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Safety and Feasibility of an Early Mobilization Program for Patients With Aneurysmal Subarachnoid Hemorrhage

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Background. Survivors of aneurysmal subarachnoid hemorrhage (SAH) are faced with a complicated recovery, which typically includes surgery, prolonged monitoring in the intensive care unit, and treatment focusing on the prevention of complications.

Objective. The purpose of this study was to determine the safety and feasibility of an early mobilization program for patients with aneurysmal SAH.

Design. This study was a retrospective analysis.

Methods. Twenty-five patients received early mobilization by a physical therapist or an occupational therapist, or both, which focused on functional training and therapeutic exercise in more progressively upright positions. Participation criteria focused on neurologic and physiologic stability prior to the initiation of early mobilization program sessions.

Results. Patients met the criteria for participation in 86.1% of the early mobilization program sessions attempted. Patients did not meet criteria for the following reasons: Lindegaard ratio >3.0 or middle cerebral artery (MCA) mean flow velocity (MFV) >120 cm/s (8.1%), mean arterial pressure (MAP) <80 mm Hg (1.8%), intracranial pressure (ICP) >15 mm Hg (1.8%), unable to open eyes in response to voice (0.9%), respiratory rate >40 breaths/min (0.6%), MAP >110 mm Hg (0.3%), and heart rate <40 bpm (0.3%). Adverse events occurred in 5.9% of early mobilization program sessions for the following reasons: MAP <70 mm Hg (3.1%) or >120 mm Hg (2.4%) and heart rate >130 bpm (0.3%). The 30-day mortality rate for all patients was 0%. Participation in the early mobilization program began a mean of 3.2 days (SD=1.3) after aneurysmal SAH, and patients received an average of 11.4 sessions (SD=4.3). Patients required a mean of 5.4 days (SD=4.2) to participate in out-of-bed activity and a mean of 10.7 days (SD=6.2) to walk ≥15.24 m (50 ft).

Conclusions. The results of this study suggest that an early mobilization program for patients with aneurysmal SAH is safe and feasible.

Aneurysmal subarachnoid hemorrhage (SAH) can be a catastrophic and disabling event. Mortality is estimated at about 10% to 15% before reaching the hospital and up to 40% within the first month.[1] Recent advances in the management of aneurysmal SAH have increased the survival rate and reduced disability,[2] but it is still estimated that 50% of patients will experience permanent physical or cognitive impairment.[3] The lifetime cost to care for patients with aneurysmal SAH is more than double that of those with an ischemic stroke.[4]

Survivors of aneurysmal SAH are faced with a complicated recovery, which typically includes surgery, prolonged monitoring in the intensive care unit (ICU), and treatment focusing on the prevention of complications. Neurologic complications include rebleeding, hydrocephalus, seizure, and delayed cerebral ischemia (DCI).[5,6] Extracranial complications following aneurysmal SAH include hyponatremia, intravascular volume depletion, and cardiac dysfunction.[6] Along with the complications specific to aneurysmal SAH, these patients also are at risk for the pulmonary, cardiovascular, and neuromuscular complications associated with immobility and critical illness that lead to cognitive, psychological, neuromuscular, and functional decline.[7–12]

Early mobilization, a multidisciplinary approach to increasing patient participation in upright functional activity, has been determined to reduce the complications associated with critical illness in certain patient populations. Early mobilization programs for patients on mechanical ventilation were found to be safe, reduce ICU and hospital length of stay, improve functional outcomes, and potentially reduce the complications of critical illness.[13–18] Likewise, AVERT (A Very Early Rehabilitation Trial) examined the effects of early mobilization on patients with all types of stroke who were not admitted to the ICU. Early mobilization within 24 hours of stroke onset was found to be feasible and did not increase 3-month mortality.[19] Patients returned to walking 2.5 days faster, experienced improved function at 3 and 12 months, and were less depressed at 7 days after stroke.[20,21] In addition, it cost less to care for patients receiving early mobilization compared with those receiving standard care.[22]

Because the clinical management of aneurysmal SAH differs from that of other types of stroke,[23,24] we examined studies supporting the mobilization of patients with aneurysmal SAH. In previous studies investigating positional changes in patients with aneurysmal SAH, it was determined that head of bed position did not increase incidence of DCI or change cerebral hemodynamics.[25,26] Likewise, passive range of motion and active exercise did not increase intracranial pressure (ICP) or cerebral perfusion pressure (CPP) in patients receiving physical therapy in the neurosurgical intensive care unit.[27,28] Although there have been no studies that specifically investigated the early mobilization of patients with aneurysmal SAH, early rehabilitation has been suggested,[29] and there has been a reduction in the rate of bed rest prescribed at admission.[23]

At our facility, patients were generally immobile and prescribed bed rest after aneurysm treatment to reduce the neurologic complications associated with aneurysmal SAH. Aware of these complications, our multidisciplinary neurocritical care team hypothesized that the benefits associated with the early mobilization of patients with aneurysmal SAH might outweigh the unknown risks. The purpose of this study was to determine the safety and feasibility of an early mobilization program designed for patients with aneurysmal SAH.

Method

Design Overview

A retrospective study was conducted to examine the safety and feasibility of an early mobilization program for patients with aneurysmal SAH.

