Emerging Clinical Application for TCD Ultrasound in Pediatric Critical Care: A Case-Based Discussion

Penetrating TBI

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Conflicts

- No conflicts or financial disclosures that relate to this session.
- The content of this presentation does not contain reference to, nor advocates use of, unlicensed medicines or devices.

Objectives

1. Review current practices of utilizing Transcranial Doppler ultrasound in pediatric neurocritical care.

2. Discuss how Transcranial Doppler ultrasound can be applied in a variety states of children with critical illness.

3. Discuss controversies in management when applying Transcranial Doppler ultrasound to guide clinical management in critically ill children.

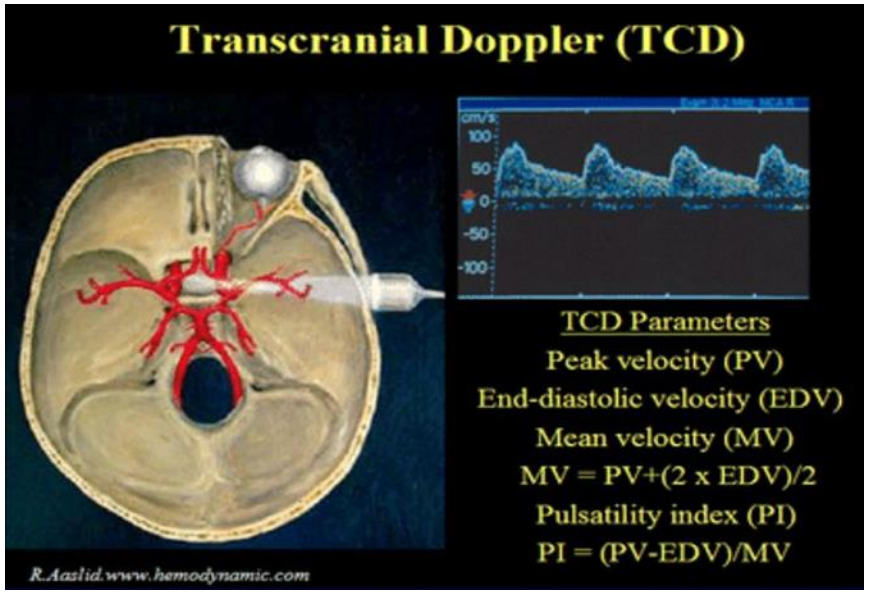
Purpose of this case

- To describe the use of Transcranial Doppler (TCD) ultrasound as an important non-invasive neuromonitoring device in penetrating traumatic brain injury (TBI)

Misrahi, S. & Reuter-Rice, K. (2020). Transcranial Doppler ultrasound use in pediatric patients with penetrating traumatic brain injuries. *Journal of Radiology Nursing*. 39(1), 39-43. PMID: 28947894. PMCID: PMC5609698

Transcranial Doppler Ultrasound

- Noninvasive, safe, portable ultrasound study
- TCD studies in pediatric TBI identify abnormalities in:
  - cerebral blood flow velocity (CBFV)
  - cerebral autoregulation
  - embolic events



Firearm-related Penetrating TBIs

- Per CDC:
  - 2010 = 1,355 per 100,000 ED visits in children 0-24 years
  - 2019 = 2,824 children age 0-19 years died by firearm with an additional 13,723 being injured/annually
- True incidence unclear as often TBI classified as “other”
- Leading suicide method for males aged 15–19 years
- Firearm related suicides result in a 90% death rate
- The most common anatomic injury location: head, face, neck, and/or spine, respectively

CDC, 2012; CDC 2019

Sequelae firearm-related Penetrating TBIs

- The projectile (bullet) trajectory can cause:
  - multiple cerebral contusions, hemorrhage from vascular damage, and localized necrosis within the brain
- Additionally compression and stretch by the shock wave, heat from the friction when the bullet penetrates the tissue, and may transect the nerve trunk(s)
- Combined, these injuries can cause:
  - cerebral edema, increase intracranial pressure, ongoing vascular injury, increased risk for cerebral vasospasm, and infarction

