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# National trends in utilization and outcomes of angioplasty and stenting for revascularization in intracranial stenosis

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ABSTRACT

*Introduction:* Angioplasty and intracranial stenting (ICS) are both endovascular revascularization procedures that have emerged as treatment options for intracranial atherosclerotic disease (ICAD). Some believe angioplasty alone is better, while others believe stenting is better. This study examines recent trends in utilization and outcomes of angioplasty alone and ICS in the United States using a population-based cohort.
*Methods:* The National Inpatient Sample (NIS) database was queried for patients with ICAD who underwent angioplasty or ICS from 2005 to 2010.
*Results:* There were 1115 patients (angioplasty: $n = 495$, ICS: $n = 620$) with ICAD who underwent endovascular revascularization. Over time, the number of endovascular revascularization procedures increased. The percentage of symptomatic patients ($p = 0.015$) as well as in the number of comorbidities of patients treated ($p < 0.001$) also increased. Combined post-procedure stroke and death rates were 16% and 28.9% for angioplasty and ICS, respectively ($p < 0.001$). A larger percentage of angioplasty patients presented symptomatically compared to those who underwent ICS ($p < 0.001$).
*Conclusion:* Angioplasty appears to be associated with higher rates of peri-procedural complications; however, that may represent patient selection bias. Further studies are needed to identify patients who would benefit from revascularization and to clarify the roles of angioplasty and ICS.
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## 1. Introduction

Intracranial atherosclerosis disease (ICAD) is a significant cause of ischemic stroke and can account up to 10% of the strokes per year [1–3]. Different mechanisms for ischemic stroke secondary to intracranial atherosclerosis have been proposed: hypoperfusion; thrombosis at the site of stenosis or distally by a thromboembolic event. Those mechanisms are related to two types of risk factors: modifiable, such as insulin-dependent diabetes mellitus, hypercholesterolemia, hypertension, and cigarette smoking, or non-modifiable such as age or gender [1]. Aggressive control of modifiable risk factors, in addition to aggressive medical treatment for symptomatic stenosis is considered first line treatment. However, symptomatic patients still have an elevated risk of stroke recurrence (12–14%; and 20% for at risk individuals) while on medical therapy, mostly occurring in the first year [4,5].

Treatment of intracranial stenosis has been the focus of many large studies, such as the Warfarin–Aspirin Symptomatic Intracranial Disease (WASID) Study and the Carotid Occlusion Surgery Study (COSS) trial [6,7]. Technological advances over the past decade have enabled endovascular treatment of intracranial atherosclerotic stenosis. Angioplasty in ICAD was originally employed in the 1980s with positive initial results [8,9]. With the advent the Wingspan Stent System with Gateway percutaneous transluminal angioplasty balloon catheter (Stryker Inc., MI, USA) and FDA approval in 2005, there was a surge in utilization of endovascular revascularization [10]. To evaluate safety and outcomes of this technology in a large prospective study, Stenting and Aggressive Medical Management for Prevention of Recurrent Stroke in Intracranial Stenosis (SAMMPRIS), was undertaken. The study was halted early due to increased risk of stroke at 30 days in patients with symptomatic intracranial stenosis [11]. The study failed to identify a group that might benefit from endovascular revascularization and studied patients who had severe ICAD with recently symptomatology (less

*Abbreviations:* ICS, intracranial stenting; ICAD, intracranial atherosclerotic disease.

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**Table 1**
ICD-9 codes used in the NIS database search.

| | |
|---|---|
| Intracranial stenosis (asymptomatic) | 433.00, 433.20, 434.00, 434.10, 434.90, 437.00 |
| Intracranial stenosis (symptomatic) | 433.01, 433.21, 434,01, 434.11, 434.91 |
| Intracranial stent | 00.65 |
| Angioplasty | 00.62 |
| Post-procedure stroke | 997.02 |

than 30 days). There have been many contestations to claims that endovascular revascularization is generally not beneficial to all types of patients with ICAD [12]. More specifically, the role of intervention in patients who have failed medical therapy remains nebulous. In addition, some advocate that since the trial did not evaluate angioplasty alone, further trials evaluating angioplasty without stenting may lower complication rates [13].

The time period from the FDA approval of the Wingspan stent (2005) to the year prior to SAMMPRIS, represents a time period where endovascular treatment for ICAD varied in many aspects. In the current study, we examine the trends in utilization and outcomes of angioplasty-alone and ICS for the management of ICAD using the National Inpatient Sample database.

