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Predictors of hospital length of stay and long-term care facility placement in aneurysmal subarachnoid hemorrhage

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ABSTRACT

Background: Aneurysmal subarachnoid hemorrhage (aSAH) is frequently associated with complications, extended hospital length of stay (LOS) and high health care related costs. We sought to determine predictors for hospital LOS and discharge disposition to a long-term care facility (LTCF) in aSAH patients.
Methods: We performed a retrospective study of a prospectively collected cohort of consecutive patients with aSAH admitted to an academic referral center from 2016 to 2021. Multiple linear regression was performed to identify predictors for hospital LOS. We then created a 10-point scoring system to predict discharge disposition to a LTCF.
Results: In a cohort of 318 patients with confirmed aSAH, mean age was 57 years (SD 13.7), 61% were female and 70% were white. Hospital LOS was longer for survivors (median 19 days, IQR 14–25) than for non-survivors (median 5 days, IQR 2–8; $p < 0.001$). Main predictors for longer LOS for this cohort were ventriculoperitoneal shunt (VPS) requirement ($p < 0.001$), delayed cerebral ischemia ($p = 0.026$), and pneumonia ($p = 0.014$). The strongest predictor for LTCF disposition was age older than 60 years (OR 1.14, 95% CI 1.07–1.21; $p < 0.001$). LTCF score had high accuracy in predicting discharge disposition to a LTCF (area under the curve [AUC] 0.83; 95% CI 0.75–0.91). Forty-one percent of patients who were discharged to a LTCF had significant functional recovery at 3 months post-discharge.
Conclusions: VPS requirement and aSAH related complications were associated with longer hospital LOS compared to other factors. LTCF score has high accuracy in predicting discharge disposition to a LTCF.

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1. Introduction

Aneurysmal Subarachnoid Hemorrhage (aSAH) is frequently associated with a high rate of complications and extended hospital length of stay (LOS).[1,2] This extended LOS is at a tremendous cost to both the hospital and the patient.[3,4] For certain patients, an extended LOS may not be necessary for adequate recovery, and instead puts the patient at increased risk for iatrogenic infection and other hospital-related complications, which lead to worsened functional outcomes.[5–8] We aimed to identify predictors for hospital LOS that would allow accurate prediction of required LOS for aSAH patients, optimize utilization of resources and potentially mitigate factors that would prolong LOS. The ultimate goal for this study is to develop a risk stratification model, similar to what has been described in other diseases in patients admitted with aSAH to predict who require placement in a long-term care facility (LTCF) after hospital discharge.[9,10] We hypothesized that aSAH-related complications would have the most direct impact on hospital LOS and can be used to construct a predictive model for LTCF placement, while the other variables including aSAH characteristics present on hospital

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admission would vary in influence.

2. Methods

2.1. Study sample and design

We retrospectively reviewed a prospectively collected cohort of consecutive patients with confirmed SAH with aneurysmal cause identified by digital subtraction angiography who were admitted to a single academic referral center from 2016 until 2021. We only included patients with confirmed aneurysmal etiology. We excluded patients who died or their care was transitioned to comfort measures only and they were withdrawn from life-sustaining activities within first day of hospital admission. Data on demographics, hospital course, clinical and radiographic features, and laboratory values were collected prospectively and compiled in a RedCap database (Vanderbilt University, Nashville, TN)[11] as part of an institutional quality improvement project. Institutional review board approval was obtained. Informed consent was waived, owing to the retrospective nature of the study. This study is compliant with Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines. Anonymized data can be made available by request from any qualified investigator.

2.2. Clinical management

As a Comprehensive Stroke Center, clinical management of patients with aSAH is primarily driven by the latest recommendations of American Heart Association and Neurocritical Care Society Consensus.[12,13] Per our institutional protocol, all patients with aSAH are admitted to a dedicated neurocritical care unit for close monitoring. Endovascular treatment modalities are predominantly utilized to secure ruptured aneurysms and are mostly performed within first 24 h of ictus. Surgical clipping is typically used when endovascular options are not feasibly given anatomical location and morphology of the culprit aneurysm. In addition, open surgery is also used for hematoma evacuation when a clinically significant mass effect is present. All patients including those with high Hunt and Hess grades and poor neurological examination on presentation are offered aggressive treatment measures unless patients' health care surrogates decide otherwise.

