Role of Magnetic Resonance Neurography on 3-Tesla in Brachial Plexus Injury Management

Palwasha Mansoor, Muhammad Rizwan Aslam, Rao Saood Ahmed, Shahid Hameed, Abu-ul-AlaNafees, Rehana Khadim*

Combined Military Hospital/National University of Medical Sciences (NUMS) Rawalpindi Pakistan, *Army Medical College/National University of Medical Sciences (NUMS) Rawalpindi Pakistan

ABSTRACT

Objective: To study the effect of magnetic resonance neurography on 3 Tesla (MRN-3T) on the outcome of brachial plexus injury management.

Study Design: Prospective comparative study.

Place and Duration of Study: Department of Plastic Surgery, Combined Military Hospital Rawalpindi Pakistan, from Apr 2017 to Mar 2019.

Methodology: Two groups of brachial plexus injury (BPI) were studied over two years. Group-A (n=29) cases whose operative intervention was decided based on history, examination, NCS/EMG and CT scan. Second group-B included (n=33) patients in which MRN-3T (magnetic resonance neurography on 3 Tesla) was the critical diagnostic tool. The comparison of preoperative diagnosis with intraoperative findings and outcome of surgery were made.

Results: Out of 29 cases in group-A, 11 (37.93%) were explored. In these 11, neurolysis was done in one case, direct repair in one case, nerve grafting in 4 patients, nerve transfers with bridging grafts in 2 cases, whereas three patients had negative exploration. Of 33 cases in group-B, 21(63.64%) were explored. From these 21 cases, neurolysis was done in four patients; the direct repair was possible in 7 and in 10 cases bridging nerve grafts were used along with primary nerve transfers.

Conclusion: MRN-3T brachial plexus has significantly improved the diagnosis, preoperative planning and surgical outcome of patients with brachial plexus injury.

Keywords: Brachial plexus injury, MRN-3T, Nerve transfer, Preganglionic, Postganglionic.

How to Cite This Article: *Mansoor P, Aslam MR, Ahmed RS, Hameed S, Nafees AUA, Khadim R. Role of Magnetic Resonance Neurography on 3-Tesla in Brachial Plexus Injury Management. Pak Armed Forces Med J 2022; 72(2): 617-621. DOI: https://doi.org/10.51253/pafmj.v72i2.4288*

INTRODUCTION

The brachial plexus is a complex network of nerves arising from the cervical part of the spinal cord and giving rise to large mixed peripheral nerves.[1]This plexus provides the motor and sensory supply of both upper limbs.[2] Spinal nerves C5-C8 and T1 make up the brachial plexus.[3] Inflammation, autoimmunology, trauma, or tumour may contribute to brachial plexus injury. [1]

The clinical differentiation of brachial plexopathy from other spine-related abnormalities often poses a considerable diagnostic challenge.[4] As the plexus is buried deep and has complicated anatomy, it is often difficult to diagnose, categorize and manage the disease, and the electrodiagnostic tests give ambiguous results.[1] The decision to treat these patients conservatively or surgically is quite difficult. It is also difficult to decide if one should get more workup done or not.

Correspondence: Dr Palwasha Mansoor, 7-A Zafar Akbar Road Lalazar Rawalpindi, Pakistan

Received: 10 May 2020; revision received: 20 Jul 2020; accepted: 29 Jul 2020

Which trunk of the brachial plexus will be affected depends on the direction of pull on the plexus in case of traumatic plexus injury.[5] The degree of motor paralysis depends on the severity of traction force. The therapeutic measures for BPI depend on the pathologic condition and the location of the injury.[4] Post ganglionic nerve injuries, diagnosed and managed (repaired/grafted) early have superior results,[6] as compared to preganglionic injuries, which need intra-plexus or extra-plexus transfer of nerves. Results of root reimplantation have not been encouraging. Therefore, it is paramount that root avulsion is differentiated from a distal injury as the prognosis and management of the two differ.[6]

