Trends in Diverticulitis Management in the United States From 2002 to 2007

Hossein Masoomi, MD; Brian S. Buchberg, MD; Cheryl Magno, MPH; Steven D. Mills, MD; Michael J. Stamos, MD

Objective: To demonstrate the recent trends of admission and surgical management for diverticulitis in the United States.

Design: Retrospective database analysis.

Setting: The National Inpatient Sample database.

Patients: Patients admitted to the hospital for diverticulitis from 2002 to 2007.

Main Outcome Measures: Patient characteristics, surgical approach, and mortality were evaluated for elective or emergent admission.

Results: A total of 1,073,397 patients were admitted with diverticulitis (emergent: 78.3%, elective: 21.7%). The emergent admission rate increased by 9.5% over the study period. For emergent patients, 12.2% underwent urgent surgical resection and 87.8% were treated with nonoperative methods (percutaneous abscess drainage: 1.88% and medical treatment: 85.92%). There was only a 4.3% increase in urgent surgical resections, while elective surgical resections increased by 38.7%. The overall rate of elective laparoscopic colon resection was 10.5%. Elective laparoscopic surgery nearly doubled from 6.9% in 2002 to 13.5% in 2007 ($P < .001$). Primary anastomosis rates increased for elective resections over time (92.1% in 2002 to 94.5% in 2007; $P < .001$). For urgent open operation, use of colostomy decreased significantly from 61.2% in 2002 to 54.0% in 2007 ($P < .001$). In-hospital mortality significantly decreased in both elective and urgent surgery (elective: 0.53% in 2002 to 0.44% in 2007; $P = .001$; urgent: 4.5% in 2002 to 2.5% in 2007; $P < .001$).

Conclusion: Diverticulitis continues to be a source of significant morbidity in the United States. However, our data show a trend toward increased use of laparoscopic techniques for elective operations and primary anastomosis for urgent operations.


In recent years, the incidence, pattern, and treatment of diverticular disease has evolved. Despite improvements in colon and rectal surgery, treatment of diverticulitis remains challenging, particularly in acute diverticulitis with regard to surgical indication and operative technique (primary anastomosis vs diversion and laparoscopic vs open).

Historically, diverticular disease in patients younger than 50 years has been described as more virulent and with more serious complications. In some series, young people have more severe disease at first presentation but less frequently have resection at that time. Regardless, the incidence of diverticular disease in the younger population is reportedly on the rise. Nonoperative management will resolve acute diverticulitis in 85% of patients, but approximately one-third will have a recurrent attack, often within 1 year of diagnosis. There is evidence demonstrating the increased use of percutaneous drainage in the management of Hinchey class I and II disease, but for patients undergoing surgery, most Hinchey class I and class II disease can be managed with a 1-stage procedure (resection and anastomosis) if the patient is stable, the extent of contamination is limited, and adequate bowel preparation is possible. Most Hinchey class III and IV disease will require a 2-stage approach but primary laparoscopic lavage may be a promising alternative to more radical surgery in select patients. Also, recent evidence suggests a possible role for resection with primary anastomosis and proximal diversion in highly selected cases without gross fecal contamination.

See Invited Critique at end of article

In recent years, the historical indications for elective surgical resection of recurrent uncomplicated diverticulitis have been challenged. Unlike recurrent, un-
complicated diverticulitis, management of complicated diverticulitis is more clear cut and surgical resection of the diseased sigmoid is generally recommended.\textsuperscript{19} In a recent systematic review, the morbidity and mortality of primary anastomosis was found to be similar to that of a Hartmann procedure for patients with even the most severe acute disease,\textsuperscript{19,20} although selection bias prevalent in the studies evaluated prevents firm conclusions.

