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Advanced Sports Medicine Concepts and Controversies

The Evolution of Diagnostic and Interventional Ultrasound in Sports Medicine

Jonathan T. Finnoff, DO

Abstract

Diagnostic and interventional ultrasound is a rapidly evolving field in sports medicine. The use of ultrasound has increased exponentially during the past decades. This imaging modality is appealing to sports medicine physicians because of its broad diagnostic and interventional capabilities. In sports medicine, the indications for diagnostic ultrasound extend well beyond the musculoskeletal realm to include other conditions such as ocular trauma, thoracoabdominal trauma, and cardiac morphology. Thus, the term "sports ultrasound" has been adopted as a more accurate representation of the broad and unique applications of ultrasound in this specialty. Ultrasound-guided procedures also have evolved from the commonly performed joint and tendon sheath injections to include ultrasound-guided surgical procedures. This article will discuss the evolution of diagnostic and interventional ultrasound in sports medicine using a case-based approach to highlight its many new applications.

Introduction

Diagnostic ultrasound uses sound waves to create a picture of soft-tissue structures and bony surfaces. This is accomplished by first generating an electric impulse in the base unit. The electrical impulse travels from the base unit to the transducer, where it is converted by crystal elements, located at the end of the transducer, into a sound wave via the reverse piezoelectric effect. The sound wave travels from the end of the transducer, through a conduction medium (eg, ultrasound gel) into the patient's body. As sound waves travel through the patient's body, some of the sound waves are reflected back towards the transducer at tissue interfaces, whereas others pass into deeper tissues and are absorbed. The reflected sound waves that travel back to the transducer are converted by the crystal elements in the transducer into an electrical impulse by the crystal elements via the piezoelectric effect. The ultrasound machine's microprocessor evaluates the electrical impulse, assigns it a shade of gray based upon the strength of the reflected sound wave (ie, strong reflection = light shade of gray, weak reflection = dark shade of gray), and a location on the ultrasound screen based upon the time it took for the sound wave to travel to and from the site of reflection within the patient's body. This results in the image seen on the ultrasound screen.

The pictures generated by ultrasound are exquisite. They provide greater-resolution images of relatively superficial soft-tissue structures than any other soft-tissue diagnostic imaging modality, including magnetic resonance imaging (MRI) (Figure 1) [1,2]. Furthermore, the significance of the dynamic capabilities of diagnostic ultrasound cannot be underestimated (Figure 2, Video 1). It not only enables clinicians to identify previously unrecognized pathology, it also enables the guidance of procedures. Although ultrasound-guided procedures initially involved predominantly joint and soft-tissue injections, they have evolved to include ultrasound-guided microsurgical procedures, and the boundaries of how ultrasound can be used continue to be expanded.

During the past decade, the frequency with which ultrasound has been used to evaluate musculoskeletal conditions has increased dramatically [3]. However, when used appropriately, ultrasound can actually lead to substantial reductions in health care costs. Parker et al [4] estimated that replacing MRI with ultrasound for the evaluation of specific shoulder pathology would save the United States $6.9 billion in health care costs

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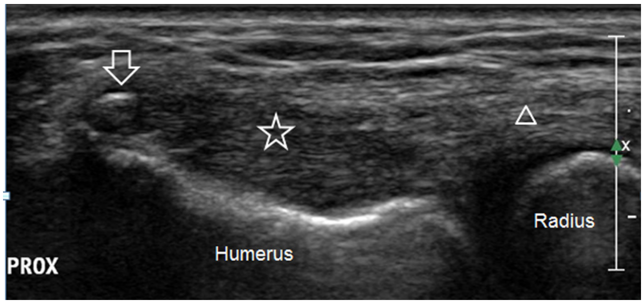

Figure 1. Ultrasound image of lateral epicondylopathy. Note the thickened, hypoechoic, and heterogeneous proximal common extensor tendon (white star) with an intra-tendinous calcification (open white arrow). The tendon develops a more normal fibrillar, hyperechoic, and homogenous appearance distally (white triangle) as it crosses over the radial head (radius). PROX, proximal; Humerus, lateral epicondyle of the distal humerus; Radius, radial head of the proximal radius. Top of picture, superficial. Bottom of picture, deep. Left of picture, proximal. Right of picture, distal. (Used with permission from the Mayo Foundation for Medical Education and Research. All rights reserved.)

between 2006 and 2020. Furthermore, Middleton et al [5] found patients preferred diagnostic ultrasound to MRI for the evaluation of shoulder problems. The Institute for Healthcare Improvement has developed an initiative referred to as the *Triple Aim* [6], the goals of which are to improve patient experience, improve population health, and lower health care costs. Ultrasound has all of the elements required to meet this triple aim.

