Factors Predicting Morbidity and Mortality in Emergency Colorectal Procedures in Elderly Patients

Edward A. McGillicuddy, MD; Kevin M. Schuster, MD; Kimberly A. Davis, MD; Walter E. Longo, MD

Objective: To identify rapidly modifiable risk factors that would improve surgical outcomes in elderly patients undergoing emergent colorectal procedures who are at high risk for morbidity and mortality.

Design: Retrospective review. Patients were identified on the basis of Current Procedural Terminology codes and admission through the emergency department. Medical records were reviewed and data were abstracted for comorbidities, procedural details, and in-hospital morbidity and mortality.

Setting: University tertiary referral center.

Patients: Two hundred ninety-two patients 65 years or older undergoing emergency colorectal procedures from January 1, 2000, through December 31, 2006.

Main Outcome Measures: Postoperative morbidity (intensive care unit days, ventilator days, pneumonia, deep venous thrombosis, pulmonary embolus, myocardial infarction, and cerebrovascular accident) and mortality.

Results: The most frequent presenting diagnoses were obstructing or perforated colorectal carcinoma (30%) and perforated diverticulitis (25%). Average age at presentation was 78.1 years, and in-hospital mortality was 15%. One hundred one patients (35%) experienced a total of 195 complications. Pneumonia (25%), persistent or recurrent respiratory failure (15%), and myocardial infarction (12%) were the most frequent complications. Operative time, shock, renal insufficiency, and significant intra-abdominal contamination or frank peritonitis were associated with morbidity. Age, septic shock at presentation, large estimated intraoperative blood loss, delay to operation, and development of a complication were associated with in-hospital mortality.

Conclusions: Emergent colorectal procedures in the elderly are associated with significant morbidity and mortality. Minimizing the delay to definitive operative care may improve outcomes. These procedures frequently involve locally advanced colorectal cancer, emphasizing the need for improved colorectal cancer screening.

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Elderly individuals represent one of the most rapidly growing segments of the American population. More than 35 million Americans are 65 years or older, and this burgeoning group represents more than 12% of the overall population. From 2000 to 2030, the proportion of the population older than 65 years is expected to grow from 12% to 20%. As average life expectancy lengthens, the number of abdominal surgical procedures performed on elderly patients will continue to increase.

See Invited Critique at end of article

Previous studies have addressed the outcomes of elderly patients undergoing a variety of elective surgical procedures, including colorectal cancer resection, carotid endarterectomy, coronary artery bypass grafting, and laparoscopic colectomy. These studies, investigating age-related morbidity and mortality, concluded that elderly patients have morbidity and mortality rates comparable to those of younger cohorts. For elective procedures, the surgeon can address pertinent comorbidities preoperatively through appropriate testing, consultation, risk stratification, and aggressive medical management. When the elderly patient presents with colorectal disease requiring emergent intervention, however, preoperative evaluation and management is much less comprehensive and often not feasible owing to a state of overall physiologic compromise. Thus, the elderly patient presenting with emergent colorectal disease may be at increased risk for postoperative complications and death.

Many surgical diseases, including colorectal cancer, colonic ischemia, and diverticulitis, are diseases of aging.
rectal cancer, for example, has a high incidence among the elderly and remains the most common primary neoplasm in patients older than 75 years.9 Elderly patients with colorectal cancer may be at risk for emergent presentation because of medical comorbidities, insufficient screening, unrecognized symptoms, and inadequate overall access to the health care system. Because emergent presentation likely confers poorer outcomes in geriatric surgical patients, identifying rapidly modifiable risk factors will be necessary to improve outcomes. We studied an elderly patient cohort undergoing emergency colorectal procedures to determine risk factors associated with in-hospital morbidity and mortality.

### METHODS

**PATIENT IDENTIFICATION**

We retrospectively identified 292 patients 65 years or older who underwent emergent colorectal procedures at the Yale New Haven Hospital, New Haven, Connecticut, a university tertiary referral center, from January 1, 2000, through December 31, 2006. The Yale University Human Investigations Committee approved the study protocol before review of the medical records.

