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Colorectal Cancer Resections in the Aging US Population: A Trend Toward Decreasing Rates and Improved Outcomes

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IMPORTANCE The incidence of colorectal cancer in elderly patients is likely to increase, but there is a lack of large nationwide data regarding the mortality and morbidity of colorectal cancer resections in the aging population.

OBJECTIVE To examine the surgical trends and outcomes of colorectal cancer treatment in the elderly.

DESIGN, SETTING, AND PARTICIPANTS A review of operative outcomes for colorectal cancer in the United States was conducted in a Nationwide Inpatient Sample from January 1, 2001, through December 31, 2010. Patients were stratified within age groups of 45 to 64, 65 to 69, 70 to 74, 75 to 79, 80 to 84, and 85 years and older. Postoperative complications and yearly trends were analyzed. A multivariate logistic regression was used to compare in-hospital mortality and morbidity between individual groups of patients 65 years and older and those aged 45 to 64 years while controlling for sex, comorbidities, procedure type, diagnosis, and hospital status.

MAIN OUTCOMES AND MEASURES In-hospital mortality and morbidity.

RESULTS Among the estimated 1,043,108 patients with colorectal cancer sampled, 63.8% of the operations were performed on those 65 years and older and 22.6% on patients 80 years and older. Patients 80 years and older were 1.7 times more likely to undergo urgent admission than those younger than 65 years. Patients younger than 65 years accounted for 46.0% of the laparoscopies performed in the elective setting compared with 14.1% for patients 80 years and older. Mortality during the 10 years decreased by a mean of 6.6%, with the most considerable decrease observed in the population 85 years and older (9.1%). Patients 80 years and older had an associated $9,492 higher hospital charge and an increased 2½-day length of stay vs patients younger than 65 years. Compared with patients aged 45 to 64 years, higher risk-adjusted in-hospital mortality was observed in patients with advancing age: 65 to 69 years (odds ratio, 1.32; 95% CI, 1.18-1.49), 70 to 74 years (2.02; 1.82-2.24), 75 to 79 years (2.51; 2.28-2.76), 80 to 84 years (3.15; 2.86-3.46), and 85 years and older (4.72; 4.30-5.18) (P < .01). Compared with patients aged 45 to 64 years, higher risk-adjusted morbidity was noted in those with advancing age: 65 to 69 years (odds ratio, 1.25; 95% CI, 1.21-1.29), 70 to 74 years (1.40; 1.36-1.45), 75 to 79 years (1.54; 1.49-1.58), 80 to 84 years (1.68; 1.63-1.74), and 85 years and older (1.96; 1.89-2.03) (P < .01).

CONCLUSIONS AND RELEVANCE Most operations for colorectal cancer are performed on the aging population, with an overall decrease in the number of cases performed. Despite the overall improved mortality seen during the past 10 years, the risk-
adjusted mortality and morbidity of the elderly continue to be substantially higher than that for the younger population.

The aging population (≥65 years) is a rapidly growing segment of the United States. The US census data from 2011 report a total of 39 million elderly, comprising 13% of the population. In fact, projected estimates report a dramatic increase (19%) between 2010 and 2030 in this population as the baby-boomer generation ages into the group 65 years and older. An estimated 50% of all cancers and 70% of all cancer deaths occur in the elderly. Gastrointestinal malignant neoplasms are considered common cancers in the elderly, with peak incidences in the sixth and seventh decades of life. Despite this increase in the aging population, the elderly are often excluded from clinical trials. This raises concerns that clinical trial data may not accurately reflect morbidity and mortality in the elderly. It is important that the surgical community recognizes this shift in the patient population and prepares accordingly, given the expected higher mortality and morbidity rates. Despite increased screening, colorectal cancer (CRC) remains the third leading type of cancer and the second leading cause of death in the United States, with an estimated 142,820 new cases in 2013. Surgical resection remains the curative modality for CRC, and most patients seek treatment after the seventh decade of life. To date, large nationwide studies that assess the effects of age on morbidity and mortality and analyze the latest trends in surgical resection in the elderly are lacking. Therefore, we aim to analyze contemporary data on the surgical treatment of CRC in the elderly in the United States in the past decade, examining the trends in the number of resections performed and the effect of age on the overall risk-adjusted in hospital mortality and morbidity.

