

# Brachial Plexus Birth Palsy: Timing and Indications

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# Acknowledgements

- Scott Kozin MD, Shriners Hospital of Philadelphia
  - Pictures



# Scenario

- 3 mo Diagnosed with BPBP at birth
- C5-6 Injury
- Biceps has not returned in first 3 months
- Should we operate?





# Outline

- Terminology and Background
- Surgical Indications
  - Global plexus injuries
  - Upper/middle trunk injuries
    - EMG
    - Imaging
    - Physical exam
  - Future directions





# Terminology for Brachial Plexus Birth Injury\*

## Extent of Injury

- Narakas Grade
  - Types 1-4
    1. C5-6
    2. C5-7
    3. Global
    4. Global with Horner's

## Functional Measurements

- Active Movement Scale/Toronto/HSC Scale
  - Example: completely absent elbow flexion would be AMS 0. Half range of motion against gravity would be AMS 5
- Mallet score
  - Example: hand to neck 'difficult' would be level 2
- Higher = better

\* Preferred term. Don't say 'obstetric' or 'palsy'



# Dilemma

- At what point will surgical intervention be better than the natural history?
  - “Intervention” meaning exploration of the plexus and nerve reconstruction
- Question One: Is there neurotmesis?
  - Needs surgery as soon as possible
- Question Two: If not neurotmesis, is this an axonometric injury that is recovering adequately?
  - Would it be better to cut out the neuroma and start over with grafts?
- Decision making algorithms attempt to answer this question



# Importance of Age

- Why we wait
  - nerves need months to recover
  - Injury at birth means  
(time allowed for spontaneous recovery) = age
  - Neuropraxia – 6 weeks
  - Axonometric injury- 1 inch per month
    - Birth humerus length is 2.5 inches
    - Thus, an axonometric injury to the upper trunk/biceps can recover in ~3 months
- Why we need to hurry
  - Muscle endplates die at 12-24 months
  - Denervated muscle leads to contractures, particularly shoulder. Longer period of denervation = more contracture





# Narakas 3-4

- Surgery at 3 months if no recovery
- Often avulsion injuries (neurotmesis, no chance of spontaneous recovery)
- Tend to do poorly without surgery
  - Al-Qattan 2000
    - 0 of 22 Narakas 4 patients had spontaneous recovery
    - 6/20 Narakas 3 patients had spontaneous recovery
- Can be improved with surgery
  - Pondaag 2006
    - 70% of patients regained useful hand function with surgical reconstruction

# Narakas 1/2

- Current area of controversy
- Recommendations range from 3-8 months
- How do we decide whether to perform surgery?
  - Risk Factors
  - EMG
  - Imaging
  - Physical Exam – gold standard



# Risk Factors for Persistent BPBI

1. Cephalic presentation
  2. Induction or augmentation of labor
  3. Birth weight > 9 lbs.
  4. Presence of Horner's syndrome
- Usefulness
    - These are present at birth
    - No invasive/expensive studies needed to determine these
  - Limitation
    - population based data. Not sure how to use this to determine an individual patient's risk
  - Variables used in predictive algorithms
  - Only Horner's syndrome is, by itself, an indication for early surgery





