

**Handouts included for this course:**

- A. Brachial Plexus Assessments
- B. Plexus Chart
- C. Brachial Plexus Illustrated Chart
- D. References

# Brachial Plexus Assessments

## Narakas Classification

Narakas, A. O. (1985). The treatment of brachial plexus injuries. *International orthopaedics*, 9(1), 29-36.

The Narakas Classification has 4 Groups based on newborn presentation and nerve roots affected.

- Group I:
  - Newborn presentation is dysfunction of deltoid and biceps brachii; no shoulder abd, ER; no elbow flexion, FA supination
  - C5 and C6 nerve roots affected
  - Typical recovery begins within 1 month, full recovery 3-6 months
- Group II:
  - Newborn presentation is impaired wrist and proximal with only function of long hand flexors is present (presents similar to Group I but with weaker active elbow extension).
  - C5, C6, and C7 nerve roots are affected
  - Greater than 1 month before recovery of shoulder and elbow flexion; steady improvement but will likely have contractures
- Group III:
  - Newborn presentation is a lack of upper limb function and may have minimal function of hand flexors. (Flail shoulder, no elbow flex, weak elbow ext, flexed wrist, fistod)
  - Whole plexus is affected (C5-T1)
  - There is slow partial recovery up to 15 months; weak with limited function; secondary deformities likely
- Group IV:
  - Newborn presentation is a lack of whole upper limb function. (Flail extremity, half-open hand, and limited finger movement)
  - C5-T1 affected, positive for Horner's
  - Poor shoulder function; arm rests in adduction & IR, elbow flexed & supinated

## Toronto Test Score

Michelow, B. J., Clarke, H. M., Curtis, C. G., Zuker, R. M., Seifu, Y., & Andrews, D. F. (1994). The natural history of obstetrical brachial plexus palsy. *Plastic and Reconstructive Surgery*, 93(4), 675-80.

The scale, based on observation, is given a clinical grade and a numerical score. This is completed for each joint of the affected UE.

- No joint movement: Clinical Grade 0; Numerical Score 0
- Flicker: Clinical Grade 0+; Numerical Score 0.3
- Less than 50% range: Clinical Grade 1-; Numerical Score 0.6
- 50% range: Clinical Grade 1; Numerical Score 1.0
- More than 50% range: Clinical Grade 1+; Numerical Score 1.3
- Good but not full range: Clinical Grade 2-; Numerical Score 1.6
- Full range: Clinical Grade 2; Numerical Score 2.0

## Mallet Scale – Original

Mallet, J. (1972). Obstetrical paralysis of the brachial plexus. 3. Conclusions. *Revue de chirurgie orthopédique et réparatrice de l'appareil moteur*, 58, Suppl-1.

This scale looks at 5 areas: active abduction, external rotation, hand to head, hand to back, and hand to mouth.

Active Abduction: Less than 30° (II), 30-90° (III), More than 90° (IV)

External Rotation: 0° (II), Less than 20° (III), More than 20° (IV)

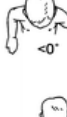
Hand to Head: Impossible (II), Difficult (III), Easy (IV)

Hand to Back: Impossible (II), Difficult (III), Easy (IV)

Hand to Mouth: Impossible (II), Difficult (III), Easy (IV)

## Mallet Scale – Nath Modification (used with permission from Dr. Nath)

Nath, R. K., Karicherla, P., & Mahmooduddin, F. (2010). Shoulder function and anatomy in complete obstetric brachial plexus palsy: long-term improvement after triangle tilt surgery. *Child's Nervous System*, 26(8), 1009-1019.

|                          | 2                                                                                                          | 2S                                                                                  | 3                                                                                                      | 3S                                                                                  | 4                                                                                                        | 4S                                                                                    | 5                                                                                     | 5E                                                                                    |
|--------------------------|------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| ARM AT REST              |                          |   |                      |   |                       |   |   |   |
| GLOBAL EXTERNAL ROTATION | <br><0°                 |  | <br>0° to 20°       |  | <br>>20°             |  |  |  |
| GLOBAL ABDUCTION         | <br><30°                |  | <br>30° to 90°      |  | <br>>90°             |  |  |  |
| HAND TO NECK             | <br>Not Possible        |  | <br>Difficult       |  | <br>Easy             |  |  |  |
| HAND TO SPINE            | <br>Not Possible        |  | <br>Difficult       |  | <br>Easy             |  |  |  |
| HAND TO MOUTH            | <br>Marked Trumpet Sign |  | <br>Partial Trumpet |  | <br><40 of Abduction |  |  |  |
| SUPINATION               | <br>Not Possible        |  | <br>Difficult       |  | <br>Easy             |  |  |  |

