Surviving Traumatic Brain Injury: The Journey

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Speaker Disclosure

• I have no financial relationships to disclose
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Learning Objectives

• Discuss the demographics of the pediatric population at highest risk to suffer a traumatic brain injury (TBI).
• Describe the neuroanatomy associated with TBI and subsequent sequelae which impact rehabilitation and long term recovery.
• Utilize a case-based approach to illustrate the progression from acute care through inpatient rehabilitation to discharge with outpatient services for the patient and family.
Traumatic Brain Injury (TBI)

- "acquired brain injury from blow to head or penetrating head injury that disrupts the normal function of the brain"
- Can be diffuse or focal
- Acquired brain injury
  - Traumatic
  - Post-embolic (stroke)
  - Post-infectious (meningitis, encephalitis)
  - Post-surgical (brain tumor)

Epidemiology

- Estimate 1.7 M TBI annually
- Age in years
  - 0-4 (highest)
  - 15-19
  - >65
- Gender
  - ~2/3 M > F across ages
  - M death 3x > F
- Contributes to ~1/3 of injury related deaths/yr

Grading of TBI

- Glasgow Coma Score (GCS)
  - Standardized 15 point test uses 3 measures
    - Eye opening
    - Best verbal response
    - Best motor response
- Severity of TBI based on GCS
  - Mild = 13-15
  - Moderate = 9-12
  - Severe = 3-8
Causes of TBI

#1 Falls  
- 50% age 0-14 yrs

#2 MVC  
- all age groups  
- 31.8% of TBI-related deaths

#3 Struck by/against events

#4 Assault  
- 2-9% child age 0-14

Annual TBI age < 19

- Bicycle 26,212
- Football 25,376
- Playground 16,706
- Basketball 13,987
- Soccer 10,436
- Baseball
- ATV
- Skateboarding
- Hockey
- Misc

Socioeconomic

- Impacts individual, family, and society  
  - Psychological stress  
  - Economic burden  
  - Loss of productivity/contribution to society

- Cost of severe TBI (fatal and hospitalized) accounts for 90% of total medical costs  
  - TBI cost $76.3 Billion in 2010  
  - About 3% of injured have disabilities 1 year post injury

- Need for supportive services  
  - Use of resources  
  - Educational forums  
  - Specialty services
Mild TBI- Concussion

• Definition: “complex pathophysiological process affecting brain induced by traumatic biomechanical forces”
• GCS- 13-15
• Simple
  — Resolves in 7-10 days
• Complex
  — Signs/symptoms persist
  — Suffered multiple concussions or with associated sequelae (seizure, LOC > 1 min or prolonged cognitive impairment)
• Sports Related Concussion
  — Typically low velocity impact
  
Epidemiology

• “Silent Epidemic”
• Recovery usually fairly rapid, spontaneous, complete
• Most of cognitive effects resolve by 3-6 months
• Results from direct or indirect blow
• Functional not Structural-
  — MRI likely WNL

Sports Related Mild TBI

• Higher in competition versus practice
  — Football (highest rate)
  — Ice hockey (concussion greatest # of total injuries)
  — Boys Lacrosse
  — Girls soccer
• F > M in gender comparable sports
• Player-player contact
• 6 x greater in organized sports than leisure per AAP

Meehan & Bachur. 2009
DeMatteo et al. 2010.
Concussion Symptoms

- Prolonged headache - may worsen with cognitive function or exercise
- Dizziness
- Impaired concentration - feel “foggy”, groggy, sluggish
- Vision Disturbances (photophobia, diplopia, blurred vision)
- Nausea/Emeris
- Impaired balance
- Confusion
- Memory Loss
- Tinnitus/Phonophobia
- Loss of smell or taste
- Hyper excitability / irritability / fatigue / personality changes
- Seizures
- LOC / altered mental status-drowsiness
- Amnesia (antegrade or retrograde)
- Symptoms may be subtle, short lived, and resolve spontaneously

www.aans.org; Meehan 2010.