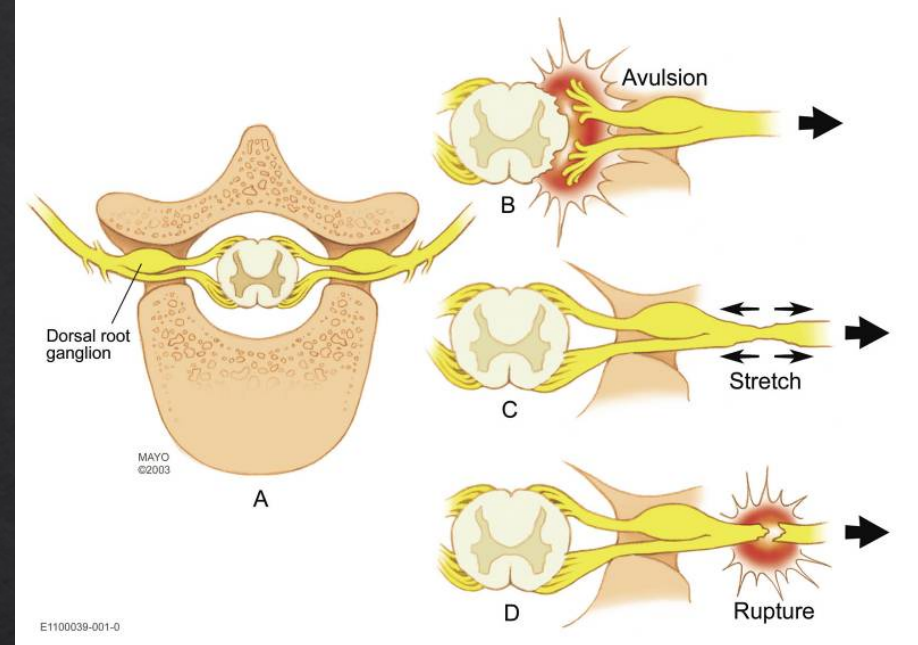
# EMG

- Invasive and painful test
- Benefit - May show recovery before it is detectable by physical exam
  - Motor units are often seen in clinically paralyzed muscles
  - Explanations
    - Overly pessimistic physical exam
    - Overestimation of the amount of EMG recruitment due to small muscle fibers
    - Persistent fetal innervation
- Limitation - Underestimates injury and overestimates chance of spontaneous recovery
- Not used by most surgeons for this reason



# Imaging

- Ultrasound
- MRI (CT Myelogram)
- Goals

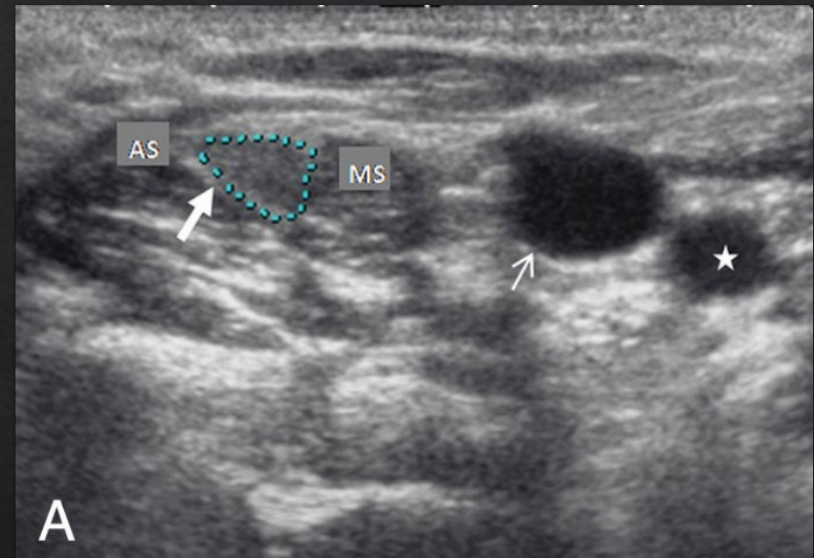


- Determine if there is a plexus injury
- Visualize the individual roots
  - Which roots? Partial or complete? Exact location?
- Determine whether the injury will recover using radiographic signs
  - Determine preganglionic/postganglionic
    - Preganglionic = avulsion (will never recover spontaneously)
    - If postganglionic, will it recover? (is it axonometric or neurotmesis?)



# Ultrasound

- Can demonstrate that there was a plexus injury
  - “periscalene soft tissue”
- Cannot visualize individual roots
- Cannot visualize preganglionic area
  - Especially in children
- Can prove there was a plexus injury, but provides little information that helps decision making





# MRI

## Strengths

- ◇ Can visualize pre vs post ganglionic injury
  - ◇ Pseudomeningocele
  - ◇ Sensitivity 68-96%
- ◇ Identify levels of preganglionic injury
  - ◇ Prognosis
  - ◇ Preoperative planning

## Limitations

- ◇ False positive and false negative results for nerve injury
  - ◇ Pseudo != root avulsion
- ◇ Root size makes individual visualization difficult
- ◇ Traditionally done under general anesthesia





# Example Pseudomeningocele on MRI



# Innovations in MRI



- 3 tesla scanners!
- Bauer 2017
  - No sedation
  - Developed scoring system to predict surgery
    - Number of levels affected
    - Degree of injury (Whether there is pseudo and/or root avulsion)

