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Hands-on Course 10

Nerve and muscle echography (Level 2)

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Hands-on Course 10: Nerve and muscle echography (Level 2)

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Conflict of Interest

In relation to this presentation and manuscript:

- ❑ the Author received speaker's honoraria from: CANNON MEDICAL

ean congress Oslo 2019 5 years ean

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INTRODUCTION

- In evaluation of nerve and muscle disorders electrodiagnostic (EDx) studies often play a key role.
- However, they have several limitations:
  - usually they can not establish etiology of the lesion;
  - often they can not establish location of (axonal) lesion;
  - they can not distinguished axonotmesis from neurotmesis early after nerve trauma;
  - EDx examination is uncomfortable.
- Although for visualization of peripheral nerves MRI is useful, it is cumbersome and expensive.
- Ultrasonography (US) seems much more useful for morphologic examination of the peripheral nerves.

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ULTRASONOGRAPHIC EQUIPMENT

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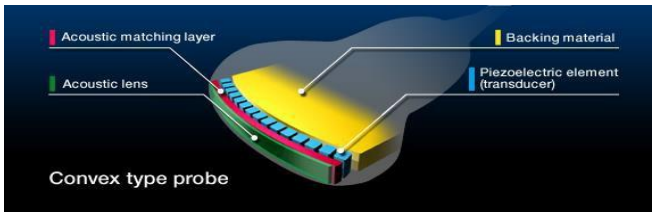
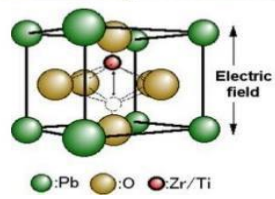
ELECTROMECHANIC TRANSDUCER: PIEZOELECTRIC ELEMENT



The piezoelectric element vibrates to generate a sound wave when applied with a voltage.

The piezoelectric element generates a voltage when applied with vibration (an ultrasonic wave).



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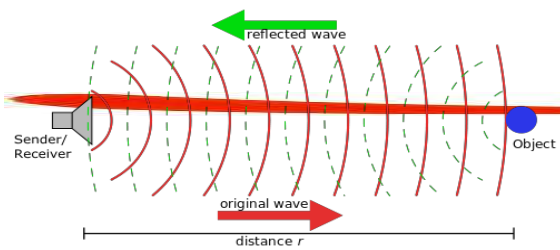
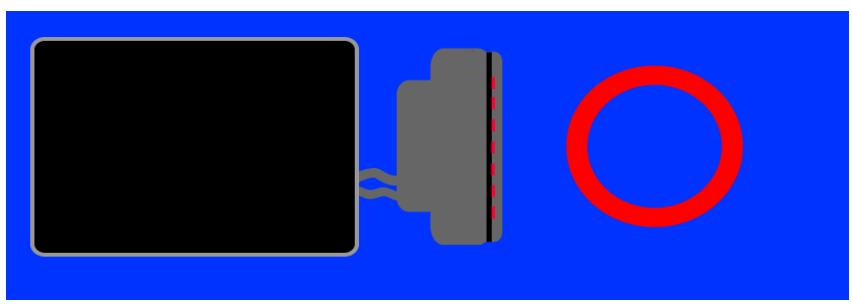


time = distance (depth)



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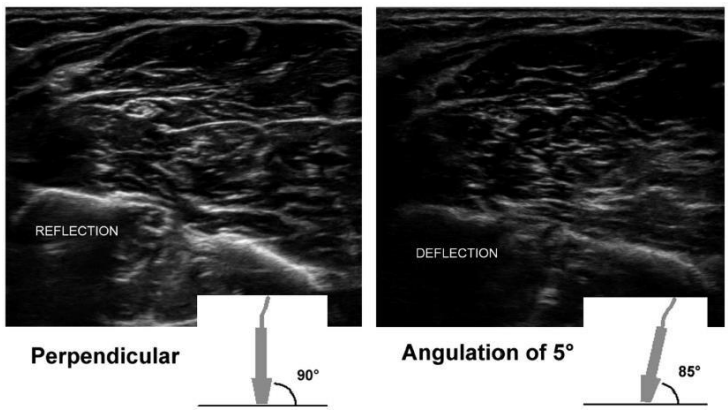
US PROBE ANGULATION



Van Alfen and Mah. Can J Neurol Sci 2018;45:505–15.

