Scholars Journal of Applied Medical Sciences (SJAMS) **ISSN 2320-6691 (Online)**
Sch. J. App. Med. Sci., 2015; 3(5C):1949-1953 **ISSN 2347-954X (Print)**

(An International Publisher for Academic and Scientific Resources)
www.saspublisher.com

Research Article

Role of MRI in Evaluation and Characterization of Brachial Plexopathies

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Abstract: Brachial plexopathies are difficult to accurately diagnose, even with a meticulous investigation because the anatomic design of the plexus pose challenges, and also because the types of lesions and injuries that occur are frequently complex. Thus establishing a precise anatomic diagnosis and estimating the severity of the lesion is imperative for prognostic, surgical, and rehabilitative purposes. Evaluation of the brachial plexus is a clinical challenge and clinical examination and EMG (electrophysiological studies) provide only functional details without providing information regarding lesion localization and characterisation. MRI is currently the imaging modality of choice for evaluation of brachial plexus pathologies. MRI is valuable in identifying, localizing and characterizing the lesions affecting the brachial plexus and in differentiating the various traumatic lesions into pre-ganglionic and post-ganglionic which is critical for decision making and surgical planning, whether to proceed with exploration, nerve repair or nerve transfer. In this study a total of 50 patients were taken out of these 28(56%) were traumatic and rest were non traumatic 22 (44%). Amongst the traumatic lesions, post-ganglionic injuries(78.5%) were more common than pre-ganglionic(60.5%). Over all stretch injury(64%) was the most common cause of traumatic brachial plexopathies. In our study MRI had an accuracy of 97.5% in cases of root avulsion with 100% accuracy in other traumatic lesions(pseudomeningocele and transected nerve) whereas it was found to be 100% in nontraumatic brachial plexopathies such as primary and secondary tumors.
Keywords: Brachial plexus MRI, brachial plexopathies, preganglionic/postganglionic nerve injuries.

INTRODUCTION

The brachial plexus is a part of the peripheral nervous system, responsible for innervation of the shoulder, upper extremity and upper chest muscles, and cutaneous nerves of the skin and hand. It is a complex anatomical structure which carries motor, sensory and autonomic fibers that supply the upper limb. The brachial plexus can be involved in many different pathological processes which can broadly be classified into two categories: traumatic and non-traumatic [1,2].

Brachial plexopathies are difficult to accurately diagnose, even with a meticulous investigation. This is not only because the anatomic design of the plexus pose challenges, but also because the types of lesions and injuries that occur are frequently complex.

The clinical examination of brachial plexopathies are often inaccurate and does not reveal any useful information.EMG is helpful in providing functional implications of the lesions but does not help in its localization.

MRI is currently the imaging modality of choice for evaluation of brachial plexus pathologies [3]. MRI is valuable in differentiating the various traumatic lesions into pre-ganglionic and post-ganglionic which is critical for management decisions and surgical planning [4].

This study is aimed to evaluate the various traumatic and non-traumatic lesions involving the brachial plexus by MRI and to compare with surgical findings in selected cases and to assess whether MRI can be used as primary diagnostic tool for brachial plexopathies.

MATERIALS & METHODS

The present study was carried out in the Department of Radio diagnosis and SRL Diagnostic Centre of Mahatma Gandhi Memorial Medical College and M.Y. Hospital, Indore, Madhya Pradesh. A total of 50 patients who were referred to our department with strong clinical suspicion of brachial plexopathies were scanned using a 1.5 Tesla Siemens MRI scanner.

Exclusion criteria

Patients with symptoms of thoracic outlet syndrome.

Observations

Young patients are most commonly affected with brachial plexopathies with mean age of 24.5yrs with majority being males (70%).

In our study traumatic(56%) brachial plexopathies were more common than non-traumatic(44%). Amongst traumatic plexopathies, stretch injury was the most common traumatic lesion involving the BPL constituting (64%) of the cases followed by traumatic root avulsion seen in (28.5%) of cases with post-ganglionic(78.5%) injuries being more common than pre-ganglionic(60.5%) injuries.C5,C6 nerve roots(62.5%) were most commonly avulsed, followed by C7(25%) and C8T1(12.5%).

Non traumatic plexopathies accounted for 44% of the cases of which secondary tumors (62%) involving the BPL were the most common cause followed by primary tumors(38%). MRI could easily differentiate between the primary tumors of BPL. It was found that neurofibroma was the most common primary BPL tumor accounting for (60%) of the primary tumors followed by schwannoma(40%).Metastatic breast cancer(38%) involving the BPL was the most common secondary tumor of the BPL followed by pancoast tumor(38%).

