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Computed tomographic measurements predict component separation in ventral hernia repair

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ABSTRACT

Background: Preoperative imaging with computed tomography (CT) scans can be useful in preoperative planning. We hypothesized that CT measurements of ventral hernia defect size and abdominal wall thickness (AWT) would correlate with postoperative complications and need for complex abdominal wall reconstruction (AWR).

Materials and methods: Patients who underwent open ventral hernia repair and had preoperative abdominal CT imagining were identified from an institutional hernia-specific surgery outcomes database at our tertiary referral hernia center. Grade III and IV hernias and biologic mesh cases were excluded. CT measures of defect size and AWT were analyzed and correlated to complications and the need for AWR techniques using univariate, multivariate, and principal component (PC) analyses. PC1 and PC2 used five AWT measures, hernia defect width, and body mass index to create a new component variable.

Results: There were 151 open ventral hernia repairs included in the study. Preoperative findings included 37.7% male; age 55.3 ± 12.5 years; body mass index (BMI) 33.3 ± 7.8 kg/m^2; 60.3% were recurrent hernias with average defect width 8.5 ± 5.0 cm and area 178.3 ± 214 cm^2; AWT at umbilicus 3.5 ± 1.8 cm; and AWT at pubis 7.0 ± 3.2. Component separation was performed in 24.0% of patients and panniculectomy in 34.4%. Wound complications occurred in 13.3% patients, and 2.7% had hernia recurrence. Increasing defect width, length, and area as well as select AWT measurements were associated with increased need for component separation, concomitant panniculectomy, and higher rates of wound and total complications (all $P < 0.05$). Using multivariate regression, PC1 was associated with wound complications (odds ratio [OR], 1.08; 95% confidence interval [CI], 1.01–1.16); PC2 (hernia defect width) was associated with the need for component separation (OR, 1.16; 95% CI, 1.03–1.30). Hernia recurrence was not predicted by AWT or defect size (OR, 1.00; 95%CI, 0.87–1.15).

Conclusions: Preoperative CT measurements of hernia defects and AWT predict wound complications and the need for complex AWR techniques. Obtaining preoperative CT imaging should be a consideration in preoperative planning and may help with patient counseling.

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1. Introduction

Computed tomography (CT) as a method for measuring adipose volume of the human body has been validated and standardized since 1983 [1–3]. Studies have shown that abdominal fat, as measured by abdominal wall thickness (AWT) on CT, has a direct correlation with medical conditions associated with obesity in abdominal surgery patients; furthermore, there is an association with longer operative time and complexity in abdominal surgery. In pancreatic surgery patients, it is an independent risk factor for poor postoperative outcomes [4–7]. In colorectal surgery, amount of visceral fat and AWT increases the risk of postoperative wound complications [8]. However, no studies have evaluated the effect of AWT on patients undergoing ventral hernia repair thus far.

Obesity is a known factor for hernia recurrence and the development of wound complications after hernia repair [9–11]. Although body mass index (BMI) is a common preoperative clinical tool for evaluating obesity, it fails to account for fat distribution and quantity across different body areas [4]. Previous studies have shown that increased hernia defect width, length and especially area, as measured at the time of operation, have been associated with the need for AWR techniques and entail worse postoperative outcomes including quality of life [12]. Additionally, one study has evaluated preoperative CT scan use to predict fascial closure after open ventral hernia repair (OVHR) with component separation techniques (CSTs) and found CT measured defect width and its relative ratio to abdominal circumference to correlate highly with ability to close the abdomen [13]. Over the past decade, several strategies have been proposed for managing ventral hernias in obese patients, including staged OVHR preceded by bariatric surgery, various CSTs, panniculectomy plus OVHR, and OVHR with CST and panniculectomy [14–17]. However, no study has evaluated the correlation of preoperative CT measurements with the need for complex abdominal wall reconstruction (AWR) techniques or to clinical outcomes.

The authors hypothesized that CT measurements of AWT as well as hernia defect size may be used to predict the need for AWR procedures, wound complications, and hernia recurrence.

2. Methods

2.1. Patient population

A prospectively enrolled and collected, institutional review board–approved, hernia-specific surgical outcomes database was queried for all consenting patients undergoing OVHR at a single tertiary hernia referral center from 2008–2012. Over 50% of the patients in this database were referred from out of state or international sources. Demographics, operative details, patient outcomes, complications, hernia recurrence, and quality of life were considered. Patients with a preoperative CT scan of the abdomen and pelvis were included in the study. Patients who had a grade III or IV hernia as defined by the Ventral Hernia Working Group classification or repair with biologic mesh were excluded from the study given the significant confounding variables with contaminated wounds, open wounds, complications following, and higher recurrence rates [18]. This study was approved by the Institutional Review Board of Carolinas Medical Center, and all patients signed consent for the study.

2.2. CT measurements

Each patient's preoperative CT scan variables were measured by two blinded, independent reviewers. The CT measurements were performed by one trained reviewer and then assessed for accuracy by random selection of one in every 10 patients for remeasurement by the second reviewer. The measurements had excellent concordance for interval quality assessment of accuracy in results. Five key measurements of AWT were obtained for each patient (Fig. 1): AWT at the umbilicus (AWT umbilical—measured length from rectus abdominis fascia to the abdominal skin at the level of the umbilicus), retrorenal AWT (AWT retrorenal—measured length from the lateral external oblique fascia to the abdominal skin at the level of the left renal calyx), retrorenal fat pad thickness (retrorenal—measured length from the kidney to the transversalis fascia at the level of the left renal calyx), AWT at the level of the pubis (AWT pubis—length from the pubis to the skin at the level of the pubic symphysis), and hip girdle thickness (hip girdle—measured length from the anterior superior iliac spine to the lateral skin). In addition, hernia defect width and length were obtained at their maximum distance for each patient, and area was calculated using the area of an ellipse as previously described (Fig. 1) [13,19].

2.3. Study design and statistical analysis

The primary outcomes of interest were overall complications, the need for component separation (CS), concomitant panniculectomy, wound complications, and hernia recurrence. Descriptive statistics including means and standard deviations, or counts and percentages, were used to describe the study population on all variables. CT measurements were compared between each of the dichotomous outcome groups using Wilcoxon two-sample tests. Statistical significance was determined at $P < 0.05$, using a two-tailed alpha.

2.4. Univariate analysis of principal components

Principal component analysis (PCA) was used to create composite "principal component" (PC) scores using the six-key CT measurements and BMI. PC analysis is an advanced statistical method, which allows one to combine any number of observed variables with high intervariable correlation (redundancy) into one composite variable, which can then be used for further analysis. All PCs contain varying degrees of the following seven variables listed in Table 1: AWT umbilical, AWT retrorenal, retrorenal, AWT