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FUNCTIONS ON US EQUIPMENT

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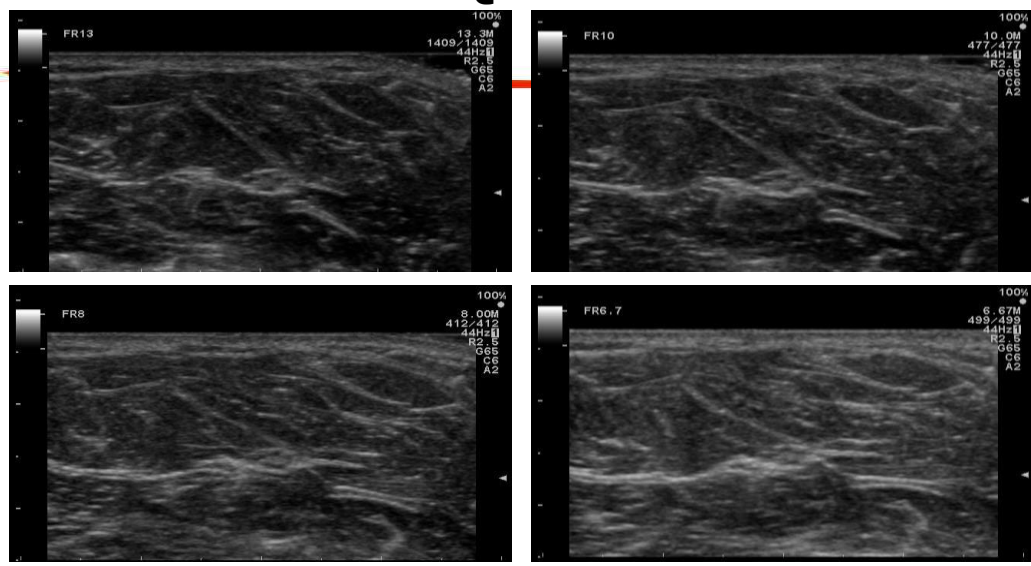
FREQUENCY



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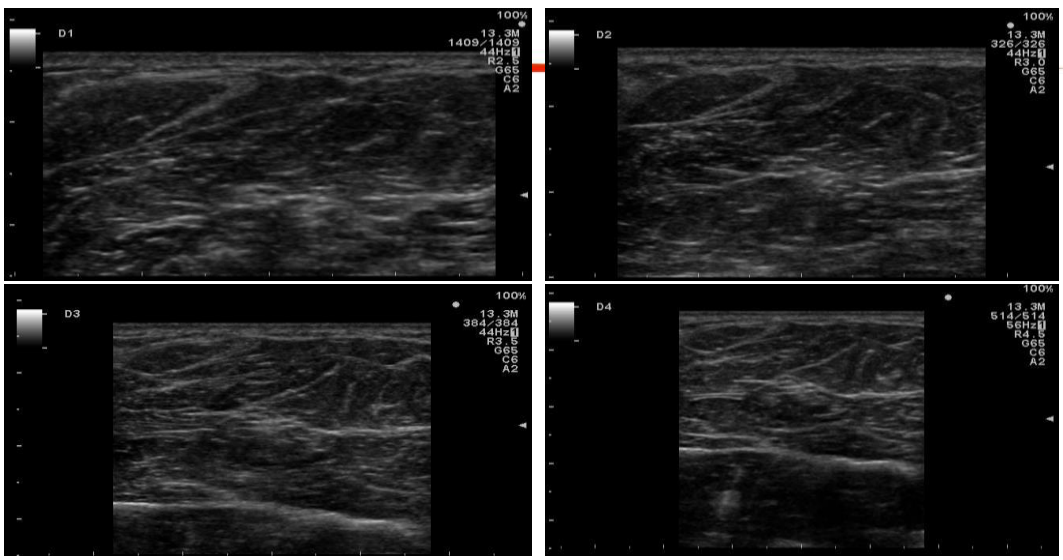
DEPTH



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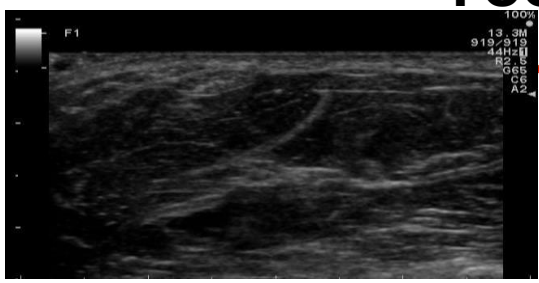
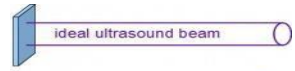
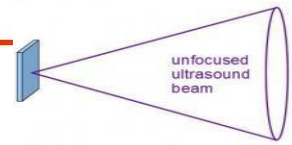
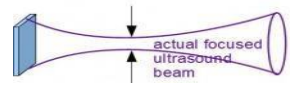
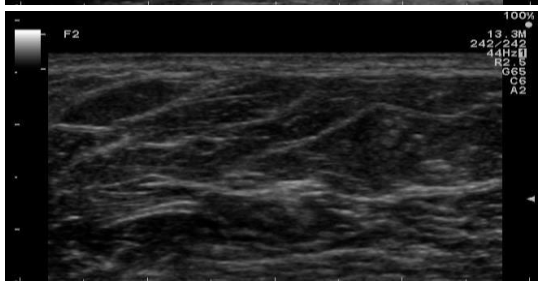
FOCUS