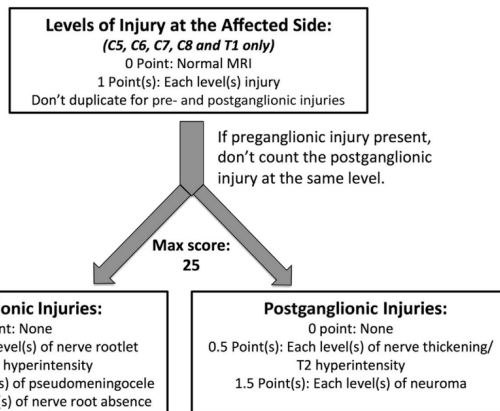
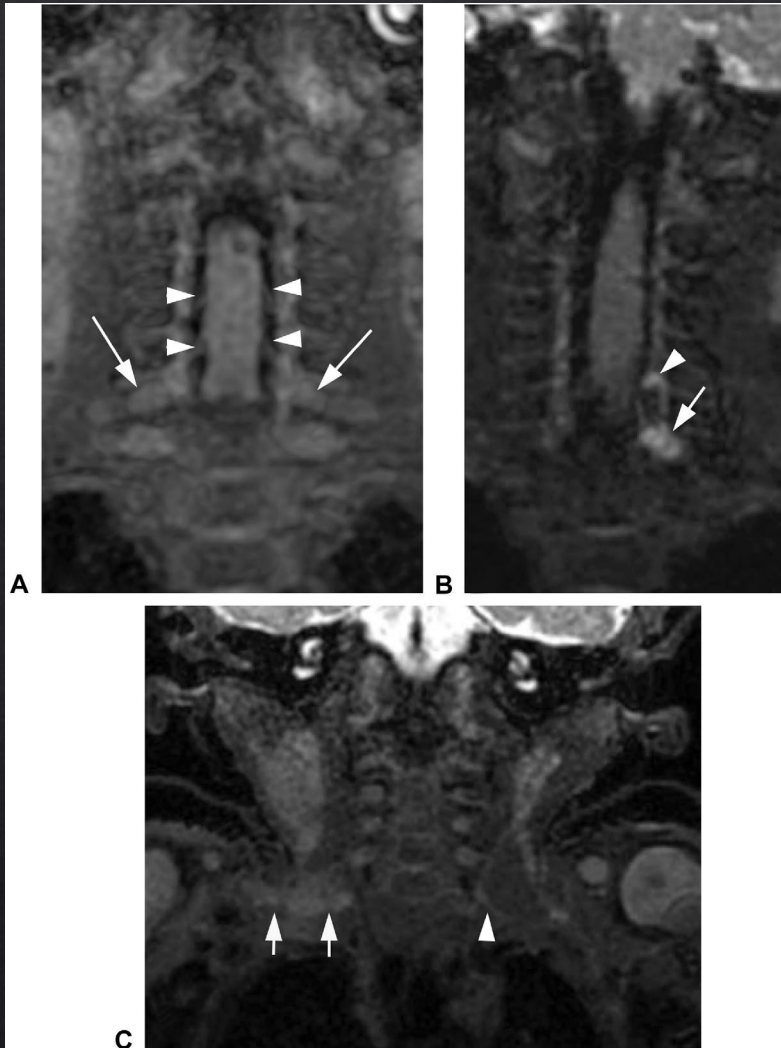


FIGURE 3: Flowsheet used to assign the radiological score.





Representative examples of typical MRI finding using the coronal 3-dimensional PD MRI sequence.

**A** Normal preganglionic nerve roots (arrowheads) and a normal dorsal root ganglion (arrows).

**B** Left C7 (arrowhead) and C8 (arrow) pseudomeningoceles and avulsed nerve roots.

**C** Right C5 and C6 nerve postganglionic ruptures with neuromas at the trunk level (arrows), with normal left C6 postganglionic nerve appearance (arrowhead).

*Andrea S. Bauer, MD et al*

# Bauer et al. Results

## Strength

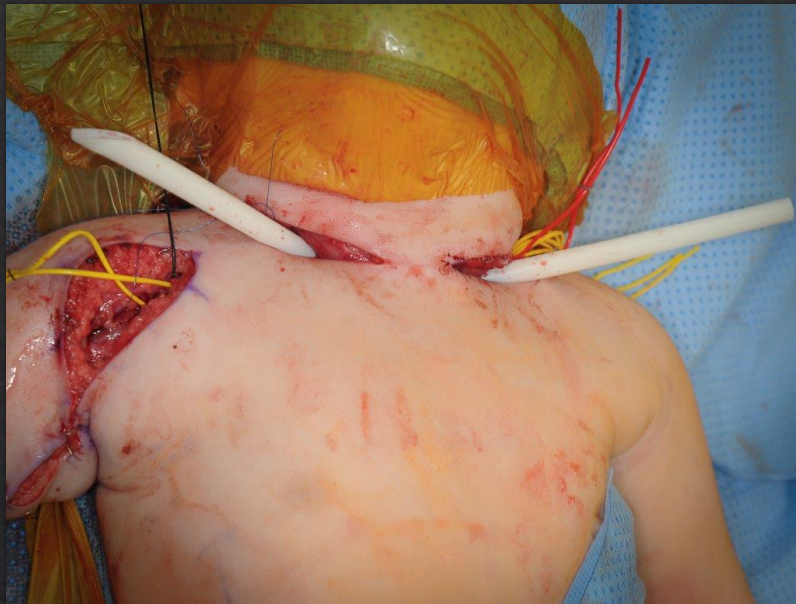
- MRI score differentiated groups that needed surgery (score avg 12) from those that didn't need surgery (score avg 3.5)
- Further validation may demonstrate usefulness to improve outcomes