The Nath Modification of Mallet's System: clinical scoring of function. In addition to assessing the classical functions of the Modified Mallet system, supination and the resting position are evaluated. To further define

deformity, fixed forearm supination (positions 2S, 3S, and 4S) as well as external rotation position (5E) are scored.

### **Active Movement Scale**

Clarke, H. M., & Curtis, C. G. (1995). An approach to obstetrical brachial plexus injuries. *Hand clinics*, 11(4), 563-80.

The Active Movement Scale looks at these 15 movements:

- Shoulder abduction
- Shoulder adduction
- Shoulder flexion
- Shoulder ER
- Shoulder IR
- Elbow flexion
- Elbow extension
- Forearm supination
- Forearm pronation
- Wrist flexion
- Wrist extension
- Finger flexion
- Finger extension
- Thumb flexion
- Thumb extension

Each movement is assigned a score:

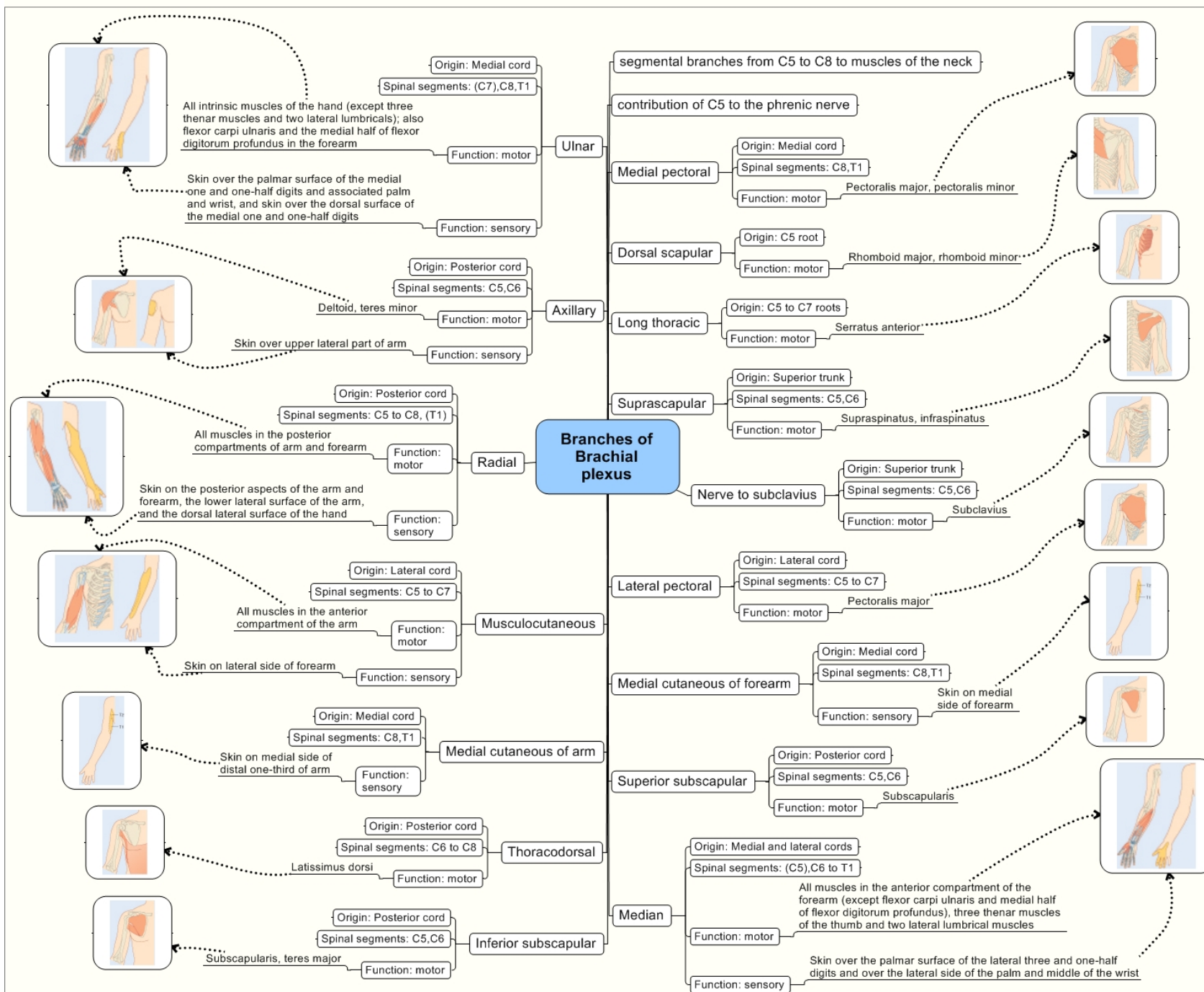
Gravity Eliminated:

