Value of Clinical Findings, Electrodiagnosis and Magnetic Resonance Imaging in the Diagnosis of Root Lesions in Traumatic Brachial Plexus Injuries

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Objective: *To evaluate the diagnostic value of clinical findings, electromyography and magnetic resonance imaging of root lesions in traumatic brachial plexus injuries*
Material and Method: *The authors clinically evaluated 175 cervical roots (C5-8, T1) in patients with traumatic brachial plexus injuries then with electromyography and magnetic resonance imaging (MRI). Each finding, taken alone and in combination with each other, was compared with the findings of exploratory surgery.*
Results: *The mean correlations of the clinical findings, electromyography and MRI in relation to the surgical findings were 60, 87 and 70 percent, respectively. The mean correlation was highest (90%) when the positive findings from the clinical, electromyographic or MRI investigations were combined. The correlation of the C5-6 root injuries was improved to 100% though the mean correlation was only 90%.*
Conclusion: *The combination of clinical findings and electromyography correlated well with the surgical findings of root lesions caused by traumatic brachial plexus injury. MRI markedly improved identification only of C5-6 root injuries.*

Keywords: *Traumatic brachial plexus injuries, Clinical finding, Electrodiagnosis, MRI*

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Brachial plexus injuries (BPI) commonly affect young persons and cause severe morbidity. Early exploration is crucial when evidence of a complete or severe injury is presented, especially of a root lesion [1,2]. Determination of the level of injury, extent of the lesion(s) and depth of neural damage are necessary. The extent and depth of neural damage is indicated by clinical features but the precise level of the injury is elusive.

Physical examination and electrodiagnosis are the usual approaches to determining treatment[1,3], but findings are time-dependent and determination of the level of injury can therefore be missed.

Myelography and CT-myelography have been used for pre-operative diagnosis of root injury but both investigations are limited to diagnosis of extra-foraminal injury. Moreover, important limitations include a considerable exposure to radiation, the possible reaction to the contrast media, and the risk of lumbar puncture[4,6].

Magnetic resonance imaging (MRI) is a non-invasive investigation and can demonstrate root pathology beyond the spinal foramina; but, accuracy varies between 58 and 87 percent and the procedure is expensive[6-8].

Most studies present the value of each modality but do not combine the investigative results. In order to assess the combined value of clinical findings, eletromyopgraphy and MRI in diagnosis of root lesion in traumatic brachial plexus injures, the authors compared the results of each, then combined them with the operative findings.

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Material and Method

Between September 1997 and November 2000; the authors investigated 175 cervical roots from 35 male patients (mean 25.7 years; range, 15 to 49) with traumatic brachial plexus injury. The primary cause of injury was motorcycle accidents (n = 34) and car accidents (n = 1).

Each patient underwent a complete physical examination, electromyography and MRI of the root lesions. All patients were examined during their initial visit and the pre-operative day by the surgeon KV. The physical examination included a complete neurological examination of the upper extremity as per Leffert and Tubiana, Tinel's sign at the supraclavicular and infraclavicular regions, Horner's syndrome and evidence of an associated injury of the neck and/or shoulder [1,3,9]. If the clinical signs changed by the preoperative assessment, the changes were recorded as part of the clinical findings.

The rhomboid muscle, supplied with dorsal scapular nerve, was used to determine the function of the C4 and 5 roots The functionality of the C5, 6 and 7 roots was determined by the weakness of serratus anterior muscle that demonstrates winging of the scapular. Presentation of Horner's syndrome including ptosis, myosis, enophthalmos and anhydrosis meant injuries to the C8 and T1 roots. Sensory deficit around a root corroborated the interpretation of the level of root injury.

Negative Tinel's sign at the supraclavicular region and pathway of electrical propagation aided determination of root injury. Electrodiagnosis was performed sometime between the initial visit and the appointment at the Department of Rehabilitation Medicine. All of the studies were completed three weeks after injuries, to ensure that the signs of denervation were well-developed[10].

Denervation of the paraspinal, serratus anterior or rhomboid muscles helped to determine the level of the root injury[3].

MRI was done [GE Signa 1.5 Tesla Horizon Echospeed, gradiant 22 mTesla/m, system software 5.6, T1W (600/800/20:TR/TE) the slice thickness was 3 mm, gap 0.5-1 mm with respiratory motion compensation, T2W (4-5000/80-100;TR/TE) with a thickness of 3 mm, a gap of 0.5-1 mm with an echo train of 4 or 8, and fat and vessel suppression]. All MRI findings were reviewed by two radiologists not apprised of the clinical features, electrodiagnosis and intraoperative findings. They independently reviewed each case and resolved differences of interpretation by consensus. They determined root injuries by the presence of pseudomeningocele, signal change, distortion of root or neuroma at the root level (Fig. 1, 2)[6,9].

The injured brachial plexus were explored by the surgeon (KV) with a standard approach at the supraclavicular region. Root avulsion was documented by complete disruption in the region of the scalenus muscle with no remaining proximal part of that root. If the remaining proximal part of the root was identified but disruption was proximal to the trunk level, root ruptures were reported (Fig. 2). Tapering or thinning of the proximal part of the roots also indicated a rupture.