Methods

The Healthcare Cost and Utilization Project Nationwide Inpatient Sample (NIS), the largest all-payer inpatient care database in the United States, contains information from nearly 8 million hospital stays each year across the country. The data set approximates a 20% stratified sample of US community, nonmilitary, and nonfederal hospitals, resulting in a sampling frame that comprises approximately 95% of all hospital discharges in the United States. Data elements within the NIS are drawn from hospital discharge abstracts that allow determination of all procedures performed during a given hospitalization. All statistical analyses were conducted on raw numbers, which were weighted to reflect national averages. Weight is based on sampling probabilities for each stratum to ensure that hospitals studied are representative of all US hospitals. Approval for the use of the NIS patient-level data in this study was obtained from the institutional review board of the University of California, Irvine Medical Center and the NIS.

We analyzed the discharge data on patients 45 years and older who underwent colorectal cancer resection (CRS) for the treatment of CRC between January 1, 2001, and December 31, 2010, using appropriate diagnostic and procedural codes as specified by the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM). Patients admitted with the diagnosis of CRC (ICD-9-CM codes 153.0, 153.1, 153.2, 153.3, 153.4, 153.6, 153.7, 153.8, 153.9, 154.0, 154.1, 154.8, 197.5, 209.17, and 230.4) were sampled. Patients undergoing colon resection (ICD-9-CM codes 45.72,
45.73, 45.74, 45.75, 45.76, 45.79, 45.8, 45.81, 45.82, and 45.83) and rectal resection (48.0, 48.4, 48.40, 48.41, 48.43, 48.49, 48.5, 48.50, 48.51, 48.52, 48.59, 48.92, 48.63, 48.64, 48.69, 48.42, and 48.51) were selected.

Patients with diverticulitis and inflammatory bowel disease were excluded. Given the unreliability of laparoscopic codes before 2009, laparoscopy was analyzed only from January 1, 2009, through December 31, 2010. Patients were then subdivided into the following age categories: 45 to 64, 65 to 69, 70 to 74, 75 to 79, 80 to 84, and 85 years and older. The control group included patients aged 45 to 64 years, and all other subgroups were compared with the control group. The temporal trends in the overall number of CRS performed during a 10-year study period were analyzed in each age group. This was further divided into the number of elective and urgent admissions. The rate of mortality per year in each subgroup was also analyzed. The mean change per year, as indicated by the variation of trends per year, was calculated using a geometric mean. Primary end points, selected a priori and including overall in-hospital morbidity and mortality, were analyzed using a multivariate regression analysis as described below. Patient demographics, hospital characteristics, payer type, preoperative comorbidities, total charge, length of stay, postoperative complications, and in-hospital mortality were also analyzed. Postoperative wound complications included ICD-9-CM codes for wound infection and dehiscence. Because of the vague nature of the ICD-9-CM code for anastomotic leak (997.4) involving complications of intestinal anastomosis and bypass, we paired this with the codes for peritoneal abscess (567.22) and fistula of the intestine (569.81). Cardiac complications comprised acute myocardial infarction and heart failure. Pneumonia included hospital acquired pneumonia.

Statistical Analysis

All statistical analyses were conducted using SAS, version 9.3 (SAS Institute, Inc), and the R statistical environment (R software, version 3.0.0; R Core Team, R Foundation for Statistical Computing, 2013). Univariate analysis comparing all groups was conducted via the Yates $\chi^2$ test, and a post hoc analysis was performed on significant variables to compare each group with the control group using $\chi^2$ analysis. For the main analysis, logistic regression analysis was used for binary end points. We adjusted for age, sex, hospital characteristics, comorbidities (deficiency anemia, rheumatoid arthritis/collagen vascular, congestive heart failure, chronic pulmonary disease, coagulopathy, uncomplicated and complicated type 2 diabetes mellitus, hypertension, hypothyroidism, liver disease, obesity, peripheral vascular disorders, renal failure, weight loss, and hypoalbuminemia), procedure type, hospital status, and admission diagnosis. The Holm method was used to account for multiple comparisons in the form of adjusted P values. A comparison was declared statistically different, with an odds ratio of 1 at the family-wise error level of .05, if adjusted P < .05. Patients with missing data points were excluded from the final analysis. Univariate and multivariate statistical analyses were conducted on unweighted numbers.