Patients undergoing emergent colorectal procedures identified by Current Procedural Terminology codes were included in this analysis. All patients were admitted through the Yale New Haven Hospital emergency department with colorectal disease requiring immediate or urgent surgical intervention after a brief period of stabilization and resuscitation.

Clinical and laboratory variables were recorded in a database. These variables included patient demographics, medical and surgical history, preoperative functional status, corticosteroid use, preoperative renal function, anticoagulant use, and physiologic factors such as vital signs on presentation, presence of shock or septic shock on admission, laboratory values at presentation (complete blood cell count, prothrombin time, and serum creatinine level), pertinent preoperative imaging studies, American Society of Anesthesiologists (ASA) class, and preoperative diagnosis. Shock was defined as systolic blood pressure of less than 90 mm Hg. Septic shock was defined as shock associated with a temperature higher than 38.4°C or lower than 36.1°C, leukocytosis or leukopenia, and a known or presumed infected focus. Also recorded were operative details including time from presentation to operation, operative time, estimated blood loss, volume of crystalloid and colloid resuscitation, and airway status at the conclusion of the operation.

### RESULTS

Postoperative variables recorded included the length of the intensive care unit stay, the overall length of stay, the number of days receiving ventilation, in-hospital mortality, and complications (ongoing or recurrent respiratory failure, pneumonia, deep venous thrombosis, pulmonary embolism, myocardial ischemia and infarction, and cerebrovascular accident).

**STATISTICAL ANALYSIS**

All information was entered and maintained in a spreadsheet (Excel; Microsoft Corp, Redmond, Washington). We used commercially available software (SPSS, version 14; SPSS Inc, Chicago, Illinois) for statistical analysis; univariate analysis was performed with the χ² test, the unpaired t test, the Pearson product moment correlation for normally distributed data, and the Wilcoxon rank sum test for nonnormally distributed data. All tests were 2-tailed. Multivariate analysis was performed with logistic regression to identify factors associated with morbidity and in-hospital mortality. All variables with an effect on morbidity or mortality with P ≤ .2 were entered into a backward stepwise logistic regression model. The ASA class was considered an ordinal variable using nonorthogonal comparisons between classes and as a dichotomous variable for the ASA class of less than 3 or of 3 or greater. P ≤ .05 was considered significant.

During the 6-year study period, 292 patients 65 years or older presented to the Yale New Haven Hospital emergency department with diagnoses that required an emergent colorectal procedure. The average age was 78.1 (range, 65-100) years, and 59% of this cohort was female (Table 1). Hypertension, coronary artery disease, diabetes mellitus, atrial fibrillation, and congestive heart failure were the most frequent presenting comorbidities. Fifteen percent of this population was receiving long-term anticoagulation therapy consisting of warfarin sodium, and 43% had a documented previous abdominal surgery. Twenty-two patients (8%) were receiving long-term corticosteroid therapy before presentation, and 7 patients (2%) were undergoing hemodialysis for end-stage renal disease.

The most frequent surgical indications were obstructing or perforated colorectal carcinoma and colonic diverticulitis with free perforation, followed by lower gastrointestinal tract hemorrhage and colorectal ischemia (Table 2). Patients also presented with sigmoid volvul-

### Table 1. Characteristics of 292 Study Patients

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male sex</td>
<td>119 (41)</td>
</tr>
<tr>
<td>Age, mean (range), y</td>
<td>78.1 (65-100)</td>
</tr>
</tbody>
</table>

**Table 1. Characteristics of 292 Study Patients**

| Male sex | 119 (41) |
| Age, mean (range), y | 78.1 (65-100) |

*Unless otherwise indicated, data are expressed as number (percentage) of patients.*

