Influence of body mass index on outcomes after major resection for cancer

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Background. *Evidence supporting worse outcomes among obese patients is inconsistent. This study examined associations between body mass index (BMI) and outcomes after major resection for cancer.*
Methods. *Data from the 2005–2012 ACS-NSQIP were used to identify cancer patients (≥18 years) undergoing 1 of 6 major resections: lung surgery, esophagectomy, hepatectomy, gastrectomy, colectomy, or pancreatectomy. We used crude and multivariable regression to compare differences in 30-day mortality, serious and overall morbidity, duration of stay, and operative time among 3 BMI cohorts defined by the World Health Organization: normal versus underweight, overweight-obese I, and obese II–III. Propensity-scored secondary assessment and resection type-specific stratified analyses corroborated results.*
Results. *A total of 529,955 patients met inclusion criteria; 32.06% had normal BMI, 3.45% were underweight, 32.52% overweight, and 17.76%, 7.51%, and 4.94% obese I–III, respectively. Risk-adjusted outcomes for underweight patients consistently were worse. Overweight-obese I fared similarly to patients with normal BMI but had greater odds of isolated complications. Obese II–III patients experienced only marginally increased odds of morbidity. Analyses among propensity-scored cohorts and stratified by cancer-resection type reported similar trends. Worse outcomes were observed among morbidly obese hepatectomy and pancreatectomy patients.*
Conclusion. *Evidence-based assessment of outcomes after major resection for cancer suggests that obese patients should be treated with the aim for optimal oncologic standards without being hindered by a misleading perception of prohibitively increased perioperative risk. Underweight and certain types of morbidly obese patients require targeted provision of appropriate care. (Surgery 2015;158:472-85.)*

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In the United States, more than 1 in 3 adults (34.9%; 95% confidence interval [95% CI] 32.0–37.9%), accounting for an estimated 78.6 million people, is obese.[1] Known to influence the development of heart disease, stroke, and diabetes,[2] high body mass index (BMI; ≥25 kg/m^2) has been attributed for as much as 2.5% of cancers in men,[3] 4.1% of cancers in women,[3] and 3.6% of all incident global cancer cases in adults ≥30 years.[4]

Given its association with a variety of medical comorbidities, obesity has long been considered a major risk factor for poor outcomes after surgery.[5] Faced with a highly prevalent overweight (BMI ≥ 25 kg/m^2) and obese (BMI ≥ 30 kg/m^2) population, surgical interventions for obese patients have, nevertheless, become an unavoidable reality of routine operative care. In response, a plethora of studies with conflicting results have attempted to elucidate the effect of BMI on outcomes after operative interventions.[5-16] Some suggest that obesity confers an increased risk of perioperative/postoperative complications, whereas others demonstrate a lack of significant difference for major complications when comparing obese and nonobese patients.[5-16] Similarly disputed trends have

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been reported for purported differences in operative time, duration of stay, and mortality among patients with varying extents of obesity.[5-16] Little to nothing is known about outcomes for underweight patients.

The present study examined associations between BMI and operative outcomes in a comparative assessment of patients undergoing 6 major types of resection for cancer. A nationally validated, outcomes-based research database was used to evaluate differences between BMI classifications defined by the World Health Organization (WHO)[17]; the database was used to compare patients of normal weight (18.5–24.9) with cancer patients who were (1) underweight (<18.5); (2) overweight (25.0–29.9) to obese I (30.0–34.9); and (3) obese II (35.0–39.9) to obese III (>39.9 kg/m^2).

METHODS

Data from the 2005–2012 American College of Surgeons' (ACS) National Surgical Quality Improvement Program (NSQIP) database were queried retrospectively for patients with an *International Classification of Diseases*, 9th revision, Clinical Modification, primary diagnosis of cancer undergoing 1 of 6 corresponding surgical resections defined by Current Procedural Terminology: lung surgery, esophagectomy, hepatectomy, gastrectomy, colectomy, and pancreatectomy. Included *International Classification of Diseases*, 9th revision, Clinical Modification, and Current Procedural Terminology codes stratified by resection type are presented in Table I. Considered patients were ≥18 years of age. Details of the ACS-NSQIP are available online.[18]

Information abstracted on patient demographic and clinical case-mix characteristics included: age (categorized as <50, 50–59, 60–69, 70–79, and >79 years), sex, race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, other, and not reported/unknown), functional status (independent, partially-totally dependent), American Society of Anesthesiology (ASA) classification (I–II, no-mild disturbance; III, serious disturbance; IV–V, life-threatening disturbance/moribund), albumin level (<2.5 abnormally low, ≥2.5 g/dL, not reported/unknown), diagnosis of diabetes, current smoker within 1 year, alcohol consumption (defined as >2 drinks/day in the 2 weeks before admission; yes/no/unknown), dyspnea, history of chronic obstructive pulmonary disease, history of heart disease (congestive heart failure and/or myocardial infarction), hypertension requiring medication, previous cardiac surgery (yes/no/unknown), >10% loss of body weight in the last 6 months, steroid use for a chronic condition, chemotherapy for malignancy within 30 days from surgery (yes/no/unknown), radiotherapy for malignancy within 90 days from surgery (yes/no/unknown), and emergent versus elective procedure nature.

Outcome measures consisted of 30-day postoperative mortality, duration of postoperative hospital stay (DOS) in days, extended DOS (defined as cases falling within the upper 25% of hospital stays), total operative time in minutes, prolonged operative time (defined as cases falling within the upper 25% of operative times), serious morbidity, and overall morbidity. Overall morbidity was defined by presence of ≥1 of the following: wound infection (superficial or deep incisional surgical-site infection, wound dehiscence), pneumonia, urinary tract infection, return to operating room, venous thromboembolic event (VTE; deep-vein thrombosis/thrombophlebitis, pulmonary embolism), cardiac complication (cardiac arrest, myocardial infarction), shock/sepsis, unplanned intubation, bleeding requiring transfusion, ventilator dependency >48 hours, or renal complication (postoperative renal failure, progressive renal insufficiency). Serious morbidity included occurrence of ≥1 of the following: return to the operating room, cardiac complication, shock/sepsis, unplanned intubation, or ventilator dependency for >48 hours. Constituent morbid conditions also were considered individually.

Variables missing <10% of information were tested for associations with 30-day mortality (the primary outcome measure). If no association ($P > .10$) was found, multiple imputation techniques were used to impute missing values. Multiple imputation uses regression modeling to fill in missing spaces with information provided from other variables. Variables missing >10% of information (albumin level, alcohol consumption, previous cardiac surgery, chemotherapy, and radiotherapy) and missing information for race/ethnicity were included as separate categories. Values were compared by WHO-defined BMI class using χ^2 tests with Bonferroni corrections for multiple comparisons (where appropriate).

Outcome measures were compared between patients of normal BMI and (1) underweight, (2) overweight-obese I, and (3) obese II–III BMI patients by the use of crude (unadjusted) and risk-adjusted logistic regression models for categorical variables to determine odds ratios (OR) and corresponding 95% confidence intervals (95% CIs). Multivariable models were adjusted for