The role of laparoscopy in the management of diverticular disease is evolving. Recent data suggest decreased overall costs are associated with laparoscopic resections when compared with open resections.\textsuperscript{21,22} Furthermore, recurrence rates match those for open procedures,\textsuperscript{23,24} while length of stay (LOS) and complications are decreased.\textsuperscript{19,21}

The purpose of this study was to examine recent trends in (1) changing incidence and patterns of diverticulitis based on age, sex, and race, (2) changes in treatment pattern of acute diverticulitis (medical or surgical), (3) changes in type of operative intervention (elective vs urgent, open vs laparoscopic, and primary anastomosis vs without primary anastomosis), and (4) improvements in outcomes (LOS and mortality) as management of diverticulitis evolves.

Using the Nationwide Inpatient Sample (NIS) database from 2002 until 2007, we retrospectively analyzed the trends in management of diverticulitis. The NIS is the largest inpatient care database in the United States, in which approximately 1000 hospitals participate, and contains information from nearly 8 million hospital stays each year across the country. The NIS is a nationally representative sample of approximately 20\% of US community hospitals, resulting in a sampling frame that comprises approximately 90\% 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 hospital admission. It also contains discharge information on inpatient hospital stay, including patient characteristics, LOS, overall and specific postoperative morbidity, and observed and expected in-hospital mortality. The NIS database has no information available on complications occurring after discharge. Approval for 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.

To identify hospitalizations resulting from diverticulitis, all discharges with International Classification of Diseases, (ICD) diagnosis codes 562.11 and 562.13 (diverticulitis with and without mention of hemorrhage) as the first diagnosis from 2002 to 2007 were selected. These patients were then divided into emergent and elective groups based on their admission type. In the next step, patients who underwent colon resection (open or laparoscopic) in each group (emergent or elective) were located. Urgent surgery was defined as the need for operative intervention of any emergent admission during the index hospital admission. Procedures were separated according to resection (sigmoidectomy or anterior resection) with primary anastomosis (with or without diverting ileostomy) and resection with colostomy only. Surgical procedures were identified using ICD-9 procedure codes (Table 1). Because there was no distinct ICD-9 procedure code for laparoscopic colectomy during these years, we identified procedures that were done laparoscopically by identifying additionally ICD-9 procedure codes for diagnostic laparoscopy or laparoscopic lysis of adhesion in combination with open procedure codes (Table 1). Patient characteristics of interest included age, sex, and race/ethnicity. Based on the incidence of diverticulitis, age was divided into 3 groups (<50, 50-70, and >70 years). Other data of interest included LOS and in-hospital mortality. We calculated the adult population-based rates of admission type and surgery for each year. We used adult (≥18 years) population estimates from the US census.\textsuperscript{25}

All statistical analyses were conducted using SAS version 9.2 (SAS Institute, Cary, North Carolina), incorporating recommended discharge and hospital weights (discharge weight used to create national estimates for all analyses). Population characteristics were explored using graphs and charts to describe the distribution of each variable. Dates are expressed as means and standard deviations and proportions. (Difference in LOS between groups was determined by 2-sample t test.) Descriptive statistics were performed using \( \chi^2 \), \( t \) tests, and trend tests where appropriate. Multivariate regression analysis was used for mortality in total diverticulitis admission. Statistical significance was set at \( P < .05 \) and odds ratios and 95\% confidence intervals that excluded 1.

**RESULTS**

A total of 1 073 397 patients were recorded in the NIS database as having been admitted with a diagnosis of diverticulitis between 2002 and 2007 (emergent admission: 840 157 [78.3\%]; elective admission: 233 240 [21.7\%]). In addition, 124 patients were admitted with a diagnosis of hemorrhagic diverticulitis. In the emergently admitted patient population, 12.2\% (102 245 pa-
tients) underwent urgent surgical resection and 87.8% were treated with nonoperative methods (percutaneous abscess drainage: 1.88% and medical treatment: 85.92%).