https://radiopaedia.org/cases/gunshot-wound-to-head-2

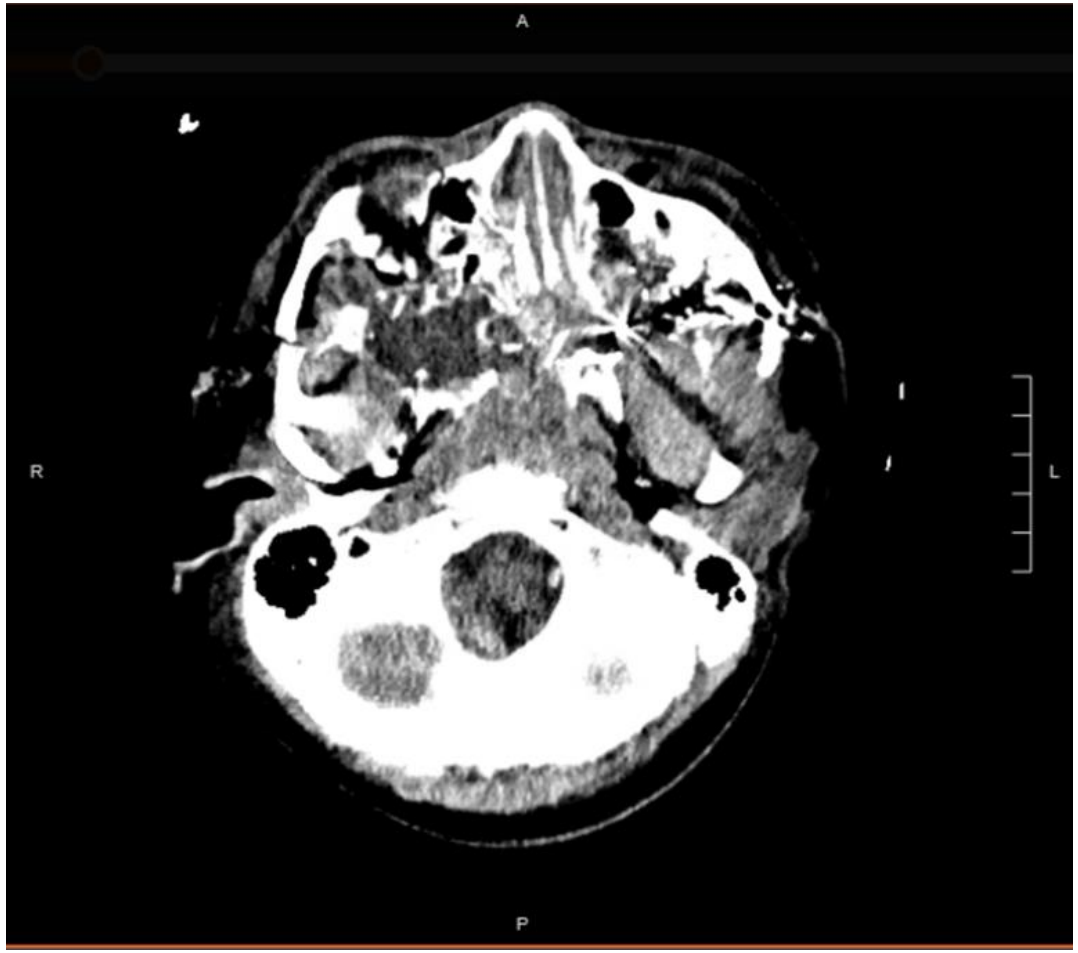
Methods

- We examined the use of daily TCDs in thirty-five children (10 days – 15 years) admitted for TBI to a level 1 trauma center
  - N=2 sustained penetrating firearm-related TBIs
- Daily TCDs by a certified TCD sonographer at the patient's bedside
- Bilateral MCAs and BAs to detect abnormal cerebral blood flow velocities (CBFV), and embolic signals "high-intensity transient signals" (HITS)
- Measurements per: **Practice recommendations for Transcranial Doppler ultrasonography in critically ill children in the pediatric intensive care unit: A multidisciplinary expert consensus statement**. *Journal of Pediatric Intensive Care*. Ahead of Print. doi: 10.1055/s-0040-1715128

Case

- Adolescent male self-inflicted gunshot wound; GCS of 5 in ED
- Obvious facial trauma and brain penetration
- Wound through-and-through with facial bone and basilar skull fractures
- CT positive for a right cerebral infarction
- Admitted to the PICU, intubated, sedated, external ventricular drain (EVD)
  - ICP of 10-16 mmHg with peaks between 21-51 mmHg
- Received one adult unit of PRBC for a H&H 7.5 gm/dL and 23%
- TBI management included maintaining a mild hypernatremic state (max sodium 158 mg/dL) and daily antiepileptic prophylaxis

