

PERIPHERAL

# Hospital Variation in Carotid Stenting Outcomes



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## ABSTRACT

**OBJECTIVES** The aim of this study was to examine variation in outcomes for patients receiving carotid artery stenting (CAS) across a sample of U.S. hospitals and assess the extent to which this variation was attributable to differences in case mix and procedural volume.

**BACKGROUND** As CAS is increasingly being used throughout the United States, assessing hospital variation in CAS outcomes is critical to understanding and improving the quality of care for patients with carotid artery disease.

**METHODS** Hospitals participating in the National Cardiovascular Data Registry–Carotid Artery Endarterectomy and Revascularization Registry contributing more than 5 CAS procedures from 2005 through 2013 were eligible for inclusion. We estimated unadjusted and risk-standardized rates of in-hospital stroke or death for each participating hospital using a previously validated prediction model and applying hospital-level random effects.

**RESULTS** There were 188 hospitals contributing 19,381 CAS procedures during the period of interest. Unadjusted and risk-standardized in-hospital stroke or death rates ranged from 0% to 18.8% and 1.2% to 4.7%, respectively. Operator and hospital volumes were not significant predictors of outcomes after adjustment for case mix ( $p = 0.15$  and  $p = 0.09$ , respectively).

**CONCLUSIONS** CAS outcomes vary 4-fold among hospitals, even after adjustment for differences in case mix. Future work is needed to identify the sources of this variation and develop initiatives to improve patient outcomes. (J Am Coll Cardiol Intv 2015;8:858–63) © 2015 by the American College of Cardiology Foundation.

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Randomized trials have established the efficacy of carotid artery stenting (CAS) in standard- and high-surgical risk patients (1,2), and this has resulted in increased use of this novel therapy across the United States in recent years (3). Understanding the impact that these changes in practice patterns have had on patient outcomes is critical because the increased adoption of carotid endarterectomy nearly 2 decades ago resulted in significant variation in periprocedural stroke events (4).

CAS is a procedure with a well-established learning curve (5) and is performed by providers from a variety of medical specialties with patient selection practices and technical expertise that may differ (6). For these reasons, significant variation in CAS outcomes might be anticipated. Using the CARE (Carotid Artery Revascularization and Endarterectomy) Registry, we analyzed hospital-level variation in-hospital stroke or death (S/D) rates and assessed the extent to which this variation could be explained by differences in patient case mix as well as differences in procedural volume. Finding significant variation across hospitals could encourage further inquiry as to why such differences exist and lead to the widespread dissemination of best practices that could improve care and outcomes.

## METHODS

**STUDY COHORT.** The CARE Registry includes patients receiving carotid revascularization with either carotid endarterectomy or CAS. The Registry uses a

standardized dataset with written definitions (7). Hospitals reporting more than 5 CAS procedures from 2005 through 2013 were eligible for inclusion. CAS procedures for acute evolving stroke were excluded.

**CAS RISK MODEL.** A CAS risk model predictive of S/D was previously published and served as the basis of risk adjustment used in this analysis (8). This model was derived from 11,122 procedures performed between 2005 and 2011 in the CARE Registry and was internally validated by bootstrapping. Variables used in this model were age, previous stroke, symptomatic target lesion within 6 months, impending major surgery, atrial fibrillation, and no previous ipsilateral carotid endarterectomy. To account for clustering at the hospital level, model coefficients were re-estimated using a generalized linear model with hospital-level random effects, as has been described for other measures of hospital performance (9).

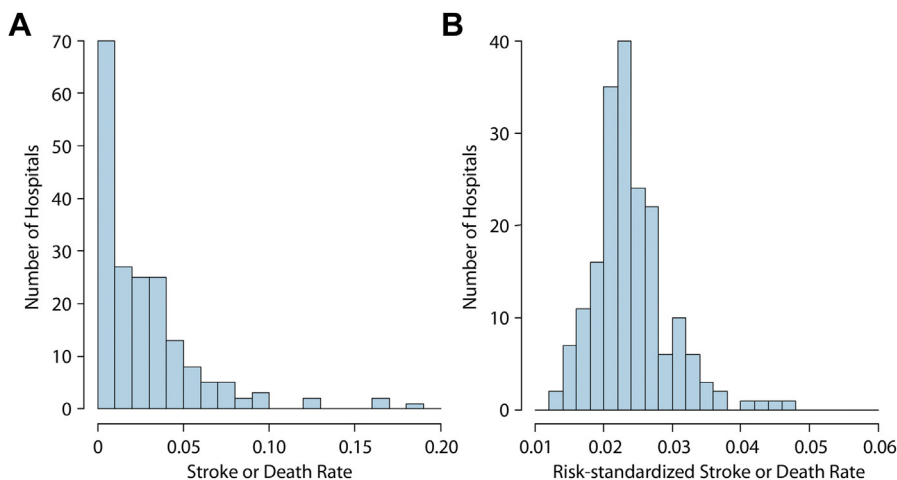
**STATISTICAL ANALYSIS.** Patient and hospital characteristics are reported across low, average, and high tertiles on the basis of hospital-level observed S/D rates. Risk-standardized S/D rates were calculated for each hospital. These values were defined as the ratio of the number of events predicted to have occurred at a particular hospital to the expected number of events at an “average” hospital with similar case mix, multiplied by the mean unadjusted event rate for all included hospitals (9). Predicted events were estimated for each hospital using its own patient mix and hospital-specific intercept; expected events were

## ABBREVIATIONS AND ACRONYMS

CAS = carotid artery stenting

S/D = in-hospital stroke or death

**FIGURE 1** Unadjusted and Risk-Standardized Rates of Stroke or Death



Distribution of hospitals by unadjusted (A) and risk-standardized (B) rates of stroke or death.

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