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Rehospitalization to Primary Versus Different Facilities Following Abdominal Aortic Aneurysm Repair

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Abstract

Objective—Reducing readmissions represents a unique opportunity to improve care and reduce health care costs and is the focus of major payers. A large number of surgical patients are readmitted to hospitals other than where the primary surgery was performed, resulting in clinical decisions that do not incorporate the primary surgeon and potentially alter outcomes. This study characterizes readmission to primary versus different hospitals after abdominal aortic aneurysm (AAA) repair and examines the implications with regard to mortality and cost.

Methods—Patients who underwent open or endovascular aneurysm repair (EVAR) for AAA were identified from the CMS Chronic Conditions Warehouse (CCW), a random 5% national sample of Medicare beneficiaries from 2005-2009. Outcomes for patients who underwent AAA repair and were readmitted within 30 days of initial discharge were compared based on readmission location (primary vs. different hospital).

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Results—885 patients underwent AAA repair and were readmitted within 30 days. 626 (70.7%) returned to the primary facility, and 259 (29.3%) returned to a different facility. Greater distance from patient residence to the primary hospital was the strongest predictor of readmission to a different facility. Patients living 50-100 miles from the primary hospital were more likely to be readmitted to a different hospital compared to patients living <10 miles away (OR = 8.50, P <.001). Patients with diagnoses directly related to the surgery (e.g. wound infection) were more likely to be readmitted to the primary hospital whereas medical diagnoses (e.g. pneumonia and congestive heart failure) were more likely to be treated at a different hospital. There was no statistically significant difference in mortality between patients readmitted to a different or the primary hospital. Median total 30-day payments were significantly lower at different versus primary hospitals ($11,978, primary vs. $11,168, different, P = .04).

Conclusion—Readmission to a different facility after AAA repair is common and occurs more frequently than for the overall Medicare population. Patients travelling a greater distance for AAA repair are more likely to return to different versus the primary hospital when further care is required. For AAA repair, quality healthcare may be achieved at marginally lower cost and with greater patient convenience for selected readmissions at hospitals other than where the initial procedure was performed.

Owing in part to the 2010 Patient Protection and Affordable Care Act, improving patient outcomes and providing more cost effective care is a focus of current efforts in health care research and administration. Accordingly, decreasing 30-day readmission rates represents an opportunity to improve outcomes and lower healthcare costs by appropriately identifying and reducing preventable readmissions. Vascular surgery, encompassing all diagnoses and procedures, has a readmission rate of 23.9%, which is markedly higher than the overall surgical readmission rate of 15.6%.[1] Of the seven categories accounting for more than 30% of potentially preventable readmissions, vascular surgery is the most costly (on a per patient basis).[2] For this reason, it is important to develop a better understanding of the causes and consequences of readmissions following vascular surgery and the mechanisms that underlie the cost of readmission. Readmission to a facility other than that where the primary procedure was performed is one factor that may lead to increased cost and mortality. Physicians at different hospitals are likely unfamiliar with the patient's intervention and postoperative course. Moreover, a community hospital may not be equipped to care for patients with high complexity. There is a robust literature indicating that survival after complex operations is related to a “failure to rescue” patients from complications rather than the avoidance of postoperative complications.[3, 4] That is, the ability of a health system to care for a patient who has a complex postoperative course may be more important than the ability to prevent the initial complications.

Abdominal aortic aneurysms (AAAs) are a significant source of mortality in the United States with ruptured AAAs being the 15th leading cause of death overall.[5] AAA repair represents one of many surgical procedures with a documented positive volume-outcome relationship.[6-9] Consequently many patients are referred to high-volume centers which offer improved peri-operative outcomes including lower mortality.[10] Unfortunately, the emphasis on regionalization predates current healthcare reform aimed at reducing readmissions. Considering that 13% of patients undergoing AAA repair experience readmission within 30 days[11] and as many as 55% within one year, [12] understanding where these patients are readmitted is necessary. Additionally, there is a 5-fold increase in mortality within one year after surgery (23.4% vs. 4.5%) for AAA patients that are readmitted.[11] It is unclear to what extent this may be related to patients' being readmitted to a hospital different from where the primary surgery was performed.

Readmission to the primary versus a different facility has not been systematically studied in any surgical population. Previous evaluations are limited to the rate of different facility rehospitalization without further analysis of the predictors or consequences of this phenomenon. This study evaluates the rates and characteristics of same versus different hospital readmission after AAA repair with particular attention to associated costs and mortality. We hypothesize that readmission to a different hospital is associated with increased cost and mortality among patients undergoing AAA repair.

