Older Age Is Not Associated with Worse Outcomes Following Decompressive Hemicraniectomy for Spontaneous Intracerebral Hemorrhage

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Background: Decompressive hemicraniectomy (DHC) is commonly offered after large spontaneous intracerebral hemorrhage (ICH) as a life-saving measure. Based on limited available evidence, surgery is sometimes avoided in the elderly. The association between age and outcomes following DHC in spontaneous ICH remains largely understudied. *Objective:* The goal of this study is to investigate the influence of older age on outcomes of patients who undergo DHC for spontaneous ICH. *Methods:* In this retrospective cohort study, inpatient data were obtained from the United States Nationwide Inpatient Sample from 2000 to 2011. Using International Classification of Diseases, ninth revision designations, patients with a primary diagnosis of nontraumatic ICH who underwent DHC were identified. The primary outcome of interest was the association of age to inpatient mortality and poor outcome. Subjects were grouped by age: 18-50, 51-60, 61-70, and more than 70 years. Sample characteristics were compared across age groups using χ^2 testing, and univariate and multivariate Poisson Regression was performed using a generalized equation to estimate rate ratios for primary and secondary outcomes. *Results:* One thousand one hundred and forty four patient cases were isolated. Death occurred in an estimated 28.9% and poor outcome in 86.4%. In multivariate Poisson regression models, there was no difference in hospital mortality or poor outcome by age group. Although younger patients were more likely to be diagnosed with herniation, total complication rate was similar between age groups. *Conclusions:* Our study results do not provide evidence that age independently predicts in-hospital mortality or poor outcomes. The true influence of age on outcomes is unclear, and further study is needed to determine which factors may be best in selecting candidates for DHC following spontaneous ICH.

Key Words: Age—decompressive hemicraniectomy—elderly—intracerebral hemorrhage—stroke

Introduction

Although spontaneous intracerebral hemorrhage (ICH) is less common than ischemic stroke, it is associated with higher morbidity and 2-year mortality exceeding 50%.[1,2] Only 20% of survivors achieve functional independence at 6 months.[2] In the acute phase, large hematomas are associated with malignant cerebral edema and intracranial hypertension, which left untreated, can result in

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herniation and death. No pharmacologic treatment for ICH has been shown to improve outcomes. Similarly, although early hematoma evacuation is feasible, clinical trials have failed to show improvement in 6-month outcomes.[3,4]

Despite low-quality evidence, decompressive hemicraniectomy (DHC) is commonly offered for large spontaneous ICH as a life-saving measure. In the ischemic stroke population, DHC increases survival and favorable outcomes when done early.[5] Additionally, in patients with aneurysmal subarachnoid hemorrhage or traumatic brain injury, surgical decompression is effective in lowering intracranial pressure.[6,7] While benefits have been demonstrated in these populations, the effect of DHC in spontaneous ICH is understudied. Studies have shown that lower admission Glasgow Coma score, ICH in the dominant hemisphere, and increasing hematoma volume are independently associated with poor outcomes[8]; however, the relationship between age and outcomes following DHC for ICH is unknown. When craniectomy is done for large middle cerebral artery (MCA) stroke, older age is a strong predictor of worse outcomes.[9-13] Given that age is the most important nonmodifiable risk factor for ICH,[14] further study is warranted. We therefore analyzed a large United States (US) database to investigate patient outcomes and the influence of age on those outcomes in this population, with the hypothesis that older age was associated with worse outcomes.

Methods

Data Source

Analysis was performed on data obtained from the Nationwide Inpatient Sample (NIS) for the period of January 1, 2000 to December 31, 2011. The NIS database is the largest publicly available inpatient care database in the United States and is maintained by the National Healthcare Cost Utilization Project of the Agency for Healthcare Research and Quality. It contains a 20% stratified sample of US hospitals, excluding rehabilitation centers, long-term nonacute care hospitals, mental health care centers, and chemical dependency treatment facilities. Each year, the NIS provides discharge-level records on approximately 8 million de-identified hospitalizations from approximately 1000 hospitals. Both clinical and resource use data are captured from discharge abstracts, with hospital and discharge weights used to provide national estimates. These features allow the NIS to effectively identify national trends in healthcare quality and patient outcomes. Detailed information on the NIS is available at www.hcup-us.ahrq.gov.