### Table 2. Surgical Diagnoses in 292 Study Patients

<table>
<thead>
<tr>
<th>Surgical Diagnosis</th>
<th>No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obstructing or perforated colorectal carcinoma</td>
<td>87 (30)</td>
</tr>
<tr>
<td>Perforated diverticulitis</td>
<td>74 (25)</td>
</tr>
<tr>
<td>Lower gastrointestinal tract hemorrhage</td>
<td>26 (9)</td>
</tr>
<tr>
<td>Colorectal ischemia</td>
<td>25 (9)</td>
</tr>
<tr>
<td>Sigmoid volvulus</td>
<td>13 (4)</td>
</tr>
<tr>
<td>Incarcerated hernia</td>
<td>13 (4)</td>
</tr>
<tr>
<td>Noncolorectal metastatic disease</td>
<td>12 (4)</td>
</tr>
<tr>
<td>Endoscopic perforation</td>
<td>10 (3)</td>
</tr>
<tr>
<td>Abdominal</td>
<td>10 (3)</td>
</tr>
<tr>
<td>Clostridium difficile colitis/toxic megacolon</td>
<td>5 (2)</td>
</tr>
<tr>
<td>Other a</td>
<td>27 (9)</td>
</tr>
</tbody>
</table>

*Includes necrotizing fasciitis, stercoral ulcer, gallstone ileus requiring ileocecectomy, and appendicitis requiring ileocecectomy.*
respiratory death, DVT, PE, CVA. Thromboembolic events, including pulmonary embolism and cerebrovascular accident, occurred in 4% of patients for both. In-hospital mortality was 15%. More than half of the survivors of multisystem organ failure. A total of 122 stomas were created (72 temporary and 50 permanent). Overall, the average length of stay was 20.9 days, and in-hospital mortality was 15%. More than half of the surviving patient population (54%) was discharged to a skilled nursing facility for postdischarge nursing care and rehabilitation. One hundred one patients (35%) experienced a total of 195 complications (Figure). Pneumonia was the most frequent complication (25%), followed by persistent or recurrent respiratory failure (15%), myocardial ischemia and infarction (12%), and deep venous thrombosis (6%). Thromboembolic events, including pulmonary embolism and cerebrovascular accident, occurred in 4% of patients for both.

On univariate analysis, age (P = .003), admission from an extended care facility (P = .05; odds ratio [OR], 2.37; 95% confidence interval [CI], 0.97-5.73), shock (P < .001; OR, 4.25; 95% CI, 2.07-8.90), septic shock at presentation (P < .001; OR, 4.97; 95% CI, 1.86-13.19), estimated blood loss (P = .002), ASA class (P = .001 as an ordinal variable), development of a complication (P < .001; OR, 28.24; 95% CI, 10.59-75.30), operative time (P = .006), and delay to operation (P = .002) were all predictive of mortality. A prolonged length of stay was associated with renal insufficiency (P = .01), malignancy (P = .002), diabetes mellitus (P = .02), ASA class (P < .001 as ordinal and dichotomous variables), complications (P < .001), operative time (P < .001), and delay to operation (P < .001). Discharge to an extended care facility correlated with the presence of coronary artery disease (P < .001), shock on admission (P = .05), renal insufficiency (P = .01), peritonitis (P = .01), ASA class (P < .001 as ordinal and dichotomous variables), the development of complications (P < .001), and increased operative time (P = .15). Postoperative complications were associated with an increased length of stay (P < .001), discharge to an extended care facility (P < .001; OR, 6.86; 95% CI, 3.17-14.82), and in-hospital mortality (P < .001).

On multivariate analysis, shock, increased duration of operation, renal insufficiency, and significant intra-abdominal contamination or frank peritonitis were associated with postoperative complications (Table 3). Septic shock, estimated blood loss of more than 1000 mL, age, time elapsed from presentation to definitive operation, and development of a postoperative complication were predictive of in-hospital mortality. On subgroup analysis of patients presenting with obstruction or perforation, there was no statistically significant difference in mortality with perforating vs obstructing disease. These findings were the same whether the cause was benign or malignant. There was a difference in univariate analysis for length of stay, with perforation predicting a longer length of stay (P = .007). In multivariate analysis that included all patients, however, perforation was not predictive of length of stay (data not shown).