Sideline Assessment Tools

SCAT2
(Sports Concussion Assessment Tool 2)

- Pocket card or download app
- Detailed exam of injured athlete at sideline
- Asks sports specific ? to test memory/cognition
- Serial exam q5min
  - until baseline

General Management Principles

- No return to play until S/S completely resolved at rest & exercise
- Younger child requires longer recovery times
- Computerized neuropsychological tests “cornerstone of concussion evaluation”
- Loss of consciousness is not necessary and relatively uncommon with concussion.

Meehan, W. et al. 2010
After Concussion

Post-concussive Syndrome

- Constellation of physical, cognitive, emotional, behavioral symptoms may persist for 1-6 weeks or months
- Irritability/mood swings, personality changes, headache (tension type or clusters), fatigue, dizziness, insomnia and excessive drowsiness, balance deficits, memory and concentration deficits
- No return to play while symptomatic or on medications
- Study by Barlow et al., ~14% school aged children were symptomatic 3 months post-injury
- If suffer repeated concussion, consider stopping sport


Immediate Post-concussion Assessment and Cognitive Testing

Making an ImpACT

Second Impact Syndrome

- “malignant brain swelling” - disrupted autoregulatory control over CBF leading to vascular engorgement and marked increased ICP followed by uncal herniation or herniation of cerebellar tonsils
- Results from diffuse cerebral edema with rapid decompensation after a second insult is sustained before complete recovery from a previous concussion.
- Increased risk of occurrence in sports such as football, soccer, boxing, hockey (ice or roller), baseball, basketball and skiing

Return-to-Play

**Stepwise approach** based on level of activity
1. Complete rest (physical & cognitive)
2. Light aerobic exercise (walk, stationary cycle)
3. Sport-specific exercises (skate, run) + light resistance training
4. Noncontact training drill/increased resistance training
5. Full contact training after medical ok
6. Game play

McCrory et al. 2009

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Treatment

Concussion can affect 4 areas:

- **COGNITION**
  - Cognitive rest
    - No return to school until symptoms abate
    - Focus deficits after 4-6 weeks
- **DISCOMFORT**
  - Headache (tension like)/dizziness
- **SLEEP**
  - Sleep disruption
- **MOOD**
  - Irritability/personality changes

**Challenges:**

- Don't look injured or unwell
- Distractibility or restlessness seen as laziness or deliberate behavior "acting out"
- Can have long-term cognitive, attentional, and behavior difficulties
- May need adaptations for school-rest periods, etc.
- Need structured environment w/ minimal distractions

Hawley, 2005; Ponsford et al. 2001

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Prevention

- **Wear sport specific Helmet & protective gear 100 % of time**
  - Helmet approved by American Society for Testing and Materials (ASTM)
  - Ongoing research re: helmet design
  - No clothing which interferes with vision
- **Adult supervision of younger child at all times**
- **Do not permit child to engage in sport unsuitable for their age/developmental level**
- **Strengthen & conditioning of neck muscles**
- **No diving in water less than nine feet deep or in above-ground pools**
- **Do not participate in sports or activities when you are ill, under influence of drugs/alcohol, or fatigued.**
- **Be alert for vehicles and avoid uneven or unpaved surfaces when cycling or skateboarding.**

www.aans.org
Moderate to Severe TBI

• Moderate
  – GCS 9-12
• Severe
  – GCS 3-8

“Meet Sam…” Case study

Impact of TBI

• Cognition (attention and memory)
• Motor (extremity weakness, impaired coordination and balance)
• Sensation (hearing, vision, impaired perception and touch/neuropathic pain and paresthesias)
• Emotion (depression, anxiety, aggression, impulse control, personality changes)
Executive Function “Umbrella”

• “set of inter-related skills necessary to maintain appropriate problem solving abilities to achieve a goal”
• Enables goal directed behavior
• Include:
  – Planning
  – Problem solving
  – Organizational skills
• Emerge 1st year of life & develop into late adolescence
• Required for independence as well as educational and social success

Executive Function Interventions

• Break it down...
  Make task shorter
  Make steps more explicit

Six strategy steps:
1. Describe the problem
2. Set a goal
3. Establish set of steps to reach goal
4. Supervise performance of steps
5. Evaluate process and make needed changes
6. Fade the supervision

Rehabilitation Goals

Mechanism of TBI recovery:
1) Restitution
2) Substitution
Rehab uses alternative strategies to compensate for cognitive deficits and lessen the functional impact

