ORIGINAL RESEARCH

Predictors of Prolonged Mechanical Ventilation Among Patients with Aneurysmal Subarachnoid Hemorrhage After Microsurgical Clipping

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ABSTRACT

Introduction: Aneurysmal subarachnoid hemorrhage (aSAH) is a fatal event with high mortality and morbidity rates. Survivors may require prolonged intubation with mechanical ventilation (MV). However, the risk factors for prolonged intubation in these patients remain unclear. The aim of this study was to determine the predictors of prolonged MV in aSAH patients who underwent surgical clipping.
Methods: In total, 108 adult patients with a primary diagnosis of aSAH who were on MV > 48 h and survived > 14 days after surgery were included. Clinicodemographic and radiological characteristics, laboratory tests on admission, and initial Glasgow Coma Scale (GCS) and its components were analyzed.
Results: The average age of the patients included in the analysis was 59.1 ± 12.5 years. Overall, 32 patients (29.6%) had prolonged MV. The group with prolonged MV showed a higher prevalence of diabetes mellitus and hypertension, lower initial GCS and its components, higher World Federation of Neurosurgeons (WFNS) and Hunt and Hess grades, and higher initial white cell counts. The independent factors associated with prolonged MV were a history of diabetes mellitus (odds ratio [OR] 5.799, 95% confidence interval [CI] 1.109–30.334; $P = 0.037$) and Hunt and Hess grade 3–5 (OR 7.217, 95% CI 1.090–47.770; $P = 0.040$).
Conclusion: A history of diabetes mellitus and Hunt and Hess grade 3–5 independently predict prolonged MV after microsurgical clipping in patients with aSAH. Thus, knowledge of potential predictors for prolonged MV is essential to improve the early initiation of adequate treatment in the early stages of treatment and provide useful information for communication between caregivers and families.

Keywords: Aneurysmal subarachnoid hemorrhage; Hunt and Hess grade; Mechanical ventilation; Microsurgical clipping

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Key Summary Points

Why carry out this study?

Survivors of aneurysmal subarachnoid hemorrhage (aSAH) may require prolonged intubation with mechanical ventilation (MV).

However, the risk factors for prolonged intubation in these patients are still unclear.

What was learned from this study?

A history of diabetes mellitus and Hunt and Hess grade 3–5 independently predict prolonged MV in aSAH patients.

Predicting the possibility of prolonged MV can help neurocritical patients benefit from tracheostomy and avoid unnecessary complications.

INTRODUCTION

Aneurysmal subarachnoid hemorrhage (aSAH) is a neurological emergency that occurs in 9–10/100,000 persons per year [1, 2]. Despite advances in neurocritical care, the mortality and morbidity rates of aSAH remain high, accounting for 2–5% of strokes [3–5]. Survivors frequently have long-term disabilities. Age, aneurysm size, Fisher grade, Hunt and Hess grade, World Federation of Neurosurgeons (WFNS) grade, presence of intracerebral hemorrhage (ICH), and Glasgow Coma Scale (GCS) have been found to influence aSAH outcomes [6–9]. Microsurgical clipping and endovascular therapy with coiling are the main treatment modalities for ruptured aneurysms. In such situations, generalized anesthesia with mechanical ventilation (MV) is required. In addition, patients are usually intubated endotracheally with MV for respiratory failure, airway protection, or altered mental status. Delayed cerebral ischemia is a common and detrimental complication after aSAH, which results in secondary brain injury [2, 10–12].

Patients with severe brain injury may have longer durations of MV use and poorer outcomes than the general population of intensive care unit (ICU) patients [13, 14]. Specific recommendations regarding weaning from MV for the patient population with aSAH are still lacking. In addition, the risk of ventilator-associated pneumonia (VAP) is increased by delayed extubation despite meeting the readiness criteria [14]. Other significant complications of prolonged MV, including airway injury, ventilator-associated lung injury, and prolonged immobility, incur significant social and economic burdens [15, 16]. Predictive models of prolonged MV in aSAH patients after microsurgical clipping can provide useful information to facilitate the management of these patients in the ICU and help patient families and caregivers to better anticipate the treatment course and decision-making. However, only a few studies have analyzed the risk factors for prolonged intubation in these patients. Thus, this study aimed to determine the predictors of prolonged MV in aSAH patients who underwent surgical clipping. We hypothesize that aSAH patients with higher disease severity and comorbidities need prolonged MV after surgery.