At our center, symptomatic hydrocephalus in aSAH is treated with external ventricular drain (EVD) placement. For EVD weaning, we use gradual or stepwise approach, meaning EVDs are raised by 5 mm Hg per day until they reach 20 mm Hg. If patients remain stable with no signs of hydrocephalus, then EVDs are clamped after being raised to 20 mm Hg. EVDs are required to be closed for 24 h prior to removal to ensure clinical and radiographic stability, and patients who undergo ventriculoperitoneal shunt (VPS) placement have failed at least 2 EVD weaning trials. The decision to clamp an EVD is based on resolution of symptomatic hydrocephalus and the clinical and radiographic assessment of the treating team comprised of neurocritical care and neurosurgery attending physicians.

2.3. Measurements and outcomes

We defined hospital LOS (per days) as the primary outcome for this study as the number of days from the time of hospital admission until discharge from the hospital to home or next facility for survivors and the day of death for non-survivors. Functional outcome was defined based on modified Rankin Scale (mRS) at 3 months after hospital discharge. Patients were dichotomized into the two groups: 0–3 was considered a favorable outcome and 4–6 was considered a poor outcome. Early neurological improvement (ENI) and deterioration (END) were defined as any decrease or increase in Hunt and Hess Grade within first 3 days of hospital admission. Hunt and Hess and modified Fischer scores were assessed by board certified attending neurointensivists, while mRS was judged based on notes written by certified health care providers, including physical therapists and rehabilitation physicians. The predictor variables include demographics, clinical and radiographic features, and laboratory data present on admission and also hospital complications.

Delayed cerebral ischemia (DCI) was defined as 1) any clinical deterioration (such as focal neurologic deficit or impairment in level of consciousness) due to suspected vasospasm or microvascular insufficiency requiring interventions such as blood pressure augmentation therapy using vasopressors with or without endovascular treatment; or 2) presence of cerebral infarct or ischemia on neuroimaging not related to aneurysm treatment or increased intracranial pressure. Coagulopathy was defined as abnormal elevation in any coagulation laboratory tests including international normalization ratio, prothrombin time, partial thromboplastin time, or any abnormal values for serum levels of activated factor Xa.

Next, we defined prolonged hospital LOS as any value longer than median LOS of patients in the study cohort. For discharge disposition, we considered skilled nursing facilities (SNF) and long-term acute care hospitals (LTACH) as LTCF.

2.4. Statistical analysis

Descriptive data following a normal distribution was reported as mean and standard deviation (SD). For non-normal distributions, we reported our data as median and interquartile range (IQR). We considered age and LOS as continuous variables and sex, race, aneurysm location and its mode of treatment, ENI, END, high clinical grade defined as Hunt and Hess grade of 4 or 5 and each hospital complication as categorical variables. The laboratory data on first day of hospital admission including serum sodium, troponin, creatinine, hemoglobin, white blood cell (WBC) count, and basic coagulation profile such as INR, PT, APTT were all considered as continuous variables. We used multiple linear regression analysis to test the association of each predictor and LOS. Mean variance inflation factor was measured to ensure lack of collinearities among variables.

Multivariate logistic regression analysis was used to identify predictors of discharge disposition to a LTCF. Receive Operating Characteristic (ROC) curve analysis was subsequently performed and Area Under the Curve (AUC) was measured to compare predictive accuracy of the variables present on admission or early hospital course for placement in a LTCF. All analyses were performed using STATA/MP 15 (College Station, TX) and $p < 0.05$ was used to determine statistical significance.

