BRACHIAL PLEXUS BIRTH INJURY
SUBTLETIES OF CARE WITH LASTING CONSEQUENCES

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Physical Medicine and Rehabilitation

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Brachial Plexus Clinic Coordinator
OBJECTIVES

- Participants will be able to list the secondary, orthopedic sequelae impacting children with brachial plexus birth palsy
- Participants will recognize there are preventative, non-surgical measures available to infants with brachial plexus birth palsy who are diagnosed and treated early
- Participants will adopt an early specialty clinic referral policy for infants suspected of having a brachial plexus birth injury
- Participants will be able to confidently provide realistic hope to parents of infants with brachial plexus birth palsy and prepare them for future care
WHAT IS THE BRACHIAL PLEXUS?
MECHANISM OF INJURY
EPIDEMIOLOGY

- Incidence: 0.1 to 5.1 per 1000 cases
- Majority of cases are unilateral
- Upper trunk injury is most common pattern of injury
MATERNAL RISK FACTORS

- Advance age > 35 years
- Pelvic anatomy
- High BMI
- Gestational diabetes
- Primiparity
LABOR AND DELIVERY RISK FACTORS

- High birth weight (> 4 kg)
- Breech position
- Shoulder dystocia
- Forceps or vacuum
- Clavicle fracture
- Gestational
- Maternal multiparity
- Previous births with brachial plexus birth palsy
### NARAKAS CLASSIFICATION

**Grade 1 = C5,6**
- Upper trunk

**Grade 2 = C5,6,7**
- Upper Trunk Extended

**Grade 3 = C5,6,7,8,T1**
- Total palsy / No Horner’s

**Grade 4 = C5,6,7,8,T1**
- Total Palsy / Horner’s

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**Table 1 — Narakas classification of obstetric palsy**

<table>
<thead>
<tr>
<th>Group</th>
<th>Name</th>
<th>Roots Injured</th>
<th>Site of Weakness/Paralysis</th>
<th>Likely Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Upper Erb’s</td>
<td>C5, C6</td>
<td>Shoulder abduction/external rotation, elbow flexion as above with drop wrist</td>
<td>Good spontaneous recovery in over 80% of cases.</td>
</tr>
<tr>
<td>2</td>
<td>Extended Erb’s</td>
<td>C5, C6, C7</td>
<td></td>
<td>Good spontaneous recovery in about 60% of cases.</td>
</tr>
<tr>
<td>3</td>
<td>Total palsy with no Horner syndrome</td>
<td>C5, C6, C7, C8, T1</td>
<td>Complete flaccid paralysed</td>
<td>Good spontaneous recovery of the shoulder and elbow in 30-50% of cases. A functional hand may be seen in many patients.</td>
</tr>
<tr>
<td>4</td>
<td>Total palsy with Horner syndrome</td>
<td>C5, C6, C7, C8, T1</td>
<td>Complete flaccid paralysed with Horner syndrome</td>
<td>The worst outcome. Without surgery, severe defects throughout the limb are expected.</td>
</tr>
</tbody>
</table>

**Table 2 — Classification of newborns with OBBP in the current study**

<table>
<thead>
<tr>
<th>Group</th>
<th>Name</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Upper Erb’s</td>
<td>C5/C6 injury as per the first examination 2-3 weeks after birth.</td>
</tr>
<tr>
<td>Iia</td>
<td>Extended Erb’s with early recovery of wrist extension</td>
<td>C5/C6, C7 injury as per the first examination 2-3 weeks after birth. Active wrist extension against gravity recovers on follow-up within the first 2 months after birth.</td>
</tr>
<tr>
<td>Iib</td>
<td>Extended Erb’s with no early recovery of wrist extension</td>
<td>C5/C6/C7 injury as per the first examination 2-3 weeks after birth. Active wrist extension against gravity does not recover on follow-up within the first 2 months after birth.</td>
</tr>
<tr>
<td>III</td>
<td>Total palsy with no Horner</td>
<td>C5/C6, C7/C8/T1 injury as per the first examination 2-3 weeks after birth. There is no Horner syndrome. Same as group IV but with a Horner syndrome present at the initial examination.</td>
</tr>
<tr>
<td>IV</td>
<td>Total palsy with Horner</td>
<td></td>
</tr>
</tbody>
</table>
• **Avulsion** — this means the nerve has been pulled out from the spinal cord and has no chance to recover (PRE GANGLION)