METHODS

Study Design and Patients

This retrospective observational study was conducted at the National Taiwan University Hospital. We evaluated adult patients (age ≥ 18 years) with aSAH who were admitted to the neurosurgical ICU after microsurgical clipping, endotracheally intubated for at least 48 h of MV, and survived > 14 days between May 2015 and December 2019. Only patients who underwent microsurgical clipping of the aneurysms were included. In contrast, patients with endovascular coiling of the aneurysm, iatrogenic aneurysm rupture, pre-existing brain diseases (stroke, brain tumor, or meningitis), substance abuse disorders (illicit drugs or alcohol), and history of lung surgery or

Table 1 Patient characteristics ($n = 108$)

Variable	Value
Age (years)	59.05 ± 12.52
Sex, male	30 (27.8)
Weight (kg)	62.10 ± 12.44
DM	13 (12%)
HTN	52 (48.1)
Initial E	3.06 ± 1.23
Initial M	5.2 ± 1.34
Initial V	3.33 ± 1.87
Initial GCS	11.6 ± 3.98
Initial WBC	13.24 ± 5.26
Initial WBC > 10,000	72 (66.7)
Initial WBC > 12,000	57 (52.8)
Initial WBC > 15,000	35 (32.4)
Location of aneurysm	
Anterior circulation	104 (96.3)
Posterior circulation	4 (3.7)
EVD for hydrocephalus	69 (63.8)
Hunt and Hess scale	
Grade 1–2	52 (48.1)
Grade 3–5	56 (51.9)
WFNS scale	
Grade 1–2	58 (53.7)
Grade 3–5	50 (46.3)
Modified Fisher grade	
Grade 1–2	25 (23.1)
Grade 3–4	83 (76.9)
Extubation failure (re-intubation)	3 (2.8)
MV ≥ 14 days	32 (29.6)

Data are presented as the mean ± standard deviation (SD) or as n (%)

DM Diabetes mellitus, *GCS* Glasgow Coma Scale (*E* eye opening, *M* motor response, *V* verbal response), *HTN* hypertension, *MV* mechanical ventilation, *WBC* white blood cell, *WFNS* World Federation of Neurosurgeons

tracheostomy, those intubated for < 48 h of MV after aSAH, and those lost to follow-up were excluded. Patients with incomplete or unavailable records and who signed a do-not-resuscitate order were also excluded.

This study was approved by the Institutional Review Board of National Taiwan University Hospital (IRB number: 201611058RINA). The study was conducted in accordance with the applicable local regulations and the Declaration of Helsinki of 1964 and subsequent revisions and in accordance with the STROBE guidelines. Written informed consent was obtained from the patients. If the patients were comatose, consent was obtained from the patients' caregivers.

Assessment and Data Collection

aSAH was defined as the diagnosis of an aneurysm with an associated non-traumatic SAH presentation based on imaging studies. All patients were followed up for at least 14 days until they had undergone spontaneous breathing trials (SBTs) and passed the weaning parameters before extubation or were confirmed to be dependent on MV > 2 weeks after endotracheal intubation. All patients underwent computed tomography angiography (CTA) in the emergency department to confirm subarachnoid hemorrhage caused by ruptured aneurysms.

All data were collected and reviewed using an electronic medical record system. We collected the following information for each patient: demographic data, medical history of hypertension or diabetes mellitus (DM), radiographic data for grading, laboratory data upon emergency department arrival, imaging data, and aneurysm-related information.

Surgical Procedure, Assessments, and Postoperative Care

The choice between endovascular coiling and microsurgical clipping to manage aneurysms was made by neurosurgeons and interventional neuroradiologists. External ventricular drains (EVD) were placed in patients with acute

hydrocephalus after aSAH. MV is essential for aSAH patients to prevent secondary brain damage by providing adequate oxygenation and ventilation and to administer general anesthesia for surgery. The intensive care of these patients was managed according to international guidelines [17]. All hyperglycemic patients were treated with insulin therapy to achieve a target blood sugar level ≤ 200 mg/dL with strict prevention of hypoglycemia during postoperative care. All patients received nimodipine at a dose of 2 mg/h to prevent vasospasm when the oral route was not available and if patients had delayed cerebral ischemia (DCI).

Postoperatively, patients were continuously monitored in the ICU to detect any clinical deterioration. Postoperative management included MV, antiepileptic drugs, antibiotic prophylaxis for at least 3 days, and early enteral nutrition using a nasogastric or orogastric tube. Neurological assessments were performed hourly, including the GCS, pupil size, and reaction to light. When vasospasm or DCI was suspected, CTA or conventional digital subtraction angiography was used to confirm the diagnosis and rule out other differential diagnoses.