**Table 3. Factors Predicting Morbidity and Mortality in Multivariate Analysis**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Effect</th>
<th>OR (95% CI)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postoperative complications</td>
<td>Morbidity</td>
<td>36.17 (11.48-113.9)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Septic shock</td>
<td>Morbidity</td>
<td>5.26 (1.21-22.5)</td>
<td>.03</td>
</tr>
<tr>
<td>Contamination</td>
<td>Morbidity</td>
<td>3.22 (1.55-6.67)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Shock</td>
<td>Morbidity</td>
<td>2.23 (1.05-4.88)</td>
<td>.04</td>
</tr>
<tr>
<td>Chronic renal insufficiency</td>
<td>Morbidity</td>
<td>1.47 (1.06-2.04)</td>
<td>.02</td>
</tr>
<tr>
<td>Time in operating room</td>
<td>Morbidity</td>
<td>...</td>
<td>.01</td>
</tr>
<tr>
<td>Time to operating room</td>
<td>Morbidity</td>
<td>...</td>
<td>.002</td>
</tr>
<tr>
<td>Age</td>
<td>Morbidity</td>
<td>...</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Estimated blood loss &gt;1000 mL</td>
<td>Morbidity</td>
<td>...</td>
<td>.02</td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; ellipses, not calculated (continuous variables); OR, odds ratio.

By 2030, 1 in 5 Americans is expected to be older than 65 years, and the most rapidly growing cohort in the elderly population consists of individuals older than 85 years. During the past decade, the percentage of operations in which the patient was older than 65 years increased from 19% to 35%. As the human body ages, cumulative physiologic stressors lead to overall decline in organ and tissue function. Physiologic reserve, robust in younger populations, is significantly diminished.
in the elderly patient, and cardiovascular, pulmonary, endocrine, and renal comorbidities are common. From a cardiovascular standpoint, rates of diastolic dysfunction rise significantly with age, and the incidence of congestive heart failure rises concomitantly.14 Atherosclerosis and hypertension are also more common. Pulmonary reserve declines predictably with age.15 Chronic renal insufficiency is more common in older patients.16,17 An estimated 20% of Americans older than 60 years have diabetes mellitus,18 a disorder that has severe adverse effects on the entire cardiovascular system. Hyperglycemia has also been shown to have a negative effect on many components of wound healing.19-21 Neurologic decline resulting in dementia and the immunosenescence of aging further complicate the diagnosis of intra-abdominal sepsis, often resulting in delays in presentation and diagnosis.22,23 Given the physiologic decline that occurs with aging, elderly patients who require an emergent colorectal procedure are at high risk for postoperative morbidity and mortality. Socioeconomic factors may also play a role because the elderly patient with colorectal disease may not have adequate access to the health care system. Preoperative risk stratification and appropriate management of medical comorbidities is compromised in these circumstances, given the severe time and information constraints.

Despite well-established guidelines for screening colonoscopy in elderly patients, colorectal cancer continues to be the second most common cause of cancer death in the United States.24,25 The incidence of detectable colorectal carcinomas peaks in the sixth and seventh decades of life.26 Unfortunately, obstructing or perforated colorectal carcinoma was the most frequent presenting diagnosis in this analysis, and this represents an opportunity to improve outcomes through comprehensive screening. Detecting colorectal carcinomas at early stages has obvious benefit in terms of disease-free survival after an elective resection.

In this analysis, perforated diverticulitis was the second most frequent presenting diagnosis. Diverticulosis is prevalent in the elderly patient with a western-style diet, and an estimated 70% of the American geriatric population has colonic diverticuli.27 Often, a hidden intra-abdominal process such as perforated diverticulitis is masked in elderly patients secondary to dementia, physical deconditioning, and immunosenescence. Sigmoid volvulus, described classically as a disease of the elderly, debilitating, institutionally bound patient,28 was surgically managed in 12 patients (4%) in this analysis after endoscopic detorsion was not achieved. Despite several recent studies reporting an increased virulence of C difficile colitis29-31 and plea for aggressive and early surgical management, including a study that documented a 66-fold increase in cases at 1 institution,32 few patients in our analysis underwent colectomy for C difficile–associated toxic megacolon. Overall, it is not surprising that obstructing or perforated colorectal cancer and perforated diverticulitis constitute more than half of the diagnoses in this study. Anatomically, diverticular disease tended to be left sided, whereas colorectal cancer was widely distributed throughout the colon and rectum.

