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## Paraspinous muscle as a predictor of surgical outcome



Leah D. Canvasser, BS,<sup>\*</sup><sup>1</sup> Alyssa A. Mazurek, BS,<sup>1</sup> David C. Cron, BS,  
Michael N. Terjimanian, MS, Eric T. Chang, MD, Chris S. Lee,  
Mitchell B. Alameddine, Jake Clafin, Elyse D. Davis,  
Tucker M. Schumacher, Stewart C. Wang, MD, PhD,  
and Michael J. Englesbe, MD

Morphomic Analysis Group, Department of Surgery, University of Michigan, Ann Arbor, Michigan

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### ABSTRACT

**Background:** Objective measures for preoperative risk assessment are needed to inform surgical risk stratification. Previous studies using preoperative imaging have shown that the psoas muscle is a significant predictor of postoperative outcomes. Because psoas measurements are not always available, additional trunk muscles should be identified as alternative measures of risk assessment. Our research assessed the relationship between paraspinous muscle area, psoas muscle area, and surgical outcomes.

**Methods:** Using the Michigan Surgical Quality Collaborative database, we retrospectively identified 1309 surgical patients who had preoperative abdominal computerized tomography scans within 90 d of operation. Analytic morphomic techniques were used to measure the cross-sectional area of the paraspinous muscle at the T12 vertebral level. The primary outcome was 1-y mortality. Analyses were stratified by sex, and logistic regression was used to assess the relationship between muscle area and postoperative outcome.

**Results:** The measurements of paraspinous muscle area at T12 were normally distributed. There was a strong correlation between paraspinous muscle area at T12 and total psoas area at L4 ( $r = 0.72$ ,  $P < 0.001$ ). Paraspinous area was significantly associated with 1-y mortality in both females (odds ratio = 0.70 per standard deviation increase in paraspinous area, 95% confidence interval 0.50–0.99,  $P = 0.046$ ) and males (odds ratio = 0.64, 95% confidence interval 0.47–0.88,  $P = 0.006$ ).

**Conclusions:** Paraspinous muscle area correlates with psoas muscle area, and larger paraspinous muscle area is associated with lower mortality rates after surgery. This suggests that the paraspinous muscle may be an alternative to the psoas muscle in the context of objective measures of risk stratification.

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<sup>\*</sup> Corresponding author. Morphomic Analysis Group, University of Michigan, 1150 W. Medical Center Dr, Med Sci 1 – SPC 5677, Ann Arbor, MI 48109 5677. Tel.: +1 734 647 7173; fax: +1 734 764 7173.

E-mail address: [lecan@med.umich.edu](mailto:lecan@med.umich.edu) (L.D. Canvasser).

<sup>1</sup> Authors contributed equally to this study.

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## 1. Introduction

Surgical risk stratification informs appropriate titration of care. Current methods for quantifying preoperative risk are subjective and poorly discriminated between patients. Many surgeons rely on the “eyeball test”—a general assessment of a patient’s physiological reserve. Measures of performance status or functional status strongly correlate with surgical outcomes, but may not be clinically relevant (because of the time they take to perform and their subjectivity) and have not been widely adopted for risk stratification. [1,2] Preoperative imaging can inform risk stratification. Using the novel approach of analytic morphomics, components of the “eyeball test” can be objectively quantified, potentially informing risk stratification for those undergoing surgical procedures.

Within this context, our previous work has correlated sarcopenia with surgical outcomes following major general, vascular, and transplant surgery [3–7]. The working definition of sarcopenia is a muscle wasting condition that is often associated with aging. Sarcopenic patients are often frail and have increased disabilities and comorbidities. The combination of these qualities often results in inferior health outcomes for sarcopenic individuals. This syndrome may make it more difficult for surgical patients to tolerate postoperative healing [8–10]. We have previously measured sarcopenia with the psoas muscle at the L4 vertebral level. This was chosen because it is easy to measure and is present on all lower abdominal cross-sectional images. For patients who have thoracic or upper abdominal surgery, preoperative imaging may not display the psoas muscle. Furthermore, the psoas muscle is difficult to image using ultrasound, making prospective and dynamic assessment of trunk muscle size difficult. Alternative targets for assessment of trunk muscle size are needed to expand the growing body of work linking trunk muscle size and surgical outcomes.