Measurement of Weaning Parameters

Once the patient was stabilized postoperatively, MV support was gradually reduced to start the transition from controlled ventilation to spontaneous ventilation. When the patients could tolerate the reduced applied airway pressure support of 5–10 cm of water, an SBT using a T-tube (T-piece) was performed to spontaneously assess the ability to breathe. The respiratory therapist measured the weaning parameters, including maximal inspiratory pressure (PiMax), maximal expiratory pressure (PeMax), respiratory rate (RR), rapid shallow breathing index (RSBI), minute ventilation (VE), and tidal volume (VT), using a standardized method.

The cutoff points of weaning parameters used to evaluate the general patients under MV in our hospital were as follows: PiMax -30 cmH$_2$O; PeMax 30 cmH$_2$O; RSBI < 105; RR < 30 breaths/min; VE < 10 L/min; and VT > 5 mL/kg. The endotracheal tube was removed if the patient had all of the aforementioned parameter values and passed the SBT. If the patients did not require re-intubation after monitoring respiratory conditions for 48 h, the weaning process was regarded as successful. Moreover, if the patients could not be extubated 14 days after the initiation of MV, they were included in the prolonged MV group.

Statistical Analyses

We analyzed sociodemographic data (age, sex, body weight, DM, and hypertension), clinico-radiological variables (GSC and its components, Hunt and Hess grade, the WFNS grade, and modified Fisher grade), and peripheral white blood cell count (WBC) at admission. Continuous variables were presented as the mean $\pm$ standard deviation (SD) in the descriptive analyses, while categorical and binary variables were presented as frequencies (n) and percentages (%). Student's t-test and Chi-squared test were used to compare outcomes between patient subgroups for continuous and categorical data, respectively. Univariate analyses were performed using logistic regression analysis to identify the independent prognostic variables. Significant variables in the univariate analysis (i.e., those with a $P < 0.10$) were entered into the multivariate logistic regression with stepwise selection to identify the independent predictors of prolonged MV. All statistical analyses were performed using SPSS version 26 for Windows (SPSS IBM Corp., Armonk, NY, USA). Statistical significance was set at $P < 0.05$.

RESULTS

Patient Characteristics

In total, 108 aSAH patients with a mean ($\pm$ SD) age of 59.05 ± 12.52 years were included (Table 1). The majority of the patients were female (72.2%, $n = 78$), and the mean GCS at admission was 11.6 ± 3.98. There were 104

Table 2 Univariate analysis of the factors associated with prolonged mechanical ventilation ($n = 108$)

Variable	MV ≥ 14 days ($n = 32$)	MV < 14 days ($n = 76$)	P value
Age (years)	63.69 ± 11.68	57.09 ± 12.41	0.012*
Sex, male	9 (28.1)	21 (27.6)	0.960
Weight (kg)	64.00 ± 12.39	61.31 ± 12.45	0.306
DM	8 (25.0)	5 (6.6)	0.007*
HTN	21 (65.6)	32 (42.1)	0.026*
Initial E	2.47 ± 1.32	3.32 ± 1.11	0.001*
Initial M	4.81 ± 1.33	5.37 ± 1.32	0.048*
Initial V	2.31 ± 1.66	3.76 ± 1.80	0.000**
Initial GCS	9.59 ± 3.78	12.45 ± 3.78	0.001*
Initial WBC	14.81 ± 5.97	12.58 ± 4.83	0.045*
Initial WBC > 10,000	24 (75.0)	48 (63.2)	0.233
Initial WBC > 12,000	21 (65.6)	36 (47.4)	0.083
Initial WBC > 15,000	15 (46.9)	20 (26.3)	0.037*
EVD	24 (75.0)	44 (57.9)	0.119
Hunt and Hess grade 3–5	27 (84.4)	29 (38.2)	0.000**
WFNS scale score 3–5	24 (75.0)	26 (34.2)	0.000**
Modified Fisher Grade (III, IV)	28 (87.5)	55 (72.4)	0.089

Data are presented as the mean ± SD or as n (%)

