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Risk-adjusted hospital outcomes in elective carotid artery surgery in patients with Medicare

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ABSTRACT

Background. The risk-adjusted outcomes by hospital of elective carotid endarterectomy that is inclusive of inpatient and 90-day postdischarge adverse outcomes have not been studied.

Methods. We studied Medicare inpatients to identify hospitals with 25 or more qualifying carotid endarterectomy cases between 2012–2014. Risk-adjusted prediction models were designed for adverse outcomes of inpatient deaths, 3-sigma prolonged duration-of-stay outliers, 90-day postdischarge deaths without readmission, and 90-day postdischarge associated readmissions. Standard deviations of predicted overall adverse outcomes were computed for each hospital. Hospital-specific z scores and risk-adjusted adverse outcomes were calculated.

Results. There were 77,086 carotid endarterectomy patients from 960 hospitals complicated by 191 inpatient deaths (0.25%), 4,436 prolonged duration of stay (5.8%), 457 90-day postdischarge deaths (0.6%), and 7,956 90-day postdischarge associated readmissions (10.3%). In the 90-day postdischarge associated readmission patients, an additional 561 patients died after readmission, for total deaths of 1,209 (1.6%) for the study period, and 11,928 (15.5%) patients had one or more adverse outcomes. There were 29 best-performing hospitals (3.0%) with z scores of –2.0 or less ($P < .05$) with a median rate of risk-adjusted adverse outcomes of 7.1%. A total of 61 suboptimal performers (6.3%) had z scores of +2.0 or greater ($P < .05$) with a median rate of risk-adjusted adverse outcome rate of 26.4%.

Conclusion. Hospital risk-adjusted adverse outcome rates for carotid endarterectomy are highly variable. Comparisons of hospital performance define the opportunity for improvement.

Carotid endarterectomy (CEA) is accepted generally for the prevention of stroke in patients with symptomatic carotid artery disease and is a common operation in hospitals with vascular surgery programs. CEA is also performed in selected patients with asymptomatic carotid stenosis to avoid future stroke events. Most CEA cases occur in the Medicare population of patients. Refinements in techniques have decreased stroke complications after these procedures, but the total adverse outcomes (AOs) after CEA and other operations remain poorly defined.

In a previous publication, we studied cases of CEA in Medicare recipients over a 3-year period and reported the inpatient and 90-day postdischarge AOs of this operation.[1] AOs of inpatient and 90-day postdischarge deaths, 3-σ postoperative duration-of-stay outliers, and 90-day readmissions after exclusions were 22.6%. The 90-day readmission rate was the major driver of the overall AO rate. Criticisms of this publication have focused on the necessity of using 90 days as the follow-up interval and that the exclusions of unrelated readmissions were insufficiently rigorous. Many still argue that readmissions should not be considered as AOs because these events are governed often by sociodemographic, advanced, and untreatable comorbid conditions, as well as other unrelated medical issues.

In the present study we used our metrics of AOs to evaluate the risk-adjusted performance of hospitals. Comparative effectiveness and benchmarking the risk-adjusted performance is of value in providing information to hospitals and surgeons for improvement in care. Furthermore, an evaluation of the reasons for readmission between hospitals with the best performances and those that are suboptimal will provide insight into why readmission is indeed an

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AO of care and provides insight into responsible causes for this expensive event in postdischarge surgical care.

Methods

We identified patients (age ≥ 65 years) undergoing elective CEA in the Medicare Limited Dataset using the *International Classification of Diseases,* 9th Revision—Clinical Modification (ICD-9) procedure codes 38.10, 38.12, 38.32, 39.22, 39.56, and 39.58. For inclusion in the study dataset, all included patients were required to have an ICD-9 principal diagnosis of 250.60–250.63, 433.00–433.91, 435.2, 435.8, or 435.9. All patients admitted from the emergency department were excluded to ensure that only elective cases were in the dataset. Patients aged <65 years were excluded. Only cases performed within 2 days of admission were included because greater preoperative hospitalization is a risk for increased adverse outcomes.[2] Other exclusions included patients with incomplete data elements, transfers from other acute care hospitals, and patients who were discharged against medical advice.

Predictive models

Stepwise logistic regression was used to develop prediction models for each of the following 4 outcome metrics: inpatient deaths (IpD), duration-of-stay outliers as surrogates for severe inpatient complications (PrDOS), 90-day postdischarge deaths without readmission (PD-90), and 90-day postdischarge readmissions (RA-90) using exclusions proposed by the Centers for Medicare and Medicaid Services (CMS) in the Bundled Payment for Care Improvement program (Table 1) for vascular surgery. We have added a few additional exclusions of infrequent events, which are identified in the Table 1. Because carotid stents and repeat endarterectomy occur only rarely in the first 30 days after the index procedure, and because procedures 31–90 days are almost always on the contralateral side, we have chosen to exclude stents and a second CEA as being an associated readmission. Readmissions that were excluded were identified by the Medicare severity diagnosis related groups (MS-DRGs) at discharge. Readmissions that were considered related to the index hospitalization and CEA were likewise evaluated and categorized by MS-DRGs.

