Pediatric Traumatic Brain Injury: Pre-Transport Stabilization

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Objectives

- Define Pediatric Traumatic Brain Injury (TBI)
- Review the pathophysiology of Traumatic Brain Injury
- Review treatment guidelines & supportive therapies indicated for initial management of Pediatric TBI
- Review pre-hospital predictors of poor outcome

Glasgow Coma Scale

- Motor Response
  - 6 – obeys commands
  - 5 – localizes pain
  - 4 – withdrawal from pain
  - 3 – flexion response
  - 2 – extension response
  - 1 - none
- Verbal Response
  - 5 – oriented
  - 4 – confused
  - 3 – inappropriate words
  - 2 – incomprehensible words
  - 1 – none
- Eye Response
  - 4 – spontaneous opening
  - 3 – opening to verbal command
  - 2 – opening to painful stimulus
  - 1 – none

GCS; Pediatric Modifications

- Child Verbal
  - 5 – appropriate words
  - 4 – inappropriate words
  - 3 – persistent cry
  - 2 – grunts
  - 1 – none
- Infant Verbal
  - 5 – coos & babbles
  - 4 – irritable cries
  - 3 – cries
  - 2 – moans
  - 1 – none

TBI Defined

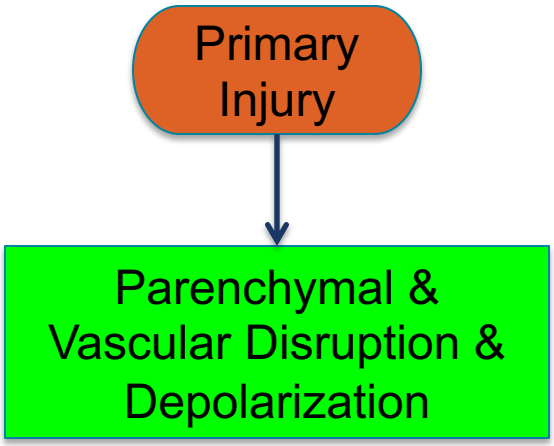
- Mild aka ‘concussion’
  - ≥1 period of transient confusion, disorientation or impaired consciousness
  - any period of observed or reported amnesia lasting <24hrs
  - signs of other neurologic or other neuropsychological dysfunction e.g. post-traumatic seizures, irritability, lethargy, or vomiting post head injury in young children
  - GCS ≥13 at time of first eval & GCS = 15 at ED discharge or at 24hrs post injury if hospitalized