3. Results

3.1. Cohort demographics

We reviewed 336 patients with confirmed diagnosis of aSAH and included 318 in our final analysis. We excluded 18 patients who could not undergo endovascular or surgical treatment for their ruptured aneurysms as they either died or their care was transitioned to comfort measures only and they were withdrawn from life-sustaining activities within first day of hospital admission (4 patients had cardiac arrest, 2 were declared brain dead and the level of care was transitioned to withdrawal of life-sustaining activities in 12 patients based on their prior wishes, comorbidities and their poor neurological conditions). Mean age was 57.1 years (SD 13.6), 62% (208) were female and 70% (235) were white. LOS was longer for survivors (median 19 days, IQR 14–25) than for non-survivors (median 5 days, IQR 2–8; $p < 0.001$). The mean, median and IQR of LOS for the study cohort were 18 and 16 days (IQR 9–23) respectively. Therefore, we chose LOS longer than 16 days as cut off to define prolonged LOS. The LOS was longer in patients with Hunt and Hess grades 1–3 (mean 19.4, median 16.5 days [IQR 12–23]) compared to those with Hunt and Hess grades 4–5 (mean 14.8, median 11 days [IQR 3–22]; $p < 0.001$). However, for survivors the LOS was shorter in patients with Hunt and Hess grades 1–3 (mean 20.2, median 17 days [IQR 13–24]) compared to those with Hunt and Hess grades 4–5 (mean 28.7, median 25 days [IQR 19–35], $p < 0.001$). Patients' characteristics including laboratory values on admission, hospital complications and functional outcome were compared in patients with prolonged LOS and those who required shorter LOS (Table 1).

3.2. Aneurysm treatment modalities

Endovascular treatment modalities were used in 289 patients (91%) and surgical clipping was used in 29 patients (9%). Multiple linear regression analysis revealed that there neither endovascular treatment options (beta coefficient −3.2 [95% CI -11.6, 5.14]; $p = 0.44$) nor surgical clipping (beta coefficient 0.82 [95% CI -2.1, 3.73]; $p = 0.53$) affected LOS after adjustment with other covariates (Fig. 1). However, surgical clipping options (16% vs 3%, $p < 0.001$) but not endovascular therapies (84% vs 87%, $p = 0.53$) were more common in patients with LOS greater than 16 days (median LOS of the study cohort) (Table 1)

Table 1
Basic characteristics, laboratory values on hospital admission, complications during hospital course and functional outcome at 3 months after discharge are compared between two groups dichotomized based on hospital length of stay (LOS).

Variable	LOS ≤16 days (*n* = 161)	LOS >16 days (*n* = 157)	*p* value
Age, mean (SD)	58.1 (13.9)	56.2 (13.2)	0.21
Female n (%)	100 (56)	99 (63)	0.29
Baseline modified Rankin Scale, median (IQR)	0 (0–1)	0 (0–1)	1
Hunt and Hess Grade, n (%)			<0.001
1–2	76 (47)	30 (19)	
3	36 (22)	81 (51)	
4	18 (11)	31 (20)	
5	31 (20)	15 (10)	
Modified Fisher Score, n (%)			<0.001
1	40 (25)	8 (5)	
2	14 (9)	14 (9)	
3	51 (32)	38 (24)	
4	54 (34)	96 (61)	
Hydrocephalus requiring EVD Placement, n (%)	95 (59)	146 (93)	<0.001
Early Neurological Deterioration, n (%)	44 (25)	45 (29)	0.01
Early Neurological Improvement, n (%)	25 (14)	12 (7)	0.42
Aneurysm mode of treatment			
Endovascular treatments, n (%)	156 (97)	133 (84)	0.52
Surgical clipping, n (%)	5 (3)	24 (16)	<0.001
Laboratory values on admission			
Serum troponin (ng/ml), mean (SD)	0.12 (1.49)	0.46 (2.4)	0.21
WBC (x10^9 cells/L), mean (SD)	12.3 (4.8)	13.6 (6.1)	0.07
Hemoglobin (g/dl), mean (SD)	15.1 (2.8)	13.9 (1.8)	0.06
Coagulopathy, n (%)	25 (14)	25 (16)	0.65
Serum sodium (mEq/L), mean (SD)	136 (3.8)	137 (4.5)	0.81
Serum creatinine (mg/dl), mean (SD)	0.77 (0.23)	0.81 (0.46)	0.32
Complications n,(%)			
DCI	32 (18)	86 (55)	<0.001
Cerebral Edema	51 (8)	87 (36)	<0.001
Endotracheal Intubation, n (%)	136 (76)	149 (94)	0.011
Reintubation, n (%)	7 (4)	33 (19)	<0.001
Pneumonia	19 (10)	52 (33)	<0.001
Acute kidney injury	2 (1)	8 (5)	0.03
Seizure	2 (1)	13 (8)	0.002
New intracranial hemorrhage	21 (12)	8 (5)	0.03
Ventriculoperitoneal shunt placement	0 (0)	35 (22)	<0.001
Poor functional outcome at 3 months after discharge	54 (34)	51 (32)	0.84

