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## How often are ischemic stroke patients eligible for decompressive hemicraniectomy?

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### Abstract

**Background and Purpose**—Malignant middle cerebral artery (MCA) infarction is estimated to occur in 10% of ischemic strokes, but few patients undergo decompressive hemicraniectomy, a proven therapy. We determined the proportion of ischemic stroke patients without significant baseline disability with large MCA infarction who would have been potentially eligible for hemicraniectomy in an era before publication of recent hemicraniectomy trials.

**Methods**—Ischemic stroke cases that occurred in 2005 among residents of the five-county Greater Cincinnati/Northern Kentucky area were ascertained. Two study physicians reviewed all clinical and neuroimaging data for patients with baseline modified Rankin Score (mRS) <2, age ≥18 years with NIHSS ≥10. Large MCA infarction was defined as >50% of the MCA territory or >145mL on diffusion-weighted MRI. Other eligibility criteria for hemicraniectomy, based on the pooled analysis of recent clinical trials, were age 18–60 years and NIHSS >15.

**Results**—Of 2227 ischemic strokes, 39(1.8%) with baseline mRS <2 had large MCA infarction. None underwent hemicraniectomy, and 16(41.0%) died within 30 days. Six patients (0.3% of all ischemic strokes) were potentially eligible for hemicraniectomy; one died within 30 days.

**Conclusion**—Based on criteria from clinical trials, only 0.3% of cases were eligible for hemicraniectomy. Given the survival and functional outcome benefit in treated patients, future studies should determine whether additional subgroups of ischemic stroke patients may benefit from hemicraniectomy.

### Keywords

decompressive surgery; stroke care; epidemiology

### Introduction

An estimated 10% of ischemic strokes are malignant middle cerebral artery (MCA) infarctions.<sup>1</sup> Under conservative management, these severe strokes are associated with up to

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80% mortality and significant disability among survivors.<sup>1,2</sup> Recent clinical trials demonstrated that early decompressive hemicraniectomy reduced mortality and improved functional outcome in healthy young patients with malignant infarction.<sup>2-5</sup>

Given the positive effect on outcomes conferred by hemicraniectomy and the reported 10% prevalence of malignant MCA infarction among all stroke patients,<sup>1</sup> increases in use of the procedure after publication of recent trials that proved its efficacy may be expected. However, less than 0.1% of ischemic stroke patients underwent hemicraniectomy in the United States in 2008.<sup>6</sup> Although delayed translation of trial results to clinical practice may account for these low treatment rates, we hypothesized that a low prevalence of *eligible* patients may account for low rates of decompressive hemicraniectomy in ischemic stroke. In a population-based study, we determined the proportion of ischemic stroke patients who would have been potentially eligible for hemicraniectomy.

## Methods

The Greater Cincinnati/Northern Kentucky (GCNK) Stroke Study is a population-based epidemiological study designed to measure incidence rates and temporal trends of stroke within a biracial population defined as the 1.3 million residents of the GCNK region, which includes 5 counties bordering the Ohio River.<sup>7</sup> Although residents of nearby counties may also seek care at these hospitals, only residents of the 5 counties were included. The study period was January 1, 2005 to December 31, 2005.

Detailed methods for case ascertainment and data collection have been previously described.<sup>7,8</sup> For this analysis, 2 study physicians (R.C. and O.A.) independently reviewed all clinical and neuroimaging data for 152 patients aged  $\geq 18$  years and with NIHSS  $\geq 10$  and mRS  $< 2$ . When available, diffusion-weighted MRI performed within 48 hours of symptom onset was the preferred imaging modality. If MRI was not performed, 24- or 48-hour CT was preferentially used to estimate involvement of the MCA territory (either  $\leq$  or  $> 50\%$ ). Large MCA infarction was defined as  $> 50\%$  of the MCA territory on CT or  $> 145\text{mL}$  on diffusion-weighted MRI. We used the following criteria (in addition to infarct size) to determine potential eligibility for hemicraniectomy: age between 18 and 60 years, baseline mRS  $< 2$ , and NIHSS  $> 15$ .<sup>2</sup> When disagreement occurred, it was resolved by consensus. Statistical analysis was performed using SAS®, version 9.2 (SAS Institute Inc., Cary, NC, USA).

## Results

We identified 2,227 adult ischemic stroke cases in the GCNK region in 2005. The most common reasons for ineligibility for consideration of hemicraniectomy (not mutually exclusive) were: NIHSS  $\leq 15$  ( $n=1973$ , 90.5%), age  $> 60$  ( $n=1679$ , 75.9%), and pre-stroke mRS  $\geq 2$  ( $n=1147$ , 50.2%).