The standard approach towards a case of brachial plexus injury is a detailed history, thorough clinical examination, EMG/NCS six weeks post-injury and a CT scan of the neck/cervical spine. Based on this nature, the location and severity of the injury were established, and a management plan was formulated. Orthodox MRI has limited resolution, signal contamination by so many vessels running in the neck, and inhomogeneous fat suppression.[8] Use of MRN in diffe-

rentiating between so many different causes of peripheral neuropathy is progressively increasing.[9]

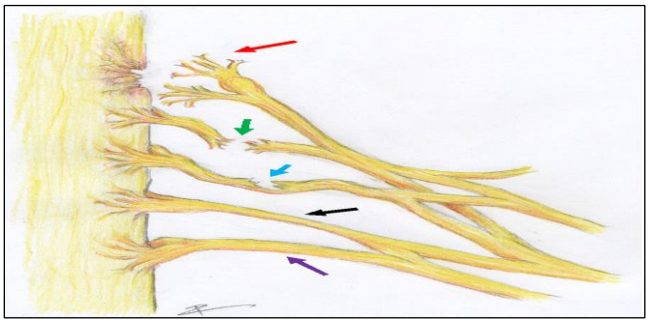

Figure: An illustration of brachial plexus (left) showing the roots, trunks and divisions. Root avulsion of C5 (red cursor). Complete transaction of the C6 root (green cursor). Partial transaction of middle trunk (blue cursor). Black arrow; shrunken C8 root in continuity (black cursor). A healthy typical T1 root (purple cursor).[7]

Our research has studied the effect of MRN performed on 3T scanners on the management (from diagnosis to treatment) of patients with brachial plexus injury.

METHODOLOGY

This study was carried out at the Department of Plastic surgery, CMH Rawalpindi. This study was carried out over two years, from April 2017 till Mar 2019. After approval from the Ethical Review Board (Reference no. 43) study was conducted. A total of 96 patients with significant brachial plexus injury presented to our department. The sample size was calculated with the help of WHO calculator with the reference prevalence of 44% of traumatic injuries10 and absolute precision of 10%.Only 62 out of 96 who fulfilled the inclusion criteria were included through consecutive sampling.

Inclusion Criteria: All the adult patients with brachial plexus injuries reported within the one-year of injury were included the study.

Exclusion Criteria: All the patients above 50 years of age were excluded because results of any plexus surgery are unpredictable and sub-optimal in such patients. All the cases previously operated or having any loose metallic foreign body or implant precluding MR scan were also excluded from this study.

These 62 cases were assigned to two groups. The cases were randomly assigned to either group. Group-A (n=29) in whom CT scan or plain MRI cervical spine were done and group-B (n=33) whose primary investigation was MRN-3T. The decision to do MRN 3T in a specific patient was decided by the senior consultant, and the unavailability of the machine due to maintenance or fault. The rest of the clinical assessment, examination and EMG/NCS studies were performed in all the cases of both groups.

The parameters studied were age, gender, cause of injury, time since injury, type of injury, type of procedure performed,comparison of preoperative diagnosis with intraoperative findings and outcome of surgery. The follow-up period ranged from 1 year to 3 years. Data were analyzed using SPSS-21. Quantitative variables were summarized as mean ± SD, t-test was used between two groups while qualitative variables were analyzed with frequency and percentages, and chi-square test was used between two groups.

RESULTS

The mean age of the patients was 25.3 ± 7.5 years, ranged from 17-43 years. Therewas a total of 55 males and seven females. Their distribution in each group was statistically significant. The main cause of injury was a road traffic accident 90.32%, fall 6.45% and stab/firearm injury 3.23%. The time since injury, type of injury, a procedure performed, the number of negative explorations and the outcome were tabulated in the Table.

