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Developing a Pediatric Acute Stroke Response Protocol

January

Disclosures

- None

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Objectives

- To review the impetus for the establishment of pediatric acute stroke response protocols
- To recognize the challenges inherent in the timely diagnosis of pediatric stroke
- To discuss the impact of pediatric stroke protocols on the time to diagnosis of acute stroke in children
- To discuss neuroimaging protocols for the diagnosis and management of acute pediatric stroke

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Epidemiology of pediatric stroke

Important cause of acquired brain injury in children

- Incidence of 1-2 per 100000 children per year in developed countries
- 50-70% suffer long-term neurologic deficits
- 7-20% develop epilepsy

Top ten cause of mortality in children

- 5-10% mortality

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Ferriero et al, Stroke 2019

Hyperacute therapy for the treatment of pediatric arterial ischemic stroke

Emerging evidence that IV-tPA and thrombectomy may be safe and effective in children

- Case reports, case series, and retrospective analyses
- 73 children from 27 stroke centers in the US and Europe
  - Improvement in median NIHSS from 14 on admission to 4 on day 7
  - 1 patient with post-interventional bleeding complication
  - 4 patients with transient peri-interventional vasospasm

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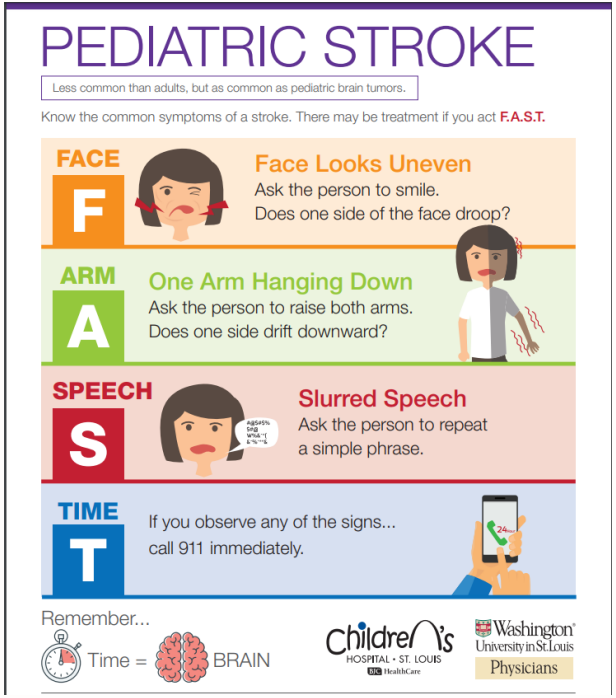
Sporns et al, JAMA Neurol 2020

Signs and symptoms of pediatric stroke

- Hemiparesis and hemifacial weakness 67-90%
- Speech or language disturbance 20-50%
- Vision disturbance 10-15%
- Ataxia 8-10%
- Headache 20-50%
- Altered mental status 17-38%
- Seizures 15-25%



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Ferriero et al, Stroke 2019

Challenges in pediatric stroke: Delays in diagnosis

15-24 hours to radiologic confirmation of diagnosis

- 1.7-21 hours from symptom onset to presentation
- Consideration of stroke by frontline providers
  - 38% of strokes suspected by initial physician
- Access to MRI
  - May be impacted by need for sedation or anesthesia

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Ferriero et al, Stroke 2019; Rafay et al, Stroke 2009

Challenges in pediatric stroke: Mimics

Majority of children with an acute neurologic syndrome have a condition other than stroke

- Migraine with hemiplegic aura
- Seizure with postictal paresis

Table III. Final diagnoses

Diagnoses	Stroke consults before stroke alert system (n = 14), n (%)	Stroke alerts after stroke alert system (n = 65), n (%)*	*P* value
Acute AIS	3 (21)	6 (9)	.19
Intraparenchymal hemorrhage	0	1 (2)	0.99
Transient ischemic attack	4 (29)	11 (17)	.43
Migraine or other headache	3 (21)	23 (35)	.36
Seizure	0	7 (11)	.34
Conversion or other psychogenic disorder	1 (7)	3 (5)	.56
Infectious or inflammatory disorder	0	5 (8)	0.99
Other†	2 (14)	11 (17)	
Unspecified	1 (7)	2 (3)	

