What is a Brachial Plexus Injury

The **brachial plexus** is the network of nerves that sends signals from your spine to your shoulder, arm and hand. A **brachial plexus injury** occurs when these nerves are stretched, compressed, or in the most serious cases, torn away from the spinal cord.

http://www.prd.uk.com/services/
Obstetrical Brachial Plexus Injury

Children and babies with brachial plexus injuries will typically have a number of the following symptoms:

• Unable to lift their arm above their head
• Unable to bring objects to their mouth
• Unable to move their fingers
• Unable to feel things or tingling/pain in their arm, hand or fingers

OBPI often occurs as a result of a difficult birth.

Traction forces on nerves can cause a spectrum of injuries, ranging from temporary conduction deficits to nerve root avulsions from the spinal cord.
BPI Classification

- Upper plexus (Erb’s) C5, C6 and +/- C7 nerve roots
- Lower plexus palsy (Klumpke’s) C8 and T1 nerve roots
- Total plexus palsy

Narakas Classification

- Narakas (1987) classified babies with obstetric palsy into four groups:
  - **Level I**: upper Erb’s, palsy: C5-C6
  - **Level II**: extended Erb’s palsy: C5-C7
    - Depending on recovery of wrist extension
      Subclassified into a (before 2 months and b (after 2 months)
  - **Level III**: total palsy: C5-T1
  - **Level IV**: total palsy with a Horner syndrome: C5-T1
Upper Plexus Injury: (Erb’s Palsy C5-C6, +/- C7) is the most common: 73%-86% of cases

General posture at birth:
- Shoulder adducted and internally rotated typically, but may be abducted and externally rotated
- Elbow extended
- Forearm pronated
- Wrist and fingers flexed
Prevalence

• Between 0.38 and 4.6 per 1,000 live births
  – Rates vary between studies
• 0.46 per 1,000 live births result in persisting injury
• Approximately 5,420 newborns in US born each year

Risk Factors

• Most common risk factor in the occurrence of an obstetric brachial plexus injury is shoulder dystocia, a situation where there is typically a mismatch between the maternal pelvic diameter and the size of the infant’s body and shoulders
• BPI is more common in above average birth weight babies
• Gestational diabetes
• Forceps delivery or vacuum extraction
Recovery

- Currently, recovery rate of around 65%
  - Varies greatly based on type of injury
    - Mildest injury (Neurapraxia) will usually have full recovery by 3 months
- Nerve regeneration occurs at an average rate of 1 inch/month
  - Can be affected by scar tissue
  - Proximal injuries will require more time to heal
- Some injuries will require surgical intervention for optimal recovery

Recovery

- Biceps recovery is a useful indicator of overall recovery by 2 months?
  - External rotation of shoulder and supination of forearm are typically most affected movements and experience recovery last
Assessments of Newborn and Child with BPI

• Active Movement Scale (AMS)
  – Designed for infants and young children to gather info on muscle activation and joint motion
  – Relies solely on observation of active limb segment movement without and against gravity

• Brachial Plexus Outcome Measure (BPOM)
  – Functional evaluation for school age children
  – Two components: activity scale and self-evaluation scale
  – Developed to provide information to assist with decision making regarding: secondary reconstructive procedures, remedial rehabilitation interventions and recommendations for adaptations and accommodations for daily living
Assessments of Newborn and Child with BPI

- Mallet Scale and Modified Mallet
  - Motor assessments for ages 3 years and older; Modified Mallet looks at 6 postures that are demonstrated by clinician for bilateral motion

Mallet

<table>
<thead>
<tr>
<th>Active Abduction</th>
<th>External Rotation</th>
<th>Head to Head</th>
<th>Head to Back</th>
<th>Head to Elbow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 30°</td>
<td>Impossible</td>
<td>Impossible</td>
<td>Impossible</td>
<td>Impossible</td>
</tr>
<tr>
<td>30° - 60°</td>
<td>Difficult</td>
<td>Difficult</td>
<td>Difficult</td>
<td>Difficult</td>
</tr>
<tr>
<td>More than 60°</td>
<td>Easy</td>
<td>Easy</td>
<td>Easy</td>
<td>Easy</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>II</th>
<th>III</th>
<th>IV</th>
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<tr>
<td></td>
<td>Less than 30°</td>
<td>30° - 60°</td>
</tr>
<tr>
<td></td>
<td>Impossible</td>
<td>Difficult</td>
</tr>
</tbody>
</table>
Modified Mallet

