Study the role of MRI & electrophysiological study in evaluation of cases of neck pain radiated to upper limb

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Abstract: Background: there was no consensus on the ideal and most sensitive method for diagnosis of the cause of neck pain radiating to the upper arm. **Aim of the work:** to study the role of magnetic resonance imaging & electrophysiological study in patients presented with pain in the neck radiated to upper limb, in the light of clinical findings as a standard. **Patients and methods:** The present study included 30 patients, selected from Neurology Department; Al-Azhar Faculty of Medicine (New Damietta). They were selected during the period from March 2016- October 2016. All were submitted to full history taking, clinical examination with stress on neurological part of examination, electrodiagnostic studies, EMG, somatosensory evoked potential of median nerve and MRI cervical spine. **Results:** EMG sensitivity in relation to clinical motor affection was 94.4%, the specificity was 41.7%, positive predictive value (PPV) was 70.83%, negative predictive value (NPV) was 83.3% and overall accuracy was 73.3%. The sensitivity of EMG in relation to sensory affection was 95.2%, the specificity was 55.6%, PPV was 83.3%, NPV was 83.3% and overall accuracy was 83.3%. The sensitivity of magnetic resonance imaging (MRI) in relation to clinical motor affection was 83.3%, the specificity was 91.7%, PPV was 57.8%, NPV was 25.0% and overall accuracy was 53.3%. The sensitivity of MRI in relation to sensory affection was 85.7%, the specificity was 11.1%, PPV was 69.2%, NPV was 25.0% and overall accuracy was 63.3%. Both techniques revealed affection in 20 subjects (66.7%) and there was disagreement between both Techniques in 10 subjects (33.3%). MRI showed positive root affection in 6 out of 10 disagreed subjects; of these 6 subjects only 1 subject (16.7%) had clinical motor and clinical sensory affection. EMG showed positive affection in 4 out of 10 disagreed subjects; of these 4 subjects 3 subjects (75.0%) had clinical motor and clinical sensory affection. **Conclusion:** Electrodiagnostic studies are superior to magnetic resonance imaging in diagnosis of cervical radiculopathies based on clinical results. In addition, both techniques revealed concordance in diagnosis in about 66.7% of patients. When there is a discrepancy between both techniques, electrodiagnostic studies correlate more efficiently than MRI with clinical results.
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1. Introduction

Pain and subsequent dysfunction around the neck is a common clinical problem amongst general population of different age. It is encountered by physicians second to pain and impairment from the low back. Many individuals can recall an episode of neck pain with or without radicular symptoms and/or signs (**Dunn et al., 2013**). Cervical radiculopathy is a common disabling condition that refer to any cervical spine disease that compromise the cervical nerve root, or roots at or near neuro-foramen through which they exit the spinal column through a variety of mechanisms**(Hsu *et al*., 2013).** The patterns of clinical presentation of spinal nerve roots compromise are subject of wide variability. They are mostly sensory, generally, proximal pain and distal paresthesia, while motor manifestation occur less frequently. Neck pain is the most common symptom of cervical radiculopathy which is often lateralized and frequently radiate to the upper limb in a dermatomal distribution. The pain may be atypical and present as chest pain (pseudo angina) or pain in the fascial region **(Cifu, 2016).** Paresthesia is often present distally in the digits. Motor symptoms are usually slight or absent, yet occasionally there is muscular weakness, wasting and fasciculation in the muscles supplied by the involved nerve roots. Deep tendon reflexes may be diminished or lost depending on a specific root injury. Certain cervical movements and postures can exacerbate radicular symptoms, and arm abduction may provide relief **(Reiman, 2016).** In general, radicular symptoms resolve in most patients with no treatment or with simple remedies. However, in some patients, radiculopathy develop insidiously disrupting work, social activities, and recreation. Since pain in the upper extremity is quite similar in most instances irrespective of its origin, determination of the cause requires a thorough knowledge of both structural and dynamic anatomy of the entire area **(Armitage, 2015).**