3.3. In-hospital complications

Main predictors for longer LOS for this cohort were VPS requirement (12.7 additional days, 95% CI 6,19.2; $p < 0.001$), EVD placement on admission (6.9 additional days, 95% CI 3.3,10.7; $p < 0.001$), DCI (3.1 additional days, 95% CI 0.36, 5.73; $p = 0.026$), and pneumonia (4.8 additional days, 95% CI 0.99, 8.6; $p = 0.014$). Other factors including admission related variables or any laboratory data did not independently predict any meaningful change in hospital LOS (Table 2). For post estimation analysis, we calculated mean variance inflation factor for this linear regression model and it was 1.46. This indicates low risk for multicollinearity (mean variance inflation <4) in our model.

We identified 93 patients in our study cohort who required EVD placement at the time of admission, of whom 35 patients (10% of the study cohort) received VPS for unresolved symptomatic hydrocephalus. Hospital LOS was longer in patients who received VPS compared to those who did not (median 36 days [IQR 25–42] vs 18 days [10–23; $p < 0.001$).

3.4. Discharge dispositions and predictors of placement in a LTCF

A total of 126 patients (37%) were discharged home with favorable outcomes, 58 patients (17% of included patients) were discharged to an acute rehabilitation facility and 64 patients (19%) required placement in a LTCF with mRS of 4 or 5 at discharge and 82 patients (24%) either died or were discharged to hospice. Of patients who required placement in a LTCF, 41% (26 patients) had significant improvement in their functional outcomes (mRS≤3) at 3 months after hospital discharge.

Age older than 60 years old (OR 4.9, 95% CI 2.67–9.1; $p < 0.001$), Hunt and Hess grade 3 (OR 1.3, 95% CI 1.1–2.4; $p < 0.001$), END (OR 3.3, 95% CI 1.26–8.7; $p < 0.001$) and modified Fisher scores of 3 or 4 (OR 1.42, 95% CI 1.14–2.0; $p = 0.004$) were associated with placement in a LTCF on univariate analyses. However, only age >60 years (OR 1.14, 95% CI 1.07–1.21; $p < 0.001$) remained significant after adjustment with other variables on a multivariate logistic regression model (Table 2).

We subsequently constructed a 10-point scoring system (LTCF score) to predict discharge disposition to a LTCF based on odds ratios of significant variables from the univariate analysis. Variables with higher odds ratios were weighted more heavily in this risk stratification scoring system (5 points for age>60 years old, 3 points for presence of END, one point for Hunt and Hess grade 3 and one point for modified Fisher score of 3 or 4) (Table 3). The LTCF score was greater in patients who were discharged to a LTCF compared to those who were not. (OR 1.24 per each point increase, 95% CI 1.1–1.4; $p < 0.001$) (Fig. 2). ROC curve analysis revealed that LTCF score had higher accuracy (AUC 0.83, 95% CI 0.75–0.91) in predicting LTCF placement after hospital discharge compared to other factors which were present on admission or early hospital course (Fig. 3).

3.5. aSAH related factors present on admission

Among a wide range of aSAH related factors present on admission and laboratory values from the emergency department (Table 2), only hydrocephalus with EVD requirement (6.9 additional days, 95% CI 3.3–10.7; $p < 0.001$) (Fig. 2) was independently associated with longer hospital LOS. However, aneurysm treatment modality was not an independent predictor of hospital LOS.

