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Original Article

Functionally dependent status is an independent predictor for worse perioperative outcomes following craniotomy for aneurysmal subarachnoid hemorrhage

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ABSTRACT

Background: Aneurysmal subarachnoid hemorrhage (aSAH) is a medical emergency, and functional status is often a predictor of adverse outcomes perioperatively. Patients with different functional statuses may have different perioperative outcomes during surgery for aSAH. This study retrospectively examines the effect of functional status on specific perioperative outcomes in patients receiving craniotomy for aSAH.

Methods: Patients with aSAH who underwent neurosurgery were identified using International Classification of Diseases (ICD) codes (ICD10, I60; ICD9, 430) in the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database from 2005 to 2021. Subjects were stratified into two study groups: functionally dependent and functionally independent, based on their documented functional status on NSQIP. Significant preoperative differences were present between groups so a multivariable regression was performed between functionally dependent and independent patients. The 30-day perioperative outcomes of the two groups were compared. Perioperative outcomes included death, major adverse cardiovascular events (MACEs), cardiac complications, stroke, wound complications, renal complications, sepsis, clot formation, pulmonary complications, return to the operating room, operation time >4 h, length of stay longer than 7 days, discharge not to home, and bleeding.

Results: For aSAH patients receiving craniotomy repair, functionally dependent patients had significantly greater rates of MACE, cardiac complications, sepsis, pulmonary complications, and discharge not to home compared to functionally independent patients.

Conclusion: This study shows specific perioperative variables influenced by dependent functional status when treating aSAH through craniotomy, thus leading to a more complicated postoperative course. Additional research is needed to confirm these findings among the specific variables that we analyzed.

Keywords: Aneurysmal subarachnoid hemorrhage, Craniotomy, Dependent functional status, Independent functional status

INTRODUCTION

Subarachnoid hemorrhage (SAH) is characterized by the accumulation of blood in the subarachnoid space, located between the arachnoid and pia mater. The subarachnoid space is comprised of cerebrospinal fluid and blood vessels that may rupture in a hemorrhagic event. Although trauma is a common cause of SAH, non-traumatic SAH events mainly are a result of a ruptured aneurysm.[6,14] The vast majority of non-traumatic SAH are due to berry aneurysms, which is more commonly known as an aneurysmal SAH (aSAH).[13,16] Approaches to repair an aSAH include craniotomy and endovascular repair.[5] Surgeons decide which approach to use based on factors such as age, comorbidities, patient preference, aneurysm characteristics such as location and size, and the surgeon's prior experience. Specifically, surgeons may prefer endovascular repair techniques when the patient is older (over age 70), the aneurysm is located in the posterior circulation, and there is no space occupying the lesion. However, a craniotomy may be preferred in younger patients, patients with giant intracranial aneurysms, and in the presence of a space occupying hemorrhage.[11]

Functional status reflects one's health status as it refers to an individual's ability to fulfill daily activities and maintain well-being.[22] The American College of Surgeons national surgical quality improvement program (ACS-NSQIP) database determines the functional status of each patient in the 30 days before an operation such as neurosurgery for SAH.[19] Functional status classifications include functionally independent and dependent. Independent functional status (IFS) is defined as being able to perform all daily activities without help from another individual, whereas dependent functional status (DFS) requires at least some assistance from another individual to perform the same daily activities.[8,18]

An aSAH is a medical emergency that warrants urgent treatment, and therefore, it is important to seek medical care early.[21] The previous studies have shown that common issues after arriving at the hospital with aSAH consist of seizure, infection, prolonged intensive care unit (ICU) stay, rebleeding, hydrocephalus, and symptomatic cerebral vasospasm or delayed cerebral ischemia.[1,10] In addition, it is important to recognize certain patient populations at higher risk for adverse events following aSAH. For example, established risk factors for increased mortality from SAH include worse clinical grade at presentation, old age, and large aneurysm size.[10] DFS has been shown to be an independent risk factor in various other surgeries.[3,4] This study aimed to investigate how preoperative functional status impacts surgical outcomes for an emergency condition such as an aSAH, specifically looking at outcomes after a craniotomy. In this retrospective study, we analyzed potential postoperative complications after craniotomy for aSAH that may require additional monitoring in patients with different preoperative functional statuses. We first analyzed outcomes among patients undergoing all approaches to treating aSAH and then further analyzed outcomes among patients receiving craniotomy to treat aSAH.

