ORTHOPAEDIC SURGERY FOR THE LOWER LIMBS IN CHILDREN WITH CEREBRAL PALSY

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I. GENERAL
A. Treatment Goals
   i. Maximize function
   ii. Delay/avoid surgery when possible
B. Optimizing outcome requires optimizing biomechanical alignment
   i. All joints affect all other joints in all planes
      1. Lever arm dysfunction
   ii. These children lack typical balance, strength and coordination
C. Non-surgical treatments
   i. Therapy
   ii. Home program
   iii. Bracing
      1. Tailor the brace to the child
         a. Coronal plane (varus/valgus): need to “capture” the hindfoot
         b. Sagittal plane
            i. Do you need to limit plantarflexion or dorsiflexion?
            ii. How is knee position?
   iv. Night splints
   v. Botulinum toxin (off label indication)
      1. 10-15 units/kg whole body dose (400 units max)
      2. Logistics
         a. Office visit (H&P and consent)
         b. 27 gauge needle
         c. Shot blocker (Bionix)
         d. No e-stim
D. Operative intervention
   i. “The decision is more important than the incision” -- Mercer Rang
   ii. Typical indications
      1. Age: 7 – 10 years
      2. Wait until child has plateaued for 6-8 months
      3. Non-operative interventions will not suffice
   iii. Single event multilevel surgery (SEMLS), addressing all bone and soft tissue issues at one time, is the standard of care
      1. Gait analysis is performed pre-op, when available
         a. Optimizes outcome
         b. Decreases rate of reoperation
2. Gait improved at 1 year & motor function at 2 years (and maintained at 5 years) (Thomason et al. *Gait Posture* 2013)

3. Post-op therapy is critical
   i. Patient and family must be committed to therapy or surgery should not be done

iv. Pre-op gait analysis
   1. Lower reoperation rate (20% vs 40% by 5 years post-op)
   2. Better results when gait data used
   3. If gait analysis not available, then;
      i. Serial examinations
      ii. Video child (e.g. with phone), when able

⇒ PEARLS:
1. All significantly affected planes and levels should be addressed with SEMLS.
2. Pre-operative decision-making is the most important determinant of surgical outcome.
3. Pre-operative gait analysis decreases rates of reoperation and cost in children with CP.
4. Post-op PT is critical.

II. HIP PROBLEMS
A. Hip flexion contractures
   1. As with other contractures, static and dynamic measures often not well-correlated
      i. 50% with HFC > 10°, do not walk with excessive hip flexion (Rethlefsen et al. *J Pediatr Orthop* 2010)
      ii. Main problem is crouch, though crouch is often seen in the absence of hip flexion contracture (HFC)
         a. Crouch in absence of HFC typically due to downstream issues (foot, ankle, tibia and/or knee)
   2. Consider surgery (psoas recession) if HFC >10 degrees and significant hip flexion in stance
      i. May do this through adductor incision if adductors require lengthening

® PEARLS:
1. Many patients who walk with excessive hip flexion do not have HFC.
2. Many with HFC do not have severe hip flexion during gait.
3. Observers tend to overestimate hip flexion during gait on observational gait analysis (OGA).

B. Hip adduction contractures
   1. Problems
      i. Scissoring
      ii. Troubles with diapering & hygiene
   2. Differentiate between dynamic scissoring and fixed contracture
When surgery necessary, the adductor longus is typically tightest.

a. Gracilis often also needs lengthening
b. Try to avoid lengthening brevis and magnus. (These rarely need lengthening, especially in GMFCS I-III)
c. Obturator neurectomy should be avoided (to avoid “frog” positioning of hips)

**PEARL:** Obturator neurectomy has risk of causing abduction contractures, and does not decrease the risk of recurrent subluxation when combined with bony procedures

### III. KNEE PROBLEMS

**A. Hamstring contracture/knee contractures**

1. Flexion contractures are much more common than extension contractures (exception: near drowning survivors)

2. Problems
   
   i. Crouch
      
      a. Types
         
         i. Jump gait (hip/knee flexion and ankle equinus)
         ii. Apparent equinus (hip/knee flexion & neutral ankle)
         iii. Calcaneal crouch (hip/knee flexion & excessive DF)
      
     ii. Difficulty sitting is rare for knee flexion contracture < 90°, but common with knee extension contractures
       
       a. Treatment
          
          i. Conservative: stretching, knee immobilizers, botulinum toxin (off label indication)
       
       ii. Surgery
          
          a. Hamstring lengthening (HSL)
             
             i. Avoid overlengthening (results in recurvatum)
             ii. Some combine with hamstring transfer
             iii. Recurvatum much more common with medial/lateral lengthening
             iv. Do not check a popliteal angle intra-op (due to increased risk of neuropraxia)
          
          b. Guided growth (anterior hemiepiphysiodesis of distal femur) – for knee contractures if physes open
             
             i. May use plate/screw construct or just screws
             ii. May be combined with patella tendon advancement (PTA)
                
                i. Extensor lag on exam
                
                ii. X-rays: patella alta ± traction on distal pole
          
          c. Distal femoral extension osteotomy (for more severe deformities and/or little or no growth remaining)
             
             i. Shortening of femur decreases risk of neurovascular injury
             ii. Better results when combined with PTA

