Objectives

- Upon completion of this course, attendants will be able to:
  - Describe disorders of consciousness including the Vegetative State, Minimally Conscious State, and Coma.
  - Understand the common neurologic and medical complications associated with Severe Traumatic Brain Injury.
  - Identify the components of a thorough Physical Therapy evaluation including Special Tests and the most commonly used Outcomes Measures including the CRS-R, GCS, and DRS.

Objectives (continued)

- Recognize the common physical, cognitive, and functional impairments seen as a result of severe traumatic brain injury.
- Identify appropriate Physical Therapy interventions along with the specialized equipment utilized and prescribed for this population.
- Write objective and functional therapeutic goals for this population.
- Identify commonly used medications and their impact on Physical Therapy.

Outline

- Incidence and etiology
- Neuromedical complications with severe TBI
- PT examination
- Examination of consciousness
- PT goal setting
- PT interventions for patients with severe TBI
- Commonly used medications and their impact on PT
- Outcome tools for patients with severe TBI
Overview

- Differentiate between head injury (HI) and TBI
- Variation by geographic location
- Variation by age, gender, race

TBI Incidence by Age and Gender

Risk of TBI and Age

Incidence by Severity

- Mild TBI = 131 cases per 100,000 people
- Moderate = 15 cases per 100,000 people
- Severe = 14 cases per 100,000 people

Causes of TBI

TBI Morbidity

- Accounts for 40% of all deaths from acute injuries in US
- Financial cost estimated at $4 billion per year
- NIH estimates that 2.5-6.5 million Americans live with TBI-related disabilities
### TBI morbidity

- **Mild head injury (80% of injuries)**
  - 10% with disabilities
- **Moderate head injury (10% of injuries)**
  - 66% with disabilities
- **Severe head injury (10% of injuries)**
  - 100% with disabilities
- 1:20 receives proper rehabilitation (NHIF)

### TBI Mortality

- **Highest mortality rate in persons 15-24 yrs** (32.8 cases per 100,000 people)
- **Elderly (65 yrs+) = 31.4 cases per 100,000 people**
- **Mortality rate by severity:**
  - Severe = 33%
  - Moderate = 2.5%

### Probability for Recovery at 3 Months Post-Injury (Adult)

<table>
<thead>
<tr>
<th>GOS Score</th>
<th>Traumatic PVS</th>
<th>Atraumatic PVS</th>
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<tbody>
<tr>
<td>Dead</td>
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### Probability for Recovery at 6 Months Post-Injury (Adult)

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<th>Atraumatic PVS</th>
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### Probability for Recovery at 3 Months Post-Injury (Pediatric)

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<tr>
<td>Moderate/good</td>
<td>32%</td>
<td>0%</td>
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### Probability for Recovery at 6 Months Post-Injury (Pediatric)

<table>
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<th>GOS Score</th>
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<th>Atraumatic PVS</th>
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</thead>
<tbody>
<tr>
<td>Dead</td>
<td>14%</td>
<td>0%</td>
</tr>
<tr>
<td>PVS</td>
<td>54%</td>
<td>97%</td>
</tr>
<tr>
<td>Severe</td>
<td>21%</td>
<td>3%</td>
</tr>
<tr>
<td>Moderate/good</td>
<td>11%</td>
<td>0%</td>
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Outcomes

- N=140
- Studied patients in VS at one month
  - At one year:
    - 51% dead; 11% vegetative; 26% severe disability; 10% moderate or good recovery
    - 83% of patients who regained consciousness did at 3 mos
    - 93% at 6 months

Prognostic Factors

- Age*
- GCS*
- Pupillary response and size*
- Presence of major extracranial injury*
- Medical complications
  - Hyperthermia
  - Elevated ICP
  - Hypoxia

“Severe” TBI defined

- Referring to patients with disorders of consciousness (DOC) including:
  - Coma
  - Vegetative state (VS)
  - Minimally Conscious state (MCS)
- Rancho Level I – III
  - Rancho Los Amigos Level of Cognitive Functioning Scale
- GCS 3 - 8
  - Glasgow Coma Scale

Coma

- No evidence of arousal and awareness
- Eyes closed
- No sleep-wake cycle
- GCS < 9 ; Rancho I
- Rarely last longer than a few weeks
- An unarousable, unresponsive state, regardless of duration, in which eyes are continuously closed
- Not obeying commands, not uttering words, not opening eyes

Vegetative State (VS)

- Spontaneous eye opening
- Sleep/wake cycle
- No awareness of environment or internal stimuli
- No purposeful movement
- No evidence of sustained, reproducible, purposeful or voluntary behavioral responses
- No cortical function, but there may be brain stem reflexes
- Rancho II

Vegetative State (VS)

- Vegetative state
  - Persistent
    - One month or longer after injury
  - Permanent
    - 3 months or longer if anoxic injury
    - 12 months or longer if traumatic injury
- Requires serial evaluation
- Often misdiagnosed
Minimally Conscious State (MCS)

- Evidence of awareness of self or environment indicating cortical function
- Inconsistent but meaningful interaction with the environment
- Intentional communication*
- Intelligible verbalization*
- Localization to noxious stimulation*
- Object manipulation*
- Automatic motor response*
- Consistent or reproducible movement to command*
- Object recognition or localization (reaching)*
- Visual pursuit or visual fixation*
- Non-stereotypical movements
- Rancho III


Minimally Conscious State (MCS)

- "Severely altered consciousness in which the patient does not meet the criteria for coma or the vegetative state because there is inconsistent but reproducible or sustained behavioral evidence of self or environmental awareness" (Aspen WF 2001)

Minimally Conscious State (MCS)

- 20% with severe TBI are unresponsive at least 1 month and may go through period of inconsistent awareness (Whyte 1995)
- Individualized Quantitative Assessments can be used to identify evidence of awareness as opposed to random movement (Whyte 1999)
- CRS-R can be used to identify MCS

Common Complications in severe TBI population

- Elevated Intracranial Pressure (ICP)
- Hydrocephalus
- Sympathetic Storming
- Seizures
- Critical Illness Polyneuropathy (CIP)
- Fractures
- Heterotopic Ossification (HO)

Elevated Intracranial Pressure

- Definition: Pressure exerted by the cranium on brain tissue, CSF, and brain blood volume
  - Can lead to decreased cerebral blood flow and brain ischemia
  - Most frequent cause of death/disability following severe TBI
  - Normal = 5-15 mmHg
- Incidence
  - >50% of patients with severe TBI and intracranial mass evacuated
  - 30-80% in patients without mass lesions (Hlatky, 2003)
- American Association of Neurological Surgeons
  - Monitor ICP in all salvageable pts w/GCS 3-8 and an abnormal CT
  - ICP monitoring indicated if 2 of 3 are present:
    - Age >40 years
    - Unilateral or bilateral motor posturing
    - SBP <90 mmHg
Elevated Intracranial Pressure

- Concern with elevated ICP is compromised cerebral perfusion pressure (CPP)
  - CPP is an important determinant of cerebral blood flow
    - CPP = MAP - ICP
  - CPP will be decreased by:
    - Elevated ICP
    - Hypotension

Elevated Intracranial Pressure

- Signs and Symptoms of elevated ICP
  - Headache
  - Altered MS
  - Nausea & vomiting
  - Papilledema
  - Visual loss
  - Diplopia
  - Cushing Triad: HTN, bradycardia, irregular respirations

Blumenfeld, 2002

Elevated Intracranial Pressure

- Impact on treatment
  - Monitoring
    - EVD must be closed to mobilize
    - Bolt: patients will remain on bedrest
  - Exercise and ICP (Brimioulle, 1997)
    - PROM showed trend to decrease ICP in pts w/ normal or higher ICP
    - Active exercise showed ICP and CPP unchanged
    - Isometric ex increased ICP and CPP w/ normal ICP, unchanged in higher ICP
  - Use caution with casting in patients with elevated ICP (Zafonte, 2004)