Study Design

This was a retrospective, observational study using the NIS database. Secondary analysis of a large national database is effective for observing large trends in health care, especially where a randomized clinical trial would be difficult.

Study Population

Data were collected for adult patients aged 18 years of age or older. To determine the influence of age on outcomes in those undergoing DHC following nontraumatic ICH, patients were grouped by age as follows: 18-50, 51-60, 61-70, and more than 70 years old. Diagnoses were identified by International Classification of Diseases, ninth revision; Clinical Modification (ICD-9-CM) designations. A primary diagnosis of nontraumatic ICH was isolated by the code 431.x. DHC was identified using ICD-9-CM procedure codes indicating a craniectomy (01.25) or hemispherectomy (01.52).

Patients with the following diagnoses were excluded: acute ischemic stroke (433.11, 433.31, 433.81, 433.91, 434.01, 434.11, and 434.91), carotid dissection (443.21), vertebral artery dissection (443.24), vertebrobasilar infarction (433.01, 433.21), cerebral arteritis (437.4), Moya-Moya disease (437.5), traumatic brain injury (800.00-801.99, 803.00-804.99, 850.00-854.19, 873.00-873.90, 747.81), subarachnoid hemorrhage (430.x), unruptured cerebral aneurysm (437.3), arteriovenous malformation (747.81), subdural hemorrhage (432.1), extra-axial hematoma (432.0, 432.1, 432.9), venous sinus thrombosis (437.6), intracranial abscess (324.0), brain tumor (191.x, 192.0, 192.1, 194.3,198.3, 198.4, 199.0, 200.5, 225.x, 227.3, 237.0, 237.5, 237.6). To further isolate the study population, those who underwent cranioplasty (02.03-02.07), aneurysm clipping (39.51, 39.52), intervention for an arteriovenous malformation (39.53), stereotactic radiosurgery (92.3x), carotid artery stenting or endarterectomy (00.63, 38.12) were also excluded. Absence of discharge-level codes assumes that the disease or clinical event was not diagnosed during the hospitalization. The Institutional Review Board approval and informed consents were not necessary as this study is retrospective without intervention, there are no patient interactions, and identifiable personal health information was not used.

Outcomes

The aim of this study was to determine the influence of age on primary outcomes of interest: inpatient mortality, and poor outcome defined as in-hospital mortality, discharge to a nursing facility, extended-care facility or hospice, or placement of a tracheostomy tube and/or gastrostomy tube. Discharge to an acute hospital or rehabilitation facility was not included in this definition. Poor outcome has been previously defined in the aneurysmal subarachnoid hemorrhage (SAH) population as the NIS-SAH Outcome Measure[15] and has been used in ischemic stroke populations using NIS data.[10]

Secondary outcomes of interest included baseline characteristics by age group, hospital length-of-stay, rate of complications, placement of a ventricular shunt (02.3x), tracheostomy (31.1, 31.2x), and gastrostomy or jejunostomy tube placement (43.1x, 44.3x, 46.32). Total complications included neurologic (997.01, 997.09), cardiovascular (410.xx, 248.xx, 427.5, 785.xx, 453.x, 415.x), pulmonary (514.x, 518.xx, 512.x), renal (584.x), gastrointestinal (578.x, 5601, 008.45), hematologic (285.x and 998.1x), and infectious complications (595.0, 996.64, 481-486, 507.0, 997.31, 038.x, 995.9x, 320.x, 041.x, 324.1, 790.7, 999.31, and 998.59).