Figure 1. Number of Colorectal Cancer Resections
A total of 1,043,108 patients (aged >45 years) with CRC undergoing CRS were identified. Most patients were 65 years or older (63.8%), including 29.0% of septuagenarians and 22.6% of both octogenarians and nonagenarians. This ratio remained consistent during the 10-year study period. The total number of CRS for CRC decreased by a mean of 5.1% and 7.0% per year for the entire population and the aging population, respectively (Figure 1). The largest decrease was seen in septuagenarians (7.5%). A similar decrease was seen in the elective and urgent settings, with a 5.4% decrease per year in the overall number of patients in each setting. There was a 7.6% decrease in the number of elective procedures per year in the aging population (≥65 years) compared with a 2.5% decrease in the control group. In the urgent setting, there was a 6.1% decrease in the number of procedures per year in the aging population (≥65 years) compared with 1.9% in the control group. Patients 85 years and older underwent urgent admission at a higher rate (50.4%) compared with the rest of the age groups: 45 to 64 years (29%), 65 to 69 years (29.6%), 70 to 74 years (31%), 75 to 79 years (34%), and 80 to 84 years (39%). From January 1, 2009, through December 31, 2010, 85,115 (51%) laparoscopies were performed. Laparoscopy was used in 62.3% of the control group compared with 59.0% in 65- to 69-year-olds, 52.3% in 70- to 74-year-olds, 47.3% in 75- to 79-year-olds, 47.3% in 80- to 84-year-olds, and 36.7% in those 85 years and older (Table 1).

Table 1. Demographics of Patients Undergoing Colorectal Resection in the United States From January 1, 2001, Through December 31, 2010

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Results

Trends

A total of 1,043,108 patients (aged >45 years) with CRC undergoing CRS were identified. Most patients were 65 years or older (63.8%), including 29.0% of septuagenarians and 22.6% of both octogenarians and nonagenarians. This ratio remained consistent during the 10-year study period. The total number of CRS for CRC decreased by a mean of 5.1% and 7.0% per year for the entire population and the aging population, respectively (Figure 1). The largest decrease was seen in septuagenarians (7.5%). A similar decrease was seen in the elective and urgent settings, with a 5.4% decrease per year in the overall number of patients in each setting. There was a 7.6% decrease in the number of elective procedures per year in the aging population (≥65 years) compared with a 2.5% decrease in the control group. In the urgent setting, there was a 6.1% decrease in the number of procedures per year in the aging population (≥65 years) compared with 1.9% in the control group. Patients 85 years and older underwent urgent admission at a higher rate (50.4%) compared with the rest of the age groups: 45 to 64 years (29%), 65 to 69 years (29.6%), 70 to 74 years (31%), 75 to 79 years (34%), and 80 to 84 years (39%). From January 1, 2009, through December 31, 2010, 85,115 (51%) laparoscopies were performed. Laparoscopy was used in 62.3% of the control group compared with 59.0% in 65- to 69-year-olds, 52.3% in 70- to 74-year-olds, 47.3% in 75- to 79-year-olds, 47.3% in 80- to 84-year-olds, and 36.7% in those 85 years and older (Table 1).
Most patients 65 years and older were white (61.9%) and female (54.0%). The overall Elixhauser–Van Walraven comorbidity score22 was highest (9) in the group 85 years and older vs 6 in the control group. The group 85 years and older had the highest percentage of comorbidities compared with the other groups with the exception of type 2 diabetes mellitus and obesity. Each group had a significantly higher percentage of comorbidities compared with the previous younger group with the exception of type 2 diabetes mellitus and obesity. The most prevalent comorbidities in the aging population (≥65 years)
were hypertension (48.1%), anemia (22.2%), type 2 diabetes mellitus (18.0%), and chronic pulmonary disease (17.2%) (Table 2).