Statistical analysis

The results of the clinical findings, EMG and MRI were presented as the percentage of correlation with the surgical findings in each modality separately. In part of the combination, physical findings plus EMG and physical examination plus electrodiagnosis and MRI were interpreted as root injury when at least one

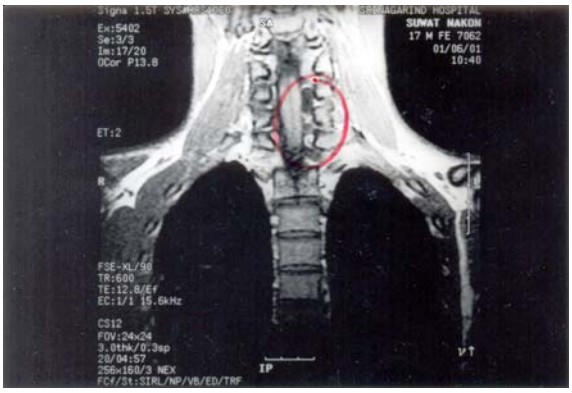

Fig. 1 Demonstrated pseudomeningocele in T1W image (circle)

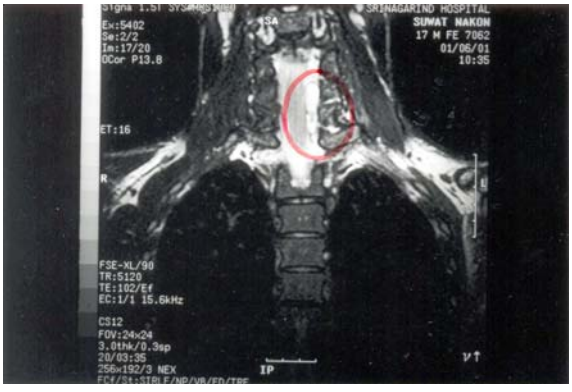

Fig. 2 Demonstrated pseudomeningocele in T2W image (circle)

of the combination findings was positive. Then the result was presented as the percentage of correlation with the surgical findings

Results

The mean duration (in weeks) from injury to: pre-operative physical examination and exploration, electrodiagnosis and MRI, was 10.6 (range, 8-26), 9.8 (range, 4-20) and 10.4 (range, 6-19.5), respectively. The intra-operative findings included: total root injuries in 21 patients, C5, 6 and 7 root injuries in 10 and C5 and 6 root injuries in 4. The exploration of 175 roots indicated the C7 root was injured in 29 of 35 patients (82%), C8 in 23 of 35 (65%), T1 in 22 of 35 (62%) and C5 and 6 in all (Table 1).

The percentage of correlation between the physical examination, electrodiagnosis and MRI for each modality in respect of the surgical findings is presented in Table 2. The correlation between the physical examination and surgical findings was < 50% for the diagnosis of C5 and 6 roots and slightly more for C7 root lesions (57%) and better in C8-T1 root level (Horner's syndrome) (80%). The percentage of correlation between electrodiagnosis and surgery was high, ranging between 77.1 to 91.4 percent. The maximum correlation was at the T1 root level (94.29%). MRI was less correlated to surgical findings when it was compared with electrodiagnosis but was superior to a physical examination.

Table 1. Number of root injury for each level (n = 35)

Root level	Number of root injuries (%)
C5	35 (100)
C6	35 (100)
C7	29 (82)
C8	23 (65)
T1	22 (62)

Table 2. The percentages of correlation between the physical examination, electrodiagnosis, MRI and combined modality

Root	PE	EDx	MRI	PE+EDx	PE+EDx+MRI
C5	37.1	91.4	51.4	91.4	100.0
C6	45.7	88.5	80.0	91.4	100.0
C7	57.1	77.1	71.4	88.8	82.8
C8	80.0	91.4	65.7	91.4	74.2
T1	80.0	85.8	80.0	94.3	91.4
Mean	60.0	86.8	69.7	90.2	89.7

PE = Physical Examination, EDx = Electrodiagnosis

Discussion

The correlation between the physical examination and surgical findings was < 50% for the diagnosis of C5 and 6 roots and slightly more for C7 root lesions. The authors used the rhomboid muscle and serratus anterior function to determine true root injuries in proximal injury of the roots. From the intra-operative findings of many cases, the C5 and 6 roots were injured proximal to Erb's point (Fig. 3) distal to the dorsal scapular nerve and the long thoracic nerve so that the function of those muscles was preserved.

The correlation of Horner's syndrome and the intra-operative findings of the C8 and T1 root injuries was 80%; like Hetz and Narakas[8] who found 25% of injured C8 and T1 roots had no Horner's syndrome. Horner's syndrome was present in pre-ganglionic injury but was absent in post-ganglionic injury though it might have been present temporarily.

The percentage of correlation between electromyography and surgery was high, ranging between 77.1 to 91.4 percent. The maximum correlation was at the T1 root level (94.29%). The nerve conduction test of the median and ulnar nerves in both motor and sensory function included an evaluation of the paraspinal muscles, which improved interpretation of root injury in cases where physical examination could not demonstrate loss of muscle function supplied by the dorsal scapular and/or long thoracic nerve or in Horner's syndrome.