Methods

Sample Definition

We utilize the CMS Chronic Conditions Warehouse (http://ccwdata.org), a 5% national random sample of Medicare beneficiaries followed over time following sample entry (2004 through 2009). Data included patient demographics and clinical characteristics, Medicare enrollment data, and facility and provider claims. We used International Classification of Diseases, 9th Clinical Modification (ICD-9-CM) diagnosis codes to identify patients with ruptured or non-ruptured AAA, and procedure codes defined endovascular and open aneurysm repair as previously reported (codes available in Appendix I).[11, 13] AAA diagnoses without an associated procedure code for repair were excluded as were aortic dissections, thoracic aortic aneurysms, and thoracoabdominal aneurysms (Appendix I). Inclusion required continuous enrollment in Medicare parts A and B for 365 days before primary admission to characterize patient comorbidities, and 60 days following the primary discharge date to examine 30-day readmission cost and mortality. Additional selection criteria per the CMS definition of 30-day readmissions[14] are available in Appendix I. Patients with multiple readmissions within 30 days of primary discharge were counted once, and only the first readmission was included in analysis. Emergent presentation with subsequent referral to another facility is attributed as a readmission to the accepting facility and treatment under observation status is not counted as a readmission, as per existing CMS readmission policy.[14]

Outcome and Explanatory Variables

The primary outcome variable is readmission to a different facility within 30 days of discharge following AAA repair. This was coded comparing the facility identification numbers of the primary hospital and readmitting hospitals. We also compared mortality rates between the readmission destinations by examining (1) in-hospital rehospitalization mortality and (2) mortality within 30 days of the date of rehospitalization. Total 30-day rehospitalization payments were calculated by aggregating all paid inpatient, outpatient, facility and provider claims occurring within 30 days of the date of rehospitalization.

Patient characteristics including age, gender, race (white or non-white), Medicaid eligibility, and Medicare disability entitlement were obtained. Rural-Urban Commuting Area (RUCA) codes[15] categorized patient residence as urban, suburban, large town, or rural. Distance from patient residence to the primary hospital was calculated as straight line distance from the center of patient's residence zip code to the address of the primary hospital. Patient mobility was assessed using the first claim date for a mobility assistive device. Additional clinical characteristics included comorbidities (Charlson index), [16] the CMS Hierarchical Condition Categories (a measure of predicted healthcare utilization), [17] and the number of hospitalizations in the year prior to the qualifying procedure. Other variables included length of stay (LOS), type of repair (open or endovascular), type and number of in-hospital postoperative complications as previously defined,[11] and whether the primary hospital had a medical school affiliation. Initial discharge destination was determined using the CMS discharge status variable in conjunction with subsequent facility claims for other transitional care settings. Discharge destination was categorized as home, home with home care, skilled nursing facility (SNF), or other.

Attributes of the readmission included in analysis include emergency visit prior to rehospitalization (claim for emergency services between initial discharge and readmission), time to readmission, and the rehospitalization LOS. For each patient, the primary readmission diagnosis was determined, and diagnoses were grouped using the Agency for Healthcare Research and Quality (AHRQ) Clinical Classification Software (CCS) multilevel CCS codes (Appendix II).[18]

Statistical Analysis

Missing observations in analysis variables comprised less than 5% of the data and were dropped from analysis. We compared explanatory variables (summarized with mean and standard deviation for continuous variables and percentages for categorical variables) for same versus different facility readmissions using student's t-test and Wilcoxon test for continuous variables and Chi-squared or Fisher's exact test for categorical variables. Logistic regression was used for multivariable analysis. Adjusted odds ratios (OR) and 95% confidence intervals (95% CI) were calculated for predictors of readmission to a different facility. Mortality rates were compared using Chi-squared tests, and median total 30-day costs were compared using a Wilcoxon test. Simultaneous quantile regression[19] was used to calculate adjusted predicted payments for readmitted patients, allowing testing of the entire payment distribution and at the 10th, 50th, and 90th percentiles of the payment spectrum. Analyses were performed using SAS 9.3 software (SAS Institute, Cary, NC) and STATA 12 software (Stata-Corp, College Station, TX). All tests of significance were at the $P < .05$ level and 2-tailed.

Results

Univariate Analysis of Patient and Clinical Predictors of Readmission to a Different Hospital

We identified 6752 qualifying patients treated with AAA repair. Of these, 885 (13.1%) were readmitted within 30 days, meeting criteria for further analysis. 362 (40.9%) were treated with an open repair, and 72 (8.1%) returned after repair of a ruptured aneurysm. Characteristics of patients readmitted to the primary (n=626, 70.7%) or different (n=259, 29.3%) hospitals are shown in Table I. RUCA code of the patient's residence was associated with readmission to a different hospital as was the distance from the patient's residence to the primary hospital.

Twenty-three percent of urban residents (n=545) were readmitted to a different hospital versus 43.0% of rural residents (n=121) ($P < .001$). Approximately 13% of patients living within 10 miles of the primary hospital (n=343) were readmitted elsewhere, whereas more than half (54%) of patients living 50 to 100 miles from the primary hospital (n=125) were readmitted to a different facility ($P < .001$). Overall, there was a significant, increasing trend in frequency of readmission to a different facility as distance from the initial hospital increased.

