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Research Article

Role of Magnetic Resonance Imaging Evaluation of Traumatic Brachial Plexus Injuries

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Abstract: Brachial plexus injury (BPI) is a severe neurologic injury that causes functional impairment of the affected upper limb. Imaging studies play an essential role in differentiating between preganglionic and postganglionic injuries, a distinction that is crucial for optimal treatment planning. Findings at standard conventional magnetic resonance (MR) imaging help determine the location and severity of injuries. ***Material and Methods:*** This is prospective and observational study descriptive study conducted at during January 2013 to June 2013 at Subbaiah Institute of Medical Sciences, Shimoga. Patients who have history of cervical spine or shoulder trauma with suspicious involvement of brachial plexus. Patients of all age with either sex groups were included in the study. ***Result:*** MRI examination of brachial plexus was done for 49 patients with clinically suspected traumatic or obstetric brachial plexopathy. Those patients were surgically explored with confirmed intraoperative findings. Thirty-eight patients were presented with traumatic brachial plexus injury: 31 males and 7 females. The most common component involved in brachial plexus injuries was roots 50% of cases followed by trunk is 42.1% of cases. and least were cord injury. Divisions and cords involved in 18.4% and 13.1% of cases respectively. In our study, no patient has involvement of branches. ***Conclusion:*** The brachial plexus can be efficiently imaged and effectively interpreted by the general radiologist when approached from a practical standpoint. Practical and useful information that can help the referring physician include, pre- vs. post-ganglionic location of lesion, mass vs. non-mass like enhancement, laterality or bilateral nature of disease, location of injury/mass/abnormality in BP segments (eg root, trunk, division, etc.), and anatomical region and surrounding structures involved (eg, interscalene space, costoclavicular triangle, relationship to subclavian/axillary vessels).
Keywords: Magnetic resonance imaging, Traumatic brachial plexus injuries, Roots injury.

INTRODUCTION

Brachial plexopathies are conditions affecting the brachial plexus, the cluster of nerves that innervate the upper limb. Disease or disruption of the brachial plexus can severely affect the function of the upper limb musculature and sensation [1]. The causes of brachial plexopathy in adults can be broadly divided into traumatic and non-traumatic aetiologies. The brachial plexus is formed by the nerve roots originating from the C5, C6, C7, C8 and T1 levels. The nerve roots are divided into pre- and postganglionic sections, with the dorsal root ganglion as the point of reference [2]. The brachial plexus itself is formed by the ventral rami of the postganglionic sections of the nerve roots. It is subdivided into the following portions, from proximal to distal: five roots, three trunks, six divisions, three cords and five terminal nerves [3]. The C5 and C6 nerve roots unite to form the upper trunk; the C7 nerve root forms the middle trunk; and the C8 and T1 nerve roots form the lower trunk. Each of these three trunks then divide into anterior and posterior divisions, i.e. six divisions in all. The trunks and divisions are found superior to the clavicle [4].

To date, magnetic resonance imaging (MRI) is the best indicator of various pathologies affecting the brachial plexus, and in the context of trauma it is superior to pre-operative nerve conduction studies, high-resolution ultrasonography and intraoperative somatosensory-evoked potentials [5]. Findings at MR imaging provide additional anatomic and physiologic information on injuries. Signal intensity changes are observed in the spinal cord in approximately 20% of patients with preganglionic injuries. Hyperintense areas on T2-weighted images suggest edema in the acute phase and myelomalacia in the chronic phase [6]. Hypointense lesions on T2-weighted images reflect hemosiderin deposition on account of hemorrhagef. Signal intensity changes are either extensive in the affected side of the spinal cord or confined to the exit zone of the ventral nerve root. In rare cases, a defect is noted in the spinal cord; such a finding infers avulsion within the cord [7].

Enhancement of intradural nerve roots and root stumps suggests functional impairment of nerve roots despite morphologic continuity. Contrast-enhanced MR imaging is the only preoperative examination that can help detect functionally impaired nerve roots with anatomic normality and is helpful in avoiding abortive reconstructive procedures. [8] At unenhanced MR imaging, signal intensity changes and volume loss are observed in paraspinal muscles in patients with root avulsion injuries, but these findings have less accuracy and visibility than paraspinal muscle enhancement [9]. Abnormal enhancement in the multifidus muscle is the most accurate of all paraspinal muscle findings, since the multifidus muscle is innervated by a single nerve root [10].