## Limitation

- No inter or intra-observer reliability
  - Even though they had 3 people doing measurements
- Numbers too small to correlate with actual intraoperative findings
- Requires further research
- Retrospectively applied

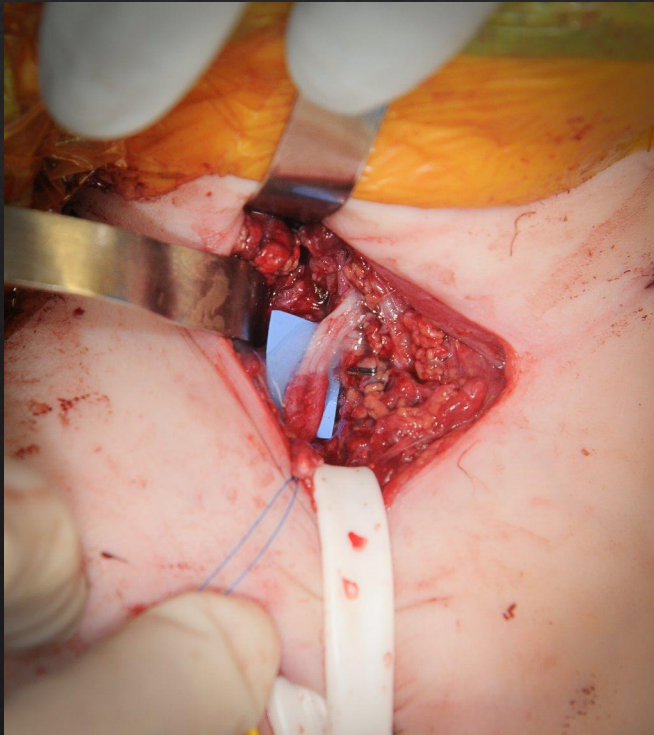






## Other Uses for MRI

- Preoperative planning
- Identify avulsions preop to estimate number of roots remaining
- If 4-5 levels look avulsed, can be prepared to do contralateral C7
  - Spine Consult





# Predicting Recovery by Physical Exam

- Currently **gold standard**
- Biceps function is the most commonly used measurement
- Best supported by literature
  - Long-term functional outcomes
- Considers age of patient and strength of various muscle groups



# Physical Exam Based on Elbow Flexion

- Most commonly used indication for surgery
- Carter 2004
  - 28 patients without biceps at 3 months, waited another 3 months
  - 22/28 recovered by 6 months and did not need surgery
  - Over half (12/22) had grade 4 (great) shoulder function
  - Recommended surgery if no biceps by 6 months
- Waters 1999
  - Large cohort study (39 patients)
  - Group that recovered biceps between 3 and 6 months had similar outcomes to group that had surgery at 3 months
  - Group that recovered biceps at 5 months did worse than patients who didn't recover at 6 months and thus received surgery
  - Recommended surgery if no biceps at 5 months



# Other Recommendations

- Gilbert
  - 3 months
  - Reasoning: patients who do not have biceps at 3 months will generally not have a full recovery. Since we know that they will likely have a full recovery, go ahead and operate
- Curtis
  - No difference in long-term outcomes between patients with no biceps at 3 months treated operatively/nonoperatively





# Algorithms

- Toronto/Hospital for Sick Children
- 3-month test score
- Based on active movement scores for elbow flexion, elbow extension, and wrist/finger/thumb extension
- Using elbow flexion alone incorrectly predicts poor recovery 12% of the time
- Score of 3.5 is threshold
- Also do 'cookie test' at 9 months

