How Often Are Patients With Ischemic Stroke Eligible for Decompressive Hemicraniectomy?

Ralph Rahme, MD; Richard Curry, MD; Dawn Kleindorfer, MD; Jane C. Khouy, PhD; Andrew J. Ringer, MD; Brett M. Kissela, MD; Kathleen Alwell, BSN; Charles J. Moomaw, PhD; Matthew L. Flaherty, MD; Pooja Khatri, MD, MSc; Daniel Woo, MD; Simona Ferioli, MD; Joseph Broderick, MD; Opeolu Adeoye, MD

Background and Purpose—Malignant middle cerebral artery infarction is estimated to occur in 10% of ischemic strokes, but few patients undergo decompressive hemicraniectomy, a proven therapy. We determined the proportion of patients with ischemic stroke without significant baseline disability with large middle cerebral artery 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 5-county Greater Cincinnati/Northern Kentucky area were ascertained. Two study physicians reviewed all clinical and neuroimaging data for patients with baseline modified Rankin Scale score <2, age ≥18 years with National Institutes of Health Stroke Scale score ≥10. Large middle cerebral artery infarction was defined as >50% of the middle cerebral artery territory or >145 mL on diffusion-weighted MRI. Other eligibility criteria for hemicraniectomy, based on the pooled analysis of recent clinical trials, were age 18 to 60 years and National Institutes of Health Stroke Scale score >15.

Results—Of 2227 ischemic strokes, 39 (1.8%) with baseline modified Rankin Scale score <2 had large middle cerebral artery 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; 1 died within 30 days.

Conclusions—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 patients with ischemic stroke may benefit from hemicraniectomy. (Stroke. 2012;43:550-552.)

Key Words: decompressive surgery ■ epidemiology ■ stroke care

An estimated 10% of ischemic strokes are malignant middle cerebral artery (MCA) infarctions.1 Under conservative management, these severe strokes are associated with up to 80% mortality and significant disability among survivors.2,3 Recent clinical trials demonstrated that early decompressive hemicraniectomy reduced mortality and improved functional outcome in healthy young patients with malignant infarction.2–5

Given the positive effect on outcomes conferred by hemicraniectomy and the reported 10% prevalence of malignant MCA infarction among all patients with stroke,1 increases in use of the procedure after publication of recent trials that proved its efficacy may be expected. However, <0.1% of patients with ischemic stroke underwent hemicraniectomy in the United States in 2008.6 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 patients with ischemic stroke who would have been potentially eligible for hemicraniectomy.

Methods

The Greater Cincinnati/Northern Kentucky 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 Greater Cincinnati/Northern Kentucky region, which includes 5 counties bordering the Ohio River.7 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.7,8 For this analysis, 2 study physicians (R.C. and O.A.) independently reviewed all clinical and neuroimaging data for 152 patients aged ≥18 years and with National Institutes of Health Stroke Scale (NIHSS) score ≥10 and modified Rankin Scale score <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 available.

Received August 5, 2011; final revision received September 7, 2011; accepted September 8, 2011.

From the Departments of Neurosurgery (R.R., A.J.R., O.A.), Neurology (R.C., D.K., B.M.K., K.A., C.J.M., M.L.F., P.K., D.W., S.F., J.B.), and Emergency Medicine (O.A.), University of Cincinnati, Cincinnati, OH; and Cincinnati Children’s Hospital Medical Center (J.C.K.), Cincinnati, OH.

Correspondence to Opeolu Adeoye, MD, University of Cincinnati, 231 Albert Sabin Way, ML0769 Cincinnati, OH 45267. E-mail opeolu.adeoye@uc.edu

© 2011 American Heart Association, Inc.

Stroke is available at http://stroke.ahajournals.org

DOI: 10.1161/STROKEAHA.111.635185

550
preferentially used to estimate involvement of the MCA territory (either ≤ or >50%). Large MCA infarction was defined as >50% of the MCA territory on CT or >145 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 modified Rankin Scale score <2, and NIHSS score >15.2 When disagreement occurred, it was resolved by consensus. Statistical analysis was performed using SAS, Version 9.2 (SAS Institute Inc, Cary, NC).

**Results**

We identified 2227 adult ischemic stroke cases in the Greater Cincinnati/Northern Kentucky region in 2005. The most common reasons for ineligibility for consideration of hemicraniectomy (not mutually exclusive) were: NIHSS score ≤15 (n=1973 [90.5%]), age >60 years (n=1679 [75.9%]), and prestroke modified Rankin Scale score ≥2 (n=1147 [50.2%]).

Of 152 patients (6.8%) with an NIHSS score ≥10, modified Rankin Scale score <2, and age ≥18 years, chart and imaging review for potential eligibility for decompressive hemicraniectomy revealed 39 (1.8% of all cases) patients with a large MCA infarction involving >50% of the MCA territory on CT (n=27) or an infarct volume >145 mL on diffusion-weighted MRI (n=12). Table 1 outlines the demographic and clinical characteristics of these patients. Of these 39, 6 (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 patients with ischemic stroke without significant baseline disability had NIHSS score ≥10 and infarcts involving >50% of the MCA territory on CT or a volume >145 mL on diffusion-weighted MRI. Although up to 10% of all patients with ischemic stroke may have malignant MCA infarction,1 the much lower proportion of not previously disabled patients with large MCA stroke likely accounts for the low rates of hemicraniectomy in patients with stroke.6

By applying the strict eligibility criteria of the pooled analysis of the European hemicraniectomy trials,2 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, explains 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 (before publication of the pooled analysis of hemicraniectomy trials);1 1 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,9 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 score of ≥10 with large MCA infarction and age <60 years 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 score of ≥10 may have missed patients who initially presented with milder symptoms but progressed to large strokes. We briefly reviewed the abstracted records of the 235 of the 1762 cases with a baseline NIHSS score <10 who experienced “clinical worsening” during hospitalization. Of these, 197 were >60 years or had a baseline modified Rankin Scale score ≥2. Of the remaining 38, we reviewed the records of seven who had a significant neurological deterioration. Four had cerebellar strokes, 2 alcohol withdrawal, and 1 hemorrhagic brain mass along with an MCA infarction. Thus, exclusion of patients with an NIHSS score <10 did not
result in a significant underestimation of patients who were eligible for decompressive hemicraniectomy.

**Sources of Funding**

Supported by NINDS 5R01NS030678.

**Disclosures**

None.

**References**


How Often Are Patients With Ischemic Stroke Eligible for Decompressive Hemicraniectomy?

Ralph Rahme, Richard Curry, Dawn Kleindorfer, Jane C. Khoury, Andrew J. Ringer, Brett M. Kissela, Kathleen Alwell, Charles J. Moomaw, Matthew L. Flaherty, Pooja Khatri, Daniel Woo, Simona Ferioli, Joseph Broderick and Opeolu Adeoye

*Stroke*. 2012;43:550-552; originally published online October 27, 2011; doi: 10.1161/STROKEAHA.111.635185

*Stroke* is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2011 American Heart Association, Inc. All rights reserved.
Print ISSN: 0039-2499. Online ISSN: 1524-4628

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://stroke.ahajournals.org/content/43/2/550

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in *Stroke* can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to *Stroke* is online at:
http://stroke.ahajournals.org/subscriptions/