MATERIALS AND METHODS

This retrospective study derived from ACS-NSQIP data does not require Institutional Review Board approval.

Data source

In this study, aSAH patients who underwent neurosurgery were identified using the international classification of diseases (ICD), $9^{th}/10^{th}$ Revision (ICD10, I60; ICD9, 430) in the ACS-NSQIP database from 2005 to 2021. In addition, patients who underwent craniotomy treatment by Current Procedural Terminology (CPT, 61697, 61700, 61698, 61702, 61703, 61705, 61312, and 61313) were identified in the ACS-NSQIP database from 2005 to 2021. Patients were grouped into either DFS or IFS based on their designation in ACS-NSQIP. Patients who were able to conduct all activities of daily living were classified as functionally independent, and those who could not be classified as functionally dependent.

ACS-NSQIP database, which includes over 400 sites nationwide, the database is used for quality control and monitors 30-day post-operative outcomes by the American College of Surgeons.

Preoperative variables

Preoperative variables included several types of patient demographics and comorbidities. Demographics included patient race, age older than 70 years old, smoking history in the past year, body mass index (BMI) >30 kg/m^2, and hospital admission status. Comorbidities included dyspnea, chronic obstructive pulmonary disease (COPD), congestive heart failure (CHF), hypertension, diabetes, acute kidney injury, dialysis, glomerular filtration rate <60 mL/min, preoperative infection, preoperative sepsis, disseminated cancer, usage of steroids, weight loss, bleeding disorders, serum albumin <3.4 g/L, white blood cell count >11,000 counts/mL, hematocrit <37%, platelet count <150,000 counts/mL, blood urea nitrogen >23 mg/dL, American Society of Anesthesiologists (ASA) Classification score of 4 or 5, and international normalized ratio >2. In addition, the aneurysm location was noted by CPT codes (carotid circulation: 61697, 61700; vertebrobasilar circulation: 61698, 61702).

Postoperative variables

Post aSAH-surgery outcomes included mortality, major adverse cardiovascular events (MACE), cardiac events, stroke, wound complications, renal complications, postoperative sepsis, clot formation, pulmonary events, return to the operating room (OR), operation time >4 h, length of stay longer than 7 days, discharge not to home, and postoperative bleeding. MACE refers to a combination of stroke, myocardial infarction, and cardiac arrest, which requires cardiopulmonary resuscitation. Wound complications in this study mean infections at the surgical site and wound dehiscence. Renal complications include progressive renal insufficiency (the National Surgical Quality Improvement Program [NSQIP] defines this as an increase in serum creatinine by >2 mg/dL relative to the preoperative value) and acute renal failure that requires renal replacement therapy. Pneumonia, unplanned reintubation, and mechanical ventilation for longer than 48 hours are what pulmonary events refer to. In addition, this study examined the same surgical outcomes in patients receiving craniotomy for aSAH.

Statistical analysis

Fisher's exact test was conducted to look for significant preoperative differences, and a multivariable regression was performed between COPD and non-COPD patients to account for the preoperative differences, and those with sufficient differences ($P < 0.1$) were included in the model. The 30-day postoperative outcomes between the two groups were then compared, and adjusted odds ratios (aOR) were determined. All statistical analyses were conducted using statistical analysis system (SAS) (version 9.4). All analyses were performed using SAS version 9.4. The authors had full access to all data and took responsibility for the integrity of the data analysis. The ACS NSQIP data were accessed from The George Washington University and all subsequent analyses were performed within the institute.