In addition to patient characteristics, we analyzed clinical and facility factors potentially associated with readmission to a different hospital (Table II). Initial length of stay (LOS), procedure type (open or EVAR), non-rupture vs. ruptured aneurysms, post-operative complications, initial discharge destination, and medical school affiliation were evaluated. Of these, initial LOS was associated with readmission to a different hospital. That is, for patients readmitted to a different facility, the initial LOS was significantly longer 9.3 ± 11.2 days versus 7.9 ± 9.2 for patients readmitted to the primary hospital ($P = .01$). Patients returning to the primary facility were more frequently treated at a hospital without medical school affiliation (43.1% vs. 29.7%, $P = .002$). Lastly, emergent readmissions occurred more frequently in patients readmitted to a different hospital (71.4% versus 63.4% , $P = .03$).

Readmission Diagnoses

Readmission diagnoses are summarized in Table III. For patients readmitted to the primary hospital, the most frequent diagnoses were gastrointestinal (18.9%), post-operative infections (18.7%), and vascular or device related complications (15.2%). For patients readmitted to a different hospital the most frequent reasons were gastrointestinal (19.7%), cardiovascular (18.9%), and pulmonary (16.6%). Post-operative infections were treated twice as frequently at the primary hospital (18.7% vs. 9.3%), which is largely driven by the four-fold higher rate of surgical site infections returning to the primary hospital ($p <.001$). Other readmission diagnoses directly related to the surgical procedure, including sepsis, gastrointestinal obstruction, and graft related issues did not occur more frequently at the primary hospital. In contrast to the high prevalence of readmission for procedural-related complications at the primary hospital, medical readmission diagnoses were more common at different hospitals. Pulmonary diagnoses were significantly more frequent, driven by the large number of patients with pneumonia (7.3% vs. 1.6%, $P < .001$). Similarly, readmission for congestive heart failure and gastrointestinal bleeding were more common at different hospitals ($P = .045$ and .029, respectively). Overall, the group of readmission diagnoses directly related to the surgical procedure accounted for 41.7% of readmissions at the primary hospital, but only 27% of readmissions to different hospitals ($P < .001$).

Multivariable Analysis of Factors Predicting Readmission to a Different Hospital

Variables significantly associated with readmission to a different hospital in univariate analysis and theoretical predictors were included in a multivariable logistic regression model (Table IV). Alternative models excluding ruptured AAA repairs did not change the results. Therefore, ruptured AAA was included in the final model. RUCA of patient residence and distance to primary hospital from patient residence were found to be highly collinear, therefore only distance was included in the final model, which has a C-statistic of 0.7426. Of the sociodemographic characteristics, age was associated with readmission to a different hospital (OR 1.03 (95% CI, 1.01-1.06)). Compared to patients who live less than 10 miles from the primary hospital, patients who lived farther were more likely to be readmitted to a different hospital (OR =4.55 for distances of 20-30 miles increasing to OR= 8.50 for distances of 50-100 miles). Readmission preceded by an emergency room visit (emergent readmission) had a greater odds of readmission to a different facility (OR 1.53 (95% CI, 1.08-2.18); p = .018). These results demonstrate that distance from patient residence to the treating facility is a major factor in predicting readmission to a different hospital following AAA repair.

Mortality and Cost of Rehospitalization at the Primary or Different Hospitals

We also compared mortality (1) during rehospitalization and (2) for 30 days from the date of rehospitalization to determine if readmission to a different hospital confers any risk of a worse clinical outcome (Table V). Per our data usage agreement (DUA) with CMS, cell sizes representing less than eleven observations must be suppressed to protect patient confidentiality. Unadjusted mortality rates for readmission to the primary hospital were not different as compared to mortality rates at different hospitals. In-hospital mortality rates were not significantly different for patients readmitted to the primary and different hospitals, P = .22. This relationship persisted when 30-day mortality rates were analyzed. Total payments were lower for rehospitalization at a different hospital ($11,978 primary vs. $11,168 different, P = .04). We stratified mortality and median costs by surgical or medical readmission diagnosis (Table III). For surgical diagnoses, we found no statistical difference for rehospitalization or 30-day mortality. Median costs were not lower for surgery-related readmissions at different facilities. For medical readmitting diagnoses, in-hospital and 30-day mortality rates were also the same between readmission destinations. For medical diagnoses, total 30-day costs were significantly greater for primary versus different hospital readmissions (median payment $12,376 vs. $11,610, P = .03). This persistent trend prompted additional analysis.

We used quantile regression to generate adjusted predicted payments for the 30 days following readmission. Predicted payments at the low (10^{th} percentile), middle (50^{th}) and high (90^{th}) areas of the cost spectrum are summarized in Table VI. First, we examined the distribution of 30-day rehospitalization costs for primary versus different hospital readmissions. We found the cost distributions to be significantly different (P = .017) overall. Subsequently, we compared rehospitalization cost at the low (10^{th} percentile), middle (50^{th} percentile), and high (90^{th} percentile) points in the distribution. Readmission to a different hospital was associated with lower adjusted total 30-day payments for patients at all points along the payment spectrum. We found a predicted savings of $936 per patient (95% CI:

238-1634; p=.009) at the low end and $5,418 at the high end (95% CI: 1037-9799; p=.015). The consistency of this finding confirms our observation that readmission to a different facility results in lower total 30-day payments compared to readmission to the primary facility.