Ultrasound has become an integral part of sports medicine. Initially, sports medicine physicians embraced the musculoskeletal and interventional applications of ultrasound because of the propensity for athletes to sustain musculoskeletal injuries such as ligament sprains, muscle strains, and contusions. However, the potential applications of ultrasound within sports medicine are much broader than just musculoskeletal. Therefore, the American Medical Society for Sports Medicine recently proposed changing the name of ultrasound used within sports medicine from "musculoskeletal ultrasound" to "sports ultrasound" to reflect the broader applications of this imaging modality.

In this article, I will use several informative and thought-provoking vignettes to illustrate some of the applications of sports ultrasound in clinical practice. Hopefully, this information will expand your knowledge of the potential applications of sports ultrasound and stimulate you to either begin using sports ultrasound in your office (after completing appropriate education and training), or to continue to apply it in a thoughtful and appropriate manner to enhance the care of your patients.

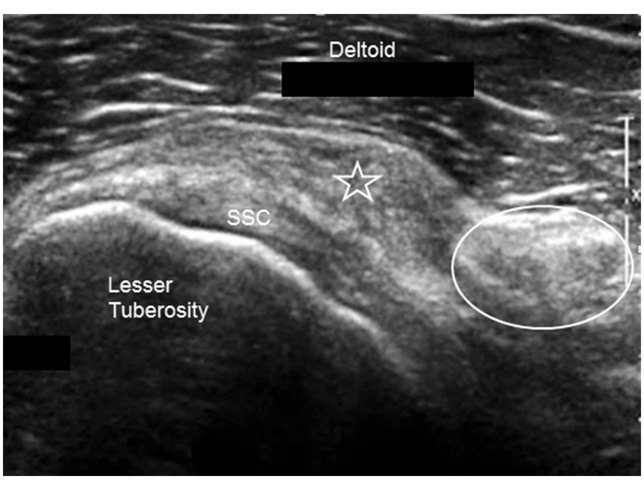

Figure 2. Still ultrasound image of the anterior shoulder to accompany Video 1. This patient had subcoracoid impingement resulting in subcoracoid bursopathy (white star) that would snap under the conjoint tendon (white circle) during shoulder internal and external rotation. SSC, subscapularis tendon. Top of picture, superficial. Bottom of picture, deep. Left of picture, lateral. Right of picture, medial. (Used with permission from the Mayo Foundation for Medical Education and Research. All rights reserved.)

Scenario 1

A 24-year-old female track athlete presents to your clinic with the chief complaint of right leg pain. The pain had an insidious onset 1 year previously during the summer when training for a marathon. The pain was a deep, aching pain that encompassed the entire leg below her knee. The pain would begin after approximately 2 miles of running and gradually increase to a 10/10 in severity, necessitating cessation of running. Within 10-20 minutes of discontinuing running, her symptoms would completely resolve. At rest, she was asymptomatic. She had been seen by a physician previously, and the work-up included a radiograph and MRI of her leg, both of which were unrevealing. Pre- and postexercise compartment pressure testing in all 4 leg compartments was normal. Previous treatments included activity modification; an appropriate physical therapy program including a running analysis, manual therapy, and addressing kinetic chain abnormalities and strength and flexibility imbalance; a 2-week course of nonsteroidal anti-inflammatory medications; and intermittent use of heat and ice. Despite these measures, she continued to have symptoms every time she ran.

When examining her, you astutely note that she has a decrement in her dorsalis pedis and posterior tibial artery pulses with active ankle plantar flexion or passive ankle dorsiflexion with her knee in full extension. You perform a diagnostic ultrasound of her popliteal fossa. There is a normal anatomic relationship between the musculature of the popliteal fossa and the neurovascular structures, but popliteal artery entrapment maneuvers (ie, active ankle plantar flexion or passive ankle dorsiflexion with her knee in full extension) completely obliterate her popliteal artery and vein beneath the soleal arch (Video 2). These findings are

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