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Decompressive hemicraniectomy for stroke by race/ethnicity in the United States

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ABSTRACT

Objective: Racial and ethnic differences in the performance of indicated neurosurgical procedures have been reported. However, it is not clear whether there are racial or ethnic differences in the performance of decompressive hemicraniectomy (DHC) for acute ischemic stroke. This study evaluated the rate, trends, and independent association of race and ethnicity with DHC among hospitalized ischemic stroke patients in the United States.

Materials and methods: We used the International Classification of Diseases, Clinical Modification (ICD-9-CM) to identify adult patients (18-year-old and older) with a primary discharge diagnosis of ischemic stroke, excluding those with a posterior circulation ischemic stroke in the Nationwide Inpatient Sample between 2006 and 2014. We computed the rate and trends of DHC. We then applied a multivariable logistic regression model to evaluate the independent association of race with DHC.

Results: A total 715,649 patients had anterior ischemic stroke, including 1514 who underwent DHC (2.1 per 1000). The rate of DHC increased overall from 1 per 1000 in 2006 to 3 per 1000 in 2014. Similar upward trends were noted among Non-Hispanic Whites, Non-Hispanic Blacks, and Hispanics. Hispanics with anterior ischemic stroke were 1.28 times more likely than non-Hispanic Whites to have DHC but no difference was observed between Non-Hispanic Blacks and Non-Hispanic Whites.

Conclusions: In this nationally representative sample of patients with anterior ischemic strokes, being of Hispanic ethnicity was independently associated with a higher frequency of receiving DHC compared to being Non-Hispanic White. Future studies should confirm this difference and explore the underlying reasons for it.

1. Introduction

One serious complication of ischemic stroke is the potential increase in intracranial pressure, which may cause part of the brain to herniate out of their normal locations and lead to death or ischemic damage to healthy brain regions [1], a condition known as malignant cerebral edema. Although this condition occurs in <10% of patients with ischemic stroke [2], it is associated with a mortality rate of up to 78% [3]. Among the available neurosurgical interventions to address the elevated intracranial pressure is decompressive hemicraniectomy (DHC), which has been shown in clinical trials to reduce mortality by 49.9% in patients with malignant cerebral infarction [4]. There are racial and ethnic disparities in the incidence of ischemic stroke in the United States, with suggestions that Blacks and Hispanics are 1.5 to 3 times more likely to have an ischemic stroke than Whites [5–7]. These disparities span across all age groups including young patients who are more at risk of malignant cerebral infarction. Furthermore, stroke may be more severe in minorities who are also less likely to receive standard of care acute reperfusion therapy such as intravenous recombinant tissue plasminogen activator [6–8] or mechanical thrombectomy [9]. In the United States, neurosurgical procedures, tend to be generally less frequently performed in racial minorities [10]. Given the excess burden of stroke in minorities, the potential higher risk of malignant cerebral infarction in minorities, we sought to ascertain the rate, trends, and

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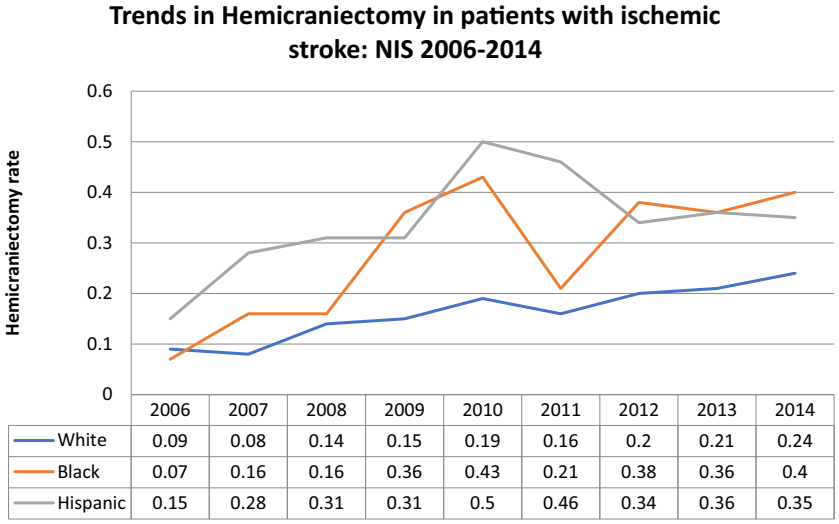
independent association of race with DHC among hospitalized ischemic stroke adult patients in the United States.