Elevated Intracranial Pressure

- Prognosis
  - Severity of elevated ICP is related to poorer outcomes post severe TBI (Sahuquillo 2008, Hlatky 2003)
    - 77% of patients with ICP <15mmHg had favorable outcome vs 43% of patients with ICP >15mmHg (Hlatky, 2003)
    - Normal ICP compared to ICP which could not be decreased to 20mmHg (Miller, 1981)
      - Mortality increased 18 to 92%
      - Frequency of good outcomes decreased from 74 to 3%
    - May also result in secondary injury
      - Cerebral ischemia
      - Distortion and compression of brainstem

Hydrocephalus

- Definition: Excess CSF in the intracranial cavity which may be caused by:
  - An excess of CSF production
  - Obstruction of flow at any point in ventricles or subarachnoid space
  - A decrease in re-absorption

- Incidence: Post-traumatic hydrocephalus (PTH) varies from 0.75% to 10.7% in severe TBI (Mazzini, 2003)
  - 45% of patients developed PTH
  - 11% of patients required surgery
  - developed within first 3 mos post injury
  - ventriculomegaly developing slowly over period of 6 mos

Hydrocephalus

- Signs and symptoms
  - Magnetic gait*
  - Incontinence*
  - Cognitive changes*
  - Decreased level of consciousness
  - Headache
  - Nausea
  - Vomiting
  - Papilledema
  - Decreased vision
  - Sixth nerve palsies
  - (similar to those of elevated ICP)
Hydrocephalus

- Impact on treatment
  - Monitor patients for change in status or signs and symptoms of hydrocephalus and report to MD
  - Patients already treated with shunting should be observed for change in status as this may reflect shunt malfunction, obstruction, or overshunting

Sympathetic Storming

- Definition: Autonomic instability following TBI
  - “Dysfunction of autonomic centers in the diencephalon or their connections to cortical, subcortical, and brainstem loci that mediate autonomic function.”
  - Also known as
    - Paroxysmal sympathetic storms
    - Diencephalic seizures
    - Midbrain dysregulatory syndromes
    - Paroxysmal autonomic instability with dystonia (PAID)
  - May persist weeks to months in pts w/ low response state (Blackman, 2004)

Sympathetic Storming

- Incidence:
  - 15-33% of pts w/ severe TBI suffer storming (Lemke, 2007)

- Signs and Symptoms
  - Intermittent agitation
  - Diaphoresis
  - Hyperthermia
  - Hypertension
  - Tachycardia
  - Tachypnea
  - Extensor posturing
  - Pupillary dilatation

- Medical treatment
  - Medication management
  - Minimize complications

- Impact on treatment
  - Noxious stimuli may trigger storming in predisposed patients
  - Monitor VS response to treatment
  - Increased tone and posturing may result in skin breakdown or contractures

Seizures

- Definition: An episode of abnormally synchronized and high-frequency firing of neurons in the brain

- Incidence: 5-10% of pts with TBI experience new onset seizures (Asikainen, 1999)
  - Early Post-Traumatic seizures associated with depressed skull fracture and intracranial hematoma

Seizures

- Type of seizures
  - Partial (focal, local) seizures
    - Simple partial
    - Complex partial
    - Partial seizures evolving to secondarily generalized seizures
  - Generalized seizures
    - Absence seizures
    - Myoclonic seizures
    - Clonic seizures
    - Tonic seizures
    - Tonic-clonic (grand mal) seizures
    - Atonic seizures
  - Unclassified epileptic seizures
Seizures

• Signs and Symptoms
  – Vary depending type and location of seizure
  – May include
    • Motor
      – Myoclonic jerks
      – Sustained contractions
    • Autonomic signs or symptoms
    • Somatosensory or special sensory symptoms

• Prognosis (Asikainen, 1999)
  – Epilepsy slightly worsens functional and social outcome
  – Employment is equivalent patients with TBI w/o seizures
  – Proper anti-epileptic treatment helps improve chance of employment

Seizures

• Impact on treatment
  – Increased fall risk
  – Medication side effects
  – Post-ictal state
    • Paresis (Todd’s paresis)
    • Lethargy
    • Confusion
    • Amnesia
    • Headache

Critical Illness Polyneuropathy

• Definition: Axon-loss neuropathy affecting patients who are significantly medically compromised
  – Closely related myopathy also exists
  – No clear consensus yet on subtypes, combination with myopathy
  – Other related names include
    • Critical care neuropathy
    • ICU-acquired neuropathy
    • “Critical illness neuromuscular abnormalities” (CINMA) (Stevens, 2007)
  – Incidence in this population: not described
    – 50% to 70% of patients with sepsis and multiple organ failure (Bolton, 2000)
    – Associated with long or complicated acute care/ICU stays
    – Also correlated with time on vent, steroid use, neuromuscular blockade

Critical Illness Polyneuropathy

• Signs and symptoms
  – Distal generally more affected vs. proximal
    • May affect limb, trunk, respiratory muscles
  – Usually motor and sensory
  – Usually symmetric
    • Impact of spasticity and CIP on each other not well described.
  – LMN vs. UMN signs
    • Diminished/absent reflexes
    • Increased muscle wasting
      – Most evident in tibialis anterior, quadriceps, suprascapular

• Impact on treatment
  – Expect longer course for recovery of strength
    • Peripheral nerve healing ~1-3 mm/day
  – Use of e-stim or aggressive strengthening is controversial
    • One study in rats suggested this may interfere with re-innervation of neuropathy (Tam, 2001)
    • Cochrane review investigating exercises in neuropathy included three studies, concluded that evidence was limited (White, 2004)
Critical Illness Polyneuropathy

- **Prognosis/outcomes**
  - Mild to moderate cases with good outcomes
  - Severe cases with mixed outcomes (deSeze, 2000)
    - 19 patients with CIP and tetraplegia or tetraparesis
    - 2 died; 11 completely recovered; 4 with tetraplegia; 2 with tetraparesis

Fractures

- **Fractures and peripheral nerve injuries**
  - Present in 40-60% of head injured patients (Kushwaha, 1998)
- **Up to 11% of orthopedic injuries undiagnosed until rehab admission** (Kushwaha, 1998)
- Life saving measures more important than orthopedic concerns
- Patients unable to complain or express concerns
- Patients not moving
- Symptoms may be confused for other medical issues. ie DVT

- **Lower extremity injuries more common than Upper extremity**
  - LE fractures 50-75% (Kushwaha, 1998)
  - Peripheral nerve injuries more common in LE (Kushwaha, 1998)

Heterotopic Ossification

- **Definition**: Presence of bone in a location where bone does not normally exist
  - Myositis ossificans now generally regarded as a subtype of H.O.

- **Incidence in this TBI**
  - “Clinically relevant” H.O. varies between 8-22% in individuals with TBI
    - (van Kampen 2011)
  - Length of coma and ventilation, surgical fixation of fractures, autonomic dysregulation, spasticity strongly associated with increased H.O. risk.
    - (van Kampen 2011, Hendricks 2007)

Heterotopic Ossification

- **Location**: Most common location in TBI is hip, followed by shoulders, elbows, knees.
  - Develops in as little as 3 weeks, or may onset months post.
  - May not be discovered until months post.