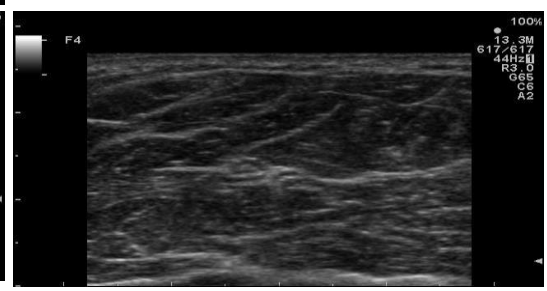












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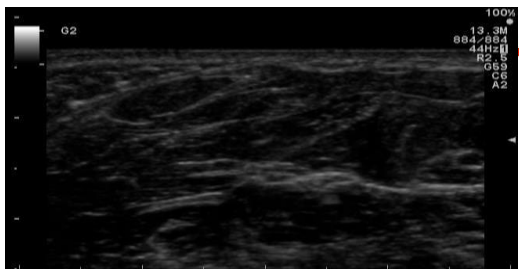
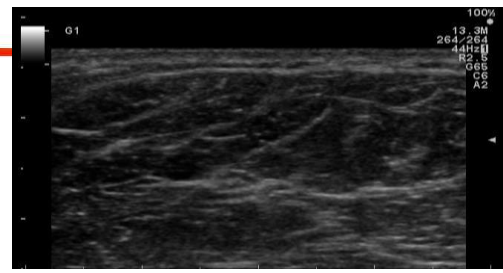
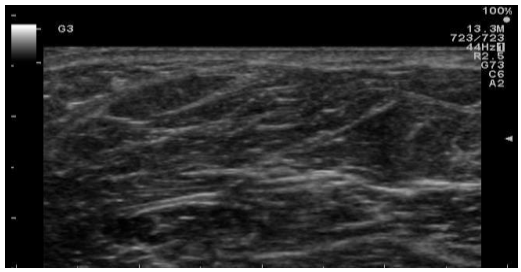
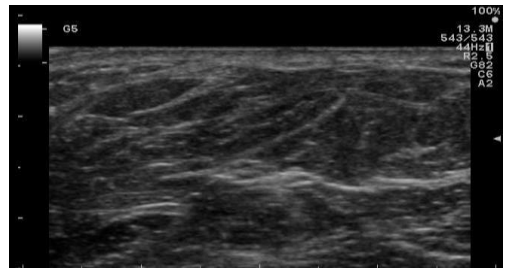
GAIN









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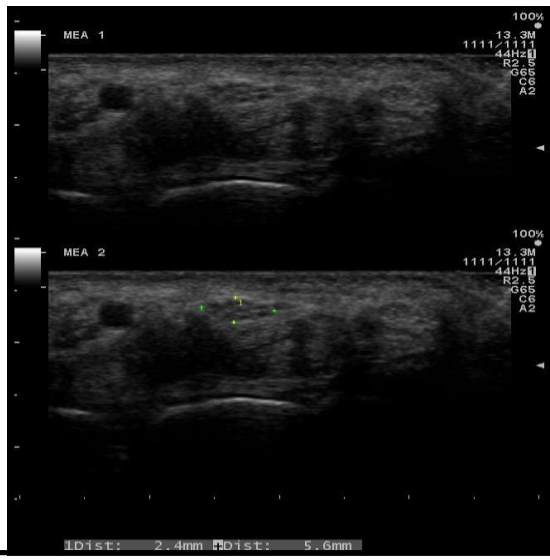
MEASUREMENTS



- For nerves either ellipse or manual tracking cross sectional area (CSA) measurements are used.

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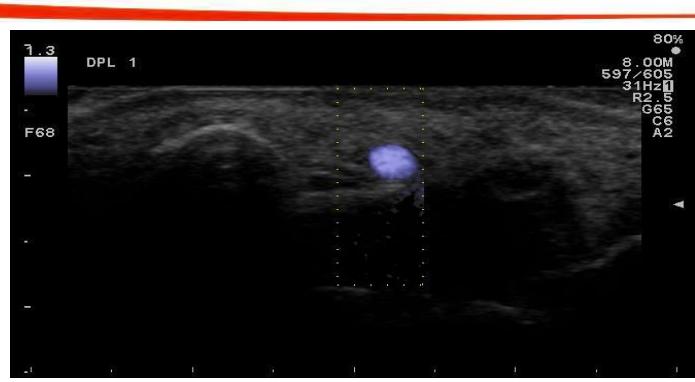
DOPPLER



- Doppler imaging is very useful for identification of nearby vessels and nerve vascularization.

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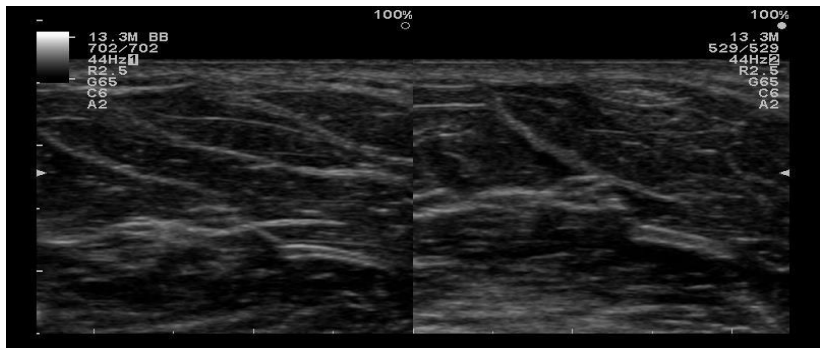
SPLIT SCREEN



- To recognize nerve pathology, comparison with neighboring segments and particularly with contralateral side is useful.