*Seven patients had 2 final diagnoses.
†Bell's palsy or other peripheral neuropathy, dystonia, necrotizing granulomatous lesion, intracranial neoplasm or other oncologic process, peripheral vertigo, recrudescence of prior stroke symptoms, subdural fluid collection, symptomatic anemia, syncope, or vaso-occlusive crisis without central nervous system involvement.

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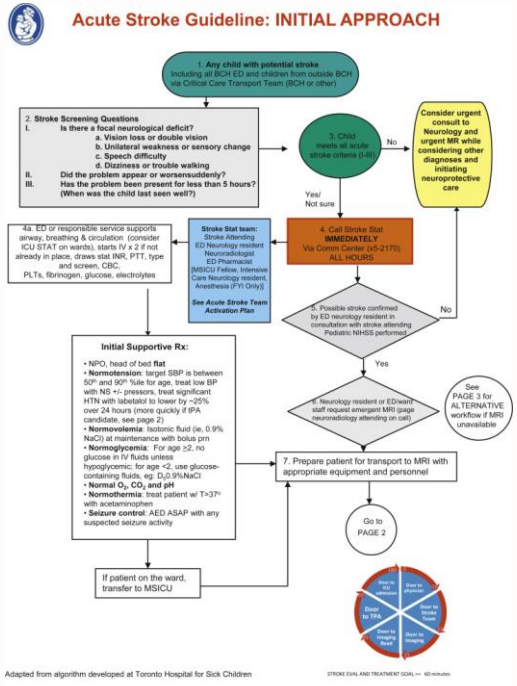
Ferriero et al, Stroke 2019; Harrar et al, J Pediatr 2019

Pediatric acute stroke protocols

TIPS (Thrombolysis in Pediatric Stroke) study

- Phase 1 clinical trial to determine the safety and efficacy of IV-tPA in children
- Closed due to low patient enrollment
- Resulted in the establishment of systems for the evaluation and management of a child with a hyperacute AIS



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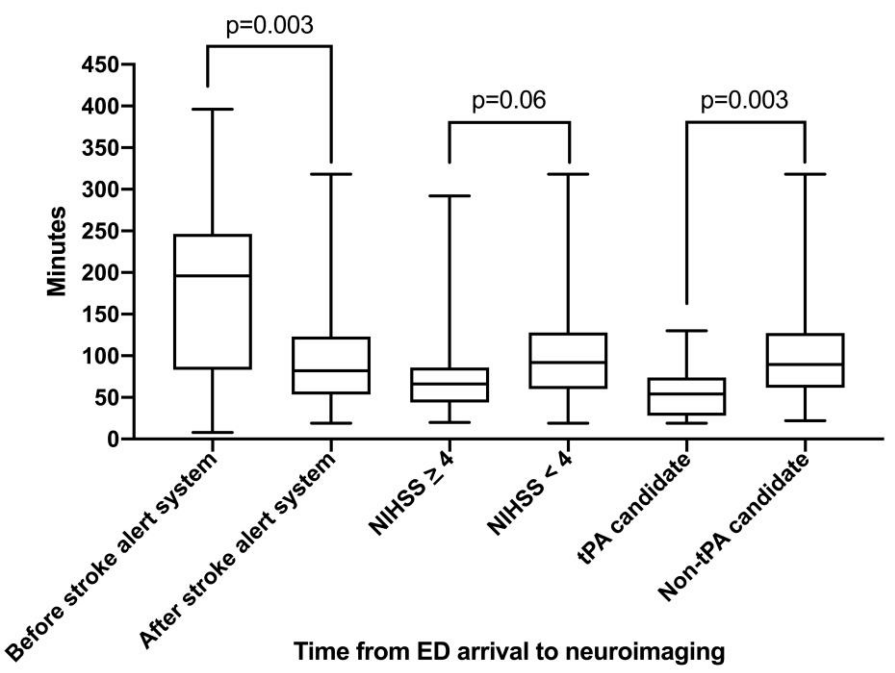
Bernard et al, Stroke 2014; Rivkin et al, Stroke 2015