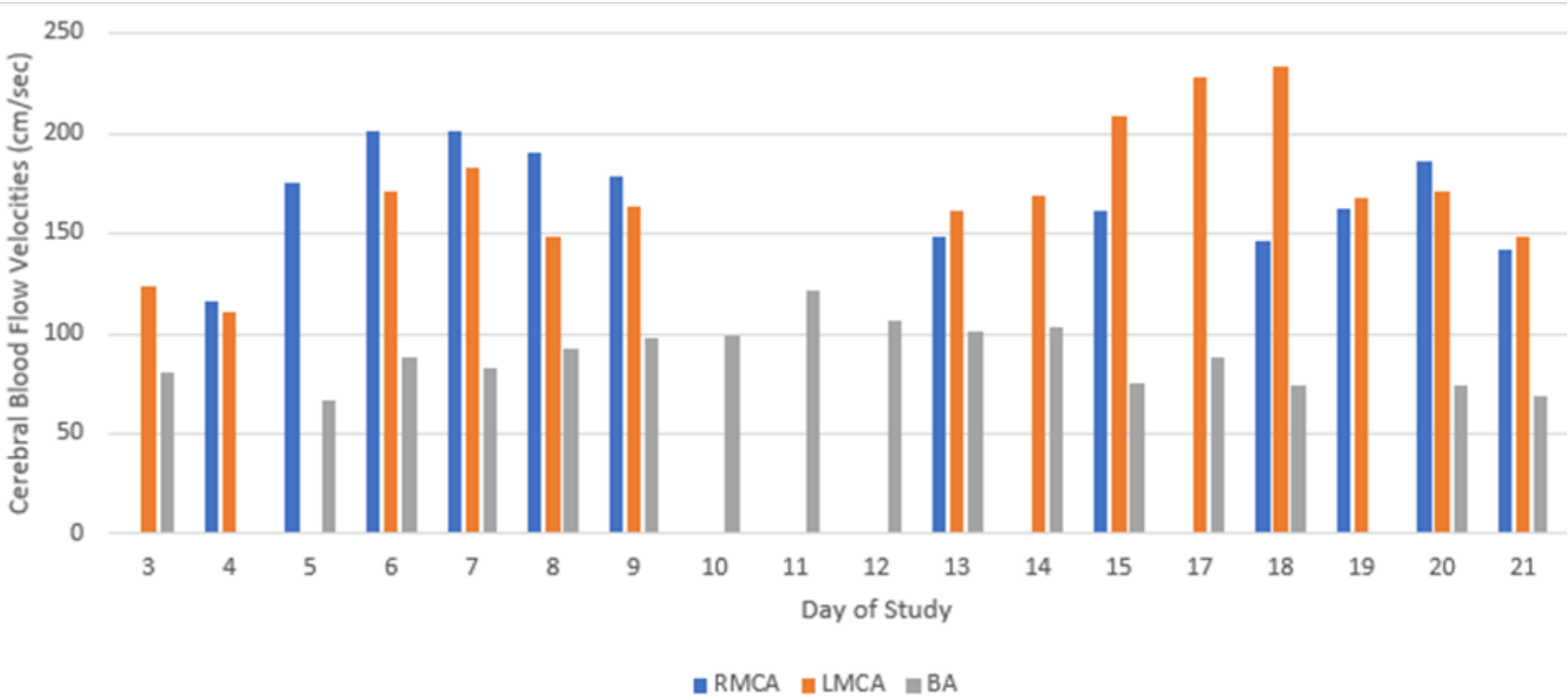
Head/Brain CT no contrast



TCD – day 7


L-MCA 50 2
139
Mean
0.98
PI
BA 85 2
Mean
-60.8
PI
0.91
R-MCA 50 2
84.3
Mean
0.59
PI
L-MCA 55 2
157
Mean
0.80
PI
BA 90 2
Mean
-73.2
PI
0.79
R-MCA 55 2
90.9
Mean
0.60
PI
L-MCA 60 2
171
Mean
0.82
PI
BA 95 2
Mean
-77.8
PI
0.79
R-MCA 60 2
201
Mean
0.62
PI
L-MCA 64 2
171
Mean
0.78
PI
BA 100 2
Mean
-87.8
PI
0.71
R-MCA 64 2
187
Mean
0.63
PI
L-EX-ICA 50 2
Mean
-37.0
PI
1.32
R-EX-ICA 50 2
Mean
-28.5
PI
1.13

