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Temporalis muscle morphomics: the psoas of the craniofacial skeleton

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ABSTRACT

Background: The psoas muscle has been shown to predict patient outcomes based on the quantification of muscle area using computed tomography (CT) scans. The accuracy of morphomic analysis on other muscles has not been clearly delineated. In this study, we determine the correlation between temporalis muscle mass, psoas muscle area, age, body mass index (BMI), and gender.

Methods: Temporalis and psoas muscle dimensions were determined on all trauma patients who had both abdominal and maxillofacial CT scans at the University of Michigan between 2004 and 2011. Age, BMI, and gender were obtained through chart review. Univariate and multivariate analyses were performed to determine the relative relationship between morphomic data of the temporalis and psoas muscles and the ability of such information to correspond with clinical variables, such as BMI, age, and gender.

Results: A total of 646 patients were included in the present study. Among the 249 (38.5%) women and 397 (61.5%) men, the average age was 49.2 y. Average BMI was 27.9 kg/m^2. Total psoas muscle area directly correlated with mean temporalis muscle thickness ($r = 0.57$, $P < 0.001$). There was an indirect correlation between age and psoas muscle area ($r = -0.52$, $P < 0.001$) and temporalis muscle thickness ($r = -0.36$, $P < 0.001$). Neither psoas nor temporalis measurements correlated strongly with BMI ($r = 0.18$, $P < 0.001$; $r = 0.14$, $P = 0.002$), although stronger correlations were found in a more "frail," subgroup as defined by a BMI of <20 ($r = 0.59$, $P = 0.002$).

Conclusions: We demonstrate that dimensions of the temporalis muscle can be quantified and may serve as a proxy for age. Going forward, we aim to assess the utility of temporalis and psoas morphomics in predicting complication rates among trauma patients admitted to the hospital to predict outcomes in the future.

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1. Introduction

Although the ability to treat illness in recent years has advanced significantly because of evolving technology and novel management strategies, the ability to predict surgical outcomes remains unchanged. Better predictive strategies are necessary to optimize outcomes for patients to determine which patients will benefit most from a particular treatment strategy. The ability of a patient to tolerate a surgical procedure is oftentimes assessed according to the overall appearance of a patient as it correlates with the judgment of a physician in terms of how debilitated or robust a particular individual may be. As physicians, we may note temporalis wasting, but do not have an objective methodology to quantify this wasting. It is obvious that such determinations lack objective methods of quantification, but it is also true that we do not have a valid assessment of the predictive accuracy of even objective data including laboratory values, such as albumin and body mass index (BMI). The term "frailty" is often used to indicate those patients who suffer from chronic diseases or conditions that affect their global state of health and serves as one of the most objective criteria available today to predict postsurgical outcomes [1]. Sarcopenia has been used as a measure of frailty because of its correlation with chronic disease states, malnutrition, and aging [2–8]. Use of muscle size as determined by perioperative computed tomography (CT) scans as a measure of sarcopenia has been found to be an accurate measure of frailty. The accuracy of this finding using the psoas muscle specifically has been well established within populations consisting of general surgery and vascular surgery patients [9–13].

The use of morphometric analysis to predict patient outcomes, however, should not be taken for granted, given that it is incorrect to assume that all muscles correlate reliably with clinical variables. For example, Anderson *et al*. demonstrate that trunk muscle attenuation on CT scan decreases with age because of increased fat accumulation but that attenuation of the paraspinal and abdominal muscles occurs to a much greater extent compared with other muscles [14]. Furthermore, because it is known that trunk muscle attenuation correlates much better with functional capacity compared with thigh muscle attenuation, it would be incorrect to use thigh muscle morphomics in clinical scenarios requiring an accurate measurement of frailty.

Although psoas muscle morphomics provide accurate assessments of the level of frailty of an individual, the use of just this muscle poses practical limitations to its application. In a patient admitted for management of an isolated head trauma with comorbidities that make it difficult to determine operative outcomes, is it cost-efficient, necessary, and safe to obtain an abdominal CT scan just to assess total psoas muscle area? The solution to this dilemma rests on the examination of other muscles and their underlying characteristics to create an index to optimize the practicality of morphomic analyses.

Similar to the psoas muscle, the temporalis muscle has also been shown to predict patient outcomes, such as number of days on the ventilator, in the ICU, and in the hospital in pediatric craniofacial and mandibular fracture patients [15,16]. The generalizability of these studies documenting the importance of the temporalis muscle is limited by small sample sizes and the presence of very specific pathologies present within the populations included in each study. The question still remains as to how predictive the psoas and temporalis muscles are within a more general population after accounting for variations in age, gender, BMI, and patient factors.

The purpose of the present study is to examine the relationship between temporalis and psoas muscle morphomics to improve our ability to use morphomic analysis in a standardized and more generalized fashion to predict frailty. Additionally, we evaluate variations in the psoas and temporalis muscles with age, BMI, and gender and assess the predictive relationships between these demographic variables to ultimately create an index to facilitate preoperative risk stratification in applicable patient populations.

2. Methods

All adult trauma patients admitted to the University of Michigan Health system between 2004 and 2011 were enrolled in this retrospective review after approval by the University of Michigan Institutional Review Board was obtained. Age, gender, BMI, and serum albumin levels were obtained for all patients. A total of 646 patients had CT scans of the abdomen and pelvis and head that were performed within 24 h of initial presentation.

2.1. *Temporalis muscle image processing*

Cross-sectional area of the temporalis muscle was obtained from CT scans of the head in a standardized fashion using the zygomatic arch, internal acoustic meatus, and supraorbital rim as landmarks. After creation of a three-dimensional image of the temporalis muscle using these specific points with image analysis and engineering software, the thickest portion of the muscle was used to calculate relative temporalis muscle area, thickness, and volume. These scans were processed using algorithms programmed in MATLAB (Natick, MD) as documented in previous studies [9–13,15] (Fig. 1).

2.2. *Psoas muscle image processing*

Using CT scans of the abdomen and pelvis, cross-sectional area of the right and left psoas muscles was obtained using MATLAB v13.0 as described in previous section. Vertebral levels were used as landmarks. The psoas muscle in its entirety on transverse sections at the L4 level was outlined bilaterally. The marked area was then used to calculate total psoas area (TPA) (Fig. 1).

2.3. *Statistical analysis*

Continuous variables were summarized using means and standard deviations, and categorical variables were characterized by frequency. The relative relationship between TPA, temporalis muscle dimensions, and patient factors was assessed using standard linear regression techniques. As all