



Readmissions After Carotid Artery Revascularization in the Medicare Population

Mohammed Salim Al-Damluji, MD, MPH,* Kumar Dharmarajan, MD, MBA,†† Weiwei Zhang, MPH,†
Lori L. Geary, MPH,† Erik Stilp, MD,*§ Alan Dardik, MD, PhD,||¶# Carlos Mena-Hurtado, MD,*§ Jephtha P. Curtis, MD*†§

ABSTRACT

BACKGROUND In appropriately selected patients with severe carotid stenosis, carotid revascularization reduces ischemic stroke. Prior clinical research has focused on the efficacy and safety of carotid revascularization, but few investigators have considered readmission as a clinically important outcome.

OBJECTIVES The aims of this study were to examine frequency, timing, and diagnoses of 30-day readmission following carotid revascularization; to assess differences in 30-day readmission between patients undergoing carotid endarterectomy (CEA) and carotid artery stenting (CAS); to describe hospital variation in risk-standardized readmission rates (RSRR); and to examine whether hospital variation in the choice of procedure (CEA vs. CAS) is associated with differences in RSRRs.

METHODS We used Medicare fee-for-service administrative claims data to identify acute care hospitalizations for CEA and CAS from 2009 to 2011. We calculated crude 30-day all-cause hospital readmissions following carotid revascularization. To assess differences in readmission after CAS compared with CEA, we used Kaplan-Meier survival curves and fitted mixed-effects logistic regression. We estimated hospital RSRRs using hierarchical generalized logistic regression. We stratified hospitals into 5 groups by their proportional CAS use and compared hospital group median RSRRs.

RESULTS Of 180,059 revascularizations from 2,287 hospitals, CEA and CAS were performed in 81.5% and 18.5% of cases, respectively. The unadjusted 30-day readmission rate following carotid revascularization was 9.6%. Readmission risk after CAS was greater than that after CEA. There was modest hospital-level variation in 30-day RSRRs (median: 9.5%; range 7.5% to 12.5%). Variation in proportional use of CAS was not associated with differences in hospital RSRR (range of median RSRR across hospital groups 9.49% to 9.55%; $p = 0.771$).

CONCLUSIONS Almost 10% of Medicare patients undergoing carotid revascularization were readmitted within 30 days of discharge. Compared with CEA, CAS was associated with a greater readmission risk. However, hospitals' RSRR did not differ by their proportional CAS use. (J Am Coll Cardiol 2015;65:1398-408) © 2015 by the American College of Cardiology Foundation.

Carotid revascularization is a commonly performed class of vascular interventions that in appropriately selected patients reduces the risk for ipsilateral stroke (1). Prior research has focused on the safety and efficacy of carotid revascularization, but few investigators have considered short-term readmission as a clinically important outcome (2). However, the potential importance of

From the *Department of Internal Medicine, Yale University School of Medicine, New Haven, Connecticut; †Center for Outcome Research and Evaluation, Yale University, New Haven, Connecticut; ‡Division of Cardiology, Columbia University Medical Center, New York, New York; §Cardiovascular Division, Department of Medicine, Yale University School of Medicine, New Haven, Connecticut; ||Yale University Vascular Biology and Therapeutics Program, New Haven, Connecticut; ¶Department of Surgery, Yale University School of Medicine, New Haven, Connecticut; and the #Veterans Affairs Connecticut Healthcare System, West Haven, Connecticut. This research was funded by the National Heart, Lung, and Blood Institute (U01 HL105270-03 [to the Center for Cardiovascular Outcomes Research at Yale University]). Dr. Curtis has received support from the Centers for Medicare & Medicaid Services to develop and maintain performance measures that are used for public reporting; and he holds stock options in Medtronic. All other authors have reported that they have no relationships relevant to the contents of this paper to disclose.

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readmissions following carotid revascularization has increased dramatically with the development of a measure of hospitals' 30-day risk-standardized readmission rates (RSRRs) following vascular procedures (3), with implications for potential financial penalties for hospitals with excess readmissions.