RESULTS

In this study, there were a total of 1925 aSAH patients who underwent neurosurgery for treatment and were stratified into 196 DFS patients and 1729 IFS patients. In the craniotomy subgroup, there were a total of 1546 patients, which were divided into 140 DFS and 1406 IFS patients. Significant preoperative differences were accounted for between the two groups, and the 30-day perioperative outcomes were compared to explore the role of functional status in the post-aSAH neurosurgery outcome.

Preoperative variables for patients receiving any neurosurgical intervention for aSAH are summarized in Table 1. Compared to IFS patients, DFS patients are more likely to have dyspnea (7.14% 1.64%, $P < 0.0001$), CHF (3.06% vs. 0.91%, $P = 0.0175$), hypertension (53.06% vs. 42.41%, $P = 0.0049$), infection (3.06% vs. 0.79%, $P = 0.0108$, preoperative bleeding disorder (9.69% vs. 4.25%, $P = 0.0022$), hematocrit <37% (50% vs. 41.05%, $P = 0.0179$), and ASA of 4 or 5 (67.35% vs. 56.74%, $P = 0.0047$).

Postoperative outcomes for patients receiving any neurosurgical intervention for aSAH are summarized in Table 2. Compared to IFS patients, DFS patients had increased risk of MACE (15.31% vs. 9.8%, aOR = 1.633, $P = 0.023$), cardiac events (6.63% vs. 2.98%, aOR = 2.075, $P = 0.025$), sepsis (21.94% vs. 9.91%, aOR = 2.51, $P < 0.0001$), pulmonary complications (55.61% vs. 36.81%, aOR = 1.87, $P = 0.0002$), and discharge not to home (77.11% vs. 58.09%, aOR = 2.253, $P = 0.004$).

Table 3 refers to the comparison of preoperative variables for IFS versus DFS patients receiving craniotomy for aSAH. Compared to IFS patients, DFS patients are more likely to have dyspnea (6.43% vs. 1.67%, $P < 0.0016$), CHF (3.57% vs. 0.76%, $P = 0.01$), hypertension (57.86% vs. 42.7%, $P = 0.0007$), infection (3.57% vs. 0.7%, $P = 0.0074$), preoperative bleeding disorder (9.29% vs. 3.76%, $P = 0.0063$), and ASA of 4 or 5 (71.43% vs. 57.51%, $P = 0.0016$). In addition, IFS patients are more likely to have their aneurysm located in the carotid circulation compared to DFS patients (75.24% vs. 59.29%, $P \leq 0.001$).

Table 4 refers to the comparison of postoperative variables for IFS versus DFS patients receiving craniotomy for aSAH. Compared to IFS patients, DFS patients had an increased risk of sepsis (9.39% vs 20.71%, aOR = 2.52, $P < 0.0001$), MACE (10.43% vs. 18.75%, aOR = 1.91, $P < 0.0067$), cardiac complications (8.57% vs. 2.85%, aOR = 2.79, $P = 0.0031$), pulmonary complications (55.57% vs. 35.88%, aOR = 1.58, $P = 0.0219$), and discharge not to home (76.56% vs. 55.76%, aOR = 2.48, $P = 0.0042$).

DISCUSSION

In our study, we compared 30-day postoperative outcomes for patients receiving craniotomy for an emergent condition (aSAH) between two groups, DFS and IFS patients. We observed higher rates of MACE, cardiac complications, sepsis, pulmonary complications, and discharge not to home among DFS patients compared to IFS patients after craniotomy. We did not see a difference in mortality and bleeding among DFS compared to IFS patients. One's functional status may be an important preoperative marker to determine outcomes, as this has been documented as an important preoperative marker for various other types of surgeries.[3,4] Therefore, it is important to analyze specific procedures and postoperative outcomes that this variable may influence.

The average percentage of people over age 60 is expected to increase dramatically over the upcoming decades.[9] As the current population ages, there will likely be more individuals with a DFS. The growing percentage of older people, and in turn, people who have a DFS, highlights the need to determine specific perioperative risks associated with one's functional dependency.

Previously, functional status has been documented to be a strong indicator of various post-operative complications

Table 1: Pre-neurosurgical demographics and characteristics of functionally independent and functionally dependent aSAH patients.