Impact of pediatric acute stroke protocols on time to diagnosis



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Harrar et al, J Pediatr 2019

Impact of pediatric acute stroke protocols on time to diagnosis

- 79 minutes from ED arrival to imaging at a free-standing children's hospital after the implementation of an acute stroke protocol (Ladner et al, Stroke 2015, Wharton et al, J Pediatr 2020)
- Time from ED arrival to MRI of 17 hours before and 4 hours after the implementation of a stroke clinical pathway at a free-standing children's hospital (DeLaroche et al, Pediatr Neurol 2016)
- 60 minutes from neurology evaluation to imaging for children at a comprehensive stroke center in MD (Catenaccio et al, J Child Neurol 2020)
- 165 minutes from symptom onset to MRI as part of a regional pediatric acute stroke protocol in France (Tabone et al, Stroke 2017)

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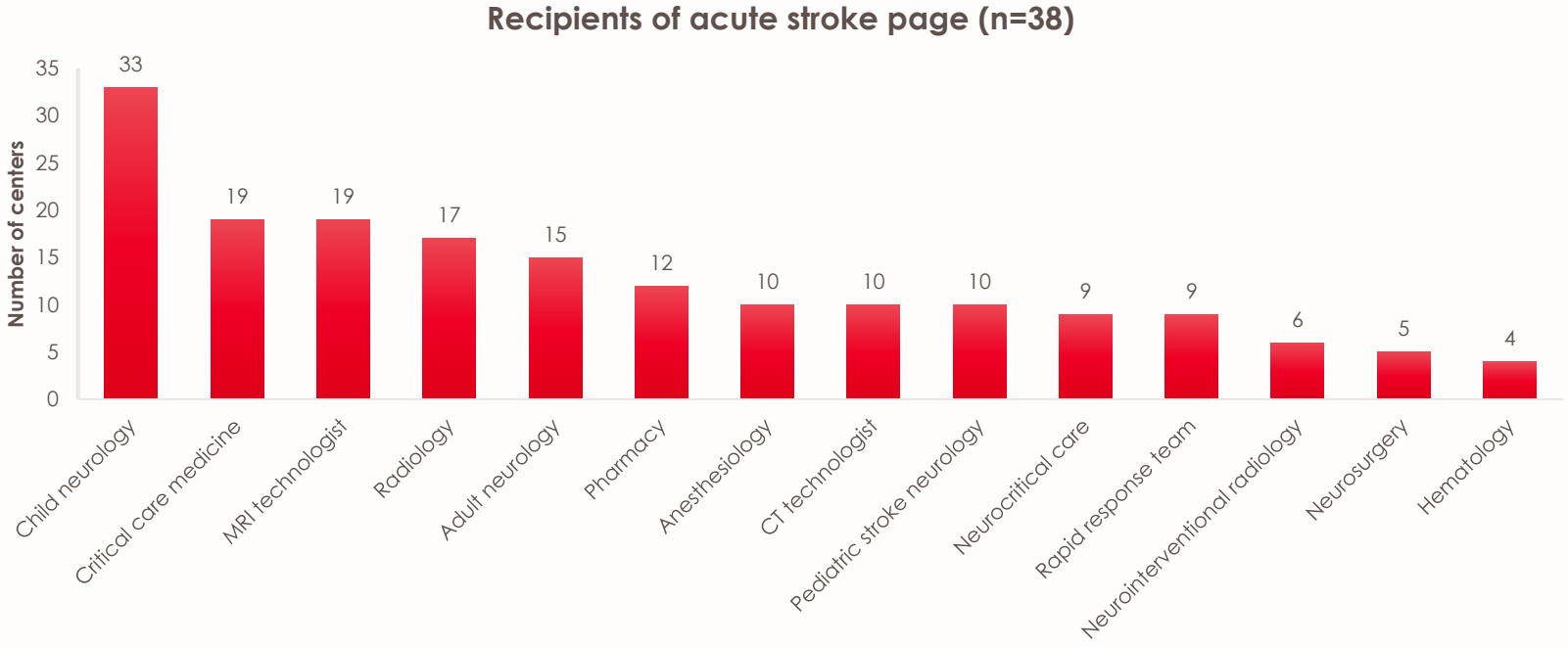
Components of a pediatric acute stroke protocol: Multidisciplinary team