At present, many aspects of readmissions following carotid revascularization are poorly understood. Specifically, the timing and reasons for readmission, as well as the extent of variation in hospitals' 30-day readmission rates, have not been described. Furthermore, like many vascular procedures, carotid revascularization can be accomplished through an open or endovascular approach (carotid endarterectomy [CEA] and carotid artery stenting [CAS], respectively). Although prior research has shown that patients undergoing CAS are at increased risk for readmission compared with patients undergoing CEA (2), it is not known whether differences in hospitals' proportional use of CAS among all carotid revascularization procedures are associated with differences in hospital 30-day readmission rates.

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To address these gaps in knowledge, we used administrative claims data to identify readmissions occurring within 30 days of the end of hospitalization during which a carotid revascularization procedure was performed. We examined the timing and diagnoses associated with readmission and characterized variation in RSRRs across hospitals. Furthermore, we assessed whether readmission rates varied by the choice of the revascularization strategy used (CAS vs. CEA) and whether hospitals' 30-day RSRRs differed by the proportional use of CAS among all carotid revascularization procedures.

METHODS

We used Medicare fee-for-service administrative claims data to identify hospitalizations with an associated carotid revascularization procedure performed between January 1, 2009 and December 31, 2011. We identified patients using International Classification of Diseases-Ninth Revision-Clinical Modification (ICD-9-CM) codes or Current Procedural Terminology codes, previously reported by the Centers for Medicare & Medicaid Services (CMS) vascular procedure readmission measure (3). As with this measure, our study sample consisted of patients who underwent either CEA (ICD-9-CM codes 00.61, 00.63, 00.64, 39.72, 39.74; Current Procedural Terminology codes 37215, 37216, 0075T) or CAS (ICD-9-CM codes 38.02, 38.12, 38.32, 38.42 or Current Procedural Terminology

codes 35201, 35005, 35231, 35301, 35701, 34001). Whether patients were symptomatic (i.e., had symptoms attributable to their carotid disease) was determined using the following ICD-9-CM codes previously described in published reports (2,4,5): 362.30, 362.31, 362.32, 362.33, 362.34, 362.35, 362.36, 362.37, 362.84, 433.11, 433.31, 434.01, 434.91, 435.0, 435.1, 435.2, 435.3, 435.8, 435.9, and 781.4. The primary outcome of interest was hospital readmission within 30 days of discharge from a hospitalization during which a carotid revascularization procedure had been performed. Among patients who had been readmitted, we examined the timing of the readmission by day after discharge (0 to 30). We categorized readmission diagnoses using the CMS condition category (CC) codes to group patients' principal discharge diagnoses. Each of the 189 CMS CCs describes a disease entity or medical condition. However, because more than 90% of these CCs contributed <1% of all readmissions, we further consolidated the 189 CMS CCs into 30 modified CCs. The categorization of CCs is described in [Online Tables 1 and 2](#).

STATISTICAL ANALYSES. We used descriptive statistics to illustrate baseline characteristics. We compared differences in baseline characteristics between CEA and CAS patients using the Mantel-Haenszel chi-square test and the Student *t* test, as appropriate. We calculated crude readmission rates following carotid revascularization procedures by dividing the number of patients readmitted within the 30-day period following carotid revascularization by the total number of patients undergoing carotid revascularization. To examine the timing of readmission following carotid revascularization, we calculated the proportion of readmissions during each day over the 30-day period. We also identified the 10 most common diagnoses associated with readmission by modified CCs and presented their distribution over the following consecutive time periods after hospital discharge: days 0 to 7, 8 to 15, and 16 to 30, reflecting the time periods in which follow-up visits to ambulatory care providers frequently occur.

PROCEDURE-SPECIFIC READMISSION RATES: CAS VERSUS CEA. To assess the difference in readmission rates between patients undergoing CEA versus CAS, we plotted Kaplan-Meier readmission-free survival curves and fitted a generalized estimating equation logistic regression model. These models adjusted for patient and hospital characteristics. In these models,

ABBREVIATIONS AND ACRONYMS

- CAS** = carotid artery stenting
- CC** = condition category
- CEA** = carotid endarterectomy
- CMS** = Centers for Medicare & Medicaid Services
- ICD-9-CM** = International Classification of Diseases-Ninth Revision-Clinical Modification
- RSRR** = risk-standardized readmission rate

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