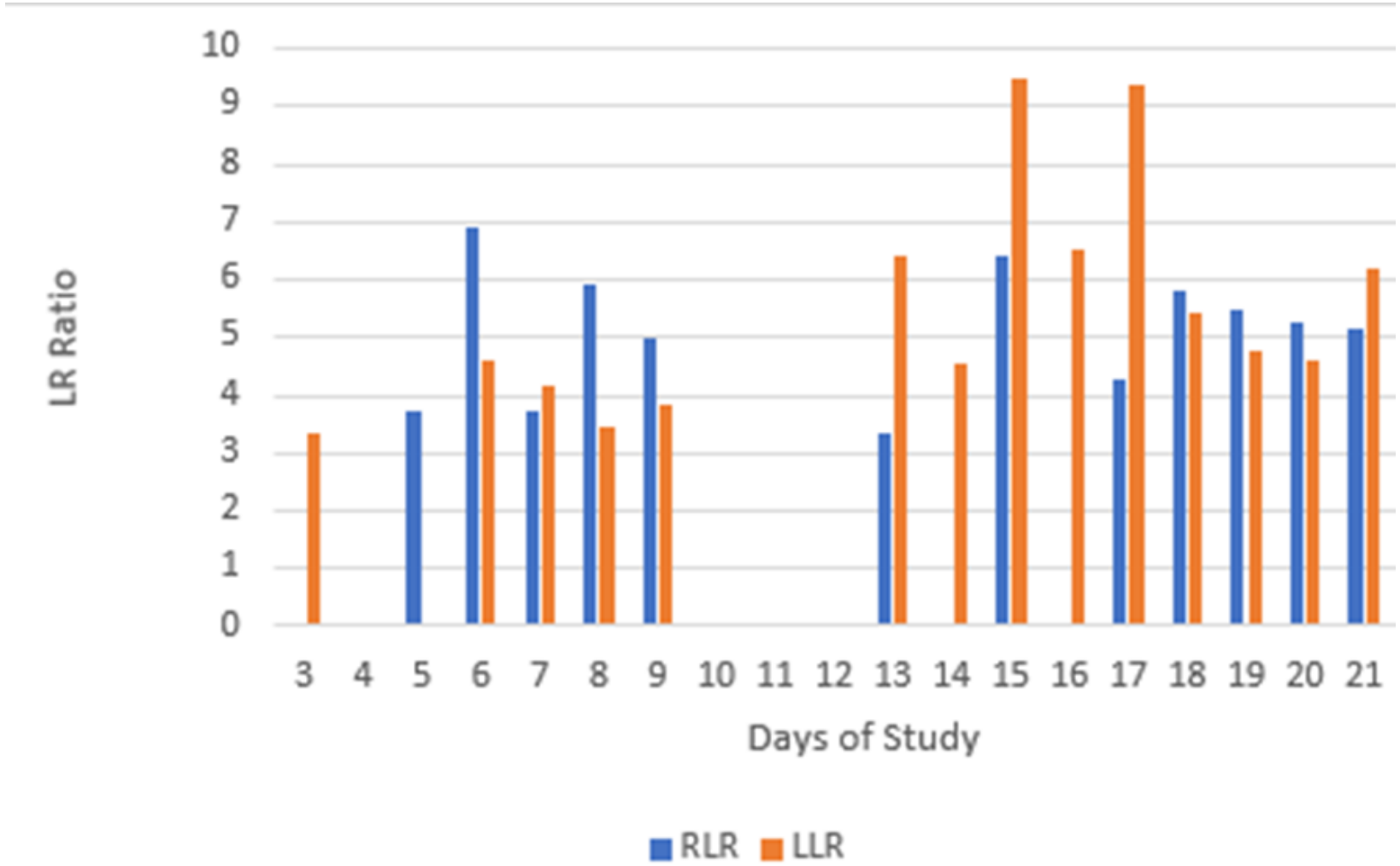
Daily Bilateral MCAs and BA CBFV in Adolescent Male



- Mean MCA velocity was > 103 cm/sec and mean BA velocity was > 90 cm/sec
- Both are higher than normal for age/sex
- Some data is missing due to study limitations

Legend: RMCA, LMCA, BA

Daily Bilateral Lindegaard Ratios in Adolescent Male



- RLR and LLR were ≥3 consistently
- This data coupled with the elevated MCA cerebral blood flow velocities indicated cerebral vasospasm
- Some data is missing due to study limitations

Results of Case

- TCD results captured unique findings that were not appreciated by clinical observation or basic bedside neuromonitoring
- TCD at the bedside for neurovascular surveillance after TBI resulted in interventions and additional management approaches
- The portable, noninvasive, non-radiation diagnostic nature of TCD allowed for frequent, safe and quick neurodiagnostics at the bedside
- TCD's utility provided timely and valuable information that led to additional and timely strategies to manage the TBI

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