2. Methods

The National Inpatient Sample (NIS) 2006–2014 served as data source. It is a publicly available database that tracks hospital admissions

Table 1
Baseline characteristics of patients by hemicraniectomy status: National Inpatient Sample.

Variable		Hemicraniectomy	No hemicraniectomy	*p*-Value
Female		60.25%	46.95%	<0.0001
Male		39.75%	53.05%	
Age	18–44 years	20.36	4.06	<0.0001
	54–64 years	57.82	27.35	
	65–84 years	21.48	48.10	
	≥ 85 years	0.34	20.48	
Race	White	55.44	70.23	<0.0001
	Black	23.82	16.97	
	Hispanic	11.62	7.20	
	Others	9.13	5.60	
Primary Payer	Medicare	24.91	66.68	<0.0001
	Medicaid	21.42	6.78	
	Private	41.08	19.03	
	Others	12.58	7.52	
Hospital size	Small	3.02	12.60	<0.0001
	Medium	17.27	25.33	
	Large	79.71	62.07	
Location/ teaching status	Rural	1.95	13.18	<0.0001
	Urban/non-teaching	14.61	39.98	
	Urban/teaching	83.44	46.85	
Weekend /weekday admission	Weekend	26.88		<0.0001
	Weekday	73.12	74.33	
		23.7	25.67	0.2805
Discharge disposition	Home	5.69	35.40	0.0002
	Transfer to another hospital	4.84	3.10	
	Other transfers	64.48	43.20	
	Homecare/home hospice	1.59	12.78	
	Left against medical advice	0.00	0.71	
	In-hospital mortality	23.40	4.81	
Median Household income	Quartile 1	31.56	30.57	0.1673
	Quartile 2	24.57	26.70	
	Quartile 3	25.38	23.22	
	Quartile 4	18.49	19.50	
Year category	2006–2008	18.97	32.16	<0.0001
	2009–2011	37.04	33.61	
	2012–2014	43.99	34.23	
Regions	North East	20.34	18.27	0.0146
	Midwest	25.25	23.10	
	South	34.88	41.86	
	West	19.53	16.76	
Intravenous r-tPA	Yes	17.86	5.01	<0.0001
	No	82.14	94.99	
Coma	Yes	11.20	0.87	<0.0001
	No	88.80	99.13	
LOS, mean (95% CI), in days		17.78	5.05 (5.01–5.14)	<0.0001
CCI, mean (95% CI), in days		0.99	1.33	<0.0001



	2006	2007	2008	2009	2010	2011	2012	2013	2014
White	0.09	0.08	0.14	0.15	0.19	0.16	0.2	0.21	0.24
Black	0.07	0.16	0.16	0.36	0.43	0.21	0.38	0.36	0.4
Hispanic	0.15	0.28	0.31	0.31	0.5	0.46	0.34	0.36	0.35

in the United States. Forty-two states participate in the database, which contains standardized information on nearly 8 million hospital discharges across 1000 hospitals, including 20% of US hospitals [11]. We identified cases of ischemic stroke using the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) primary diagnostic codes of ischemic stroke 433.X1, 434.X1 and 436. These codes have been used in previous studies [12]. We excluded the ICD-CM codes 433.01(occlusion and stenosis of basilar artery with cerebral infarction) and 433.21 (occlusion and stenosis of vertebral artery with cerebral infarction) given that clinical trials have established the benefit of DHC for ischemic stroke of the anterior circulation. DHC was identified using the procedure codes: 01.2 (Craniotomy and craniectomy) and 01.25 (Other craniectomy).