MRI was less correlated to surgical findings when it was compared with electrodiagnosis but was superior to a physical examination alone. The poorest correlation (i.e. 51.43%) was found for C5 root injuries. The lower correlation was perhaps due to an artifact of motion (since axial slices were 3 to 5 mm thick); thereby providing a poor correlation with the intra-

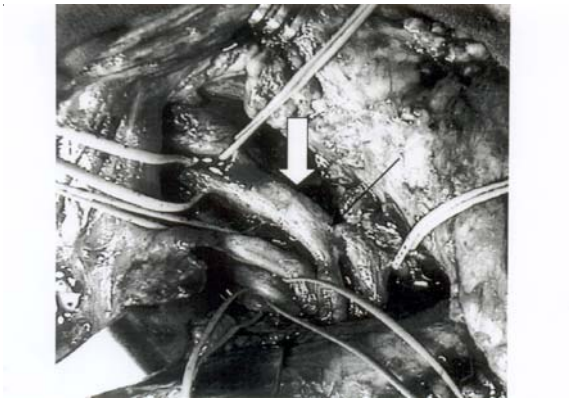

Fig. 3 Scar at root 5, 6 (Fat white arrow) that's proximal to Erb's point (Thin back arrow)

dural rootlets, which are smaller, partial root avulsions, not causing pseudomeningocele or intradural fibrosis. As a consequence, hematoma and fibrosis at the scalenus muscle would obscure the injured nerve[6,9].

Conclusion

The mean percentage of correlation of each modality was not better than the combination of physical examination and electrodiagnosis used in common practice except for C5 and 6 root injuries, which were increased to 100%. MRI study provide superiority when combined with physical examination and electrodiagnosis in a case with C5-C6 root injuries only. In the present study, all C7 to T1 root injuries were total arm types of brachial plexus injuries, usually caused by severe trauma, and where clinical findings combined with electrodiagnosis have already well documented the lesion.

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การวินิจฉัย พยาธิสภาพบริเวณรากแผงเส้นประสาทแขนที่ได้รับบาดเจ็บ: คุณประโยชน์ของการตรวจร่างกาย, อิเล็คโตรไมโอกราฟฟี และเอ็มอารไอ

ชลวิช จันทร์ลลิต, กิติวรรณ วิปุลากร, กิตติ จิระรัตนโพธิชัย, เอมอร ไม้เรียง, ปรารถนา เชาว์ชื่น

วัตถุประสงค์: *เพื่อศึกษาคุณประโยชน์ของการตรวจร่างกาย ตรวจอิเล็คโตรไมโอกราฟฟีและเอ็มอาร์ไอในการวินิจฉัยการบาดเจ็บของเส้นแนวประสาทแขน บริเวณรากประสาท*

วัสดุและวิธีการ: *ทำการศึกษา รากเส้นประสาทคอ จำนวน 175 รากเส้นประสาท โดยเข้ารับการตรวจร่างกาย, ตรวจทางอิเล็คโตรไมโอกราฟฟี่ และตรวจด้วยเครื่อง เอ็มอาร์ไอ โดยนำผลการศึกษา มาเปรียบเทียบกับพยาธิสภาพของรากเส้นประสาทที่พบในการผ่าตัด สำรวจ*

ผลการศึกษา: *ค่าผลเฉลี่ยความสัมพันธ์ในการตรวจร่างกาย,ตรวจทางอิเล็คโตรไมโอกราฟฟีและตรวจด้วยเครื่องเอ็มอาร์ไอ เทียบกับผลของการผ่าตัดสำรวจได้ดังนี้คือ 59.9%, 86.8%, 69.7% เรียงตามลำดับ โดยเมื่อนำผลการศึกษาทั้ง 3 ชนิดมาประเมินร่วมกัน โดยถือว่าการตรวจวิธีใดก็ตามบ่งถึง พยาธิสภาพ บริเวณรากเส้นประสาท ให้ถือว่าผลรวมคือบ่งถึงการบาดเจ็บบริเวณรากเส้นประสาท ค่าเฉลี่ยความสัมพันธ์จะมีค่าสูงสุดคือ 90.23% รากเส้นประสาทคอที่ 5 และ 6 สามารถบ่งถึงพยาธิสภาพบริเวณรากเส้นประสาทก่อนการผ่าตัดถึง 100% เมื่อนำเอ็มอาร์ไอมาร่วมด้วย*

สรุป: *การวินิจฉัย การบาดเจ็บ ของข่ายเส้นประสาทแขน โดยการตรวจร่างกายร่วมกับการตรวจด้วยอิเล็กโตรไมโอกราฟฟี มีความสัมพันธ์ ที่ถูกต้องเพียงพอ การตรวจเอ็มอาร์ไอเพิ่มเติมสามารถบ่งบอกถึงการบาดเจ็บบริเวณรากเส้นประสาทได้ดีขึ้นเมื่อใช้ตรวจเส้นประสาทคอที่ 5 และ 6*