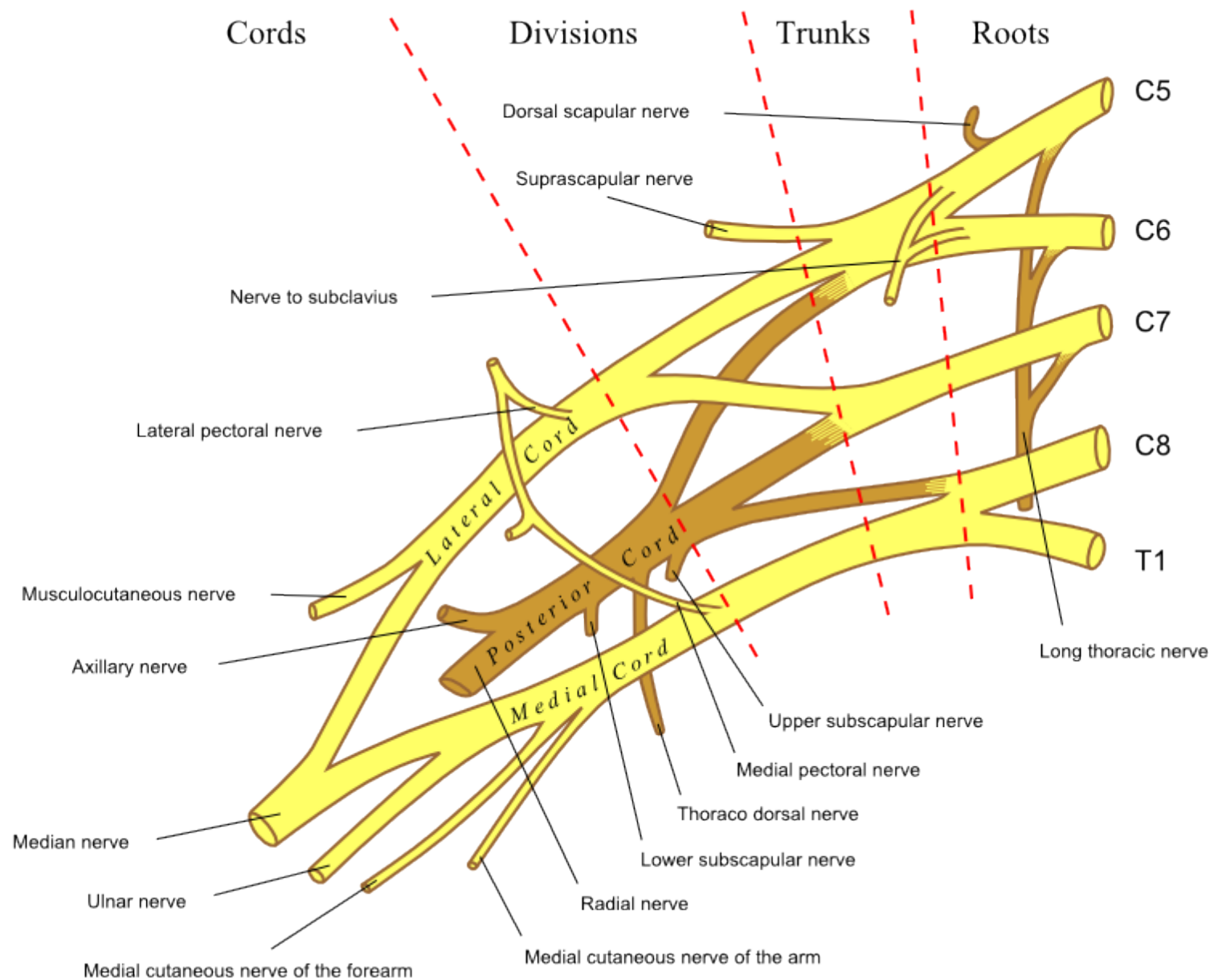
- No contraction: 0
- Contraction, no motion: 1
- $\leq 50\%$  motion: 2
- $> 50\%$  motion: 3
- Full motion: 4