2.1. Statistical analysis

We used the STATA ver.14 software (College Station, TX: StataCorp LP). All analyses were performed considering the complex sampling design of the NIS. We applied survey weights, which allowed us to produce estimates at the national level. We extracted the following categorical variables: age (18–44 years, 45–64 years, 65–84 year and ≥ 85 years). Gender (Male vs. Female), race/ethnicity (Whites, Blacks, Hispanics, and others), primary payer (Medicare, Medicaid, Private and self-pay/no charge/others), hospital bed size (small, medium and large size hospital), hospital location/teaching hospital status (urban teaching, urban non-teaching and rural), admission day (weekday i.e. Monday-Friday and weekend), median household income for patient's ZIP code (classified into four quartiles: quartile 1, quartile 2, quartile 3 and quartile 4 with higher quartiles representing higher income), hospital census region (Northeast, Midwest, South, and West), and death status (yes vs. No). Length of stay (LOS) and Charleson Co-morbidity Index (CCI) were continuous variables expressed as mean and standard deviation. The CCI is a weighted score of 17 conditions developed and validated to assess medical comorbidities [13]. We used these variables to compare patients who had DHC with those who did not receive DHC with differences tested using chi square (χ^2) for categorical variables and t-Student test for continuous variables. We assessed potential changes in the annual rates of DHC overall and by race among adults with ischemic stroke from 2006 to 2014. Finally, we evaluated the association between DHC and race among adults with anterior ischemic stroke using a multivariable logistic regression model, adjusting for the effect of age, sex, race/ethnicity, primary payer, hospital bed size, unban-teaching status, admission day, median household income, census region, length of stay (LOS), Charleson Comorbidity Index (CCI), and year of hospitalizations.

3. Results

3.1. Baseline characteristics

A total of 715,649 patients had an anterior ischemic stroke, including 1514, who underwent DHC (2.1 per 1000). In the univariate model (Table 1), males, younger patients, racial minorities (Blacks and Hispanics), privately insured patients, patients in large bed size academic centers, those hospitalized in the most recent years, those who received intravenous recombinant tissue plasminogen, and those with a reduced level of consciousness were more likely to undergo DHC. (See Table 2.)

3.2. Trends in decompressive hemicraniectomy by race between 2006 and 2014

The rate of decompressive hemicraniectomy increased from 1 per 1000 in 2006 to 3 per 1000 in 2014. Similarly, upward trends were noticed among Non-Hispanic Whites (from 0.9 per 1000 to 2.4 per 1000), Blacks (from 0.7 per 1000 to 4.4 per 1000), and Hispanics (from 1.5 per 1000 to 3.5 per 1000). We observed an increase in the rate of DHC across all races; but the procedure was performed less frequently in Whites compared with other races each year from 2006 and 2014.

Table 2
Logistic regression model: adjusted odds-ratio for thrombectomy among adults with ischemic stroke.