TRENDS IN ADMISSION

Table 2 shows the trends in admission characteristics of patients with diverticulitis for the population of hospitals accounted for in the NIS database from 2002 to 2007. From 2002 to 2007, the annual emergency admission rate for diverticulitis increased by 9.5% per 100 000 adult population, while the annual rate of medical therapy for emergently admitted patients increased 10.13% (Figure 1). Also in emergently admitted patients, the likelihood of percutaneous abscess drainage as a principal procedure increased 3.3 times over time from 0.57% to 1.88% (P < .001). During this period, there was only a 4.3% increase in the annual rate of urgent surgical resection, while there was a 38.7% increase in elective surgical resection. From a different perspective, elective resection composed a slight majority of the surgical treatments in 2002 (elective: 53.8%). This value increased to 60.8% in 2007, which resulted in a significant decrease in the percentage of urgent surgery (46.2% to 39.3%) over the same period (P < .001) (Figure 2).

PATIENT CHARACTERISTICS

Age

The mean (SD) age of all patients admitted for diverticulitis from 2002 to 2007 was 60.2 (35.4) years (elective admission: 58.8 [31.7] years; emergent admission: 60.6 [36.3] years; P < .001). For total admissions, 29.6% of patients were younger than 50 years, 40.2% were between ages 50 and 70 years, and 30.2% were older than 70 years. Similar trends existed for elective and emergent admissions (Figure 3). The most common age group admitted was the age 50 to 70 years group, with total admission rates increasing from 39.6% in 2002 to 43.1% in 2007. Over the period, there was only a 1.3% increase in admission rate in the younger than 50 years group. There was a 4.8% decrease in admission rate in the older than 70 years group for 2002 to 2007.

Sex

Overall, 57.8% of patients admitted for diverticulitis were female (elective admission: 56.9%; emergent admission: 58.3%), which remained stable over the period. However, the number of female patients undergoing urgent surgical resection decreased from 53.0% in 2002 to 49.4% in 2007.

Race/Ethnicity

The information on race/ethnicity was limited, containing only 71% to 75% of race data over the specified pe-
period since several states do not report race data on their discharge abstracts. Regardless, the race/ethnicity of the patient population admitted for diverticulitis changed very little during the period of this study. While a decrease of 3.6% in the white population was observed, an increase in the black and Hispanic population composing the treated patient population also occurred. However, this increase was relatively small (Table 3).

**OPERATIVE VARIABLES**

**Use of Laparoscopy**

For elective surgery, the overall rate of laparoscopic colon resection with and without primary anastomosis was 10.5%. The use of laparoscopy in elective surgery nearly doubled from 6.9% in 2002 to 13.5% in 2007 (P < .001). In urgent surgery, the overall rate of laparoscopic colon resection was 2.8% of total urgent surgeries, with the use of laparoscopy increasing more than 2-fold from 1.6% in 2002 to 3.9% in 2007 (P < .001) (Figure 4).

**Use of Primary Anastomosis**

As expected, the likelihood of requiring a colostomy during an elective operation steadily decreased, from 7.9% in 2002 to 5.5% in 2007. This translated to a significant increase in primary anastomosis (with or without diversion) rates, ranging from 92.1% to 94.5% (P < .001) for elective colon resections over the study period. In urgent open surgery, the likelihood of colostomy formation significantly decreased over time, from 61.2% in 2002 to 54.0% in 2007 (P < .001). For urgent laparoscopic surgery, the likelihood of colostomy formation decreased from 20.9% to 9.0%. For patients who underwent urgent surgery with primary anastomosis during the study period, receiving a diverting ileostomy was rare, accounting for less than 1% (mean, 0.15%; range, 0.08%-0.26%) of the population (Table 4).

**HOSPITAL VARIABLES**

**Length of Stay**

Over the study period, we observed a significant decrease in LOS in both elective and urgent surgery (mean [SD] elective: 6.03 [9.74] days in 2002 to 5.56 [9.21] days in 2007; P < .001; mean [SD] urgent: 12.1 [18.1] days in 2002 to 11.6 [19.1] days in 2007; P = .01). In addition, patients undergoing elective surgery were discharged on average 6 days earlier than those undergoing urgent surgery.