Out of 29 patients in group-A after complete diagnostic workup, only 11(37.93%) were thought to benefit from brachial plexus exploration. The rest of the 18 (62.16%) cases were diagnosed as either pan plexopathy with late presentation or lower plexus preganglionic injuries. The cervical procedure was not beneficial, and intra plexus or extra plexus nerve transfers were done. Out of the 11 cases which underwent brachial plexus exploration, neurolysis was done in 1 (9.09%)patient, the direct repair was possible in only 1 (9.09%) patient. In 4 (36.36%) patients, nerve grafts were used to repair the brachial plexus. Nerve transfers with bridging grafts were performed in 2(18.18%) cases. In 3(27.27%) patients, root avulsion was found to be the injury and surgery was abandoned (negative exploration).

Out of 33 patients in group-B, in which MRN-3T was performed to objectively identify the injury's size, location, type, and severity, 21(63.64%) patients were identified to have a postganglionic injury at various levels and of variable severity. They all were found suitable for early plexus exploration. From these 21 cases, neurolysis was done in 4(19.04%) patients, direct repair of brachial plexus was possible in 7(33.33%), in 10(47.62%) cases ridging nerve grafts were used along with primary nerve transfers in the same sitting using

sural nerve cable grafts. After the MRN-3T introduction, we did not have to abandonany surgery, andwe did not find any surprises per operatively.

MRN 3T is a new imaging technique. It has a high sensitivity for defining, localizing and evaluating lesions of the roots, trunks, cords and peripherals nerves.[12] MRN is a high-resolution MRI that scans the

Table: Comparison of demographics, intra-operative findings and outcome of surgery between the groups.

Parameters		Group A (n=29)	Group B (n=33)	*p*-value
Age	Years (Mean ± SD)	25.0 ± 3.4	23.8 ± 6.4	<0.001
Gender				
Male	55 (88.71%)	26 (89.66%)	29 (87.88%)	0.825
Female	7 (11.29%)	3 (10.44%)	4 (12.12%)	
Cause of Injury				
Road Traffic Accidents	56 (90.32%)	25 (86.21%)	31 (93.94%)	0.498
Fall	04 (6.45%)	03 (10.34%)	01 (3.03%)	
Stab/Fire Arm Injury =	02 (3.23%)	01 (3.4%)	01 (3.0%)	
Type of Injury				
Preganglionic	30 (48.39%)	18 (62.0%)	12 (36.3%)	0.04
Postganglionic	32 (51.61%)	11 (37.9%)	21 (63.6%)	
Time Since Injury				
2 weeks	4 (6.45%)	1 (3.4%)	3 (9.0%)	0.388
3 months	5 (8.06%)	3 (10.3%)	2 (6.0%)	
6 months	46 (74.19%)	20 (41.3%)	26 (78.7%)	
9 months	7 (11.29%)	5 (17.2%)	2 (6.0%)	
Procedures				
	Neurolysis	1 (3.4%)		-
	Direct repair	1 (3.4%)		
	Nerve graft	4 (13.7%)		
	Nerve transfer	2 (6.8%)		
	Negative exploration	3 (10.3%)		
	Intra/extra plexus nerve, Transfers/ancillary procedures	18 (62.0%)		
Conservative	Expectant treatment	0	4 (12.12%)	-

DISCUSSION

Road traffic accidents are major contributors (94%) to traumatic brachial plexus injury in adults. Of these, 90% are associated with two-wheelers.[8] Same is the case in our study. Most of our patients have traumatic brachial plexus injuries resulting from road traffic accidents (90.32%). The other etiologies of BPI are birth palsy,[4] athletic injury, gunshot wounds,[11] backpack injury and iatrogenic injuries during anaesthesia.[12]

Most of the patients of road traffic accident brachial plexus injuries are young and suffer significantly due to a non-functional limb which makes them dependable for even small day to day activities. The more proximal the injury is, the greater is the chance that the motor endplates will be lost and muscles will atrophy by 18 months of injury. Therefore, the diagnosis must be made early and similarly; early intervention is required to return maximum function.

zone of C3 to T3. There are two types of images T1 weighted (T1-W) images and T2 weighted (T2-W). While the former helps with the anatomy of the plexus and show structures (muscles, bone, vessels etc.) that surround it, the latter helps in pointing out the site and extent of the pathology.[8] MRN is a3D stir space sequence, which shows nerves as bright structure in contrast to a fat repressed dark backdrop.[2,13] Complete brachial plexus, from its roots to the last peripheral branch, can be sketched by meticulously interpreting the MRN. In scenarios where trauma is the cause of plexus pathology, there is a high chance of misinterpretation of results of MRN due to oedema and haemorrhage. To avoid this, MRN is performed six weeks after the trauma.