3.6. In-hospital complications

Among hospital and aSAH related complications, VPS requirement (12.7 additional days, 95% CI 6–19.2; $p < 0.001$), pneumonia (4.8 additional days, 95% CI 0.99–8.6; $p = 0.014$), and DCI (3.1 additional days, 95% CI 0.36–5.7; $p = 0.026$) were independently associated with longer hospital LOS (Table 2).

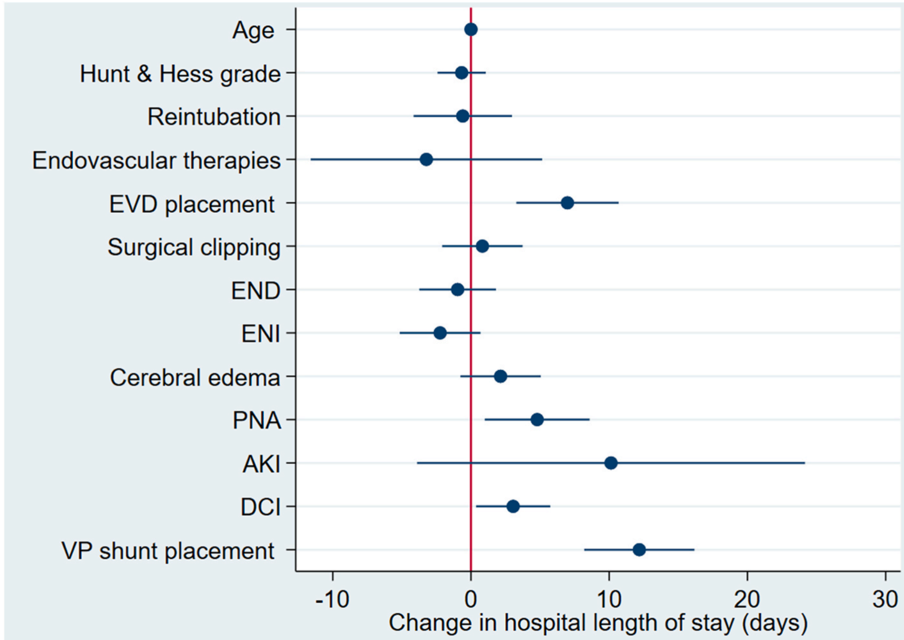

Fig. 1. Predictors of hospital length of stay (LOS) based on multiple linear regression analysis. Beta coefficients with 95% confidence interval are shown here. Abbreviations: EVD: external ventricular drain; END: early neurological deterioration; ENI: early neurological improvement; PNA: pneumonia; AKI: acute kidney injury; DCI: delayed cerebral ischemia; VP shunt: Ventriculoperitoneal shunt.

Table 2
Univariate and multivariate analyses for predictors of disposition to a long-term care facility. END: Early Neurological Deterioration.

	Univariate analysis		Multivariate analysis	
Predictor	Odds ratio; 95%CI	*p*-value	Odds ratio; 95% CI	*p*-value
Age>60	4.9 (2.67–9.1)	<0.001	1.14 (1.07–1.21)	<0.001
Hunt & Hess grade 3	1.3 (1.1–2.4)	<0.001	1.1 (0.97–1.69)	0.18
Modified Fisher score 3–4	1.42 (1.14–2)	0.004	1.08 (0.35–1.322)	0.22
END	3.3 (1.26–8.7)	<0.001	1.78 (0.55–5.8)	0.33
WBC count	1.03 (0.98–1.09)	0.17	1.13 (0.88–1.46)	0.31
Endovascular treatments	0.69 (0.06–7.8)	0.77	NA	NA
Surgical clipping	1.29 (0.57–2.9)	0.54	NA	NA

Table 3
Long-term care facility (LTCF) score components.

