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Outcomes of Aortic Surgery for Abdominal Aortic Graft Infections

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Abstract

Background: Literature on postoperative outcomes following aortic surgery for aortic graft infection (AGI) is limited by relatively small sample sizes, resulting in lack of national benchmarks for quality of care. We report in-hospital outcomes following abdominal aortic surgery for AGI and identify factors associated with postoperative complications using the Nationwide Inpatient Sample (NIS) database. **Methods:** Patients who underwent aortic graft resection for AGI were identified from the 2002 to 2008 NIS database, a multicenter database capturing 20% of all US admissions. Multivariable logistic regression analyses were performed. **Results:** Among 394 patients (men: 73.4%) who underwent abdominal aortic surgery for AGI, 53% of the admissions were emergent/urgent. A significant trend for decreasing number of abdominal aortic surgery for AGIs per year was observed (Pearson *r* correlation: $-.96$; $P = .0006$). Over the same time span, a significant correlation was also seen with decrease in open and increase in endovascular aortic aneurysm repairs in the NIS database. In-hospital rates of overall postoperative morbidity and mortality were 68.3% and 19.8%, respectively. In-hospital rates of postoperative respiratory failure, renal failure, and cardiac arrest were 35.5%, 14.2%, and 8.9%, respectively. Median length of stay was 26 days, with median hospital charges being US$184 162. On multivariable analysis, increase in age per year (odds ratio [OR] 1.07; 95% confidence interval [CI]: 1.03-1.12) was independently associated with postoperative morbidity, while higher hospital volume for this procedure was protective (OR: 0.71; 95% CI: 0.56-0.89). No preoperative factors were independently associated with postoperative mortality. **Conclusion:** Incidence of abdominal aortic surgery for AGI has progressively declined over the span of our study in association with decreased open and increased endovascular aortic aneurysm repairs. Aortic surgery for AGI is associated with very high morbidity and mortality rates along with prolonged lengths of stay and elevated hospital charges. The outcomes of operations for AGI are better in younger patients and higher volume hospitals.

Keywords
aortic, graft, infection, resection

Introduction

Aortic graft infection (AGI) is an uncommon but catastrophic condition,[1] and its surgical management remains one of the most demanding challenges of aortic surgery.[2,3] Conservative medical treatment is usually insufficient because microbial seeding of the aortic graft results in persistent bloodstream infection and increases the risk of local (pseudoaneurysm or mycotic aneurysm formation) and systemic (sepsis, aortic rupture, and death) complications.[4]

Studies of patients undergoing aortic surgery for removal of infected grafts are scarce, and the existing literature is based on single-center data with limited number of patients. There is also lack of data about the trend of AGI over time, as endovascular aneurysm repairs (EVAR) have increased and open repairs declined in the last decade.[5,6]

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The objectives of our study were to use the Nationwide Inpatient Sample (NIS) data set to report in-hospital national outcomes following abdominal aortic surgery for AGI, identify factors associated with postoperative complications, and study the trend of AGI treated with abdominal aortic surgery over time.

Material and Methods

Data Set

Data were extracted from the 2002 to 2008 NIS. The NIS is the largest all-payer inpatient care database in the United States and is maintained by the Agency for Healthcare Research and Quality as part of the Healthcare Cost and Utilization Project (HCUP).[7] The database is a stratified, cross-sectional sample that includes approximately 20% of all hospital discharges from nonfederal facilities within the United States. Nationwide Inpatient Sample data are available from 1988 to 2008, over which time the number of states in the NIS has grown from 8 to 44. The present study combined NIS data from 2002 to 2008. The NIS is drawn from those states participating in HCUP; for 2009, these states comprise 96% of the US population. The NIS contains data on approximately 8 million hospital stays each year from more than 1000 hospitals. To ensure the representative nature of the databases, the NIS is stratified by geographic region, urban versus rural location, teaching status, hospital ownership, and hospital bed size.

