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Ultrasound Examination in the Surgical Treatment for Upper Extremity Peripheral Nerve Injuries: Part I

Üst Extremite Periferik Sinir Yaralanmalarının Cerrahi Tedavisinde Intraoperatif Ultrasonografinin Kullanılması

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ABSTRACT

AIM: The aim of this clinical study was to evaluate the benefits of ultrasonographic imaging in the surgical treatment of upper extremity peripheral nerve lesions.

MATERIAL and METHODS: Peripheral nerves in the upper extremity were evaluated by using real-time ultrasonographic examination. The capability of ultrasonography in terms of determination the type of injury, the position of the proximal and distal nerve stumps, the presence or absence of a neuroma and perilesional scar tissue were evaluated in cases with peripheral nerve injury.

RESULTS: Thirty-six cases with upper extremity peripheral nerve injury aged between 24 and 60 years were included in this study. Four (11%) had brachial plexus injury, 9 (26%) ulnar nerve injury, 6 (16%) radial nerve injury and the remaining 17 (47%) cases had median nerve injury. The capability of ultrasonographic examination was satisfactory for all evaluation parameters.

CONCLUSION: Preoperative and intraoperative ultrasonography for upper extremity peripheral nerve lesions may be used in the description of the degree of injury, determination of complete or incomplete nerve sectioning, the presence of hematoma and foreign body, the continuity of the nerve, determination of nerve stumps and perilesional scar tissue, and the presence of neuroma.

KEY WORDS: Peripheral nerve injury, Ultrasonography, Surgical treatment

ÖZ

AMAÇ: Bu klinik çalışmanın amacı üst extremite periferik sinir lezyonlarinin cerrahi tedavisinde ultrasonografik görüntülemenin yararlarını incelemektir.

YÖNTEM ve GEREÇ: Üst extremite periferik sinirleri real-time ultrasonografik inceleme ile değerlendirildi. Ultrasonografinin yaralanma tipinin belirlenmesi, proksimal ve distal sinir uçlarının pozisyonu, nöroma varlığı veya yokluğu, lezyon çevresindeki skar dokusunun gösterilmesindeki kapasitesi incelendi

BULGULAR: Bu çalışma üst extremite periferik sinir yaralanması olan 24-60 yasları arasında 36 olguyu kapsamaktadır. 4 (%11) olguda brakial pleksus yaralanması, 9 (%26) olguda ulnar sinir yaralanması, 6 (%16) olguda radial sinir yaralanması, kalan 17 (%47) olguda ise median sinir yaralanması bulundu. Tüm inceleme parametreleri temel alındığında ultrasonografik inceleme yeterli olarak bulundu.

SONUÇ: Üst extremitenin periferik sinir lezyonlari için preoperative ve intraoperatif ultrasonografi yaralanma derecesinin belirlenmesinde, sinirin tam veya kısmen kesildiğinin anlaşılmasında, hematom veya yabancı cisim tanısının konulmasında, sinirin devamlılığı ve sinir uçlarının bulunmasında, perilezyonal skar dokusu ve nöroma bulunup bulunmadığının anlaşılmasında yararlıdır.

ANAHTAR SÖZCÜKLER: Periferik sinir yaralanması, Ultrasonografi, Cerrahi tedavi

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INTRODUCTION

Peripheral nerve injuries of the upper extremity compromise an important part of peripheral nerve lesions in clinical practice. Penetrating, oppressive, sharp, and hard objects such as knives, glass and missiles are frequent causes of nerve injuries. The history, physical and neurological examination, and electro-diagnostic tests are generally used to diagnose the pathology (1,3,5,6,7). Electro-diagnostic tests have been defined as the gold standard in the diagnosis, localization, and description of a nerve lesion. However, these tests may not yield reliable information, especially in the acute stage of injury. In addition, a variety of parameters may affect electro-diagnostic examination (1,2,4).

On the other hand, electro-diagnostic tests may not be able to give any information about the localization and description of injury, visualization of nerve stumps, diagnosing a neuroma, evaluation of perilesional tissue and foreign missiles in the acute and chronic periods. A physician needs a reliable, cheap, practical, and readily available diagnostic method in clinical practice. We hypothesized that ultrasonographic evaluation of the upper hand may offer some useful information about the injury site.

This clinical study aimed to evaluate the benefits and feasibility of presurgical and intraoperative ultrasonographic examination of the upper extremity in the localization and description of injury, evaluation of nerve stumps, diagnosing a stump neuroma, determination of perilesional scar formation and foreign missiles in and around the injury site, and assessing the severity of the lesion.