- **Signs and symptoms**
  - Stiffness, limited ROM, edema, erythema, pain
  - These signs can be difficult to discern in this population
  - Must be differentiated from DVT, local infection, local trauma/fracture

- **Impact on treatment**
  - PT seen as an adjunctive role in prevention of H.O. formation
  - Relationship of ROM activities to H.O. very controversial
  - “Gentle exercise within pain-free ROM” is consensus guideline, not supported by literature or evidence
  - May need to premedicate for pain
  - Early rabbit studies indicated that aggressive ROM could worsen H.O., but not clinically proven (Vandenbossche, 2005)
  - CPM may increase ROM
Heterotopic Ossification

• Impact on Treatment (con’t)
  – Review by Cullen (2007) indicates that “there is limited evidence that forceful manipulation under general anesthesia increases ROM in patients with H.O. following brain injury”
  – Emerging evidence for pulse low intensity electromagnetic field therapy (Aubut 2011)
  – May need medical assistance for spasticity management

Heterotopic Ossification

• Treatment: Limited literature both medical and PT management
  – Medication/Medical:
    • NSAID, Diphosphates, Cox-2 inhibitors may prevent and/or decrease severity
    • Diphosphates (disodium etidronate) - early phase
    • NSAIDs – early and intermediate phase
    • Indomethacin - has shown efficacy s/p THA
  – Radiation
  – Further management dependent on impact on function or symptoms
    • Surgical resection with significant recurrence
      – Overall 19.8% in recent review (Chalidis, 2007)
      – Recurrence increased with increased coma duration
      – Also dependent on location, observation periods

Heterotopic Ossification

• Surgical Treatment
  – goals: mobility, decrease spasms, hygiene, positioning
  – Recommended 1.5 years post TBI
    • but must balance risk/benefit
  – Post-operatively
    • early gentle joint mobilization and prophylaxis
  – Recurrence rate varies
    • clinically insignificant seen in 82-100%
    • clinically significant HO 17%-85%

Heterotopic Ossification

• Prognosis
  – Positive prognosis:
    • High level neurologic function is best single predictor of a good surgical result and lowest rate of recurrence
    • Patients with selective limb control, primary HO resections, and HO associated with trauma
    • Continuously passive ROM exercises have better outcomes post-op
  – Poorer outcomes:
    • Immature HO or long delays until surgery
    • Lack of selective limb control
    • Involvement of multiple joints
    • Previous recurrence of HO

Physical Therapy Examination

• Examination consists of:
  – History
  – Review of systems
  – Tests and Measures
PT Examination

- Goals of your exam
  - Describe movement dysfunction and how it impacts functional independence
    - Relevant to meaningful tasks
  - Identify impairments
  - Test hypotheses formulated from history and systems review
  - Develop prognosis

- Pathophysiology
  - Anoxia/hypoxia
    - Basal ganglia, cerebellum, hippocampus, cortex
  - Diffuse axonal injury (DAI)
    - Hallmark of TBI
    - Often responsible for discrepancy between imaging studies and clinical presentation
    - White matter, cranial nerves
  - Coup/contrecoup
  - Hemorrhagic insult
  - Ischemic insult

PT Examination

- Use neuroanatomy and pathophysiology to guide examination
  - Consider location of lesion/injury on imaging studies
    - Left temporo-parietal lobe injury:
      - suspect language and right motor control deficits
      - may modify communication style
    - Zygomatic fracture:
      - anticipate vestibular involvement
    - Occipital lobe fracture or bleed
      - anticipate vision deficits
    - Frontal lobe injury
      - anticipate behavioral issues
      - Impulsivity, initiation, inhibition, self monitoring

Patient/Client History

- Demographics
  - Age, sex

- Social history
  - Activity pattern, interests, hobbies

- Employment (job/school/play)
  - Prior work and/or education level

- Living environment and options for home setup
  - Support available at home
  - Entrance to home or first floor setup

Patient/Client History

- Growth and development
  - Handedness

- General health status
  - Pre-morbid health conditions
    - Cardiopulmonary
    - Orthopedic
    - Musculoskeletal
  - Exercise pattern and history

Patient/Client History

- History of current condition
  - Time since injury
  - Course since injury
  - Complicating factors
  - Medical interventions

- Medications
  - Be aware of secondary or side effects of medications
    - i.e. lethargy, confusion, tachycardia

- Clinical tests
  - Blood tests (lab values)
  - Diagnostic imaging
Review of Systems

- Cardiopulmonary
  - Respiratory rate, HR, BP, edema
  - Cardiac status: HR, heart rhythm, BP
- Integumentary
  - Pressure sores, abrasions, post-surgical incisions, scars
- Musculoskeletal
  - Gross A/PROM, strength, restrictions related to fractures, orthopedic precautions, height, weight
- Neuromuscular
  - Gross coordination of movements, motor function (motor control and learning)
- Communication, Affect, Cognition, Language and Learning Style
  - Consciousness
  - Verbal vs. non-verbal, tactile cues, demonstration
  - Ability to make needs known

PT Examination

- Arousal, attention, cognition
- Aerobic Capacity
- Peripheral Nerve Integrity/Sensory
- Vision/Vestibular
- Motor function, motor control, motor learning
- Muscle Performance
- Reflex Integrity
- Pain
- Posture
- Gait/locomotion
- Balance
- Work, community, leisure re-integration

Tests and Measures for Patients with Severe Brain Injury

- Standardized assessments
  - Often will not be able to be used in this population
  - Inability to follow commands, communicate
- General principles
  - Describe what is observed as objectively as possible
  - Consider both spontaneous and elicited behavior

Tests and Measures

- Observation is key to examination
  - What does the patient do at rest?
  - Positioning, movement, gaze, verbalization
  - What reactions do you see during Nursing care
- Be aware of the different stimuli introduced and note responses
  - Auditory
  - Visual
  - Tactile
  - Combination
- Be aware of patient’s care schedule
  - Nursing care sessions may result in overstimulation or fatigue

Tests and Measures

- Arousal
  - Arousal is actually an internal state of readiness that is unable to be directly measured
  - Very frequently impacted by severe TBI and secondary issues
  - Indirectly assess arousal through eye opening
  - Can be problematic with eye injuries, or subset of patients who tend to keep eyes closed even when aroused
  - Document spontaneous eye opening, or with stimulation

Tests and Measures

- Attention
  - Internal process that we are attempting to evaluate
  - Includes many different aspects
  - Attention is generally assessed with regard to engagement in a task or activity in other populations
    - Often unable to be performed in this population.
    - Ability to attend to an object presented
    - If patient unable to physically interact, consider visual attention
      - Ability to sustain and/or track visually
      - Consider attention to both left and right
Tests and Measures

- Cognition
  - Unable to be evaluated formally
  - Describe any evidence of higher-order cognitive processing
    - Command following, communication
  - Differentiate reflexive behavior from behavior which requires processing
    - Reaching for objects
    - Purposeful object use
    - Non-reflexive responses to stimuli

Tests and Measures

- Ventilation, Respiration, and Circulation
  - HR, BP, SaO2, need for supplemental O2
  - Auscultation
  - Respiration
    - Rate
    - Pattern
    - Muscle use
    - Cough
  - Monitor response to interventions

Tests and Measures

- Cranial nerve exam
  - Facial expression – CN VII
    - Elicit grimacing if no spontaneous expression
  - Hearing – CN VIII
    - Try to assess right and left
    - If no response, assess auditory startle
  - Gag reflex – CN IX, X
  - Tongue protrusion – CN XII

Tests and Measures

- Muscle performance
  - Description of observed movements
    - Quality/smoothness
    - Speed/timing
    - Isolated control vs. synergistic/patterned
    - Spontaneous and elicited
      - Type of stimulation to elicit
  - May be observed during postural control challenges
  - Tone/spasticity assessment
    - Modified Ashworth Scale
    - Tardieu scale

Tests and Measures

- Range of Motion
  - Assess and document key areas
    - Areas with current significant limitations
    - Areas most at risk for loss of ROM
      - Ankles: dorsiflexion, eversion
      - Hips: extension, internal rotation
      - Shoulders: flexion, abduction, external rotation
      - Pelvis: anterior tilt
      - Trunk: extension
      - Scapulae: upward rotation, general mobility
      - Cervical: throughout