Statistical Analysis

All eligible patient records were used in the analysis to increase the power of the study. Demographic and sample characteristics were compared using χ^2 testing across age groups. Univariate Poisson regression with a generalized estimating equation (GEE) was used to estimate crude rates for primary and secondary outcomes of interest and unadjusted rate ratios (RR). Multivariate Poisson regression with GEE estimation was performed to derive adjusted RR with gender, length-of-stay, and Charlson comorbidity index as covariates. The GEE estimation considers data structure for patient nesting within hospitals and hospital sampling strata. The difference in age trend by coma and herniation status was analyzed using an interaction test in a multivariate model. Sampling weight was not used since it was not expected that the same proportion of patients was sampled from each hospital. All statistical testing was performed at a 2-sided 5% level of significance using Statistical Analysis Software version 9.4 (SAS Institute, Cary, NC). STROBE guidelines were implemented in the reporting of this observational study.

Results

After applying inclusion and exclusion criteria to the NIS data, 1144 patient cases were isolated. Those more than 70 years old represented the largest group (n = 331), while the smallest group was aged 61-70 (n = 232). Demographic and sample characteristics compared across age groups are shown in Table 1. Older populations were more often white, female and had more diagnosed comorbidities. Brain herniation was more commonly diagnosed in younger patients ($P < .01$). Coma tended to occur more frequently in groups aged 18-50 and 51-60 (P = .16). DHC performed beyond postadmission day 2 occurred most frequently in those aged 18-50, while surgery tended to be performed most on admission day for patients aged more than 70; however, this trend did not reach statistical significance (P = .26).

Crude rates of primary outcomes by age are shown in Figure 1. Unadjusted and adjusted RRs of both primary and secondary outcomes of interest are displayed in Table 2. In our cohort, poor outcome occurred in an estimated 86.4% with in-hospital death occurring in 28.9% (Fig 1). Among survivors, 75.6% were discharged to institutional care. In-patient mortality was similar between age groups (P = .57). Unadjusted and adjusted RRs for death were not different between ages in univariate and multivariate regression. The unadjusted RR of poor outcome was significantly higher in those aged 61-70 (1.08, 95% confidence interval [CI]: 1.01, 1.16, P = .03) and more than 70 (1.09, 95% CI: 1.02, 1.16, $P < .01$). After adjusting for gender, length-of-stay, and Charlson comorbidity index, the adjusted RR of poor outcome was not significantly different between groups. In those more than 70 years old, the unadjusted and adjusted RR for discharge to institutional care was significantly higher than other age groups (adjusted RR = 1.28, 95% CI: 1.03, 1.59, P = .02).

Total and neurological complication rate was similar between groups in both univariate and multivariate regression models. The adjusted RR of tracheostomy, gastrostomy or jejunostomy tube placement was significantly higher in patients aged 61-70 (1.4, 95% CI: 1.04.1.88, P = .03). The adjusted RR of renal complications was significantly lower in patients aged 61-70 (.55, 95% CI: .31, .96, P = .04).

Discussion

In this study of 1144 cases of DHC for nontraumatic ICH, age did not have a significant impact on short-term outcomes. In multivariate analysis, age did not independently predict in-patient mortality or poor outcome. Total complication rate was also similar between groups.

The study results are unexpected. Although age has been reported to predict outcomes in ICH,[16,17] especially in those more than 80 years old,[18-20] others have suggested a lesser prognostic value.[21,22] After large MCA stroke, age strongly predicts death and disability.[9-11,13] In a clinical trial of hemicraniectomy in stroke patients more than 60 years old, no subjects randomized to DHC achieved functional independence.[2] Given these findings, many physicians hesitate to offer surgery to families of elderly patients. Although we were unable to study long-term outcomes, our results do not provide evidence that age alone should be used to select candidates for DHC in the ICH population. We found younger patients were more frequently diagnosed with herniation. Additionally, those aged 18-50 were more commonly diagnosed with coma and receive DHC beyond postadmission day 3; however, these trends did not reach statistical significance. Increased herniation risk in younger patients may have counterbalanced any protective effect of lower age. In spontaneous ICH, herniation is associated with increased mortality[23]; however, in mixed populations of neurologic injury, it does not invariably result in poor outcome if reversed early.[24,25] The optimal timing of DHC in ICH is unknown; but, in malignant MCA stroke, outcomes worsen after 48 hours.[26,27] In our study, it is unclear

