Pediatric Rehabilitation
Beyond Acute Care

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Objectives

- Describe Incidence of injury in the pediatric population.
- Describe habilitation and rehabilitation of motor skills through neuromuscular re-education
- Identify how swallowing is impacted by abusive head trauma and the role of motor learning in suck/swallow coordination
- Identify intervention techniques used in pediatric rehabilitation
**Pediatric Stroke**

- Prior estimates of pediatric ischemic stroke incidence have ranged from 0.54 to 1.2 per 100,000 U.S. children.
- A total of 205 ischemic stroke cases were confirmed, yielding an ischemic stroke incidence of 2.4 per 100,000 person-years.  
  (Agrawal, et al 2009)

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**Pediatric Spinal Cord Injury**

- The overall incidence of pediatric SCI in the United States is 1.99 cases per 100,000 children.  
  (Vitale et al. 2006)
- 1455 children are admitted to US hospitals each year for treatment of SCI.
  - motor vehicle accident (56%)
  - accidental fall (14%)
  - firearm injury (9%)
  - sports injury (7%)

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**Pediatric TBI**

- 70 Cases per 100,000 children < 17 years of age.  
  (Schneier, 2006)
Traumatic Brain Injury

- CDC Reporting Highest Incidence by Age
  - 0 – 4 yrs
  - 15-19
  - 65+
  - 30.5% = Death

Pediatric TBI

- Leading cause of death in children > 1 year of age
- Responsible for > 64,000 hospital admissions and 2,000 deaths each year
- Annual Cost > $60 billion
- Lifetime cost for 1 year of injuries: $406 billion
- Over 60% require ongoing outpatient services post discharge
- Approximately 5% of individuals with severe brain injuries have adequate funding for necessary long term treatment

Pediatric TBI

- 1° Injury: Membranes and axons disrupted
  - Mechanical forces causing surface contusions
  - Shearing forces from deceleration/rotation occurring in diffuse white matter or gray-white interface
- 2° Injury: Complications following initial trauma
  - Hypoperfusion/hypoxia/ischemia
  - Vasospasm
  - Diffuse edema
  - Seizures
  - Excitotoxicity
Pediatric TBI

Primary injury:
- Diffuse Axonal Injury (DAI): disruption and tearing of small axons and blood vessels from angular acceleration; results in neuronal death and petechial hemorrhages
- Focal Injury: contusions, lacerations, mass effect from hemorrhage and edema (hematoma)
- Coup Contracoup Injury: injury at point of impact and opposite point of impact
- Closed or open injury (with skull fracture)

Secondary Injury:
- Hypoxic Ischemic Encephalopathy (HIE): results from systemic problems which compromise cerebral circulation (cardiovascular or respiratory compromise)
- Swelling/edema: can result in mass effect with increased intracranial pressures (ICP), brain herniation (uncal, central or tonsillar) and even death
- Electrolyte imbalance and mass release of damaging excitatory neurotransmitters

Brain Injury Severity:
- Mild: momentary LOC, may see retrograde amnesia
  - Concussion: loss of consciousness resulting from injury or blow to the head with impaired functioning of the brainstem reticular activating system (RAS); may see changes in HR, RR, BP
- Moderate: transient LOC that resolves within 24 hours, may see retrograde and post-traumatic amnesia
- Severe: LOC for >24 hours, associated with DAI and coma
Abusive Head Trauma

- Shaken baby syndrome (SBS)
- Shaken impact syndrome (SIS)
- Shaken slam syndrome (SSS)
- Non-accidental trauma (NAT)

Abusive Head Trauma

- Primarily children < 2 years
- Majority of cases < 1 year
- Average victim: 3-8 months of age
- Male infants (60%)
- Estimated 600-1400 cases/year in US
- Most common cause of death and long term disability in infants and young children who are victims of child abuse

Abusive Head Trauma

- Shaking, with or without rapid deceleration of the head when it impacts a surface
- May cause:
  - Subdural hematomas (SDH)
  - Subarachnoid hemorrhage (SAH)
  - Direct trauma to the brain itself
  - Shearing or breakage of axons
  - Hypoxia/anoxia
  - Chemical injury to the brain
  - Retinal hemorrhages
  - Skull and other fractures
Complications of TBI

• Physical/Motor deficits (e.g., hemiplegia/hemiparesis, balance impairments, altered coordination, motor processing difficulties, tone/spasticity)
• Cognitive/Psych deficits (e.g., attention, memory, executive function, behavioral challenges)
• Communication and feeding deficits (e.g., aphasia, dysarthria, dysphagia)
• Sensory deficits (e.g., visual, olfactory or hearing impairment)

Why rehab?