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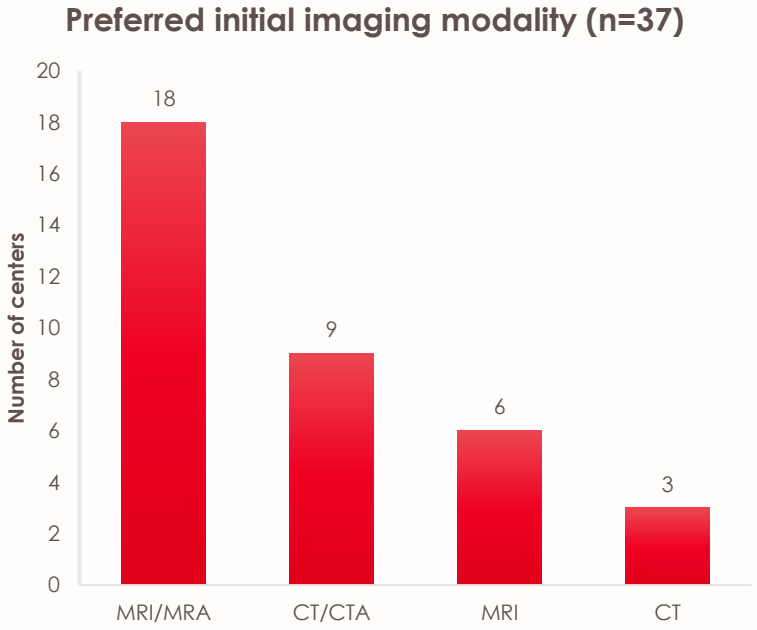
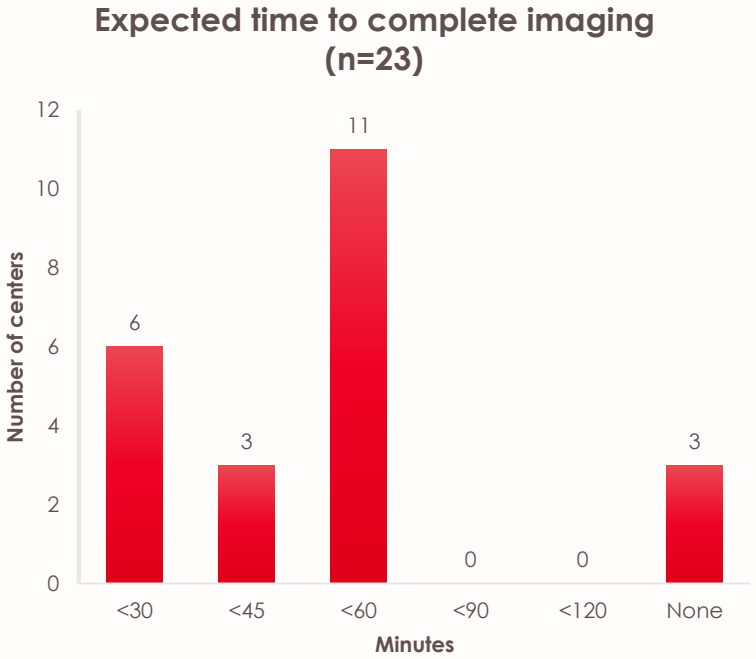
Components of a pediatric acute stroke protocol: Timely neuroimaging





