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Computed tomography evidence of psoas muscle atrophy without concomitant tendon wasting in early sepsis

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ARTICLE INFO

Article history:
Received 22 November 2017
Received in revised form
22 August 2018
Accepted 6 September 2018
Available online xxx

Keywords:
Morphomics
Tendon
Sarcopenia
Sepsis
ICU-acquired weakness

ABSTRACT

Background: Morphomic studies have demonstrated a correlation between sarcopenia and clinical outcomes in septic patients. However, tendon morphomics has not yet been studied in this context. The purpose of the present study was to evaluate tendon morphology in septic patients through analytic morphomics. We hypothesized that morphomic analyses would reveal concomitant muscle and tendon wasting in sepsis patients. The results of this study may help to implement different rehabilitation modalities for critically ill patients.

Materials and methods: The volume and fat content of bilateral psoas muscles and tendons were measured on abdominal computed tomography scans of 25 ICU septic and 25 control trauma patients admitted to the University of Michigan between 2011 and 2012. Univariate and multivariate analyses were performed to determine the relationship between psoas muscle and tendon morphometric data, and the association with clinical variables such as smoking and comorbidities.

Results: Average psoas muscle volume was 12.21 ± 5.6 cm^3 for control patients and 9.318 ± 3.3 cm^3 in septic patients ($P = 0.0023$). The average psoas muscle/fat ratio for septic patients was 0.0288 ± 0.071 cm^3, compared with 0.0107 ± 0.008 cm^3 in the control group ($P = 0.075$). Average tendon volume in the septic population (0.508 ± 0.191 cm^3) was not different than the control cohort (0.493 ± 0.182 cm^3) ($P = 0.692$).

Conclusions: Our results demonstrate significantly smaller psoas muscle volume in septic patients than in age-, gender-, and BMI-matched trauma patients but no demonstrable change in tendon morphology between patient groups. These findings begin to define the boundaries of clinical application within the field of morphomics.

Introduction

Muscle wasting in the acutely ill has become a well-established and extensively studied phenomenon[1-4] that is estimated to occur in 50%-100% of septic ICU patients.[5-9] The severity of sarcopenia has been shown to be both a marker for overall patient health status as well as a predictor of patient outcomes.[6,10-13] The biochemical mechanisms behind the

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0022-4804/$ – see front matter
https://doi.org/10.1016/j.jss.2018.09.010

physiology of muscle wasting in acute illness are complex and multifactorial.[1-4,14,15] Acute systemic illness leads to inflammation and metabolic derangements resulting in dysregulation of protein metabolism with increased protein degradation and decreased protein synthesis.[3] Moreover, the loss of muscle mass has also been repeatedly associated with increased intramuscular fatty accumulation.[16-18]

While the clinical implications of muscle wasting and ICU-acquired weakness are well established, tendon morphology in these acutely ill patients has thus far been unexplored. The tendon attached to the terminal aspect of a sarcopenic muscle (i.e., the psoas major muscle) are subject to the same inflammatory cytokines and metabolic derangements of acute illness and it is therefore reasonable to surmise that tendon tissues would also be adversely affected. In addition, cell scleraxis lineage found in high densities in tendon tissues, have been implicated in both muscle fibrosis and atrophy.[19] Findings of tendon degradation or atrophy in septic patients could have significant implications with development of ICU mobility protocols or rehabilitative efforts. For example, muscle health is often optimized with movement, weight bearing, and exercise, whereas tendon injury is typically treated with weight-bearing relief, immobilization, and rest. If both muscle and tendon are found to be adversely affected in an acutely ill patient, one might consider reformatting therapeutic or rehabilitative efforts.

Morphomics has recently emerged as a technique for measuring morphological characteristics of biological systems in three-dimensional space.[20-23] This measurement tool was first used as a predictor of patient outcomes based on the quantification of trunk muscle area using computed tomography (CT) scans. Specifically, the psoas major muscle volume has since been shown to be a predictor of patient functional status, postoperative morbidity, length of stay, cost of care, and overall mortality for surgical patients.[10,24-26] Morphomics has subsequently been used in a variety of clinical contexts with applications across the pediatric,[27] geriatric,[28] oncologic,[29-32] endocrinologic,[33] and nutrition[26] literature. Muscle volume, muscle density, visceral fat, subcutaneous fat, body fat content, vessel calcification, trabecular, and cortical bone density have all been studied with this method. However, morphomic analysis of tendons has not yet been examined.

The purpose of the present study was to evaluate tendon morphology septic patients through analytic morphomics. Through evaluation of psoas major muscle and psoas major tendon in both septic and healthy patients, we set to examine for concomitant muscle and tendon wasting in acute illness. We hypothesized that morphomic analyses would reveal concomitant muscle and tendon wasting in sepsis patients. The results of this study may help to implement earlier or different rehabilitation modalities for critically ill patients.

Methods

This study was approved by the University of Michigan Institutional Review Board, allowing access to any CT scan performed retrospectively on patients for trauma and nontrauma indications within the University of Michigan Health System. Informed consent was waived by the Institutional Review Board.

Patient enrollment

A sepsis patient cohort was selected from a group of adult patients admitted to the University of Michigan Surgical Intensive Care Unit with sepsis between July 2011 and June 2012. Patients with CT scan of the abdomen and pelvis obtained 0-25 d after ICU admission were included in the study. Patients were excluded if there was incomplete or temporally inappropriate imaging. Control patients were selected from a group of blunt trauma patients admitted from January 2011 to September 2012. Blunt trauma patients were included in the control cohort as these individuals are likely to represent a healthy member of the general population as well as have an abdominal CT scan on admission.

On first examination of our database, a total of 35 septic patients met inclusion criteria. Thirty-five blunt trauma patients admitted to UMHS with comprehensive CT imaging within 24 h of admission were included as control patients. Patients were excluded from the control cohort if they had a personal history of sepsis or if they were victim of penetrating or musculoskeletal trauma that would preclude accurate morphometric measurements.

The characteristics of the initial patient cohorts ($n = 35$) are presented in Table 1. Morphomic analysis in revealed dramatic differences in both psoas muscle volume and psoas

Table 1 – Summary of patient demographic and clinical data with $n = 35$ in each group.

	Control patients ($n = 35$)	Sepsis patients ($n = 35$)	*P* value
Men	23 (65.7%)	18 (51.4%)	0.3319
Age	42.6 ± 17.94	59.25 ± 18.57	0.0003*
BMI (kg/m^2)	26.31 ± 7.17	27.60 ± 6.34	0.4280
Smoking history	7 (20.0%)	20 (57.1%)	0.0029*
No. of comorbidities			
0	16 (45.7%)	6 (17.1%)	
1	13 (37.1%)	16 (45.7%)	
2 +	6 (17.1%)	13 (37.1%)	

Patient cohorts were not age or gender matched. Malignancy, diabetes, COPD, kidney disease, heart disease, liver disease, hypertension, and hyperlipidemia were included as comorbidities in this analysis.
* Denotes statistical significance.