Imaging

- **X-ray**: rule out clavicle or humeral fracture
- **Magnetic resonance imaging (MRI)**: uses powerful magnets and radio waves to produce detailed views of your body in multiple planes. It often can show the extent of the damage caused by a brachial plexus injury and can help assess the status of arteries that are important for the limb or for reconstruction of it. New methods of high-resolution MRI, known as magnetic resonance neurography, may be used.
- **Computerized tomography (CT)**: uses a series of X-rays to obtain cross-sectional images of your body; can visualize cartilaginous surfaces of the glenohumeral joint in young children; evaluates bony structures after ossification
CAT scan: 4 year old with OBPI

MRI: Child with Right OBPI
Imaging

- **Ultrasound**: can visualize joint in real time with no sedation required; can also provide info on muscle integrity and nerves
- **EMG**: inserts a needle electrode through your skin into various muscles; evaluates the electrical activity of your muscles when they contract and when they're at rest; high probability of false negative findings in neonatal period and false positive findings a few months post term; an electromyogram is used to assess electrophysiological health of a muscle and can assist in distinguishing between nerve rupture and neurapraxia.
- **Nerve conduction studies**. These tests are usually performed as part of the EMG, and measure the speed of conduction in your nerve when a small current passes through the nerve. This provides information about how well the nerve is functioning.

Surgical Procedure Options

**Nerve graft**
- In this procedure, the damaged part of the brachial plexus is removed and replaced with sections of nerves harvested from other parts of your body. This helps restore your arm's function.

**Nerve transfer**
- When the nerve root has been torn from the spinal cord, surgeons often take a less important nerve that's still attached to the spinal cord and connect it to the nerve that's no longer attached to the spinal cord.
- In some cases, surgeons may perform this technique at a level close to the targeted muscle in an effort to speed up recovery rather than doing a repair (nerve graft) farther from the muscle. Sometimes doctors may perform a combination of nerve graft and nerve transfer.
- Nerve tissue grows slowly, about an inch (2.5 centimeters) a month, so it can take several years to know the full benefit of surgery.

**Mod Quad**
- Involves 5 procedures which improve shoulder abduction and flexion
- The latissimus dorsi, teres major, subscapularis and pectoralis muscle contractures are released; the latissimus dorsi and teres major muscles are sutured to a low position in the teres minor muscle which enhances the stabilizing effect of the rotator cuff, enabling the deltoid to act more effectively
Surgical Procedure Options

**Triangle Tilt**
- used to correct a SHEAR deformity (scapular hypoplasia, elevation and rotation); consists of osteotomy of the clavicle at the junction of the middle and distal thirds, osteotomy of the acromion process as its junction with the spine of scapula, ostectomy of the superomedial angle of the scapula to reduce scapular winging, and splinting of the extremity in adduction, external rotation and forearm supination.

Surgical Procedure Options

**Muscle transfer**
- Muscle transfer is a procedure in which your surgeon removes a less important muscle or tendon from another part of your body, typically the thigh, transfers it to your arm, and reconnects the nerves and blood vessels supplying the muscle.

**Glenohumeral capsule release**
- rotates the humerus within the abnormal glenoid; does not address the abnormal structure/angle of scapula.
BPI in Older Children

• 20-30% of children with BPI will have residual neurological deficits at 3 years of age
• Of those children who have delayed but full recovery, there is still a 30% incidence of shoulder joint contractures and glenohumeral deformities
• Muscle atrophy and imbalances between muscle groups are common

BPI in Older Children

• Challenges as children get older
  – Growth spurts
  – Higher demands for motor performance in extra curricular activities
    • Encourage participation in sports
  – Higher demands for ADL skills
• Posture
BPI in Older Children

- Changes in therapy with older child
  - Exercise/stretches become more client driven
  - Updating orthotics/adaptive equipment
- Addressing coordination and balance deficits
  - Children with BPI are at risk for body coordination and balance issues as they grow.
  - In a 2015 study of 39 children 5-15 with BPI, 26 children (66.7%) scored below average on the balance subtest of the MABC-2 (Movement Assessment Battery for Children)
- Addressing posture

Role of OT: Splinting

- Purpose of splinting in BPI: protection, positioning, joint integrity, function
- Many different options for shoulder, forearm, elbow, wrist and hand
- Type of splint and wear schedule will vary based on each child’s needs
Role of OT: Splinting

Theratogs: Theratogs.com
Trunk Dynamic Movement Orthosis

Scapula/ Shoulder DMO
Fabrifoam Shoulder Wrap

- Fabrifoam or neoprene material can be cut to provide dynamic assist into shoulder external rotation. Fabrifoam.com

FREO: Forearm Rotation Elbow Orthosis

- Dynamic tension at elbow with Ultraflex joint
- Static forearm with adjustable supination
- Static wrist
- Ultraflexsystems.com
- Article in JPO
Fabrifoam Elbow Extension

- Fabrifoam or neoprene material can be cut to provide dynamic assist into elbow extension.