Against Gravity:

- $\leq 50\%$  motion: 5
- $> 50\%$  motion: 6
- Full motion: 7

| Plexus Segments | Nerves           | Muscles                                                          | Motion                                   |
|-----------------|------------------|------------------------------------------------------------------|------------------------------------------|
| C5              | Dorsal scapular  | Rhomboid, Levator scapulae                                       | Scapular elevation                       |
| C5-7            | Long thoracic    | Serratus Anterior                                                | Scapular stabilization                   |
| C5-6            | Suprascapular    | Supraspinatus & Infraspinatus                                    | Shoulder abduction & ER                  |
| C5-T1           | Pectoralis       | Pectoralis                                                       | Shoulder flexion, extension, adduction   |
| C5-6            | Axillary         | Deltoid, Teres minor, Triceps                                    | Shoulder abduction & ER, elbow extension |
| C6-8            | Thoracodorsal    | Latissimus dorsi                                                 | Shoulder extension, adduction, IR        |
| C5-7            | Musculocutaneous | Biceps & Brachialis                                              | Elbow flexion                            |
| C5-T1           | Radial           | Triceps, Extensor carpi, Radialis longus, Radialis brevis        | Elbow extension, wrist extension         |
| C5-T1           | Median           | Pronator teres & quadratus, Flexor carpi radialis, digit flexors | Wrist & digit flexors                    |
| C8-T1           | Ulnar            | Interossei & lumbricals, Adductor polices                        | Movement of medial 2 digits              |