Table 2. Comorbidities of Patients Undergoing Colorectal Resection in the United States From January 1, 2001, Through December 31, 2010a

<table>
<thead>
<tr>
<th>Comorbidity</th>
<th>Age Group, y</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>45-64 (n = 177 120)</td>
</tr>
<tr>
<td>Comorbidity score, mean (SD)b</td>
<td>6 (2)</td>
</tr>
<tr>
<td>Deficiency anemiab</td>
<td>0.8</td>
</tr>
<tr>
<td>Rheumatoid arthritis/collagen vascularb</td>
<td>2.2</td>
</tr>
<tr>
<td>Congestive heart failureb</td>
<td>9.6</td>
</tr>
<tr>
<td>Chronic pulmonary diseaseb</td>
<td>1.7</td>
</tr>
<tr>
<td>Coagulopathyb</td>
<td>13.2</td>
</tr>
<tr>
<td>Type 2 diabetes mellitus, uncomplicatedb</td>
<td>1.1</td>
</tr>
<tr>
<td>Hypertensionb</td>
<td>35.9</td>
</tr>
<tr>
<td>Hypothyroidismb</td>
<td>4.7</td>
</tr>
<tr>
<td>Liver diseaseb</td>
<td>1.9</td>
</tr>
<tr>
<td>Obesityb</td>
<td>7.4</td>
</tr>
<tr>
<td>Perineal vascular disordersb</td>
<td>1.3</td>
</tr>
<tr>
<td>Renal failureb</td>
<td>1.5</td>
</tr>
<tr>
<td>Weight lossb</td>
<td>4.6</td>
</tr>
<tr>
<td>Hypoaalbuminemia8</td>
<td>0.6</td>
</tr>
</tbody>
</table>

a Values are presented as percentages unless otherwise indicated.  
b P < .05 comparing all groups.  
c P < .05 compared with the control group (aged 45-64 years).

Outcomes

Patients in the group 85 years and older also had the highest in-hospital charge ($58 863) and hospital length of stay (12 days) compared with the control group ($47 395 for 9 days). Each subsequent age group had a higher in-hospital charge and length of stay compared with the younger age groups as well as the control group. Anastomotic leak, intra-abdominal abscess, and intestinal fistula rates and ileus or bowel obstruction rates were not statistically different among the groups. However, the rate of acute renal failure, cardiac complications, respiratory failure, urinary tract infections, and pneumonia rose as age increased (P < .01) (Table 3). Using a multivariate regression analysis, compared with patients aged 45 to 64 years, significantly higher risk-adjusted in-hospital mortality was observed in patients with advancing age: 65 to 69 years (odds ratio, 1.32; 95%CI, 1.18-1.49), 70 to 74 years (2.02; 1.82-2.24), 75 to 79 years (2.51; 2.28-2.76), 80 to 84 years (3.15; 2.86-3.46), and 85 years and older (4.72; 4.30-5.18) (P < .01) (Table 4).

On univariate analysis, in-hospital mortality was significantly higher in every subsequent age group, and patients 85 years and older had a 6.3 times higher likelihood of death than did the control group (Table 3). On multivariate risk-adjusted regression analysis, compared with patients aged 45 to 64 years, significantly higher risk-adjusted morbidity was observed in patients with advancing age: 65 to 69 years (odds ratio, 1.25; 95% CI, 1.21-1.29), 70 to 74 years (1.40; 1.36-1.45), 75 to 79 years (1.54; 1.49-1.58), 80 to 84 years (1.68; 1.63-1.74), and 85 years and older (1.96; 1.89-2.03) (P < .01) (Table 4). There was an overall 3.0% mortality rate, with the control group having the lowest
mortality at 1.3% and patients 85 years and older having the highest mortality at 8.0% (Table 3). There has been a mean decrease in mortality rates of 6.6% per year in the past decade. Patients 85 years and older had a 9.1% decrease (Figure 2) in mortality per year compared with the following age groups: 80 to 84 years, 6.4%; 75 to 79 years, 7.5%; 70 to 74 years, 7.7%; 65 to 69 years, 5.4%; and 45 to 64 years, 1.7%.