**In-Hospital Mortality**

From 2002 to 2007, in-hospital mortality significantly decreased in both elective and urgent surgery (elective: 0.53% in 2002 to 0.44% in 2007; P = .001; urgent: 4.5% in 2002 to 2.5% in 2007; P < .001). The significant improvement in mortality observed in urgent surgery translated to a 55% relative reduction (Figure 5).

**MULTIVARIATE ANALYSIS**

A multivariate regression analysis was also performed to identify any predictive variables leading to an increased risk of mortality associated with diverticulitis. Being Asian/Pacific Islander (odds ratio, 2.17; 95% confidence interval, 1.64-2.88) and having emergent admission status (odds ratio, 1.42; 95% confidence interval, 1.30-1.55) significantly increased the risk of in-hospital mortality, while being female (odds ratio, 0.88; 95% confidence interval, 0.82-0.94) seemed to be protective (Table 5).

**COMMENT**

We set out to perform a thorough review of the current data on diverticulitis to demonstrate the changes in trends of admission practices and surgical management. With an improved patient and surgeon awareness of disease pathology along with improving technology, physicians...
are more readily able to diagnose, treat, and hopefully prevent diverticular disease.

Interestingly, the frequency of elective surgical resection for diverticulitis has dramatically increased by 38%, which is nearly 9 times greater than the relative increase in urgent surgical resection. This may reflect the influence of the American Society of Colon and Rectal Surgeons guidelines from 2000, suggesting elective colectomy after the first attack in patients younger than 50 years and after the second episode in patients older than 50 years. In 1 study, of those patients requiring hospitalization for acute diverticulitis, only 20% to 50% required an operation. In our study, only 12.2% of the acute diverticulitis population required an operation, which may indicate that this percentage is actually decreasing. In addition, improvements in medical therapy (ie, timing of antibiotic administration, improved control of patient comorbidities, and increased use of percutaneous abscess drainage) may have contributed to the observed decrease in the percentage of urgent resections performed.

It is well known that the presence of diverticulosis is age dependent. Only 5% to 10% of the population younger than 40 years has diverticula.28 We found almost a third of patients admitted for diverticulitis were younger than 50 years. Although our study shows a high incidence of diverticulitis in young patients, there was only an approximately 1% increase in incidence during this period. In comparison, the incidence of diverticulitis in the 50 to 70 years age group increased 3 times more than that of the younger population. Other studies have demonstrated that diverticulitis is on the rise in the younger population; however, we show that this incidence has remained relatively stable. Between 2002 and 2007, population growth was greatest in individuals aged 50 to 70 years (12.5% increase) with relatively no growth in individuals aged 18 to 50 years. As a result, our findings may be due to the aging of the US population, leading to a relative decrease in the incidence of diverticulitis in the younger population.

Several studies have shown that laparoscopic colectomy for diverticular disease results in less blood loss, shorter time to first bowel movement, fewer postoperative complications, shorter LOS, and improved quality of life. In addition, the rate of diverting ileostomy creation after urgent resection increased by almost 7% for open cases. In addition, the rate of diverting ileostomy creation was very small in our study and remained stable over the study period. These findings may be an indication of increasing surgeon comfort and acceptance of this technique’s safety profile, leading to a movement by surgeons toward a single-stage procedure, thereby eliminating the risks associated with ostomy creation. Although, to our