Another advantage of MR imaging is visualization of the postganglionic brachial plexus. Edema and fibrosis of the brachial plexus can manifest as thickening of the plexus [11]. MR imaging is a good method for evaluating benign and malignant tumorous lesions and, therefore, for evaluating stump neuroma derived after BPI [12]. It is sometimes complicated to assess the brachial plexus when severe traumatic changes or surgical intervention distort normal anatomic structures.

Our rationale for conducting this study is to summarise the diagnostic accuracy of MRI for the identification of root avulsion in adult traumatic Brachial plexus injury. Radiologists and surgeons may use this information to rationalise such imaging, aid in its interpretation and guide future research focused on improving imaging of Brachial plexus injury.

MATERIAL AND METHODS

This is prospective and observational study descriptive study conducted at during January 2013 to June 2013 at Subbaiah Institute of Medical Sciences, Shimoga.

Inclusion Criteria

- Patients who have history of cervical spine or shoulder trauma with suspicious involvement of brachial plexus.
- Patients of all age with either sex groups were included in the study.

Exclusion criteria

- Patients with metallic implants, cardiac pacemakers, cochlear implants and metallic foreign body.
- Patients who are lactating or pregnant.
- Patients who are claustrophobic.
- Patients who are unwilling for imaging.

Image Processing

The study was carried out on the patients visiting the OPD/IPD referred from other health centre for advance treatment of brachial plexus injuries to the Department of Radiodiagnosis, Subbaiah Institute of Medical Sciences, Shimoga. MR imaging was performed 0.35T Siemens Magnetom C. Imaging were performed in the axial, coronal and oblique sagittal planes covering the axilla to middle of the neck. Axial images parallel to the disc spaces, coronal images parallel to the vertebrae and shoulders and oblique sagittal images perpendicular to the brachial plexus are obtained. All images were obtained with use of a body coil and section thickness of 3-5 mm and 1.5 mm intersection gaps. MRI contrast agents was not routinely used.

RESULT

MRI examination of brachial plexus was done for 49 patients with clinically suspected traumatic or obstetric brachial plexopathy. Those patients were surgically explored with confirmed intraoperative findings. Thirty-eight patients were presented with traumatic brachial plexus injury: 31 males and 7 females.

Table-1: Sex Distribution of Patients

	Gender		Total
	Male	Female	
Number of Patients	31	7	38
Percentage	81.5	18.4	100

Table-2: Distribution of components of Brachial plexus injury

	Number of components	Percentage
Roots	19	50
Trunk	16	42.1
Division	6	15.7
Cord	5	13.1

In Table-2, the most common component involved in brachial plexus injuries was roots 50% of cases followed by trunk is 42.1% of cases and least were cord injury. Divisions and cords involved in 18.4% and 13.1% of cases respectively. In our study, no patient has involvement of branches.

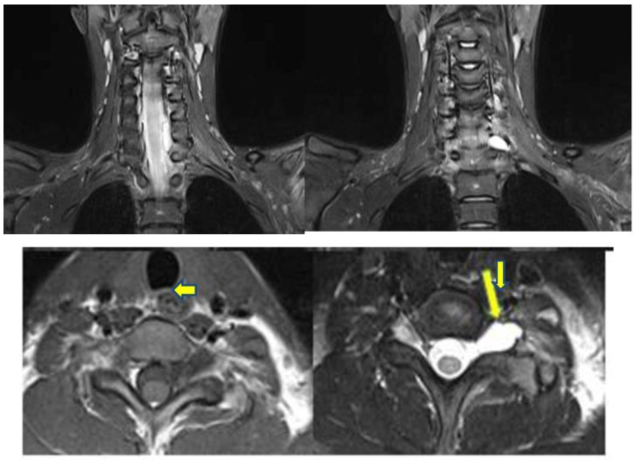

Fig-1: Root injury with meningocele at C7/T1 level on left. STIR coronal weighted images (A, B), axial T1 and axial T2 Fat suppressed (C, D) images (yellow arrow)

Table-3: Segment of Root Involved

	Number of Patients (n=19)	Percentage
C5	7	36.8
C6	13	68.4
C7	13	68.4
C8	5	26.3
T1	4	21.0

In Table-3, 19 cases with nerve root pathology, the most common segment involved was C6 and C7 in 68.4% (13 patients) of cases followed by C5 in 36.8% (7 patients) of cases. 9 patients show multiple root injuries.