Magnetic resonance imaging (MRI) scans can usually identify the presence of a structural lesion entrapping the nerve roots. However, it is important to note that radiculopathy and poly radiculopathy may both occur without a structural lesion seen on MRI. Apart from that imaging studies are associated with high false-positive rates. In such cases further investigation is required, usually with nerve conduction studies and electromyography (EMG) **(Levin, 2002).** Electrophysiological studies are important to evaluate spinal nerve root compromise as they can identity abnormalities and can determine the prognosis as well. Moreover, with the introduction of accurate diagnostic neuroimaging techniques, the management of patients with cervical radiculopathy has largely evolved during the past few decades. Nevertheless, the optimal management and treatment outcomes of patients with cervical radiculopathy are still debated **(Carter *et al*., 2015).**

The aim of this study is to study the role of magnetic resonance imaging & electrophysiological study in patients presented with pain in the neck radiated to upper limb. The agreements between these two procedures and clinical findings will be also examined.

2. Patients and methods

This is across-sectional study that was done on 30 patients. Cases of this study were selected from Neurology Department; Al-Azhar Faculty of Medicine (New Damietta). They were selected during the period from March 2016- October 2016. Patients with the following criteria were included in the study: The consecutive patients that presented with pain in the neck radiated to the upper limb, weakness and muscle atrophy in myotomal distribution, dermatomal sensory impairment and depressed or absent reflexes. Patients had the manifestations of radiculopathy. In addition, the analysis was limited to patients with MRI cervical spine taken within 1 month prior to the study.

Patients with clinical or electrophysiological evidence of poly or mononeuropathy, patients with plexopathy and myopathy, participants with previous spine surgery were excluded from the study. Additionally, for exclusion of non-structural causes of roots lesion, patients with the involvement of more than two nerve roots in clinical examination or electrodiagnostic study were excluded from the study. Included patient were subjected to the following: 1- Full history taking (personal history, past history, family history); 2- General examination and full neurological examination that included tone, sensory system testing, motor examination; 3- Electrodiagnostic studies (motor nerve conduction studies of median, ulnar, axillary and musculocutaneous nerves, bilateral F-wave from median and ulnar nerves, bilateral H reflex from flexor carpi radialis; 4 - MRI cervical spines (sagittal and axial T1- and T2-weighted sequences) and 5- Needle electro-myographic examinations of deltoid, biceps brachii, triceps, extensor indicis, supraspinatus, pronator teres and para spinal cervical muscles were be obtained during rest, minimal and maximal contractions.

3. Results

In the present study, age ranged from 30 to 50 years; the mean age was 41.03±5.15 years; 13 subjects (43.3%) were males and radiation was to the right side in 66.7% (see table 1). All neurophysiological examinations revealed normal values for distal latency, amplitude and conduction velocity. As regard to F wave or right median nerve, it was normal in 25 subjects (83.3%), while left median nerve F-wave was normal in 28 subjects (93.3%). In addition, right ulnar F-wave was normal in 24 subjects (80.0%) and left ulnar nerve F-wave was normal in 27 subjects (90.0%). H-reflex on right side was normal in 27 subjects (90.0%); while the left H-reflex was normal in 28 subjects (93.3%) of studied populations. Somatosensory evoked potential of median nerve was normal in 17 subjects (56.7%) and delayed in 13 subjects (43.3%) (See table 2).

As regard to results of EMG, each of supraspinatus and deltoid muscles was affected in 19 subjects (63.3%); while each of biceps and pronator teres was affected in 14 subjects (46.7%) and each of triceps and extensor indices was affected in 11 subjects (36.7%). Overall EMG results revealed affection in 24 out of 30 subjects, representing 80.0% of studied populations, and it revealed no-affection in 6 subjects (20.0%). MRI examination revealed root affection at C5-C6 in 26 subjects (86.7%); root affection at C6-C7 in 12 subjects (40.0%) and root affection in C7-T1 in 9 subjects (30.0%). Overall all MRI was positive (affected) in 26 subjects out of 30 subjects, representing (86.7%) and negative (not-affected) in 4 subjects (13.3%). Clinical results of motor examination revealed positive results (affection) in 18 out of 30 subjects (60.0%) and negative results in 12 subjects (40.0%). Clinical examination of sensory affection was positive (show affection) in 21 subjects (70.0%) and negative in 9 subjects (30.0%) (Table 3).