Discussion

In our analysis, we found the rate of readmission to a different hospital among readmitted patients (n=885) is high at 29.3%. Previously, our group reported a rate of readmission to an outside facility of 36% for a similar group of patients readmitted after AAA repair.[11] Although these rates are similar, a difference between this analysis and the prior was the inclusion of patients undergoing repair of ruptured AAA in addition to elective repair. Patients surviving ruptured AAA likely require more complex postoperative management and would be a subgroup expected to return to the primary hospital. Also the number of readmissions evaluated in the current analysis is larger.

Literature on this subject is sparse. However, in a recent study of surgical patients it was found that 25% of rehospitalized patients return to a different facility, which is somewhat lower than the rate found in our study.[20] In contrast, Yermilov et al found that 47% of patients undergoing pancreaticoduodenectomy in California were readmitted to a hospital other than where the primary procedure occurred.[21] It is difficult to compare this high number with our findings since the follow-up interval for this study was one year, not 30 days. However, half of patients undergoing this complex procedure were readmitted to a different hospital. Kind et al found, among all-cause Medicare beneficiaries, that 22% of patients are rehospitalized at a different hospital.[22]

In addition to determining the rate of readmission, we characterized the predictors of readmission to a different hospital. Distance between the patient's residence and the initial treating hospital was the strongest predictor of readmission to a different facility. A greater distance travelled for treatment increased the odds of readmission to a different hospital. Similarly, the RUCA code of patient residence was significantly associated with readmission to a different hospital. Nearly twice as many patients from rural areas (43%) were readmitted to different hospitals as compared to patients from urban areas (23%). These findings confirm our hypothesis that patients who travel a longer distance for AAA repair return to a more convenient, local hospital for subsequent treatment.

This issue is particularly relevant for AAA repair. It has been shown for AAA that volume predicts outcome, wherein operations performed at high volume centers are associated with lower mortality and reduced post-operative morbidity.[10] Moreover, in recent years, patients from rural areas undergoing AAA repair have improved access to high-volume centers[23] and are consequently willing to travel significant distances for improved postoperative outcomes.[24] In the event of a complication, it is not surprising that many of these patients seek care and are readmitted to their local community hospital. Our data suggest that patients are willing to travel to the referral center for AAA surgery; however, for post-operative complications these same patients patronize a local hospital. Patients choose to remain closer to home for access to familiar physicians, less separation from family and friends, and a reduction in the cost of travel and accommodations.[25] The financial, physical, and psychological burdens associated with travel for medical care have been detailed, [26] and our findings suggest that patients perceive value in traveling for an intervention such as AAA repair. In contrast, patients appear to perceive that complications can be cared for in the local environment. Acute patient distress is another plausible explanation for the phenomenon of "staying local".[27] If the complication is urgent or the patient is in distress, patients, families and emergency health care providers will seek care at the most proximate facility.

Although geography is an important determinant of readmission to a different hospital, our findings suggest that AAA patients and their providers were indeed selective to the extent allowed by the healthcare system. When complications directly related to the surgical procedure developed, patients more often traveled (or were referred) to the primary hospital. For example, patients with postoperative infections (18.7% vs. 9.3%) and graft related complications (3.8% vs. 1.9%) were treated twice as frequently at the primary hospital. This suggests that patients return to the primary hospital when they are experiencing post-operative issues directly related to the surgical intervention. In contrast, medical complications were treated at higher rates at different hospitals. Thus, for post-operative issues that are not obviously direct complications of the surgery itself, patients appear to seek care closer to home or their healthcare system is structured in such a way as to keep them closer to home for these conditions. This may reflect the patient's preference to receive care in the local setting, except when they perceive local expertise is not available, as may be the case with issues directly related to the operative procedure.

The question arises as to whether there are negative consequences associated with treatment at a local rather than primary hospital. The unadjusted rehospitalization mortality rate was no different for AAA patients treated at different hospitals as compared to the unadjusted rehospitalization mortality rate of 5.9% observed at the primary hospital. We hypothesized that unfamiliarity and excess caution may lead providers at different hospitals to admit lower acuity patients with less complex medical issues and that these patients would be more likely to survive readmission. Alternatively, if all patients with serious complications return to or are transferred to the primary hospital, one might expect this sicker group to experience greater overall mortality; however, this is not reflected in the overall comparison. This issue was examined by separating surgical and medical causes of readmission. Mortality remained equal for readmissions related to surgical and medical complications regardless of the care setting. These findings suggest that there is no evident decrease in the odds of survival if patients seek care locally rather than returning to the primary hospital.