MATERIALS and METHODS

Study Population:

The study population included 36 patients (12 females and 24 male) who were admitted to our department (Department of Neurosurgery, Ondokuzmayıs University Medical Faculty) because of peripheral nerve injury of the upper extremity between 2001 and 2004.

Ultrasonography technique:

The ultrasonographic examination was performed by the first author using a Tosbee ultrasound (Toshiba Inc., Tokyo) with 5-7.5 MHz linear probe. The patients were positioned in the supine position. Ultrasound gel was plastered on the probe surface and the skin to enhance visualization of peripheral nerves and musculoskeletal structures of the upper extremity. Before starting the ultrasonographic examination, we grossly determined and localized the injured nerve and injury site using the neurological examination, the results of electro-diagnostic studies, anatomical landmarks, and skin indents (Figure 1,2,3). We started our examination at about 10 cm proximal to the suspected region and continued 10 cm distally to the injury site. Bone, muscles, tendons, vascular structures, and peripheral nerves were identified and distinguished (Figure 4,5 and 6). The continuity, architecture, shape, calibration and integrity of the involved nerve and peripheral tissues were examined in the perpendicular and transverse planes (Figure 7,8). Images were paused on the monitor screen and printed on paper for archives and further

Figure 1: 37-year-old woman injured by glass Arrows shows skin indents 3 weeks after injury.

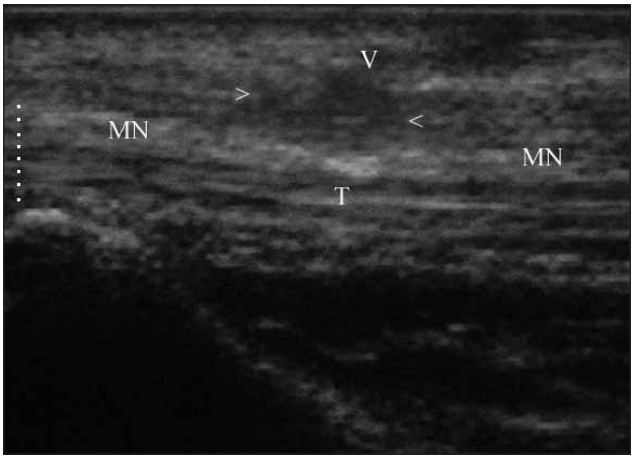

Figure 2: Ultrasonography shows median nerve, tendons, and scar formation arount the nerve (MN: Median nerve, T: tendons, dotted line show carpal tunnel, arrows shows scar formation).

Figure 3: Operative photo shows scar formation and median nerve (MN: Median nerve, arrows shows scar formation).

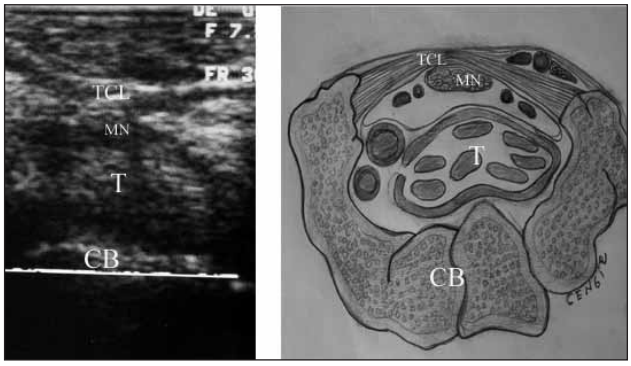

Figure 4: A. This figure an example for carpal tunnel ultrasonography (TCL: Transverse carpal ligament, MN: Median nerve, T: Tendons, CB: Carpal bones).
B. This schematic figure shows the structures imaged in ultrasonographic image (TCL: Transverse carpal ligament, MN: Median nerve, T: Tendons, CB: Carpal bones).