Surgical correlation revealed that the number of root avulsions cases detected on MRI, positive on surgery (true positive) were 7 whereas the number of root avulsions detected on MRI which were normal on surgery was (false positive)-1. The number of root avulsions not detected on MRI which were positive on surgery(false negative) were 0 with number of normal roots detected on MRI which were normal on Arthroscopy (true negative) being 32. Thus MRI showed excellent correlation with surgical findings of nerve root avulsions

RESULTS

Stretch injury was the most common traumatic lesion involving the BPL constituting (64%) of the cases followed by traumatic root avulsion seen in (28.5%) of cases (Table-1).

Secondary tumors(62%) involving the BPL were the most common cause of non-traumatic brachial plexopathy followed by primary tumors (38%) (Table-2).

Clinical examination findings showed poor correlation with operative findings, where as in comparison, MRI showed excellent positive correlation with operative findings (Table-3).

DISCUSSION

The brachial plexus is part of the peripheral nervous system which innervates the shoulder and upper limb. The brachial plexus is a complex anatomical structure, it originates from roots C5 to T1 with occasional contributions from C4 and T2, before the formation of the brachial plexus itself, there is a complex intermingling of the ventral rami of the roots, via three trunks, six divisions and three cords and it ends in five peripheral nerves (ulnar, median, musculocutaneous, radial and axillary nerves), which are responsible for the critical motor and sensory function of the upper limb [15]. Any pathology involving the brachial plexus can cause significant morbidity ranging from pain, paraesthesias to complete paralysis of the involved upper limb.

Diagnostic workup includes clinical examination, electro-physiological studies and imaging. Because of the complex nature of the lesions, clinical examination is often inaccurate. EMG is an electrophysiologic test, which provides functional information by testing the muscles innervated by the BPL,but cannot do further localization nor can it diagnose the cause of plexopathy.

Imaging has an important role in the identification, localization, and characterization of the cause, which may be inadequately evaluated by clinical examination or electrophysiological studies.

Imaging of the brachial plexus is technically and anatomically challenging because of its complex anatomy. MRI, due its distinct advantages of excellent soft tissue contrast and multi-planar capabilities, plays a central role in imaging of the brachial plexus and the various pathologies involving it.

We attempted to determine the role of magnetic resonance imaging in the evaluation of brachial pathologies and tried to demonstrate the diagnostic value of MRI in identification, localization, and characterization of various brachial plexopathies by comparing MRI results with the surgical findings.

In our study, young patients were most commonly affected with majority of patients being males(70%) in second decade of life(36%), mean age being 24.5yrs. These results are in concordance with the observations seen by Mark R Foster et al [8].

Traumatic brachial plexopathies(56%) were more common than non-traumatic(44%).Amongst the traumatic lesions, post-ganglionic injuries(78.5%) were more common than pre-ganglionic(60.5%) which is in accordance with A. Aralasmak et al [5] study with stretch injury(64%) being the most common cause of traumatic brachial plexopathies. Similar findings were also observed in study conducted by Mark R Foster et al [8]. In the pre-ganglionic injuries, a total of 8(28.5%) nerve root avulsions were seen with C5,C6 roots(62.5%) most commonly avulsed, followed by C7(25%) and C8T1(12.5%) being the least commonly avulsed

On surgical follow-up in these patients of root avulsions, it was observed that among the 8 root avulsions diagnosed on MRI only 7 were present on surgery and one case was wrongly diagnosed on MRI as root avulsion(false positive). In our study, the 1 false positive case was diagnosed on MRI as root avulsion. On retrospective analysis of MRI, there was poor visualization of the nerve root due to motion artifact. Our study showed a sensitivity, specificity and accuracy for detecting nerve root avulsion of 100%, 96.9% and 97.5%. These findings are in concordance with the observations seen by Medina LS et al [7] and Penkert G et al [9].

A total of 22 patients presented with non-traumatic brachial plexopathies, these included primary tumors of BPL i.e neurofibromas 3(13.6%), schwannomas 2(9%), post radiation plexitis 2(9%), post radiation fibrosis 2(9%), viral plexitis 2(9%), cervical disc pathology 2(9%), metastasis from breast cancer 5(22.5%) and metastasis from pancoast tumors 3(13.6%). Similar results were observed by Kichari JR et al [6] in his study.

Amongst the primary BPL tumors, 3(60%) were neurofibromas and 2(40%) were schwannomas, the former being more common than the later. Neurofibroma correlated well with the "target sign appearance" on T2WI and Schwannoma correlated well with the "salt and pepper appearance"on T2WI with MRI showing 100% sensitivity, specificity and accuracy in diagnosing the primary tumors of the BPL [14].

Metastasis(secondary tumors) involving the BPL were the most common cause of non-traumatic brachial plexopathy constituting 36.3% of the cases. Metastasis from breast cancer(22.5%) were the most common, followed by those from pancoast tumors(13.6%) with 100% correlation with the MRI findings.