COMMON GOALS
• Manage comorbidities and minimize complications
• Maximize potential for functional independence
• Facilitate neurocognitive recovery
• Educate parents/caregivers for transition to home
• Initiate reintegration into school
• Establish ongoing outpatient care
• Establish medical home

Catroppa & Anderson. 2006
Mechanism of Injury

Coup ("blow")
- Shearing
- Twisting

Contrecoup ("counter-blow")
- Contusion
- Swelling
- Blood clots

Diffuse Axonal Injury (DAI)

Axon
- Is the elongated fiber that extends from the cell body to the terminal endings and transmits the neural signal.

Myelinated axons transmit signals faster.

Most neurons have a single axon.
**Discharge Planning**

- Begins on admission/identify barriers
  - Parent employment
  - Parental physical or emotional limitations
  - Sibling or additional family members
- Home assessment
  - Structure, access, ability to accommodate needs
- Initial contact with school

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**Sam’s Rehab Story**

- Admitted one month post-injury
- **Rancho Los Amigos Level II - Generalized Response**
  - Patient reacts inconsistently and non-purposefully to stimuli in a non-specific manner.
    - Responses are limited in nature
    - Responses may be physiological changes, gross body movements, and/or vocalization.
    - Responses are likely to be delayed and often only to deep pain.
- Suggest to parents:
  - Bring familiar objects (toy), smells, and sounds (voices or music)

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**Rancho Los Amigos Scale**

- Responsiveness to stimuli
- Ability to follow commands
- Presence of non-purposeful behavior
- Cooperation
- Confusion
- Attention to environment
- Focus
- Coherence of verbalizations
- Appropriateness of verbalizations and actions
- Memory recall
- Orientation
- Judgment and reasoning

www.rancho.org/research_Rancholevels
www.rancho.org/research/cognitive_levels.pdf
Decompressive Craniectomy

Wee-FIM™

- Wee-FIM™ (Functional Independence Measure for children)
- 18 item performance based instrument that assesses mobility, self-care and cognitive abilities.
- Evaluated on admission q8hours for 24 hours and at discharge
- Evaluated for wheelchair seating upon admission
  - Tilt-in-space
  - Standard

Midbrain Dysfunction

- Corpus callosum
- Thalamus
- Pituitary gland
- Pars tuberalis
- Pons
Sam’s Week 2
Rancho Los Amigos Level III - Localized Response
- Patient reacts specifically, but inconsistently, to stimuli.
  - May withdraw to painful stimuli.
  - May inconsistently follow simple commands.
Suggest to parents:
  - Recognize and point out new responses.
  - Know that responses will be inconsistent at first.

Family/Team conference held:
- Discussed progress made/barriers
- Re-establish goals
- Discuss expectations
- Discharge planning - home vs. skilled nursing facility

FEN: Dysphagia

4 Stages of Swallowing:
1. Oral preparatory
2. Oral
3. Pharyngeal
4. Esophageal
Compensatory maneuvers: head position/texture modifications
Neuromuscular electrical stimulation
  - VitalStim

Deep Vein Thrombosis
- Requires 3-6 months of anticoagulation
  - Initially receiving subq enoxaparin or fragmin
  - Transitioned to oral warfarin with goal INR 2-3
  - Bridge with sub q anticoagulant until therapeutic
- Monitor extremities
- Imaging (Venous Duplex Scan)
Dyspraxia

- Difficulty performing motor tasks
- Is a sensory processing disorder
- Postural control is needed to perform refined movement of the head, eyes, and extremities
- Goal is to improve muscle tone, balance, coordination and motor planning

Spasticity/Hyper-reflexia

- Monitor for two weeks for natural improvement or development of contractures
- Maximize physical therapy
- Ask does it cause pain or interfere with function or quality of life?
- Use Ashworth Scale 0-4
  - Ordinal scale for measuring muscle tone
- Maximize pharmacological management with baclofen, dantrolene, diazepam, or clonidine
- Temporary local treatment
  - Botulism toxin serotype A: target muscle/ binds with acetylcholine receptor
- Evaluate for need of surgical intervention
**Dysphasia/Dysarthria**

- Broca’s aphasia
  - motor aphasia
- Wernicke’s aphasia
  - sensory aphasia
- Global aphasia
  - extensive damage to language centers
  - severe communication deficits
- Dysarthria
  - Damage to muscles used to form words and produce sounds

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**Sam’s Week 4**

**Rancho Los Amigos Level IV- Confused & Agitated**

- Patient is in a heightened state of activity with severely decreased ability to process information.
- Thrashing in bed, constant movement, safety concern
- Sensitive to light, noise, movement

Suggest to parents:
- Take a break!
- Quiet, safe environment. Limit visitors. Don’t be embarrassed.