Table 1. *Demographic and estimated sample characteristics comparison across age groups for patients with spontaneous intracerebral hemorrhage who underwent decompressive hemicraniectomy*

	Total (n = 1144)	Aged 18-50 (n = 307)	Aged 51-60 (n = 274)	Aged 61-70 (n = 232)	Aged >70 (n = 331)	*P* value
Sex (%)						.02
Male	53	57	57	50	47	
Female	47	43	43	50	53	
Race (%)						<.01
White	47	35	42	47	63	
Missing	21	27	16	23	19	
Black	16	21	25	13	6	
Hispanic	9	11	11	9	6	
Other	7	6	6	8	6	
Comorbidities (%)						
CAD	13	6	10	18	20	<.01
CHF	9	6	7	8	13	<.01
COPD	16	10	14	19	22	<.01
Coagulopathy	9	13	10	5	8	.02
Diabetes	21	14	22	26	24	<.01
Hypertension	72	61	77	76	77	<.01
Obesity	10	12	15	6	6	<.01
CKD	9	10	12	6	6	.02
Charlson Comorbidity Index (%)						.4
≥0 and <1	56	57	51	59	55	
≥1 and <3	31	28	34	32	32	
≥3	13	15	15	9	13	
Neurologic Severity Indices (%)						
Coma	11	13	13	11	8	.16
Herniation	9	14	11	7	4	<.01
Timing of surgery (%)						.26
Admission day	48	43	52	46	51	
Post admission day 1-2	25	24	23	27	24	
Post admission day ≥ 3	11	14	11	11	8	
Missing	16	19	14	16	16	

Statistically significant values are given in bold (*P* value ≤ .05).
Abbreviations: CAD, coronary artery disease; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; CKD, chronic kidney disease.

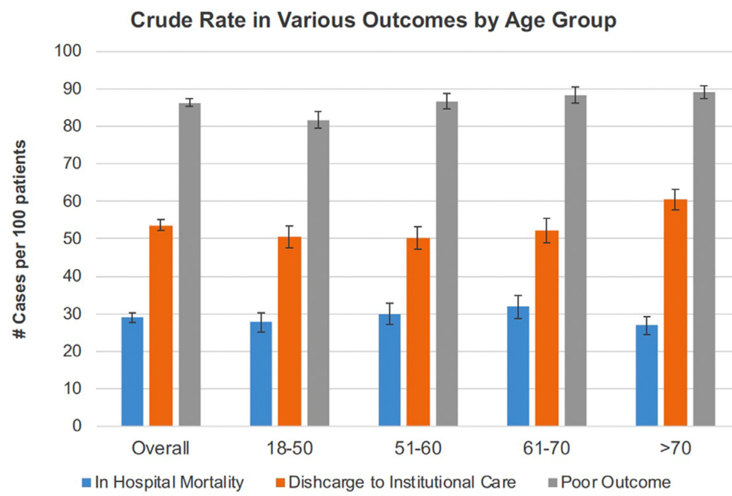

Figure 1. *Crude estimated rates of primary outcomes by age group for patients with spontaneous intracerebral hemorrhage who underwent decompressive hemicraniectomy. Crude rates are estimated using a generalized estimating equation when applied to Nationwide Inpatient Sample Data.*

if younger patients were more likely to herniate secondary to delayed surgery. Using the NIS data, we could not determine if herniation occurred before or after craniectomy.