• **Rupture** — this means the nerve has been stretched and at least partially torn, but not at the spinal cord (POST GANGLION)

• **Neurapraxia** — this means the nerve has been gently stretched or compressed but is still attached (not torn) and has excellent prognosis for rapid recovery

• **Axonotemesis** — this means the axons (equivalents of the copper filaments in an electric cable) have been severed. The prognosis is moderate

• **Neurotemesis** — this means the entire nerve has been divided. The prognosis is very poor
PROGRESSION OF PATHOLOGY IN BPI

1-3 Months
- Prolonged Muscle Weakness
- Muscle Imbalance at the GHJ
- Learned Neglect of the Limb Begins

3 - 6 Months
- Glenoid Malformation
- Muscle / Joint Contractures
- Posterior Humeral Head Dislocation

1 - 3 Years
- Compensatory Trunk/Scapula Motion
- Bony Changes More Difficult to Remedy
- Permanent Glenohumeral Incongruity
## SUBTLETIES OF CARE

<table>
<thead>
<tr>
<th>Topic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Wait &amp; See Approach”</td>
<td>Majority of BP injuries recover</td>
</tr>
<tr>
<td>Resident MD Education</td>
<td>The mother is the patient</td>
</tr>
<tr>
<td>Litigious Nature of BPI</td>
<td>Incidence of lawsuits brought against MDs</td>
</tr>
<tr>
<td>Caregiver Education</td>
<td>What is said matters...</td>
</tr>
</tbody>
</table>
“WAIT & SEE”

Why?

• Because most birth injuries recover spontaneously (evidence reports 65% - 90%)?

• Difficult conversation to have with the family for the first time?

• May have high threshold for referral to specialty clinic due to lack of updated information?

The Danger?

• Recent evidence has shown ~30% of patients had a posterior humeral head dislocation on ultrasound between the ages of 3 and 6 months

• A wait and see approach can increase risk of orthopedic issues requiring surgical intervention

• Delayed or infrequent care can limit surgical options for patients who go on to need orthopedic surgery (e.g. latissimus transfer vs. humeral external rotation osteotomy)
RESIDENT PHYSICIAN EDUCATION

Why?

- Residents are taught early on in their Obstetrics/Gynecology rotation that the mother is their patient and the pediatrician is responsible for the newborn

The Danger?

- May result in delayed identification of a brachial plexus injury and therefore delayed care
LEGAL ASPECTS OF BPBI

Why?

• The nature of BPBI
• General rise in lawsuits in America over the years
• The need to not declare fault in the medical setting
• A referral may be viewed as an admission of something wrong

The Danger?

• Delayed referrals push back an infant's initial evaluation with a specialist
• Good surgical decision making depends on serial assessment of the infant
CAREGIVER EDUCATION

• “Most of these injuries get better”
• “Protect the arm and follow up with your pediatrician”
• “We will wait and see how he/she progresses”
• “They didn’t say anything about his/her arm”
**IMPACT OF WHAT IS SAID**

- “Most of these injuries get better”
- “Protect the arm and follow up with your pediatrician”
- “We will wait and see how he/she progresses”
- “They didn’t say anything about his/her arm”

- True, but ignores sequelae that can impact incomplete recoveries
- Yes, but can delay care and do little to prepare parents for a home exercise program
- Traditional approach that delays surgery if needed and opens the child up to avoidable orthopedic issues
- Unfortunate, delays care, and does nothing to prepare family for the continuum of care
HOW SHOULD CARE LOOK?

