MSK-S01

Applications of Sonoelastography in Plantar Fascia

Chueh-Hung Wu, MD, PhD, CIPS
Department of Physical Medicine and Rehabilitation, National Taiwan University Hospital Hsin-Chu Branch, Hsinchu, Taiwan

Sonoelastography is a method that can evaluate the mechanical properties of soft tissue via ultrasound imaging. Compression elastography, also described as static strain elastography, is based on the principle that the compression of tissue produces strain.

By using such system with quantitative imaging analysis, we found that the plantar fascia softened with age and in patients with unilateral plantar fasciitis. We also found that the plantar fascia was softer in patients with typical clinical manifestations of plantar fasciitis, even if they exhibited no abnormalities on B-mode sonography. A one-year follow-up of plantar fascia stiffness after shock wave therapy for plantar fasciitis showed that the plantar fascia would become softer initially and then regained its stiffness 12 months later.

Sonoelastography may be used to complement conventional B-mode US in assessment of musculoskeletal disorders. More studies focusing on its clinical applicability are necessary due to its unsatisfactory reliability.

MSK-S02

Applications of Sonoelastography in Nerves and Other Tissues

Ke-Vin Chang[1,2]
[1]*Department of Physical Medicine and Rehabilitation, National Taiwan University Hospital, Bei-Hu Branch, Taipei, Taiwan* [2]*Department of Physical Medicine and Rehabilitation, National Taiwan University Hospital and College of Medicine*

Sonoelastography has been widely used in the neuromuscular systems. There are two types commonly employed for clinical practice, including the strain and shear wave modes. In the beginning of this talk, we would elaborate the pros and cons of both modes as well as how to use them in a correct manner. Furthermore, we will use two of our meta-analyses (Utility of sonoelastography for the evaluation of rotator cuff tendon and pertinent disorders: a systematic review and meta-analysis. Eur Radiol 2020; Utility of Ultrasound Elastography in Evaluation of Carpal Tunnel Syndrome: A Systematic Review and Meta-analysis. Ultrasound Med Biol. 2019) to demonstrate the application of sonoelastography on nerves and rotator cuff tendons. In addition, a novel application of sonoelastography is its use on obstructive sleep apnea by using the following publication: Reliability of Sonoelastography Measurement of Tongue Muscles and Its Application on Obstructive Sleep Apnea.

Front Physiol. 2021.

MSK-S03

Deep learning in MSKUS: Physician Aspect

Jiunn-Horng Kang, MD, MS, PhD[1,2,3]
[1]*College of Biomedical Engineering, Taipei Medical University*
[2]*Physical Medicine and Rehabilitation, School of Medicine, Taipei Medical University*
[3]*Professional Master Program in Artificial Intelligence in Medicine, College of Medicine, Taipei Medical University*

Deep learning (DL) is a fast-evolving algorithm in the field of machine learning. DL have been successfully applied to fields including computer vision, speech recognition, natural language processing, bioinformatics, drug design, medical image analysis, and board game programs. Medical image analysis using DL for the problems such as cancer cell classification, lesion detection, image and lesions segmentation, automatic report generation and image enhancement achieves compatible results with human experts. Musculoskeletal ultrasound (MSKUS) is an important tool in orthopedic, rheumatologic, pain and rehabilitation clinical settings. It has been demonstrated that applying DL in MSKUS yields good results as well. Nevertheless, MSKUS has the features including high operator dependent, poor standardized machine parameters and protocols, and relatively low inter-rater's reliability compared with other image modalities. It is important to realize the acquirement the image, the protocol settings, the pre-procession of images, and the labeling will influence the optimal results of DL in MSKUS analysis. Physicians should note that common procedures in DL training process such as data quality check, resizing and normalization, data augmentation, and ROI selection. It is also necessary to obtain inter-rater's reliability test to determine the quality of labelling. After the DL model is constructed, physicians should justify the performance of DL model but only based on confusion matrix and F score but also the domain knowledge and clinical scenario since the DL model is still largely un-explainable. Finally, Physicians should consider how to implement the DL model into clinical workflow. Although DL solution in clinical applications of MSKUS is expected, further study is still advised to establish its value in clinical setting.

MSK-S04

Deep learning in MSKUS: Engineer Aspect

Po-Ling Kuo
National Taiwan University

In MSKUS, deep-learning has been emerging as the leading machine-learning tool to assist recognition and segmentation of a variety of anatomical structures, such as muscles, nerves, vessels, and spinous processes. Most of the approaches employed models based on convolutional neural network, particularly U-net, an architecture of symmetric u-shape to overcome the progressive loss of feature resolution when the structure increases depth. This model and the followers proposed an encoder-decoder structure to obtain better semantic information with preserved spatial information. An alternative to the encoder-decoder structure is atrous (dilated) convolution, which replaces the convolution striding by dilating the kernel scale to broaden the receptive field. Despite the success of these models in the application of other imaging domains, the main challenge impeding the blooming of deep-learning systems in MSKUS applications is the scant access to well-labeled image datasets for model pretraining, mostly resulting from the expensive annotation by human experts. In this talk, the basic principles of the widely employed models and the approaches aiming to tackle the limitation, such as transfer learning, will be addressed.