Patient selection may have contributed to our results. Compared to older patients who did not undergo craniectomy, the surgically treated population was likely to be healthier. In contrast, providers may have been less selective in choosing DHC candidates in younger patients. As would be expected in a generalized population, we found that older patients represented the largest age groups and had significantly more pre-existing comorbidities when compared to younger groups. These findings suggest that although a selection bias may be present, clinicians performed DHC in elderly populations despite age and an increase in co-morbidities.

Estimated rates of neurologic and total complications were similar between age groups, with at least a single complication occurring in more than 70% in all groups. Given older patients had more comorbidities, this was unexpected. In the ICH literature, older age is associated with increased risk of venous thromboembolism,[28,29] while several medical complications affect all age groups and are associated with worse outcomes.[30-33] Following craniectomy for mixed neurologic injury, patients are at risk for postoperative systemic infections,[34] and neurologic complications associated with DHC and subsequent cranioplasty.[35] Evaluation of long-term complications was out of the scope of this study.

Based on our results, we did not find evidence to support that age alone should be used to select candidates for DHC. Given the absence of high-quality data from the literature, the true influence of age on outcomes in this population is unknown. To date, there are no well-designed clinical trials to guide practice, while prognostication after ICH remains difficult. Despite recent studies suggesting outcomes are better than predicted from the ICH Score,[35,36] clinician pessimism and level of medical support provided remain important prognostic variables. Hospital use of do-not-resuscitate (DNR) orders influences the likelihood of DNR in those with less severe injury,[37] while age, insurance status, and hospital volume also affect DNR and palliative care use.[38,39] Because older age is regarded as a poor prognostic factor, there is the potential that elderly patients are less likely to receive DHC for ICH, while those who do undergo craniectomy are unlikely to withdraw support afterwards.[40] Importantly, a systematic review of DHC after MCA stroke showed the majority of subjects were satisfied with their decision for surgery despite physical disabilities.[41] In our study, older patients were more likely to be discharged to institutional care, potentially due to social and economic reasons; however, this outcome may not negatively impact patient and family satisfaction. Further study is needed to understand patient factors that influence the decision to consent to DHC, and to better define "acceptable" outcomes in the ICH population.

This study has additional limitations. As a retrospective analysis, results demonstrate correlation and not causation between variables. Additionally, the estimates generated from NIS data are dependent on several factors, including coding practices and sampling methods. The NIS reflects discharge level records from heterogenous acute care hospitals; therefore, we were unable to control for confounding factors or measure long-term functional outcomes such as validated modified Rankin Scores. Patient characteristics that may significantly impact outcomes, including hematoma volume, hematoma location, and performance of hematoma evacuation in addition to DHC could not be captured with ICD-9-CM coding and limits the strength of this study. Lastly, we did not include the most recent 4-year period; however, clinical practice

Table 2. *Univariate and multivariate Poisson regression analysis evaluating the association of patient age and hospital outcomes*