Of 152 patients (6.8%) with an NIHSS  $\geq 10$ , mRS  $< 2$  and age  $\geq 18$ , chart and imaging review for potential eligibility for decompressive hemicraniectomy revealed 39 (1.8% of all cases) patients with large MCA infarction involving  $> 50\%$  of the MCA territory on CT ( $n=27$ ) or an infarct volume  $> 145\text{mL}$  on diffusion-weighted MRI ( $n=12$ ). Table 1 outlines the demographic and clinical characteristics of these patients. Of these 39, six (0.3% of all cases) were potentially eligible for hemicraniectomy based on the predefined criteria. In 2005, no patients actually underwent hemicraniectomy. Of the 6 potentially eligible patients, 1 (16.7%) died within 30 days (Table 2).

## Discussion

We found that only 1.8% of ischemic stroke patients without significant baseline disability had NIHSS  $\geq 10$  and infarcts involving  $>50\%$  of the MCA territory on CT or a volume  $>145\text{mL}$  on diffusion-weighted MRI. While up to 10% of all ischemic stroke patients may have malignant MCA infarction,<sup>1</sup> the much lower proportion of not previously disabled large MCA stroke patients likely accounts for the low rates of hemicraniectomy in stroke patients.<sup>6</sup>

By applying the strict eligibility criteria of the pooled analysis of the European hemicraniectomy trials,<sup>2</sup> we found that only 0.3% of cases among residents of our region would have been potentially eligible for decompressive hemicraniectomy. Not all patients with large MCA infarctions develop the severe edema and mass effect that is characteristic of malignant MCA infarction. Thus, our finding of a low overall prevalence of large MCA infarction in patients without significant disability, coupled with the other inclusion and exclusion criteria for eligibility for hemicraniectomy, explain the few patients we found that would have been eligible. Importantly, none of the 6 patients we identified as eligible in fact underwent the procedure in 2005 (prior to publication of the pooled analysis of hemicraniectomy trials)<sup>2</sup>; one died within 30 days. Future studies should determine whether these missed opportunities for treatment persist in the era *after* publication of recent trials.

Our study had some limitations. We used retrospectively derived NIHSS from chart review to determine potential eligibility for hemicraniectomy. Although this methodology has been validated,<sup>9</sup> it has also been reported to slightly underestimate stroke severity and we were not able to reliably ascertain item 1a on the NIHSS. However, we do not believe we grossly underestimated the proportion of eligible patients. Inclusion of all cases with an NIHSS of 10 or greater with large MCA infarction and age less than 60 would result in 0.4% of all ischemic strokes being eligible for hemicraniectomy. Limiting our chart and imaging review to only those patients with an NIHSS of 10 or greater may have missed patients who initially presented with milder symptoms but progressed to large strokes. We briefly reviewed the abstracted records of the 235 out of the 1,762 cases with a baseline NIHSS less than 10 who experienced “clinical worsening” during hospitalization. Of these, 197 were older than 60 or had a baseline mRS  $\geq 2$ . Of the remaining 38, we reviewed the records of seven who had a significant neurological deterioration. Four had cerebellar strokes, two alcohol withdrawal and one hemorrhagic brain mass along with an MCA infarction. Thus, exclusion of patients with an NIHSS less than 10 did not result in a significant underestimation of patients who were eligible for decompressive hemicraniectomy.

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**Table 1**

## Demographics of Patients with Large MCA Infarction

N	39
Age (years), median (range)	71.0 (46.0–92.0)
Race (black), N (%)	7 (18.0%)
Gender (female), N (%)	17 (43.6%)
NIHSS, median (range)	19 (10–37)
Baseline mRS, (zero)	19 (48.7%)
History of Diabetes, N (%)	8 (20.5%)
History of Hypertension, N (%)	25 (64.1%)
History of Coronary Disease, N (%)	13 (33.3%)
History of Atrial fibrillation, N (%)	10 (25.6%)
30-day mortality, N (%)	16 (41.0%)
Timing of CT/MR From Estimated Symptom Onset*	
<24 hours	8 (20.5%)
24–48 hours	14 (35.9%)
>48 hours	17 (43.6%)

\* Symptom onset was estimated based on last known normal time.

**Table 2**

Characteristics of Patients Potentially Eligible for Hemispherectomy

	Age (years)	Race	Gender	NIHSS	Discharge mRS
1	46	Black	M	29	5
2	48	Black	F	17	3
3	53	White	M	21	3
4	47	White	M	19	4
5	56	White	M	25	5
6	55	Black	M	21	expired