• “For many children, rehabilitation is the final common pathway that may define the success or failure of their treatment – their ultimate outcome.”

Intervene Early OR Wait and See?

• Waiting is Expensive
  – Early intervention saves special education dollars.
  – Early intervention establishes a practice of active habilitation
  – Early intervention establishes a physical foundation for new learning to occur.
Pediatric Rehabilitation is the first step to Early Intervention

We don’t have time to waste

Rehab Considerations

• Acute Rehab vs. Day Rehab vs. Traditional Outpatient therapies
• Pediatric facility vs. general facility
• Developmental-based therapy vs. intense neuro-based therapy
• Lifelong Impact of early decisions

Rehabilitation Needs

• Research in infants with spastic diplegia found early intervention supported better outcomes (Kanda, Pidcock, Hayakawa, Yamori, & Shikata, 2004)
• The smaller the delay between acute care & rehabilitation, the greater the gains & cost efficiency, especially true for kids with the greatest potential for recovery and less severe injuries (Tepas et al., 2009)
• Previously learned skills recover with good success
• New learning and adapting information is extremely difficult for BI survivors, especially pediatrics
TBI Rehabilitation

• N=21,399
• 41% Either OT/PT Eval Completed
• 26% Either Speech/Swallow Eval Completed
• 1st OT/PT Eval by day #5
• 1st Speech/Swallow Eval by day #7
• Wide Variation between Hospitals

— Bennett et. Al. (2013)

Infants & Toddlers

• Largest amount of brain development occurs within the first five years of life.
• Foundation is not complete
• Acute rehab post injury is critical to provide the stimulation needed to:
  • Maximize recovery
  • Encourage new neural pathways
  • Provide the extra support needed for continued development
  • Train family and network of support personnel
• Understanding TBI in this population to be a DEVELOPING disability

Neuroplasticity and Rehab

• Capacity of the nervous system to reorganize and create new connections in response to stimulation and injury
• Critical periods of neuroplasticity occur in childhood
  – Two similar injuries occurring at different times in development create two drastically different outcomes
• Rehab: interventions influence reorganization and building of new circuitry following injury
  – Task specificity
  – Mass practice
The Challenge

• Enabling **mass repetition** of skills with optimal quality
• REhabilitation of previously learned skills AND HABILITATION of new skills in light of impairments
• Bottom line: INTENSE rehab is IMPERATIVE

Rehabilitation and HABILITATION

• What contributes to success?
  – Strong multidisciplinary team
  – Daily team meeting
  – 24 hour rehab model
  – Consistent approach to motor skill acquisition and refinement
  – Firm foundation in normal development
  – Comprehensive discharge planning

Multi-disciplinary Team

- Patient
- Family/Caregivers
- Physiatry
- Pediatric Hospitalists
- Neuropsychology
- Physical Therapy
- Occupational Therapy
- Speech Therapy
- Respiratory Therapy
- Nurse Therapist
- Rehab/General Nursing
- Registered dietician
- Social Work
- Case Management
- Recreation Therapy
- Spiritual Care Services
- Volunteer Services
- Optometry
- Specialty Physicians
- Orthotist
- Assistive Tech specialist

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**WHAT TO DO?**

### Assessment of the Infant and Child

- Physiatrist
- Pediatrician
- Nursing
- Nutrition
- Respiratory
- Developmental and Medical History
- Reflexes
- Tone/Spasticity
- Posture/Positioning
- Gross Motor Skills
- Fine Motor Skills
- Sensory Functioning/Processing
- Vision
- Feeding
- Language/Cognition
- Child Passenger Safety

### Treatment of the infant and child

- Acute Rehab: 3+ hours/day of scheduled therapy
  - Speech therapy: (60 minutes/day)
    - coordinated w/ meal times
  - Occupational therapy: (60-90 minutes/day)
    - AM ADL session
    - varied other sessions (may include aquatics)
  - Physical therapy: (60-90 minutes/day)
    - ROM session scheduled in conjunction w/ nap time
    - varied other sessions (may include aquatics)
- Scheduled room rest time
- Educational opportunities for parents/caregivers
- Neuropsychology services
Rehab Focus with the Infant and Child

