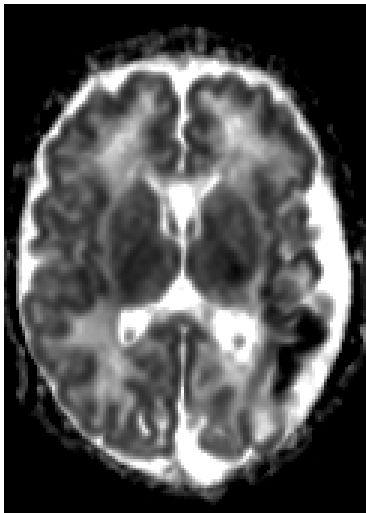
3DT1 8 min. or
SE T1 4 min.



TSE T2
2.5 min.

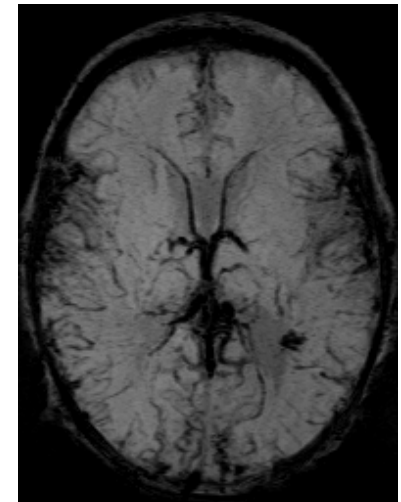


MRV
4.5 min.



Diffusion
1.5 min.

SWI/GE T2
4.5 min.





QUESTIONS?