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US EVALUATION OF PERIPHERAL NERVES

- US device > 12 MHz linear array transducer.
- Standard limb positioning.
- Examination of the affected nerve along the whole visible course.
- Exclusion of the hyperechoic rim from nerve CSA measurement using a trace method.
- CSA on transverse views at standard positions + where the nerve is thickest or thinnest.
- Obtain longitudinal views on sites of abnormalities.
- Report CSA, its location, reference values and images.
- Perform dynamic studies:
  - finger flexion-extension for median nerve mobility at the wrist,
  - elbow full flexion to assess for ulnar nerve dislocation, etc.

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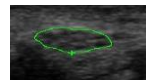
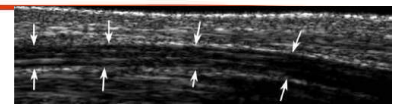
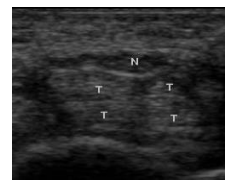
NERVES CAN BE RECOGNISED BY:

- Characteristic appearance:
  - honeycomb on cross section,
  - fibrillary on longitudinal views.
- Lower anisotrophy compared to tendons
- Anatomical position:
  - large nerves often lie near arteries,
  - sensory nerves often in fat filled flat spaces.
- Identification is improved by fast movement of US probe with changing inclinations.

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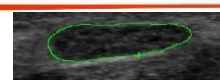
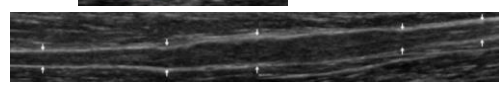
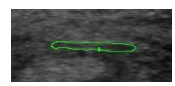
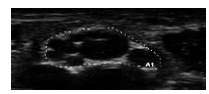
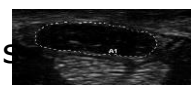
NERVE PATHOLOGY CAN BE RECOGNISED BY:

- Thickening in:
  - compressions and entrapments
  - trauma and tumors
  - demyelinations
- Constriction in severe entrapments
- Thickening of individual nerve fascicles
- Reduced echogenicity due to edema and inflammation
- Increased echogenicity due to fibrosis

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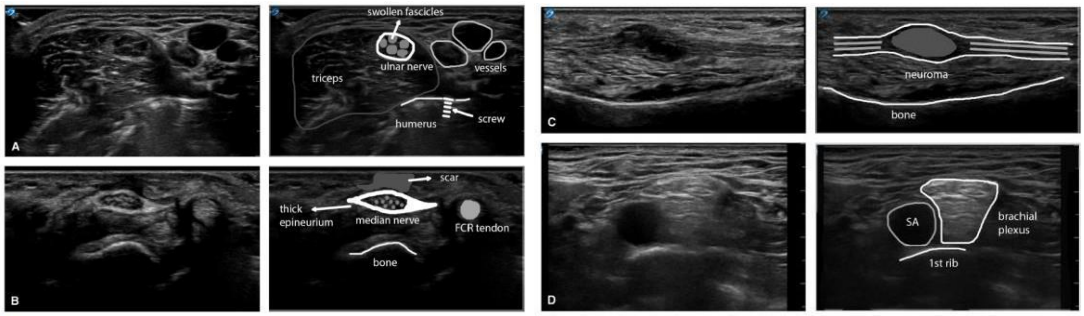
MORE US IN NERVE PATHOLOGY



Van Alfen and Mah. Can J Neurol Sci 2018;45:505–15.

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PATIENT POPULATION IN US LAB

Table 1 The most common indications for peripheral nerve ultrasonography (US) in a series of 231 consecutive patients.

Indications	Number (percentage [%])
Ulnar neuropathy at the elbow	96 (42)
Carpal tunnel syndrome	57 (25)
Fibular, tibial or sciatic nerve lesions	22 (10)
Other ulnar nerve lesions	17 (7)
Other median nerve lesions	10 (4)
Radial nerve lesions	9 (4)
Median and ulnar nerve lesions	9 (4)
Polyneuropathy	6 (2)
Meralgia paresthetica	3 (1)
Femoral nerve lesion	1 (0.5)
Morton's metatarsalgia	1 (0.5)

Table 2 The most common ultrasonographic (US) diagnoses in a series of 231 consecutive patients.

US diagnoses	Number (percentage [%])
Ulnar neuropathy in the RTC groove	55 (24)
Median neuropathy at the wrist	50 (22)
Ulnar neuropathy under the HUA	17 (7)
Other ulnar nerve lesions	10 (4)
Carpal tunnel injections	6 (2)

RTC: retroepicondylar; HUA: humeroulnar aponeurosis.

Podnar S. Neurophysiol Clin 2018;48:119–23.

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FOCAL ENTRAPMENT AND COMPRESSION NEUROPATHIES

- These were the first and the most common neuropathies assessed by US.
- Nerves can by either:
  - compressed from the outside or
  - entrapped by structures intrinsic to the body – usually ligaments (probably not hypertrophic muscles).
- At the level of compression nerve is usually swollen – CSA > upper reference limit.
- In nerves with severe entrapment constriction can be observed - CSA ↓ compared to proximal and distal sites (e.g., > 1 mm^2 for ulnar nerve); i.e. hourglass appearance.