• Initial & Ongoing Assessment(s)?
• Caregiver Education?
• Imaging?
• Therapeutic Management?
• Conservative Medical Management?
• Nerve Surgery Decision Making?
• Orthopedic Surgery Decision Making?
CARE OVERVIEW

# Active Movement Scale (0 – 8 Yr)

## AMS Evaluation Form

<table>
<thead>
<tr>
<th>Movement Grade</th>
<th>Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>no muscle tone or contraction</td>
</tr>
<tr>
<td>1</td>
<td>muscle contraction, no motion</td>
</tr>
<tr>
<td>2</td>
<td>joint motion ≤ ½ range</td>
</tr>
<tr>
<td>3</td>
<td>joint motion &gt; ½ range</td>
</tr>
<tr>
<td>4</td>
<td>full joint motion</td>
</tr>
<tr>
<td>5</td>
<td>joint motion ≤ ½ range</td>
</tr>
<tr>
<td>6</td>
<td>joint motion &gt; ½ range</td>
</tr>
<tr>
<td>7</td>
<td>full joint range</td>
</tr>
</tbody>
</table>

### Motion Table

<table>
<thead>
<tr>
<th>Motion</th>
<th>AMS</th>
<th>AROM</th>
<th>PROM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoulder Abduction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shoulder Adduction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shoulder Flexion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shoulder ER @ 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shoulder ER @ 90</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shoulder IR @ 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shoulder IR @ 90</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elbow Flexion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elbow Extension</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forearm Pronation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forearm Supination</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wrist Flexion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wrist Extension</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finger Flexion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finger Extension</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thumb Flexion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thumb Extension</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Modified Mallet Classification (3+ Yrs)

<table>
<thead>
<tr>
<th>Modified Mallet classification (Grade I = no function, Grade V = normal function)</th>
<th>Not Testable</th>
<th>Grade I</th>
<th>Grade II</th>
<th>Grade III</th>
<th>Grade IV</th>
<th>Grade V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global Abduction</td>
<td>Not Testable</td>
<td>No function</td>
<td>&lt;30°</td>
<td>30° to 90°</td>
<td>&gt;90°</td>
<td>Normal</td>
</tr>
<tr>
<td>Global External Rotation</td>
<td>Not Testable</td>
<td>No function</td>
<td>&lt;0°</td>
<td>0° to 20°</td>
<td>&gt;20°</td>
<td>Normal</td>
</tr>
<tr>
<td>Hand to neck</td>
<td>Not Testable</td>
<td>No function</td>
<td>Not possible</td>
<td>Difficult</td>
<td>Easy</td>
<td>Normal</td>
</tr>
<tr>
<td>Hand to spine</td>
<td>Not Testable</td>
<td>No function</td>
<td>Not possible</td>
<td>T1</td>
<td>Normal</td>
<td></td>
</tr>
<tr>
<td>Hand to mouth</td>
<td>Not Testable</td>
<td>No function</td>
<td>Marked trumpet sign</td>
<td>Partial trumpet sign</td>
<td>Marked abduction</td>
<td>Normal</td>
</tr>
<tr>
<td>Internal rotation</td>
<td>Not Testable</td>
<td>No function</td>
<td>Cannot touch</td>
<td>Can touch with wrist flexion</td>
<td>Palm on belly</td>
<td>No wrist flexion</td>
</tr>
</tbody>
</table>
ULTRASOUND SCREENING

- Identifying at risk shoulders much earlier (3 – 6 months)
- When <60 degrees of ER/Adduction is available it is recommended an US be ordered
- 30% of patients with BPBP had posterior dislocation in the first year of life
- Narakas Grade of Injury
  1 (upper trunk palsy) 41 (62%)
  2 (extended upper trunk palsy) 14 (21%)
  3 (global palsy) 3 (5%)
  4 (global palsy with Horner syndrome) 8 (12%)