We found that adjusted predicted payments (Table VI) were lower for AAA patients readmitted to a different hospital. This stands in contrast to the findings of Kind et al., who found an added cost of $1308 for general Medicare patients readmitted to different hospitals.[22] One possible explanation for our finding is that patients treated at these facilities have a lower severity of illness or that AAA patients are different than the general Medicare population. Sicker patients are more resource intensive and are likely to be transferred to regional treatment centers (the primary hospital) for more intensive care. On the other hand, patients with less complex illness can be diagnosed and treated faster and with fewer resources in the community setting. For some conditions, by choosing local healthcare, patients may effectively choose less costly healthcare. Moreover, there is significant overhead associated with tertiary and quaternary care facilities even if less intense conditions are treated. A tertiary care hospital cannot treat a simple pneumonia with the same cost-efficiency as can a local community hospital. Our results demonstrate that, for less clinically complex AAA readmissions, particularly medical readmissions, it may be more cost effective to be readmitted to a local community hospital. Our results should be interpreted in the context of certain limitations. First, our sample size is small, which left our study underpowered to detect significance in small variations in our population, and due to the small number of mortalities, we were unable to accurately model mortality as an outcome. Additionally, although claims data provides detailed information regarding payments and rehospitalizations, there is a lack of clinical insight and detailed clinical information. We are unable to comment on patient and provider choices regarding episodes of care. Also, our results are not generalizable beyond the Medicare population; however we can speculate that in younger patients there would be a lower overall rate of readmission due to a lower burden of comorbid illness. Additionally, had we been able to examine the VA population, we might expect to see a lower rate of readmission to different facilities due to the centralization and coordination of medical care within the VA hospital system. Lastly, we studied only patients undergoing AAA repair, which represent a distinct subset of patients undergoing vascular surgical procedures. Additional study of this phenomenon is warranted in other surgical populations and other specific cohorts of vascular surgery patients, namely patients with peripheral arterial disease (PAD). The chronic progressive nature of PAD, often in spite of vascular surgical intervention, may contribute to entirely different patterns of readmission, cost, and mortality.

We have demonstrated that readmission to a different hospital following AAA repair may be less costly without any obvious associated trade-off in mortality. Additional unmeasured benefits and risks associated with local care may exist for patients and their families. Our study suggests that patients who present with diagnoses frequently encountered in the local or community hospital setting that are treated via readmission to a different hospital, do not experience greater mortality. These diagnoses include pneumonia, congestive heart failure, acute coronary syndromes, acute renal failure, or other medical conditions. Readmission diagnoses more directly related to the surgical procedure, including wound infections or issues related to the vascular device or graft may be optimally treated with return, when possible, to the primary hospital to benefit from the expertise of the primary surgeon. Considering the major findings of this study, we conclude that readmission to a different hospital for less complex medical complications following AAA repair may not lead to increased mortality.

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Appendix

Appendix I
Cohort and 30-Day Readmission Definition Criteria

ICD-9–CM, International Classification of Diseases, Ninth Revision, Clinical Modification.Appendix I contains inclusion and exclusion criteria establishing the definitions of our patient cohort and 30-day readmissions.

Cohort Inclusion Criteria	**Cohort Exclusion Criteria**
Ruptured abdominal aortic aneurysm (AAA); ICD-9-CM Diagnosis Codes 441.3 and 441.5	Aortic dissection; ICD-9-CM Diagnosis Codes 441.0, 441.00-441.03
Non-Ruptured AAA; ICD-9-CM Diagnosis Codes 441.4 and 441.9	Thoracic aortic aneurysms; ICD-9-CM Diagnosis Codes 441.1 and 441.2
Open aneurysm repair; ICD-9-CM Procedure Codes 38.34, 38.44, 38.64, 39.52, 38.40, 38.60, and 39.25	Thoracoabdominal aneurysms; ICD-9-CM Diagnosis Codes 441.6 and 441.7
Endovascular aneurysm repair (EVAR); ICD-9-CM Procedure Codes 39.71 and 39.78	Medicare Health Maintenance Organization (HMO) enrollment (incomplete data)
Age 65 to 99 years at time of AAA repair	Railroad benefit enrollment (incomplete data)
	Deaths during primary hospitalization
	Left against medical advice (AMA) during primary hospitalization

CMS 30-day readmission criteria	
Readmission Inclusion Criteria	**Readmission Exclusion Criteria**
Rehospitalized within 30 days of primary discharge following a qualifying AAA repair	Transfers between acute care facilities (continuous with the initial hospitalization)
Readmissions to any short-stay, acute-care, or critical access hospital within 30 days of primary discharge excluding	Readmission to specialty hospitals (i.e. psychiatric or rehab)
	Same-day, same-facility, same-diagnosis readmissions

Appendix II

AHRQ Clinical Classification Software (CCS) Multilevel Codes

AHRQ, Agency for Healthcare Research and Quality; SSI, surgical site infection; UTI, urinary tract infection; CHF, congestive heart failure; AMI, acute myocardial infarction; ACS, acute coronary syndrome; HTN, hypertension; VTE, venous thromboembolism; ARF, acute renal failure; CVA, cerebrovascular accident; TIA, transient ischemic attack; DM, diabetes mellitus. Appendix II includes the multilevel CCS codes appearing in our sample; it is not an exhaustive list of all available multilevel CCS codes.