MRI is particularly important in evaluation in carcinoma breast cases to differentiate metastatic plexopathy and post-radiation plexopathy with 100% sensitivity, specificity and accuracy. Metastatic involvement showed discrete T2 hyper-intense masses involving the BPL with nodular thickening whereas post radiation plexopathy showed diffuse/ focal thickening of BPL in the region of radiation, without evidence of discrete masses [11]. Similar findings were seen by Kichari JR et al [6] and Stojan Perić et al [10] in their study.

2 out the 22 patients presenting with non-traumatic plexopathies were diagnosed as viral plexitis(9%), they had pain and fever as presenting complains with MRI showing smooth uniform thickening and hyper-intense signal in the BPL. Similar findings were observed by A. Aralasmak et al [5] in his study.

Table-1: Gross MRI Findings in Traumatic BPL Lesions

Sl. No.	MRI Imaging Features	MRI Finding	No Of Cases	% Of Cases
1.	Thickening With T2 Hyperintense Signal In Injured BPL.	Stretch Injury	18	64%
2.	Complete Absence Of Nerve Roots In Subarachnoid Space On Space Sequence.	Root Avulsion	8	28.5%
3.	T2 Hyperintense Signal In Cord	Cord Contusion	4	14%
4.	T2 Hyperintense Extra-Arachnoid Collection Of CSF Around The Affected Nerve Root.	Pseudomeningocele	7	25%
5.	Loss Of Continuity Of Clavicular Bone	Clavicle Fracture	2	7%
6.	T1 & T2 Hyperintense Mass	Hematoma	1	3.5%
7.	Discontinuity Of Nerve	Transected Nerve	1	3.5%
8.	T2 Hyperintense Signal With Vertebral Body Collapse	Cervical Vertebral Injury	4	14%
9.	Normal	Normal	3	10.5%

Table 2: Gross MRI Findings in Non-Traumatic BPL Lesions

Sr. no	MRI imaging features	Finding	No of cases	% of cases
1.	T1 Iso To Hypo & T2 Hyperintense Nodular Thickening	Breast Metastasis	5	22.5%
2.	Loss Of Normal T1 Hyperintensity Of Interscalene Fat Pad With Infiltration Of BPL	Pancoast Tumor	3	13.6%
3.	Target Sign(T2 Central Hypointensity With Peripheral Hyperintensity)	Neurofibroma	3	13.6%
4.	Salt & Pepper Appearance(Heterogenous T2 Hyperintensity)	Schwannoma	2	9%
5.	BPL Thickening With T2 Hyper-Intense Signal In Region Of Radiation.	Post Radiation Plexitis	2	9%
6.	BPL Thickening With T1 & T2 Hypo-Intense Signal	Post Radiation Fibrosis	2	9%
7.	T2 Hypo-Intense Signal With Disc Protrusion.	Cervical Disc Pathology	2	9%
8.	BPL Thickening With T2 Hyper-Intense Signal	Viral Plexitis	2	9%
9.	Normal	Normal	1	4.5%
		Total	22	100%

Table-3: Correlation of clinical and MRI findings with surgery

Sr NO	Clinical localization of lesions	MRI localization of lesions	Operative findings (levels affected)
1.	C5C6	C5C6	C5C6
2.	C5-T1	C8T1	C8T1
3.	C5-T1	C5C6	C5C6
4.	C5-T1	C5C6	C5C6
5.	C5-T1	C7	C7
6.	C5C6	C5C6	Intact Roots
7.	C5-T1	C5C6	C5C6
8.	C5-T1	C7	C7

Table-4: Results of Data Analysis of 20 Patients Where Surgical Correlation aas Available MR Sensitivity in Traumatic Lesions

Sr no	Finding	MR Positive	Intra-Op	Sensitivity	Specificity	Accuracy
1.	Root avulsion	8	7	100%	96.9%	97.5%
2.	Pseudomeningocele	7	7	100%	100%	100%
3.	Transected nerve	1	1	100%	100%	100%

CONCLUSION

MRI is an excellent, non-invasive diagnostic modality having high sensitivity, specificity and accuracy in the diagnosis and characterization of the various pathologies involving the brachial plexus. Good correlation existed between findings at MR imaging and those at surgery in assessment of brachial plexopathies. MRI is the only imaging modality which can reliably distinguish between pre and post-ganglionic lesions [2], post-radiation plexitis and metastatic tumors; it is also valuable in differentiating and staging the primary and secondary tumors involving the BPL. Thus it provides crucial information for the management and surgical planning of the lesions. MRI is the single most valuable diagnostic tool in the evaluation of brachial plexopathies obviating the need for multiple imaging or diagnostic procedures.

MRI should be done in every patient of suspected brachial plexus pathology, to guide the appropriate management and treatment of the patient.

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