	Functionally independent (*n*=1,729) (%)	Functionally dependent (*n*=196) (%)	*P*-value
Asian	140 (7.93)	17 (8.67)	0.6781
African	280 (15.86)	24 (12.24)	0.2118
White	879 (49.77)	102 (52.04)	0.5983
Hispanic	251 (14.21)	21 (10.71)	0.1924
DM	153 (8.66)	21 (10.71)	0.353
Smoker	567 (32.11)	59 (30.1)	0.6281
Dyspnea	29 (1.64)	14 (7.14)	<.0001
COPD	59 (3.34)	7 (3.57)	0.8342
CHF	16 (0.91)	6 (3.06)	0.0175
Hypertension	749 (42.41)	104 (53.06)	0.0049
AKI	6 (0.34)	1 (0.51)	0.5219
Dialysis	11 (0.62)	3 (1.53)	0.1574
History of sepsis	510 (28.88)	59 (30.1)	0.7401
Cancer	9 (0.51)	2 (1.02)	0.3022
Infection	14 (0.79)	6 (3.06)	0.0108
Steroid use	38 (2.15)	4 (2.04)	1
Weight loss	9 (0.51)	1 (0.51)	1
Bleeding disorders	75 (4.25)	19 (9.69)	0.0022
Age >70 years	227 (12.85)	26 (13.27)	0.8231
BMI >30	539 (30.52)	59 (30.1)	0.935
eGFR <60 mL/min	134 (7.59)	16 (8.16)	0.7766
Serum albumin <34 g/L	245 (13.87)	29 (14.8)	0.7444
White blood cell >11,000 counts/mL	922 (52.21)	110 (56.12)	0.3271
Hematocrit <37%	725 (41.05)	98 (50)	0.0179
Platelet <150,000 counts/mL	125 (7.08)	18 (9.18)	0.3089
Blood urea nitrogen >23 mg/dL	132 (7.47)	22 (11.22)	0.069
ASA score of 4 or 5	1002 (56.74)	132 (67.35)	0.0047
Inpatient	1760 (99.66)	195 (99.49)	0.5219
Outpatient	6 (0.34)	1 (0.51)	0.5219
INR >2	122 (6.91)	15 (7.65)	0.6586

AKI: Acute kidney injury, ASA: American society of anesthesiology, aSAH: Aneurysmal subarachnoid hemorrhage, BMI: Body mass index, CHF: Congestive heart failure, COPD: Chronic obstructive pulmonary disease, DM: Diabetes mellitus, eGFR: Glomerular filtration rate, INR: International normalized ratio

Table 2: Comparison of 30-day post-aSAH neurosurgical outcomes between aSAH patients with IFS and DFS in multivariable regression.

	IFS (*n*=1,729) (%)	DFS (*n*=196) (%)	aOR for DFS/IFS with 95% CI	*P*-value
Mortality	251 (14.21)	46 (23.47)	0.594 (0.267–1.32)	0.2012
MACE	173 (9.8)	30 (15.31)	1.633 (1.069–2.496)	0.0234
Cardiac events	51 (2.89)	13 (6.63)	2.075 (1.097–3.927)	0.0248
Stroke	128 (7.25)	18 (9.18)	1.316 (0.781–2.218)	0.3025
Wound complication	43 (2.43)	5 (2.55)	1.029 (0.402–2.632)	0.9522
Renal complication	18 (1.02)	3 (1.53)	1.506 (0.428–5.297)	0.5234
Sepsis	175 (9.91)	43 (21.94)	2.51 (1.705–3.695)	<.0001
Clot formation	105 (5.95)	18 (9.18)	1.477 (0.866–2.518)	0.1523
Pulmonary events	650 (36.81)	109 (55.61)	1.87 (1.349–2.593)	0.0002
Return to OR	354 (20.05)	49 (25)	1.287 (0.909–1.823)	0.1556
Operation time>4 h	811 (45.92)	81 (41.33)	0.89 (0.655–1.21)	0.458
Length of stay>7 days	1439 (81.48)	158 (80.61)	0.986 (0.671–1.45)	0.9425
Discharge not to home	898 (58.09)	64 (77.11)	2.253 (1.3–3.902)	0.0038
Bleeding	274 (15.52)	32 (16.33)	0.895 (0.589–1.36)	0.6049

aOR: Adjusted odds ratio, aSAH: Aneurysmal subarachnoid hemorrhage, MACE: Major adverse cardiovascular events, OR: Operating room, IFS: Independent functional status, DFS: Dependent functional status, CI: Confidence interval