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MEDIAN NERVE ENTRAPMENT AT THE WRIST

- The median CSA is usually measured:
  - at the level of pisiform bone,
  - 10 cm proximal in the forearm.
- CSA values are compared to median nerve reference values:
  - CSA at the wrist: > 9-12 (11) mm^2,
  - wrist/forearm CSA ratio: > 1.8.

Podnar S. Neurophysiol Clin 2018;48:119–23.

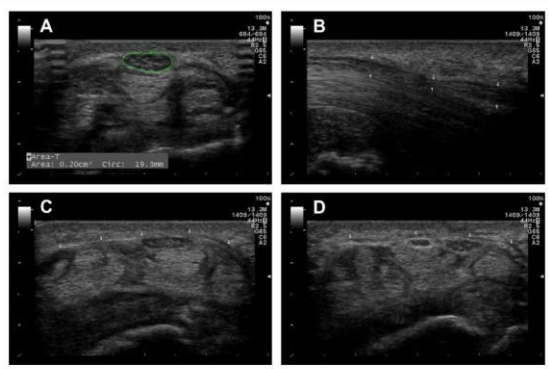

Figure 1 Ultrasonographic findings in a 70-year-old man with persistent symptoms of the median nerve entrapment at the wrist 18 months after flexor retinaculum release on the left. A. Transverse view just proximal to the carpal tunnel showing swelling of the left median nerve (our upper reference limit for cross sectional area is 0.11 cm^2). B. Longitudinal view of the median nerve (arrows) demonstrating persistent entrapment (middle pair of arrows). C. Transverse view at the level of persistent left median nerve entrapment by transverse carpal ligament (arrows). D. Transverse view of the contralateral (right) hand showing split median nerve (bellow middle two arrows) below the transverse carpal ligament (arrows).

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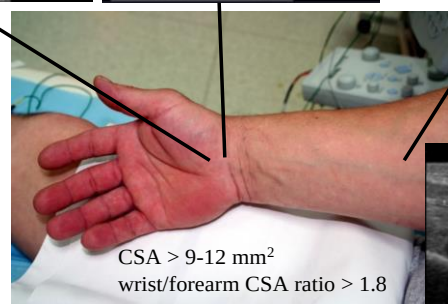
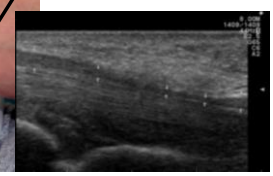
SONOGRAPHY IN EXTREME CTS

Absent median nerve CMAP and SNAPs.





CSA > 9-12 mm^2
wrist/forearm CSA ratio > 1.8

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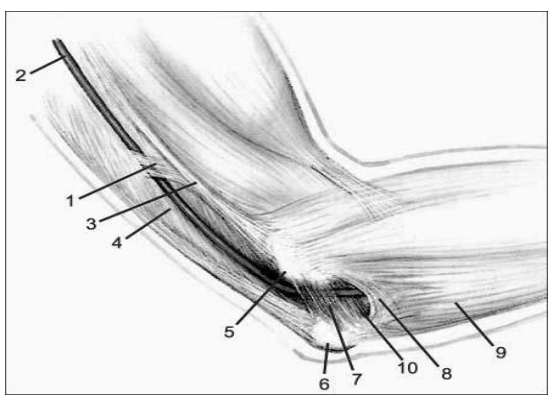
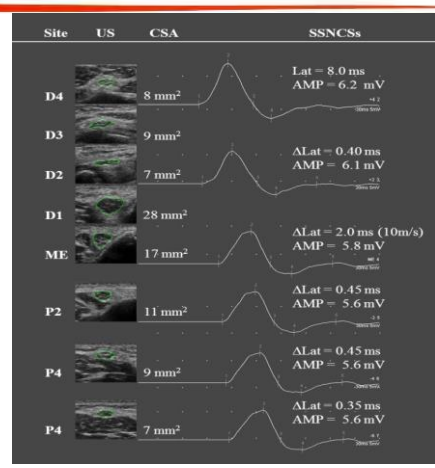
ULNAR NEUROPATHY AT THE ELBOW (UNE) DISTAL TO MEDIAL EPICONDYLE





Podnar et al. Muscle Nerve 2017;56:E65–E72.

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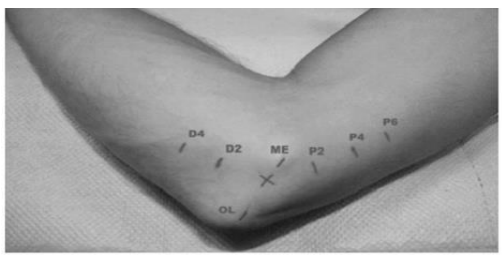
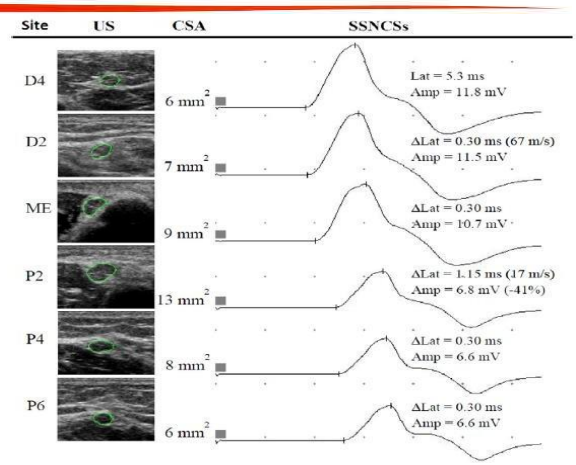
UNE AT OR PROXIMAL TO MEDIAL EPICONDYLE

- In our US lab patients with suspected UNE are the most common.





