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## Cross-sectional area of the abdomen predicts complication incidence in patients undergoing sternal reconstruction

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### ABSTRACT

**Background:** Sternal reconstruction with vascularized flaps is central to the management of sternal wound infections and mediastinitis but carries a high risk of complications. There is a need to identify reliable predictors of complication risk to help inform patients and clinicians in preparation for surgery. Unfortunately, body mass index and serum albumin may not be reliable predictors of complication rates. Analytic morphomics provides a robust quantitative method to measure patients' obesity as it pertains to their risk of complications in undergoing sternal reconstruction.

**Methods:** We identified 34 patients with preoperative computed tomography scans of the abdomen from a cohort of sternal reconstructions performed between 1997 and 2010. Using semiautomated analytic morphomics, we identified the patients' skin and fascia layers between the ninth and 12th thoracic spine levels; from these landmarks, we calculated morphomic measurements of the patients' abdomens, including their total body cross sectional area and the cross sectional area of their subcutaneous fat. We obtained the incidence of complications from chart review and correlated the incidence of complications (including seroma, hematoma, recurrent wounds, mediastinitis, tracheostomy, and death) with patients' morphomic measurements.

**Results:** Sixty-two percent of patients ( $n = 21$ ) suffered complications after their operation. Those who suffered from complications, relative to those who did not have complications, had increased visceral fat area (12,547.2 mm<sup>2</sup> versus 6569.9 mm<sup>2</sup>,  $P = 0.0080$ ), subcutaneous fat area (16,520.2 mm<sup>2</sup> versus 8020.1 mm<sup>2</sup>,  $P = 0.0036$ ), total body area (91,028.6 mm<sup>2</sup> versus 67,506.5 mm<sup>2</sup>,  $P = 0.0022$ ), fascia area (69,238.4 mm<sup>2</sup> versus 56,730.9 mm<sup>2</sup>,  $P = 0.0118$ ), total body circumference (1101.8 mm versus 950.2 mm,  $P = 0.0017$ ), and fascia circumference (967.5 mm versus 868.1 mm,  $P = 0.0077$ ). We also demonstrated a significant positive correlation between the previously mentioned morphomic measurements and the incidence of complications in multivariate logistic regression models, with odds ratios ranging from 1.19–3.10 ( $P$  values ranging from 0.010–0.022).

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**Conclusions:** Increases in abdominal morphomic measurements correlate strongly with the incidence of complications in patients undergoing sternal reconstruction. This finding may influence preoperative risk stratification and surgical decision making in this patient population.

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## 1. Introduction

The median sternotomy is an essential surgical approach for many cardiac and thoracic operations. Many of the patients who require cardiothoracic surgery through a median sternotomy are those patients who are already at an increased risk of developing surgical complications. Complications after median sternotomy have severe repercussions for patient outcomes. Sternal wound infections are one such serious complication and can lead to dehiscence of the sternal wound [1]. Dehiscence is a serious complication occurring in 0.2%–5% of all median sternotomy cases [2–5]. Obese patients are, in particular, at increased risk for infection and dehiscence after median sternotomy, although not all obese patients will experience these complications [5–9]. For this reason, it is crucial to find more precise ways to stratify these patients by their surgical risk.

Aggressive debridement of nonviable tissues followed by reconstruction using vascularized flaps is a common technique for the management of sternal wound infection resulting in dehiscence. This surgical approach has resulted in a decrease in infections and mortality in this patient population [10]. However, the operation remains one relatively fraught with complications. One study found that the rate of reoperation for complications—including infection, dehiscence, and tissue necrosis—in flap repairs for sternal reconstruction is nearly 20%. They found that diabetes mellitus, hypertension, and congestive heart failure are significant predictors of the aforementioned complications of sternal reconstruction [11].

There is a paucity of research; however, linking increased abdominal fat specifically to clinical outcomes in sternal reconstruction, rather than obesity measured by body mass index (BMI). In this study, we apply morphomic analysis, the measurement of patient anatomy from routine preoperative computed tomography (CT) scans, to identify patient morphologic characteristics that correlate with a higher risk of surgical complications in this patient population.

## 2. Methods

### 2.1. Study population

After receiving Institutional Review Board approval, a comprehensive retrospective electronic medical record review was conducted on all patients who underwent sternal reconstruction at the University of Michigan Health System between 1997 and 2010. Only patients who had an abdominal CT scan related to their preoperative evaluation were included in this study; these scans were not performed for the sole purpose of this study. We identified a total of 34 patients who

underwent sternal reconstruction with vascularized flaps and received preoperative abdominal CT scans. Patient demographics, preoperative risk factors, surgical indications, operative technique and details, and postoperative complications including recurrence rates were obtained from the clinical records. Follow-up data were extracted from analysis of office charts, hospital and outpatient electronic medical records, and postoperative abdominal CT scans.

### 2.2. Recurrence and complication assessment

Complications in this cohort of patients included, but were not limited to, seroma, hematoma, infections, recurrent wounds, mediastinitis, tracheostomy, and death. Sternal wound recurrences after reconstruction were recorded only if unequivocally documented through imaging studies or physical examination by a plastic surgeon, general surgeon, or emergency room physician. Infection was recorded only if documented by a plastic or general surgeon and required the presence of surrounding cellulitis or a purulent discharge from the wound. A chronic wound was defined as any postoperative wound requiring packing.

### 2.3. Analytic morphomics

Preoperative abdominal CT scans were processed using semi-automated algorithms programmed in MATLAB version 13.0 (The MathWorks, Inc, Natick, MA) as previously described [12–14]. These algorithms use novel, semi-automated, high-throughput techniques that we have named analytic morphomics.

The initial processing step identified individual vertebral levels on each patient's scan from T9 through T12, which served as anatomic landmarks for standardization for the subsequent analyses. The next processing step identified the *linea alba* and the anterior abdominal skin along the midline at each vertebral level from which the skin layer and fascia layer are extrapolated (Fig. 1A). We then isolated the subcutaneous (Fig. 1B) and visceral (Fig. 1C) fat portions within the total body area and fascial area by density in Hounsfield units to calculate the cross-sectional surface area of these regions.

### 2.4. Statistical analysis

We performed two-sample comparisons between patients with and without complications for age, BMI, gender, diabetes mellitus status, smoking status, and serum albumin using Student t-test. Used t-tests to compare the morphomic measures identified to describe patient obesity—the visceral fat area, subcutaneous fat area, total body area, fascia area, total body circumference, fascia circumference, body depth, and body width—between those who had complications and those

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