Tests and Measures

- Peripheral Nerve Integrity
  - DTR’s
  - Sensation
    - Response or lack of response to tactile stimuli
    - Localizing vs withdrawal
  - Muscle atrophy
    - EMG’s to supplement clinical findings
    - Consider Critical Illness Polyneuropathy (CIP)
Tests and Measures

- Neuromotor development and Sensory Integration
  - Decorticate or decerebrate posturing
  - Primitive reflexes
    - ATNR, STNR
- Pain
  - Can be difficult to assess
    - Facial expression/grimacing may not be reliable
    - Heart rate and other physical signs may be confounded
  - Assess response to noxious stimulus
    - Groaning/moaning, flexion withdrawal, localizing, facial expressions
- Tests and Measures
  - Reflex integrity
    - Can help identify LMN involvement
    - Grasp reflex
      - May confound assessment if not recognized
    - VOR (doll’s eye)
    - DTRs
    - Spasticity
- Sensory integrity
  - As in cranial nerve assessment
  - Evidence of sensation throughout
  - Reaction to deep pressure throughout

Tests and Measures

- Posture
  - Description of resting position
    - Include head/neck, eyes, trunk
    - May include supine or seated in wheelchair
  - Examine in supine, supported and unsupported sitting
    - Assess fixed vs flexible deformity
- Postural control and righting reactions
  - Note righting and protective reactions to displacement

Role of PT in Evaluating Consciousness

Evaluating Consciousness: The Challenge

- Patients can remain vegetative or minimally conscious for prolonged periods
- Routine assessment of cognitive abilities depends on voluntary engagement of the patient and consistency of performance
- Variable behavior/arousal is the hallmark of minimally conscious state and is present in vegetative patients

Evaluating Consciousness: The Assessment Challenge

- Observed behaviors may be volitional, spontaneous, reflexive
- Clinical observations and conclusions are biased by “extremes”
- Observation alone does not provide accurate information
- Errors in classification as VS vs MCS range from 15-43% (Tresch, 1991; Childs, 1993; Andrews, 1996)
Examination of Consciousness

- Standardized behavioral scales
  - Glasgow Coma Scale (GCS)
  - Full Outline of UnResponsiveness Scale (FOUR)
  - JFK-Coma Recovery Scale—Revised (CRS-R)
  - Rancho Los Amigos Level of Cognitive Functioning Scale (RLCFS)
- Patient specific measures

Glasgow Coma Scale (GCS)

- Brief measure of brain injury severity
- Assesses the function of the cerebral cortex and the upper brainstem, the reticular activating system
  - Eye-opening response - arousal mechanism of the brainstem
  - Verbal response - integration of cerebral cortex and brainstem
  - Motor response - integrity of cerebral cortex and spinal cord

International use in ERs and trauma units
- Total score usually documented
  - Mild = 13-15
  - Moderate = 9-12
  - Severe = 3-8
  - 3-4 = very severe

Glasgow Coma Scale

<table>
<thead>
<tr>
<th>Eye Opening</th>
<th>Score</th>
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<tbody>
<tr>
<td>Spontaneous</td>
<td>E4</td>
</tr>
<tr>
<td>To Speech</td>
<td>E3</td>
</tr>
<tr>
<td>To Pain</td>
<td>E2</td>
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Best Motor Response

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Verbal Response

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Rancho Los Amigos Level of Cognitive Functioning Scale

- Commonly used tool used to describe a patient's level of cognitive function across the continuum of recovery after TBI
- Correlates with 24 hour CGS scores, length of coma, and duration of posttraumatic amnesia (PTA)
- Limited as a predictor of long term outcome or to monitor progress within levels
- Every patient does not go through all levels.
- Inter-rater reliability = 0.89 (Gouvier 1987)
- Includes 8 levels ranging from "No Response" to "Purposeful and Appropriate Responses"

Cognitive deficit limiting function

- Arousal
- Awareness of environment
- Consistency of awareness
- Filtering and Attention
- Attention
- Memory
- Executive Functioning
- Abstract Thinking
Rancho Los Amigos Level of Cognitive Functioning Scale

• Level I - No Response
  – Patient appears to be in a deep sleep and is completely unresponsive to any stimuli
• Role of PT
  – Provide orienting information in simple language with pauses to allow processing time
  – In some facilities, PT role at this stage is limited to periodic consultation.

Rancho Los Amigos Level of Cognitive Functioning Scale

• Level II - Generalized Response
  – Generalized reflex response to painful stimuli
  – Responds to external stimuli with
    • physiological changes
    • non-purposeful vocalization
  – Responses noted above may be same regardless of type and location of stimulation
  – Responses may be significantly delayed
  – Patient reacts inconsistently and non-purposefully to stimuli in a nonspecific manner
• Role of PT
  – Try to increase patient’s awareness of the environment by providing information using the modalities to which the patient is responsive

Rancho Los Amigos Level of Cognitive Functioning Scale

• Level III - Localized Response
  – Withdrawal or vocalization to painful stimuli
  – Turns toward or away from auditory stimuli
  – Blinks when strong light crosses visual field
  – Follows moving object passed within visual field
  – Responds to discomfort by pulling tubes or restraints
  – Responds inconsistently to simple commands
  – Responses directly related to type of stimulus
  – Reacts specifically but inconsistently to stimulus
  – Responses directly related to type of stimulus provided
  – May follow simple commands in an inconsistent, delayed manner
  – May respond to some persons (especially family and friends) but not to others.
• Role of PT
  – Try to build on responses observed

JFK Coma Recovery Scale – Revised (CRS-R)

• 23 Items with 6 subscales
  – Auditory Function
  – Visual Function
  – Motor Function
  – Oromotor/Verbal Function
  – Communication
  – Arousal
• Hierarchical: lowest item is reflexive, highest item is cognitively-mediated

JFK Coma Recovery Scale – Revised (CRS-R)

• Original scale 1991 (Giacino, et al)
• Revised 2004 (Giacino, Kalmar & Whyte)
• Developed to characterize and monitor patients at Rancho Levels I–IV
• Discriminate MCS from VS
• Used widely in clinical and research settings
• Reliable and Valid
  – Inter-rater reliability (0.84)
  – Test-retest reliability (0.94)
  – Concurrent validity (0.97) with the CRS
  – Concurrent validity (0.90) with the Disability Rating Scale (DRS)
• Differential diagnosis of DOC and tracks recovery (Giacino, 2004; Giacino, 2006)
• Recommended to assess DOC with only minor reservations (Seel et al, 2010)
• www.tbims.org/combi/crs/index.html

Rancho Los Amigos Level of Cognitive Functioning Scale

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Physical Therapy Management for Patients with Disorders of Consciousness

CRS-R Administration Overview

- Conduct 1 minute baseline observation
  - Determine level of arousal
  - Facilitate selection of appropriate commands
  - Differentiate voluntary from random/coincidental movement
  - Resting position of extremities, eye opening status, spontaneous visual fixation or tracking, spontaneous movement

- Administer Arousal Facilitation Protocol (AFP)
  - May administer protocol any time
  - Purpose is to increase the length of time arousal is sustained
  - Deep pressure, vestibular

- Administer CRS-R items in sequence
  - Score elicited responses only
  - Do not score responses that occur after 10 seconds
  - Score best response within each subscale

CRS-R Auditory Function Scale

- Score = 4 = Consistent Movement to Command
  - Clearly discernible & accurate responses occur on all 4 trials
  - Functional significance:
    - Capable of sustained environmental interaction
    - Signals readiness for active rehabilitation
    - Able to tolerate more complex cognitive assessment
    - Denotes MCS