TBI Defined

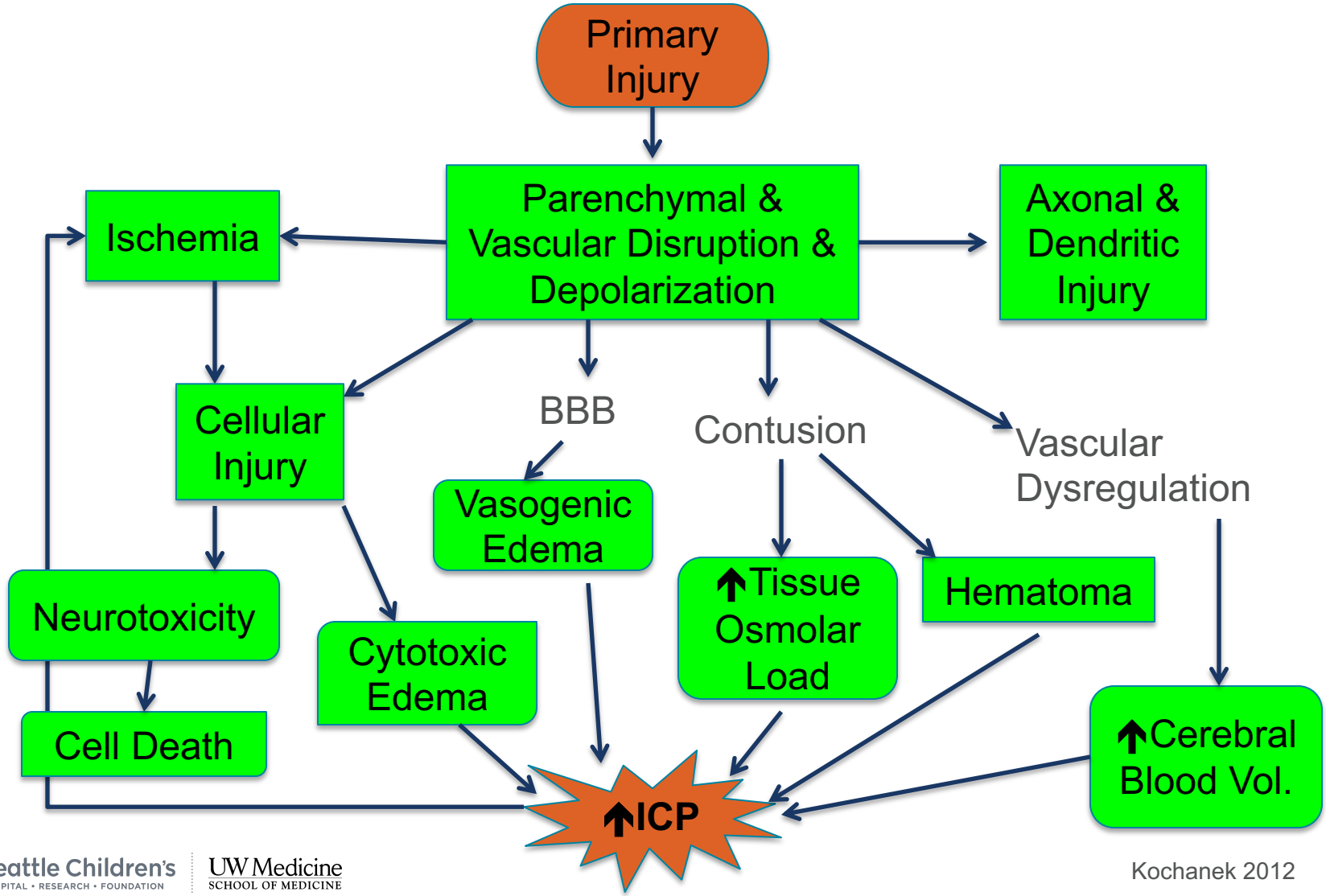
- Moderate
  - all of ‘Mild’ plus
  - motor GCS = 4 or 5 at 24hrs post injury or motor GCS = 6 but doesn’t meet Mild criteria
- Severe
  - all of ‘Mild’ plus
  - maximal motor GCS < 4 in the 24hrs post injury