<table>
<thead>
<tr>
<th></th>
<th>0 to 91 Days Old</th>
<th>92 to 182 Days Old</th>
<th>183 to 273 Days Old</th>
<th>274 to 365 Days Old</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dislocation in internal rotation</td>
<td>1/17 (6%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dislocation in external rotation</td>
<td>1/15 (7%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dislocation in internal rotation</td>
<td>14/38 (37%)</td>
<td>4/35 (11%)</td>
<td>5/28 (18%)</td>
<td></td>
</tr>
<tr>
<td>Dislocation in external rotation</td>
<td>13/32 (41%)</td>
<td>6/28 (21%)</td>
<td>4/21 (19%)</td>
<td></td>
</tr>
</tbody>
</table>
MAGNETIC RESONANCE IMAGING

• Preferred imaging for confirmation of avulsed injuries

• For our clinic, we do not order these before ~3 months of age unless there is a panplexopathy with poor recorded improvement since birth

• Some clinics do not order MRIs and rely solely on clinical exam for surgical decision making

• Findings are not always consistent with intraoperative assessment

• Presence of pseudomeningocele(s) are indicative of root avulsion
EMG / NCS

- Not standard of practice for infants who are being considered for primary nerve surgery
- Assist with surgical planning for older child who is being considered for secondary tendon transfer surgery (e.g. FCR → ECRB, Latissimus)
BOTOX®

Internal Rotation Contracture

Overactive Triceps
BOTOX® + CASTING

Botox to Internal Rotators

Casting in External Rotation
PRIMARY NERVE SURGERY (3 – 9 MONTHS)
SECONDARY ORTHOPEDIC SURGERIES

- Anterior Release
- Humeral Derotational Osteotomy
- Latissimus Transfer
THERAPY SERVICES

CRUCIAL CARE TIMELINE

1 Month
- Recommended age for initial clinic visit with surgical specialist / multi-disciplinary brachial plexus team

3 Months
- Muscle / joint contractures can be present and posterior humeral head developmental dislocation is a concern

3 - 9 Months
- Most primary nerve surgeries take place

12 Months
- Cut-off for primary nerve surgery
WHO AM I?

2011
Master’s Degree in Occupational Therapy
University of Texas Medical Branch

2011 - 2013
Adult Hand
Bay Area Rehabilitation

2013 - 2017
Pediatric Hand
Shriners Hospital

2017 - Present
Brachial Plexus Coordinator
Texas Children’s Hospital
THERAPEUTIC MANAGEMENT

- ROM
- Sensory opportunities
- Neurodevelopmental Therapy (NDT)
- Therapeutic Taping
- Positioning
- CIMT / Forced Use
- Splinting
I don’t believe you can overeducate caregivers when it comes to ROM exercises

- People don’t want to appear incompetent and when asked if they understand something 9 times out of 10 they will tell you yes even if they don’t
- If English is not their first language and you don’t fluently speak their preferred language, make sure they are understanding what you are teaching them
- Always have the caregiver complete the exercises in front of you to ensure they are comfortable with the hand positioning and execution

Make stretching fun

- Sing songs like, “I’m A Little Teapot” “Row Your Boat”

Counting

- Help the child to know that there is an end for each stretch (well defined boundaries)

Be sure the caregiver understands this is an ongoing need in their child’s care

- As long as the child is growing, their joints remain at risk
- Discharge criteria should be the parent independently taking their child through exercises and interventions you have taught them
SENSORY OPPORTUNITIES

• Normal contact with the limb by the parent during daily activities
• Intentional washing/drying at bath time
• Massage / Touch
• Variable material textures to supplement for natural environmental exploration
NEURODEVELOPMENTAL THERAPY

• Therapy uses facilitated movements as a treatment strategy to ensure correlation of input from tactile, vestibular, and somatosensory receptors within the body.

• NDT was developed with the understanding that patients with injuries have a limited repertoire of movement patterns.