- Score = 3 = Reproducible Movement to Command
  - 3 clearly discernible, accurate responses occur over the 4 trials
  - Functional significance:
    - Retain capacity for cortically based processing and cognitively mediated behavior
    - Clearest indication of recovery of consciousness
    - Denotes MCS

CRS-R Visual Function Scale

- Score = 3 = Visual Pursuit
  - Eyes follow movement of mirror without loss of fixation to 45° of midline in at least one field
  - Functional significance:
    - Retains capacity for visual exploration of environment
    - Indication of emergence from VS
    - Denotes MCS

- Score = 2 = Fixation
  - Eyes change from initial fixation point and re-fixate on new target
  - Two episodes of fixation are required
  - Functional Significance
    - Retains capacity to detect and locate visual stimuli
    - Denotes MCS

CRS-R Visual Function Scale

- Score = 1 = Visual Startle
  - Eyelid flutter or blink immediately following visual threat
  - Functional Significance:
    - Retains capacity to detect movement

- Score = 0 = None
  - No discernible visual response
  - Functional Significance:
    - Arousal dysfunction
    - Sedation
    - Visual impairment
    - Cortical blindness

CRS-R Auditory Function Scale

- Score = 2 = Localization to Sound
  - Head/eyes orient toward location of stimulus in >/= one direction, both trials
  - Functional significance:
    - Retains capacity for detection and gross discrimination of location of sound

- Score = 1 = Auditory Startle
  - Eyelid flutter or blink occurs immediately following stimulus on at least 2 trials
  - Functional significance:
    - Retains capacity to detect sound

- Score = 0 = None
  - No discernible auditory response
  - Functional significance:
    - Arousal dysfunction, sedation
    - Hearing loss

CRS-R Visual Function Scale

- Score = 5 = Object Recognition
  - 3 to 4 clearly discernible, accurate responses occur over 4 trials
  - Functional significance:
    - Retains capacity to follow commands and discriminate visual stimuli
    - Indicative of MCS

- Score = 4 = Object localization: Reaching
  - Limb must move toward object on 3 of 4 trials
  - Functional significance:
    - Retains capacity to detect, locate and apprehend stimuli in the immediate environment
    - Indicative of MCS

- Score = 3 = Visual Pursuit
  - Eyes follow movement of mirror without loss of fixation to 45° of midline in at least one field
  - Functional significance:
    - Retains capacity for visual exploration of environment

- Score = 2 = Fixation
  - Eyes change from initial fixation point and re-fixate on new target
  - Two episodes of fixation are required
  - Functional Significance
    - Retains capacity to detect and locate visual stimuli
    - Denotes MCS

- Score = 1 = Visual Startle
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  - Functional Significance:
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- Score = 0 = None
  - No discernible visual response
  - Functional Significance:
    - Arousal dysfunction
    - Sedation
    - Visual impairment
    - Cortical blindness

(Giacino lecture, 2003; www.tbims.org/combi/crs/CRS%20Syllabus.pdf)
Physical Therapy Management for Patients with Disorders of Consciousness

CRS-R

Motor Function Scale

• Score = 6 = Functional Object Use
  — Limb movement is generally compatible with specific function of each object across all 4 trials
  — Functional significance
    • Returns basic capacity for instrumental ADL's
    • Indicative of emergence from MCS

• Score = 5 = Automatic Motor Response
  — 2 episodes of automatic motor behavior are observed, each episode can be differentiated from a reflexive response
  — Patient performs a familiar gesture when demonstrated
  — Patient performs the oral movement pattern when presented a spoon or a straw
  — Functional significance
    • Maintains access to over-learned behavioral routines
    • Indicative of minimally conscious state (MCS)

• Score = 4 = Object Manipulation
  — On at least 3 of 4 trials wrist must rotate, fingers must extend and object must be grasped and held for 5 seconds
  — Ball cannot be held by means of grasp reflex or flexor hypertonus
  — Functional significance:
    • Retains capacity for exploratory sensorimotor behavior
    • Indicative of MCS

• Score = 3 = Localization to Noxious Stimulation
  — Non-stimulated limb must locate and make contact with stimulated body part on at least 2 trials
  — Functional significance:
    • Retains awareness of body schema
    • Capable of self-protective behavior
    • Denotes MCS

• Score = 2 = Flexion Withdraw
  — Isolated flexion withdraw occurs in at least 1 limb, away from point of stimulation
  — Functional significance:
    • Retains capacity for active movement (maybe unable to initiate or regulate)

• Score = 1 = Abnormal Posturing
  — Slow, stereotyped flexion or extension of the upper and/or lower extremities immediately after stimulation is applied
  — Functional significance:
    • Unable to initiate or regulate movement secondary to loss of competing extensor tone

• Score = 0 = None/Flaccid
  — No discernible motor response
  — Functional significance:
    • Movement not possible

CRS-R

Oromotor/Verbal Function Scale

• Score = 3 = Intelligible Verbalization
  — 2 different words, each consisting of at least consonant-vowel-consonant ("Mom" not "Ma")
  — Intelligible, but not necessarily appropriate
  — Writing or alphabet board acceptable
  — Functional significance
    • Retains capacity for expressive language
    • Indicative of MCS

• Score = 2 = Vocalization/Oral Movement
  — At least one episode of non-reflexive oral movement and/or vocalization occur spontaneously or in response to sensory stimulation
  — Functional significance
    • Speech apparatus functional

• Score = 1 = Oral Reflexive Movement
  — Clamping of jaws, tongue pumping and/or chewing movement occurs following introduction of tongue blade into mouth
  — Functional significance:
    • Loss of inhibition and regulation of primitive reflexive oromotor activity (incompatible with speech)

• Score = 0 = None
  — No discernible vocalization or oromotor activity
  — Functional significance:
    • No evidence of capacity for verbal communication

CRS-R

Communication Scale

• Score = 2 = Functional: Accurate
  — Accurate responses to all 6 questions situational orientation questions from protocol
  — Verbal, motor, or gestural means of communication
  — Functional significance
    • Immediate memory intact
    • Language comprehension and expression reliable
    • Denotes emergence from MCS

• Score = 1 = Non-Functional: Intentional
  — Clearly discernible responses to at least 2 of the 6 questions
  — Functional significance
    • Suggestive of capacity for interactive communication
    • Indicative of MCS

• Score = 0 = None
  — No discernible verbal or non-verbal communicative responses occur at any time

1/22/2013
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San Diego, CA   January 21-24, 2013
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Physical Therapy Management for Patients with Disorders of Consciousness

CRS-R Arousal Scale

- **Score = 3 = Attention**
  - No more than 3 occasions across the length of evaluation in which patient does not respond to a verbal prompt
  - Functional significance:
    - Retains basic capacity to direct attention and sustain attentional focus
- **Score = 2 = Eye Opening without Stimulation**
  - Eyes remain open across the length of examination without the need for tactile, pressure, or noxious stimulation
  - Functional significance:
    - Sleep/wake cycle is re-established

(Giacino lecture, 2003; www.tbims.org/combi/crs/CRS%20Syllabus.pdf)

CRS-R Arousal Scale

- **Score = 1 = Eye Opening with Stimulation**
  - Tactile, pressure or noxious stimulation must be applied at least once during the examination in order for the patient to sustain eye opening
  - Length of time eyes remain open is not considered in scoring
- **Score = 0 = Unarousable**
  - No spontaneous or elicited eye opening at any time during the assessment
  - Functional significance:
    - Persistent disturbance of wakefulness
    - Sedation
    - Chemical paralysis

(Giacino lecture, 2003; www.tbims.org/combi/crs/CRS%20Syllabus.pdf)

Full Outline of UnResponsiveness (FOUR)

- Evaluates visual functioning, command following, brainstem reflexes, breathing patterns, evidence of brain herniation (Wijdicks, 2005)
  - Developed to address limitations of GCS, but not widely used
  - Does not depend on verbal response
  - Able to identify locked-in syndrome
- Adequate reliability, validity.
- Predicts recovery at 3 months