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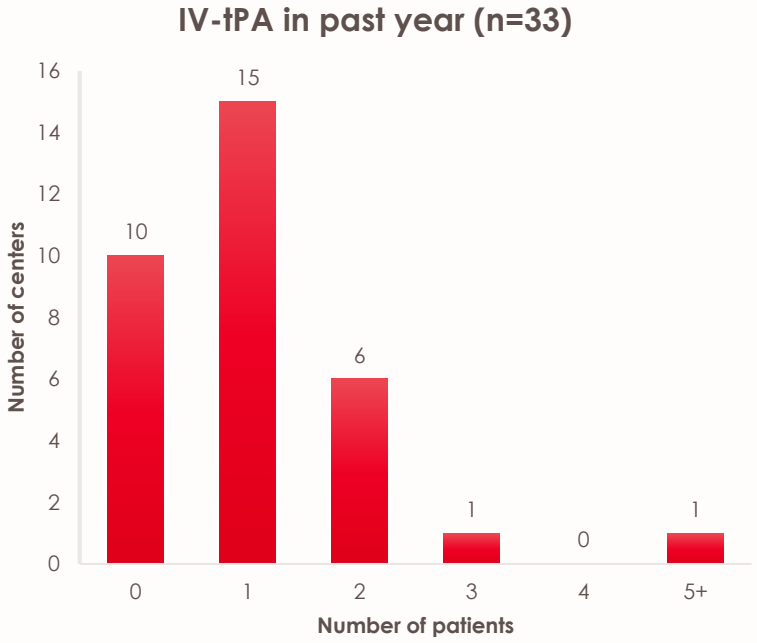
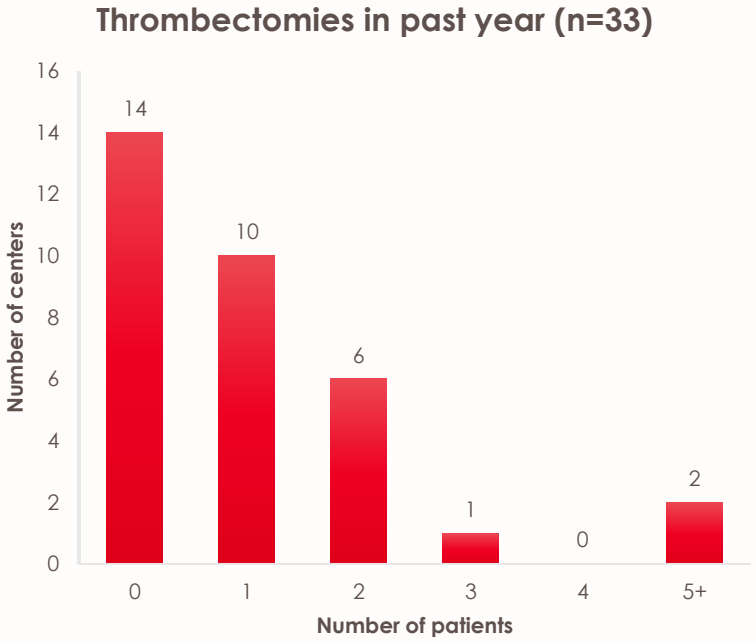
Components of a pediatric acute stroke protocol: Hyperacute therapies





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Goals of acute imaging in suspected pediatric stroke

To assist in the differentiation of a stroke from a stroke mimic

If a stroke is present, to identify:

- Vascular distribution
- Size of infarct
- Presence of associated hemorrhage
- Presence of an arterial clot
- Presence of an acute or chronic arteriopathy