MSK-S05

Application of Deep Learning in MSKUS: Auto-annotation of Anatomical Structures

Wen-Shiang Chen
Physical Medicine & Rehabilitation, National Taiwan University Hospital

In recent years, musculoskeletal ultrasound (MSKUS), which focuses on the diagnosis or guided therapy of tendon, ligament, muscle, nerve or joint disorders, is no doubt the fastest growing and widest spanning fields among specialties of medical ultrasound. MSKUS is also one of the earliest to enter the point-of-care site (POCUS) and has been widely used. However, MSKUS involves many body parts with complex anatomical structures, resulting in high difficulties in identifying anatomical structures. Moreover, the complicated 3-D relationship and highly variable disordered structures further force the beginners to face the difficulties in finding good tutors and have long learning curves. The existing textbooks with scarce pictures make the beginners hard to become familiar with the parts they are examining.

In this talk, I will explain the motivation, methods and preliminary results of developing an AI and deep learning-based, real-time, auto- annotation system. The system was applied on identifying structures around an elbow joint as an example, and could help examiners to differentiate and track the various anatomical structures on MSKUS images. Beginning with the normal structures, the same method could be applied to other parts of the body. Having the basic databases of normal structures, the system may be used to compare normal and disordered structures, and provide first-line physicians suggestions on accurate diagnosis and guidance on echo-guided interventional therapy.

Key Words: Ultrasound, MSK ultrasound, POCUS, Deep learning, AI

MSK-F01

Ultrasound Computer-aided Detection for Upper Limb Using Deep Convolution Neural Network

Hsin-Yuan Zhu[1], Yen-Fu Tu[1], Chung-Ping Chen[1], Wen-Shiang Chen[2]
[1]Graduate Institute of Electronics Engineering, National Taiwan University
[2]Department of Physical Medicine and Rehabilitation, National Taiwan University Hospital

Background: musculoskeletal ultrasound is a practicable alternative for the clinicians. However, because many body parts come with complex anatomical structures and changeable tissue texture, it is hard for beginners to find suitable tutors and to learn from existing textbooks with few pictures.

Materials and Methods: We use YOLOv5 algorithm to achieve accurate and real-time detection for musculoskeletal ultrasound image detection to alleviate the problem as mentioned above.

Results: The experimental results have shown that YOLOv5 reaches over 80% in mAP50 for cross-validation and 89% in mAP50 for testing, which means over 2% improvement in mAP50 for cross-validation and 7% in mAP50 for testing compared to YOLOv3.

Conclusion: In this paper, we propose the use of a better neural network and different data augmentation operation to improve the performance of musculoskeletal ultrasound image detection around the elbow joint structures.

(Key words: ultrasound image, musculoskeletal ultrasound, deep learning, image recognition, object detection, convolutional neural network, real-time system)

MSK-F02

Sonographic Evaluations of the Skeletal Muscles in Patients with Pompe Disease

Yi-Hsiang Chiu[1], Chun-Li Liao[1], Yin-Hsiu Chien[2,3], Chueh-Hung Wu[1,4], Levent Özçakar[5]
[1] Department of Physical Medicine and Rehabilitation, National Taiwan University Hospital, Taiwan; [2]Department of Pediatrics, National Taiwan University Hospital, Taiwan; [3]Department of Medical Genetics, National Taiwan University Hospital, Taiwan; [4]Department of Physical Medicine and Rehabilitation, National Taiwan University Hospital Hsin-Chu Branch, Taiwan; [5]Department of Physical and Rehabilitation Medicine, Hacettepe University Medical School, Turkey

Introduction: Patients with Pompe disease often suffer from muscle weakness due to glycogen accumulation. This study aimed to determine whether quantitative ultrasonographic parameters from B-mode scan (H index) and elastography (shear modulus) can replace the qualitative Heckmatt scale assessment of muscles and correlate to the motor function in patients with Pompe disease.

Methods: Patients with Pompe disease were recruited. Manual muscle testing, six-minute walking test and four-limb stair climb test were assessed. The H index (standard deviation divided by mean of echogenicity with Image J analysis) and shear modulus were recorded in rectus femoris, biceps femoris, tibialis anterior, medial gastrocnemius, biceps brachii and triceps brachii muscles. The correlations among ultrasonographic parameters and motor functions were analyzed.