Bamboo Splint/ Immobilizer
Sup-ER Splint

Wrist/ Hand DMO
Benik

Wrist/ Hand Splint
Lumbrical Splint: use if MCP extension dominant (Klumpkes)

Fabrifoam and McKie for Hand

- Fabrifoam or neoprene material can be cut to provide dynamic assist into forearm supination and thumb abduction.
- Can be used with McKie thumb splint
- McKiesplints.com
- Fabrifoam.com
Role of OT: CIMT

• While there has been significant research conducted CIMT on children with cerebral palsy, there has been little research investigating the efficacy of CIMT approaches in children with brachial plexus injuries.

• The research that has been done has shown improvements in ability to perform bimanual tasks, shoulder function, forearm/elbow function, hand grasp and upper extremity strength.

CIMT Cont.

• When to start CIMT?
  • Start early; hold the child’s non-affected arm back, use a soft wrap (sock, fabrifoam, coban)
  • Begin with very motivating activities: finger feeding, musical toys, etc.
  • Slowly increase time interval: start with 15-20 minutes at a time and work up; one hour per day for 1 year old is good goal
  • Can do more intensive constraint programming when child shows readiness; can tolerate 1-3 hours of therapy, no significant behaviors, tolerates cast well, family is invested in process, etc.
**Strengthening**

- Anti-gravity movements
- Weight bearing
  - Encourage crawling
  - Play in prone
- Pushing activities
- Pulling activities
- Grip and pinch strength on weak side

**Stretching**

- Helps maintain ROM and prevent joint contractures
- Education of parents
- Encourage a schedule
- Update stretching as child grows
Protection

- Support arm in carseat
- Support arm when carrying
- No lifting child up by hands/arms
- Provide handouts for daycare, babysitter, etc.

Positioning

- Play with child laying in sidelying with the affected arm facing up
- Place toys towards the affected side to encourage awareness
Positioning

• Play in prone with towel roll
• Make sure both arms are up on tray when in high chair
• Bilateral toys for older children

Caregiver Education

• Education on BPI
• What to expect for recovery
• Importance of ongoing therapy
• Education for home
  – Stretching
  – Strengthening
  – Splint wear and care
Risk of Torticollis with BPI

- Infants with brachial Plexus injury may present with a concurrent torticollis. A retrospective review study was done at the University of Michigan, evaluating 128 patients presenting between 2005-2009.

Risk of Torticollis with BPI

- Study investigated the incidence of torticollis associated with neonatal brachial plexus palsy and whether the severity of brachial plexus palsy affects outcomes and the rate of recovery.
- A retrospective review of 128 consecutive neonatal brachial plexus palsy patients evaluated at the University of Michigan from 2005-2009. Patients were followed for at least 3 months, with regular physical examinations and imaging.
- 43% presented concurrently with torticollis. Significant differences were evident in mean age at first brachial plexus examination, suggesting that patients with concurrent torticollis present earlier for clinical examination.
- Recovery from torticollis was evident in 62% of patients by 23 ± 12 weeks with conservative management.
Risk of Torticollis with BPI

• No statistically significant differences were evident between torticollis and nontorticollis groups after reviewing their severity of neonatal brachial plexus palsy (Narakas score), recovery from neonatal brachial plexus palsy (biceps function at 6 months), need for nerve repair or reconstructive procedures, or infant, maternal, or other factors associated with labor.

• Results suggest that although torticollis occurs with increased frequency in children with brachial plexus palsy, its presence is not related to severity and does not affect the probability of recovery from brachial plexus palsy. Conservative management for torticollis yields reasonable recovery.

Trunk and Lower Extremity Involvement and Asymmetries

• Children with a history of OBPI often present with issues in their trunk and lower extremities including:
  • Increased sacral angle and anterior pelvic tilt
  • Tight hip flexors and weak gluteals
  • Weak abdominals
  • Scoliosis
  • Asymmetrical LE weightshift and weightbearing
  • Pronated feet
AB: sacral angle

AB hip flexor tightness
AB: 5 years and 7 years sit-up
AR: 15 years old Right BPI
A multidisciplinary team is essential to the management of the infant and child with OBPI. The team should include:

- Pediatrics or family medicine, pediatric neurology, pediatric orthopedics, physiatry, occupational therapy, physical therapy, and orthotics.
- Team may also include neuroradiology, plastic surgery, an neurosurgery.
Additional Interventions

• Serial Casting
• FSM (Frequency Specific Microcurrent)
• Threshold Electrical Stimulation
• Botox
• Elastic Therapeutic Taping
• Aquatics

Sports and Activities KEY to maintaining strength and range of motion
Case Study: S.V

• Diagnosed with Erb’s Palsy and Shoulder Dystocia of the LUE at birth following prolonged labor and use of forceps
• He has received occupational and physical therapy on an every other week basis beginning at 2 weeks of age
• First 6 months of OT focused on splinting (wrist support splint), caregiver education, strengthening and achievement of developmental milestones
• Limited spontaneous recovery observed; assessed by two different BPI centers- one recommended surgical intervention, one did not. Family elected to not have surgery.