Computed tomography (CT) myelography, which was previously used for imaging brachial plexus injuries, has been superseded by MRN. MRN is gradually becoming the gold standard for patients with

brachial plexopathy. While CT myelography only shows pathology of proximal plexus, MRN helps view the entire plexus from proximal (roots) to distal end (peripheral nerves).[14,15]

From a surgical point of view, the nature of the lesion is essential for deciding the treatment.[14] In cases of post-ganglionic injuries (transactions or ruptures), the anterior horn cells of the spinal cord survive. So if the lesion is repaired, a better prognosis is achieved (expectant motor recovery).[15] On the other hand, in pre-ganglionic injuries (root avulsions), cell bodies of the motor neurons diminish, and primary repair cannot be done. Nerve transfers are the option for such injuries as definite positive results of root reimplantation have not been achieved as yet.[7] As different surgical procedures can be used to achieve better results, the procedure's choice depends on the lesion.[16,17]

A few authors have quoted surgical exploration to be the reference standard for detection of brachial plexus injuries in their studies but most of them used outdated technology of MRI or pulse sequences.[11-14] There are few studies on the diagnostic accuracy of MRN, so the data to support MRN as a diagnostic tool for brachial plexus injury is lacking.[6] Wade *et al*, compared the diagnostic value of surgical exploration of brachial plexus with the MRN for recognizing a root avulsion in cases of brachial plexus injury. Their study shows a higher significance of MRN.[16] Similarly, another study showed MRN specificity of 92%, 95%, and 100% for identifying root integrity, root injury, and pseudomeningocele.[17]

MRN demarcates the point of nerve injury and shows whether the nerve is intact or interrupted. It demonstrates if neuroma is in continuity or at the end of a completely transected nerve. This way, it helps classify nerve injury, outlines the pre-operative plan, and augments the findings of electrodiagnostic studies.[18] Tear in dura may result in pseudomenin-gocele, which a regular MRI may detect, but this is not specifically indicative of root avulsion. MRN, however, shows another critical feature that is a much specific sign of nerve root avulsion, i.e. out of the ordinary enhancement of paraspinal muscles (changes in regional muscles due to denervation).

This study also showed how much MRN is beneficial in the diagnosis and management of brachial plexus injury patients. The accuracy of the exact nature of the lesion, its extent and location clarified by MRN made it possible to plan with confidence the best procedures and line of action for the individual patient.

It suggested that this investigation can markedly help in the evaluation of brachial plexus injury patients since the clinical examination and judgment usually leads to false-positive or false-negative findings. MRN gives an objective assessment and accurate localization of lesions for preoperative planning. Our study clearly showed that MRN helps in sorting outpatients who will and who will not benefit from surgery, thus avoiding unnecessary and expensive workup and surgery.

CONCLUSION

MRN-3T brachial plexus has significantly improved the diagnosis, preoperative planning and surgical outcome of patients with brachial plexus injury.

Conflict of Interest: None.

Authors' Contribution

PM: Research, data collection, article writing, MRA: Conception of research topic, proof reading, data collection, RSA: Study design, proof reading, SH: Writing of discussion and referencing, AUAN: Data collection and interpretation, RK: Data analysis.