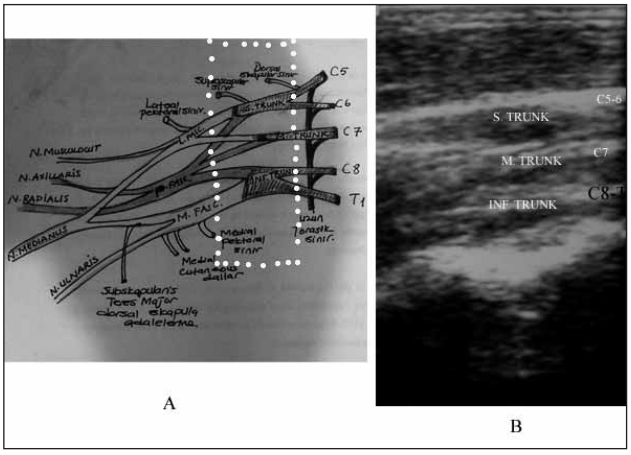

Figure 5: A. This schematic figure shows the brachial plexus. Dotted areas mark the examination area in ultrasonography.
B. Ultrasonographic photo shows brachial plexus structures (S. TRUNK: Superior Truncus, M. TRUNK: Middle Truncus, INF. TRUNK: Inferior Truncus).

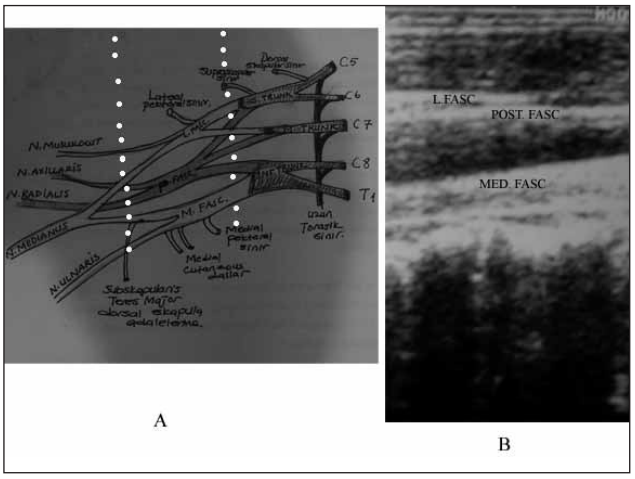

Figure 6: A. This schematic figure shows the brachial plexus. Dotted areas mark the examination area in ultrasonography.
B. Ultrasonographic photo shows brachial plexus structures (L. FAC: Lateral Fasciculus, Post. FASC: Posterior Fasciculus, MED. FASC: Medial Fasciculus).

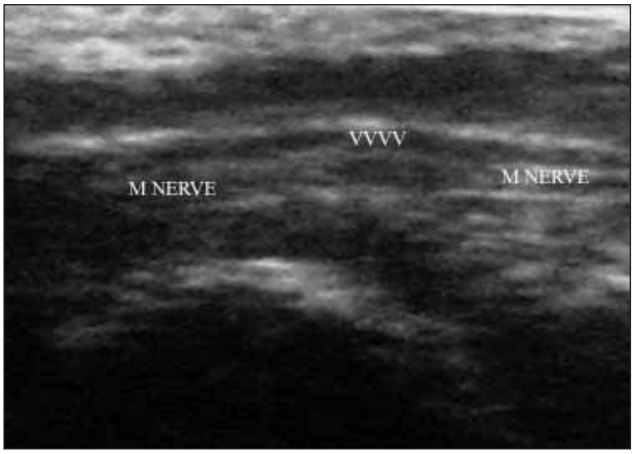

Figure 7: This is an example for incomplete median nerve injury (M NERVE: Median Nerve, arrows shows incomplete injury area).

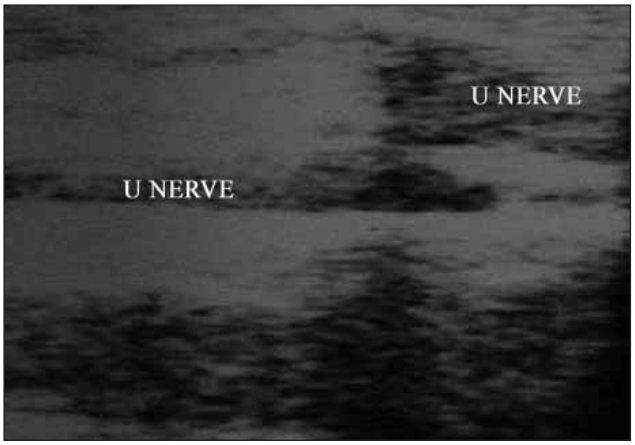

Figure 8: This is an example for total ulnar nerve transsection (U NERVE: Ulnar nerve).

examination. Sonographic findings of the patients who underwent surgery were compared with gross surgical observations.