Omejec & Podnar. Clin Neurophysiol 2015;126:2390–6.

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CHARACTERISTICS OF BOTH UNE

Under the HUA		**In the RTC groove**
2-3 cm distal to ME	↔	0-2 cm proximal to ME
less common (17%)	↔	more common (76%)
older hard manual laborers - dominant arm	↔	younger clerks, students - non-dominant arm
clinically more severe - mainly axonal (73%)	↔	clinically less severe - mainly demyelinating (82%)
constriction in 54% – nerve ENTRAPMENT	↔	nerve constriction in 0% – EXTRINSIC COMPRESSION

Omejec & Podnar. Clin Neurophysiol 2015;126:2390–6.

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NERVE TRAUMA

- US contributed to diagnosis or modified therapy in 60% of patients with nerve trauma (Padua et al., 2013).
- In nerve trauma US is essential in establishing continuity of the peripheral nerves.
- US also contributes to:
  - identification of etiology (e.g., contact with screws),
  - demonstration of multiple sites of damage (i.e., tandem lesions),
  - surgical planning precisely describing the anatomic situation,
  - showing dynamic conflicts that might be missed during surgery.
- It can be performed immediately after nerve lesion speeding up patients‘ treatment and recovery.
- Large posttraumatic neuromas suggest poor prognosis.

Padua et al. Clinical Neurophysiology 2013;124:1237–1243.

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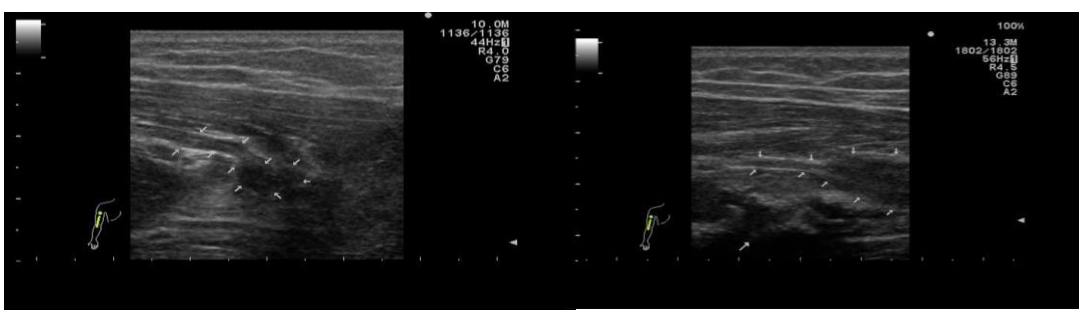
NEUROTMESIS AFTER NERVE INJURY



Humerus fracture and radial palsy in a 23-years-old man.

Radial nerve in discontinuity – surgery indicated.

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NERVE TUMORS

- US should be the first line imaging modality for a suspected mass connected to a peripheral nerve.
- The orientation of a tumor along the nerve, assessment of the nerve fascicles and tumor perfusion (using color Doppler and duplex mode), are easily feasible and important features for the differential diagnosis and treatment planning.
- In our department we rarely saw nerve tumours before introduction of US.

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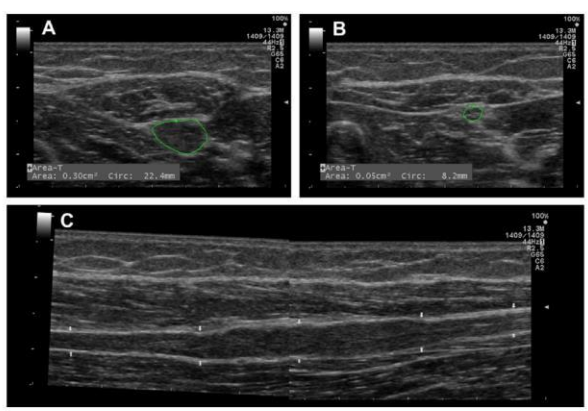
NERVE TUMOUR



Podnar S. Neurophysiol Clin 2018;48:119–23.

Figure 2 Ultrasonographic findings in a 25-year-old woman with painless atrophy and weakness of the ulnar hand muscles. She also reported ulnar sensory loss. A. Transverse view in the middle of the forearm showing swelling of the ulnar nerve (our upper reference limit for cross sectional area is 0.08 cm^2). B. Transverse view 10 cm distal to swelling showing normal caliber ulnar nerve. C. Longitudinal view of the ulnar nerve (arrows) demonstrating about 7 cm long segment of the ulnar nerve tumorous swelling.

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POLYNEUROPATHIES

- It is often a challenge to differentiate:
  - sporadic CMT patients from CIDP,
  - AIDP from CIDP,
  - MMN from ALS, etc.
- In general on US nerves are:
  - uniformly thickened in CMT 1,
  - non-uniformly thickened in CIDP,
  - focally (regionally) thickened in MMN and MADSAM ,
  - only slightly thickened in vasculitis ,
  - not thickened in axonal polyneuropathies.