Table 3. Postoperative Outcomes of Patients Undergoing Colorectal Resection in the United States From January 1, 2001, Through December 31, 2010a

<table>
<thead>
<tr>
<th>Outcome</th>
<th>45-64 (n = 377,129)</th>
<th>65-69 (n = 132,807)</th>
<th>70-74 (n = 143,132)</th>
<th>75-79 (n = 154,433)</th>
<th>80-84 (n = 128,686)</th>
<th>≥85 (n = 106,921)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anastomotic leakb</td>
<td>11.8</td>
<td>13.0</td>
<td>13.0</td>
<td>13.0</td>
<td>13.0</td>
<td>12.9</td>
</tr>
<tr>
<td>Wound infectionb</td>
<td>1.2</td>
<td>1.1</td>
<td>1.0</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>Pneumoniob</td>
<td>2.6</td>
<td>3.4</td>
<td>3.7</td>
<td>4.6</td>
<td>5.6</td>
<td>7.3</td>
</tr>
<tr>
<td>Ileus or bowel obstrucb</td>
<td>14.8</td>
<td>16.5</td>
<td>17.2</td>
<td>16.9</td>
<td>16.9</td>
<td>17.1</td>
</tr>
<tr>
<td>Urinary tract infectionb</td>
<td>3.4</td>
<td>4.3</td>
<td>5.0</td>
<td>5.9</td>
<td>7.7</td>
<td>10.5</td>
</tr>
<tr>
<td>Failure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory</td>
<td>3.5</td>
<td>4.9</td>
<td>5.6</td>
<td>6.5</td>
<td>7.0</td>
<td>8.7</td>
</tr>
<tr>
<td>Acute renal</td>
<td>4.4</td>
<td>6.5</td>
<td>7.7</td>
<td>8.9</td>
<td>10.1</td>
<td>11.8</td>
</tr>
<tr>
<td>Cardiac complicationsb</td>
<td>1.2</td>
<td>2.1</td>
<td>2.9</td>
<td>3.5</td>
<td>4.0</td>
<td>4.5</td>
</tr>
<tr>
<td>Subacute deliriumb</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Drug-induced deliriumb</td>
<td>0.2</td>
<td>0.4</td>
<td>0.6</td>
<td>0.8</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>Disposition</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Routineb</td>
<td>74.1</td>
<td>67.3</td>
<td>61.3</td>
<td>52.4</td>
<td>40.0</td>
<td>24.4</td>
</tr>
<tr>
<td>Short-term facilityb</td>
<td>3.4</td>
<td>8.2</td>
<td>12.1</td>
<td>19.0</td>
<td>29.3</td>
<td>43.3</td>
</tr>
<tr>
<td>Hospiceb</td>
<td>16.2</td>
<td>17.9</td>
<td>18.9</td>
<td>10.6</td>
<td>10.7</td>
<td>17.3</td>
</tr>
<tr>
<td>Otherb</td>
<td>0.4</td>
<td>0.4</td>
<td>0.5</td>
<td>0.8</td>
<td>1.1</td>
<td>1.7</td>
</tr>
<tr>
<td>Missing</td>
<td>3.9</td>
<td>3.7</td>
<td>3.9</td>
<td>3.9</td>
<td>4.1</td>
<td>4.2</td>
</tr>
<tr>
<td>In-hospitalb</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mortality</td>
<td>27.4</td>
<td>22.2</td>
<td>24.0</td>
<td>27.2</td>
<td>40.0</td>
<td>44.9</td>
</tr>
<tr>
<td>Length of stay, mean (SD)b</td>
<td>9 (1.5)</td>
<td>9 (1.5)</td>
<td>10 (4.1)</td>
<td>10 (3.0)</td>
<td>11 (4.5)</td>
<td>12 (5.6)</td>
</tr>
</tbody>
</table>

a Values are presented as percentages unless otherwise indicated.
b P < .05 comparing all groups.
c P < .05 compared with the control group (aged 45-64 years).