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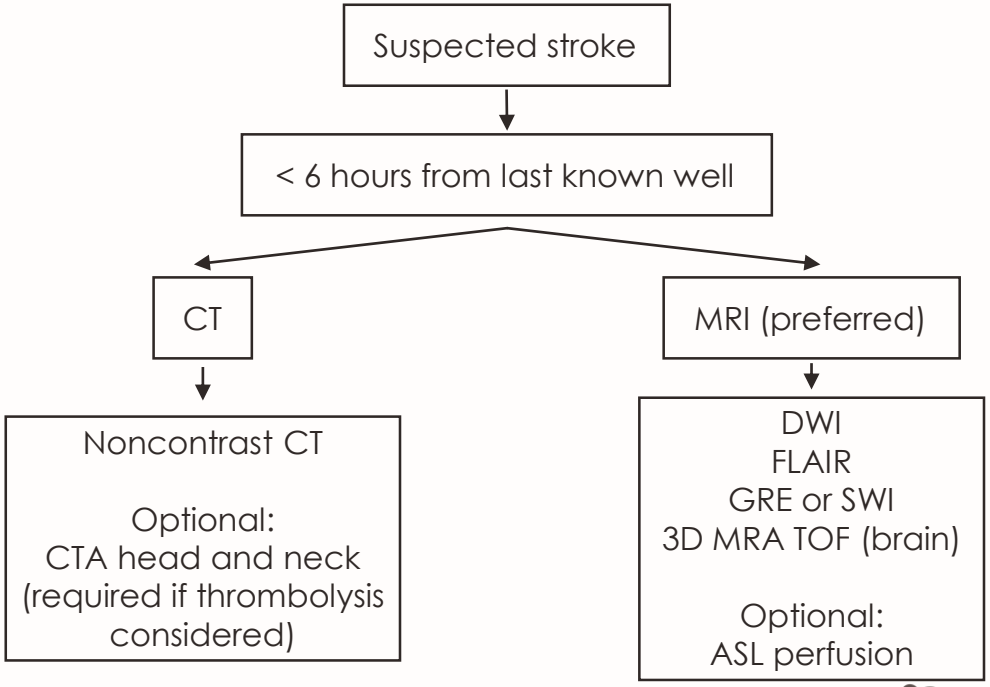
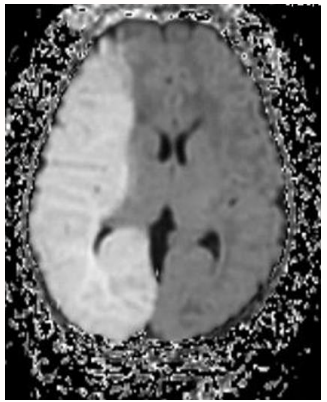
Mirsky et al, Pediatr Neurol 2017

International Pediatric Stroke Study Neuroimaging Subgroup





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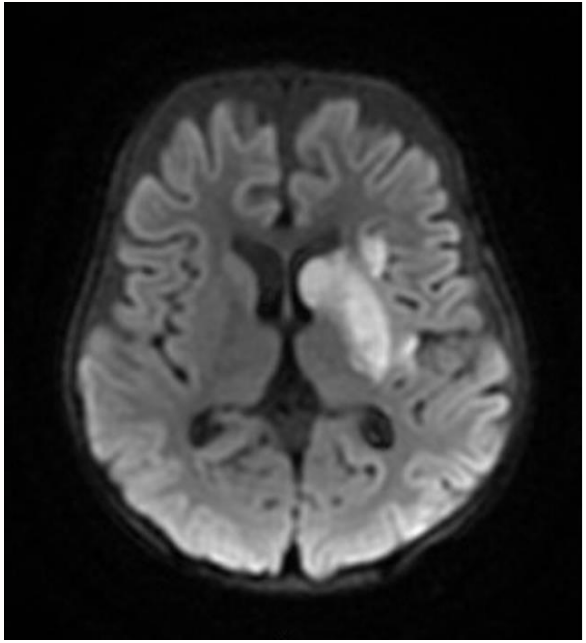
Adapted from Mirsky et al, Pediatr Neurol 2017

Acute neuroimaging protocols in pediatric stroke

Quick brain MRI + DWI

- Quick brain = Sagittal, axial, and coronal T2-weighted fast spin-echo images
- Axial DWI added for AIS evaluation
- 10 patients with AIS
  - Median age 3.4 years
  - Mean of 5.4 minutes acquisition time
  - 100% sensitive for AIS
  - Missed petechial hemorrhage in one patient