The NIS has numerous internal quality assurance procedures that check the consistency and validity of data points.[7] Furthermore, HCUP validates the NIS annually by comparing its contents with those of 2 similar databases, the National Hospital Discharge Survey and the Medicare Provider Analysis and Review, to assess potential biases in the data set.[7]

The reported data conform to the data use agreement for the NIS from the HCUP. Additional information about NIS is available from the Agency for Healthcare Research and Quality, which administers the database as part of the HCUP.[7]

Patients

Patient identification was based on the 2008 *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*) diagnosis and procedure codes.[8] To identify patients with AGI, *ICD-9* diagnostic code 996.62 was used. This code includes infection and inflammatory reaction as a result of any vascular device, implant, or graft. This code was then combined with appropriate *ICD-9* codes for aortic resections associated with AGI: (1) 38.34, resection of vessel with anastomosis, abdominal aorta; (2) 38.44, resection of vessel with replacement, abdominal aorta; and (3) 38.64, other excision of vessel, abdominal aorta. All other patients were excluded, and our study cohort reflected only patients undergoing abdominal aortic resection with an associated code of infected graft at the same admission. To further assure that we did not overestimate, all patients with the code for dialysis and renal failure, preoperatively and Postoperatively, were excluded (v56.0) to remove any possibility of dialysis graft infections in the cohort. Further, any patient with a cardiac or thoracic aortic procedure during the inpatient stay was also excluded.

Outcome

The primary outcome of interest was in-hospital mortality following aortic surgery for AGI. Secondary outcomes included perioperative overall morbidity (presence of any perioperative complication) and hospital length of stay.

Statistical Analysis

For each patient in the extracted cohort, a combined comorbidity risk score was calculated based on their comorbidities using a modification of the method of Elixhauser et al.[9,10] Postoperative complications were identified using the diagnoses *ICD* codes in the NIS data set. Hospital volume for AGI cases was calculated based on the hospital identifier number.

Stepwise multivariable logistic regression analyses were performed to identify preoperative variables associated with increased risk of postoperative in-hospital overall morbidity and mortality. All preoperative variables were included in the analyses, and the P value stay criterion for the logistic regression models was .05. Interactions between the significant predictors were assessed. Categorical predictors such as race were incorporated into the models using reference coding. This means that one level of the categorical predictor is chosen as a reference category, and the remaining levels of the predictor are compared to the reference.

To study the relationship between year of presentation and number of AGIs, Pearson r correlation was obtained. This was further correlated with the total number of open and endovascular aortic aneurysm repairs in the NIS database for 2002 to 2008.

Statistical analysis was performed using SAS (version 9.2; SAS Institute, Cary, North Carolina). P value $<.05$ was considered as significant.

Results

In the 2002 to 2008 NIS data set, 394 patients underwent abdominal aortic surgery for AGI. As the NIS data set includes approximately 20% of all hospital discharges, this implies approximately 2000 abdominal aortic operations for AGI in the United States in 2002 to 2008. The median age was 72 years (interquartile range [IQR]: 66-77 years). There were 289 (73.4%) males and 105 (26.7%) females in this patient cohort. The demographics and preoperative characteristics are listed in Table 1.

The median (range) hospital volume of abdominal aortic surgery for AGI over the study period was 1 (1-8) case. A significant trend for decreasing number of AGIs treated with abdominal aortic surgery per year was observed over the study span (Pearson r correlation: $-.96$; $P = .0007$). Over the same

Table 1. Preoperative Variables.

Variable	Incidence, n (%)
Age, median (IQR), years	72 (66-77)
Admission type	
Emergent	149 (42.6)
Urgent	37 (10.6)
Elective	164 (46.9)
Comorbidity risk score (mean)	6.4
Gender	
Male	289 (73.4)
Female	105 (26.7)
Hospital region	
West	97 (24.6)
South	129 (32.7)
Northeast	75 (19.0)
Midwest	93 (23.6)
Hospital volume for aortic graft infection cases (mean ± SD)	2.2 ± 1.7
Race	
White	244 (84.1)
Black	22 (7.6)
Hispanic	11 (3.8)
Asian or Pacific Islander	3 (1.0)
Other	10 (3.5)
Year	
2002	80 (20.3)
2003	72 (18.3)
2004	70 (17.8)
2005	59 (15.0)
2006	51 (12.9)
2007	44 (11.2)
2008	18 (4.6)
Number of days from admission to procedure, median (IQR)	0 (0-1)

Abbreviations: IQR, interquartile range; SD, standard deviation.

time span, a significant correlation was also seen with decrease in open (total n = 22 231) and increase in endovascular aortic aneurysm repairs (total n = 31 783) in the NIS database (Figure 1).