One of 7 patients in this analysis did not survive to hospital discharge, and more than half of the remaining cohort required discharge to an extended care facility for rehabilitation and comprehensive nursing care. Longer operative times and intra-abdominal contamination, resulting in increased evaporative losses and extensive resuscitation, were associated with higher rates of postoperative complications. Sepsis and high estimated blood loss were associated with mortality. The immune dysregulation and decline in humoral function that occurs in elderly patients makes this group particularly vulnerable to intra-abdominal sepsis. Studies have demonstrated that induction of proinflammatory cytokines after septic stimuli is not adequately counterbalanced by anti-inflammatory mechanisms in elderly persons.33 The elderly patient with sepsis and diminished, or even absent, physiologic reserve is at high risk for multisystem organ failure and subsequent death,34 as reflected in this analysis. The potentially modifiable risks for mortality in our population were delay to operative management and reductions in postoperative complications. A focus on aggressive resuscitation and nonsurgical source control may have improved outcomes. Because of the retrospective nature of this analysis, it was impossible to determine whether these outcomes could have been improved for this cohort of patients.

In terms of postoperative complications, pneumonia was the leading complication. Most cases of pneumonia were ventilator associated. Despite the addition of measures, such as maintaining the head of the bed at 30° and daily holding of sedation, pneumonia rates were constant during the period included in this review. Because of the high incidence of postoperative delirium in elderly patients, this population may not reap the pulmonary benefits from these measures seen in the global population of patients undergoing elective procedures. Risk factors for pneumonia in the elderly surgical patient include a large abdominal incision, decreased pulmonary reserve, physical debilitation, preexisting malnutrition, and respiratory failure requiring mechanical ventilation. These findings are corroborated by studies that document the high incidence of postoperative pneumonia in elderly patients,35,36 including a large Department of Veterans Affairs study that documented a 30-day mortality rate of 21% in patients who developed postoperative pneumonia.37 In that study, emergent procedures with general anesthesia were associated with high rates of postoperative pneumonia. Recurrent respiratory failure requiring reintubation was the second most frequent complication in this analysis, and this reflects the diminished pulmonary reserve that occurs with aging and the respiratory sequel of a debilitated patient with a large abdominal incision. Postoperative myocardial ischemia and resultant infarction occurred in 1 of 7 elderly patients in this analysis. In the United States, perioperative myocardial infarctions continue to be a leading cause of morbidity and mortality.38 When an elderly patient requires emergent surgery, time constraints preclude detailed cardiovascular workup and intervention. Preoperative electrocardiograms are a rapid, reliable method for assessing cardiac rhythm and ruling out ischemia. The rate of venous thromboembolic phenomena in this analysis was surprising considering that, at our institution, unfractionated or low-molecular-weight heparin administered by postoperative day 1 and sequential compression
to the calf initiated in the operating room are routine, whereas duplex ultrasonographic surveillance is not.

Despite yielding clinically relevant results, the limitations of this study must be acknowledged. Although the purpose of this study was the identification of modifiable risk factors that may have a negative effect on outcome in this surgical cohort, factors such as advanced ASA class and admission from an extended care facility represent indicators of chronic illness and deconditioning that are not immediately rectifiable. Several important modifiable risk factors, however, including time elapsed to definitive operation and development of renal insufficiency or shock, were identified in this study. These results suggest a morbidity and mortality benefit in patients who receive a diagnosis without undue ancillary testing and who undergo aggressive resuscitation and prompt surgical exploration. Also, 59% of our study subjects were female. This may be attributed to differences in life expectancy, with women in the United States living an average of 5.4 years longer than men.39 There were, however, no differences in outcomes based on sex. The study population included patients from a single institution who are representative of a single geographic region, with a particular spectrum of surgical disease. Despite the existence of basic general surgery and critical care principles with regard to intra-abdominal emergencies, the care of each patient may have been influenced by local standards of practice, as well as by individual surgeon preferences. All of these limitations stem from the retrospective nature of this review.