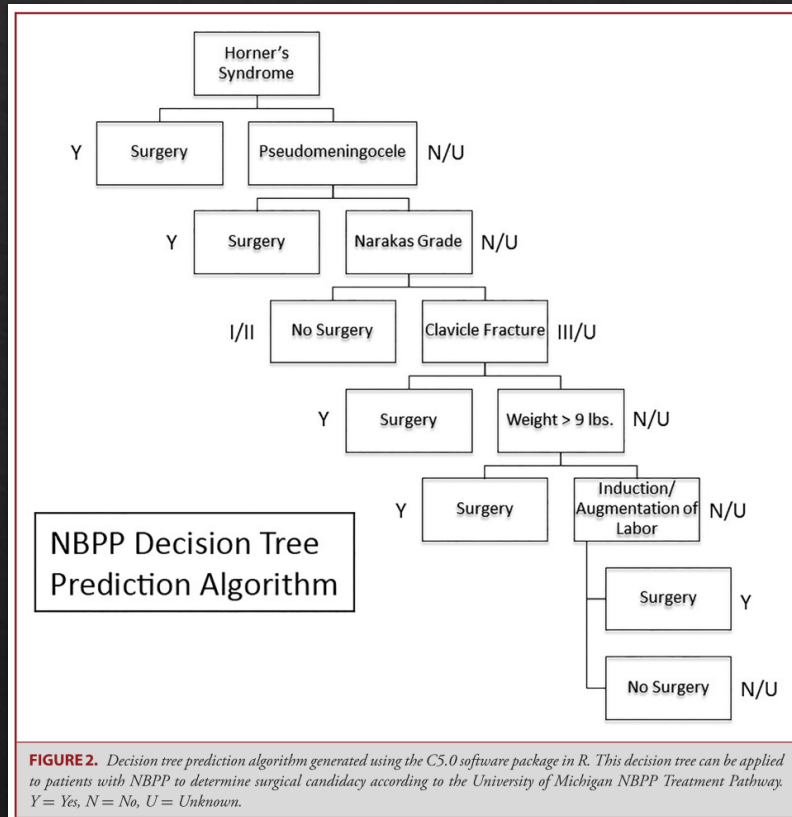
**Table 3. The Hospital for Sick Children Active Movement Scale Conversion for Use in Calculating Test Score\***

Muscle Grade	Converted Score
0	0
1	0.3
2	0.3
3	0.6
4	0.6
5	0.6
6	1.3
7	2.0

\*Adapted, with permission, from Clarke HM, Curtis CG. An approach to obstetrical brachial plexus injuries. *Hand Clin.* 1995;11:563-580.



# University of Michigan Decision Tree Generated Algorithm

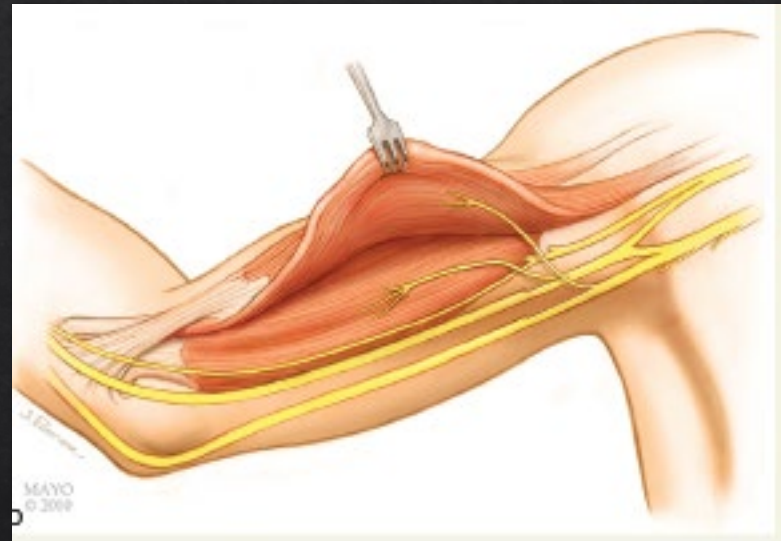


- Sensitivity 0.71 specificity 0.96, PPR 0.94, NPR 0.79
- Correlated to whether it was actually decided that patient should get surgery
- Patients that the algorithm selected were 56.7% more like to actually get surgery
- Limitation: the endpoint they use is whether a surgeon decided that surgery was needed
  - Post-hoc analysis
  - Needs to be done prospectively
  - Does not consider functional outcome of surgery vs not surgery, It does not predict when surgery will be better than natural history
- However, it may allow earlier application of an algorithm based on physical exam
- Requires further study



# Nerve Transfers

- In general, have decreased the need for early surgery
- Offer reliable reconstructive options
- Have quicker recovery times
  - Time = muscle
- Example: Oberlin transfer very reliably (85-90%) restores elbow flexion and can have good (AMS7) results even at 16-18 months of age





# Conclusion

- Recovery at 0-3 months – no surgery
- Global plexus – operate at 3 months if no recovery
- 3-6 months controversial
- No recovery by 6 months indication for brachial plexus exploration
- Future directions for research: improved MRI, validated algorithms



# Thank You!





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