The in-hospital rate of overall postoperative morbidity was 68.3%, with rates of postoperative respiratory failure, renal failure, and cardiac arrest/myocardial infarction being 35.5%, 14.2%, and 8.9%, respectively. Median (IQR) length of stay was 25 (17-40) days, with the median hospital charges being US$184 162. In-hospital mortality was 19.8%. Fifty-one percent of the patients were discharged to a skilled nursing facility or a short-term hospital, whereas 29% were discharged home. Postoperative complications are listed in Table 2.

On multivariable analysis, increase in age per year (odds ratio [OR]: 1.07; 95% confidence interval [CI]: 1.03-1.12) was independently associated with postoperative morbidity, whereas higher hospital volume for this procedure was associated with decrease in postoperative morbidity (OR: 0.71; 95% CI: 0.56-0.89). On multivariable analysis, no preoperative factors were independently associated with postoperative mortality.

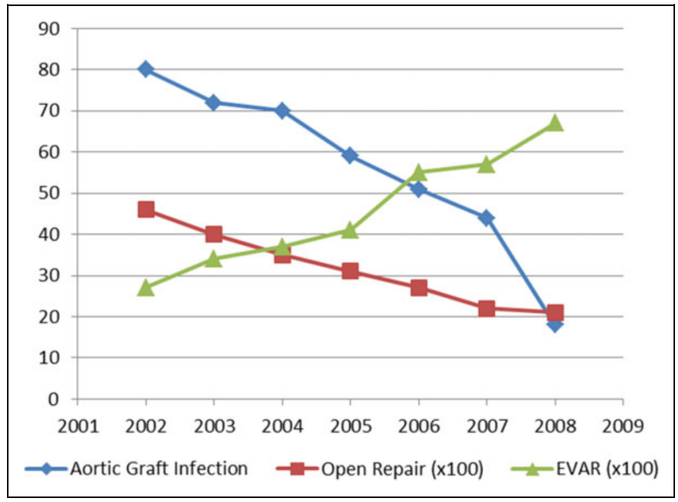

Figure 1. Correlation of aortic graft infection rates with open and endovascular abdominal aortic aneurysm repairs.

Discussion

Advances in vascular graft manufacturing, improvements in surgical techniques, and an aging population have led to an increased utilization of vascular prosthetic grafts.[11] Around 450 000 prosthetic vascular grafts are inserted in the United States every year and around 16 000 implants get infected annually,[12] resulting in approximately US$640 million in health-care expenditure.[11] Among the various vascular prosthetic graft infections, those of aortic grafts are the least common, with an incidence in the range of 1% to 2%.[3,13,14] These infections are associated with a high morbidity, mortality, amputation, and reinfection rate.[11] The general consensus with AGI is that infected graft material should be completely removed and replaced by autogenous material or reconstructed extra-anatomically, as conservative management is usually associated with poor outcome.[1,15] In order to evaluate the surgical outcomes and time trends of AGI in the United States after both open and endovascular aortic surgeries, we analyzed the NIS database.

In this study, the postoperative in-hospital mortality rate after abdominal aortic graft explantation was 19.8% and did not change significantly over the study period from 2002 to 2008. The mortality, however, is lower than the 20% to 40% mortality rate reported in the literature based on data from the last 50 years.[1,3,16-21] This could be due to the availability of better antibiotics and newer graft materials, adherence to Surgical Care Improvement Project (SCIP) protocols, improved perioperative care, and improved options for distal revascularization after graft explantation.

The in-hospital postoperative morbidity rate was 68.3%. This is comparable with the postoperative morbidity rate of 25% to 75%, which has been reported in the literature.[22] The high postoperative respiratory failure rate of 35.5% could be due to multiple factors including a high-risk surgery, emergency procedure, preoperative sepsis, and higher American Society of Anesthesiologists (ASA) class, which are all known

Table 2. Postoperative Variables.