Table 3: Presurgical demographics and characteristics of functionally independent and functionally dependent aSAH patients who underwent craniotomy repair.

	Functionally independent (*n*=1,406) (%)	Functionally dependent (*n*=140) (%)	*P*-value
Asian	112 (7.79)	13 (9.29)	0.5123
African	232 (16.13)	19 (13.57)	0.4699
White	689 (47.91)	70 (50)	0.6584
Hispanic	206 (14.33)	14 (10)	0.2001
DM	119 (8.28)	17 (12.14)	0.1532
Smoker	476 (33.1)	46 (32.86)	1
Dyspnea	24 (1.67)	9 (6.43)	0.0016
COPD	54 (3.76)	6 (4.29)	0.648
CHF	11 (0.76)	5 (3.57)	0.01
Hypertension	614 (42.7)	81 (57.86)	0.0007
AKI	5 (0.35)	1 (0.71)	0.4279
Dialysis	8 (0.56)	2 (1.43)	0.2203
History of Sepsis	407 (28.3)	39 (27.86)	1
Cancer	7 (0.49)	1 (0.71)	0.5253
Infection	10 (0.7)	5 (3.57)	0.0074
Steroid use	31 (2.16)	3 (2.14)	1
Weight loss	7 (0.49)	1 (0.71)	0.5253
Bleeding disorders	54 (3.76)	13 (9.29)	0.0063
Age>70 years	181 (12.59)	20 (14.29)	0.5947
BMI>30	437 (30.39)	38 (27.14)	0.4421
eGFR<60 mL/min	107 (7.44)	15 (10.71)	0.1827
Serum albumin <34 g/L	192 (13.35)	19 (13.57)	0.897
White blood cell >11,000 counts/mL	759 (52.78)	77 (55)	0.6577
Hematocrit <37%	587 (40.82)	67 (47.86)	0.1263
Platelet <150,000 counts/mL	98 (6.82)	14 (10)	0.167
Blood urea nitrogen >23 mg/dL	101 (7.02)	16 (11.43)	0.0633
ASA score of 4 or 5	827 (57.51)	100 (71.43)	0.0016
Inpatient	1436 (99.86)	140 (100)	1
Outpatient	2 (0.14)	0 (0)	1
INR >2	78 (5.42)	10 (7.14)	0.4372
Location of aneurysm			
Carotid circulation	1082 (75.24)	83 (59.29)	<0.0001
Vertebrobasilar circulation	164 (11.4)	11 (7.86)	0.2582
Unknown/unrecorded locations	254 (17.66)	49 (35)	<0.0001

AKI: Acute kidney injury, ASA: American society of anesthesiology, aSAH: Aneurysmal subarachnoid hemorrhage, BMI: Body mass index, CHF: Congestive heart failure, COPD: Chronic obstructive pulmonary disease, DM: Diabetes mellitus, eGFR: Estimated glomerular filtration rate, INR: International normalized ratio

in procedures related to the vasculature, such as endovascular repair of abdominal aortic aneurysms and carotid stenting.[8,23] It has been hypothesized for vascular and neurological surgery that DFS patients have a lower threshold of stress their bodies can handle, potentially due to lower fitness, and therefore, even after adjusting for comorbidities, postoperative outcomes are worse for this group.[4,8] In addition, DFS patients may be more likely to be frail,[4] which is defined as "multisystem dysregulation yielding decreased physiological reserves and increased vulnerability to stressors" in geriatric literature.[7] Frail patients are more likely to have limited independence, and it has been documented that frail patients are at an increased risk of falls, fractures, disabilities, infection, death, and increased length of stay compared to non-frail patients following surgical procedures.[4,12] These factors may account for why DFS patients have worse outcomes after craniotomy for aSAH compared to IFS patients for some of the variables that we analyzed (sepsis, MACE, cardiac complications, and pulmonary complications).