LTCF Score Components	Points
Age	
>60 years old	5
≤ 60 years old	0
END	
present	3
Absent	0
Hunt and Hess grade 3	
Yes	1
No	0
Modified Fisher Score	
3 or 4	1
1 or 2	0
Total Score Range	**0–10**

3.7. Subgroup analysis for survivors and impact of ENI on LOS

After excluding those who died prior to hospital discharge or those whose level of care was transitioned to withdrawal of life-sustaining activities with a possible hospice disposition, leaving a cohort of 210 survivors. Patients with favorable outcome had shorter LOS compared to those with poor outcome (median 14, IQR 12–23 vs median 25, IQR 19–40; $p < 0.001$). Higher LOS was associated with worse functional outcome (odds ratio 1.07 pear each day, 95% CI 1.05–1.11; $p < 0.001$). Multiple regression analysis revealed that VPS requirement (12.6 additional days, 95% CI 8.3–17; $p < 0.001$), Hunt and Hess grade (2.8 additional days per grade increase, 95% CI 1.4–4.3; $p < 0.001$) were associated with longer LOS, however, ENI was the only factor which was associated with a shorter LOS (3.4 fewer days, 95% CI -6.5, −0.3; $p = 0.033$).

3.8. Subgroup analysis for patients with high Hunt and Hess grades

In a subgroup analysis of patients with Hunt and Hess grades 4 or 5 (95 patients), mean age was 58.7 years (SD 13.5) and 60% ($n = 57$) were female. All patients were intubated upon hospital admission for depressed level of consciousness and they all required EVD for symptomatic hydrocephalus. Multiple regression analysis showed that VPS requirement was the main factor which was associated with longer LOS (6 additional days, 95% CI 2.5–9.6; $p = 0.001$). However, other factors such as age ($p = 0.64$), END ($p = 0.44$) or ENI ($p = 0.11$) did not independently impact LOS in this subgroup of patients.

4. Discussion

Long hospital LOS continues to carry an immense burden for aSAH patients and their families, despite best efforts at improving patient outcomes. Currently, patient outcomes are limited by a lack of consensus on how to best optimize patients' care and reduce hospital LOS, particularly those with poor-grade aSAH. Massive sets of clinical data must be examined to reveal trends in patient outcomes and to inform patient care decision-making strategies. This study leveraged a cohort of aSAH patients to determine predictive variables for prolonged hospital

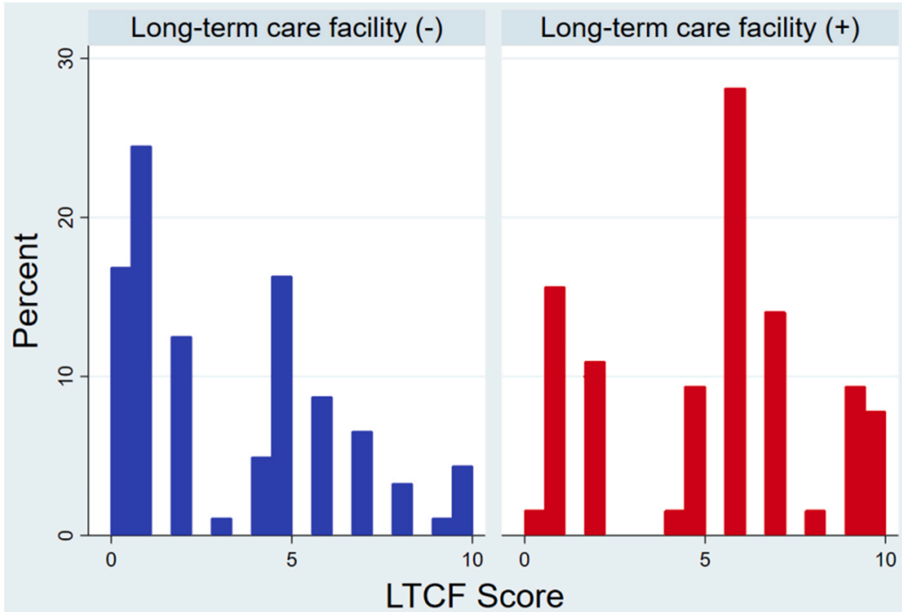

Fig. 2. Distribution of LTCF scores dichotomized based on need for placement in a long-term care facility (LTCF) for discharge disposition.