Table 4. Trends in Operative Characteristics, 2002 to 2007

<table>
<thead>
<tr>
<th>Likelihood of Colostomy</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open and elective</td>
<td>7.9</td>
<td>7.4</td>
<td>7.0</td>
<td>6.7</td>
<td>5.7</td>
<td>5.5</td>
</tr>
<tr>
<td>Laparoscopic and elective</td>
<td>1.1</td>
<td>0.9</td>
<td>0.8</td>
<td>2.0</td>
<td>1.7</td>
<td>1.1</td>
</tr>
<tr>
<td>Open and urgent</td>
<td>61.2</td>
<td>58.5</td>
<td>56.8</td>
<td>57.6</td>
<td>54.8</td>
<td>54.0</td>
</tr>
<tr>
<td>Laparoscopic and urgent</td>
<td>12.9</td>
<td>20.9</td>
<td>19.5</td>
<td>14.0</td>
<td>13.8</td>
<td>9.0</td>
</tr>
<tr>
<td>Ileostomy in open urgent</td>
<td>0.11</td>
<td>0.19</td>
<td>0.17</td>
<td>0.26</td>
<td>0.08</td>
<td>0.10</td>
</tr>
</tbody>
</table>

Table 5. Independent Risk Factors for Mortality in Diverticulitis

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Odds of Mortality (95% CI)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>1.07 (1.07-1.08)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Female</td>
<td>0.88 (0.82-0.94)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Race/ethnicity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>1.06 (0.94-1.20)</td>
<td>.51</td>
</tr>
<tr>
<td>Black</td>
<td>1.06 (0.93-1.20)</td>
<td>.51</td>
</tr>
<tr>
<td>Hispanic</td>
<td>1.06 (0.93-1.20)</td>
<td>.51</td>
</tr>
<tr>
<td>Asian/Pacific Islander</td>
<td>2.17 (1.64-2.88)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Native American</td>
<td>0.50 (0.21-1.24)</td>
<td>.08</td>
</tr>
<tr>
<td>Other</td>
<td>0.78 (0.61-1.00)</td>
<td>.07</td>
</tr>
<tr>
<td>Length of hospital stay</td>
<td>1.02 (1.02-1.03)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Elective admission</td>
<td>1.02 (1.02-1.03)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Emergent admission</td>
<td>1.42 (1.30-1.55)</td>
<td>&lt; .001</td>
</tr>
</tbody>
</table>

Abbreviation: CI, confidence interval.
knowledge, there has never been a randomized prospective trial of the Hartmann procedure and primary anastomosis creation for patients with similar-stage diverticulitis, a recent collective review of this topic demonstrates that reported morbidity and mortality results for both techniques are similar.31

Over the study period, we showed that LOS gradually decreased in both elective and emergent patients undergoing operation. Although these changes are small, they remain significant. Such improvements may be due to improved diagnostic accuracy with the use of computed tomographic scanning,34,35 the increase in the use of laparoscopic resection, and improvements in overall postoperative care. Furthermore, because the LOS for urgent surgery is nearly twice that of elective surgery, such a difference may motivate surgeons to operate earlier after a diagnosis is made before emergent conditions arise.

Overall, we observed a trend toward decreased mortality in the surgical treatment of diverticulitis but were most pleased with the significant relative reduction in mortality after urgent resection by 50%. Other studies have shown similar trends in mortality rates37,38 and such improvements may be due, at least in part, to earlier intervention in patients needing operation.

Multivariate analysis has identified Asian race and emergent admission status as predictors of increased mortality. From our data, increased caution should be used and potentially earlier treatment provided when encountering Asian patients with diverticulitis because of their increased risk of mortality. Interestingly, although statistically significant, age does not appear to be a clinically significant predictor of mortality. As a result, timing of surgery with regard to age alone may not be as important as previously thought.

Our study limitations are similar to other studies making use of a large administrative database. A dedicated laparoscopic colectomy ICD-9 code was not in effect until 2009, which may have led to inaccuracies in case collection. Because a majority of patients with acute diverticulitis are treated medically as outpatients and the NIS database is limited only to inpatient hospital admissions, our study lacks information on the true incidence of acute diverticulitis and any postdischarge complications. Lastly, we lack information regarding the exact indication for surgery and the severity (Hinchey classification) of diverticulitis, and clearly, differences in these may have affected the surgical approach and contributed to patient outcomes.