Table 4. Risk-Adjusted Outcomes of Colorectal Surgery in the Elderly Compared With Patients Aged 45 to 64 Years (Control Group)
Figure 2. Improved Mortality in the Elderly

<table>
<thead>
<tr>
<th>Age, y</th>
<th>Adjusted Odds Ratio (95% CI)</th>
<th>P Value</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>In-hospital mortality</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>65-69</td>
<td>1.32 (1.18-1.49)</td>
<td>&lt;.01</td>
<td></td>
</tr>
<tr>
<td>70-74</td>
<td>2.02 (1.82-2.24)</td>
<td>&lt;.01</td>
<td></td>
</tr>
<tr>
<td>75-79</td>
<td>2.51 (2.28-2.76)</td>
<td>&lt;.01</td>
<td></td>
</tr>
<tr>
<td>80-84</td>
<td>3.15 (2.86-3.46)</td>
<td>&lt;.01</td>
<td></td>
</tr>
<tr>
<td>≥85</td>
<td>4.72 (4.30-5.18)</td>
<td>&lt;.01</td>
<td></td>
</tr>
<tr>
<td>In-hospital morbidity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>65-69</td>
<td>1.25 (1.21-1.29)</td>
<td>&lt;.01</td>
<td></td>
</tr>
<tr>
<td>70-74</td>
<td>1.40 (1.36-1.45)</td>
<td>&lt;.01</td>
<td></td>
</tr>
<tr>
<td>75-79</td>
<td>1.54 (1.49-1.58)</td>
<td>&lt;.01</td>
<td></td>
</tr>
<tr>
<td>80-84</td>
<td>1.68 (1.63-1.74)</td>
<td>&lt;.01</td>
<td></td>
</tr>
<tr>
<td>≥85</td>
<td>1.96 (1.89-2.03)</td>
<td>&lt;.01</td>
<td></td>
</tr>
</tbody>
</table>

Decrease in mortality rates as demonstrated by the linear line comparing patients in the group 85 years and older with the control group (aged 45-64 years).

Discussion

As the aging US population grows, physicians and surgeons are faced with difficult treatment decisions. This population poses challenges in terms of preoperative consulting,
as well as perioperative and postoperative treatment. Data regarding the national surgical trends and specific rates of mortality in this population are rare, especially since this subset of patients frequently is excluded from large randomized clinical studies. Therefore, it is important to analyze the effects of age on mortality and morbidity on a large nationwide scale. This study is unique in that it allows for assessing the trends of patients with CRC undergoing surgical resection, as well as examining small incremental age increases (specifically 5 years) and the effects on overall morbidity and mortality. Our data clearly demonstrated that as patients age, their comorbidity index increases. However, once all patient factors and comorbidities are controlled for, risk-adjusted outcomes demonstrated that age continues to be associated with higher rates of mortality and morbidity. In fact, all 5 age groups compared with the control group had an increase in the odds ratio of mortality and morbidity, and as age rose, this ratio increased as well. Patients 85 years and older had a 4.7 increase in the odds ratio of in-hospital mortality. However, during the 10-year study period, mortality rates in all age groups, especially the elderly, improved. In the past decade, there has been a steady decrease in the number of CRS (6.1% per year), and despite a continued higher risk-adjusted mortality and morbidity, there has been a marked improvement in surgical outcomes in the elderly.

From 2001 through 2010, CRS for CRC has decreased by 5.1% annually, with the largest decrease seen in the elderly at 7.0% annually compared with 2.2% in patients aged 45 to 64 years. This decrease mainly can be attributed to the overall 2% per year decrease in the incidence of CRC in patients older than 50 years. Screening for CRC appears to have had a considerable effect on reducing incidence. The greater reduction in the number of cases in the elderly may be explained by this population’s higher access to screening programs, given that most of these patients have Medicare and thereby have access to Medicare preventative service benefits for CRC. This outcome would lead us to hypothesize that the number of patients undergoing urgent admissions would decrease at a higher rate than would elective admissions. However, our data show that the decrease in the rate of urgent admissions in the elderly was only slightly lower than that for elective admissions (6.1% vs 7.6%). The 6.1% decrease was mainly attributed to the large proportion of patients 80 years and older requiring urgent admissions. The US Preventive Services Task Force suggests screening individuals aged 50 to 75 years, and perhaps the increase in the number of urgent admissions may be due to lack of screening in patients 80 years and older.

Laparoscopy was half as likely to be used in those 80 years and older. We can hypothesize that this finding may be secondary to the fact that these patients were sicker, with a higher percentage needing urgent operations. However, Kang et al., in a retrospective review of the NIS, demonstrated that laparoscopic surgery was safe for high-risk patients. Perhaps the implementation of laparoscopy in this high-risk population may in fact decrease their postoperative mortality and morbidity. The elderly were less likely to be treated at a teaching institution. Although we cannot explain this phenomenon, and a large proportion of these individuals may have sought care at nonteaching facilities, it may be a contributing factor of the observed decreased use of laparoscopy in these patients.