Overall, this study has broad implications for the care of elderly patients with emergent colorectal disease. The most frequent diagnosis in our study was an obstructing or perforated colorectal carcinoma. This finding underscores the importance of appropriate colorectal screening because early diagnosis and resection of colorectal cancer has obvious benefits. Although the in-hospital mortality rate among elderly patients presenting with colorectal cancer in this study was only 6% compared with the overall mortality of 15%, their late stage at diagnosis portends a poor long-term survival. Cardiopulmonary complications occurred most often in our study population, emphasizing the need for close surveillance and early aggressive treatment. Finally, the results of this study stress the importance of prompt evaluation and surgical intervention in elderly patients with colorectal surgical emergencies.

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Author Contributions: Dr Schuster had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Schuster, Davis, and Longo. Acquisition of data: McGillicuddy. Analysis and interpretation of data: McGillicuddy and Schuster. Drafting of the manuscript: McGillicuddy and Schuster. Critical revision of the manuscript for important intellectual content: Schuster, Davis, and Longo. Statistical analysis: McGillicuddy and Schuster. Administrative, technical, and material support: Davis and Longo.

Study supervision: Schuster, Davis, and Longo.

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REFERENCES

Getting Old Shouldn’t Be an Emergency

As a Baby Boomer, I find this article depressing. Whatever happened to ‘65 is the new 45’? McGillicuddy et al have provided us with a picture of worsening outcomes as our population ages, especially if the patient presents at the end of the disease spectrum when emergency care becomes necessary. The authors emphasize that preventive care for patients in the area of colorectal disease as well as comorbidities will benefit the patient and society. The high perforation/obstruction rate for colorectal cancer in the group (30%) suggests that education of primary care physicians and patients regarding appropriate screening measures may be a useful way to spend a portion of President Obama’s stimulus package. This might lead to a reduction of medical expenditures as emergency care costs and the high cost of complications disappear without penalizing physicians for allowing “never” events to occur in high-risk patients. The authors also emphasize that a raised level of awareness and appropriate surveillance for cardiopulmonary complications in this patient population may improve outcomes. Because all patients older than 65 years have access to health care already, access to care should not be as significant a factor as the authors suggest. Once again, awareness on the part of patients and primary care physicians is important.

Unfortunately, the data collected from this patient group did not include dementia and TNM stage of cancer, so these factors cannot be used as prognostic indications based on the current analysis. It is possible that these two areas may confound some of the findings and should be remembered for future studies.

The design of this retrospective review does not allow comparison of outcomes for elderly patients undergoing elective and emergent operations. Thus, the conclusion that age is affecting their outcome is not as strong as it might be. In fact, the best case-controlled method would consist of 4 groups comparing young and old and emergent and elective for the same disease processes.

Sklow et al used this method to define the benefit of laparoscopy in elderly patients. In only 1 group, patients older than 75 years undergoing laparoscopic left colectomy, did a true benefit appear. As the authors have suggested in this study, factors such as discharge to a nursing home become very important in the evaluation of surgical outcomes. Because no mention was made of the use of a laparoscopic technique, we are not able to determine whether outcomes would have been affected by using less invasive methods.

The patient population itself may have greatly influenced the outcomes of this analysis, as the authors have suggested. An extraordinarily high percentage of the operations performed (47%) were right and transverse colectomies. This is unusual because most perforating or obstructing colon cancers occur on the left side of the colon. Obstruction rarely occurs in the right or the transverse colon, which have large diameters, unless disease is ignored for a prolonged period. There is no cure for stoicism, and refusal to seek medical help cannot be punished more than the disease process has already done. Because 25% of the population presented with complications of diverticulitis, we can also assume that lack of fiber is a characteristic of the diet of these individuals. Education is therefore extremely important to raise awareness of symptoms, screening methods, and preventative care in our attempts to modify the outcomes of our operative treatments.

In many ways, this article has demonstrated the difficulty of performing retrospective outcomes research. Length of hospital stay is one of the outcome variables used by the authors. This is an objective data point but is controlled by many subjective inputs. The authors have not provided us with a standardized perioperative protocol, information regarding ostomy construction (which necessitates prolonged in-hospital education), or the economic status of the patients (which influences willingness to be discharged). A multivariate analysis may compensate for some of these issues but cannot overcome the lack of a control group and the use of such a heterogeneous group of patients. Therefore, the reader should consider the warnings generated by this report but understand the possible flaws of making strong conclusions based on retrospectively gathered data.

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