Medical and Surgical Approaches to Tone Management

Goose Ridge Vineyards and Estate Winery
Richland, WA

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Objectives

- Introduction to the Tone Management Program
- List various treatment options for spasticity
- Explain why an SDR reduces tone
- Describe the evaluation of a child who might benefit from an SDR
- Explain the surgical approach to an SDR
- Design a post-SDR rehabilitation program
- Describe the outcomes expected from an SDR
Tone Management Program – Team Members

**Physicians**
- Mark C. Dales, MD
  - Orthopedics
- John F. McLaughlin, MD
  - Developmental Pediatrics
- Tom McNalley, MD, MA
  - Rehabilitation Medicine
- Marisa Belem Osorio, DO
  - Rehabilitation Medicine
- William O. Walker, MD
  - Division Chief, Developmental Pediatrics

**Nurse Practitioners**
- John Forrest Bennett, ARNP
  - Rehabilitation Medicine
- Mandy Breedt, ARNP
  - Neurosurgery
- Angela Forbes, ARNP
  - Neurosurgery
- Nadine Nielsen, ARNP
  - Neurosurgery
- Lindsey Price, ARNP
  - Neurosurgery
- Laura Zapata, ARNP
  - Neurosurgery
Tone Management Program – Team Members (continued)

**Therapists**
- Cathy Graubert, PT, Clinic Manager
- Connie Liebow, PT
- Carrie Miller, PT
- Rachelle Steijn, PT
- Leslie Vogel, PT
- Shannon Wells, PT
- Francine Won, PT

Wendy McGrath, OT, Clinic Manager
Heather Browne, OT
Elizabeth Chappelle, OT
Cherie Duval White, OT
Jennifer Fernandez, OT
Sharon Greenberg, OT
Peggy Smith, OT
Madelaine Stoer, OT
Laura Surges, OT

**Program Manager**
Erin Hooper, RN, BSN
Comprehensive Evaluation Process

- Initial Evaluation
- Coordinate Surgical Plan with Neurosurgery
- Postoperative Care Plan
- Long Term Management

Rehab

- Initial Evaluation
- Preoperative Assessment
- Postoperative Care Plan
- Long Term Management

PT/OT

- Short Term/Long Term Coordination of Orthopedic Interventions

Orthopedics

- Initial Evaluation
- Surgical Intervention
- Postoperative Management

Neurosurgery

Rehabilitation Medicine
Spasticity

- Velocity dependent tone
- Disruption of the UMN pathways at cerebral cortex/brainstem/spinal cord
  - Excitatory
    - Corticospinal tracts
    - Medial reticulospinal tract
    - Lateral vestibulospinal tract
  - Inhibitory
    - Lateral reticulospinal tract
Treatment of Spasticity

- Rehabilitation therapies
- Oral Medications
- Neurosurgery
- Orthopedic surgery
- Injections
Tone management (cont)

- Botulinum toxin
  - Blocks release of Ach at NMJ
  - Localized tone reduction
  - Reversible
  - Limited muscles based on weight

- Baclofen
  - Gabba agonist
  - Enteral or intrathecal
  - Side effects and complications problematic
  - Reversible
Selective Dorsal Rhizotomy

Premise: abnormally responding sensory nerve rootlets are the same rootlets that contribute to spasticity and the elimination will decrease spasticity and improve motor function

- Abnormal roots under less inhibitory control
- Abnormal roots result in abnormal motor response
- Selective ablation of sensory nerve roots from L2-S1 results in permanent reduction of spasticity
• Diminish the afferent arc of the aberrant myotatic reflex
SDR Evaluation - History

- HPI
  - Age of child
  - Current and past history of tone management strategies
  - Therapy program
- PMH
  - Birth history
  - Etiology of CP
  - Associated conditions
- PSH
Evaluation – History (cont)

- Family history
- Medications
- Social history
- Functional history
  - Cognitive
  - Motor
    - Gross
    - Fine
Evaluation - Examination

- General
- Musculoskeletal
  - ROM
  - Hips
- Neurological
  - Tone (spasticity vs dystonia)
  - Reflexes
  - Strength
Evaluation - Function

- Gait
- Strength
- Transitions
- Objective testing
  - GMFM
  - GMFCS

- Team members
  - Rehab MD
  - Neurosurgeon
  - Orthopedic surgeon
  - Physical therapist
  - Occupational therapist
Evaluation – Key Points

