



Coma and Stroke Following Surgical Treatment of Unruptured Intracranial Aneurysm: An American College of Surgeons National Surgical Quality Improvement Program Study

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■ **OBJECTIVE:** A large national surgical registry was used to establish national benchmarks and associated predictors of major neurologic complications (i.e., coma and stroke) after surgical clipping of unruptured intracranial aneurysms.

■ **METHODS:** The American College of Surgeons National Surgical Quality Improvement Program data set between 2007 and 2013 was used for this retrospective cohort analysis. Demographic, comorbidity, and operative characteristics associated with the development of a major neurologic complication (i.e., coma or stroke) were elucidated using a backward selection stepwise logistic regression analysis. This model was subsequently used to fit a predictive score for major neurologic complications.

■ **RESULTS:** Inclusion criteria were met by 662 patients. Of these patients, 57 (8.61%) developed a major neurologic complication (i.e., coma or stroke) within the 30-day post-operative period. On multivariable analysis, operative time (log odds 0.004 per minute; 95% confidence interval [CI], 0.002–0.007), age (log odds 0.05 per year; 95% CI, 0.02–0.08), history of chronic obstructive pulmonary disease (log odds 1.26; 95% CI, 0.43–2.08), and diabetes (log odds 1.15; 95% CI, 0.38–1.91) were associated with an increased odds of major neurologic complications. When patients were categorized

according to quartile of a predictive score generated from the multivariable analysis, rates of major neurologic complications were 1.8%, 4.3%, 6.7%, and 21.2%.

■ **CONCLUSIONS:** Using a large, national multi-institutional cohort, this study established representative national benchmarks and a predictive scoring system for major neurologic complications following operative management of unruptured intracranial aneurysms. The model may assist with risk stratification and tailoring of decision making in surgical candidates.

INTRODUCTION

Unruptured intracranial aneurysms (UIA) are a common intracranial pathology. The prevalence of UIA is approximately 2%–3% in the general U.S. population.^{1,2} With the advent of advanced imaging techniques, detection of UIA has dramatically increased. Therefore, it is important that clinicians have a detailed understanding of the patients who are most likely to benefit from surgery as well as the patients who are most likely to experience complications in the perioperative period.

There has been extensive work to quantify which UIAs are at increased risk of rupture and are most likely to benefit from intervention. The International Study of Unruptured Intracranial

Key words

- Clipping
- Coma
- Major neurologic complication
- National Surgical Quality Improvement Program
- Stroke
- Surgery
- Unruptured intracranial aneurysm

Abbreviations and Acronyms

- ACS:** American College of Surgeons
CI: Confidence interval
COPD: Chronic obstructive pulmonary disease
ISUIA: International Study of Unruptured Intracranial Aneurysms
mNCS: Modified neurologic complication score
NCS: Neurologic complication score

NSQIP: National Surgical Quality Improvement Program

UIA: Unruptured intracranial aneurysm

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Aneurysms (ISUIA) indicated a low risk of rupture in small aneurysms without a history of subarachnoid hemorrhage. Specifically, anterior circulation aneurysms <10 mm in size were found to have an annual rupture rate of 0.05%.³ This study and others have revealed that although the risk of rupture in posterior circulation aneurysms is higher, it is still size dependent.⁴ Therefore, treatment of unruptured aneurysms must balance the benefits in regard to reducing the predicted risk of future hemorrhage with the risk of treatment.

Many published studies have provided data regarding the morbidity and mortality associated with clipping or coiling of UIAs (Table 1). Data from ISUIA first revealed that the complications associated with surgery for smaller UIAs were prohibitively high.³ Single-institution series have reported rates of 22.7%¹⁴ for total adverse events after elective clipping. However, findings from single-institution studies may not be generalizable beyond the reporting institution and may have observation bias. Surgical registries, by comparison, are better poised to provide national benchmarks of perioperative complications in a representative patient population. Literature on the rates and predictors of major neurologic complications after elective surgical clip occlusion of UIAs in a representative national patient population is lacking. This study used the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) to provide insight in this regard.

MATERIALS AND METHODS

Data Source

The ACS-NSQIP data set between the years 2007 and 2013 was used for this retrospective cohort analysis. Because the NSQIP data are deidentified, this analysis was exempt from review by the institutional review board. NSQIP is a prospectively collected surgical registry that currently holds information for >1.7 million patients from >500 hospitals. As of 2008, 58% of hospitals enrolled in NSQIP were large academic institutions. Of all hospitals enrolled at that time, 49% had ≥500 licensed beds, and 33% had 300–499 beds.¹⁵ This database contains >130 variables on preoperative risk factors and intraoperative data. It also reports 30-day perioperative outcomes and explicitly defines whether neurologic complications such as stroke or coma occurred within 30 days of surgery. Data collectors employed at each participating institution receive extensive training for accurately acquiring this information. Quality control processes, including interrater reliability audits, are performed by surgical clinical reviewers to ensure that data are collected and maintained with high fidelity.¹⁶

Inclusion and Exclusion Criteria

Patients were included for analysis if they were enrolled in the NSQIP data registry with an *International Classification of Diseases, Ninth Revision* code indicating that they had a primary postoperative diagnosis code of 437.3 (cerebral aneurysm, unruptured). Patients who underwent surgical clipping (*Current Procedural Terminology* codes 61697, 61698, 61700, and 61702) were sampled. Patients were excluded from the analysis if they had a history of disseminated cancer, underwent endovascular treatment (i.e., coiling), or required emergent surgery.

Table 1. Published Studies on Surgical Clipping for Unruptured Intracranial Aneurysms

Study	Design	Patient Population	Major Complication Rate			
Wiebers et al., 2003 ⁵	International, multi-institutional prospective (ISUIA)	1917	30 days			
			Overall morbidity and mortality: 13.7%			
			Mortality: 1.8%			
			Disability: 12.0%			
			1 year			
			Overall morbidity and mortality: 12.6%			
Krisht et al., 2006 ⁵	Single-institution, prospective	116	Permanent surgical related morbidity: 3.44%			
Brinjikji et al., 2011 ⁷	National, multi-institutional (NIS)	29,918	Cerebral artery occlusion: 3.3%			
			Hemiplegia/paresis: 3.9%			
			Aphasia: 2.7%			
McDonald et al., 2013 ⁸	National, multi-institutional (Premier Perspective Database)	1380	Ischemic complications: 10%			
Bekelis et al., 2014 ⁹	National, multi-institutional (NIS)	3682	Stroke: 5.3%			
Mahaney et al., 2014 ¹⁰	International, multi-institutional prospective (ISUIA)	1917	Cerebral infarct			
			Age <50 years: 2.0%			
			Age 50–65 years: 3.6%			
Bruneau et al., 2016 ¹¹	International, multi-institutional, retrospective	183	Symptomatic neurologic complications: 6.6%			
			Jalbert et al., 2015 ¹²	National, multi-institutional (Medicare beneficiaries)	7942	30-day mortality: 1.6%–3.2%
						In-hospital complications: 25.0%–28.9%
Chen et al., 2015 ¹³	Single-institution, retrospective	150	Permanent neurologic deficit: 0.7%			
Suzuki et al., 2015 ¹⁴	Single-institution, retrospective	141	Serious adverse event: 12.1%			
			Total adverse event: 22.7%			

ISUIA, International Study of Unruptured Intracranial Aneurysms; NIS, Nationwide Inpatient Sample.

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