Results: Eighteen patients were enrolled in the study. The H index, but not the shear modulus, was negatively correlated with the rating of Heckmatt scale in all muscle groups. H index = 0.356 was able to differentiate between grade 2 and grade 3 of Heckmatt scale, with a sensitivity of 78.6% and a specificity of 88.9%. The H indices pertaining to tibialis anterior (r=0.698, p=0.008) and medial gastrocnemius (r=0.615, p=0.025) muscles showed positive correlations with the walking distance. The H indices of four lower limb muscles were negatively correlated with the duration of stair climbing.

Conclusions: The H index but not the shear modulus can be used to describe the muscle involvement in a quantitative way. In addition, lower limb muscle H indices are associated with worse motor function in patients with Pompe disease.

MSK-F03

A Single Low-energy Shockwave Pulse Opens Blood-cerebrospinal Fluid Barriers and Facilitates Gastrodin Delivery to Alleviate Epilepsy

Ming-Yen Hsiaoa, Yi Kung a, Shu-Mei Yanga, Tz-Yi Wenb, Moxian Chenc, Wei-Hao Liaoa, Chueh-Hung Wua, Lijuan Aoc, Wen-Shiang Chena,da

[a]Department of Physical Medicine and Rehabilitation, National Taiwan University Hospital & National Taiwan University College of Medicine, Taipei city, Taiwan. [b] University of California, Davis, California, US. [c] School of Rehabilitation, Kunming Medical University, Kunming, People's Republic of China. [d] Institute of Biomedical Engineering and Nanomedicine, National Health Research Institutes, Miaoli, Taiwan.

Blood-cerebrospinal fluid barrier (BCSFB) is another gatekeeper between systemic circulation and central nervous system (CNS), it mainly distributed at the boundary between choroid plexuses and the ventricular system. In this study, BCSFB opening in rat by single pulse of low-energy focused shockwave (FSW, energy flux density 0.03 mJ/mm2, 2× 106 Microbubbles/kg) treatment at lateral ventricle significantly elevated CSF concentration of systemically-administered gastrodin (GTD) (4 times vs. control within 3 hrs), that remained detectable at 24 hrs. The FSW-GTD group had significantly lower Racine's scale (< 4) and zero mortality (n=30) after lithium-pilocarpine- induced epilepsy, electrophysiological recordings showed decreased epileptiform discharges, and brain section histology revealed reduced inflammation, oxidative stress and apoptosis, when compared with groups without FSW (Racine's scale: 4~5; mortality: 26.67~36.67%). FSW-mediated BCSFB opening provides a promising alternative of controlled-delivery of therapeutics into the CNS, offering rapid and widespread medication distribution. The technique could by applied in developing novel therapy in various CNS diseases.

MSK-F04

Very Low Intensity Ultrasound for Brain Stimulation: Influence and Application of Glymphatic System

Wei-Hao Liao, Chueh-Hung Wu, Yi Kung, Wen-Shiang Chen
Department of Physical Medicine and Rehabilitation, National Taiwan University Hospital and National Taiwan University College of Medicine

Background: The main function of the glymphatic system is to regulate the circulation between cerebrospinal fluid and interstitial fluid, and play an important role in the supply of nutrients and clearance of wastes in the brain. The dysfunction of glymphatic system is associated with many central nervous system (CNS) pathologies including Alzheimer's disease, traumatic brain injury, stroke, and hydrocephalus.

Materials and Methods: We use cerebrospinal fluid (CSF) tracers to observe the circulation of the glymphatic system and compare the effects of ultrasound stimulation on the glymphatic system.

Results: The results indicate that ultrasound can enhance the circulation of glymphatic system, thus facilitating waste clearance from CNS.

Conclusion: It is expected that this new perspective of ultrasound stimulation of the glymphatic system can be a novel strategy for treatment of CNS diseases.

MSK-F05

Facilitating Drug Delivery In The Central Nervous System By Opening The Blood-Cerebrospinal Fluid Barrier With A Single Low Energy Shockwave Pulse

Yi KUNG, Ming-Yen Hsiao, Wen-Shiang Chen
Department of Physical Medicine and Rehabilitation, National Taiwan University Hospital & National Taiwan University College of Medicine, Taipei City, Taiwan.

Background: The blood-cerebrospinal fluid (CSF) barrier (BCSFB) is critically important to the pathophysiology of the central nervous system (CNS). However, this barrier prevents the safe transmission of beneficial drugs from the blood to the CSF and thus the spinal cord and brain, limiting their effectiveness in treating a variety of CNS diseases.

Materials and Methods: This study demonstrates a method for reversible and site-specific opening of the BCSFB via a noninvasive, low-energy focused shockwave (FSW) pulse (energy flux density 0.03 mJ/mm2) with Sono Vue microbubbles (2× 106 MBs/kg), posing a low risk of injury.