- 70% exhibit agitation
- Safety concern

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**Sam’s Week 5**

**Rancho Los Amigos Level V- Confused & Inappropriate**

- Patient appears alert and is able to respond to simple commands fairly consistently
  - Appears alert; Easily distracted
  - Confused with impaired memory
  - Easily agitated

Suggest to parents:
- Reorient child to present and share details of past
- Provide and protect scheduled rest periods
- Be patient!
Sam's Week 6

Rancho Los Amigos Level VI- Confused & Appropriate

- Patient shows goal-directed behavior, but needs cues.
- He follows simple directions consistently and shows carry-over for tasks he has relearned (as self-care)

Suggest to parents:
- Be consistent. Repeat, repeat, repeat! Foster independence.

Sam's Week 7

Rancho Los Amigos Level VII- Automatic-Appropriate

- Performs daily routine automatically
  - Unsafe without supervision
  - Poor judgment, problem solving and planning skills
  - Remembers new things but at slower pace

Suggest to parents:
- Supervise at all times!
- Avoid teaching unnecessary skills
- Provide opportunities for independence such as chores and practice situational skills

Discharge

- Planning:
  - Final family/team conference
  - Therapy points: car and tub transfers
  - 8 and 24 hour care session
  - Medication education
  - Handicap parking
  - Durable medical equipment (bed, WCH, etc)
  - Home nursing
  - Outpatient therapies (PT, OT, SLP) scheduled
  - School reintegration prescription/phone or personal conference with school/ school based therapies
  - Follow up appointments with specialists and PCP
    - Bone flap replacement
Rehabilitation and Reintegration

• Regain function and adapt to disability
  — Affects physical, emotional, and behavioral aspects
• Reintegrate into family, community, school
  — Impacted by pre-existing factors (function & stressors)
  — Evidenced by stress &/or mental health issues, disorganization, any unmet needs (medical or social)
  — Severe TBI reported higher burden for up to 6 years
• Need modifiable factors to reduce burden (provision of services and improved identification of unmet needs)

• Challenges:
  — Availability of comprehensive services/medical home to coordinate care
  — Insurance reimbursement limitations
  — Family function/dysfunction
  — Long term quality of life

Aitken, M et al. 2009
Micklewright, J et al. 2012
Rivara, F et al. 2011

Education

• May have unmet or unrecognized needs during first year post-injury (socially, emotionally, educationally)
• Significant needs for cognitive services
• Section 504 of the Rehabilitation Act of 1973
• Individualized Education Program (IEP)
• Early Intervention Services/Intermediate Unit
• School based PT, OT, SLP/Occupational Vocational Rehab
  — May have pre-existing service needs
• Parental expectations may need re-adjusted
• Resources available for college options at The Brain Injury Association’s National Brain Injury Information Center

Wang, A et al. 2010; www.biausa.org

Primary Prevention of Severe TBI

• Educate and enforce effective interventions
  — Firearm safety (locks/storage)
• MV related - restraints /car seats, airbags, vehicle technology
• Sports-
  — HELMETS! Protective equipment.
  — Enforce rules/Sportsmanship play
  — Practice skills/strengthening/conditioning
• Falls - window guards/step safety gates
• Inflicted brain injury (SBS)-Parent education.
  — Identify at-risk child.
• Know signs of TBI
• Respond to suspected TBI appropriately
• Return to activity/play only after cleared by HCP

Glang, A et al. 2010; www.biausa.org
Research

• Hypothermia
• Neural Stem Cell
  – Oligodendrocytes
• Plasticity
• ProTECT Study
  – Progesterone
  – Vitamin D

References & Resources

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References & Resources

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