Variables	Incidence, n (%)
Complications	
Fistula	
No	389 (98.7)
Yes	5 (1.3)
UTI	
No	362 (91.9)
Yes	32 (8.1)
Pneumonia	
No	362 (91.9)
Yes	32 (8.1)
Respiratory failure	
No	254 (64.5)
Yes	140 (35.5)
Pulmonary embolism	
No	391 (99.2)
Yes	3 (0.8)
Stroke	
No	386 (98.0)
Yes	8 (2.0)
Cardiac arrest/MI	
No	359 (91.1)
Yes	35 (8.9)
Bleeding complication	
No	369 (93.7)
Yes	25 (6.4)
Renal failure requiring dialysis	
No	338 (85.8)
Yes	56 (14.2)
Wound complication	
No	342 (86.8)
Yes	52 (13.2)
Intra-abdominal abscess	
No	368 (93.4)
Yes	26 (6.6)
Ileus/SBO	
No	338 (85.8)
Yes	56 (14.2)
Overall morbidity	
No	125 (31.7)
Yes	269 (68.3)
Other postoperative variables	
Length of stay, median (IQR), days	25 (17-40)
Total charges (median)	US$184 162
Disposition of patient	
Routine	67 (17.0)
Short-term hospital	26 (6.6)
Skilled nursing facility	175 (44.4)
Home health care	47 (11.9)
Against medical advice	1 (0.3)
Died	78 (19.8)

Abbreviations: IQR, interquartile range; MI, myocardial infarction; SBO, small bowel obstruction; UTI, urinary tract infection.

predictors of postoperative respiratory failure.[23] Similar risk factors such as higher ASA class, high-risk surgery, and older age may account for the high rate of postoperative cardiac events.[24] This high complication rate probably accounts for the prolonged length of hospital stay and subsequent discharge to a skilled nursing facility or a short-term hospital for majority of the patients.

Hospitals in which greater volume of vascular surgery procedures are performed tend to have lower perioperative morbidity and mortality rates.[25] We similarly found hospital volume for AGI surgery to be a protective factor for morbidity after AGI surgery. This finding suggests that we should refer these patients to tertiary centers for management when possible. Advanced age was the only factor predictive of morbidity after aortic graft explantation in our study and has been shown to be associated with adverse outcomes after abdominal aortic aneurysm repair in the literature.[26,27]

There was a significant trend to decreasing AGIs treated with abdominal aortic surgery over time during the study. This trend could be due to a more widespread adaptation of SCIP protocols and some of the principles described by Bandyk[28] to minimize graft infections including avoidance of prolonged preoperative hospitalization, use of antibacterial soap by patients the night before the operation, and use of preoperative prophylactic antibiotic to prevent subsequent development of infection. A significant decrease in open and an increase in endovascular aortic aneurysm repairs in the NIS database were observed during the study period. We, however, cannot make any definite conclusions as to whether an increase in EVAR and decrease in open aneurysm repairs led to decrease in AGIs as this may be an incidental finding or a coding issue. Unlike our study, a previous study by Vogel and colleagues[29] based on data from the state of Washington from 1987 to 2005 did not show a significant correlation of EVAR with incidence of AGIs. It is possible that their finding was due to the predominance of open aneurysms (n = 12 626) in contrast to EVARs (n = 1276) and also due to older data.

This study based on the NIS database has many strengths not seen in other studies. It is the largest study to date on AGIs. The study sample is from a broad nationwide population, and data are obtained from academic and community hospitals, taking into account multiple preoperative variables and trends over time.

The limitations of the current study include the retrospective nature of the data source. Our study, which analyzes trends and outcomes after AGIs, is an ideal one for utilization of the NIS database given the rarity of the condition. Administrative databases are, however, limited by lack of disease-specific information such as the patient presentation, anatomic information about extent of graft infection, type of reconstruction, index procedure details such as EVAR or open aortic surgery, and coding being based on *ICD* codes. In-hospital complications are present in the NIS database; however, readmission and long-term data are not available.

In conclusion, incidence of AGI treated with abdominal aortic surgery has progressively declined over the span of our study. Aortic surgery for AGI is associated with very high morbidity and mortality rates along with prolonged lengths of stay and elevated hospital charges. The outcomes of operations for AGI are better in younger patients and higher volume hospitals.

Authors' Note

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Declaration of Conflicting Interests

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