- Tone/Spasticity and ROM management
- Gross motor skills
- Fine motor skills
- Sensory/Vision
- Feeding
- Language/Cognition/Communication
- Play
- Positioning
- Child Passenger Safety

Tone/Spasticity and ROM Management

- Pharmacological: led by physiatry
  - Therapy’s role: patient advocacy and effective communication with the MD’s
- Non-pharmacological: OT and PT
  - Serial/inhibitory casting
  - Splinting

Sensory Needs

- State regulation
  - Attention/arousal in low level pt’s
- Vision
**State**

Infant transitions from:
- Quiet Sleep ➔ Active Sleep ➔ Drowsy ➔
- Quiet Alert ➔ Active Awake ➔ Crying (Brazelton, 1973)

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**Vision Therapy**

- Optometry/Ophthalmology involved as indicated
- Spot patching
- Prisms

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**Neuro Re-Education**

Positional AND Transitional focus
- Head control
- Weight-shifts
- Rolling
- Sitting
- Crawling
- Standing
- Cruising/Walking
Gait Retraining
Utilize a harness system to support a percentage of patient’s body weight to unload the lower extremities while walking
1. Partial Body Weight Support Treadmill Training
2. Mobile Partial Body Weight Support Systems
3. Pediatric Robotic Lokomat
Improvements in:
• Optimal movement pattern
• Walking speed
• Endurance
• Functional balance
• Motor recovery

Aquatic Therapy
• Warmth may provide temporary reduction in spasticity
• Provides ‘safe’ and engaging environment for motor skill practice
• Dynamic nature of the environment provides increased challenge for stabilization
• Increased sensory input

Therapy Tools
## Equipment

- Positioning aides
- Seating systems
- Strollers
- Wagons
- Wheelchairs
- Standing frames
- Gait trainers
- Bath/shower chairs
- Toileting systems
- High chairs
- Splints/Braces
- Feeding equipment

## Electrical stimulation

- Motor and Sensory goals
- Electrodes positioned over specific muscles
- Used to assist muscle contraction during repetitive training
- Use during static & functional activities

## KinesioTape

- Input to facilitate and/or inhibit various muscle groups to promote optimal movement and postural alignment.
- Used to augment proprioceptive and postural feedback.
Snoezelen Multi-Sensory Room

Feeding & Swallowing Difficulties

Early Feeding Skills

Complex Task
1. Engage & maintain a physiologically & behaviorally challenging task
2. Organization of motor movements
3. Coordination of swallowing & breathing
4. Regulate depth & frequency of breathing to remain stable

(Thoyer, Shaker & Pridham, 2005)
Feeding & Swallowing Needs after injury

State of child’s health:
• Ability to coordinate their suck, swallow, breathe sequence is affected
• Impact of neuromuscular changes

Oral Feeding Experience:
• History of intubation, ventilation, and lack of oral stimulation
• Rely on supplemental tube feedings

Babies have increased nutritional needs post neural insult for repairing damage
(Adamkin, 2008; Ashton, 2010; Dabydeen, Thomas, Aston, Hartley, Sinha, & Eyre, 2008; Thoyrne et al., 2005)

Factors influencing feeding and swallowing
1. State
2. Stability and mobility
3. Coordinated/Rhythmic SSB
4. Physiological Considerations
5. Sensory & Behavior
6. Respiration
7. Medical needs
8. Tube Weaning
9. Changes with development

Evaluation of Infants Responses to Environmental Stress

Level 1: Attention-Interaction System
• Eye-floating
• Gaze aversion
• Weak cry
• Staring
• Glassy-eyed
• Panicked, worried, dull look

Level 2: Motor System
• Fluctuating tone
• Hypertonicity (leg extensions, arching, finger splays, tongue extensions, fisting)
• Excessive, diffuse movements

Level 3: Autonomic System
• Irregular breathing, nasal flaring
• Breath holding
• Tachypnea (> 60 bpm)
• Any color change (e.g., around mouth, eyes, or nostrils)
• Hiccups
• Splitting up
• Sneezing
• Sigh, Yawning
• Seizures
• Grunting
• Tremors
• Startles
Feeding Readiness