Evaluation of the capability of ultrasonographic examination:

We examined the capability of ultrasonographic examination in terms of visualization and identification of a peripheral nerve, localization of injury, description of the type of the injury, determination of nerve stumps and foreign missiles, diagnosing a neuroma, and evaluation of perilesional scar tissue. Ultrasonographic evaluation of these seven parameters were graded into three grades as poor, good, and excellent according to the examiner's description. Poor grade was scored as 1, good as 2, excellent as 3. Data were expressed here as a mean ± standard error of the mean score. Differences in mean score between poor and excellent-good results were analyzed using Student's t-test with p<0, 001 being required for significance.

RESULTS

This study included 36 adult and pediatric cases (12 females and 24 males, aged 7 to 57 years). Six subjects were children, and 30 were adults. Four (11%) had brachial plexus injury, 9 (26%) ulnar nerve injury, 6 (16%) radial nerve injury and the remaining 17 (47%) cases had median nerve injury.

In all cases, the nerves had been injured by penetrating and non-penetrating objects. Seven (19%) had been injured by a knife, 17 (47%) by glass, 8 (22%) by other metallic objects, 2 (6%) by civilian gun-shoot and the remaining 2 (6%) by squeezing.

Six (19%) patients had an acute injury (first 72 hours after the injury) at admission. The remaining 30 (81%) were chronic (more than 72 hours after the injury) cases.

A total nerve trans-section (neurotmesis in Seddon classification and fourth and fifth degree in Sunderland classification, Group I lesion in the intra-operative grading system) was diagnosed in 14 (39%) cases. Perilesional scar tissue formation was found in 8 (22%) cases. Nine (25%) cases had a stump neuroma diagnosed by sonographic examination. Three (8%) cases had foreign missiles in injury site.

The capability of ultrasonographic examination was satisfactory in all evaluation parameters. The differences between poor and good/excellent results was statistically significant (p<0.0001). (Table I) presents the capability of ultrasound in the surgical treatment of peripheral nerve injury.

DISCUSSION

The timing of surgical intervention to injured peripheral nerves is a challenging issue in the practice of peripheral nerve surgery. There is no common consensus among authors in the timing of surgical exploration. Some authors advocate early repair and prefer delayed surgical intervention for up to three weeks after a traumatic injury (4,13). Others suggest early surgical exploration with repair of the injured segment as soon as possible (4,13). The main

Table I. The capability of ultrasound in the surgical treatment of peripheral nerve injury.

Evaluation Parameters	Capability					
	Poor		Good		Excellent	
	n	%	n	%	n	%
Visualization and identification of a peripheral nerve (n=36)	1	2,8	15	1,6	20	55,6
Localization of injury (n=36)	6	16,7	10	27,8	20	55,5
Description of type of injury (n=36)	4	11,1	8	22,2	24	66,7
Determination of the position of proximal and distal nerve stumps (n=14)	2	14,3	4	28,5	8	57,2
Determination of foreign particles (n=3)					3	100
Diagnosing stump neuroma (n=9)			2	22,2	7	77,8
Determination of perilesional excessive scar tissue (n=8)	1	12,5	3	37,5	4	50
Mean score (mean ± standard deviation)	2,8±2,16		14±9,95		39±24,06	

objectives of authors who suggest late surgical intervention are the possibility of spontaneous nerve repair, and waiting for reliable information from electro-diagnostic studies. In the early stage of injury (within three weeks), electro-diagnostic studies may not provide reliable information about the injury. On the other hand, even if electro-diagnostic studies are performed up to three weeks after an injury, we may not be able to obtain objective information about the patho-morphological status of the nerve. The term of patho-morphological status compromises the continuity, architecture, shape, calibration, and integrity of a nerve segment.

The authors who suggest acute surgical intervention prefer direct visualization via a wide exposure compromising skin indents from injury. The presence of hematoma, foreign particles, necrotic tissues, and the presence of tendon and vessel injury are also important parameters in selecting the time for surgery. Direct exploration offers visualization of the complete patho-morphological status of an injury.

We hypothesized that ultrasonographic examination of upper extremity may offer some reliable information about the patho-morphological status of the injured nerve, including detection of a hematoma and foreign particles. Ultrasonography is a real-time, mobile, and radiation-free image processing technique. It may be able to show the continuity, architecture, shape, calibration, and integrity of a nerve. Some previous studies have been conducted to evaluate peripheral nerves by ultrasound (8,9,10,11,12). These authors described the normal ultrasonographic appearance of peripheral nerves (8,9,10,11,12). Computerized tomography (CT) and magnetic resonance imaging (MRI) can also be used for neuroradiological imaging of nervous and musculoskeletal tissues. MRI has higher capability than CT for this purpose. These techniques have some difficulties in terms of non-real time images, and the necessity of reconstruction for determining and distinguishing the nerves.