Variables	Odds ratio	95% CI	*p* value
Primary independent variable			
Race/ethnicity			
Non-Hispanic White (Ref.)	–	–	–
Non-Hispanic Black	0.98	0.84–1.16	0.902
Hispanic	1.28*	1.02–1.6	0.030
Others	1.17	0.91–1.50	0.205
Male (Ref.)	–	–	–
Female	0.84**	0.74–0.94	0.004
Covariates	–	–	–
No IV-tPA (Ref.)	–	–	–
IV-tPA	2.64***	2.21–3.16	<0.001
Age category			
Age 18–44 (Ref.)	–	–	–
Age 45–64	0.50***	0.0.42–0.58	<0.001
Age 65–84	0.16***	0.13–0.21	<0.001
Age 85^{+}	0.00765***	0.0031–0.0018	<0.001
Primary payer			
Medicare (Ref.)	–	–	–
Medicaid	1.57***	1.26–1.94	<0.001
Private	1.71***	1.44–2.04	<0.001
Self-pay/no charge/others	1.05	0.83–1.33	0.659
Hospital bed size			
Small (Ref.)	–	–	–
Medium	2.61***	1.74–3.91	<0.001
Large	4.86***	3.30–7.10	<0.001
Urban-teaching status			
Rural (Ref.)	–	–	–
Urban nonteaching	1.58	0.86–2.9	0.142
Urban teaching	6.62***	3.64–12.05	<0.001
Admission day			
Week day (Ref.)	–	–	–
Weekend	0.97	0.85–1.11	0.718
Median household income for patient's ZIP code			
Quartile 1 (Ref.)	–	–	–
Quartile 2	1.13	0.94–1.34	0.171
Quartile 3	1.29*	1.07–1.54	0.005
Quartile4	1.11	0.90–1.36	0.311
Hospital census region			
Northeast (Ref.)	–	–	–
Midwest	1.27	0.98–1.65	0.065
South	0.91	0.72–1.13	0.394
West	1.11	0.86–1.44	0.423
LOS, mean in days	1.031***	1.027–1.036	<0.001
	–	–	–
Coma	15.9***	13.01–19.26	<0.001
Charleson Co-morbidity index (CCI), mean	0.87***	0.82–0.91	<0.001
Year Category			
Year 2003/06 (ref)	–	–	–
Year 2007/10	1.68***	1.33–2.13	<0.001
Year 2011/14	1.81***	1.44–2.27	<0.001

* Level of significance $p < 0.05$.
** level of significance $p < 0.01$.
*** level of significance $p < 0.001$.

3.3. Association of race and other factors with decompressive hemicraniectomy

In the multivariable logistic model with race as the primary independent variable, adjusted for potential confounders (Table-2), Hispanics with anterior ischemic stroke were 1.28 times (OR: 1.28, 95%CI: 1.02–1.06) more likely than non-Hispanic Whites to have DHC. However, we observed no difference between Blacks and Non-Hispanic Whites (OR: 0.98, 95%CI: 0.84–1.16). Other factors associated with the increased use of DHC included the presence of coma (OR: 15.9, 95% CI: 13.01–19.26), the use of intravenous thrombolysis with Alteplase

(OR: 2.68, 95%CI: 2.21–3.16), hospitalization in medium or large-sized hospital (OR: 2.61, 95%CI: 1.74–3.91 and OR: 4.78, 95%CI: 3.30–7.10 respectively), hospitalization in an urban teaching hospital (OR: 6.62: 95%CI: 3.64–12.05) or urban nonteaching hospital (OR:1.58, 95%CI: 0.86–2.9) compared to a rural hospital.

Decompressive hemicraniectomy rates also varied by insurance type with privately insured patients (OR: 1.71, 95%CI: 1.44–2.04) and Medicaid beneficiaries (OR: 1.57 CI 1.26–1.94) being less more likely to receive DHC than Medicare beneficiaries. Similarly, more DHC were performed in the more recent years (OR for 2007/10 vs. 2003/07: 1.68, 95%CI 1.33–2.13 and OR for 2011/14 vs. 2003/07: 1.81, 95%CI 1.44–2.27). Conversely, the current analysis revealed that as patients grew old, their likelihood of receiving DHC decreased (OR for 45–64 years vs. 18–44 years: 0.50, 95%CI: 0.42–0.58; OR for 65–84 years vs. 18–44 years: 0.16, 95%CI: 0.13–0.21, and OR for 85+ years vs. 18–44 years: 0.007, 95%CI: 0.003–0.018). Women were also less likely to receive DHC than men (OR: 0.85, 95%CI: 0.74–0.94). In the same line, the presence of medical comorbidities defined as assessed by the mean CCI (OR: 0.87, 95%CI: 0.82–0.91) was inversely associated with DHC among patients with anterior ischemic strokes.

4. Discussion

Pivotal trials that have established the benefits of DHC in acute malignant ischemic stroke of the anterior circulation [14–16], but provided no data on race or ethnicity. The current study fills this gap as it provides additional data on DHC by breaking down estimates by race and ethnicity using a large representative sample of hospitalized patients in the United States. Blacks and Hispanics were more likely to receive decompressive hemicraniectomy after an acute ischemic stroke, compared with Non-Hispanic Whites but the difference persisted only for Hispanics after adjustment in the logistic regression model.