**PEARLS:**

1. Overlengthening of hamstrings is an under-appreciated problem and
results in genu recurvatum and stiff-knee gait.
2. Lateral hamstrings often do not require lengthening, particularly before adolescence.
3. Consider bone surgery for recurrent and/or severe contractures
4. Guided growth can result in good correction, even in adolescence

B. Stiff-knee gait
1. Interferes with foot clearance in swing phase
2. Often due to rectus femoris spasticity
3. Consider surgery (distal rectus femoris transfer) if following criteria are ALL met:
   i. If you have access to computerized gait analysis (CGA)
      i. Stiff knee in swing
         i. Kinematics: delayed timing of peak knee flexion in swing
            ± decreased excursion from stance to swing < 50°
         ii. EMG shows rectus is overactive in swing phase
      iii. GMFCS I or II function
   ii. If you do NOT have access to CGA
      i. Stiff knee in swing
      ii. Positive Duncan-Ely (prone rectus) test
      iii. GMFCS I or II

IV. Ankle/Foot problems
A. Equinus
1. Important to make sure:
   i. Whether equinus is dynamic or due to static contracture
2. Be sure that toe-walking is due to equinus and not knee and/or hip flexion
   i. Toe-walking in AFO’s is a tip-off that knee/hip are issues rather than heelcord
3. Remember: Observers (even very experienced ones) overestimate ankle equinus on visual gait analysis
4. Avoid surgery whenever possible (by using stretching, braces, serial casting...)
   i. Heelcords are better a little tight than a little loose
   ii. Calcaneus gait more common with age (even without previous surgery)
   iii. Calcaneus reported in up to 30-40% of patients following heelcord surgery
      a. Rate much lower with gastroc recession than TAL
5. If you don’t have access to CGA
   i. Do serial exams
   ii. Remember the tendency to overestimate equinus
   iii. Video of child walking

© PEARLS:
1. Toe-walking in AFO’s is usually due to the hamstrings.
2. Observers tend to overestimate equinus when observing gait
3. Heelcords are better a little too tight than too loose.

B. Varus
1. Contributors
   i. Anterior tibialis ~ 1/3 of cases
   ii. Posterior tibialis ~ 1/3
   iii. Anterior & Posterior tibialis ~ 1/3
2. Differentiate between flexible and rigid deformities
3. Surgery
   i. Balance soft tissues
      a. I prefer tendon to tendon transfer for 2 reasons:
         i. Easier to get optimal tension
         ii. No risk of pressure sore from button on bottom of foot
      ii. Bony surgery also needed for rigid deformity
      iii. May consider talectomy in long-standing severe, rigid equinovarus deformities in GMFCS IV and V

© PEARLS:
1. Anterior tibialis is a significant contributor to varus feet in children with CP, contrary to traditional teaching.
2. Always balance soft tissues, regardless of whether deformity is flexible or rigid

C. Valgus
1. Common
   i. More common in bilaterally-involved than unilaterally-involved
2. Leads to out-toeing
3. Causes lever arm dysfunction
4. Differentiate pes valgus from ankle valgus
   i. Clinical exam – lateral malleolus should be distal to medial malleolus
   ii. AP ankle x-ray – if clinical exam suspicious for ankle valgus
      a. If “normal” ankle, distal fibular physis is at level of ankle joint
5. Often associated with tight gastrocnemius and peroneals
6. If surgery is needed, calcaneal osteotomies help preserve hindfoot motion
7. Talonavicular fusion may be needed for severe midfoot break

© PEARL:
1. Contributes to lever arm dysfunction and out-toeing
2. Make sure that valgus is from the foot and not the ankle (standing AP ankle x-ray may be needed).
3. If the valgus is from the ankle, address the tibia with hemiepiphysiodesis or osteotomy.
V. LEVER ARM DYSFUNCTION

A. General
   1. Problematic due to abnormalities in balance, strength and coordination
   2. Surgery may be needed to address lever arm dysfunction due to torsional deformity, foot deformity and/or hip subluxation