Multiple small series in the 1990s have established that increased age, specifically older than 70 years, is associated with worse postoperative outcomes secondary to an increase in the number of comorbidities and a decrease in functional status. This
outcome was confirmed by larger studies\textsuperscript{28,29} that collectively reported that postoperative mortality and morbidity rose with increased age. Our data demonstrated a steady increase in risk-adjusted mortality as patients age. In a recent study of the American College of Surgeons National Surgical Quality Improvement Program during 2005 through 2007, Kiran et al\textsuperscript{30} concluded that patients undergoing surgical procedures had an increased associated risk of mortality with age. They further indicated that this increase was most prominent in patients 70 years and older. Our data confirmed this observed increase in mortality and, when further broken down, demonstrated that the greatest increase in mortality rates was in patients older than 85 years by a factor of 6. A report by Kunitake et al\textsuperscript{29} supported our findings and added that 1-year mortality in patients 80 years and older continued to be as high as 29%. Despite the higher mortality rates, we found that in the past 10 years, mortality rates have improved across all age groups. The largest, a 9.1% decrease per year, was seen in patients 85 years and older. The decrease in mortality can be attributed to improved surgical technique as well as better understanding of the physiologic demands of these patients.

However, mortality is not the only factor considered during preoperative decision making. In fact, postoperative complications can lead to higher cost, increased length of stay, and decreased quality of life, especially in the elderly, who often have a lower functional reserve. We demonstrated that almost all postoperative complications in the elderly were significantly higher than those in the control group. With the exception of anastomotic leak and wound infection, all other complications had a steady rise in prevalence as age increased. Kiran et al\textsuperscript{30} also observed the finding that the elderly have an increased morbidity of 33% compared with 26% of the nonelderly (<70 years). Kunitake et al\textsuperscript{29} stated that readmission rates secondary to surgical complications among the elderly were 23\% after CRS, and age was an independent risk factor for readmission. Length of stay, disposition to a short term facility, and cost also steadily increased as patients aged. This may be attributed in part to the increase in the rate of postoperative complications secondary to a lower reserve of strength in these patients. Social factors, such as the need for extra assistance at the time of discharge, may also delay discharge and increase the rate of discharge to a short-term facility. Therefore, the elderly require vigilant postoperative treatment and anticipation of their social needs, which have to be factored into their preoperative counseling and postoperative planning.

This study is limited by the inherent biases of a large retrospective review. The NIS database is limited to in-hospital morbidity and mortality without outpatient follow-up data such as post discharge complications, readmission or long-term outcomes, survival benefits, and/or cost. The NIS lacks clinical information, such as previous history of chemotherapy or radiation and the level and stage of the tumor. There is also a lack of intraoperative factors as well as functional status of the patient. Although admission maybe designated as urgent, we cannot discern the diagnosis for urgent admission. We are also unable to comment on intensive care unit admissions and/or ventilator status. Multiple preoperative factors were used for adjustment in the primary analysis; however, some unmeasured confounding variables may explain the differences observed. In addition, coding for certain comorbidities and postoperative complications can be vague and subjectively defined. Despite these limitations, to our knowledge, this study is the first to report on the temporal trends of CRS in the elderly and specific morbidity in this population subset.
Conclusions

In this extensive review of national trends of CRS, we observed that, despite the improvements in mortality and a decrease in the incidence of CRS, older patients continue to have worse risk-adjusted outcomes compared with those who are younger. A clear association between worse outcomes and age was established. Even patients aged 65 to 69 years have poorer outcomes than those younger than 65 years. Since most (63.8%) procedures in the United States are performed on patients 65 years and older, measures to improve outcomes need to be implemented in all settings. The higher percentage of patients requiring nursing facilities for rehabilitation postoperatively reiterates the importance of outcomes as well as the social impact of age. Therefore, we believe our data not only supply the modern surgeon with the tools to counsel patients but also reveal a demand for a reevaluation of current care patterns, reinforcing the need for future studies to account for the changing population landscape in the United States.

REFERENCES

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