• During treatment interventions, repeated experience in movement ensures that a particular pattern is readily accessible for motor performance.
KINESIOTAPE

• Can offer mechanical assist to weak / emerging motions
  • Shoulder External Rotation
  • Shoulder Abduction
  • Elbow Flexion
  • Forearm Pronosupination
  • Wrist Extension

• Can help facilitate stabilizing periscapular musculature
  • Lower Trapezius
  • Middle Trapezius

• Can inhibit deforming/overactive musculature of shoulder girdle and arm
  • Pectoralis Minor
  • Triceps
POSITIONING

- NICU
- Swaddling
- Car seat
- Crib
- Stroller
- Daily Activity / Play
CONSTRAINT INDUCED MOVEMENT THERAPY

• Yes?
• No?
• Maybe so?
• When?
• How often?
• How long?

What parents may think you mean...

What you actually mean...
BRITISH COLUMBIA CHILDREN’S SUP-ER SPLINT

• Addresses (3) most common contractures by reversing the resting posture of babies diagnosed with BPBP

• Effectiveness is measured via ultrasound

• Wear times can include night time, night and nap time, and full time (off only for bathing) depending on the extent of dysplasia and PHHD
FAMILY EXPERIENCE

Is this my fault?

What tests need to be done?

What is the brachial plexus?

What caused this injury?

New schedules

New Roles / Responsibilities

Will they get better?

Will I hurt my baby if I move their arm?

What exercises do I need to do?

Exhaustion

Work

Will my baby need surgery?
WHAT PROMPTED ALL OF THIS?

Being a Dad

Metaphor Analysis
So much to fight for: fighting for insurance, fighting for therapy, fighting the school system, fighting the doctors, fighting for services, and fighting their child to wear splints, braces, and machines.

Which path through this maze would give our child the most recovery possible from this injury? One doctor says your child needs 1 surgery, another says 3 surgeries, and another doctor says no surgery.
I STARTED ASKING QUESTIONS...

- Are we providing palatable information during clinic visits?
- Are the parents following our clinical reasoning and if not, how might we augment our educational efforts?
- Are clinic visits a conversation between providers and parents that make sense over time?
- Are we equipping our parents over the continuum of care?
- How can we bridge the gap between the informed, longitudinal lenses of the providers and the uninformed, immediate lenses of the parent?
WHERE DO WE START?

• There is no way to address all of these questions.

• Where can we start that will make the most impact for our patients?

• What has already been done?
RICE UNIVERSITY COLLABORATION:
CLINIC TOOL FOR PARENT EDUCATION

- Visual aid when describing shoulder pathology / contractures to parents
- Decreases anxiety by affording parents the opportunity to move a model before moving their child
- Allows for identification of the scapula and how to block it effectively when completing the prescribed exercises
WHAT ARE WE BATTLLING AGAINST?

• Joint contractures
• Learned nonuse
• Compensatory, maladaptive motion of the trunk & scapula
• Development / Independence
• Caregiver efficacy
• Access to care
• Evidence for treatment
• Consensus in care
FUTURE DIRECTION

• Consensus in care?
  • Plexus - Nexus

• Telehealth for initial triage and caregiver education?

• App to help parents and patients walk through this injury with support over the continuum of care?
CURRENT CLINIC

TEXAS CHILDREN’S HOSPITAL WEST CAMPUS

Available Days & Times

- 2nd, 3rd & 4th Monday of every month
- Plastic Surgery, Orthopedic Surgery, PM&R, Occupational Therapy
REFERRAL PROCESS

Internal Referral
• If the patient’s pediatrician or PCP is part of the TCH network, we will have their information on file and scheduling can be completed shortly after the referral is received
• When you email or call their provider be sure they are aware of the EPIC referral option and encourage them to send a referral specifically to the brachial plexus clinic vs. orthopedic surgery

External Referral
• Providers can print the referral PDF at https://www.texaschildrens.org/refer/brachial-plexus-program and fax it back to (832) 825 - 9613
• Details concerning the brachial plexus clinic at Texas Children’s Hospital can be found at https://www.texaschildrens.org/departments/brachial-plexus-program
CONTACT

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PM & R / Plastic Surgery
Texas Children's Hospital
p. 832-822-NERV (6378)
f. 832-825-9613
jhnorthc@texaschildrens.org
REFERENCES


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COMMENTS/QUESTIONS?