	Age (years)	Crude rate (%)	Unadjusted RR (95% CI), *P* value	Adjusted RR (95% CI)*, *P* value
In hospital mortality	18-50	27.73	Ref.	Ref.
	51-60	30.01	1.08 (95% CI: .84, 1.4), *P*: .55	1.09 (95% CI: .81, 1.48), *P*: .56
	61-70	31.76	1.15 (95% CI: .88, 1.49), *P*: .31	1.19 (95% CI: .87, 1.62), *P*: .28
	>70	26.82	.97 (95% CI: .75, 1.25), *P*: .80	.91 (95% CI: .68, 1.23), *P*:.56
Total complication rate	18-50	76.03	Ref.	Ref.
	51-60	78.86	1.04 (95% CI: .96, 1.12), *P*: .38	1.08 (95% CI: .89, 1.3), *P*:.46
	61-70	75.67	1 (95% CI: .91, 1.09), *P*: .92	1.03 (95% CI: .84, 1.26), *P*: .81
	>70	72.87	.96 (95% CI: .88, 1.04), *P*: .32	.99 (95% CI: .82, 1.2), *P*: .91
Total neurological complications	18-50	1.83	Ref.	Ref.
	51-60	1.36	.74 (95% CI: .21, 2.61), *P*: .65	.8 (95% CI: .22, 2.91), *P*: .73
	61-70	.8	.44 (95% CI: .09, 2.14), *P*: .31	.52 (95% CI: .1, 2.65), *P*: .43
	>70	1.37	.75 (95% CI: .23, 2.44), *P*: .63	.97 (95% CI: .28, 3.33), *P*: .96
Cardiac complications	18-50	5.94	Ref.	Ref.
	51-60	8.06	1.36 (95% CI: .74, 2.47), *P*: .32	1.29 (95% CI: .7, 2.4), *P*: .41
	61-70	9.09	1.53 (95% CI: .83, 2.8), *P*: .17	1.58 (95% CI: .84, 2.95), *P*: .15
	>70	6.38	1.07 (95% CI: .58, 1.98), *P*: .82	1.13 (95% CI: .6, 2.13), *P*: .70
Pulmonary complications	18-50	57.31	Ref.	Ref.
	51-60	61.44	1.07 (95% CI: .94, 1.22), *P*: .29	1.13 (95% CI: .91, 1.41), *P*: .27
	61-70	55.69	.97 (95% CI: .84, 1.12), *P*: .69	1 (95% CI: .79, 1.27), *P*: 1
	>70	52.56	.92 (95% CI: .8, 1.05), *P*: .21	.94 (95% CI: .75, 1.18), *P*: .60
Renal complications	18-50	15.17	Ref.	Ref.
	51-60	10.97	.72 (95% CI: .47, 1.11), *P*: .14	.73 (95% CI: .46, 1.15), *P*: .18
	61-70	7.34	.48 (95% CI: .29, .82), ***P*: <.01**	.55 (95% CI: .31, .96), ***P*: .04**
	>70	7.87	.52 (95% CI: .33, .82), ***P*: <.01**	.63 (95% CI: .39, 1.03), *P*: .06
Gastrointestinal complications	18-50	9.43	Ref.	Ref.
	51-60	8.36	.89 (95% CI: .53, 1.49), *P*: .65	.94 (95% CI: .54, 1.63), *P*: .81
	61-70	5.99	.63 (95% CI .34, 1.17), *P*: .15	.74 (95% CI: .39, 1.42), *P*: .37
	>70	5.68	.6 (95% CI: .34, 1.05), *P*: .07	.74 (95% CI: .41, 1.34), *P*: .32
Infectious complications	18-50	47.18	Ref.	Ref.
	51-60	46.74	.99 (95% CI: .84, 1.17), *P*: .91	1.05 (95% CI: .81, 1.36), *P*: .71
	61-70	43.97	.93 (95% CI: .78, 1.11), *P*: .44	1 (95% CI: .76, 1.32), *P*: .99
	>70	42.44	.9 (95% CI: .76, 1.06), *P*: .21	.99 (95% CI: .77, 1.28), *P*: .95
Hematological complications	18-50	25.01	Ref.	Ref.
	51-60	21.06	.84 (95% CI: .62, 1.14), *P*: .26	.84 (95% CI: .6, 1.19), *P*: .32
	61-70	20.93	.84 (95% CI: .61, 1.15), *P*: .27	.87 (95% CI: .6, 1.24), *P*: .44
	>70	17.32	.69 (95% CI: .51, .94), ***P*: .02**	.72 (95% CI: .51, 1.02), *P*: .07

Table 2 (*Continued*)