Table-4: Level of Pseudo meningocele Formation

	Number of Patients (24)	Percentage
C3-C4	1	4.1
C4-C5	3	12.5
C5-C6	4	16.6
C6-C7	9	37.5
C7-T1	4	16.6
T1-T2	3	12.5

Out of 9 patients with pseudo meningocele formation, the most common level involved was C6-C7 in 37.5% (9 patients) of cases. Second most common level involved were C5-C6, C7-T1 and T1-T2 of cases each.

Table-5: Segment of Trunk injury

	Number of Patients (16)	Percentage
Upper trunk	11	68.7
Middle trunk	8	50.0
Lower trunk	9	56.2
Multiple trunk	8	50.0

In Table-5, 16 cases with trunk injury, 68.7% (11 patients) cases shows upper trunk involvement while middle and lower trunk involved in 50.0% (8 patients) and 56.2% (9 patients) of cases respectively. 8 patients (50.0%) has multiple trunk involvement.

Table-6: Segment of division injury

	Number of Patients (6)	Percentage
Anterior division	6	100.0
Posterior division	6	100.0

In Table-6, out of 6 patients with division involvement, both anterior and posterior divisions are involved in 100.00% (7 patients) of cases.

Table-7: Segment of cord injury

	Number of Patients (5)	Percentage
Lateral cord	4	80
Posterior cord	4	60
Medical cord	4	60
Multiple cord	2	40

In Table-7, out of 5 patients with cord involvement, all the segment; lateral, posterior and medial cord are involved in 80.00% (4 patients) of cases each. 2 patients (40%) have multiple cord involvement.

DISCUSSION

The incidence of traumatic brachial plexus injuries is increasing in India, mainly due to the increase in motorcycle accidents. Consequently, it is important to identify tests which permit earlier and more accurate diagnosis to improve decision-making related to nerve reconstruction and consequently improve prognosis. The earlier surgical reconstruction of the brachial plexus is performed (when this is indicated), the better the prognosis. In patients with symptoms suggesting favorable neuropraxis or partial lesions, watchful treatment may be an option if additional high-accuracy tests are not available to stage the lesions. In these cases, it is possible to wait for clinical improvement over time, avoiding an unnecessary surgical procedure. But in lesions with unfavorable prognoses (axonotmesis and neurotmesis), time is a decisive factor in surgical reconstruction. In these cases, earlier staging of lesions and indication for surgery provides better reconstructive planning and prognosis [13].

Topographic knowledge of the lesions prior to surgery is important to avoid unnecessary dissections. Consequently, if the type and location of the lesions have not been precisely determined before surgery, supra- and infraclavicular approaches may be performed for this purpose, increasing morbidity and surgical time [14]. Therefore, when MRI with diffusion-weighted sequences and volumetric reformatting of fluid-sensitive sequences is applied to traumatic lesions of the brachial plexus it provides new diagnostic perspectives, with sensitivity and specificity similar to those of computerized myelotomography for diagnosing pre-ganglionic lesions (avulsion) and greater accuracy for post-ganglionic lesions [15]. This technique provides greater contrast between the nerves and adjacent tissues, improving the image of the nerve pathways in the brachial plexus. Adding this sequence does not extend the examination excessively, only by approximately 5 minutes. When combined with the other sequences and planes of conventional MRI of the brachial plexus, this examination can provide a more accurate assessment without increasing morbidity [16].

The brachial plexus is a complex component of the nervous system. Injury to the brachial plexus can affect the peripheral nervous system and, potentially, the central nervous system; this highlights the need for a deep knowledge of the modalities currently available for the evaluation of the brachial plexus. Traditional MRI is and should be, for the time being, the imaging method of choice for non-traumatic plexopathies [17].

Limitation of the study

This is a preliminary study carried out over a short period of time, which explains the low number of patients evaluated. Studies with larger numbers of patients should be performed in order to confirm these data.

CONCLUSION

Optimal treatment of traumatic brachial plexus injuries involves a multidisciplinary approach. Upper plexus injuries should be promptly and accurately diagnosed and described because the success of nerve transfer surgery is high in this patient population. Among the radiologist's objectives, the most paramount include optimizing imaging modality selection and protocoling to identify the area of injury, classify the degree of injury, assess the integrity of potential donor nerves or muscles for tendon transfers, and find denervation edema to better characterize the nerve injury and predict prognosis. Secondary goals include exclusion of confounding factors, such as cervical spondylosis, suprascapular nerve entrapment, or the presence of incidental tumors. This information, in combination with clinical and electrodiagnostic data, helps to predict which patients will likely require surgery and what surgical approach should be used to improve patient prognosis.

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