- **History**
  - Young child (3-7 years)
  - Diagnosis consistent with CP*
  - Tone management maximized without optimal response
  - Intensive therapy program without optimal response
- **Spasticity predominant pattern**
- **Good strength and motor control**
- **Good follow-through anticipated**
Surgical Approach

• Laminectomy
  • Multi-level (L2-S1): rootlets sectioned as root exits intervertebral foramina
  • Single level (L1): rootlets sectioned at level of conus

• Dorsal and ventral roots identified
  • Visually and electrically
    • Ventral roots activated at low threshold
  • Segmental level verified
  • Ventral roots placed behind a silastic dam
Monitoring (cont)

- Electrode placement – subdermal electrodes
  - L1/L2 – adductors
  - L2/L3 – vastus medialis
  - L4 – anterior tibialis
  - L5 – gastrocnemius
  - S1 – biceps femoris
  - S2/S3 – perirectal
Surgical Approach (cont)

• Dorsal root teased into 3-8 rootlets
  • Rootlets looped and pulled away from CSF for stimulation and monitoring
  • Transection of the aberrant nerve roots
Intra-operative stimulation

Step 1. **Threshold stimulation**

- current ranges from 0.5 to 10.0 mA,
- 0.1 milliseconds constant current square wave pulse is administered at 0.5–1.0 Hz
- gradually increasing stimulus intensity until a unilateral response is obtained.
- Threshold current recorded
Intraoperative Stimulation

Step 2. **Train stimulation**

- 50 HZ train of stimuli for 1 second duration
- EMG responses recorded and *scored*
Intraoperative monitoring – rootlet selection

• Phillips and Park’s grading system
  • 0 = no sustained discharge
  • 1+ = sustained discharge only in muscles innervated by the segmental level stimulated
  • 2+ = sustained response as in 1+ but also in additional segmental level
  • 3+ = sustained response in multiple ipsilateral segmental levels
  • 4+ = sustained responses with spreading to contralateral extremity
Intraoperative Monitoring

• Goal
  • Separate the ‘normal’ from the ‘abnormal’ by scoring system
  • Section the ‘most abnormal’ and leave the rest
  • 30-70% rootlets sectioned*
Selection criteria - summary

- **Normal response**
  - Single response to repetitive stimulation
  - Multiple response with decremental amplitude pattern

- **Abnormal response**
  - Incremental amplitude pattern
  - Motor response in non-targeted muscle
  - Response is sustained
Monitoring – challenges to interpretation

- Handling of rootlets may lead to minor trauma which changes response
- Anesthesia may change responses
- Abnormal responses have been reported in children without CP
- Stimulation of rootlets may sensitize adjacent segments
- Re-stimulation may desensitize rootlets
- Anatomical differences
Electrophysiological monitoring, tone, and outcomes

- No consistent relationship between number of abnormal responses with spasticity
- Abnormal responses correlate with gross motor at baseline
- No consistent relationship between number of rootlets ablated and reduction in tone
- Number of rootlets ablated correlates with improvements in some motor skills

Electrophysiological guided vs non-guided SDR

- Percent of rootlets sectioned similar
- No difference in Ashworth scores, ROM, strength, WeeFIM
- No difference in complications
- Operative time reduced when non-guided

Surgical Approach (cont)

- Comparison single level vs multi-level
  - Single-level: Smaller incision, less muscle dissection
  - Multi-level: Technically easier

- No difference pain, use of opioids, time to mobilize
- Length of stay less in single level

Rehabilitation following SDR

- No evidenced based protocols exist
- Intensive therapy recommended
  - Daily PT and OT typical
  - Inpatient setting common for 2-4 weeks
  - Transition to outpatient program with minimum 3x/week PT for 6 months
Rehabilitation – goals of therapy

- ROM
  - Serial casting if needed
  - Knee immobilizers
- Strengthening
- Transition movements
  - Bed mobility
  - Transfers (slide board)
- Improve sitting tolerance in wheelchair
Rehabilitation – goals of therapy (cont)