*, **Significant difference at *$P < 0.05$ and **$P < 0.001$

EVD External ventricular drain

(96.3%) and four (3.7%) patients with anterior and posterior circulation aneurysms, respectively. All patients underwent microsurgical clipping of the ruptured aneurysms, and 69 of them underwent placement of EVD for acute hydrocephalus. Thirty-three (30.5%) patients were diagnosed with DCI 4–12 days after aSAH and surgical clipping. We diagnosed brain tissue injuries, including cerebral edema and hemorrhagic contusions, in nine (8.3%) patients, stroke in six (5.6%) patients, and deep vein thrombosis in the lower extremities in three (1.9%) patients. Overall, 32 (29.6%) patients were mechanically ventilated for > 14 days. During postoperative intensive care, 79 patients (73.1%) were weaned off MV after passing the SBT within 14 days after surgery. The majority of these patients (96.2%, $n = 76$) had successful extubation without re-intubation, and only three patients were re-intubated within 72 h after extubation.

Factors Associated with Prolonged MV

Prolonged MV (≥ 14 days) was observed in 32 patients (29.6%). Patient characteristics of short MV group (< 14 days) and the prolonged MV group are compared in Table 2. Compared to the short MV group, the prolonged MV group was significantly older (63.69 vs. 57.09 years; $P = 0.012$), with a higher rate of DM (25.0 vs. 6.6%; $P = 0.007$), a significantly lower initial GCS before surgery (9.59 vs. 12.45; $P = 0.001$), significantly higher initial WBC counts (14.81 ×

Table 3 Multivariate analysis of the factors associated with prolonged intubation

Factors	Exp (B)	95% Confidence interval	P value
Age (years)	1.044	0.992–1.099	0.100
DM	5.799	1.109–30.334	0.037*
HTN	1.856	0.575–5.997	0.301
Initial GCS	0.929	0.793–1.088	0.361
Initial WBC > 15 K	2.534	0.825–7.785	0.104
Hunt and Hess grade 3–5	7.217	1.090–47.770	0.040*
WFNS 3–5	13.64	0.254–7.319	0.718

*Significant at $P < 0.05$

10^3 vs. 12.58×10^3; $P = 0.045$), a higher percentage of patients with Hunt and Hess grade > 2 (84.4 vs. 38.2%; $P < 0.001$), and a higher percentage of patients with WFNS grade > 2 (75.0 vs. 34.2%; $P < 0.001$). All components of the initial GCS were also lower in this group (all $P < 0.05$). When WBC counts were dichotomized at 15,000/μL, the prolonged MV group included a higher percentage of patients with high initial WBC counts (46.9 vs. 26.3%). There was no significant between-group difference with respect to sex, body weight, or modified Fisher grade.

To identify the independent prognostic variables, multivariate regression analysis was performed using variables with a $P < 0.10$ in the univariate analysis. In the multivariate analysis, a history of DM (odds ratio [OR] 5.799, 95% confidence interval [CI] 1.109–30.334; $P = 0.037$) and Hunt and Hess grade 3–5 (OR 7.217, 95% CI 1.090–47.770; $P = 0.040$) independently influenced the incidence of prolonged MV. Meanwhile, age (OR 1.044, 95% CI 0.992–1.099; $P = 0.100$), hypertension (OR 1.856, 95% CI 0.575–5.997; $P = 0.301$), initial GCS (OR 0.929, 95% CI 0.793–1.088; $P = 0.361$), initial WBC > 15,000 (OR 2.534, 95% CI 0.825–7.785; $P = 0.104$), and WFNS grade (OR 13.64, 95% CI 0.254–7.319; $P = 0.718$) had no influence on prolonged MV incidence (Table 3).

DISCUSSION

Despite the importance of predictors of prolonged MV in facilitating the management of patients with aSAH, there are only a limited number of studies analyzing the risk factors for prolonged intubation in these patients. In this study we found that DM and Hunt and Hess grades were significantly associated with prolonged MV. To the best of our knowledge, this is the first study to provide a comprehensive characterization and analysis of the predictors of prolonged MV in patients who underwent microsurgical clipping to secure cerebral aneurysms (CAs) after aSAH.

Only patients who underwent clipping surgery after aSAH were included in the analysis. We focused on the unique considerations relating to airway management and analyzed prolonged MV in the aSAH population after microsurgery. Considering the deficits in neurological functions and changes in consciousness after aSAH, these patients may be weaned off MV when they pass the screen of weaning parameters. However, they may need re-intubation or continue to require an artificial airway. Based on the weaning parameters for the general critical care patients (PiMax − 30 cmH$_2$O, PeMax 30 cmH$_2$O, RSBI < 105, RR < 30 breaths/min, VE < 10 L/min, and VT > 5 mL/kg), 79 (73.1%) patients were extubated after passing the SBT; however, three (3.8%) of these patients were re-intubated within 72 h.

