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The effect of hospital volume on resection margins in rectal cancer surgery

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ARTICLE INFO

Article history:
Received 23 February 2016
Received in revised form
7 April 2016
Accepted 15 April 2016
Available online 23 April 2016

Keywords:
Rectal cancer
Positive margin
Hospital volume

ABSTRACT

Background: We hypothesized that after controlling for case-mix differences, the rates of positive resection margin after rectal cancer surgery vary substantially in the United States and that high-volume hospitals have lower margin positivity rates.

Materials and methods: Patients treated with oncologic resection for stage I-III rectal cancer were selected from the 1998-2010 National Cancer Data Base. Hierarchical regression models were used to calculate risk- and reliability-adjusted positive margin rates and hospital level variability in positive margin rates using Empirical Bayes techniques.

Results: A total of 113,113 patients were treated at 1446 hospitals. The mean overall risk- and reliability-adjusted positive margin rate was 7.3%. High-volume hospitals did not have a lower rate of adjusted margin positivity (7.4%, $P = 0.75$). When both case mix and hospital volume differences were factored into the model, variability in margin positivity rates increased by 9.8%, implying that referral to high-volume hospitals alone would not improve margin positivity rates.

Conclusions: Rectal cancer margin positivity rates vary substantially in the United States, despite adjusting for differences in case mix. These results support standardization of surgical technique and pathologic assessment as part of a broader initiative that identifies and refers patients to higher performing hospitals rather than simply to higher volume hospitals.

Introduction

Outcomes at high-volume centers are superior for patients with pancreatic, liver, and esophageal cancer, but it remains unclear whether this trend holds true for rectal cancer.[1-6] In rectal cancer surgery, circumferential resection margin is the major determinant of local recurrence and positive resection margins are associated with decreased survival.[7-9] Although improvements in chemotherapy and radiation have helped to reduce the rates of local recurrence of rectal cancer, they cannot compensate for positive surgical resection margins.[10,11] Because of the fixed anatomy of the pelvis and close proximity to vital structures, obtaining negative resection margins can be challenging and multiple reports have found

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0022-4804/$ – see front matter
http://dx.doi.org/10.1016/j.jss.2016.04.041

specialty trained surgeons have lower recurrence rates, but no conclusions have been made regarding high-volume centers.[3,12-14]

Although the implementation of the surgical technique of total mesorectal excision has decreased local recurrence and improved survival, margin positivity is estimated between 5% and 10% but reported as high as 17% at some hospitals.[15-17] Margin positivity is an ideal metric for comparing hospital performance because it is a near immediate end point compared to mortality and allows for faster performance evaluations and modifications.[18] However, interhospital comparisons are often difficult due to the case mix of identified patient and tumor variables that are associated with a higher risk of a positive surgical margin.[19] Evidence also indicates that variation in surgical outcomes between hospitals can occur due to chance alone. To account for statistical noise and report outcomes that are reflective of surgical quality, reliability adjustment techniques have been proposed.[20,21] We hypothesized that the rates of positive resection margin after surgery for rectal cancer vary substantially across hospitals in the United States and that higher volume centers have lower risk- and reliability-adjusted rates of positive margin.

Methods

Data source

Our study used the 1998-2010 National Cancer Data Base (NCDB). The NCDB is a database sponsored jointly by the American College of Surgeons and the American Cancer Society that contains oncologic outcomes from over 1500 hospitals in the United States.[22] Patient demographic data include sex, age, race, insurance, and Charlson-Deyo score, a comorbidity index based on ICD diagnosis codes assigned to each patient. Tumor variables included tumor grade, size, American Joint Committee on Cancer (AJCC) tumor stage, AJCC nodal stage, and whether tumors were irradiated preoperatively, postoperatively, or not at all.

Inclusion criteria

Patients treated with low anterior resection, low anterior resection with coloanal anastomosis, abdominoperineal resection, or pelvic exenterations for stage I-III rectal cancer were selected from the 1998-2010 NCDB.

Exclusion criteria

Patients who underwent a local excision or patients with a pathologic complete response to neoadjuvant chemoradiation (yPT0) were excluded from analysis. Hospitals with less than one surgical case per year were excluded from the analysis.

End points

Surgical resection margin, defined as macroscopic residual tumor (R2), microscopic residual tumor (R1), or no residual tumor (R0), was the major end point used for all patients. R1 and R2 margins were considered positive. Patient, tumor, and hospital factors were compared between negative surgical margin and positive surgical margin patients using the chi-square test, *t*-test, or rank sum test, where appropriate. Univariate analysis was conducted using logistic regression to identify patient, tumor, and hospital factors associated with positive resection margin. Facility type was excluded from the multivariate analysis due to multicollinearity between it and hospital volume. Volume quintiles were determined by taking 20th percentiles. Quintile 1 represented <6 cases per year, quintile 2 = 7-10 cases per year, quintile 3 = 8-15 cases per year, quintile 4 = 16-23 cases per year, and quintile 5 $>$ 24 cases per year. Two-tailed *P* values less than 0.05 were considered statistically significant.

Hierarchical modeling and reliability adjustment

After determining patient and tumor factors associated with margin positivity, we combined these patient and tumor factors into a patient risk score. This was accomplished using postestimation commands in Stata (College Station, TX) to predict the log(odds) of positive margin for each patient. Those patient variables that were significant in the univariate analysis (age, race, and insurance status) were included in the patient risk score. Tumor variables included were pathologic tumor (T) stage, nodal (N) stage, radiation sequence, tumor grade, tumor size, and surgery performed. The log of this score was used because it provides a linear response with respect to the outcome variables. The patient risk score was used as a single independent variable in hierarchical models to decrease the risk of nonconvergence of the model, which can occur if hierarchical models are overfit.[20] We performed a sensitivity analysis to be sure that the same results were obtained using the single risk score *versus* using individual variables in the hierarchical models.

Because variation in margin positivity rates between hospitals could differ due to chance alone, we used empirical Bayes techniques to adjust the margin positivity rates of hospitals for reliability. Empirical Bayes models filter out statistical noise and shrink the observed rate closer to the mean depending on the reliability of the measure. Larger degrees of shrinkage are seen at centers with lower volume because observed margin positivity rates at these centers are less statistically reliable. Hierarchical logistic regression models were created (using the meqrlogit command in Stata). This technique can simultaneously model variation at the patient and hospital levels. The models were two levels, with patients being level 1 and hospitals being level 2. The patient risk score allowed for a single variable that incorporated patient and tumor variables, while hospital volume was accounted for separately. The hospital ID number was used as the second level random effect. We used postestimation commands to create empirical Bayes estimates of each hospital's random effect in log(odds). We then added this random effect to average patient risk, also in log(odds), and calculated an inverse logit to obtain risk- and reliability-adjusted margin positivity for each hospital.[20,21] Hospitals were then ranked from best to worst and based on their risk-adjusted margin positivity rates, and their rates were plotted with 95% confidence intervals (CIs). Those hospitals with a surgical volume in the top quintile were considered "high volume" and denoted as such.