Strategies to achieve appropriate state

**Calming Cues**
- Swaddling
- Hands to mouth
- Slow, rhythmical rocking
- Deep pressure
- Quiet environment
- Dim lights, neutral color
- No noise, white noise

**Alerting cues**
- Light touch, tickles
- Change diaper before feeding
- Cold cloth
- Irregular movements, tapping, vibration, bouncing
- Changing visual environment
- Bright lights and colors, contrast, movement
- Arrhythmic music
- Fluctuating pitch and loudness
- Unpredictable
- Bold-tasting foods, more texture, strong smells

Stability & Mobility

**Oral stability depends on neck and shoulder stability which depends on trunk and pelvic stability**
- Difficulty latching, poor suction – from the onset
- Lip, jaw, cheek support
- Positioning
  - Cradle hold
  - Sidelying
  - Front
  - Lap

**Coordinated/Rhythmic SSB**
- Start with smooth suckling, but falls apart
- Non Nutritive Suck
  - Oral Stimulation
  - Oral exploration
  - Negative resistance
- Nutritive Suck
- External pacing
- Consistent repetition to establish motor plan
Physiologic Considerations
• Oral Prep, Oral, Pharyngeal, Esophageal
• Food and liquid consistencies
• Equipment needs
  – Bottle (angle, air bubbles)
  – Nipple (flow rate, stiffness, size, shape)
  – Spoon (size, texture)
  – Cup (cut out, spout)

NTrainer System
Synthetic Orocutaneous Stimulation
• Non-Nutritive Training Device
• Supports
  – Suck Swallow Pressure
  – Feeding “bursts”
  – Duration parameters
• Preliminary Findings Promising
• Mass Repetition/Neuroplasticity
Respiration

- Sufficient, coordinated respiration & $O_2$ saturation
- Trach/Vent
  - Reduced laryngeal elevation
- Airway protection changes
- Respiratory compromise
- Nasal breathers

Sensory & Behavior

- Reduce oral aversions
- Adjust volume, temperature, taste, consistency
- Behavior Plan
Medical Needs
- Nutrition
- Reflux
- Medications
- Healing Process

Tube Weaning
- Volume - decrease tube feedings to create hunger
- Positive environment
- Appetite - balance with meds to create hunger
- Hydration - increase water, may take a couple of days for hunger to kick in
- Schedule - not after tube feeding - give stomach time to feel hunger (4-5 hours for stomach to empty)

Changes with Development
Habilitation & Retraining – Developmental Challenges
- A & P changes at 4-6 months
  - Introduction to solids
    - Munching
    - Lateral tongue movement
    - Finger Feeding
    - Rotary chew
- Transition to cup
- Self-feed
*Sensitive periods for feeding development
Assessment Recommendations

- Getting infant in appropriate state
- Positioning
- Utensils
- Feeding Schedule
- Environment
- Stress signals
- Consistencies
- Pacing
- Sensory
- Calories
- Further eval/therapy
- Consult/specialists

Treatment

Compensatory Strategies
- Optimal State/Feeding Readiness
- Organizing infant/altering environment
- Optimal position
- External supports
- Consistency, temp, volume and taste of food
- Utensils
- Diet modifications

Facilitative Strategies
- Establish NNS
- External Pacing/establish internal rhythm
- Oral stimulation
- Reduce oral aversions
- Develop chewing skills
- Behavioral Feeding Program
- Oral-motor therapy

Language, Cognition and Communication

- Deficits often seen as child enters school
- See difficulties with:
  - Attention/arousal
  - Behavior
  - Memory
  - Executive functions
- Communication: mass repetition with faded cueing
- Involve school team from the get-go to ease transition and improve outcomes
Successful Discharge Planning

- Family/caregiver education and training
- Outpatient facility selection
- Direct communication between IP and receiving OP therapists
- Equipment needs
  - Address EARLY so equipment is available at time of discharge
- Referral for educationally-based services
- Scheduled routine follow-up
- Other community and peer supports as appropriate

Community Re-Entry

- Taking the next step
- Group Action Planning
- Vocational Rehabilitation
- Transition Modified
- Community Outings
- Job/Career training
- Social/Emotional supports

Challenge vs. Frustrate
References