	Age (years)	Crude rate (%)	Unadjusted RR (95% CI), *P* value	Adjusted RR (95% CI)*, *P* value
VTE	18-50	9	Ref.	Ref.
	51-60	7.2	.8 (95% CI: .46, 1.38), *P*: .43	.88 (95% CI: .49, 1.58), *P*: .67
	61-70	5.62	.62 (95% CI: .33, 1.18), *P*: .15	.65 (95% CI: .34, 1.27), *P*: .21
	>70	5.16	.57 (95% CI: .32, 1.03), *P*: .06	.62 (95% CI: .34, 1.15), *P*: .13
Tracheostomy or gastrostomy placement	18-50	31.6	Ref.	Ref.
	51-60	35.41	1.12 (95% CI: .89, 1.41), *P*: .33	1.28 (95% CI: .95, 1.71), *P*: .10
	61-70	37.49	1.19 (95% CI: .94, 1.5), *P*: .15	1.4 (95% CI: 1.04, 1.88), ***P*: .03**
	>70	33.52	1.06 (95% CI: .85, 1.33), *P*: .61	1.31 (95% CI: .99, 1.75), *P*: .06
VPS	18-50	26.03	Ref.	Ref.
	51-60	29.99	1.15 (95% CI: .89, 1.5), *P*: .29	1.29 (95% CI: .94, 1.77), *P*: .11
	61-70	27.65	1.06 (95% CI: .8, 1.41), *P*: .67	1.21 (95% CI: .86, 1.7), *P*: .27
	>70	18.79	.72 (95% CI: .54, .97), ***P*: .03**	.87 (95% CI: .61, 1.22), *P*: .41
Discharge to institutional care	18-50	50.51	Ref.	Ref.
	51-60	50.27	1 (95% CI: .85, 1.17), *P*: .95	1.03 (95% CI: .81, 1.29), *P*: .83
	61-70	52.18	1.03 (95% CI: .88, 1.22), *P*: .70	1.08 (95% CI: .85, 1.38), *P*: .52
	>70	60.46	1.2 (95% CI: 1.04, 1.38), ***P*: .01**	1.28 (95% CI: 1.03, 1.59), ***P*: .02**
Poor outcome	18-50	81.72	Ref.	Ref.
	51-60	86.63	1.06 (95% CI: .99, 1.14), *P*: .10	1.06 (95% CI: .89, 1.27), *P*: .53
	61-70	88.31	1.08 (95% CI: 1.01, 1.16), ***P*: .03**	1.09 (95% CI: .91, 1.32), *P*: .34
	>70	89.07	1.09 (95% CI: 1.02, 1.16), ***P*: <.01**	1.11 (95% CI: .94, 1.32), *P*: .21

Statistically significant values are given in bold (*P* value ≤ .05).

Abbreviations: RR, rate ratio, VPS, ventriculoperitoneal shunt; VTE, venous thromboembolism.

*Rate ratio adjusted for gender, hospital length-of-stay and Charlson comorbidity index.

has largely remained unchanged over this time. Despite these limitations, our study maintains generalizability to the larger ICH population, as a large nationwide data source was used.

Although this study does not provide definitive evidence of the true impact of age on outcomes in the ICH population undergoing DHC, it does highlight the absence of high-quality data in the literature on this topic. A priority should be made for randomized clinical trials comparing DHC to best medical therapy, as in the enrolling SWITCH trial.[42] Minimally invasive surgery for ICH, including research from the MISTIE group[43] and the enrolling ENRICH trial,[44] may demonstrate the benefit of this approach; however, DHC will likely remain a common emergent option as a life-saving measure. In this population, determining the influence of extreme age and timing of surgery (early versus delayed) on outcomes requires additional and urgent investigation.

Conclusions

Despite the lack of high-quality evidence, DHC for nontraumatic ICH is used as a life-saving measure. Our study results do not provide evidence that age independently predicts in-hospital mortality or poor outcomes. Factors that should be used to select candidates for craniectomy are still unknown. Further study is needed to explore the utility of both DHC and minimally invasive surgical approaches in the treatment of ICH and determine what effect age has on both clinical outcomes and measures of quality of life.

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