Diverticulitis continues to be a source of significant morbidity in the United States. In summary, our analysis has found that between 2002 and 2007, admission for diverticulitis continued to increase. Younger individuals composed nearly a third of all admissions; however, there was no noticeable change in the pattern or frequency of admission for any age group. With regard to treatment patterns, the number of patients undergoing elective colon resections have increased significantly. Rates of primary anastomosis for urgent surgery have increased during the period, but not as much as expected. These findings are interesting given the growing body of evidence demonstrating the safety of primary anastomosis. Use of laparoscopy in diverticulitis continues to increase because surgeons are becoming more familiar with this technique and previous data have proven its feasibility and safety. All of these changes have culminated in decreased observed mortality in patients presenting with diverticular disease. Such findings will hopefully help physicians gain a better understanding of the disease process and guide them in its prevention and treatment.

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Correspondence: Michael J. Stamos, MD, University of California, Irvine, Division of Colon and Rectal Surgery, 333 City Blvd West, Ste 850, Orange, CA 92868 (mstamos@uci.edu).

Author Contributions: Study concept and design: Masoomi and Buchberg. Acquisition of data: Masoomi, Buchberg, Magno, and Mills. Analysis and interpretation of data: Masoomi, Magno, Mills, and Stamos. Drafting of the manuscript: Masoomi and Buchberg. Critical revision of the manuscript for important intellectual content: Masoomi, Buchberg, and Magno. Administrative, technical, and material support: Mills and Stamos. Study supervision: Mills and Stamos.

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REFERENCES
Clarity, Confusion, or Conundrum

It is not a surprise that Masoomi and colleagues documented that patients hospitalized for diverticulitis between 2002 and 2007 continue to experience significant morbidity. What may be surprising to many is that their analysis of more than a million patients in the NIS database revealed an unexplained dramatic increase of 38% in elective colectomy and a 4.3% increase in urgent colectomy. This occurred despite a growing consensus that indication(s) for surgery should be more restricted than in the past. Additionally, it is surprising that they could only discern “a trend toward increased use of laparoscopic techniques for elective operations and primary anastomosis for urgent operations.” This conclusion flies in the face of anecdotes that “nearly everyone” is successfully using laparoscopic resection and primary anastomosis for diverticulitis. The facts, as reported in this retrospective trends analysis, are that laparoscopic colectomy increased to only 13.5% for elective cases and a mere 3.9% for urgent surgery by 2007. Primary anastomosis with or without diversion increased from 38.8% in 2002 to 46% in 2007 following urgent surgery. Etzioni et al. in a similar study of trends from 1998 to 2005, reported “little change over time in the likelihood of a primary anastomosis” after resection for diverticulitis.

Thus, when it comes to surgery for diverticulitis, American surgeons seem to be operating electively on more patients than ever and yet we are slow to adopt techniques that may lower morbidity and possibly cost less. This article cannot explain these trends. Masoomi and colleagues found no trends relevant to today’s “hot debate” in the management of diverticulitis, ie, laparoscopic lavage without resection. Myers and Winter suggest that current best practice calls for computed tomographic imaging to stratify patients with clinical evidence of peritonitis and that patients with free perforation should undergo laparoscopy. If purulent peritonitis from a sealed perforation is found, they recommend laparoscopic lavage without resection.

As is often the case, the current study raises more questions than it answers. One thing is for certain; clinical expertise and skills cannot be separated from decision making. If surgeons are uncertain of their technical ability to do a laparoscopic colectomy for diverticulitis, they are unlikely to adopt it as their preferred procedure. Surgeons need to have a full arsenal of techniques at their disposal to make decisions in the best interest of their patients.

David A. Rothenberger, MD

Author Affiliation: Department of Surgery, University of Minnesota, Minneapolis.

Correspondence: Dr Rothenberger, Department of Surgery, 420 Delaware St, SE MMC195, University of Minnesota, Minneapolis, MN 55455 (rothe002@umn.edu).

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