In 2017, De La Garza Ramos *et al*. demonstrated that after adult spinal deformity surgery, DFS patients are at an increased risk of stroke and myocardial infarction compared to IFS patients.[4] This adds to a growing body of literature that shows an increased risk of stroke and cardiac-related events for DFS patients undergoing various procedures compared to IFS patients. For example, Albright *et al.*

Table 4: Comparison of 30-day post-aSAH surgical outcomes between aSAH patients with IFS and DFS who underwent craniotomy repair in multivariable regression.

	IFS (*n*=1,406) (%)	DFS (*n*=140) (%)	aOR for DFS/IFS with 95% CI	*P*-value
Mortality	192 (13.35)	32 (22.86)	0.48 (0.196–1.19)	0.1138
MACE	150 (10.43)	26 (18.57)	1.91 (1.196–3.04)	0.0067
Cardiac complications	41 (2.85)	12 (8.57)	2.79 (1.42–5.51)	0.0031
Stroke	113 (7.86)	15 (10.71)	1.51 (0.84–2.70)	0.1649
Wound complication	34 (2.36)	3 (2.14)	0.94 (0.282–3.10)	0.9123
Renal complication	16 (1.11)	2 (1.43)	0.98 (0.21–4.62)	0.9788
Sepsis	135 (9.39)	29 (20.71)	2.52 (1.59–3.99)	<.0001
Clot formation	84 (5.84)	14 (10)	1.61 (0.88–2.95)	0.1221
Pulmonary complications	516 (35.88)	75 (53.57)	1.58 (1.07–2.33)	0.0219
Return to OR	284 (19.75)	35 (25)	1.26 (0.83–1.90)	0.2736
Operation time >4 h	685 (47.64)	65 (46.43)	1.2 (0.82–1.75)	0.3417
Length of stay >7 days	1192 (82.89)	115 (82.14)	1.26 (0.78–2.05)	0.3488
Discharge not to home	707 (55.76)	49 (76.56)	2.48 (1.33–4.61)	0.0042
Bleeding	228 (15.86)	23 (16.43)	0.90 (0.55–1.48)	0.6799

aOR: Adjusted odds ratio, aSAH: Aneurysmal subarachnoid hemorrhage, MACE: Major adverse cardiovascular events, OR: Operating room, IFS: Independent functional status, DFS: Dependent functional status, CI: Confidence interval

demonstrated an increased risk of myocardial infarction for DFS patients after a ventral hernia repair [2], and Mounsey *et al*. found an increased risk of cardiac arrest and stroke after thyroidectomy among DFS patients compared to IFS patients.[15] These observations are in accordance with our results of increased risk of MACE and cardiac complications among DFS patients compared to IFS patients when analyzing craniotomy to treat aSAH. This enables us to expand on these findings to relate them to surgery for NSAH. In addition, Sastry *et al*. observed that frail patients were more likely to be discharged to a destination other than the patient's home after a craniotomy for a brain tumor compared to non-frail patients.[17] Since frailty is closely related to functional status, this is in agreement with our observation that DFS patients are more likely to be discharged to a destination other than home compared to IFS patients after receiving a surgical procedure for aSAH. We hypothesize that this may be due to functionally dependent status patients often residing outside the home given their dependence on others and, therefore, may be discharged to a caretaker's residence or an assisted living facility. Further research is needed to confirm this.