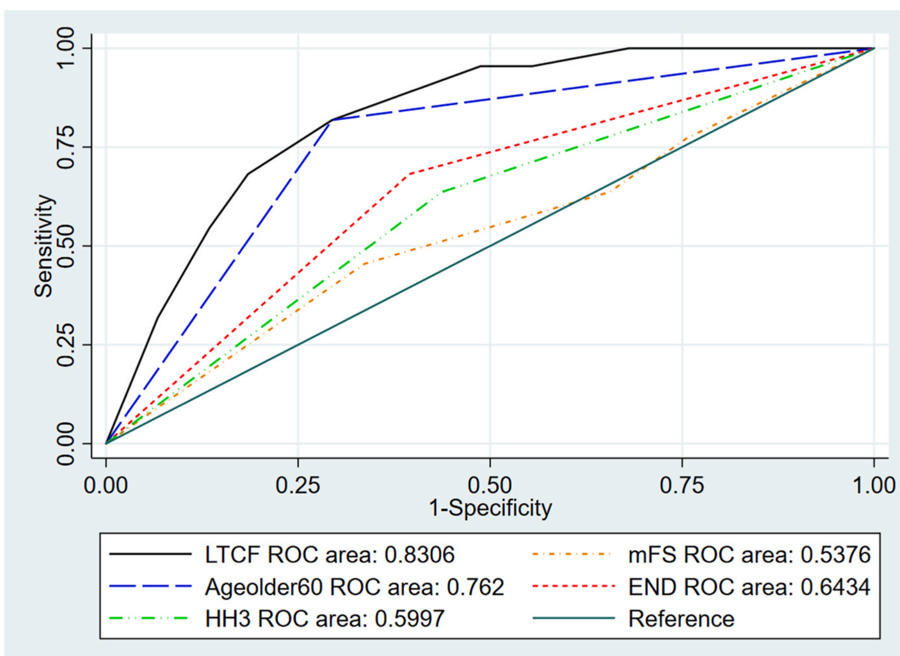

Fig. 3. ROC curve analysis showing predictive accuracy of factors present on admission or early hospital course in predicting placement in a long-term care facility (LTCF) as discharge disposition. Area Under Curve (AUC) is represented in the figure legend. Abbreviations: HH3: Hunt and Hess grade 3; mFS: modified Fisher scores 3–4; END: early neurological deterioration; Ageolder60: age>60 year-old.

LOS and disposition to a LTCF. Previous studies have looked at predictors of post-SAH LOS, but consistent trends have yet to be outlined.[14–16] Other studies have identified various hospital complications as factors that extend LOS, but our study expands the scope of these efforts to include more variables than have previously been examined, such as aSAH related factors, laboratory values on admission and in-hospital complications. This large set of variables, combined with our sample size, enabled an extensive investigation of hospital LOS predictors in aSAH patients.

4.1. ENI and decreased LOS in survivors

Our study underscores the importance of establishing early and aggressive resuscitative interventions in patients presenting with aSAH. Our analyses highlighted a significant decrease in LOS in survivors that have improvement in their neurological status prior to day 3 post-admission. With aSAH patients being particularly vulnerable to hospital-related complications and fluctuations in neurological status, it may seem counterintuitive to advocate for rapid, aggressive treatment. However, this study adds to a growing body of evidence that supports a time-sensitive approach to aSAH care.[17–19]

Our findings indicate that immediate neurological assessment on hospital admission may not be as predictive for LOS as assessment on day 3 post-admission, where most cases will have stabilized following any events causing ENI or END. As our results clearly demonstrate, ENI serves as a useful predictor for LOS, thereby emphasizing the importance of waiting for patient neurological status to reach a point where trajectory is more predictable. This is an important distinction because it allows providers to shape goals of care discussions with families based on early changes to neurological status rather than condition upon arrival to the emergency department. Among patients that present with poor-grade aSAH, we support the previous findings that early, aggressive therapeutic interventions may be beneficial in increasing the odds for ENI and thereby reducing LOS.[20]

4.2. Hydrocephalus and LOS

From the factors which were specific to aSAH and were associated with longer hospital LOS, hydrocephalus requiring EVD placement and VPS requirement had the highest impacts. Current evidence suggests that a rapid EVD weaning strategy can be associated with shorter LOS and lower incidence of ventriculoperitoneal shunt placement; however, there is still no consensus on how to manage EVD in aSAH patients among health care providers.[21–23] Although the purpose of our study was not specifically to test the association of EVD duration and outcome measures in aSAH, our data support previous studies suggesting that EVD prolongation affects LOS and therefore may contribute to worse outcome. Further prospective studies are required to address this issue further.