Management guidelines for CAs have been developing continuously since the 1990s [18–20]. CAs are treated either surgically or endovascularly, and treatment decisions should consider the location and morphology of the aneurysms, comorbidities, or the need for emergency surgical hematoma evacuation. Critically ill patients on prolonged MV have significantly higher morbidity and mortality, and tracheostomy should be indicated [21]. Compared with prolonged use of a translaryngeal tube, a tracheostomy with decreased airway resistance can better accelerate the weaning process and the rate of success, improve patient comfort, and decrease in-hospital mortality and the duration of hospitalization [22, 23].

However, a limited number of studies have analyzed the risk factors for tracheostomy and prolonged intubation in patients with aSAH. In ICH, other risk factors for prolonged intubation include hematoma location, hydrocephalus, chronic obstructive pulmonary disease, and obesity [24–26]. Unlike other forms of stroke, DCI and increased intracranial pressure from hydrocephalus should be considered during the treatment course after the ruptured aneurysm has been secured. Neurogenic pulmonary edema and respiratory distress syndrome occur in 20–23% [26–28] and 18–50% [29–31] of aSAH patients, respectively. In a study of 146 patients with poor-grade aSAH, Gessler et al. demonstrated that tracheostomy within 1 week was associated with a lower possibility of pneumonia and shorter MV but did not affect ICU length of stay, neurological function, or mortality [32].

The results of another study showed that a later tracheostomy in poor-grade aSAH patients was associated with longer hospitalization, venous thromboembolic events, and pneumonia [33]. Also, in a study comparing 1069 patients who underwent endovascular approach and 519 patients who underwent surgical approach after aSAH, rates of MV, pneumonia, deep vein thrombosis, and tracheostomy were higher in patients treated surgically [34]. Of the patients in these two treatment groups, 27.6% and 42.4% underwent MV > 4 days, and 19% and 32.4% patients underwent tracheostomy after prolonged MV, respectively [34]. The reasons for the disadvantage of craniotomy over the endovascular approach remain unclear, and further research is needed to understand the surgery-related physiological changes to discover the specific patient group requiring a tailored treatment.

In general, intubation is indicated in aSAH patients with GCS $\leq$ 8, elevated intracranial pressure, status epilepticus, elective surgical intervention, poor oxygenation or hypoventilation, hemodynamic instability, and a need for therapeutic hyperventilation or demand for heavy sedation [35, 36]. Furthermore, weaning off MV is a crucial process in these patients when the ruptured aneurysms are secured from rebleeding, their cardiovascular condition stabilizes, and they do not deteriorate neurologically and have an adequate gas exchange. Patients requiring prolonged MV are prone to skeletal muscle atrophy due to limited physical activity, respiratory muscle weakness, and many other complications, which can be improved by early weaning and physical rehabilitation [15, 16, 37].

Patients are first assessed for their readiness to wean based on satisfactory weaning parameters and an SBT, followed by the decision regarding possible extubation [38, 39]. Weaning parameters are used to evaluate respiratory physiology capacity and the ability to breathe adequately without assistance. The commonly used weaning parameters include PiMax, PeMax, VT, VE, RR, RSBI, airway resistance, and compliance [40, 41]. Compared to critically ill patients requiring MV due to other diseases, patients with aSAH and impaired consciousness may have a low respiratory drive and impaired coughing reflex to clear secretions and protect the airway, and these cannot be assessed by weaning parameters. Therefore, even if patients pass the weaning parameters, they may develop extubation failure and require re-intubation and MV for adequate airway protection and oxygenation [42, 43]. Additionally, these patients may benefit from continued endotracheal intubation to prevent aspiration and maintain the ability to suction secretions until the improvement of neurological functions.