## References

- Abdel-Kafy, E. M., Kamal, H. M., & Elshemy, S. A. (2013). Effect of modified constrained induced movement therapy on improving arm function in children with obstetric brachial plexus injury. *Egyptian Journal of Medical Human Genetics*, 14(3), 299-305.
- Bae, D. S., Ferretti, M., & Waters, P. M. (2008). Upper extremity size differences in brachial plexus birth palsy. *Hand*, 3(4), 297-303.
- Bae, D. S., Waters, P. M., & Zurakowski, D. (2003). Reliability of three classification systems measuring active motion in brachial plexus birth palsy. *JBJS*, 85(9), 1733-1738.
- Berggren, J., & Baker, L. L. (2015). Therapeutic application of electrical stimulation and constraint induced movement therapy in perinatal brachial plexus injury: A case report. *Journal of Hand Therapy*, 28(2), 217-221.
- Buchanan, P. J., Grossman, J. A., Price, A. E., Reddy, C., Chopan, M., & Chim, H. (2018). The Use of Botulinum Toxin Injection for Brachial Plexus Birth Injuries: A Systematic Review of the Literature. *HAND*, 1558944718760038.
- Buesch, F. E., Schlaepfer, B., de Bruin, E. D., Wohlrab, G., Ammann-Reiffer, C., & Meyer-Heim, A. (2010). Constraint-induced movement therapy for children with obstetric brachial plexus palsy: two single-case series. *International Journal of Rehabilitation Research*, 33(2), 187-192.
- Chauhan, S. P., Blackwell, S. B., & Ananth, C. V. (2014, June). Neonatal brachial plexus palsy: incidence, prevalence, and temporal trends. In *Seminars in perinatology* (Vol. 38, No. 4, pp. 210-218). Elsevier.
- Clarke, H. M., & Curtis, C. G. (1995). An approach to obstetrical brachial plexus injuries. *Hand clinics*, 11(4), 563-80.
- Curtis, C., Stephens, D., Clarke, H. M., & Andrews, D. (2002). The active movement scale: an evaluative tool for infants with obstetrical brachial plexus palsy. *Journal of Hand Surgery*, 27(3), 1.
- DeFrancesco, C. J., Shah, D. K., Rogers, B. H., & Shah, A. S. (2017). The Epidemiology of Brachial Plexus Birth Palsy in the United States: An Analysis of Trends and Risk Factors over 16 Years: Level 4 Evidence. *Journal of Hand Surgery*, 42(9), S22-S23.
- Duijnisveld, B. J., van Wijlen-Hempel, M. S., Hogendoorn, S., de Boer, K. S., Malessy, M. J., Keurentjes, J. C., ... & Nelissen, R. G. (2017). Botulinum Toxin Injection for Internal Rotation Contractures in Brachial Plexus Birth Palsy. A Minimum 5-Year Prospective Observational Study. *Journal of Pediatric Orthopaedics*, 37(3), e209-e215.
- Duijnisveld, B. J., Steenbeek, D., & Nelissen, R. G. H. H. (2016). Serial casting for elbow flexion contractures in neonatal brachial plexus palsy. *Journal of pediatric rehabilitation medicine*, 9(3), 207-214.
- El-Shamy, S., & Alsharif, R. (2017). Effect of virtual reality versus conventional physiotherapy on upper extremity function in children with obstetric brachial plexus injury. *Journal of musculoskeletal & neuronal interactions*, 17(4), 319.
- Elbasan, B., Akkaya, K. U., Akyüz, M., & Oskay, D. (2017). Effects of neuromuscular electrical stimulation and kinesio taping applications in children with cerebral palsy on postural control and sitting balance. *Journal of back and musculoskeletal rehabilitation*, (Preprint), 1-7.



- Elnaggar, R. K. (2016). Shoulder function and bone mineralization in children with obstetric brachial plexus injury after neuromuscular electrical stimulation during weight-bearing exercises. *American journal of physical medicine & rehabilitation*, 95(4), 239-247.
- Foad, S. L., Mehlman, C. T., Foad, M. B., & Lippert, W. C. (2009). Prognosis following neonatal brachial plexus palsy: an evidence-based review. *Journal of children's orthopaedics*, 3(6), 459-463.
- Foad, S. L., Mehlman, C. T., & Ying, J. (2008). The epidemiology of neonatal brachial plexus palsy in the United States. *JBJS*, 90(6), 1258-1264.
- Fritz, S. L., Butts, R. J., & Wolf, S. L. (2012). Constraint-induced movement therapy: from history to plasticity. *Expert review of neurotherapeutics*, 12(2), 191-198.
- Garg, R., Merrell, G. A., Hillstrom, H. J., & Wolfe, S. W. (2011). Comparison of nerve transfers and nerve grafting for traumatic upper plexus palsy: a systematic review and analysis. *JBJS*, 93(9), 819-829.
- Greenhill, D. A., Wissinger, K., Trionfo, A., Solarz, M., Kozin, S. H., & Zlotolow, D. A. (2018). External rotation predicts outcomes after closed glenohumeral joint reduction with botulinum toxin type A in brachial plexus birth palsy. *Journal of Pediatric Orthopaedics*, 38(1), 32-37.
- Ho, E. S., Klar, K., Klar, E., Davidge, K., Hopyan, S., & Clarke, H. M. (2018). Elbow flexion contractures in brachial plexus birth injury: function and appearance related factors. *Disability and Rehabilitation*, 1-5.
- Hoare, B., Imms, C., Carey, L., & Wasiak, J. (2007). Constraint-induced movement therapy in the treatment of the upper limb in children with hemiplegic cerebral palsy: a Cochrane systematic review. *Clinical Rehabilitation*, 21(8), 675-685.
- Hoeksma, A. F., Ter Steeg, A. M., Dijkstra, P., Nelissen, R. G., Beelen, A., & De Jong, B. A. (2003). Shoulder contracture and osseous deformity in obstetrical brachial plexus injuries. *JBJS*, 85(2), 316-322.
- Kase, K., Martin, P., & Yasukawa, A. (2006). *Kinesio Taping in Pediatrics: Fundamentals and Whole Body Taping*. Kinesio.
- Liggio, F. J., Tham, S., Price, A., Ramos, L. E., Mulloy, E., & Grossman, J. A. I. (1999). Outcome of surgical treatment for forearm pronation deformities in children with obstetric brachial plexus injuries. *Journal of Hand Surgery*, 24(1), 43-45.
- Mallet, J. (1972). Obstetrical paralysis of the brachial plexus. 3. Conclusions. *Revue de chirurgie orthopédique et réparatrice de l'appareil moteur*, 58, Suppl-1.
- Michelow, B. J., Clarke, H. M., Curtis, C. G., Zuker, R. M., Seifu, Y., & Andrews, D. F. (1994). The natural history of obstetrical brachial plexus palsy. *Plastic and Reconstructive Surgery*, 93(4), 675-80.
- Narakas, A. O. (1985). The treatment of brachial plexus injuries. *International orthopaedics*, 9(1), 29-36.
- Nath, R. K. (2006). *Obstetric Brachial Plexus Injuries*. Texas Nerve and Paralysis.
- Nath, R. K., Karicherla, P., & Mahmooduddin, F. (2010). Shoulder function and anatomy in complete obstetric brachial plexus palsy: long-term improvement after triangle tilt surgery. *Child's Nervous System*, 26(8), 1009-1019.
- Nath, R. K., & Somasundaram, C. (2016). Biceps Tendon Lengthening Surgery for Failed Serial Casting Patients With Elbow Flexion Contractures Following Brachial Plexus Birth Injury. *Eplasty*, 16.