REFEERENCES

1. Paper F. Clinical impact of magnetic resonance neurography in patients with brachial plexus neuropathies. Br J Radiol 2016; 89(1067): 20160503
2. Chhabra A, Thawait GK, Soldatos T, Thakkar RS, Del Grande F, Chalian M, et al. High-resolution 3T MR neurography of the brachial plexus and its branches, with emphasis on 3D imaging. Am J Neuroradiol 2013; 34(3): 486–497.
3. Vilar CF, Say LB, Diniz PRB, Souza H, Oliveira DA De, Clarice F, et al. SC. Clin Neurol Neurosurg [Internet]. 2017; Available from: http://dx.doi.org/10.1016/j.clineuro.2017.11.003 (Assessed on April 15,2020)
4. Imaging N. Brachial Plexus Injury: Clinical Manifestations , Conventional Imaging Findings , and the Latest Imaging Techniques 1.Radiographics 2006; 26 (Suppl 1): S133-S143.
5. Smith AB, Gupta N, Strober J, Chin C. Magnetic resonance neurography in children with birth-related brachial plexus injury. Pediatr Radiol 2008; 38(2): 159–163.
6. Wade RG, Itte V, Rankine JJ, Ridgway JP, Bourke G. The diagnostic accuracy of 1 . 5T magnetic resonance imaging for detecting root avulsions in traumatic adult brachial plexus injuries. Radiology 2019; 293(1): 125-133.
7. Wade RG, Takwoingi Y, Wormald JCR, Ridgway JP, Tanner S, Rankine JJ, et al. Magnetic resonance imaging for detecting root avulsions in traumatic adult brachial plexus injuries: protocol for a systematic review of diagnostic accuracy. Syst Rev 2018; 7(1): 76.
8. Upadhyaya V, Upadhyaya DN, Kumar A, Pandey AK, Gujral R, Singh AK. Magnetic resonance neurography of the brachial plexus. Indian J Plast Surg 2015; 48(2): 129–137.
9. Cejas C, Rollán C, Michelin G, Nogués M. High resolution neurography of the brachial plexus by 3 Tesla magnetic resonance imaging. Radiology 2016; 58(2): 88–100.
10. Rankine JJ. Adult traumatic brachial plexus injury. Clin Radiol. 2004; 59(9): 767–774.
11. Park HR, Lee GS, Kim IS, Chang J. Brachial Plexus Injury in Adults. Radiology 2017; 3(1): 1–11.

12. Zhou L, Yousem DM. Role of magnetic resonance neurography in brachial plexus lesions. Muscle Nerve 2004; 30(3): 305–309.
13. Mürtza P, Kaschner M, Lakghomi A, Gieseke J, Willinek WA, Schild HH, et al. Diffusion-weighted MR neurography of the brachial and lumbosacral plexus: 3.0 T versus 1.5 T imaging. Eur J Radiol 2015; 84(4): 696–702.
14. Thatte MR, Babhulkar S, Hiremath A. Mini Series: Brachial Plexus Brachial plexus injury in adults: Diagnosis and surgical treatment strategies. Ann Indian Acad Neurol 2013; 16(1): 26-33.
15. Hems TEJ, Birch R. The role of magnetic resonance imaging in the management of traction injuries to the adult brachial plexus. J Hand Surg Eur 1997; 22(1): 16.
16. Wade RG, Wormald JCR, Rankine JJ. MRI for Detecting Root Avulsions in Traumatic Adult Brachial Plexus Injuries: A Systematic Review and Meta-Analysis of Diagnostic Accuracy. AJR Am J Roentgenol 1996; 167(5): 1283-1287.
17. Sakellariou VI, Badilas NK, Stavropoulos NA, Mazis G, Kotoulas HK, Kyriakopoulos S, et al. Treatment Options for Brachial Plexus Injuries. ISRN Orthop 2014; 2014(1): 314137. https://pubmed.ncbi.nlm.nih.gov/24967125
18. Du R, Auguste KI, Chin CT, Engstrom JW, Weinstein PR. Magnetic resonance neurography for the evaluation of peripheral nerve, brachial plexus, and nerve root disorders: Clinical article. J Neurosurg 2010; 112(2): 362–371.