Only hospitals that met coding standards using screens that we have designed were used for the development of risk models.[3] More than 500 candidate risk factors with aggregation of small-incidence diagnoses were used in development of the model by methods we have used for CEA[1] and other surgical conditions.[4,5] Linear models were developed using the same pool of candidate risk factors to predict duration of stay, and moving-range control charts were applied for each hospital in the study database to identify PrDOS patients by methods that we have reported previously.[4,5] Dummy variables were used to eliminate hospital effects on final models.[6] Only variables with $P \leq .001$ were included in final models. The Schwarz criterion was used to avoid overfitting the final models.[7] The discrimination of final models was validated with C statistics. SAS software (Version 9.4, SAS Institute, Cary, NC) was used in all analyses.

Risk-adjusted hospital outcomes

Risk-adjusted outcomes of hospitals with a minimum of 25 evaluable cases regardless of coding quality were chosen for comparative evaluation. Because small predicted values distort comparative evaluation of hospital performance, only those facilities with predicted values ≥ 4.5 for total AOs were retained for this analysis. Hospitals with fewer than 25 cases commonly had predicted AO rates <4.5, which was the reason for choosing the 25-case cut point.

Table 1
Details of the excluded readmissions by category and by specific MS-DRG.

Excluded categories	Specific MS-DRGs excluded
Transplants	001-02; 005-010; 014-017; 652
Tracheostomy; head/neck disease	011-013
Craniotomy	023-27
Spine procedures/disease	028-030; 052-53; 453-60; 471-73
Ventricular shunts	031-033
Carotid stent procedures	*034-036*
Carotid surgery; open	037-39
Peripheral/cranial nerve procedures/ diseases	040-42
Central nervous system neoplasms	054-055
Chronic neurologic disease	*056-060*
Eye disease	113-17; 123-25
Otolaryngology disease	129-148
Major chest procedures	163-65
Lung neoplasm	180-82
Cardiac valve operations	216-221
Vascular procedures	237-38; 252-54; 263
Pacemaker procedures	258-62; 265
Congenital heart disease	306-07
Other circulatory disease	314-16
Intestine/rectal resections	329-334
Appendectomy/other intestine procedures	338-49
Hernia procedures	350-55
Esophageal disorders	368-370
Digestive malignancies	374-76
Inflammatory bowel disease	*385-87*
Pancreato-biliary disease	405-437; 444-46
Joint replacement	461-62; 466-70
Miscellaneous musculoskeletal disease	477-79; 503-38; 542-47; 562-63
Breast surgery/disorders	582-85; 597-601
Trauma/injuries	082-090; 183-85; 604-05; 901-14; 927-35; 955-65
Endocrine disorders	614-15; 625-30; 642
Obesity	619-21
Genito-urinary disorders; not renal failure	653-75; 686-88
Male genital disorders	707-24
Female genital disorders; maternity issues	734-756; 765-795
Splenectomy	799-801
Reticuloendothelial diseases	814-849
Mental operations	876
Rehabilitation	945-46
HIV operations	969-970

Italic categories and MS-DRGs are those exclusions added in addition to the basic list of vascular surgery exclusions in the CMS Bundled Payment for Care Improvement program.
CMS, Centers for Medicare and Medicaid Services; *MS-DRG,* Medicare severity diagnosis related groups.

The 4 prediction models for each of the AOs were then used to define the expected total AOs for the unique risk profile of each hospital. Hospitals with favorable-risk profiles were expected to have low predicted AO events, whereas those with high-risk patients were expected to have greater AO rates. The IpD model was used for all CEA patients in each hospital. The PrDOS model was used only for live discharges. The PD-90 model was used for all live discharge patients who did not have a valid readmission, and the RA-90 model was used for live discharge patients who were not classified as 90-day deaths without readmission. In the final analysis, each hospital had the total number of patients who had 1 or more AOs identified, and the 4 prediction models were aggregated to provide the expected total number of patients to have 1 or more AO events. Different individual AOs in the same patient were only counted as a single outcome for hospital analysis. The total number of predicted AOs in the study population of hospitals for comparative evaluation was then set equal to the total observed events by multiplication of each hospital's predicted value by the ratio of total observed AOs to total predicted AOs.

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