(Giacino lecture, 2003; www.tbims.org/combi/crs/CRS%20Syllabus.pdf)

Coma/Near-Coma Scale (CNC)

- **Description:** 11-item measure of sensory/perceptual functioning, primitive responses in patients with DOC (Rappaport, 1982)
- Sensitive to changes in severe TBI
- Predicts recovery of consciousness one year after injury (Rappaport, 2002)
- Five categories of Awareness/Responsivity
  - No Coma, Near Coma, Moderate Coma, Marked Coma, Extreme Coma

Review of Disorders of Consciousness Scales

- The CRS-R may be used to assess DOC with minor reservations
- The SMART, WNSSP, SSAM, WHIM, and DOCS may be used with moderate reservations
- The CNC may be used with major reservations
- The FOUR is not recommended at this time because of a lack of content validity, lack of standardization, and/or unproven reliability (Seel et al, 2010)

Patient-Specific Measures

- **Purpose:** Evaluate clinically meaningful questions
  - Is the person under-aroused?
  - Can the person see?
  - Is the person demonstrating “purposeful behaviors”?
    - Tracking, pulling at tubes, reaching for caregiver, pushing away noxious stimuli
  - Can the person follow commands?
  - Is the person’s behavior changing over time or with medications?
Physical Therapy Management for Patients with Disorders of Consciousness

Patient-Specific Measures

- Stimuli (e.g., specific commands) and responses (e.g., particular movements) are operationalized
- Uses patient specific behaviors
- Selection of measure depends on clinical question
- Patient measures (“Protocols”) developed by the interdisciplinary team
- Pilot data may be collected for inter-rater reliability/feasibility of protocol
- Data collection continues until the clinical question is answered
- Data analyses are reported to the treatment team and family

Examples of Patient-Specific Measures

- Arousal
  - Time sampling of degree of eye-opening across therapy session
  - Therapists record level of eye opening every 5 min
    - 0 = closed,
    - 0.5 = half-open
    - 1.0 = open
  - Average score reflects arousal
  - Average across days, time
  - Evaluates progress, medication effects

Examples of Patient-Specific Measures

- Command following
  - Identify spontaneously generated behaviors
  - Evaluate patient’s ability to perform behavior “to command”
  - Example: A patient is able to follow command for “thumbs up” and “thumbs down” with verbal and gestural command. His ability to follow a verbal command only is unclear.
  - Protocol will clarify command following and language comprehension.

Arousal data

Verbal command only, RR = 55%, Acc = 65%

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Verbal plus gesture, RR = 83%, Acc = 86%

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Examples of Patient-Specific Measures

- Stimuli (e.g., specific commands) and responses (e.g., particular movements) are operationalized
- Pilot data may be collected for inter-rater reliability/feasibility of protocol
- Data collection continues until the clinical question is answered
- Data analyses are reported to the treatment team and family
Physical Therapy Management for Patients with Disorders of Consciousness

Changes in Command Following Over Time

Conclusions

• Patient is able to follow verbal commands
• Patient benefits from gestural cues, suggesting impaired language comprehension
• Command following has improved over time

Summary

• Correct diagnosis of level of consciousness is important for patient care and services
  – Misdiagnosis rate very high (15-43%)
• Use of standardized tools such as CRS-R and patient specific measures have been found to be best for diagnosing consciousness.

Goal Setting for patients with DOC

• Focus on prevention of secondary complications: contractures, skin breakdown, pulmonary
• Ongoing assessment of function and cognitive changes
• Maximize abilities as recovery occurs
• Family education and training
• Identification of appropriate level of care

Sample Goals for Low Level BI Patients

• Command follow:
  "Pt will demonstrate yes/no response via thumbs up/down to biographical information in 4/6 trials."
• Head or trunk control:
  "Pt will maintain head in neutral after positioning, with visual and verbal cues for 30 seconds."
• Endurance:
  "Pt will tolerate tilt table for with VSS at 60 degrees x 20 minutes."
• ADLs:
  "Pt will assist in grooming with suction toothbrush by demonstrating intact grasp and mouth opening after presentation with verbal cues."
• Tracking:
  "Pt will track a picture of a family member when it is moved to the right and left of midline, 3 out of 5 times, in supported sitting."

Physical Therapy Interventions
Interventions for Patients with Severe TBI

- Focus of goals
  - Prevention of secondary impairments
  - Ongoing assessment of abilities
  - Family/caregiver education and instruction
  - Maximizing abilities as natural recovery occurs
  - Identification of appropriate next level of care

Therapeutic objectives for individuals with severe disability

- Mobility goals that will improve quality of life for pt and caregiver as well as reduce risk for secondary complications
- Developing a communication system
- Being able to control eye and head movement to orient towards stimuli of interest improves quality of life for patient and caregiver.
- Caregiver training and education

Interventions for Patients with Severe TBI

- Ongoing assessment
  - Each session is an assessment of current abilities
    - Remember, inconsistency is a hallmark of these patients
    - Even small changes very important
      - Positive changes improve prognosis
      - Negative changes give concern for medical issues
    - Therapist consistency is crucial
      - Independent of setting

Body Structures and Function

- Arousal
- Range of Motion
- Strength and motor control
- Muscle tone/spasticity
- Postural control
- Endurance

Body Structures and Function: Arousal

- Goals of interventions include
  - Increase arousal & attention
  - Increase reactive, adaptive, or meaningful responses
- Types of Sensory Stimulation
  - Vestibular
  - Proprioceptive/Kinesthetic
  - Auditory
  - Visual
  - Olfactory
  - Gustatory
  - Tactile

PT Interventions for Low Arousal: Sensory Stimulation

- Vestibular
  - Stimulated using motion and gravity
  - Incorporate rocking, rolling, spinning into treatment
  - Tracking with and without head movement
  - Supine to/from sit
  - Elicit balance/righting reactions
  - Large ball
  - Large bolster
  - Rocker board
PT Interventions for Low Arousal: Vestibular Stimulation

- Cerebellum and proprioceptors in muscles, tendons and joints work to regulate posture, equilibrium, muscle tone and orientation of body and head in space
- Found to have positive effect on arousal, exploratory behavior, visual fixation ability, ocular pursuit activities, and motor function
- Vestibular stimulation is the most important form of stimulation for acquisition of visual alertness and awareness in children (Ottenbacher 1983)

PT Interventions for Low Arousal: Sensory Stimulation

- Proprioceptive & Kinesthetic
  - Weightbearing & joint compression
  - Facilitating normal alignment (NPT, lumbar lordosis)
  - ROM activities
  - Positional changes
  - Tilt table
  - Prone over wedge, sidelying over a wedge with WB through UE
  - Motomed®
  - Erigo®

PT Interventions for Low Arousal: Sensory Stimulation

- Auditory
  - Pleasant and unpleasant sounds
  - Familiar and unfamiliar sounds
  - Use normal tone of voice when addressing patient
  - Assume he/she understands what you say
  - Visualization
  - Familiar music
  - Modulate your voice for the activity
  - Orient patient frequently
  - Loud noise, music, or clapping to increase arousal

PT Interventions for Low Arousal: Sensory Stimulation

- Visual
  - Present personal or familiar items, pictures
  - Mirror image
  - Assess awareness of surroundings using “blink to threat”
  - Encourage families to bring in pictures of meaningful people and possessions
  - Facilitate tracking
  - Observe righting responses via eye gaze during therapy

PT Interventions for Low Arousal: Sensory Stimulation

- Olfactory
  - Noxious or pleasant odors
  - Incorporate cologne or perfume into treatment sessions

- Gustatory
  - Stimulated using pleasant or sour tastes
  - Incorporate tooth brushing with suction toothbrush into ADL sessions