The general question appears about the necessity of imaging modalities in peripheral nerve lesions. It is clear that neuroradiological imaging is necessary to obtain advanced information about the current situation of nerve after an injury. Even if early surgical exploration is selected, neuroradiological imaging studies are necessary to obtain useful information regarding the current situation of the nerve. In the acute stage, the degree of injury, determination of complete or incomplete nerve sectioning, the presence of hematoma and foreign body may be detected by sonographic examination. In the chronic stage, the continuity of nerve, presence of nerve stumps, perilesional scar tissue, and neuromas may be also demonstrated by using ultrasonography.

Our results from this study demonstrated that ultrasonography could be helpful in the imaging of peripheral nerves in the acute and chronic stage of injury. The capability of visualization and identification of a peripheral nerve was found excellent in 55.6% of cases. Only 2.8% of cases demonstrated poor visualization. The capability of demonstrating foreign particles and diagnosing stump neuroma were excellent in 100% and 77, 8% of the cases respectively.

A future aim for peripheral nerve imaging should be to demonstrate the anatomo-physiological continuity of the nerves. Axonal flow, loss of Schwann sheet, and degenerative and regenerative findings should be monitorised using imaging techniques for peripheral nerves.

CONCLUSION

This clinical study aimed to evaluate the ability of ultrasonography in the examination of peripheral nerve injuries. Our study revealed that ultrasonography in peripheral nerve injuries is a cheap, simple and readily available diagnostic tool in clinical practice. Future detailed studies are necessary to design the grading of lesions and the grouping of injury type using the knowledge obtained from neuroradiological evaluation.

REFERENCES

1. Cokluk C, Aydin K, Senel A. Presurgical ultrasound assisted neuroexamination in the surgical repair of peripheral nerve injury. Minim Invasive Neurosurg 2004; 47: 169-72.
2. Gentili F, Hudson AR, Midha R. Peripheral nerve injuries: Types, causes, and grading. In: Wilkins RH, Rengachary SS ed. Neurosurgery. Vol 3. New York: McGraw-Hill, 1996; 3105-3114.
3. Kline DG. Surgical repair of peripheral nerve injury. Muscle Nerve 1990; 13: 843-52.
4. Kline DG, Hudson AR. Acute injuries of peripheral nerves. In: Youmans JR (ed) Neurological surgery Vol 4. Philadelphia: W. B. Saunders Company, 1990; 2423-2510.
5. Lee SK, Wolfe SW. Peripheral nerve injury and repair. J Am Acad Orthop Surg 2000; 8: 243-52.
6. Lilla JA, Phelps DB, Boswick JA Jr. Microsurgical repair of peripheral nerve injuries in the upper extremity. Ann Plast Surg 1979; 2: 24-31.
7. Mailander P, Berger A, Schaller E, Ruhe K. Results of primary nerve repair in the upper extremity. Microsurgery 1989; 10:147-50.

8. Martinoli C, Bianchi S, Dahmane M, Pugliese F, Bianchi-Zamorani MP, Valle M. Ultrasound of tendons and nerves. Eur Radiol 2002; 12: 44-55.
9. Martinoli C, Bianchi S, Giovagnorio F, Pugliese F. Ultrasound of the elbow. Skeletal Radiol 2001; 30: 605-614.
10. Martinoli C, Serafini G, Bianchi S, Bertolotto M, Gandolfo N, Derchi LE. Ultrasonography of peripheral nerves. J Peripher Nerv Syst 1996; 1: 169-78.
11. Peer S, Bodner G, Meirer R, Willeit J, Piza-Katzer H. Examination of postoperative peripheral nerve lesions with high-resolution sonography. AJR, 2001; 177: 415-19.
12. Peer S, Kovacs P, Harpf C, Bodner G. High-resolution sonography of lower extremity peripheral nerves. Anatomic correlation and spectrum of disease. J Ultrasound Med 2002; 21: 315-22.
13. Worth RM. Anatomy and physiology of peripheral nerves. In: Wilkins RH, Rengachary SS ed. Neurosurgery. Vol 3. New York: McGraw-Hill, 3099-3104, 1996.