• Standing program in stander
• Gait training
  • Starts when standing posture adequate
  • Quality of gait critical
    • Goal to avoid use of old patterns
    • Walking in therapy only
    • Assistive device as needed
  • Orthotics as appropriate
• OT to address daily care skills throughout rehab
Outcomes - General

- Reduction in spasticity
- Improvements in range of motion
- Improvements in function*
- Decrease in need for orthopedic procedures
- High satisfaction
- Minimal risk surgery

### SDR – Meta-analysis of randomized, controlled trials

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<th></th>
<th>Vancouver</th>
<th>Toronto</th>
<th>Seattle</th>
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<tbody>
<tr>
<td><strong>Age</strong></td>
<td>3-7 (4.1)</td>
<td>3-7 (5.2)</td>
<td>3-18 (6.8)</td>
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<tr>
<td><strong>Baseline GMFM</strong></td>
<td>56.4</td>
<td>52.7</td>
<td>70.7</td>
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<tr>
<td><strong>Baseline MAS</strong></td>
<td>3.4</td>
<td>3.1</td>
<td>2.3</td>
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<tr>
<td><strong>Roots transected</strong></td>
<td>45%</td>
<td>41%</td>
<td>25%</td>
</tr>
<tr>
<td><strong>Difference in MAS</strong></td>
<td>-1.1*</td>
<td>-1.0*</td>
<td>-1.0*</td>
</tr>
<tr>
<td><strong>Change GMFM</strong></td>
<td>6.1%*</td>
<td>7.7*</td>
<td>0.2%</td>
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<tr>
<td><strong>PT hours</strong></td>
<td>81.8/9 mo</td>
<td>110.6/12 mo</td>
<td>152.6/12 mo</td>
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Outcomes - Strength

- Isometric strength without significant change at 6 months
- Absolute increase in knee extension and ankle DF at 1 year
- Normalized strength values without any increase or decrease in any muscle at any time period

Outcomes – Gait Analysis

- Kinematic improvement
  - Ankle DF in stance
  - Hip and knee extension in stance
  - Hip abduction in stance*
- Improved velocity and stride length*

*Thomas SS et al. J Pediatric Ortho 1996 Nov-Dec; 16 (6): 747-752
Outcomes – 5 and 10 year follow-up

- Tone reduction maintained
- No significant change in range of motion
- Motor function improved in GMFM

Mittal S et al. J Neurosurg 2002; August; 97: 3153-25
Outcome – predictors of poor outcome

- Type of CP (quadriplegia)
- Intellectual disability
- Age
- Trend toward lower GMFCS

Outcomes - orthopedic

• Orthopedic surgery post SDR 18%-65%
• Decreased orthopedic procedures post SDR
• Fewer procedures in GMFCS I and II vs III
  • 24% vs 51%
• Soft tissue > boney

• Recommend being patient after SDR

Comparison of ITB and SDR

- Both procedures reduce tone, increase ROM, improve function in GMFCS III-V
- High degree of satisfaction for both groups
- SDR
  - Greater improvement in tone, ROM, gross motor function
  - Less need for orthopedic procedures at 1 year

SDR - Complications

- Transient sensory changes (up to 10%)
- Infection
- Dural leak
- Rare bladder incontinence
  - Transient urinary retention
- Rare impotence
- Back pain

Steinbok P and Schrag C. Pediatric Neurosurg 1998;28:300-13
SDR – Thinking outside of the box

- Hemiplegia
  - Decrease in spasticity
  - Quality of gait improves
  - Step length and velocity improves in most

SDR in Moderate to Severe CP

- Decreased tone, improved PROM
- High degree of patient satisfaction
- 50% patients improved 1 GMFCS level
- Potential option for non-ambulatory children in certain situations
  - Rural locations
  - No goals or potential for ambulation/weight-bearing

SDR in the patient without CP

- TBI
- SCI
- CVA
- Adults

*Theoretical benefit or case reports only
Summary

• SDR reduces spasticity and improves function
• Long-term benefits
• Surgical approach varied without one better than the other
• Complications rare
• Post-operative therapy standard
• Potential for less traditional patients to benefit
How to Make a Referral to the Tone Management Program

By phone: (206) 987-2114 (Option #1)
By fax: (206) 985-3121
Online: www.seattlechildrens.org – search “Referrals”

For assistance, please contact:
Erin Hooper, Program Manager
(206) 987-5917
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THANK YOU!