Diagnosis Category	Multilevel CCS Codes
Post-Operative Infection	
Wound/SSI	16.10.2.6 16.10.2 12.1.1.7 16.10.2.7 7.5.4 12.1.1.5 12.1.2 17.1.4
Sepsis	17.1.2 1.1.2.6 1.1.2.2 17.1.5
UTI	10.1.4.3 10.1.4.1
Pulmonary	
Unspecified Lower Respiratory Disease	8.8.3
Pneumonia	8.1.1.3 8.1.1.2
Other	8.6.1 8.2.3 8.5.1 16.10.2.2 8.4 8.6.2 8.9 8.2.1 8.2.2 8.3.1.3 8.5.3
Cardiovascular	
CHF	7.2.11.1 7.2.6 7.2.11
AMI/ACS	7.2.5 7.2.3 7.2.4.4 7.2.4.1 7.2.10 7.2.4.2
Arrhythmia	7.2.9.3 7.2.9.7 7.2.9.2 7.2.9.1
Other (including HTN)	7.1.2.1 16.10.2.1 7.1.1 7.2.1.2 7.2.2.2 7.2.4.5 7.2.7
Gastrointestinal	
Abdominal Pain	17.1.7
Obstruction	17.1.6 9.12.3 9.6.3.4 9.12.1 16.10.2.3 9.6.3.1 9.6.3.2 9.4.1.2 9.5.1.1 9.5.3.7 9.6.3.3
Bleeding	9.10.7 9.10.2 9.10.5 9.10.6 9.10.1
Inflammation & Infection	9.11 9.1 9.9.1 9.4.3.1 9.6.1.2 9.6.2 9.6.4.2 9.6.6 9.7.1 9.7.5
Other	9.8.2.4 9.5.1.2 9.5.3.8 9.5.3.9 9.8.2.3
Vascular/Device	
Bleeding	16.10.2.5 4.1.3.7 7.4.4.1 7.4.4.2 4.2.2 4.2.1 4.2.3
Device/Graft	16.10.1.3 16.10.1.1 16.10.1.2
VTE	7.5.1.2
Other Vascular Disease	7.4.2.1 7.4.2.2 7.4.1.1 7.4.1.2 7.4.3.1 7.4.3.2 7.4.3
Renal/Urologic	
ARF	10.1.2.1
Other	10.1.8.2 10.1.6.2 10.1.8.1 10.1.5.2 10.1.2.2 10.1.3 10.1.5.1 10.2.1 16.10.2.4
Musculoskeletal	13.3.3.3 13.2.3 13.3.3.6 3.7
Trauma	16.12 16.2.5.1 16.2.1 16.4.2 16.5

Diagnosis Category	Multilevel CCS Codes
Neurologic	
CVA/TIA	7.3.1.2 7.3.2 7.3.4
Other (including syncope)	17.1.1 6.9.3 6.5.2 6.4.2 6.8.2
Other Medical	
DM	3.11.3 3.3.7 3.4
Electrolyte Disturbance	3.8.2 3.8.1 3.8.3 3.8.4 3.8.5
Cancer Related	2.3 2.1.1 2.9.1 2.9.2 2.1.2 2.12.4 2.2.4
Miscellaneous	13.8 18 17.1.8 10.2.3 10.2.2 12.3.1 16.11.1 4.3 13.1 17.1.9 3.11.1 5.10 5.15.8

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Table I

Sociodemographic Characteristics of Medicare Beneficiaries Readmitted within 30 Days of AAA Repair, by Readmission Location

Characteristic	Primary Hospital, (n= 626)	Different Hospital, (n= 259)	P-value
Age, mean (SD)	76.7 (6.4)	77.4 (6.0)	.14
Female, n (%)	193 (30.8)	79 (30.5)	.92
Race, n (%)			.47
White	584 (93.3)	245 (94.6)	
Non-White	42 (6.7)	14 (5.4)	
Medicare Disability Entitlement, n (%)	72 (11.5)	36 (13.9)	.32
Medicaid Enrollment, n (%)	12 (1.9)	--[a]	.21
Charlson comorbidity index, mean (SD)	2.5 (2.1)	2.5 (2.0)	.95
Number of hospitalizations in year prior to AAA repair, mean (SD)	0.8 (1.3)	0.9 (1.2)	.64
RUCA for patient residence, n (%)			< .001
Urban	418 (66.9)	127 (49.2)	
Suburban	69 (11.0)	35 (13.6)	
Large Town	69 (11.0)	44 (17.0)	
Rural/Small Town	69 (11.0)	52 (20.2)	
Distance from residence to index hospital (miles), n (%)			< .001
Less than or equal to 10	297 (47.7)	46 (17.8)	
> 10 - 20	123 (19.7)	31 (12.0)	
> 20 - 30	49 (7.9)	30 (11.6)	
> 30 - 40	28 (4.5)	26 (10.1)	
> 40 - 50	23 (3.7)	21 (8.1)	
> 50 - 100	57 (9.1)	68 (26.4)	
Greater than 100	46 (7.4)	36 (14.0)	
Mobility, n (%)			.28
No assistive device	357 (57.0)	141 (54.4)	
Use cane, crutch, or walker	173 (27.6)	67 (25.9)	
Use wheelchair or motorized wheelchair	96 (15.3)	51 (34.7)	

SD indicates standard deviation; %, column percentage.