PT Interventions for Low Arousal: Sensory Stimulation

- Tactile
  - Incorporate ice or different textures into session
  - Sternal rub
  - Pressure to nail bed
  - Deep pressure using a therapy ball
  - Face, hands, feet, usually greatest response
  - Refer to arousal facilitation protocol of CRS-R
Evidence for Sensory Stimulation

- Termed “Coma Stim” or “Intense Multisensory Stimulation” (IMS) programs
  - Started 1950’s at Institute of Achievement for Human Potential (Lombardi, 2008)
  - “In comatose patients, although the problem is primarily cerebral, there is a condition of environmental deprivation that could lead to widespread impairment of intellectual and perceptual processes accompanied by changes in cerebral electrical activity”
  - Sensory deprivation leads to physical deterioration of the brain in animals and humans (Bragin, 1992)

- Systematic review by Lombardi et al, 2008 found there is no reliable evidence to support, or rule out, the effectiveness of multisensory programs in patients in coma or vegetative state
- Article by Gerber, 2005 encouraged researching the possibility of implementing structured coma stimulation programs as early as 72 hours post injury in the intensive care unit
- Sosnowski and Ustik, 1994 found that an individualized coma stimulation program in the early stages of recovery from brain injury is paramount in stimulating the reticular activating system and promoting brain reorganization
- Altering the environment by providing meaningful yet novel sensory stimulation may enhance plasticity and lead to reorganization of structures that support cognitive processes (Davis AE, 2000)

- When possible, observe patients & perform neurological assessments in the standing position
  - In one preliminary study, patients (3 VS, 5 MCS) showed consistent improvements in the highest ranked behaviors (p=0.008) and total number of behaviors (p=0.013) observed in the standing position using the Wessex Head Injury Matrix (WHIM) compared to lying in bed
  - Results suggest that positional changes may have an impact on behaviors demonstrated by patients in the VS and MCS
  
  [Elliot et al, 2005]

Evidence for Sensory Stimulation

- Several studies have reported positive effects of providing sensory stimulation programs for patients in coma (Johnson 1993, Kater 1989, Mitchell 1990)
- Wood (1991) argues bombardment with undifferentiated stimulation results in decreased ability to process information. He recommends creating a quiet environment and providing selective input.
- Multimodal stimulation produced greater behavioral changes than unimodal stimulation, and the use of personally salient stimuli in multimodal stimulation produced the greatest changes of all (Wilson SL, et al 1996)
- Sensory stimulation for coma arousal is not included as an intervention in the Guide to Physical Therapist Practice.

Sensory Stimulation

- Clinical Applications:
  - Make team aware of stimuli meaningful to the patient
    - Information boards with pictures of family members, friends, favorite sayings, topics of interest, favorite music, tv show, hobbies, etc.
    - Encourage visitors to talk to the patient about important or familiar events
    - Request family members to provide meaningful objects
      - e.g. favorite hat, football, stuffed animal, etc
    - Be aware of sensory input intrinsic to each examination procedure or intervention applied to patient and observe responses
    - Incorporating sensory input into treatment may improve interaction with environment and provide a more “normal” sensory experience
    - Interventions may include:
      - Noxious stimuli to facilitate response
      - Muscle vibration
      - Muscle tapping
      - Visual stimuli

Body Structures and Function:

- Goal: to maintain or increase PROM
  - Allow for proper postural alignment, including:
    - Neutral alignment of head, trunk, pelvis, upper and lower extremities
    - Preparation for sitting, standing, gait, functional use of extremities
  - Passive stretching
    - Helps to prevent loss of ROM in acute setting
    - Appears to provide short-term decrease in spasticity (Zafonte, 2004)
    - Recent review inconclusive as to effects of stretching on spasticity (Bovend’Eerdt, 2008)
    - ROM can be a skilled intervention in this compromised population, not maintenance
Body Structures and Function: ROM

• Goal: maintain functional ROM of extremities
• Prevention of secondary impairments
• Splinting/bracing/casting/bivalves
  – Serial casting is the only intervention with evidence suggesting that it can change spasticity over long term (Zafonte, 2004) (Hellweg S and Johannes S, 2008)
  – Serial casting shown to increase ROM or prevent further loss of ROM (Hellweg S and Johannes S, 2008)
  – Superior to positioning for elbow contractures in TBI patients (Moseley, 2008)
  – Reduced spasticity noted in serial casting
  – Effects on ROM and spasticity appeared short-lived

Body Structures and Function: ROM

• Positioning: bed and wheelchair
  – Focus on: Skin protection, Tone inhibition, ROM preservation
  – Pictures, training
  – Positioning devices
  – If developing an imbalance of tone that might cause contracture, use positioning to minimize chance of contracture
  — Identify 2 or 3 positions that will minimize integumentary compromise given the neuromusculoskeletal status and medical precautions
  — Customized wheelchairs
    • Tilt in space wheelchair, headrest, contoured back, contoured cushion, upper extremity support, legrests
    • Neutral alignment of head, trunk, pelvis, upper and lower extremities
    • Increased time OOB
    • Greater interaction with environment, staff, and family

Body Structures and Function: Increased Muscle Tone/Spasticity

• Oral Medications (Rekand T, 2010)
  — Baclofen
  — Titizanidine
  — Dantrolene
  — Diazepam
  — Gabapentin

• Injections (Esquenazi A, et al, 2012)
  — Chemodenervation with botulinum toxin A
  — Chemical neurolysis with phenol

• Intrathecal Baclofen Pump (Rekand T, 2010)

• Rhizotomy (Rekand T, 2010)

• Tendon Lengthening and Soft Tissue Release (Rekand T, 2010)

• Serial casting
  — evidence suggesting that it can change spasticity over long term (Zafonte, 2004) (Hellweg S and Johannes S, 2008)

Body Structures and Function: Strength/Motor Control

• Strength
  – Indirect strength training achieved through positioning
  • Maintain static positions
  • Therapeutic transitions
  – Address muscle activation, strength, coordination, motor planning
  – Provide opportunities for patient to practice purposeful movements

Body Structures and Function: Postural Control

• Postural Control
  – Sitting
    • Interaction w/ environment
    • Cardiopulmonary benefits
    • Considerations: ROM, Integumentary status, VS response
    • Facilitation of automatic postural reactions
    • Proprioceptive feedback may be provided through tactile cues to the
      — Trunk
      — Upper extremities
      — Lower extremities
  – Provide challenges
    • Rapid displacement of center of mass

Body Structures and Function: Endurance/Upright Tolerance

• Endurance/Cardiopulmonary
  – Upright tolerance
    • Gradually raise head of bed
    • Sitting
      — Wheelchair, unsupported edge of bed/mat, perched sitting
    • Standing
      — Tilt table, standing frame
      — Moveo™, Erigo®
      — Some ICU beds may reverse trendelenburg and allow for standing/upright progression
Body Structures and Function: Endurance/Upright Tolerance

- **Tilt Table**
  - Allows for graded progressive standing of patients in VS/MCS
  - Benefits
    - Load vertebrae
    - Pressure relief
    - Improved respiratory function
    - Improved alertness and orientation (Symons 2008, Elliott 2005)
    - Prolonged stretch for ankles, knees, hips
    - Inhibition of flexor patterns
    - Bone Mass Density
    - Improved circulation
    - Improved renal function
  - Considerations
    - VS response to upright posture
    - Wounds
    - WB status related to orthopedic issues

Family Training and Education

- **Course of rehabilitation**
  - Plan of care
  - Behavioral and cognitive challenges
- **PROM and sensory/environmental stimulation**
  - Alternating time with TV or radio on/off
  - Soft voices if patient “storming” or showing agitation
- **Positioning**
  - WC and Bed
- **Integumentary Integrity**
  - Weight shifts, skin checks, positioning