Studies on disparities in utilization of neurological care in the US [17] have shown that Hispanics and Blacks are less likely to receive neurologic care than their White counterparts. Similarly, for planned cranial surgery such as epilepsy surgery [18] and vagal nerve stimulation [19], an overrepresentation of Non-Hispanic Whites has consistently been reported. Racial disparities have also been reported for emergency neurosurgical procedures such as mechanical thrombectomy among stroke patients although the pattern of disparities may not be similar for mechanical thrombectomy and DHC [9,20]. In the current study, there was no difference in DHC utilization between Black patients and Non-Hispanic White patients, but Hispanic patients were more likely to receive DHC. Attempts to explain the higher likelihood of DHC in Hispanic patients with ischemic stroke should consider traditional predictors of having the procedure such as stroke severity. An index stroke may also be more severe in some racial/ethnic groups, therefore contributing to explain some of the disparities observed in the rate of utilization of DHC in ischemic stroke patients. For example, elderly (75+ years) Mexican Americans may have more severe strokes than Non-Hispanic Whites [21]. Unfortunately, we could not test that hypothesis in the current study as the NIS does not contain information on stroke severity. Although it should be noted that Non-Hispanic Blacks tend to have the most severe strokes and we did not find an independently higher frequency of DHC among non-Hispanic Blacks in this study.

Commonly evoked factors to explain racial disparities in surgeries such as epilepsy surgeries and other surgeries include fear of treatment, access to care, communication barriers, education, trust between patient and physician and social support [22]. Although these factors for the most part may explain disparities in planned surgical procedures, how they fit into neurosurgical emergencies is still unclear and requires further studies.

The current analysis found a steady increase in the rates of DHC since 2006 across all races although it was performed at a lower rate among Non-Hispanic Whites during each year studied. This trends closely mirror the publication of pivotal DHC trials [14–16], which have set DHC as the standard of care in patients with malignant ischemic stroke and show that all races have benefited from the procedure. The racial differences observed across years may be inherence to unchanged factors not completely captured in the current study.

5. Limitations

This study has limitations, which should be accounted when interpreting its results. Firstly, even though the NIS is a large dataset that has been extensively used for nationwide trends analyses, this is a retrospective analysis and diagnoses and procedures were obtained using ICD billing codes, which may be a source of bias. There are also limitations to our racial categorization as all the data is self-reported by the patient. Our study timeline ended in 2014 thereby limiting our ability to make inferences about current practice guidelines surrounding decompressive hemicraniectomy. Furthermore, we couldn't account for several variables including but not limited to the etiology of stroke, stroke severity, brain imaging characteristics eligibility for decompressive hemicraniectomy, patient/surrogate denial for treatment, withdrawal of care/life supporting therapy, and time between onset of symptoms and presentation to the hospital. Despite these limitations, the current study is the first to provide data on the rate and trends in the utilization of DHC by race in the United States.

6. Conclusion

The current study analyzed the rate and association of DHC in patients with anterior ischemic stroke across racial groups in the United States using the Nationally Inpatient Sample. Non-Hispanic Whites received DHC at lower rates than Hispanics and Blacks between 2006 and 2014. Hispanics were 28% more likely to undergo DHC than Non-Hispanic Whites to undergo DHC after anterior ischemic stroke. There was no difference between Non-Hispanic Whites and Blacks in the utilization of DHC.

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Data availability

The NIS is a publicly available database and can be obtained upon request from: http://www.hcup-us.ahrq.gov/reports/methods/methods.jsp

Credit author statement

Alain Lekoubou: Conceptualization, methodology, validation, writing - original draft, writing-review & editing.

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Kinfe G. Bishu: Conceptualization, statistical analyses, writing-review & editing.

Bruce Ovbiagele: Supervision, conceptualization, methodology, validation, and draft revisions.

Conflict of interest

None to declare.

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