4.3. Endovascular therapies vs. surgical clipping

Endovascular treatment modalities such as coiling or placement of flow diverting devices were used in the vast majority of our patients as they are preferred over surgical clipping for treatment of ruptured intracranial aneurysms in our institution. Endovascular aneurysm repair did not affect hospital LOS in our study cohort in contrast to surgical clipping was more common in patients who had hospital LOS longer than 16 days. However, after adjustment with other predictors such as DCI and EVD requirement for hydrocephalus, surgical clipping was not independently associated with LOS in our multiple linear regression model.

4.4. Discharge dispositions and predictors of placement in a LTCF

Our proposed risk stratification scoring model has high accuracy in predicting discharge disposition to a LTCF which has financial impact on families and the society. Early utilization of case management and social work services may be considered to expedite hospital discharge process in anticipation of LTCF placement and potentially reduce financial burden in high risk patients. Although such predictive model can be informative for discharge planning and preparing family members, this should not be misconstrued as a prognostication tool in goals of care discussion with patients and their health care surrogates. More than one-third of patients who were discharged to LTCF had significant functional recovery (mRS$\leq$3) at 3 months post hospital discharge which underscores the importance of rehabilitation strategies and avoidance of self-fulfilling prophecies in goals of care discussion in early hospital course.

4.5. Study limitations

This study has several limitations. Because we used a single-center, retrospective cohort of patients, we are unable to determine direct causation of our variables and hospital LOS. However, most data points were captured prospectively. Long-term functional outcome was not the main focus or primary outcome of our study, therefore, we did not collect mRS or other outcome measures such as cognitive function data at 6 months or beyond. Further studies could utilize a Cox proportional-hazards model to identify differences in trends between surviving patients and non-survivors. Our study is also limited in its ability to detect ultra-early neurological changes (i.e., those that occur in transit to satellite hospitals or our center). Although patient neurological status is certainly vulnerable to fluctuation at this point, our data suggests that almost all patients who presented to a satellite hospital were transferred to our center within 24 h, limiting the impact on LOS calculations.

5. Conclusions

Hydrocephalus is the main modifiable factor which is associated with longer hospital LOS compared to other predictors including admission related factors and in-hospital complications. EVD management strategies as potential targets for improvement in outcomes and hospital LOS should be explored further. LTCF score has high accuracy in predicting discharge disposition to a LTCF which is not necessarily equivalent to poor outcome as more than one-third of patients had significant functional recovery at 3 months post hospital discharge. Larger prospective studies are needed for better identification and potential mitigation of factors associated with prolonged LOS in patients with aSAH.

CRediT authorship contribution statement

Ryan Snow: Conceptualization, Data curation, Funding acquisition, Methodology, Writing – original draft, Writing – review & editing. **Alizeh Shamshad:** Data curation, Writing – original draft, Writing – review & editing. **Alexandra Helliwell:** Data curation, Writing – original draft, Writing – review & editing. **Linda C. Wendell:** Writing – original draft, Writing – review & editing. **Bradford B. Thompson:** Writing – original draft, Writing – review & editing. **Karen L. Furie:** Resources, Writing – review & editing. **Michael E. Reznik:** Writing – original draft, Writing – review & editing. **Ali Mahta:** Writing – review & editing, Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing – original draft.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Abbreviation list

aSAH: aneurysmal subarachnoid hemorrhage
AUC: area under the curve
CI: confidence interval
ENI: early neurological improvement
END: early neurological deterioration
EVD: external ventricular drain
INR: international normalization ratio
IQR: interquartile range
IRB: institutional review board
LOS: length of stay
LTCF: long-term care facility
mRS: modified Rankin Scale
PT: prothrombin time
PTT: partial thromboplastin time
ROC:: Receiver Operating Characteristic
SAH: subarachnoid hemorrhage
SD: standard deviation
WBC: white blood cell