Activity

- **Transfers**
  - Utilize lift devices as needed
  - Functional transfers including low pivot and sit to stand
  - Provide opportunity to stimulate and assess spontaneous muscle activation
- **Gait training**
  - LiteGait®
  - Lokomat®
  - Platform walker
  - Up n Go Walker®
- **Strong evidence exists that intensive task-orientated rehabilitation programmes lead to earlier and better functional abilities** (Poletti, L. and Sharrard, W., 2008)

Prevention of Secondary Complications

- **Pulmonary**
  - Relax increased tone around thoracic area
  - Mobilize rib cage
  - Reposition for postural drainage
  - Prone, sidelying over wedge
  - Prevent positioning in upper cervical extension
  - Can cause aspiration pneumonia

Pharmacology in TBI – DOC and Arousal

- **Amphetamines (Adderall) and methylphenidate (Ritalin)**
  - Increase dopamine and norepinephrine availability
  - Few studies and no conclusive evidence support the use of neurostimulants to enhance emergence from states of impaired consciousness
- **Amantadine (Symmetrel)**
  - Anti-parkinsonian, antiviral agent
  - Increase pre- and postsynaptic dopamine availability, is also a weak NMDA receptor antagonist
  - Growing body of evidence supports its use in impaired consciousness due to TBI
- **Zolpidem (Ambien)**
  - Acts as an agonist on a sub-type of GABA-A receptors
  - A number of case reports exist on its use as an “awakening” agent in patients in PVS or MCS
- **Bromocriptine (Parlodel)**
  - Another dopamine enhancing agent, postsynaptic D2 dopamine receptor agonist
  - Has been examined less extensively
  - Associated with a greater rate of transition from persistent VS (PVS) to MCS in a retrospective chart review
  - [Chiew C, & Altmann D. 2000]

Pharmacology in TBI – Amantadine

- **The acute phase of recovery from severe traumatic brain injury is characterized by a brief period of neuronal excitability followed by a longer period of hypoexcitability, involving depletion of multiple neurotransmitters, including dopamine.**
- **Amantadine may promote dopaminergic activity by facilitating presynaptic release and blocking reuptake postsynaptically.**
- **The favorable neurobehavioral effects of amantadine may reflect enhanced neurotransmission in the dopamine-dependent circuits that are responsible for mediating arousal, drive, and attentional functions.**
Pharmacology in TBI – Amantadine

- More rapid recovery
- Affected functionally meaningful behaviors:
  - consistent responses to commands
  - intelligible speech
  - reliable yes/no communication
  - functional-object use
- The benefits consistent regardless of the interval since injury or whether patients were in a VS or MCS at enrollment
- Gains were generally well maintained but the rate of recovery attenuated after treatment
- Exposure did not increase the risk of adverse medical, neurologic, or behavioral events, including seizure

(Chiaravalli, J. et al 2012)

Pharmacology in TBI – Attention

- Methylphenidate (Ritalin)
  - Despite limitations, reasonable strength of evidence exists to support its use for various aspects of attention, processing speed, concentration, and sustained attention in the acute and subacute phases of recovery
- Cholinesterase inhibitors (Physostigmine, Donepezil or Aricept)
  - Compelling evidence is lacking,
  - Preliminary evidence for improving attention encourages further investigation
  - A double-blind, placebo controlled study found improvement in scores on one measure of attentional processes in the physostigmine group
  - One randomized crossover trial demonstrated attention and memory benefits following TBI with Donepezil, which were sustained after the washout period
  - Another case series reported subjective improvement and improvement in processing speed, verbal memory, and divided attention in 8 of 10 subjects treated with Donepezil

(Chew E & Zafonte D, 2009)

Pharmacology in TBI – Memory

- Memory disturbance remains a primary concern of patients with severe TBI and their families.
- Attempts have been made to enhance memory via the cholinergic and adrenergic systems
- Further investigation into the role of cholinergic augmentation with cholinesterase inhibitors for those with impaired memory following TBI is warranted
- Use of neurostimulants for this purpose has met with mixed results
- No clear conclusion regarding agents to improve memory can be made at this time

(Chew E & Zafonte D, 2009)

Identification of Next Level of Care

- Post acute care disposition frequently dictated by physical therapist
  - Complete understanding of patients’ current functioning and prognosis is essential to make proper recommendations
- In rehab, LOS significantly longer, but discharge planning by the team is important from the start
  - Consider family goals and resources

Evidence to Support Post Acute Rehabilitation

- Strong evidence exists that more intensive rehabilitation programmes lead to earlier functional abilities (Helmig S and Johannes S, 2008)
- Postacute rehabilitation effective in improving functional outcome after TBI, including persons with stable neurologic recovery at 12 or more months post injury (Helmig S et al 2006)
  - Improvements
    - on measures of overall disability
    - independence
    - home competency
    - productivity
    - gains were maintained at follow up
  - For the group beginning postacute rehabilitation < 6 months post injury independence continued to improve after discharge
  - Community integration and home competency also continued to improve even after discharge

Negative Prognostic Indicators

- Predictors of poor outcome 6 months post-TBI:
  - low GCS overall
  - Low GCS on admission
  - low motor score on GCS
  - presence of midline shift on CT scan
  - presence of subdural hematoma

(Husson E, et al 2010)
Physical Therapy Management for Patients with Disorders of Consciousness

Negative Prognostic Indicators
- Prolonged coma (> 1 week)
- Prolonged PTA (>2 weeks)
- Coexisting injury
- Secondary injury
- Delayed access to trauma care
- Presence of DAI
- Presence of hypoxic or anoxic injury
- Little or no change in GCS or RLCFS (within 4 weeks)
- Positive brain injury imaging findings several weeks after injury

(Review by McCulloch and Crea, 2002)

Positive Prognostic Indicators
- Early or rapid improvement in cognitive and/or motor skills
- Young Age
- Higher IQ
- Higher educational achievement
- No history of drug abuse
- No previous TBI
- Stable work history
- Access to and continuity of rehab
- Specialized care for TBI
- Access to case management
- Consistent communication between professionals and patient/family
- Patient/Family acceptance and understanding of TBI

(Review by McCulloch and Crea, 2002)

PHYSICAL THERAPY OUTCOME MEASURES

Glasgow Outcome Scale (GOS)
- Commonly used before other scales were developed as a brief descriptive outcome scale
- Replaced by the DRS
- Still seen occasionally in the literature investigating early acute medical predictors of gross outcome.
- The five categories of the original scale are:
  - Dead
  - Vegetative = Unable to interact with environment; unresponsive
  - Severely disabled = Able to follow commands; unable to live independently
  - Moderately disabled = Able to live independently; unable to return to work or school
  - Good recovery = Able to return to work or school

(www.tbims.org/combi/gos/index.html)

The Disability Rating Scale (DRS)
- Developed and tested with individuals with moderate and severe TBI in an inpatient rehabilitation setting
- The scale is intended to measure accurately general functional changes over the course of recovery
- Addresses impairment, disability and handicap
  - The first three items of the DRS (Eye Opening, Communication Ability and Motor Response) are a modification of the GCS and reflect impairment ratings
  - Cognitive ability for “Feeding,” “Toileting” and “Grooming” reflect level of disability
  - The Level of Functioning and Employability items reflects handicap
- The maximum score is 29 (extreme vegetative state)
- Limitations
  - Relative insensitivity at the low end of the scale (mild TBI)
  - Inability to reflect more subtle but sometimes significant changes

(www.tbims.org/combi/drs/index.html)
Take Home Message

- Formalized rehabilitation is an important part of the rehab process.
- Observation is key...as is documentation of these changes!
- Use of objective tools can support care and change.
- Medical and pharmacologic issues must be considered with this population.
- Prevention of secondary complications is important for future function.
- Recognize your part as an important part of the rehab team.

References