As regard to sensitivity of EMG in relation to clinical motor affection, it was 94.4%, the specificity was 41.7%, PPV was 70.83%, NPV was 83.3% and overall accuracy was 73.3%. While the sensitivity of EMG in relation to clinical sensory affection was 95.2%, the specificity was 55.6%, PPV was 83.3%, NPV was 83.3% and overall accuracy was 83.3% (table 4).

As regard to sensitivity of MRI in relation to clinical motor affection, it was 83.3%, the specificity was 91.7%, PPV was 57.8%, NPV was 25.0% and overall accuracy was 53.3%. While sensitivity of MRI in relation to clinical sensory affection, was 85.7%, the specificity was 11.1%, PPV was 69.2%, NPV was 25.0% and overall accuracy was 63.3% (table 4).

When considering positive affection diagnosed by both MRI and EMG, both techniques revealed affection in the same 20 subjects (66.7%) and there was disagreement between both Techniques in 10 subjects (33.3%). MRI showed positive root affection in 6 out of 10 disagreed subjects; of these 6 subjects only 1 subject (16.7%) had clinical motor and clinical sensory affection. EMG showed positive affection in 4 out of 10 disagreed subjects; of these 4 subjects 3 subjects (75.0%) had clinical motor and clinical sensory affection (table 5).

Table (1): Characteristics of studied subjects

Variable		Statistics
Age		41.03±5.15; 30-50
Sex (n, %)	Male	13(43.3%)
	Female	17(56.7%)
Side of radiation (n, %)	Right	20(66.7%)
	Left	10(33.3%)

Table (2): F-wave, H-reflex and somatosensory evoked potential in studied subjects

		n	%
Right median F-wave	Normal	25	83.3
	Abnormal	5	16.7
Left median F-wave	Normal	28	93.3
	Abnormal	2	6.7
Right ulnar F-wave	Normal	24	80.0%
	Abnormal	6	20.0%
Left ulnar F wave	Normal	27	90.0%
	Abnormal	3	10.0%
Right H-reflex	Normal	27	90.0
	Abnormal	3	10.0
Left H-reflex	Normal	28	93.3
	Abnormal	2	6.7
Somatosensory evoked potential of Median nerve	Normal	17	56.7
	Delayed	13	43.3

Table (3): EMG, radiological and clinical motor and sensory results in studied populations

		Affected		Not affected	
		n	%	n	%
Supraspinatus		19	63.3%	11	36.7%
Deltoid		19	63.3%	11	36.7%
Biceps		14	46.7%	16	53.3%
Pronator teres		14	46.7%	16	53.3%
Triceps		11	36.7%	19	63.3%
Extensor indices		11	36.7%	19	63.3%
Overall positive results of EMG		***24***	***80.0%***	***6***	***20.0%***
MRI	C5-C6	26	86.7%	4	13.3%
	C6-C7	12	40.0%	18	60.0%
	C7-T1	9	30.0	21	70.0
Overall MRI		***26***	***86.7%***	***4***	***13.3%***
Clinical motor examination		18	60.0%	12	40.0%
Clinical sensory examination		21	70.0%	9	30.0%

Table (4): Sensitivity of EMG or MRI in relation to clinical motor or sensory results

		Clinical motor affection				Clinical sensory affection			
		Positive		Negative		Positive		Negative	
		n	%	n	%	n	%	n	%
Overall EMG Results	**Affection**	17	94.4	7	58.3	20	95.2	4	44.4
	No affection	1	5.6	5	41.7	1	4.8	5	55.6
Sensitivity		***94.4%***				***95.2%***			
Specificity		***41.7%***				***55.6%***			
PPV		***70.83%***				***83.3%***			
NPV		***83.3%***				***83.3%***			
Overall accuracy		***73.3%***				***83.3%***			
Overall MRI Results	**Affection**	15		83.3		11		91.7	
	No affection	3		16.7		1		8.3	
Sensitivity		***83.3%***				***85.7%***			
Specificity		***91.7%***				***11.1%***			
PPV		***57.8%***				***69.2%***			
NPV		***25.0%***				***25.0%***			
Overall accuracy		***53.3%***				***62.3%***			

Table (5): Relation between MRI or EMG with clinical evaluation in disagreed cases