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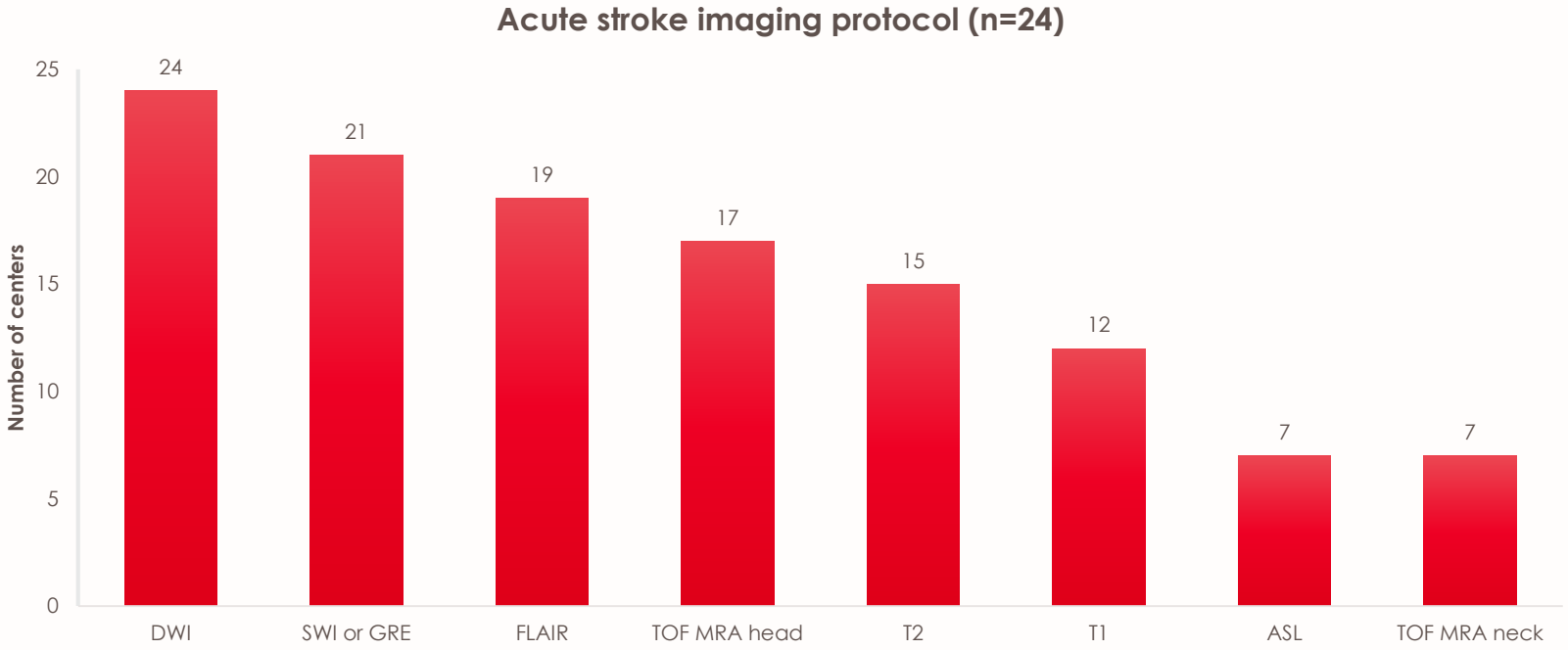
Christy et al, Pediatr Neurol 2018

Acute neuroimaging protocols in pediatric stroke



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Advanced imaging techniques in acute pediatric stroke

Perfusion imaging pivotal in selecting adults for mechanical thrombectomy 6-24 hours from time last seen well

Perfusion imaging also feasible in children

- Optimal penumbral thresholds may differ from adults
- Case series of 12 pediatric patients considered for thrombectomy
  - Tmax threshold of > 4 seemed to better represent critical hypoperfusion
  - ASL lesion appeared to correlate with the Tmax > 4 volume