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POLYNEUROPATHY - CIDP

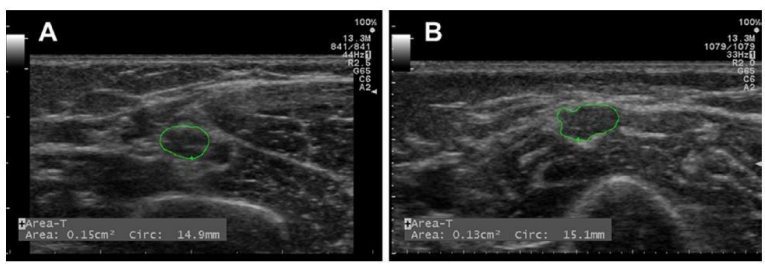

Figure 3 Ultrasonographic findings in a 18-year-old girl with chronic inflammatory demyelinating polyneuropathy. A. Transverse view in the middle of the upper arm showing swelling of the median nerve (our upper reference limit for cross sectional area is 0.10 cm^2). Note also enlarged nerve fascicles. B. Transverse view in the middle of the upper arm showing swelling of the ulnar nerve (our upper reference limit for cross sectional area is 0.10 cm^2). US of the forearm demonstrated normal nerve calibers, and continuous twitching (i.e. fasciculations) of the flexor muscles.

Podnar S. Neurophysiol Clin 2018;48:119–23.

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US PATTERN SCORES

- Several authors developed scores aimed to differentiate polyneuropathies (Grimm et al., 2015, Kerasnoudis et al, 2016).
- These scores revealed other interesting features of PNP:
  - nerve roots are mainly thickened in GBS ,
  - nerves in forearm are most often thickened in MMN,
  - nerve thickening at the usual entrapment sites in MADSAM,
  - normal nerves are found in non-immune-mediated axonal neuropathies, ALS, lumbar stenosis.

Grimm et al. Clin Neurophysiol 2015;126:2216–25.
Kerasnoudis et al. Muscle Nerve 2016;54:864–71.

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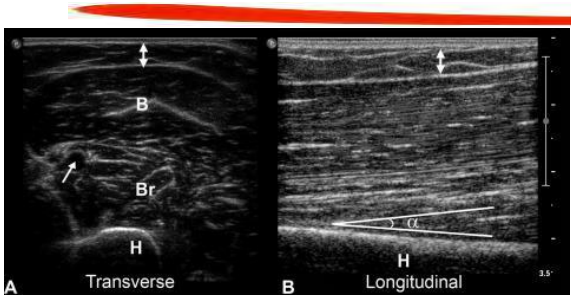
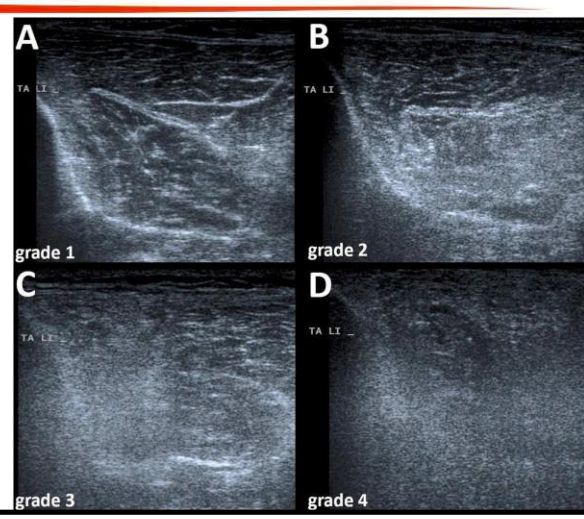
MUSCLE US



Pillen et al. Handb Clin Neurol 2016;136:843–53.

Grade 1: Normal, with predominantly dark muscle with bright, distinct bone reflection
Grade II: Mildly abnormal, with increased muscle echogenicity but with preserved bone reflection
Grade III: Moderately abnormal, with increased muscle echo intensity and reduced bone reflection
Grade IV: Markedly abnormal, with greatly increased muscle echogenicity and absent bone reflection



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US IN MUSCLE DISORDERS

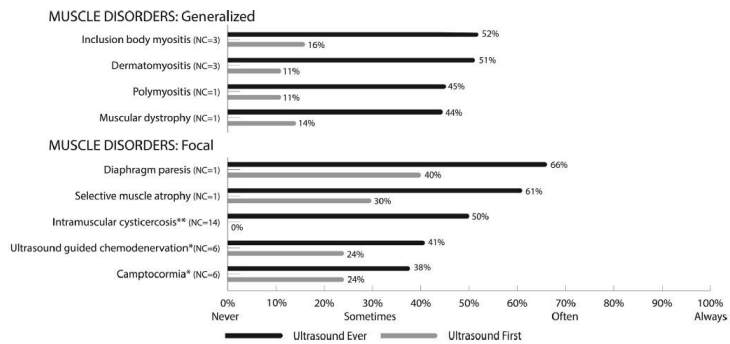

Fig. 1. This figure is a summary slide describing expert usage for the indications listed. Although experts graded responses as no cases seen, never, sometimes, often, and always, the responses were assigned percentages to assist in information display: Never = 0%, Sometimes = 30%, Often = 70%, Always = 100%. The responses were designed to assess current usage, not anticipated future usage. The upper, top dark line represents how frequently they use ultrasound in evaluation of specific indications, the slightly lighter lower line, indicates the frequency with which they use ultrasound first, before other electrodiagnostic studies. NC stands for the number of experts who reported having seen no cases for that indication in their laboratory.