Case Study: S.V

• At 6 months of age, family was provided with soft constraint (coban and soft strapping material) to begin gentle constraint of RUE for short periods of time
• At 12 months of age, first constraint cast was fabricated (Delta Cast Conformable) for constraint in home 1-hour per day (also using benik wrist splint to prevent injury when crawling up on wrist)
• Between 12-24 months of age had a DMO for wrist support and supination but very difficult to don with limited wear.
Case Study: S.V

- 2 years of age, participated in intensive therapy intervention focusing on CIMT to improve deficits in: active shoulder flexion, shoulder abduction and adduction, external rotation of the shoulder and supination of the forearm (using SPIO vest at this time for core stability and decreasing compensatory trunk movement patterns)
- Also focused on improving left upper extremity strength
Case Study: S.V

- The program duration was 3 weeks in length. A cast that could be removed for skin checks as well as emergency situations was donned on his right upper extremity. The cast was removed a total of 5 times for less than one hour in duration. Intervention in clinic setting was 2 hours per day, 4 days per week for week 1 and 2, and 1 hour per day for 4 days during week 3. An activity log of age-appropriate play and self-care activities was utilized during therapy sessions and in the home throughout the duration of the program.

Case Study: V.S

- PMAL and AHA administered pre and post intervention with positive changes noted on both assessments
- 41 point improvement on PMAL in both the “how often” and the “how well” categories
- Change from a score of 64 to a score of 74 on the AHA logit scale
- Continued traditional therapy following intensive program
- Completed another intensive program the following summer at the age of 3 with following changes:
Case Study: V.S

• Continues to demonstrate following deficits: active shoulder flexion, shoulder abduction/adduction, poor core strength, poor shoulder stability and scapular alignment, decreased strength/musculature of back and shoulder girdle
• Good in-hand manipulation skills and compensates with other movement patterns very well
Case Study: M

• Born at 39 weeks gestation by normal vaginal delivery
  – Prenatal ultrasounds were normal
  – Labor not prolonged
  – Head was to one side, shoulder dystocia
  – Birth weight of 9 pounds, 12 ounces
• Started PT at 2 weeks of age
• OT was added 1 month later

Case Study: M

• Early intervention
  – Wrist cock-up splint
  – Supination strapping
  – Positioning, stretching strengthening, taping
• Imaging
  – EMG completed at 3 months of age and MRI at 6 months of age
  • Upper & middle trunk brachial plexopathy
  • Showed signs of recovery with reinnervation
  • No signs of root avulsion
Case Study: M

- Initial recovery was slow, very little active movement noted until 3 months of age
- Functional level by 6 months of age
  - Improved tone, but still low
  - ~90 degrees shoulder flexion
  - Good use of fingers, grasp slightly weaker than R
  - Improved wrist extension
  - No active supination, elbow flexion, shoulder abduction or external rotation

Case Study: M

- Surgery
  - Surgical repair (nerve graft) on January 29, 2016 at St. Louis Children's Hospital at 6.5 months old
- Recovery
  - 6 weeks in immobilization brace after surgery
  - Therapy resumed after brace removed
  - Grip present, some shoulder elevation, but no other active arm movements
Case Study: M

• Current level of function (14 months old)
  – Shoulder flexion to 110 degrees
  – Initiating reaching with affected arm
  – Improving bilateral skills
  – Good hand function
  – Still lacking in elbow flexion, supination
    • Cannot bring hand to mouth
## Active Movement Scale

<table>
<thead>
<tr>
<th>Movement</th>
<th>2 weeks (evaluation)</th>
<th>6 months (prior to surgery)</th>
<th>14 months (7 months post surgery)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoulder Abduction</td>
<td>0</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Shoulder Flexion</td>
<td>0</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Shoulder External Rotation</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Elbow Flexion</td>
<td>0</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Forearm Supination</td>
<td>0</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Wrist Extension</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Finger Extension</td>
<td>5</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Thumb Extension</td>
<td>5</td>
<td>3</td>
<td>6</td>
</tr>
</tbody>
</table>

- Scores for Shoulder Adduction, Shoulder internal rotation, Elbow extension, Forearm pronation, Wrist Flexion, Finger flexion, and Thumb flexion were 7 at all 3 administrations of AMS.
References


References