The paraspinous muscle is an attractive alternative to the psoas muscle for assessing trunk muscle size. The paraspinous muscles are easy to image via ultrasound and run the entire length of the thorax and abdomen. Within this context, this study evaluates the association between paraspinous muscle area and surgical outcomes. Our hypothesis is that the paraspinous muscle at the T12 vertebral level will correlate with the psoas muscle at the L4 vertebral level and that patients with larger paraspinous muscles will demonstrate better surgical outcomes compared with those with smaller paraspinous muscles. To address this hypothesis, we examined the 1-y mortality rates of patients undergoing elective, inpatient surgical procedures at the University of Michigan.

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## 2. Methods

This study was approved by the Institutional Review Board at the University of Michigan. Our cohort included general and vascular surgery patients within the Michigan Surgical Quality Collaborative (MSQC) database who had surgery at the University of Michigan between 2006 and 2011. The MSQC data collection methods are well-described elsewhere. [11,12] For our study, patients were excluded if they had outpatient or

emergency surgical procedures. The study population was further limited to patients who had an abdominal or thoracic computerized tomography (CT) scan within 90 d before surgery. The MSQC database has standard definitions for comorbidities and complications. Data collection is audited by the MSQC. All clinical data were collected by a full-time nurse reviewer.

Paraspinous muscle area is defined as any muscle contained within the region posterior to the spine and ribs, and no more lateral than the lateral-most edges of the erector spinae muscles. Patient CT scans were processed by the following steps using semiautomated algorithms in MATLAB version 13.0 (MathWorks, Natick, MA). Initially, scans were labeled at each vertebral level to provide anatomic landmarks for subsequent measurements. Next, a posterior muscle line was drawn on abdominal and thoracic slices separating muscle from subcutaneous fat. Points were placed at the lateral-most clefts of the erector spinae muscle. An area was mapped out between these points, the central point of the spinal canal and the posterior muscle line. Within this region, paraspinous muscle area was calculated based on density thresholds. We chose paraspinous muscle area at the T12 level to be our primary measurement as it is protocolled for both thoracic and abdominal scans. Total psoas area was also measured as described in our previous work. [13] Briefly, a transverse slice of L4 was used to outline the psoas muscles. This enclosed area was computed as the total psoas area.

The relationship between paraspinous muscle area, psoas muscle area, and postoperative mortality (1 y) was assessed. We have chosen 1-y mortality in this research study, and historically in other work affiliated with Englesbe *et al.* [4–6] because we have postulated that trunk musculature is a measure of physiologic reserve. Therefore, by accounting for mortality a year after the surgical event we are looking at populations that have not only had positive surgical outcomes but tolerated the postoperative course and rebounded to a state of stable health. Descriptive statistics were computed for the study population. Continuous variables were summarized by mean and standard deviation and compared using a Student t-test. Categorical variables were summarized with frequency tables and compared using Fisher exact test. For comparison, patients were divided into sex-stratified tertiles of paraspinous area and total psoas area. Univariate logistic regression was used to identify potential predictors of mortality. Multivariate logistic regression was then applied to identify factors independently associated with 1-y mortality. All candidate predictors (threshold  $P \leq 0.20$ ) from the univariate analysis were entered into the logistic regression analysis, and backward stepwise selection was used to determine a subset of adjustment covariates. Age was kept in the models regardless of statistical significance, and regression models were performed separately for each sex. For regression analysis, muscle measurements were standardized to facilitate interpretation. Area under the receiver operating characteristic (AUROC) was used to compare the predictive ability of paraspinous area and total psoas area.

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## 3. Results

There were 1309 patients who underwent elective, inpatient general or vascular surgery procedures and fulfilled our

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