[a]Exact cell size suppressed to protect patient confidentiality; $n < 11$.

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Table II

Univariate Analysis of Clinical Characteristics for Medicare Beneficiaries Readmitted within 30 Days of AAA Repair, by Readmission Location

Characteristic	Primary Hospital, (n= 626)	Different Hospital, (n= 259)	P-value
Repair Type, n (%)			.37
Open Repair	262 (41.8)	100 (38.6)	
EVAR	364 (58.2)	159 (61.4)	
Ruptured Aneurysm, n (%)	55 (8.8)	17 (6.6)	.27
Had in-hospital complication during initial hospitalization, n (%)			
Any complication	322 (51.4)	146 (56.4)	.18
Respiratory	197 (31.5)	96 (37.1)	.11
Hemorrhage/Shock	112 (17.9)	37 (14.3)	.19
Vascular/Device	52 (8.3)	26 (10.0)	.41
Cardiac	59 (9.4)	33 (12.7)	.14
Wound/SSI	26 (4.2)	--[a]	.64
Renal/Urologic	111 (17.7)	54 (20.9)	.28
Neurologic	54 (8.6)	11 (4.3)	.02
Reoperation	--[a]	--[a]	.24
Venous thromboembolism	18 (2.9)	--[a]	.06
Number of in-hospital complications, mean (SD)	1.0 (1.3)	1.1 (1.2)	.67
Initial length of stay, mean (SD)	7.9 (9.2)	9.3 (11.2)	.01
Initial discharge destination, n (%)			.73
Home	351 (56.1)	144 (55.6)	
Home with home care	107 (17.1)	49 (18.9)	
Skilled nursing facility	118 (18.8)	41 (15.8)	
Other	50 (8.0)	25 (9.6)	
Index hospital medical school affiliation, n (%)			.002
Major	205 (32.9)	104 (40.1)	
Emergency Visit Prior to Readmission, n (%)	398 (63.4)	185 (71.4)	.03
Time to Readmission, mean (SD)	11.2 (8.3)	12.1 (8.2)	.15

Characteristic	Primary Hospital, (n= 626)	Different Hospital, (n= 259)	P-value
Rehospitalization length of stay, mean (SD)	6.6 (8.3)	5.8 (5.2)	.07

SD indicates standard deviation; %, column percentage.

EVAR, endovascular aneurysm repair; SSI, surgical site infection.

[a]Exact cell size suppressed to protect patient confidentiality; n < 11.

Table II

Readmission Diagnoses After AAA Repair, by Readmission Location

Diagnosis	Classification	Primary Hospital, (%)	Different Hospital, (%)	P-value
Post-Operative Infection		18.7	9.3	< .001
Wound/SSI	Surgical	11.3	3.1	< .001
Sepsis	Surgical	6.2	4.6	.354
UTI	Medical	1.1	1.5	.603
Pulmonary		11.7	16.6	.048
Unspecified Lower Respiratory Disease	Medical	6.6	6.6	.994
Pneumonia	Medical	1.6	7.3	< .001
Other	Medical	3.5	2.7	.537
Cardiovascular		13.7	18.9	.051
CHF	Medical	5.3	8.9	.045
AMI/ACS	Medical	5.9	7.0	.560
Arrhythmia	Medical	1.0	2.7	.065
Other (including HTN)	Medical	1.6	0.4	.191
Gastrointestinal		18.9	19.7	.772
Abdominal Pain	Surgical	4.3	5.8	.347
Obstruction	Surgical	8.5	6.2	.248
GI Bleeding	Medical	3.0	6.2	.029
Inflammation & Infection	Medical	2.2	1.2	.421
Other	Medical	0.8	0.4	.677
Vascular/Device		15.2	9.7	.029
Hemorrhage/Bleeding	Surgical	5.9	5.4	.769
Device/Graft	Surgical	3.8	1.9	.148
VTE	Surgical	1.6	0.0	.040
Other Vascular Disease	Medical	3.8	2.3	.257
Renal/Urologic		4.0	5.4	.352
ARF	Medical	1.4	2.7	.265
Other	Medical	2.6	2.7	.901

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Diagnosis	Classification	Primary Hospital, (%)	Different Hospital, (%)	P-value
Musculoskeletal	Medical	1.0	1.5	.490
Trauma	Medical	0.6	1.2	.424
Neurologic		3.4	3.5	.928
CVA/TIA	Medical	1.1	1.9	.348
Other (including syncope)	Medical	2.2	1.5	.507
Other Medical		4.6	6.2	.341
DM	Medical	0.6	0.8	1.000
Electrolyte Disturbance	Medical	2.2	3.9	.176
Cancer Related	Medical	1.8	1.5	1.000
Miscellaneous	Medical	8.2	8.1	.985

SSI, surgical site infection; UTI, urinary tract infection; CHF, congestive heart failure; AMI, acute myocardial infarction; ACS, acute coronary syndrome; HTN, hypertension; VTE, venous thromboembolism; ARF, acute renal failure; CVA, cerebrovascular accident; TIA, transient ischemic attack; DM, diabetes mellitus.