Nath, Rahul K., and Chandra Somasundaram. "Significant improvement in nerve conduction, arm length, and upper extremity function after intraoperative electrical stimulation, neurolysis, and biceps tendon lengthening in obstetric brachial plexus patients." *Journal of orthopaedic surgery and research* 10, no. 1 (2015): 51.

Pondaag, W., de Boer, R., van Wijlen-Hempel, M. S., Hofstede-Buitenhuis, S. M., & Malessy, M. J. (2005). External rotation as a result of suprascapular nerve neurotization in obstetric brachial plexus lesions. *Neurosurgery*, 57(3), 530-537.

Qi, Y. C., Niu, X. L., Gao, Y. R., Wang, H. B., Hu, M., Dong, L. P., & Li, Y. Z. (2018). Therapeutic Effect Evaluation of Neuromuscular Electrical Stimulation With or Without Strengthening Exercise on Spastic Cerebral Palsy. *Clinical pediatrics*, 57(5), 580-583.

Santamato, A., Panza, F., Ranieri, M., & Fiore, P. (2011). Effect of botulinum toxin type A and modified constraint-induced movement therapy on motor function of upper limb in children with obstetrical brachial plexus palsy. *Child's Nervous System*, 27(12), 2187-2192.

Sheffler, L. C., Lattanza, L., Hagar, Y., Bagley, A., & James, M. A. (2012). The prevalence, rate of progression, and treatment of elbow flexion contracture in children with brachial plexus birth palsy. *The Journal of Bone and Joint Surgery. American volume.*, 94(5), 403.

Smania, N., Berto, G., La, E. M., Melotti, C., Midiri, A., Roncari, L., ... & Faccioli, S. (2012). Rehabilitation of brachial plexus injuries in adults and children. *European journal of physical and rehabilitation medicine*, 48(3), 483-506.

Vaz, D. V., Mancini, M. C., do Amaral, M. F., de Brito Brandão, M., de França Drummond, A., & da Fonseca, S. T. (2010). Clinical changes during an intervention based on constraint-induced movement therapy principles on use of the affected arm of a child with obstetric brachial plexus injury: a case report. *Occupational therapy international*, 17(4), 159-167.

Yam, A., Fullilove, S., Sinisi, M., & Fox, M. (2009). The supination deformity and associated deformities of the upper limb in severe birth lesions of the brachial plexus. *Bone & Joint Journal*, 91(4), 511-516.

Resting hand splint for a 12 day old baby with BPBI

