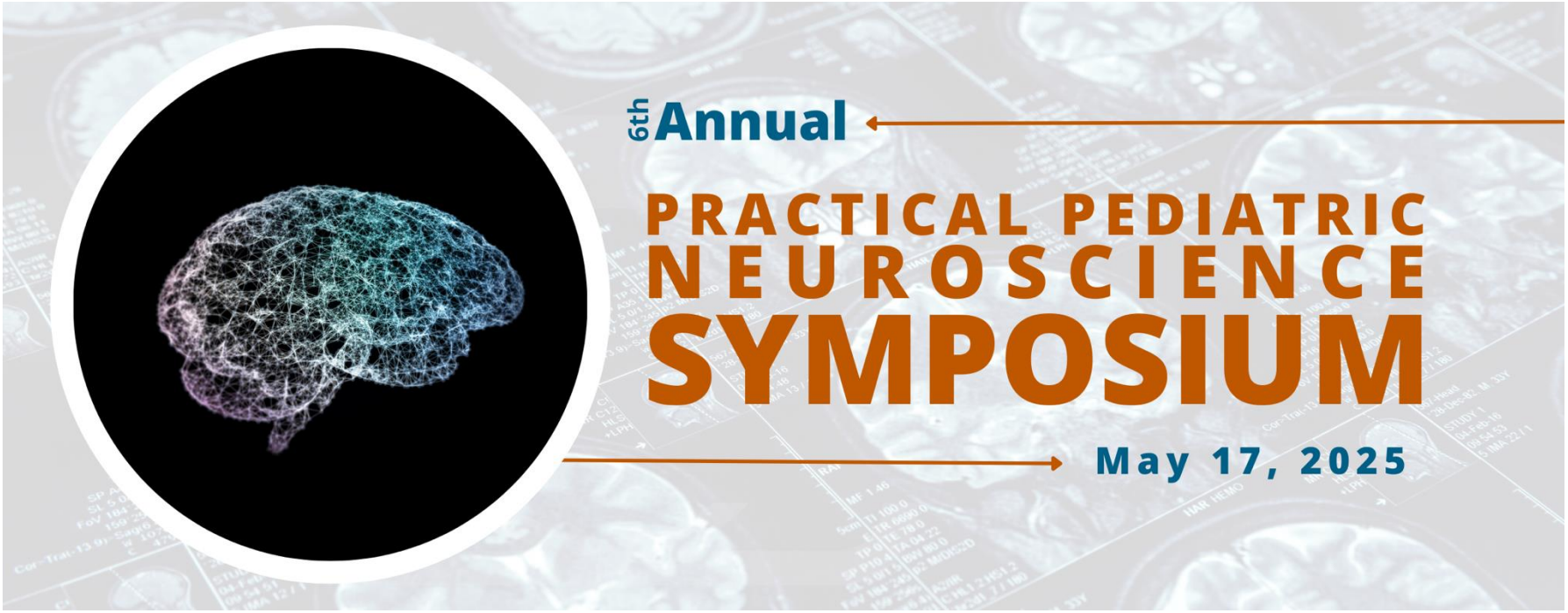


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# Brachial Plexus Injury (BPI)

## Diagnosis & Management

**Allan Lara, MD**

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Madonna and Child c.1496/1499

Wilhem II of Germany

Joseph Stalin


Martin Sheen

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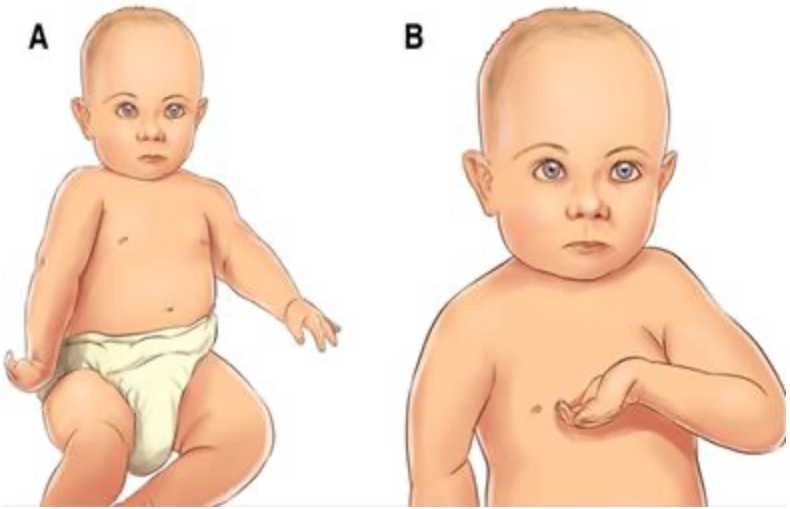
# Objectives

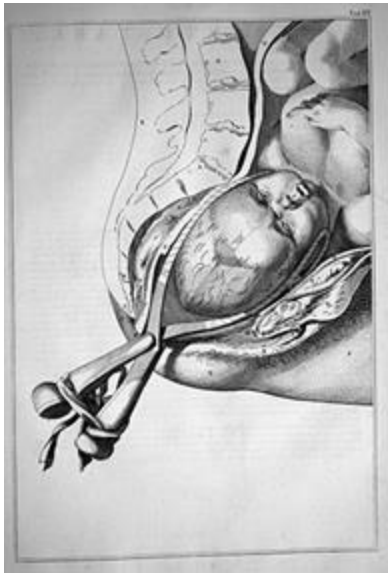
- Review a brief history of BPI diagnosis and management.
- Discuss current management and rehabilitation strategies for BPI in infants.
- Become familiar with secondary complications.

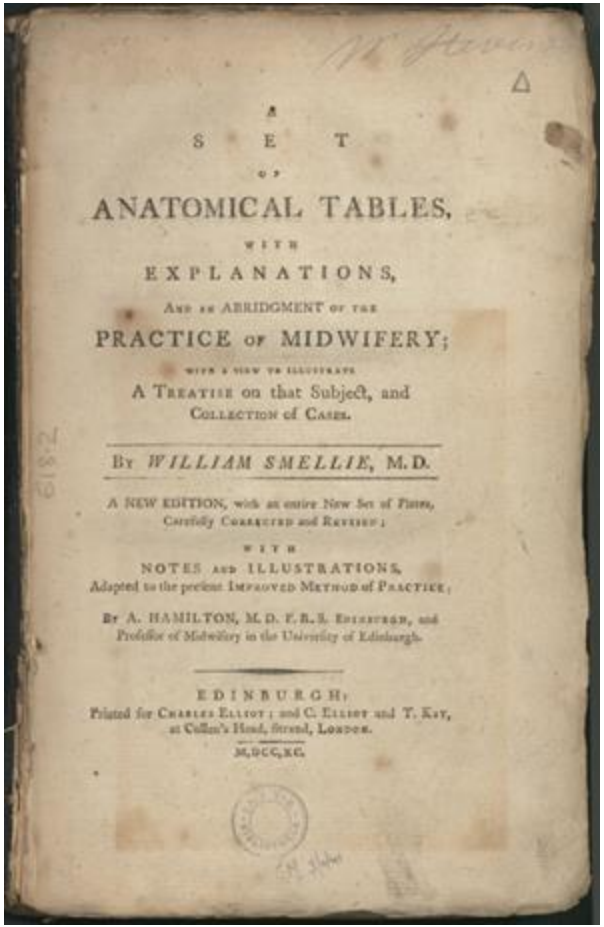



***A.*** ***Erb's*** palsy (C5-6)
***B.*** ***Klumpke's*** palsy (C8-T1)

Socolovsky M, et al. Obstetric brachial plexus palsy: reviewing the literature comparing the results of primary versus secondary surgery. Childs Nerv Syst. 2016;32(3):415-425.

# First Clinical Description (1768)

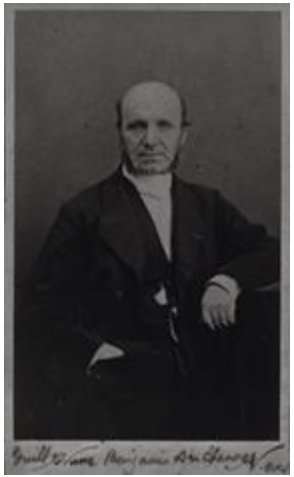





[William Smellie, MD]

- Trained in Scotland / obstetrics in Paris
- Pioneered the participation of doctors in obstetrics (opposed by the midwives)
- Designed several types of obstetric forceps

# Obstetric Palsy of the Brachial Plexus (1862)



Guillaume Benjamin Amand Duchenne, MD

- Neurologist
- Used electrical stimulation
- First documented cases


6-year-old boy with typical shoulder and elbow presentation now known as Erb-Duchenne brachial plexus palsy. Appeared in Duchenne's work published in 1862, *Album de Photographies Pathologiques*.

# Erb's Palsy

## Description of classic brachial plexus injury *upper roots* (C5-C6) (1877)

„Ueber eine eigenthümliche Localisation von Lähmungen im Plexus brachialis".

Wilhelm Heinrich Erb, MD

- German neurologist

- Contributions to our understanding of peripheral nerve physiology, deep tendon reflexes, and the muscular dystrophies
- Founded the *German Journal of Neurology* and the Society of German Neurologists
- Erb's point
- Deltoid, biceps, and subscapularis palsies are derived from radicular lesions at the level of C5 and C6 rather than isolated peripheral nerve lesions.

# Klumpke's Palsy

**Damage to *lower plexus* (C8-T1) affects function and sensation of forearm, wrist, hand, and fingers (1885)**

CONTRIBUTION A L'ÉTUDE

DES

PARALYSIES RADICULAIRES

DU PLEXUS BRACHIAL

*Paralysies radiculaires totales.*

*Paralysies radiculaires inférieures. De la participation des fibres sympathiques oculo-pupillaires dans ces paralysies.*

Par Mme A. KLUMPKE

Augusta Dejerine-Klumpke, MD

- 1st woman to graduate from University of Paris School of Medicine
- Neurologist
- Horner's syndrome

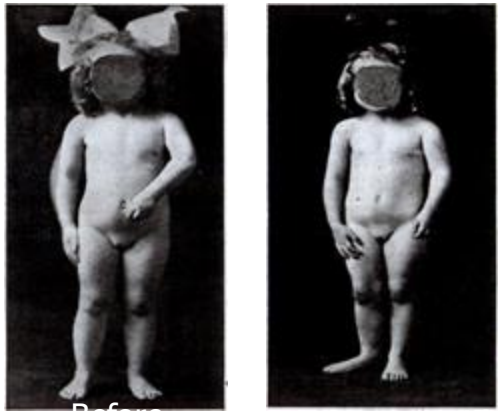
# Contracture Release Surgery Results (1916)

(1878-1964)

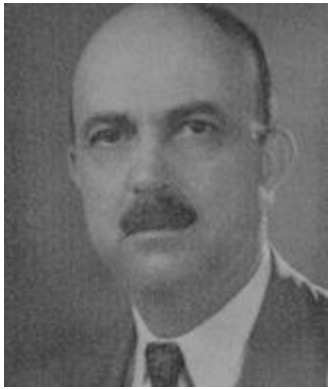
[James Warren Sever, MD]

- Orthopedist
- Reviewed etiologic, pathologic, and clinical course (471 infants)

"The treatment of these cases at once resolves itself into two divisions, i.e., those to be treated with massage and exercises, principally those of the upper arm type, and those to be treated by operation on the plexus, usually those of the lower arm type. Unless the early treatment has been adequate, the upper arm type will also come to operation, not for plexus repair, but to correct contraction deformities."



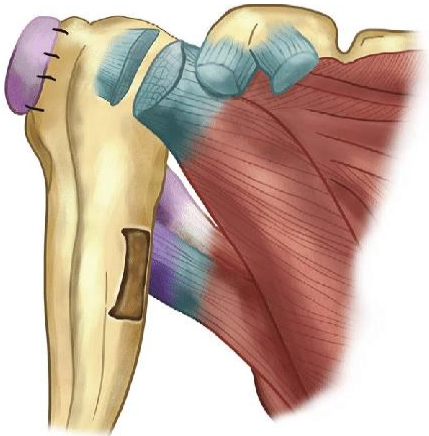
# Tendon Transfer Surgery



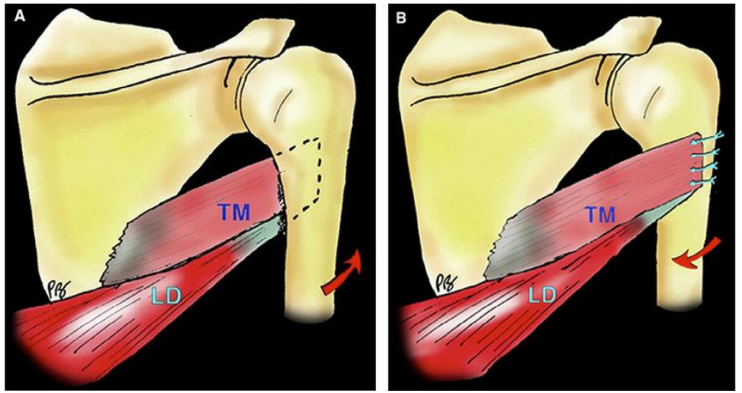
(1890-1947)

[Joseph B. L'Episcopo, MD]

- Orthopedist
- Developed surgeries:
  - Tendon transplantation (muscle balance restoration)
  - Adaptation of Sever's procedure (Sever-L'Episcopo)



https://www.researchgate.net/figure/The-LEpiscopo-procedure-The-contracted-anterior-tissues-such-as-subscapularis-tendon_fig2_349892072 [accessed 16 May 2025]




https://www.researchgate.net/figure/The-LEpiscopo-procedure-The-contracted-anterior-tissues-such-as-subscapularis-tendon_fig2_349892072 [accessed 16 May 2025]

# Narakas Classification

(1927-1993)

| Narakas Classification | | | |
|---|---|---|---|
| Group I | C5-6 | No elbow flexion | Erb's palsy |
| Group II | C5-7 | No elbow flexion or extension | Upper middle trunk |
| Group III | C5-T1 | No elbow flexion/extension + poor hand function | Total plexus palsy |
| Group IV | C5-T1 | No elbow flexion/extension + poor hand function + Horner's | |

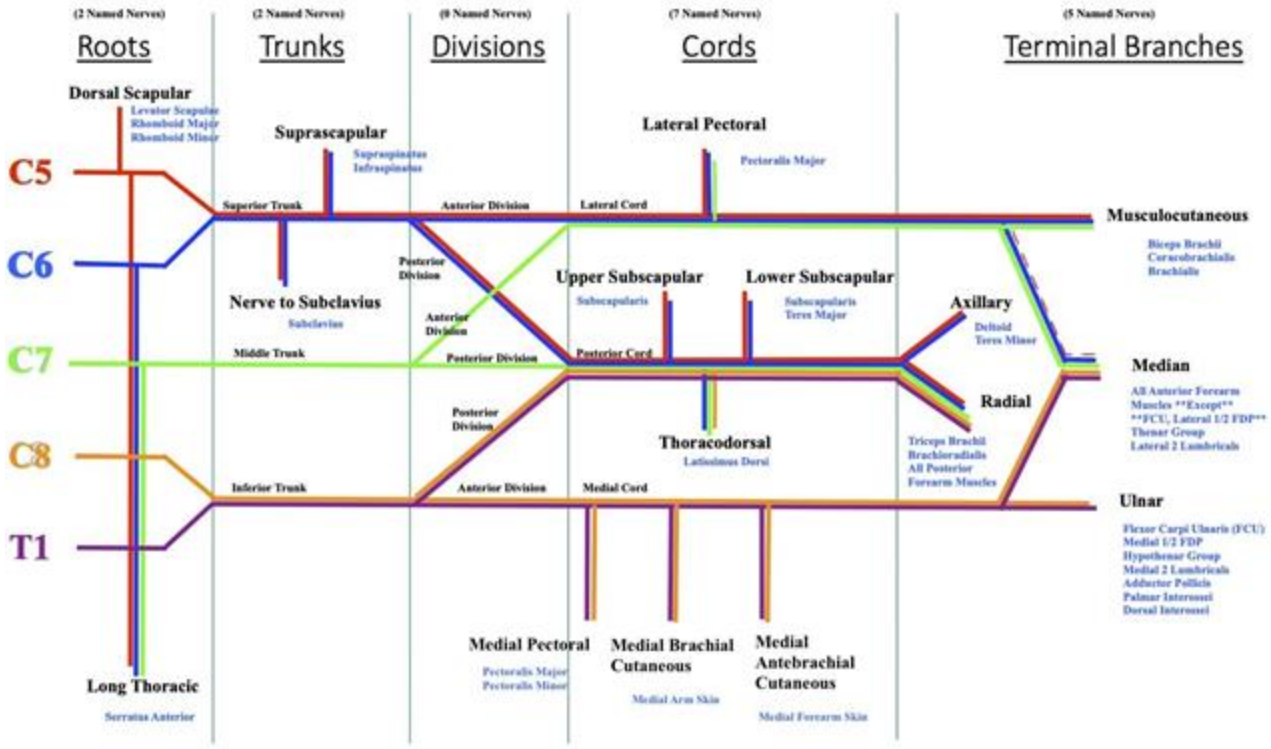
Algimantas Otonas Narakas, MD

- General surgery, neurosurgery, reconstructive surgery, and orthopedics
- Dexterous and methodical observations of the brachial plexus (adults and newborns)

# Brachial Plexus Injury (BPI)

- Neonatal brachial plexus injury
- Congenital brachial plexus injury
- Obstetric brachial plexus injury
- Birth brachial plexus injury
- Erb's palsy
- Klumpke's palsy

# Brachial Plexus

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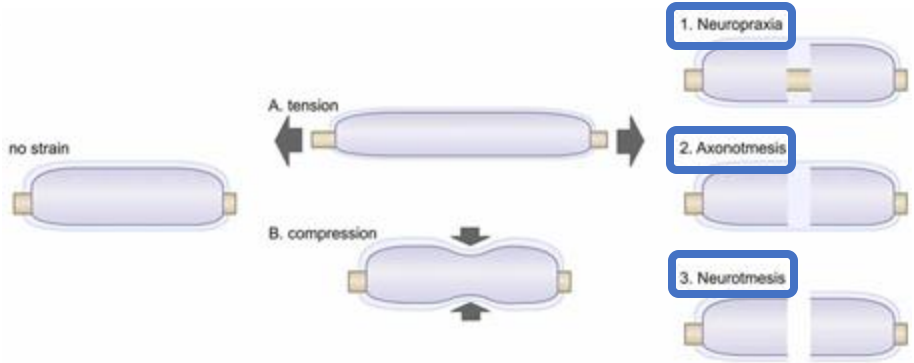
# Brachial Plexus Injury

- Neonatal BPP vs BPI
- Epidemiology: ***0.9-1.74 per 1000*** live births
- Types:
  - Erb's palsy (C5-6)
  - Klumpke's palsy (C8-T1)
- Nerve injury
  - Neuropraxia
  - Axonotmesis
  - Neurotmesis

**Types of Nerve Injury**

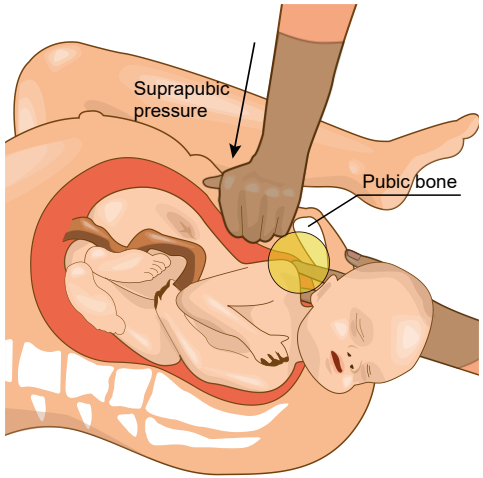



Belin S, et al. Influence of Mechanical Stimuli on Schwann Cell Biology. Front Cell Neurosci. 2017;11:347.

# Risk Factors

- Baby weight > 4 kg (8 lb 13 oz)
- Difficult delivery (e.g., shoulder dystocia, vacuum extraction)
- Maternal diabetes (GDM), prolonged labor, breech presentation
- Previous child with BPI (prior history)





# Differential Diagnosis

- BPI *(lower motor neuron disorder)*
- Cervical spinal cord injury
- Hemiparesis or hypotonia
- Amyoplasia congenita
- Humeral or clavicular fracture


## Active Movement Scale

| OBSERVATION | SCORE |
|---|---|
| **Gravity eliminated** | |
| No contraction | 0 |
| Contraction, no motion | 1 |
| <50% range of motion | 2 |
| >50% range of motion | 3 |
| Full motion | 4 |
| **Against gravity** | |
| <50% range of motion | 5 |
| >50% range of motion | 6 |
| Full motion | 7 |

*Scores are given for each of the following joint movements:
*shoulder flexion, shoulder abduction, shoulder adduction, shoulder internal rotation, shoulder external rotation, elbow flexion, elbow extension, forearm pronation, forearm supination, wrist flexion, wrist extension, finger flexion, finger extension, thumb flexion, and thumb extension.*

# Clinical Presentation

- Limp arm
- Clavicular or humeral fractures
- Absent DTRs
- Asymmetric Moro
- + Horner's syndrome
  - ptosis, miosis, anhidrosis
- Torticollis
- Cephalohematoma
- Respiratory status? *(phrenic nerve injury)*

CMAJ



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# Clinical Course

- 20-30% residual deficits
  - ⅔ resolve
  - *⅓ residual deficits*
    - ⅓ require surgery
- Rate of recovery
  - Partial antigravity muscle strength in first 2 months full and complete recovery over first years of life
  - No antigravity biceps strength by 5-6 months permanent progressive limitations (shoulder) if no surgical intervention
- Functional scales:
  - Mallet classification
  - Active movement scale


**I: none** **V. Normal**

**Mallet Classification**



Nath RK et al. Arm rotated medially with supination - the ARMS variant: description of its surgical correction. BMC Musculoskelet Disord. 2009; 10:32.

# Narakas Classification

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

# Prognosis

- Neuropraxic lesions
  - Complete recovery by 1 month
- Incomplete recovery
  - Useful limb function possible
- Toronto test scores
  - Predict outcomes based on ***elbow flexion*** and extensor function at 3 months
  - Shoulder abduction alone not statistically significant
  - Score < 3.5 (at **age 3 months**)
    - Poor outcome
    - Plexus exploration recommended
- Movements scored:
  - Elbow flexion (EF)
  - Elbow extension (EE)
  - Wrist extension (WE)
  - Finger extension (FE)
  - Finger flexion (FF)
  - Thumb extension TE)

| Parameter | Rate of Incorrect Prediction |
|---|---|
| EF (3 months) | 12.8 |
| EF (3 mo) + FF (b) | 7.1 |
| EF + FE (3 mo) | 5.2 |
| EF + EE + WE + FE + TE (3 mo) | 5.2 |

| Toronto Grading System | |
|---|---|
| *Observation* | *Score* |
| No joint movement | 0 |
| Flicker of movement | 0.3 |
| <50% range | 0.6 |
| 50% of range mov't | 1 |
| >50% of range | 1.3 |
| Good, but not full range | 1.6 |
| Full range of mov't | 2 |

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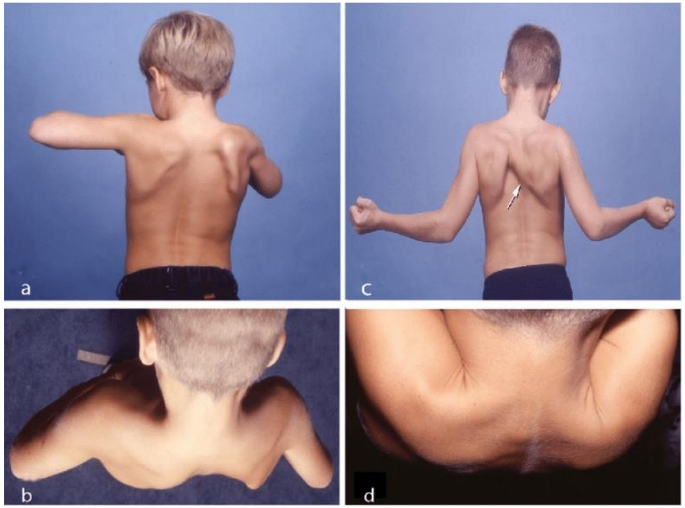
# Long-Term Sequelae

- Muscular weakness
- Abnormal posture
- Bony deformities
- Shoulder + elbow contractures
- Dislocations
- Limb length discrepancy

*Other:*

- *Accidental contact burns*
- *Self-mutilation*
- *Developmental apraxia*
- *Behavioral problems*
- *Neglect*




Terzis JK, et al. Morphometric analysis of the effect of scapula stabilization on obstetric brachial plexus paralysis patients. Hand. 2014;9(3):303-314.

# Management Goals

- Prevent contractures, dislocations, and muscular imbalance.
- Prevent maladaptive patterns of movement.
- Maintain range of motion (ROM).
- Optimize functional use of the affected limb.
- Strengthening exercises
- Facilitation of functional movement patterns
- Sensory awareness
- Static and dynamic splinting

# Non-operative Measures

- ROM exercises, strengthening, sensory awareness
- Static and dynamic splinting
- Functional electrical stimulation (FES) to prevent atrophy and improve muscle mass




Berggren J, Baker LL. Therapeutic application of electrical stimulation and constraint induced movement therapy in perinatal brachial plexus injury: A case report. J Hand Ther. 2015;28(2):217-221.

# Botulinum Toxin Injections (Botox)

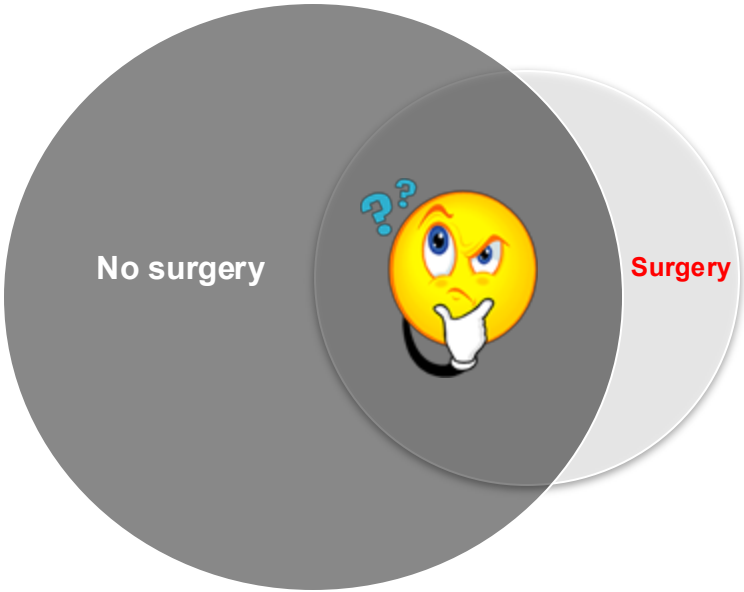
- Fourteen (14) babies treated with botulinum toxin A over 3 years. Triceps and teres major. Improvement in elbow function by 2 grades. (Hierner and Berger 2001)

- Six (6) patients treated with botulinum toxin at 9 to 12 months. Improvement in elbow shoulder abduction. Dose 60 to 90 units (Limbo, Lancon, Vedanarayanan, CNS meeting 2005).

Adobe Stock

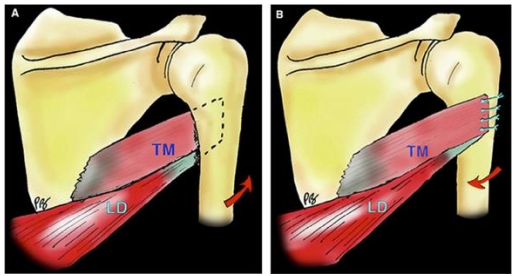
# Preoperative Investigations

- CT myelography
- High-resolution MRI
- Ultrasound
- Electrodiagnostics

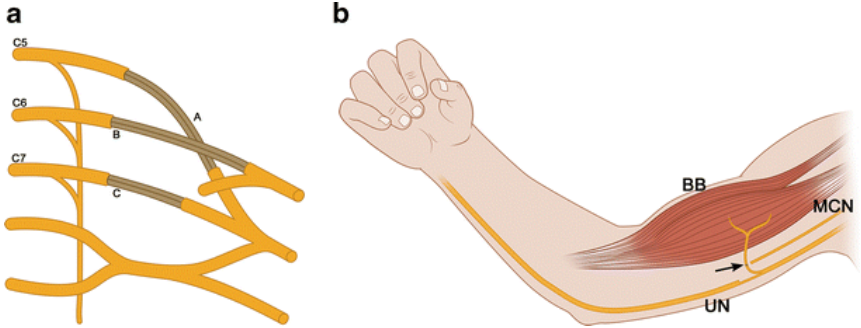


# Surgical Options

- Primary nerve exploration
  - Neurolysis, nerve grafting, neurotization, and reconstruction
- Secondary reconstructive
  - Muscle transfers, osteotomies, and complex shoulder surgeries

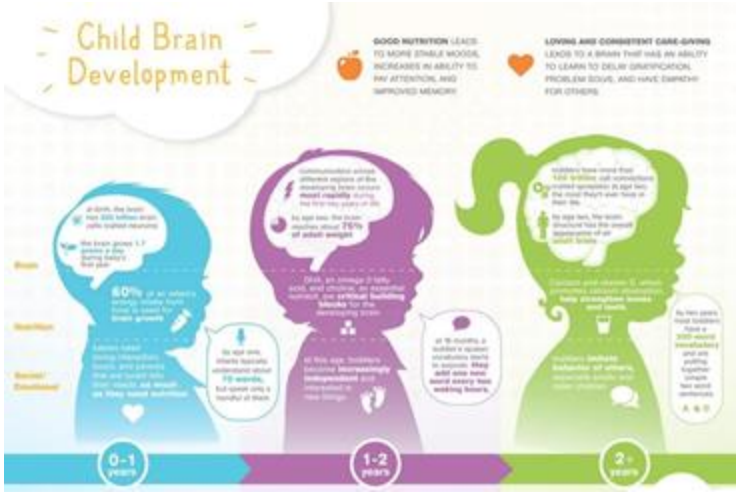


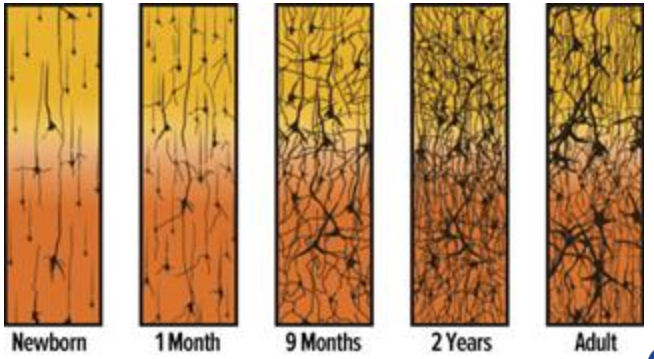

Turkmen I, et al. Latissimus dorsi tendon transfers: a historical journey. SICOT J. 2021; 7:9.




Somashekar DK, et al. The current role of diagnostic imaging in the preoperative workup for refractory neonatal brachial plexus palsy. Childs Nerv Syst. 2016;32(8):1393-1397.

# Rehabilitation

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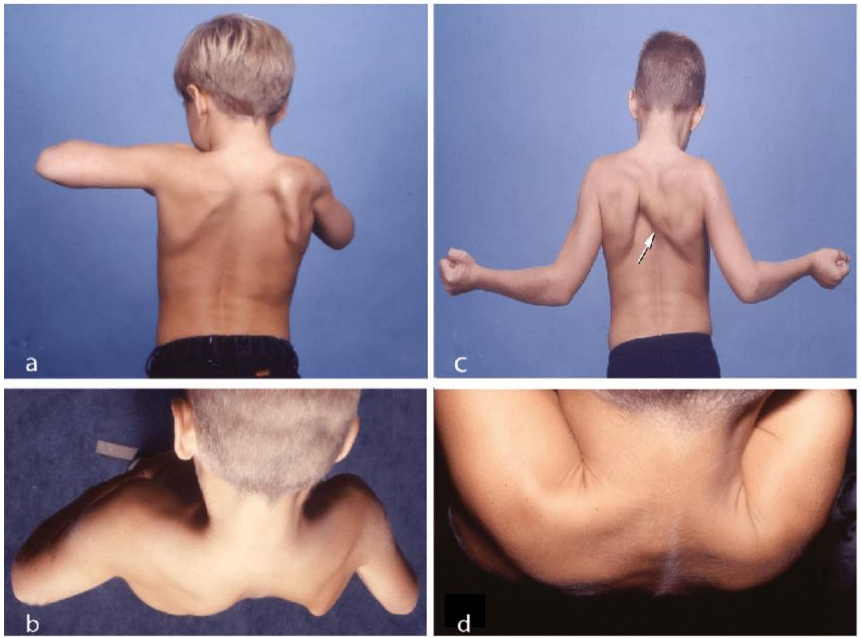
# Rehabilitation Strategies

- Early ROM exercises (first 2 weeks)
- Occupational/physical therapy:
  - Passive/active ROM, strengthening, and sensory integration
- **Activity-based rehabilitation therapy:**
  - High-intensity, task-specific practice
  - Weight-bearing exercises to improve posture and joint development
- **Functional electrical stimulation (FES)**

# Summary

- *Early identification* and *management* are *critical* for BPI.
- Non-operative and surgical options are *tailored to individual needs.*
- *Rehabilitation* plays a key role in *optimizing outcomes*.
- Continued research is needed to improve understanding and treatment.




Terzis JK, et al. Morphometric analysis of the effect of scapula stabilization on obstetric brachial plexus paralysis patients. Hand. 2014;9(3):303-314.

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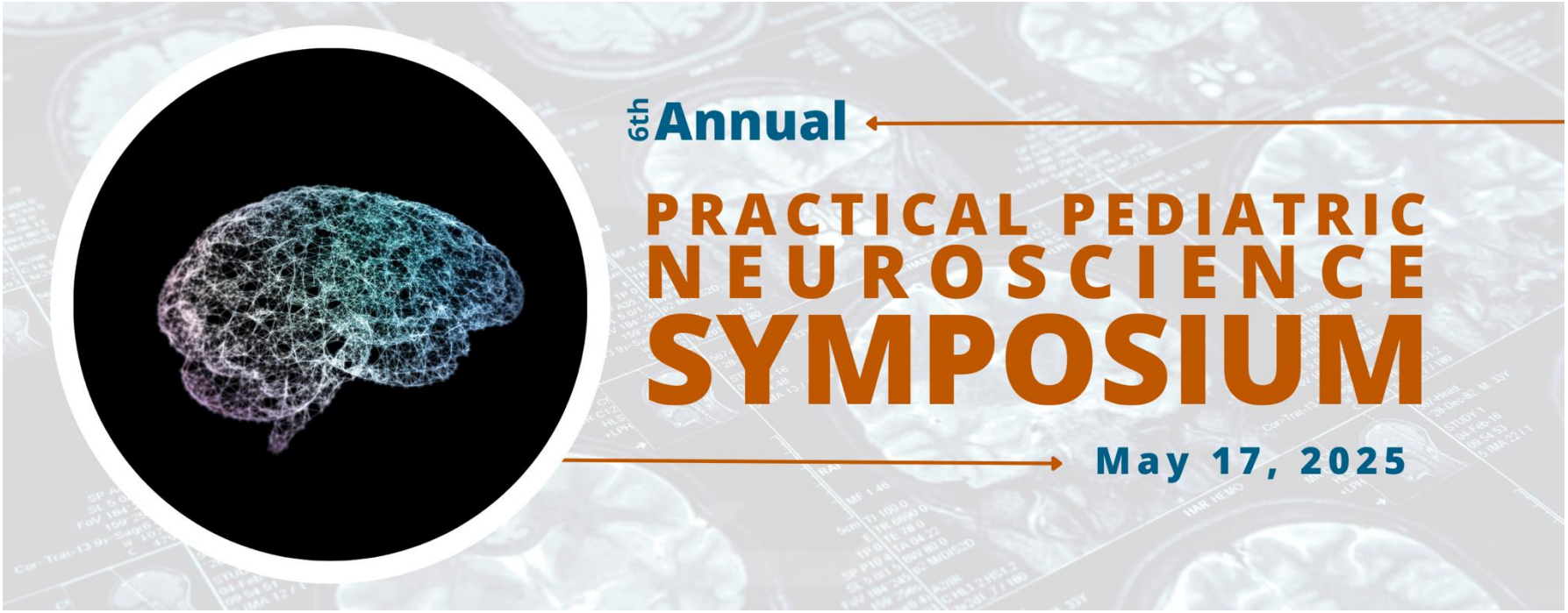


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