Pathophysiology

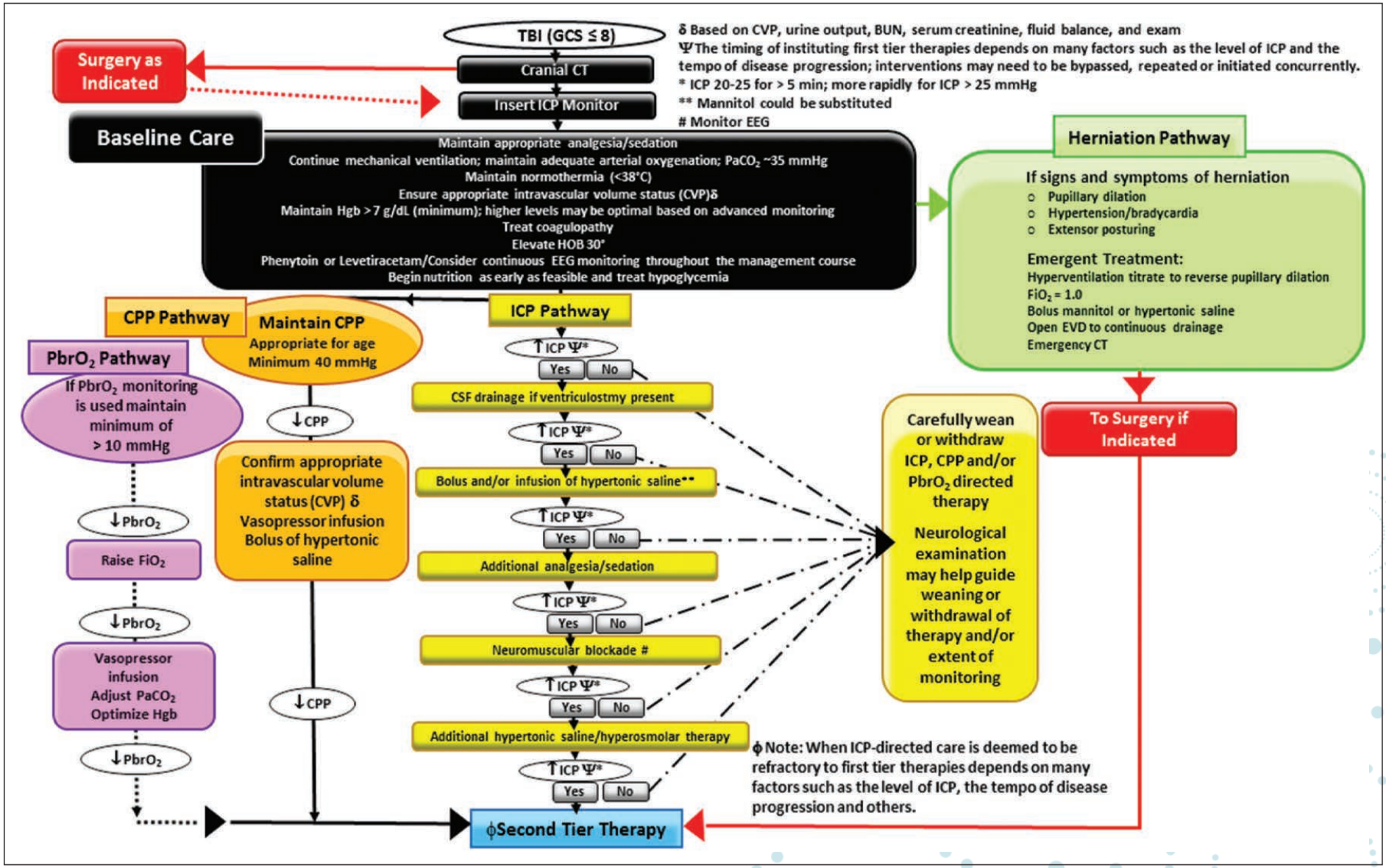
- Primary Injury
  - direct disruption of brain parenchyma
  - varies substantially based on mechanism