B. Long bone torsion (femur and/or tibia)
   1. Consider osteotomy if torsion persists and interferes with function
   2. Physical exam
      i. Femur/hip
         1. Hip IR/ER
         2. Trochanteric prominence anteversion test (TPAT)
      ii. Tibia
         1. Transmalleolar angle (TMA)
         2. Thigh foot angle (TFA) – correlates best with tibial torsion
   3. Observational gait analysis
      i. Foot progression angle (FPA) – usually 10-15° external
      ii. Foot progression angle (KPA) – usually ~ neutral
      iii. Compare FPA to KPA
         1. If significantly different, then deformity below knee (tibia and/or foot)
   4. Femoral osteotomy
      i. Comparable results for proximal and distal osteotomies
      ii. Proximal osteotomy indicated if:
         1. Coxa valga, and/or
         2. Hip subluxation
      iii. Surgical correction should be 1.5 – 2:1 of what is deemed clinically
   5. Tibial osteotomy
      i. Distal osteotomy is much safer than proximal osteotomy
      ii. Fibular osteotomy is not needed for rotational correction
      iii. Surgical correction should be 1:1

® PEARLS

1. Bony malalignment is more problematic in children with CP due to limitations in balance, strength and coordination.
2. Proximal and distal femoral osteotomies have equivalent results.
3. Tibial osteotomies are best done distally.
4. Surgical correction should be 1.5 – 2:1 for femoral osteotomies and 1:1 for tibial osteotomies.

REFERENCES [1-28]

Clinical evaluation:
- Incidence correlates with disease severity
  - 25-80%; GMFCS V up to 80%
  - ~ 50% of GMFCS IV or V patients will have a moderate to severe curve by age 18
- Change in activity or spasticity
- Pain and positioning problems
- Spinal deformity Develops in 75% of patients with hip subluxation/dislocation, but no correlation between unilateral or bilateral dislocations
  - *marker of disease severity rather than a cause
- Scoliosis develops more rapidly or simultaneously with hip subluxation in most cases
- Physical exam: evaluate sagittal and coronal balance, hip ROM, UE contractures, how much purposeful movement in LE, able to follow commands, weight, skin issues

Nonoperative treatment:
- Bracing
  - main objective to improve seating/positioning and maintain function
  - conflicting evidence as to whether bracing slows progression
    - no study with brace monitors to evaluate compliance
  - our preference: custom molded TLSO (soft or hard-depending on skin issues and patient/parent tolerance)
- Wheelchair Modification
- Baclofen pump and dorsal rhizotomy may help with spasticity but do not improve scoliosis

Operative treatment:
- Indications and Timing of Surgery
  - Prior to development of severe restrictive lung disease or pulmonary HTN
  - Important to sit upright for quality of life?
  - Higher rate of complications with larger curve magnitude
    - flexibility may be the most important factor

Preoperative Protocols:
- Optimize nutrition
• Pulmonology evaluation
• Cardiology evaluation (echocardiogram) if >70 degrees
• Chlorhexidine gluconate wipes

**Intraoperative Protocols:**
- Antibiotic prophylaxis (important to cover for gram negative organisms)
  - Best Practice Guidelines for SSI prevention in high risk patients protocol
- Tranexemic acid (TXA)
- Neuromonitoring (checklist)
- Discussion of MAP goals for phases of procedure with anesthesia
- Intraoperative wound irrigation prior to closure
- Topical vancomycin in bone graft/on fascia

**Surgical techniques Fixation:**
- Sacral-Alar-Iliac screws (SAI) -> fewer implant complications than Iliac Bolts (SAI screws fail 75% less than Iliac Bolts)
- Pedicle screws preferred over wires
- Sublaminar bands if unable to achieve pedicle fixation

**Correction:**
- Halofemoral traction
- Temporary rod (provides stability if staging)
- Occasionally Halogravity traction for a few weeks
- Anterior releases (rarely used- patients with severe enough curve to benefit often have poor pulmonary status and cannot safely tolerate it)
- Ponte osteotomy – osteotomy workhouse
- Serial reducers for load sharing during reduction – Keep MAPs > 75mmhg!
- T-square of Tolo to evaluate correction

**Postoperative Care:**
- Impervious dressing (jiban)
- Continue antibiotics for 24 hrs – Cefazolin/Ceftazidime
- Optimize nutrition
- PICU for at least first night
- Mobilize early and often

**Complications:**
- Respiratory (PICU postoperative management) – Most common complication
- Wound Infection (high risk)
- Pseudoarthrosis

**Outcomes:**
- High Satisfaction rate (92%) despite high complication rate (27%)
Complication rate: 46.4% at 1 year
Complications did not correlate with HRQoL gains and perceived satisfaction with surgery as reported by the caregivers
92% of caregivers reported an improvement in the quality of life of their child after surgery at 1 year which was maintained at 5 years

References: