**BACKGROUND**:

Point-of-care ultrasound is a well-validated imaging modality that is proven to reduce time to diagnosis, eliminate radiation exposure, improve patient satisfaction, and decrease healthcare cost. This tutorial was designed to introduce a variety of musculoskeletal (MSK) ultrasound applications. Assuming that learners have a basic prior knowledge of ultrasound knobology and probe-handling, this module covers both normal MSK anatomy and pathological sonographic findings. With practice and review, the normal anatomical structures and pathologic findings may be easily recognizable, empowering an emergency provider to make an immediate bedside diagnosis and plan early intervention in cases of injury or trauma.

The video is not narrated, which gives the instructor the ability to stop at any point to discuss findings, review the images, or answer questions. A recap slide at the end of each short segment gives the learner an opportunity to process the material. The quiz should be given after the tutorial to solidify knowledge and provide the learners a slide-based image bank for review. The quiz may also be given pre-tutorial to evaluate more intermediate or advanced learners’ prior knowledge.

**PURPOSE & GOALS:**

To provide an overview of basic MSK ultrasound applications with images of both normal anatomy and pathologic findings.

**EDUCATIONAL OBJECTIVES:**

After completion of the module, the learner will be able to:

* Understand the indications for performing MSK ultrasound at the bedside.
* Understand probe selection and positioning to optimize image acquisition.
* Recognize normal MSK structures in anatomical regions including:
  + Knee joint
  + Elbow joint
  + Ribs and sternum
  + Shoulder joint
* Identify sonographic evidence of MSK pathology including:
  + Tendon disruption
  + Joint effusion
  + Fracture
  + Shoulder dislocation
  + Muscle hematoma

# RESOURCE FILES:

1. **MSK Ultrasound** module
   * This video (.MOV) presentation is meant to be reviewed either independently or with a narrating instructor as an asynchronous tutorial. The video reviews ultrasound probe selection & positioning, views of normal anatomical structures, and views of pathologic findings in specific MSK regions.
   * Estimated time: 30 minutes
2. **MSK Ultrasound quiz**
   * These slides present sonographic images and ask the learner to:
     + Identify the structure shown.
     + Identify if the structure appears normal or abnormal.
     + If abnormal, to identify the pathology.
   * Answers are provided in the presenter notes.
   * Estimated time: 30 minutes

**TOTAL MODULE DURATION:** 60 minutes

# REQUIRED RESOURCES:

* Computer with capability of running a .MOV file (i.e., Quicktime Player) and Keynote

# DESCRIPTION OF MODULE:

Intended Audience

* This module was developed for both medical students and residents prior to beginning a clinical or ultrasound rotation in an emergency department. This provides early exposure to MSK ultrasound so learners may develop their diagnostic imaging skills and add MSK applications to their future sonographic practice.

Pre-­‐reading

# Secko MA, Reardon L, Gottlieb M, Morley EJ, Lohse MR, Thode Jr, HC, Singer AJ. Musculoskeletal Ultrasonography to Diagnose Dislocated Shoulders: A Prospective Cohort. *Ann Emerg Med*. 2020 76(2):119-128. doi:10.1016/j.annemergmed.2020.01.008 PMID: 32111508

1. Situ-LaCasse E, Grieger RW, Crabbe S, Waterbrook AL, Friedman L, Adhikari S. Utility of point-of-care musculoskeletal ultrasound in the evaluation of emergency department musculoskeletal pathology. World J Emerg Med. 2018;9(4):262-266. doi: 10.5847/wjem.j.1920-8642.2018.04.004. PMID: 30181793; PMCID: PMC6117542.
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3. Perone MV, Yablon CM. Musculoskeletal Ultrasound in the Emergency Department: Is There a Role? Semin Roentgenol. 2021 Jan;56(1):115-123. doi: 10.1053/j.ro.2020.09.004. Epub 2020 Sep 4. PMID: 33422179.

Recommended Implementation/timeline

* + Pre-reading
    - Prior to viewing the tutorial, the pre-­‐reading should be made available to the learners to provide foundational knowledge as to the indications for and evidence behind the use of MSK ultrasound in the Emergency Department.
* MSK Ultrasound Video
  + - May be given as an independent study or in lecture format with an instructor narrating the video and pausing for discussion and students’ questions.
    - Suggested lecture points by section:
      * Evaluation of the Knee
        + Use the linear probe in longitudinal view to evaluate the patellar tendon.
        + A normal intact tendon has uninterrupted horizonal fibrillar pattern (which looks like an elastic band) with uniform width.3
        + View of the intact tendon insertion may be examined at the patella (proximal) and tibial tuberosity (distal).
        + A tendon disruption, partial tear, or complete rupture may show sonographic evidence of a “hypoechoic gap” without fibrous structures representing fluid or edema at the site of the damage or rupture.2,3 Most tendon ruptures occur near boney attachments.
        + Images and/or clips should always be taken of both the non-affected and affected side for comparison.
        + A quadriceps tendon may also be evaluated for rupture (the videos depict a complete tear). It is important to determine a partial from complete rupture, as the latter will require surgical management.3
        + Joint space exam for fluid (knee effusion). The probe should be held perpendicularly to the joint space to examine for presence of fluid (black).
        + In the absence of fluid, an effusion and therefore septic joint may be effectively ruled-out.
        + Providers can use ultrasound to identify the shortest route and guide arthrocentesis to reduce failed attempts and complications.1
        + Arthrocentesis may be performed under live ultrasound-guidance (dynamic) or with a landmark technique (static) once the most accessible fluid pocket has been found.1
      * Evaluation of the Elbow
        + In the case of a patient with a painful and swollen elbow joint, evaluate the olecranon and elbow joint with a linear probe in a linear and/or transverse view.
        + Fluid (black) may be present within the well-demarcated bursae or in the joint space.1,3 These images show evidence of olecranon bursitis and cellulitis with cobblestoning.
        + The medial and lateral epicondyles may be evaluated with a linear probe in the transverse view. This is ideal for children with suspected supracondylar fracture.
        + Longitudinal view is over the humerus and lateral epicondyle. Normal posterior fat pad shown. In case of occult fracture, may see anechoic hemarthrosis in that area.
        + Normal transverse epicondyles show intact hyperechoic boney cortex vs the supracondylar fracture showing a disrupted cortex with step-off deformity. Supracondylar fractures are the most common elbow fractures in children.
      * Shoulder Dislocation
        + A curvilinear probe in the posterior transverse view provides an optimal sonographic window. A linear probe may also be used in smaller adults and children.
        + From the patient’s posterior, place the probe on the scapular spine and trace laterally to the glenoid & humeral head junction. The indicator on the probe should match the indicator dot on the ultrasound screen.
        + A non-dislocated shoulder will show the glenoid in close proximity to and aligned with the humeral head (<0.5 cm distance).4
        + A provider may also ask the patient to internally and externally rotate the arm to show normal humeral head articulation within the glenoid.
        + Anterior dislocation: the humeral head will appear displaced >0.5 cm from the glenoid (towards the far-field of the sonographic window).4
        + Posterior dislocation: the humeral head will appear displaced >0.5 cm from the glenoid (towards the near-field of the sonographic window).4
        + Another advantage of this ultrasound technique is to confirm shoulder reduction in real-time and avoid multiple x-rays.
        + Depending on current standard-of-care at your institution, ultrasound may replace pre- and/or post-reduction plain films. Ultrasound is more sensitive than x-ray for the diagnosis of shoulder dislocation and confirming reduction.4
        + Providers may visualize Hill-Sachs and Bankart lesions. Ultrasound has high sensitivity for proximal humerus and other clinically relevant fractures.4
      * Rib and Sternal Fractures
        + Suggested technique is to ask the patient to indicate the point of maximal tenderness. Place the linear probe parallel (longitudinal) to the rib at that point.
        + An intact bone cortex will look like a single, uninterrupted, and hyperechoic (bright) line.
        + A fracture will reveal a cortex step-off.
        + This technique may also be used to evaluate the sternum.
        + Sensitivity of plain radiographs for rib fracture is reported at 41% while ultrasound has a high sensitivity reported between 78-98% and specificity of 100%.2
        + Ultrasound may reveal underlying pathology, as in this case of a mediastinal mass causing a pathologic sternal fracture.
      * Miscellaneous MSK Cases
        + The purposes of these images are to show the variety of ways ultrasound can be used to diagnose occult pathology.
        + In the case of this 90 year old man s/p fall, his pain was localized over the mid-shaft femur. No fracture was detected, but instead a R quadriceps hematoma. Color doppler reveals vascularity at the center of the heterogenous mass suggesting blood flow.
        + Technique recommendation: to evaluate extremities, the patient may place a hand or foot in a water bath. This provides a large liquid sonographic window (takes the place of gel) to allow higher-resolution evaluation of the extremity. These images show normal phalanges.
        + Final image shows a comminuted and displaced clavicular fracture. No x-ray was required.
  + MSK Ultrasound Quiz
    - May be given as a pre-quiz if the learner has some prior knowledge of MSK ultrasound.
    - May be given as a post-quiz and the answers reviewed in real-time with the learners.

# CONCLUSIONS:

MSK Ultrasound is an accessible application that is growing in utility. With practice and review, the normal anatomical structures and pathology are easily recognizable. Ultrasound gives the Emergency Physician the ability to make the diagnosis at the bedside. In cases of fracture reductions and shoulder dislocation reductions, MSK ultrasound gives the provider the ability to confirm reduction without a need for repeat x-ray imaging. This tutorial is appropriate for beginner, intermediate and advanced learners with all levels of ultrasound exposure. Residents will be able to incorporate this information into their own current practice and improve their patient’s care at the bedside.

# REFERENCES:

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**ACKNOWLEDGEMENTS:**

All images and clips were taken on models or actual Emergency Department patients by the faculty at UVM Medical Center, specifically Drs. Lindsay Reardon, Peter Weimersheimer, Tabitha Ford, Ash Weisman, Katie Dolbec, and EM residents Xavier Schwartz, John Priester, and Wendell Bliss. Several clips by ultrasound fellowship directors, Dr. Michael Secko t Stony Brook University Hospital and Dr. Bill Scheels at Medical College of Wisconsin were used with permission from the operators. Thank you to Dr. Katie Dolbec and resident Dr. Jake Lehman for your help with this module.