		Overall MRI				Overall EMG			
		Positive (6)		Negative (4)		Positive (4)		Negative (6)	
		n	%	n	%	n	%	n	%
Clinical motor	Positive	1	16.7%	3	75.0%	3	75.0%	1	16.7%
	negative	5	83.3%	1	25.0%	1	25.0%	5	83.3%
Clinical sensory	Positive	1	16.7%	3	75.0%	3	75.0%	1	16.7%
	negative	5	83.3%	1	25.0%	1	25.0%	5	83.3%

4. Discussion

The aim of the present study was to study the role of magnetic resonance imaging & electrophysiological study in patients presented with pain in the neck radiated to upper limb. The agreements between these two procedures and clinical findings will be also examined. The present study included 30 patients, selected from Neurology Department; Al-Azhar Faculty of Medicine (New Damietta). They were selected during the period from March 2016- October 2016. All were submitted to full history taking, clinical examination with stress on neurological part of examination, electrodiagnostic studies, EMG, somatosensory evoked potential of median nerve and MRI cervical spine.

In the present work, motor and sensory nerve conduction studies revealed normal values. These results are in agreement with **Tsao (2007)** who reported that, Motor NCS typically are normal in patients who have radiculopathy, because only a portion of nerve fascicles within a nerve root trunk is injured. They added, rarely, if the radiculopathy results in sufficient motor axon loss (up to 50% of motor axons within a nerve trunk), the compound motor action potential (CMAP) amplitude may be reduced significantly, as defined by age-related norms or a 50% or greater reduction in amplitude compared with the contralateral limb. Even in the presence of severe axon loss, however, routine motor NCS may appear normal unless the CMAP is generated from a muscle that receives innervation from the injured nerve root (eg, for a suspected C5-6 radiculopathy, routine motor NCS assess only the median innervated thenar [mainly T1-derived] and ulnar innervated hypothenar [mainly C8-derived] muscles). In this instance, to detect motor axon loss, if present, a CMAP would have to be recorded over the biceps or deltoid muscles. In chronic axon loss radiculopathy, CMAPs may normalize if sufficient reinnervation occurs. The pathophysiology of radiculopathy at the root level infrequently is a focal, purely demyelinating conduction block. If this occurs, routine motor NCS remain normal even if weakness is present in corresponding myotomes.

As regard to F wave or right median nerve, it was normal in 25 subjects (83.3%), while left median nerve F-wave was normal in 28 subjects (93.3%). In addition, right ulnar F-wave was normal in 24 subjects (80.0%) and left ulnar nerve F-wave was normal in 27 subjects (90.0%). This high level of normality of F-wave in spite that clinical findings, EMG and MRI findings discovered a higher rate of radiculopathy indicated that, F-wave had a limited role in diagnosis of cervical radiculopathy. This is in line with previous studies reported that, the low correlation of F wave parameters with levels of cervical spine radiculopathy (CSR) suggests that generation of F waves is not localized to a single root level **(Weber, 1999).** However, **Toyokura *et al.* (1996)** have reported that F-wave has a prognostic value compared with conventional motor nerve conduction studies. In addition, **Aminoff (2002)** concludes that F waves often are normal in patients who have suspected radiculopathy, and ‘‘even when they are abnormal, their findings are inconsequential because the (needle electrode examination) findings are also abnormal and help to establish the diagnosis more definitively.’’

As regard to H-reflex on right side, it was normal in 27 subjects (90.0%); while the left H-reflex was normal in 28 subjects (93.3%) of studied populations. **Jankus *et al*. (1994)** and **Tsao (2007)** reported that, despite its sensitivity in radiculopathy, reduced H-reflex amplitude is not specific for etiology or precise localization, as a focal lesion anywhere along the sensory afferent, spinal synapse, or motor efferent pathways may diminish the H amplitude. Diagnosing radiculopathy based on prolonged H latency alone is insensitive, because focal slowing may be obscured by the long segment of nerve assessed and, even if present, does not localize the lesion along the nerve segment studied. Last, the H-reflex technically may be difficult to obtain in obese patients and may be absent in patients over 60 years of age. Thus, in the present work, we did not depend on H-reflex for diagnosis of radiculopathy.