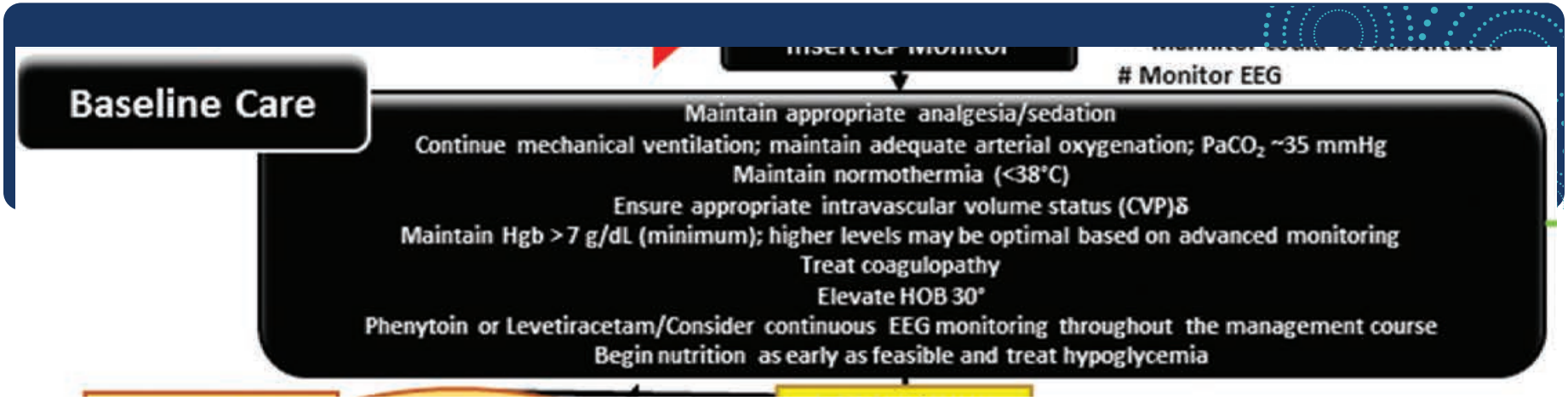
Pathophysiology



Kochanek 2012



Kochanek 2019



- 'Baseline Care' AKA – 'Tier 1'
  - Appropriate Analgesia & Sedation
  - Normoxia (SpO2 ≥ 95%; PaO2 90-100mmHg)
  - Eucapnia (PaCO2 35-40mmHg)
  - Aggressive Normothermia (< 38°)
  - Euvolemia
  - Normotension (MAP 50% for age)
  - Head of Bed ≥ 30° (if possible)
  - Prevent & Treat seizures
  - Normoglycemia
  - Normonatremia

Kochanek 2019

daily for ICP > 25 mmHg

Herniation Pathway

If signs and symptoms of herniation

- Pupillary dilation
- Hypertension/bradycardia
- Extensor posturing

Emergent Treatment:

Hyperventilation titrate to reverse pupillary dilation

$FiO_2 = 1.0$

Bolus mannitol or hypertonic saline

Open EVD to continuous drainage

Emergency CT

To Surgery if Indicated

Carefully wean or withdraw ICP, CPP and/or

Kochanek 2019

Pre-Hospital Therapy & Guidelines

- The Guidelines 2003, 2012 & 2019
- Trauma Systems: good

- Airway & Breathing
  - Hypoxemia → Avoid
  - Field Intubation → ? (but if done, train & use EtCO2)
  - "Prophylactic" hyperventilation → Avoid
- Circulatory Support
  - Hypotension → Avoid
    - Defined: 5% for age >1 SBP = 70 + 2 x age (yrs)
  - Normotension → Ideal
    - Defined: Median for age >1 SBP = 90 + 2 x age (yrs)

Adelson 2003; Kochanek 2012 & 2019

Pre-Hospital Therapy & Guidelines

- Circulation/Disability
  - Cerebral Perfusion Pressure
    - MAP – ICP
    - 40 – 50mmHg for infants & toddlers
    - 50 – 60mmHg in children
    - > 60mmHg in adolescents
  - Clinical Example
    - 2 ½ yo with an ICP ~ 20mmHg
      - 5% SBP ~ 75 mmHg → MAP ~ 60mmHg CPP = 40mmHg
      - Median SBP ~ 95 mmHg → MAP ~ 70mmHg CPP = 50mmHg

Kochanek 2012 & 2019

Pre-Hospital Therapy & Guidelines

- Disability
  - Hyperosmolar Therapy
    - Hypertonic Saline
    - Mannitol
- Exposure
  - Temperature
    - 2 RCTs of Therapeutic hypothermia in Peds TBI
    - Both showed no difference in outcomes
    - Aggressive Normothermia is the current standard of care

Kochanek 2012, 2019; Adelson 2013; Hutchison 2008

Outcomes

- King County
  - Overall: 5% Hospitalized & 1.2% mortality
  - Of hospitalized: ~24% mortality
  - ‘Health related Quality of Life’ in moderate & severely Injured
    - Lower at 3, 12 & 24 months post injury
    - Some improvement at 24 months
    - Activities impaired at 3 months
    - Activities improved at 12 & 24 months but still quite impaired
    - Communication & self care impaired at 3 months
    - Communication & self care not improved by 24 months

Koepsell 2011; Rivara 2011

Outcomes

- Risk factors for Poor (GOS ≤ 3) outcome
  - Rome Series (15% mortality)
    - GCS
    - Coagulopathy
    - Episode of Hypoxia or Hypotension
    - Early Post-traumatic seizures
    - Hyperglycemia
  - Paris Series (22% mortality)
    - GCS
    - Injury Severity Score
    - Hypotension on arrival

Chiaretti 2002; Ducrocq 2006

Key Points

- The primary severe TBI represents the onset of a cascade of secondary injuries
- Detailed management & manipulation of multiple organ systems in TBI patients is focused on preserving brain perfusion & thereby preventing secondary injury
- Preventing secondary brain injury after TBI is rooted in the ABCs
- Pre-hospital hypoxemia & hypotension have been associated with morbidity & mortality

Pediatric Traumatic Brain Injury

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