5-2019

The Echogenic Appearance of the Diabetic Deltoid Muscle on Shoulder Ultrasound: Is This Simply from Adipose Tissue Infiltration, Can This Appearance Predict Type 2 Diabetes and Be Used to Detect Pre-Diabetes?

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**Recommended Citation**  
Rosen, Kelli and Soliman, Steven B, "The Echogenic Appearance of the Diabetic Deltoid Muscle on Shoulder Ultrasound: Is This Simply from Adipose Tissue Infiltration, Can This Appearance Predict Type 2 Diabetes and Be Used to Detect Pre-Diabetes?" (2019).  
*High Value Care*. 4.  
The Echogenic Appearance of the Diabetic Deltoid Muscle on Shoulder Ultrasound:
Is This Simply from Adipose Tissue Infiltration, Can This Appearance Predict Type 2 Diabetes and Be Used to Detect Pre-Diabetes?

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Introduction - Ultrasound and Diabetes

- Musculoskeletal ultrasound (MSK US) use has significantly increased over the past two decades\(^1\)
  - Particularly for evaluation of pain and rotator cuff pathology\(^2,3\)

- Lower cost, accessibility, and dynamic capabilities with the opportunity for direct patient care are reasons it has become the modality of choice at multiple institutions

- Approximately 9.4% of the U.S. population and 382 million people globally are affected by diabetes\(^4\)

- Age related rotator cuff degeneration is more common in diabetics\(^14\)
Reversal of the Deltoid Muscle to Rotator Cuff Tendon Gradient

Figure 1: US images of the shoulder in the modified long axis

Image A: Normal gradient of the hypoechoic deltoid muscle to the hyperechoic supraspinatus tendon

Image B: Reversal of the normal gradient in a type 2 diabetic patient

D - Deltoid, S - Supraspinatus, H - Humerus
Methods

**Subjects:** Retrospective chart review of patients having undergone shoulder ultrasound from 2005-2017
- 124 type 2 diabetics, 13 pre-diabetics, 49 obese non-diabetics

**Sonographic Evaluation:** De-identified images of diabetic, pre-diabetic, and obese non-diabetics were randomly ordered by a radiologist not involved in the blinded review.
- Single short-axis image of the deltoid muscle overlying the anterior proximal humerus at the level of the bicipital groove

**Blinded Image Review:** IRB approval was obtained
- Two MSK radiologists blindly reviewed 186 US images of the deltoid muscle and using deltoid muscle echogenicity as criteria, assigned each patient to one of three categories: normal, suspected diabetes, or definite diabetes
- In the event of a discrepancy, a third MSK radiologist served as arbitrator
Results- Diabetic Patients

- Consensus diagnosis of ‘definite diabetes’, based on a hyperechoic deltoid muscle on US, proved a powerful predictor of positive diabetes status
  - 89% positive predictive value
    - 70 of 79 ‘definite diabetes’ diagnoses accurate
  - 77% sensitivity
    - 106 of 137 diabetics designated ‘suspected’ or ‘definite diabetes’

- A hyperechoic deltoid muscle on US was also a powerful predictor of pre-diabetes
  - 100% sensitivity
    - 13 of 13 pre-diabetics given consensus diagnosis of ‘suspected diabetes’ or ‘definite diabetes’
  - 77% sensitivity
    - 10 of 13 pre-diabetics were given a ‘definite diabetes’ designation
Figure 5: Diabetes Sensitivity

- Definite & Suspected Diabetes: 77%
- Normal: 23%

106 of 137 diabetics designated ‘suspected’ or ‘definite diabetes’
Results- Obese Non-Diabetic Patients

- MSK radiologists appropriately withheld diagnosis of ‘definite diabetes’ in obese non-diabetic patients
  - 82% specificity
    - 40 of 49 obese non-diabetics accurately characterized as not having ‘definite diabetes’

- BMI cannot solely explain the hyperechoic deltoid muscle on US
Discussion - Ultrasound to Diagnose Diabetes, Pre-Diabetes?

- First large study demonstrating increased echogenicity of the deltoid muscle as a strong predictor of type 2 diabetes
- With increasing utilization of MSK US, there is new opportunity for detection of undiagnosed type 2 diabetes
  - Nearly one in four diabetic individuals in America are left undiagnosed\(^4\)
  - Anecdotally, at our institution this has resulted in new diagnoses of diabetes

- Study showed that increased echogenicity of the deltoid muscle can be used to detect early insulin resistance or pre-diabetes
  - An estimated 84.1 million American adults are pre-diabetic
    - 90% are completely unaware of their pre-diabetic status\(^4,10\)
    - Earlier identification could help delay or halt progression of disease
Discussion- Adipose Infiltration, Glycogen Storage

- Studies have shown that diabetic individuals are more likely to be obese, have increased adipose infiltration of muscle, and decreased intramuscular glycogen levels\(^{34}\).

- Glucose (glycogen) in the liver and muscles is the body’s primary source of energy and aids in prevention of hypoglycemia. Insulin regulates glycogen storage and synthesis.

- Muscle is believed to represent the principal site of insulin resistance in type 2 diabetics\(^{32,33}\).

- Studies have shown that US can be used to detect adipose infiltration and glycogen depletion in muscle\(^{16-18,23}\).

- Despite these confounders, our study demonstrates increased echogenicity is more pronounced in type 2 diabetics whether non-obese or obese.
Conclusion

▪ The hyperechoic US appearance of the deltoid muscle is a strong predictor of type 2 diabetes and early insulin resistance (pre-diabetes)

▪ Limitations include reliance on subjective determination of deltoid muscle echogenicity
  - A fact mitigated by the use of three MSK radiologists

▪ Decreased intramuscular glycogen due to insulin resistance is the likely cause of the hyperechoic appearance of the deltoid muscle

▪ Additional questions arise regarding appropriate time to initiate treatment for pre-diabetes in the presence of this sub-clinical finding