As regard to somatosensory evoked potential of median nerve, it was normal in 17 subjects (56.7%) and delayed in 13 subjects (43.3%). It was reported that, although SEPs offer the theoretic advantage of assessing proximal portions of sensory nerves, their routine use is limited by a variety of factors. As with the H-reflex and F wave, SEPs record responses only from the fastest conducting nerve fibers, so that focal or partial conduction block or slowing is not apparent, masked by normally conducting afferent fibers and diluted by the long nerve segment over which the SEP travels. Furthermore, because of the normal interside and inter-subject variation in amplitude of SEPs, only an absent or un-elicitable response may indicate underlying pathology. Lastly, abnormal SEPs may localize a lesion to the plexus region but cannot discriminate further between plexus and root localization. The consensus of reviews is that SEPs by nerve trunk stimulation are unhelpful in the diagnosis of suspected radiculopathy, whereas cutaneous and dermatomal SEPs are insensitive and only support, at best, the presence of radiculopathy when the diagnosis is defined more clearly clinically or by EDX **(Aminoff and Eisen, 2005).**

As regard to results of EMG, each of supraspinatus and deltoid muscles was affected in 19 subjects (63.3%); while each of biceps and pronator teres was affected in 14 subjects (46.7%) and each of triceps and extensor indices was affected in 11 subjects (36.7%). The high normal rate in such examined muscles may be explained by previous work by **Dillingham (2013),** who reported that, because EMG evaluates muscles for the presence of abnormalities (eg, fibrillations from denervated muscle fibers) that indicate motor axon loss, a radiculopathy that affects only the sensory roots or that results only in demyelination will not result in EMG abnormalities. If the rate of denervation is balanced by reinnervation, then spontaneous activity is less likely to be found. For cervical radiculopathies, the sensitivities are similar, from 50% to 71% **(Partanen *et al*., 1991; So *et al*., 1990).** It is apparent that EMG is not a good screening test, although it is helpful to assess the clinical relevance of symptoms and imaging findings. EDX testing is also useful for excluding other disorders, such as entrapment neuropathies or polyneuropathy. For example, a patient may have a median neuropathy at the wrist and shoulder impingement that, in combination, mimics cervical radiculopathy. The astute electro-diagnostician can clarify the picture with a focused physical examination coupled with EDX testing **(Dillingham, 2013).**

In the present study, we found higher sensitivity of EMG studies when related to either motor (94.4%) or sensory (95.2) clinical data; than that reported by MRI when related to either motor (83.3%) or sensory (85.7%) clinical results. These results are in contradiction to those reported by **Ashkan *et al*. (2002),** who in their study of patients with cervical radiculopathy who had undergone preoperative neuro-physiologic studies and MRI, found a higher sensitivity for MRI compared to neurophysiologic studies in the diagnosis of cervical radiculopathy. On the other hand, our results correlated with **Lee and Lee (2012)** study of patients with lumbosacral intervertebral herniated disc or spinal stenosis, diagnosed by clinical assessment and magnetic resonance imaging, indicated that electrodiagnostic study correlated more significantly with clinical data and had a higher specificity than MRI.

When considering positive affection diagnosed by both MRI and EMG, both techniques revealed concordance in the same 20 subjects (66.7%) and there was disagreement between both Techniques in 10 subjects (33.3%). In addition, in disagreed patients, the EDX study was able to correlate with clinical data than MRI. These results are comparable to those reported by **Nicotra *et al*. (2011)** who reported that, concordance between the level of abnormality on EMG and MRI was found in 71% of patients with non-dermatomal symptom distribution. Concordance between clinical level, EMG and MRI abnormality was found in 50% of patients with C5, in 70% of patients with C6 and in 67% of patients with C7 symptom distribution. They added, in those patients whose EMG and MRI level of abnormality was discordant, the EMG abnormalities corresponded to the clinical level of symptom distribution.

The percentage of concordance in the present study is higher than that reported by **Soltani *et al.* (2014)** who reported that, the results of EDX studies, MRI, and clinical findings in a sample of patients with cervical or lumbosacral radiculopathy were compared. Total agreement between EDX and MRI studies was 59.6 %. In addition, another study by similar to **Nardin *et al.* (1999)** reported a concordance rate of 60.0% in their cervical radiculopathy group (27 patients), 14 (52%) had a clinically relevant NPS and 13 (48%) had a clinically relevant MRI. None of the patients, however, underwent surgery and, thus, no peroperative confirmation of the diagnosis nor outcome study was possible. These differences can be explained by different inclusion criteria and sample size.