## 2. Methods

The National Inpatient Sample (NIS) is a database obtained from the Agency for Healthcare Research and Quality for the years 2005–2010. This database includes approximately 8 millions hospitalizations annually. It represents a stratified sample of roughly 20% of all hospital admissions per year, and it serves as a representative sample of inpatient admissions in the United States (http://www.hcup-us.ahrq.gov/nisoverview.jsp).

For the purposes of this study, the NIS was queried using ICD-9 (international classification of disease, ninth edition) codes to identify individual cases of patients with the diagnosis of intracranial stenosis who underwent intracranial stenting (IS) or percutaneous angioplasty of an IC vessel from 2005 to 2010. The ICD-9 codes for the diagnoses and procedures used to identify these patients are listed in Table 1.

Patient characteristics, including age, gender, race, and pre-existing comorbidities were identified. For each record, the comorbidity score was calculated based on the Elixhauser comorbidity scoring system [14]. For the purposes of this study, the Elixhauser comorbidity score was modified by removing the "paralysis" and "other neurological disorders" sub-scores. Additionally, the Elixhauser comorbidity sub-scores for "diabetes-uncomplicated" and "diabetes complicated" were combined into a single sub-score referred to as "diabetes". Similar modifications to the Elixhauser comorbidity sub-score have been made in other research using the NIS databases to study carotid artery revascularization procedures [15,16]. The primary endpoints of the study were inpatient post-procedure stroke and death. The NIS captures information from single inpatient hospitalization experiences, which prevented measurement of long-term ICH, stroke, and mortality risks. Secondary endpoints of interest include length of stay (LOS) and hospital charges. Hospital charges were compared overall or annually, but not between years, in order to prevent bias due to inflation. Discharge status was separated into home and transfer. Home includes patients who were discharged routinely home or were discharged with home health care, and transfer includes patients who were transferred to another hospital or other care facility, such as a skilled nursing facility or intermediate care. Patient primary payer information was also collected, and divided into public, private, and other. Public includes patients who were covered by Medicare or Medicaid.

**Table 2**
Demographics, characteristics, and hospitalization data for patients who underwent revascularization for intracranial stenosis.

| | |
|---|---|
| Total # of patients | 1115 |
| Age (mean ± SD) | 61.9 ± 14.6 years |
| Gender | |
| Male | 50.4% |
| Female | 49.6% |
| Race | |
| White | 67.3% |
| Black | 16.0% |
| Hispanic | 8.8% |
| Asian | 4.7% |
| Other | 3.3% |
| Comorbidities (mean ± SD) | 2.5 ± 1.6 CMs |
| No comorbidities | 8.2% |
| 1–3 comorbidities | 68.1% |
| ≥4 comorbidities | 23.8% |
| Presentation | |
| Asymptomatic | 31.6% |
| Symptomatic | 68.4% |
| Admission | |
| Non-elective | 74.5% |
| Elective | 25.5% |
| Hosp. teaching status | |
| Non-teaching | 13.8% |
| Teaching | 86.2% |
| Procedure | |
| Stent | 55.6% |
| Angioplasty | 44.4% |
| Complications | |
| Stroke | 9.1% |
| Death | 12.6% |
| Discharge | |
| Home | 54.5% |
| Transfer | 45.5% |
| Payer | |
| Public | 53.3% |
| Private | 36.0% |
| Other | 10.8% |
| LOS | |
| Median | 7 days |
| IQR | 3–14 days |
| Total charges | |
| Median | $102,859 |
| IQR | $56,384–174,855 |

The data was stratified into earlier years (2005–2006), middle years (2007–2008), and later years (2009–2010). Patients were compared across these groups in order to identify trends in revascularization procedures over time. A comparison was also made between the patients who were stented and those who had angioplasty. Statistical analysis was done using Chi-Square, Mann–Whitney *U*, and Kruskal–Wallis tests where appropriate. A multivariate analysis was done to identify predictors of the various outcomes. Logistic regression was used for categorical variables, and linear regression was used for continuous variables.

## 3. Results

### 3.1. Patient characteristics and demographics

During 2005–2010, there were 1115 patients with intracranial stenosis who underwent IS ($n = 620$, 55.6%) or angioplasty ($n = 495$, 44.4%). See Table 2. The mean age of these patients was 61.9 ± 14.6 years. There were a similar amount of males and females, and the majority of were white. The mean number of comorbidities these patients had was 2.5 ± 1.6 comorbidities. Most patients had 1–3 comorbidities (68.1%), but 8.2% of patients had no comorbidities and 23.8% had 4 or more comorbidities. Most patients were symptomatic at presentation (68.3%) and were admitted to the hospital