Table IV

Odds Ratios for Readmission to a Different Hospital

Factor	Odds Ratios (95% CI)	P-value
Age (per year)	1.03 (1.01-1.06)	.018
Non-white (vs. white)	1.15 (0.55-2.38)	.715
Male (vs. female)	1.05 (0.73-1.50)	.800
Charlson Comorbidity Index (per unit difference from mean)	0.97 (0.89-1.05)	.447
Mobility		
None	Referent	n/a
Cane/walker	1.06 (0.73-1.53)	.756
Wheelchair/scooter	1.49 (0.94-2.37)	.09
Distance from residence to index hospital (miles)		
Less than or equal to 10	Referent	n/a
> 10 - 20	1.69 (0.99-2.81)	.054
> 20 - 30	4.55 (2.56-8.10)	< .001
> 30 - 40	6.70 (3.53-12.72)	< .001
> 40 - 50	6.03 (3.02-12.06)	< .001
> 50 - 100	8.50 (5.17-13.97)	< .001
Greater than 100	5.60 (3.13-9.99)	< .001
Non-rupture vs. Ruptured aneurysm	1.38 (0.74-2.57)	.318
Open repair vs. EVAR	1.20 (0.83-1.76)	.335
Initial LOS (per day)	1.02 (1.00-1.05)	.09
Number of Post-Operative Complications (per unit change from mean)	0.96 (0.81-1.14)	.622
Discharge Destination		
Home	Referent	n/a
Home with services	1.31 (0.85-2.03)	.224
Skilled Nursing Facility	0.97 (0.58-1.60)	.895
Other	1.00 (0.52-1.94)	.988
Index Hospital Medical School Affiliation		
Other	Referent	n/a

Factor	Odds Ratios (95% CI)	P-value
Major	1.14 (0.81-1.58)	.169
Emergent vs. non-Emergent readmission	1.53 (1.08-2.18)	.018

n/a, not applicable.

Odds ratios are adjusted for the variables displayed in the table: age, gender, race, Charlson comorbidity index, use of mobility assistive device, distance from patient residence to index hospital, type of aneurysm (ruptured vs. non-ruptured), AAA repair type, initial length of stay, number of postoperative complications, initial discharge destination, index hospital medical school affiliation, and type of readmission.

Table V

Unadjusted Mortality Rates and Median Total 30-Day Cost, by Readmission Destination

All Diagnoses	**Primary Hospital (n=626)**	**Different Hospital (n=259)**	**P-value**
Deaths during rehospitalization, n (%)	37 (5.9)	--[a]	.22
Deaths within 30 days of rehospitalization, n (%)	53 (8.5)	21 (8.1)	.86
Total 30 day payments following rehospitalization in $, median (IQR)	11,978 (7,377-20,475)	11,168 (6,719-17,420)	.04
Surgical Readmission Diagnoses	Primary Hospital (n=261)	Different Hospital (n=70)	
Death during rehospitalization, n (%)	13 (5.0)	--[a]	.76
Death within 30 days of rehospitalization, n (%)	19 (7.3)	--[a]	.72
Total 30 day payments following rehospitalization in $, median (IQR)	11,562 (6,966-19,860)	10,542 (6,273-16,744)	.40
Medical Readmission Diagnoses	Primary Hospital (n=365)	Different Hospital (n=189)	
Death during rehospitalization, n (%)	24 (6.6)	--[a]	.09
Death within 30 days of rehospitalization, n (%)	34 (9.3)	15 (7.9)	.59
Total 30 day payments following rehospitalization in $, median (IQR)	12,376 (7,678-20,697)	11,610 (7,052-17,420)	.03

%, indicates column percentage; $, indicates dollars (Unites States).

[a] Exact cell size suppressed to protect patient confidentiality as n < 11.

Table VI

Predicted Total 30-Day Payments From the Date of Rehospitalization, by Readmission Location

Characteristic	10th Percentile			50th Percentile			90th Percentile		
	Payment, $	**Difference (95% CI)**	**P-value**	**Payment, $**	**Difference (95% CI)**	**P-value**	**Payment, $**	**Difference (95% CI)**	**P-value**
Rehospitalization at primary facility	5444	reference		12586	reference		26193	reference	
Rehospitalization at different facility	4508	−936 (−238 to −1634)	.009	10995	−1591 (−128 to −3053)	.033	20775	−5418 (−1037 to −9799)	.015

$, indicates dollars (Unites States).

Based on our sample of 885 readmitted patients, quantile regression modeling was used to determine predicted payments at the 10th, 50th, and 90th percentiles (low, middle and high points) of the cost distribution for total payments from the date of rehospitalization to 30 days after. The model adjusted for patient characteristics (age, gender, race, Charlson comorbidity index, and use of mobility assistive device), clinical factors (duration of initial hospitalization, ruptured AAA, number of in-hospital complications, and initial discharge destination), the Centers for Medicare & Medicaid Services hierarchical condition category score, and the medical school affiliation of the index hospital. Bootstrapping of 95% CIs was performed using 10,000 analytic repetitions.