Data on agreement of EDX and MRI with clinical findings in radiculopathy are conflicting. The variability of results regarding these diagnostic methods in addition to the absence of a gold standard for diagnosis may be related in part to the patient population or method of investigation employed **(Soltani *et al.*, 2014).**

In other studies, agreements between MRI and surgical findings in cervical and lumbar disc diseases were reported 93 and 82.6 %, respectively **(Matsumoto *et al.*, 2001; Ashkan et al., 2002).** There is also a high prevalence of abnormal neuroimaging findings in asymptomatic individuals **(Borenstein *et al.*, 2001; Jensen *et al.*, 1994),** whereas in the study done by **Bertilson *et al.* (2010)** MRI-visible nerve involvement was significantly less common than and showed weak agreement with physical examination of nerve involvement in patients with long-standing nerve root symptoms in the lumbar spine. In addition, **Shafaie *et al.* (1999)** reported that the correlation between MRI and surgical findings was frequently unreliable.

Recording the standard MRI in supine position, leakage of chemical mediators or inflammatory cytokines through annular tear, functional instability, fluctuating disc bulges, and restrictions caused by discoligament injuries are some of the explanations proposed for this weak agreement **(Peng *et al.*, 2007; Madsen *et al.*, 2008; Krakenes and Kaale, 2006).** Furthermore, duration of symptoms could be a causative factor as **Jensen *et al.* (2007)** indicated that improvement of disc herniations and nerve root compromise over time did not coincide with definite recovery. However, some previous studies have shown the value of electrodiagnosis in localizing the involved root level as well as predicting surgical outcome and selecting patients who benefit from surgery **(Alrawi *et al.*, 2007).**

The difference between electrodiagnostic studies and MRI findings in cases of radiculopathies can be interpreted in the light of the following clinical entities. Physiological consequences of the anatomical lesion seen in EMG of radiculopathies can be determined. First of all, the most important factor affecting the EMG study is timing. Spontaneous activities in radiculopathies are firstly seen in muscles within 7–10 days, and later they spread to the involved myotomes of the extremities within 2–3 weeks. Reinnervation findings appear in between 3 to 6 months. EMG gives negative results, if performed before denervation or after disappearance of the denervation findings or if reinnervation has not occurred. Secondly, possibility of finding spontaneous activity in the muscles can be related to which axons have been involved in the root level, ratio and size of denervation, rate of denervation and extension of the remaining axons **(Dillingham *et al.*, 1998).**

There are also studies investigating the relationship between the imaging studies and electrodiagnostic studies. The results of EMG in 47 patients with cervical and lumbar radiculopathy were compared by using MRI and physical examination, and it has been concluded that MRI was not very compliant with EMG and physical examination **(Nardin *et al.*, 1999).**

Not every radiculopathy case requires electrophysiological tests, electrodiagnostic studies can be particularly helpful in individuals with multi-level radiological pathologies and patients with inconsistences between physical examination and imaging findings **(Lipetz and Lipetz, 2005).**

Going with results of the present study, it had been reported that, in the screening of patients with cervical radiculopathy, electrophysiological studies are carried out to assess nerve root function (with needle EMG examination) and to rule out other neurological causes for the patient's complaints, such as median or ulnar entrapment neuropathies or peripheral neuropathy (with nerve conduction studies; NCS). Needle EMG examination is undoubtedly the mainstay of the evaluation of nerve root function, providing the extent and degree of dysfunction, prognostic information like prediction of surgical treatment outcome and, most importantly, dynamic changes of root function **(Alrawi *et al.*, 2007).**

In conclusion, results of the present work revealed the superiority of the electrodiagnostic studies than magnetic resonance imaging in diagnosis of cervical radiculopathies based on clinical results. In addition, both techniques revealed concordance in diagnosis in about 66.7% of patients. When there is a discrepancy between both techniques, electrodiagnostic studies correlate more efficiently than MRI with clinical results.

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