A possible reason for our observation of no difference in mortality or bleeding is that functional status may impact this variable beyond the 30-day period that we analyzed. In addition, mortality and bleeding in aSAH patients are often due to early re-rupture, but by the time a patient gets a craniotomy, their blood pressure has been controlled in the ICU. Therefore, mortality differences may not be seen as aSAH patients who make it to a craniotomy have controlled blood pressure. In addition, our sample size among craniotomy aSAH patients may not be large enough to detect differences in these variables that may be present. Furthermore, it is possible that due to the selectivity requirements to receive craniotomy, patients receiving this may have unique characteristics different from the general IFS or DFS population that would eliminate any differences in outcomes. Although not precisely the same as functional status, previous literature has demonstrated increased mortality among more frail patients receiving brain tumor resections.[20] More research is needed to determine if our finding is unique to craniotomy for aSAH, if there is no difference in mortality, or if this observation is a result of the limitations of NSQIP.

We additionally observed that DFS patients are less likely than IFS patients to have their aneurysm located in the carotid circulation before craniotomy. DFS patients are more likely to have comorbidities that make a surgeon prefer endovascular approaches versus craniotomy. In addition, surgeons may be more inclined to do an endovascular approach if the aneurysm is located in the posterior circulation, which is not mainly supplied by the carotid arteries.[11] Therefore, a surgeon may be more likely to conduct a craniotomy on an aneurysm in the carotid circulation if a patient is not a DFS patient, given the accompanying comorbidities, and we hypothesize that this may be why we see higher rates of aneurysm location in the carotid circulation in IFS patients versus DFS patients before craniotomy. More research is needed to determine the exact reason for this difference.

Multiple important limitations are present in this retrospective study. First, there is the possibility of unknown or uncontrolled bias. In addition, relevant aSAH variables such as the clinical grade, the Hunt and Hess Scale, the World Federation of Neurological Surgeons scale, the Glasgow outcome scale, the modified Rankin scale, and the size of the aneurysm are not recorded in the NSQIP database. Another variable, endovascular coiling, is not recorded in the NSQIP database. Analyzing postoperative differences in outcomes using endovascular coiling compared to craniotomy could not be accomplished as a result. Furthermore, due to the nature of the NSQIP database exclusively tracking 30-day postoperative outcomes, and not further, outcomes that occur beyond this period following the neurosurgery for aSAH could not be examined.

We adjusted that the data were multiple preoperative variables; however, unrecorded confounding variables may still be present. Additional variables that may have an impact but are not recorded in the NSQIP database are differences in hospital resources, volume, physician experience, and socioeconomic variables (for example, hospital type). In addition, NSQIP does not record if patients were living at home preoperatively, and this may account for differences between DFS and IFS patients in their rates of discharge, not at home. Furthermore, there may be selection bias in NSQIP-participating hospitals. Due to this potential selection bias in NSQIP participating sites, it is possible that this database does not accurately represent the American aSAH population. Postoperatively, other aSAH adverse outcomes may exist that were not recorded in NSQIP and, thus, were not analyzed. Examples include cerebral vasospasm, hydrocephalus, and delayed cerebral ischemia. Furthermore, it is possible that even given the large sample size NSQIP provides, differences in the outcomes analyzed would be detected only if examining larger sample sizes.

Even given the above limitations, this retrospective study establishes a framework for examining the impact of a single variable, functional status, on craniotomy outcomes for aSAH and NSQIP, which has the advantage of having large patient sizes which are unmatched by most institutional datasets. Future investigation is needed using data that can account for the missing preoperative and postoperative variables when comparing post-aSAH surgical outcomes. In addition, future research is needed that examines outcomes beyond the 30-day post-neurosurgery period.

CONCLUSION

In summary, in this study, we observed that dependent functional status significantly increases the risk of MACE, cardiac complications, sepsis, pulmonary complications, and discharge not to home compared to functionally independent patients. Mortality and bleeding risk following craniotomy for aSAH were not significantly different between these groups. We analyzed two different groups of patients with aSAH, DFS, and IFS patients and compared their postoperative outcomes after surgery for aSAH. Our analyses aimed to provide healthcare providers with insights into the risks associated with DFS in patients undergoing surgery for aSAH and plan for corresponding management.

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Ethical approval

The Institutional Review Board approval is not required, as it is a retrospective study derived from ACS-NSQIP data.

Declaration of patient consent

Patient’s consent was not required as there are no patients in this study.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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