Walker et al. Clin Neurophysiol 2018;129:2658–79.

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US IN MUSCLE DISORDERS:

- Suspected inclusion body miositis (IBM),
- Recognition of pattern of muscle involvement in suspected myopathy or camptocormia,
- Demonstration of calcinations or cysts after muscle inflammation, bleedeing or infection,
- Identification of the muscle most appropriate to biopsy,
- Assesment of the diaphragm morphology and function and US guided EMG needle insertion,
- Quantitative muscle US for differentiation of central and peripheral causes of weakness in young children.

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INCLUSION BODY MYOSITIS

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EDX AND US STUDIES

- EDx studies serve as an extension of the neurologic examination, and US studies serve as an extension of the EDx studies
- US studies are most useful to answer specific questions unresolved by the neurologic examination, and EDx studies
- Often it is very useful to have US equipment nearby ready during EDx studies.
- For more difficult patients and those referred by colleagues separate sessions need to be organized.

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CONCLUSIONS

- US brought a new dimension into the neuro-muscular diagnostics - now we neurologists using can directly diagnose entities we have never before (e.g., tibial neuropathies in the thigh, tumors, ganglion cysts).

- US also enabled us to perform US guided:
  - nerve injections (e.g., CTS, meralgia paresthetica),
  - EMG examinations (e.g., diaphragm).

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OUR CURRENT INDICATIONS FOR PERIPHERAL NERVE US:

- Suspected complete nerve transections after trauma,
- Severe polyneuropathy with suspected additional focal neuropathy (e.g., CTS in a diabetic patient),
- EDx confirmed ulnar neuropathy of unclear localization,
- Other focal neuropathies (e.g., radial, fibular, tibial),
- Neuralgic amyotrophy,
- Polyneuropathies:
  - demyelinative: CMT 1A, CIDP, GBS, MMN, sy. Lewis-Summner,
  - amyloidosis, NF1,…

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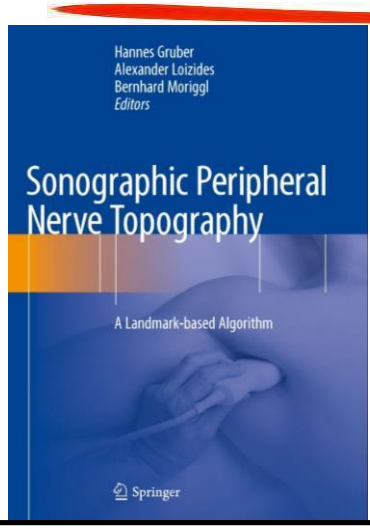
FINDING NERVES



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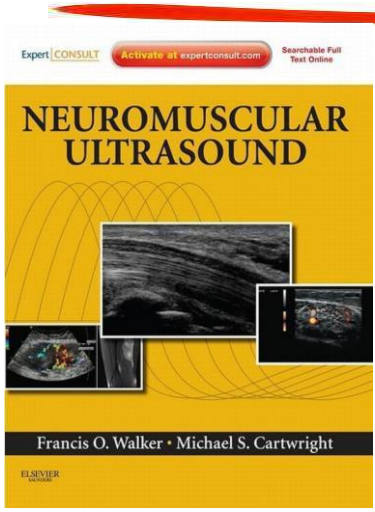
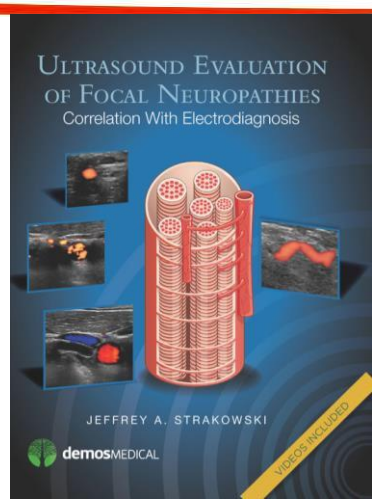
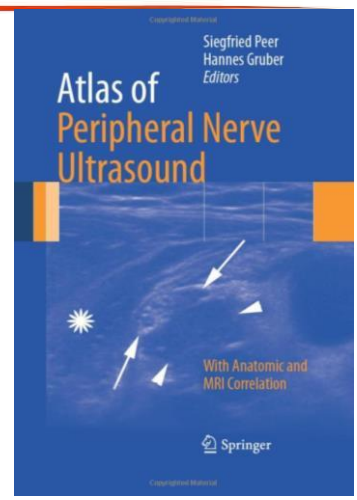
FEW OTHER BOOKS…







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…AND TEACHING COURSES

Canon
CANON MEDICAL

Invitation

2nd International Workshop for Nerve Sonography

New ways in pain control and US-guided regenerative medicine

14–15 June 2019, London
The Royal Society of Medicine
1 Wimpole Street, London, W1G 0AE

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THANK YOU!