Results: By opening the BCSFB, the concentrations of certain CNS-impermeable indicators (70 kDa Evans blue and 500 kDa FITC-dextran) and drugs (penicillin G, doxorubicin, and bevacizumab) could be significantly elevated in the CSF around both the brain and the spinal cord. Moreover, glioblastoma model rats treated by doxorubicin with this FSW-induced BCSFB (FSW-BCSFB) opening technique also survived significantly longer than untreated controls.

Conclusion: This is the first study to demonstrate and validate a method for noninvasively and selectively opening the BCSFB to enhance drug delivery into CSF circulation. Potential applications may include treatments for neurodegenerative diseases, CNS infections, brain tumors, and leptomeningeal carcinomatosis.

Keywords: low-energy extracorporeal focused shockwave pulse, blood-brain barrier, blood-cerebrospinal fluid barrier, central nervous system, glioblastoma multiforme, leptomeningeal carcinomatosis.

MSK-P01

Grading Score for Deep and Superficial Multifidus Using Dynamic Ultrasonography in Patients in Different Stages of Low Back Pain

Shing-Tian Chiang, Shwu-Fen Wang
School and Graduate Institute of Physical Therapy, College of Medicine, National Taiwan University, Taipei, Taiwan Physical Therapy Center, National Taiwan University Hospital, Taipei, Taiwan

Background: The measurement of deep multifidus (dMF) and superficial multifidus (sMF) is essential to assess trunk stability. While measuring the change of thickness of dMF in patients with low back pain (LBP), the change is approximate to the resolution (1 mm) of ultrasound imaging (USI). The measurement of sMF could not exclude the segmental movement of the spine. The aims are to establish a grading score for dMF and sMF, and to investigate the reliability. Whether the grading score differed among patients and correlated to functional disability score is also investigated.

Materials and Methods: Eight participants in four groups, asymptomatic adults, patients with recurrent LBP, non-specific LBP and spondylolisthesis, were recruited. USI was used to record dMF and sMF on L4/5 during contralateral leg lift. The images were classified by a five-grade scale for dMF and sMF based on the unclearness/clearness of the image; and degree of change in thickness (no/mild/obvious) during contraction. The Oswewtry Disability Index (ODI) was used. The grading was performed blindly twice by one PT with 2-year experience of using USI.

Results: The intra-rater reliability of grading of dMF and sMF are excellent (ICC=0.9, CI=0.79-0.95; ICC=0.9, CI=0.82-0.96). The dMF is different between asymptomatic adults (4/0.8) (Median/Interquartile range) and patients with non-specific LBP (2/2.3) and with spondylolisthesis (0/2). The scores of dMF are moderately negative correlated to the ODI (Spearman's rho=-0.7). The grade of sMF is different between patients with recurrent LBP (4/0.8) and with spondylolisthesis (2/2), yet no correlation of sMF with ODI.

Conclusion: The grading scores of sMF and dMF are reliable. The score of dMF suggest be an index to monitor early change of low back pain and related to functional disability. The score of sMF suggest be an index in late stage of spinal degeneration.

(Key words: Real-time ultrasound, Deep multifidus, Superficial multifidus, Low back pain)

MSK-P02

Watching a Foot Tumor under the Ultrasonoscope

Ching-Yueh Lin.1.2 Kuo Hsien, Tu1

[1] Department of Physical Medicine & Rehabilitation, Kaohsiung Armed Forces General Hospital.

[2] School of Medicine, National Defense Medical Center.

Case report: A 32-year-old female incidentally found a painful nodule slowly growing in her right foot. No past history or family history was related. The nodule was noted since it became painful and irritating while in the middle of long-range walking or running. In physical examination, the nodule was non-compressible, non-movable in the subcutaneous layer (non-contact with the dermis), located postero-inferiorly away from the lateral malleolus. Ultrasound revealed an anechoic, well-demarcated, ovoid lesion, measuring 3mm in size located in the subcutaneous layer without surrounding invasion. It also showed moderate intratumoral vascularity and posterior acoustic enhancement.(Fig 1) Under the impression of neurogenic tumor, nerve hidrodissection with 5% dextrose solution was first used, and triamcinolone and lidocaine infiltration around the nodule was tried later. Both attempts were failed, then surgical intervention was sought after. The lesion was completely removed and the outcome after 5 years follow-up was excellent without recurrence.

Thanks to the advancement of ultrasound technology, physicians can easily and readily assess superficial lesions in any time at any place. By defining the lesions in terms of size, location, echogenicity, vascularity, and its relations with surroundings, it is not only a diagnostic tool, but also a useful tool for image-guided intervention. In this case report, we reviewed literature to find out important sonographic features to help make diagnoses between angioleiomyomas, peripheral neurogenic tumors, and ganglion cysts since they are not scarce findings on foot but yet have well-distinguished sonographic features.

Key words: angioleiomyoma, ganglion cyst, peripheral neurogenic tumor, ultrasound.