

# Outcomes of EC – IC bypass for the treatment of occlusive cerebrovascular disease in the United States between 2000-2009: Trends over time

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## Introduction

Following the negative results of the EC-IC Bypass Study and more recently the Carotid Occlusion Surgery Study (COSS), the continued role of EC-IC bypass for the treatment of cerebrovascular disease has been questioned. Procedures recorded in the Nationwide Inpatient Sample between 1992-2001 have previously been analyzed. We herein report an update analyzing data for the following decade.

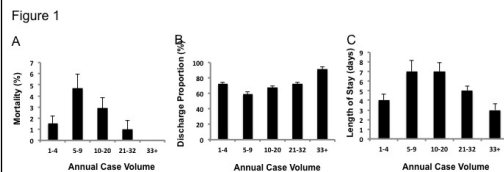
**Table 1. Clinical characteristics in 6,027 patients who underwent EC-IC bypass for treatment of Moyamoya disease, occlusive cerebrovascular disease, or aneurysm**

Characteristic	Moyamoya disease (n=2,456)	Occlusive cerebrovascular (n=2,428)	Intracranial aneurysm (n=1,143)
Patient age (yrs)			
Median (range)	34 (0-75)	57 (16-88)	54 (10-84)
Female gender (%)	69	46	62
Race (%)			
Caucasian	54	77	78
African-American	14	12	8
Hispanic	8	6	9
Asian/Pacific Islands	17	4	3
Native American	1	1	0
Other	7	1	3
Admission Type (%)			
Emergency	9	19	27
Urgent	8	16	18
Routine	84	64	56
Admission Source (%)			
Emergency	2	13	11
Acute care	3	10	20
Long-term	1	2	1
Routine	94	74	69
Insurance (%)			
Medicare	7	33	25
Medicaid	18	10	14
Private	64	53	52
Self-pay	2	1	4
Comorbidity index			
Mean (IQR)	1.17 (1-2)	2.23 (2-3)	1.72 (1-3)
Non-elective (%)	16	36	43
LOS			
Mean (IQR)	5.52 (3-6)	9.73 (3-12)	19.28 (7-23)
Hospital charge (\$)			
Mean (IQR)	83,981 (61,002 – 106,575)	90,617 (62,241 – 110,789)	217,041 (144,462-256,977)
Discharge proportion			
Routine	86.4	64.3	45
Short-term	1.6	1.4	2.6
Transfer to other facility	7.0	23.9	39.8
Home-Health	4.7	8.9	4.4
Deceased	0.2	1.6	8.3

## Methods

We performed a retrospective study of admissions from 2000-2009 in the Nationwide Inpatient Sample. We assessed trends in safety, quality, and value of care with primary outcomes of mortality, discharge proportion, length of stay (LOS), and hospital charges.

**Figure 1: Breakdown of (a) in-hospital mortality, (b) discharge proportion, and (c) length of stay by annual hospital case-volume. Case-volume is categorized into quartiles, with an additional category for the highest decile providers.**



**Table 2. Prognostic value of patient characteristics after EC-IC bypass**

Characteristics	Mortality OR (95% CI)	P	Routine Discharge OR (95% CI)	P
Diagnostic Category				
Moyamoya Disease	0.00		0.00	
Occlusive without stroke	8.21 (3.16-21.29)	0.00	0.45 (0.38-0.52)	0.00
Occlusive with stroke	7.00 (2.33-21.03)	0.001	0.09 (0.03-0.11)	0.00
Unruptured Aneurysm	28.5 (11.23-72.28)	0.00	0.17 (0.14-0.20)	0.00
SAH	88.6 (34.9-224.7)	0.00	0.06 (0.05-0.08)	0.00
Age				
<18 yrs	0.00		0.00	
18-44 yrs	0.91 (0.31-2.69)	0.86	0.16 (0.11-0.26)	0.00
45-64 yrs	5.52 (2.29-13.68)	0.00	0.08 (0.05-0.11)	0.00
>65 yrs	5.7 (2.22-14.67)	0.00	0.04 (0.02-0.05)	0.00
Female gender	1.3 (0.92-1.86)	0.14	1.0 (0.89-1.12)	1.0
African-American race	0.48 (0.20-1.15)	0.10	1.03 (0.84-1.27)	0.79
Primary payer:				
private vs other				
Admission:				
urgent/emergent vs routine	3.39 (2.39-4.82)	0.00	0.26 (0.29-0.30)	0.00

## Results

We identified 6,027 EC-IC bypass patients treated in US hospitals. The annual nationwide caseload increased significantly from 444 cases/yr (2000-2004) to 761 cases/yr (2005-2009) ( $p=0.008$ ) with moyamoya emerging as the predominant diagnosis in the second half of the decade. The number of hospitals at which bypass was performed remained stable, but there was a shift towards a larger proportion being treated at high-volume centers ( $p<0.001$ ). There was a concomitant decrease in mortality (3.7% to 1.6%,  $p<0.001$ ), LOS (11 to 9 days,  $p<0.001$ ), and an increase in routine discharge proportion (64% to 72%,  $p<0.001$ ). Rates of hemorrhage/infarction and hematoma formation decreased ( $p=0.006$  and  $p=0.001$ ), although the rate of deep venous thrombosis/pulmonary embolus increased ( $p=0.004$ ). Mean total charges increased from \$82,839 to \$127,320, which is a 34% inflation-adjusted increase. Multivariate analysis revealed a decrease in mortality in the second half of the study ( $p=0.05$ , OR 0.42) adjusting for age, gender, race, geographic region, admission type, hospital volume, medical comorbidity score, and primary diagnosis.

## Conclusions

During the study interval the US annual caseload for EC-IC bypass increased significantly. Charges increased by one-third over the study period, and there was a trend toward progressive concentration of EC-IC bypass admissions at the highest volume centers that was accompanied by a decline in mortality rates and length of stay, and higher discharge proportion. This is a reversal of the prior decade's trends, and may reflect a shift in the treatment population and centralization of care.

**Figure 2: Breakdown of (a,d,g,j,m) in-hospital mortality, (b,e,h,k,n) discharge proportion, and (c,f,i,l,o) length of stay by annual hospital case-volume and by primary diagnosis. Diagnoses include Moyamoya disease (a,b,c), occlusive cerebrovascula**