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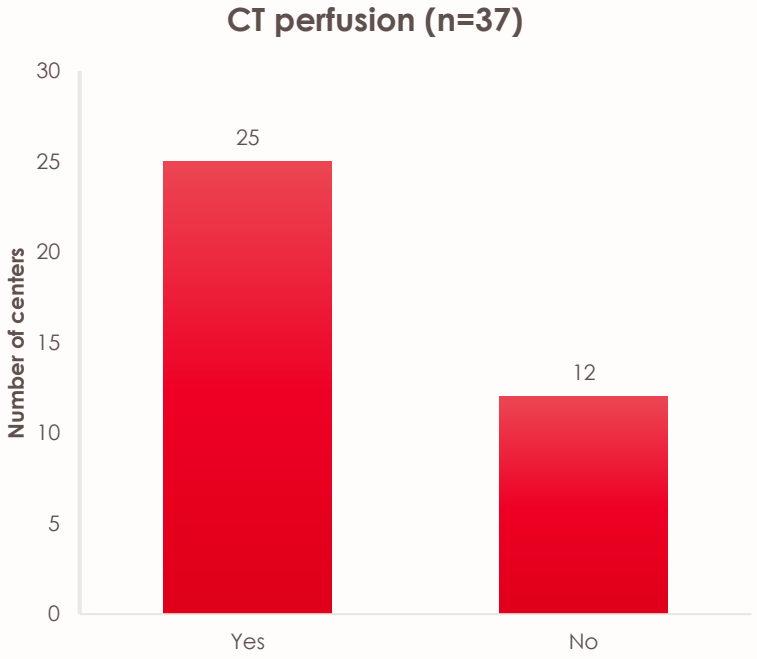
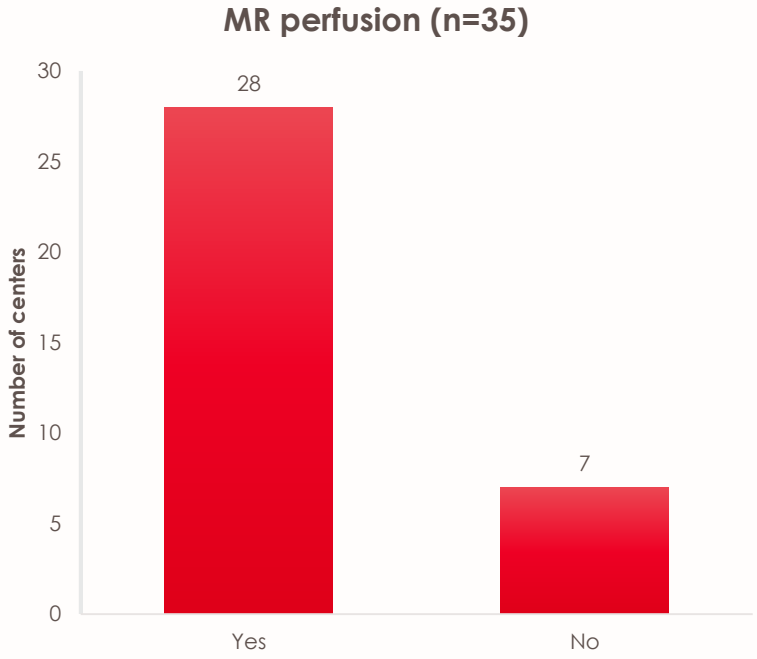
Lee et al, J Neurointerv Surg 2019

Availability of perfusion imaging at centers with pediatric stroke protocols





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Future directions

Streamlining stroke imaging protocols with goal of:

- Diagnosing stroke syndromes with minimal delay
- Evaluating the vasculature for risk factors that might impact management

Determining the role of perfusion weighted imaging in candidates for late-window thrombectomy

Establishing regional stroke protocols for the rapid evaluation, management, and transfer of children presenting to hospitals without pediatric stroke expertise

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Acknowledgements

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Thank You!

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