The plasma glucose level at admission is an independent predictor of prognosis after

myocardial infarction, coronary artery bypass graft surgery, and traumatic brain injuries, and in critically ill patients [44–48]. In a study of 228 patients with endogenous diseases aged ≥ 75 years, DM was an independent predictor of extubation difficulty, including the use of MV > 14 days, re-intubation within 48 h after extubation, and tracheotomy [49]. In a meta-analysis of 39 studies involving 359,783 patients with ischemic and hemorrhagic stroke, DM was prevalent in 28% of the patients [50]. Most of the included studies found that DM was associated with higher mortality, poor functional outcomes, and longer hospital stays. In a retrospective study of 2540 aSAH patients, 9.4% of whom had DM, long-term MV was an independent predictor of poor functional outcome [34]. Patients with hyperglycemia have an approximately threefold increased risk for poor outcome after aSAH [51, 52]. In our study, 12% of the aSAH patients had a history of DM, which was a significant predictor of prolonged MV. The DCI usually occurs in 30–40% of aSAH patients, mostly between days 4 and 10, and it can progress to irreversible cerebral infarction with subsequent poor clinical outcomes [53–55]. The authors of a systemic review concluded that there is an increased risk of DCI in patients with hyperglycemia (OR 3.2, 95% CI 1.8–5.8) and history of DM (pooled OR 6.7, 95% CI 1.7–26) [56]. DCI, which is the leading cause of secondary neurological deficits after aSAH, may be one of the factors associated with the pathophysiology of prolonged MV after aSAH.

Grading systems based on initial evaluation and imaging findings have been used to classify patients with aSAH. The most widely used grading systems are the Hunt and Hess grading system, Fisher grade, and the WFNS grading system. The Hunt-Hess and WFNS scales are the most widely used grading systems for clinical assessments in patients with aSAH. They primarily focus on the consciousness and neurological deficits that reflect the severity of brain injury [57]. In contrast, the modified Fisher scale is a commonly accepted radiological grading system that assesses the severity of brain injury by quantifying the amount and distribution of hemorrhage on computed tomography images to predict the incidence of vasospasm and DCI [58]. A higher Hunt and Hess grade implies a decreased level of consciousness and focal neurologic deficits, which may lead to impaired protective reflexes and an increased risk of aspiration.

A retrospective study of 669 aSAH patients compared the performances of different grading scores for predicting functional outcomes between patients who underwent microsurgical clipping and endovascular coiling. The results demonstrated that the clinical grading systems have significantly better predictive performance than the radiological grading systems in both groups [59]. These results are supported by other studies [60, 61]. A higher score on the WFNS scale, which uses the GCS and focal neurological deficits to grade the severity of aSAH, independently predicted prolonged intubation in patients with aSAH after surgical or endovascular treatment [62]. Rass et al. reported that a higher Hunt and Hess grade in aSAH patients was associated with an MV > 7 and 14 days [63]. Consistent with this, the current study found that a Hunt and Hess scale grade of 3–5 was an independent predictor of prolonged MV after clipping in aSAH patients. In contrast, modified Fisher grade (dichotomized to grade 1–2 and grade 3–4) was not significantly associated with prolonged MV in both the univariate and multivariate analyses. The WFNS scale score, as a clinical score, was significantly associated with MV in the univariate analysis but not in the multivariate analysis. These findings emphasize the importance of using different scoring systems for predicting different aspects of outcomes after aSAH.

As a common hospital-acquired infection after > 48 h of MV use, VAP is the leading cause of death from nosocomial infections in critically ill patients [64]. It is associated with prolonged hospitalization and increased healthcare costs, morbidity, and mortality [65, 66]. In patients on MV, the incidence of VAP increases with the duration of ventilation at approximately 1.5% per day [67]. With late tracheostomy or prolonged MV as a reference, early tracheostomy in patients requiring intensive care who are on MV at ≤ 7 days and ≤ 10 days after intubation have no significant benefits with respect to the length of ICU

stay, hospital stay, duration of MV use, or survival [68–70]. Further, it is important to predict the possibility of prolonged MV in neurocritical patients and determine the necessity and timing of tracheostomy. This can help patients benefit from tracheostomy and avoid unnecessary complications.

This study has some limitations. First, our data were collected retrospectively from a single institution. Thus, important confounders relevant to the results may have been missed. Therefore, future studies involving larger populations are needed to validate the generalizability of our results. Second, the patients were treated surgically by three neurosurgeons, and the postoperative treatment strategy may have varied. Third, not all patients had their blood sugar and glycated hemoglobin levels measured on arrival to the emergency room, which limited further detailed analysis of diabetic patients. Despite these limitations, this study remains valuable as it investigates an important aspect of MV use in a selected patient cohort and provides baseline evidence for further studies to improve the outcomes of aSAH patients.

CONCLUSION

In conclusion, a history of DM and Hunt and Hess grade 3–5 independently predict prolonged MV after microsurgical clipping in patients with aSAH. This finding may help to improve current weaning protocols and provide useful information to help both clinicians and families in better clinical decision-making.

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