Setting and Participants

Patients admitted to the neurosurgical ICU at the Capital Health Regional Medical Center between January 2011 and May 2011 with a diagnosis of SAH were included in the study. The diagnosis of SAH was confirmed from computed tomography scans or xanthochromia of the cerebrospinal fluid. Patients were excluded if they were younger than 18 years of age, were admitted more than 14 days after SAH onset, care was withdrawn, or the SAH was determined to be caused by trauma or arteriovenous malformation. Aneurysmal SAH was confirmed by intra-arterial digital subtraction angiography.

Patients included in the study received transcranial Doppler (TCD) ultrasonography at least daily. The middle cerebral artery (MCA) mean flow velocity (MFV) and Lindegaard ratio (mean MCA velocity/mean internal carotid artery velocity) were

Table 1.
Early Mobilization Program Interventions[a]

Intervention	Position			
	Supine	Sitting	Standing	Walking
Positioning	Pressure ulcer prevention Edema reduction Joint protection Pain reduction	Pressure ulcer prevention Joint protection Pain reduction	Joint protection	Joint protection
Education	Positioning Safety Family training	Positioning Safety Family training	Safety Assistive device Family training	Safety Assistive device Family training
Functional training	Bed mobility Transfer	Transfer Weight shifting Balance ADL Posture	Balance ADL Posture Weight shifting	Gait Posture Balance ADL
Therapeutic exercise	PROM AROM Breathing	PROM AROM Breathing Reaching Weight shifting	AROM Breathing Reaching Weight shifting	Breathing Endurance Balance

[a] ADL=activities of daily living, AROM=active range of motion, PROM=passive range of motion.

calculated from TCD ultrasonography and used as a predictor for the development of DCI.[30–32] Continuous electroencephalography was conducted on patients in the study but did not preclude participation in the early mobilization program unless there was evidence of ischemia or seizure. Likewise, mechanical ventilation, external ventricular or lumbar drains, and arterial lines did not preclude patients from participating in the study.

Early Mobilization Program

The criteria to participate in the early mobilization program were derived from an early mobilization protocol for patients on mechanical ventilation in the ICU[18] and modified for patients with aneurysmal SAH (Appendix 1). The criteria focused on ensuring neurologic and physiologic stability prior to the initiation of early mobilization program sessions. Preventing DCI and elevated ICP while maintaining adequate CPP are major components in the management of patients with aneurysmal SAH.[24] Because the effects of early mobilization on patients with aneurysmal SAH were unknown, participation in the early mobilization program was limited to patients at lower risk for the development of complications. Patients meeting the criteria for participation had a lower risk for DCI (Lindegaard ratio $\leq$3.0, MCA MFV $\leq$120 cm/s),[30–32] adequate CPP (mean arterial pressure [MAP] $\geq$80 and $\leq$110 mm Hg),[24] and normal ICP ($\leq$15 mm Hg).[24]

Patients identified for the study were assessed daily by a physical therapist or an occupational therapist, or both, to determine whether criteria were met to participate in the early mobilization program. Patients not meeting the criteria to participate in the early mobilization program were reassessed the following day. Early mobilization program sessions were conducted by the physical therapist or occupational therapist and lasted from 30 to 60 minutes, depending on patient tolerance. Patient participation in the early mobilization program was discussed daily with the multidisciplinary neurocritical care team, which consisted of neurosurgeons, intensivists, nurses, respiratory therapists, physical therapists, and occupational therapists. Neurologic presentation and physiologic stability were monitored during the early mobilization program sessions. Adverse events (Appendix 2) were similar to the participation criteria with the exception that the MAP threshold was set at 10 mm Hg above and below the participation criteria range because of the MAP variability associated with activity and positional changes. If an adverse event occurred during the session, the session was terminated. The physical therapist and occupational therapist documented in the medical record their intervention and adverse events that occurred during the session.

Early mobilization program sessions focused on positioning, education, functional training, and therapeutic exercise in the supine, sitting, standing, and walking positions (Tab. 1). Initially, functional training in the supine position consisted of bed mobility training and the transition in patient position from supine to with the head of bed elevated 30

degrees. When physiologic stability and patient tolerance were achieved in the head-of-bed 30-degree position, the patient transferred to sitting on the edge of the bed. Once physiologic stability and patient tolerance were achieved in a sitting position, the patient performed transfer, balance, posture, and activity of daily living (ADL) training as determined appropriate by the physical therapist or occupational therapist. During the supine and sitting phases of the early mobilization program, patients received active or passive range of motion, or both, to the following joints and motions as determined appropriate by the physical therapist or occupational therapist: glenohumeral flexion, elbow flexion and extension, wrist flexion and extension, finger flexion and extension, hip flexion, hip abduction and adduction, knee flexion and extension, and ankle dorsiflexion and plantar flexion.

After seated training activities were completed and as long as the patient remained physiologically stable and tolerant, the patient transferred to the standing position. Patients unable to actively participate in transferring to a standing position were transferred out of bed with a mechanical lift until they were able to actively assist the therapist. Patients able to participate in transferring to a standing position received standing balance, posture, and ADL training as determined appropriate by the physical therapist or occupational therapist. After standing training activities were completed and as long as the patient remained physiologically stable and tolerant, the patient was either transferred to a bedside chair using a stand-pivot technique or received gait or ADL training from the physical therapist or occupational therapist. Time spent sitting out of bed was encouraged as long as the patient remained physiologically stable and tolerant. Patients transferred back to bed with assistance from the physical therapist, occupational therapist, or nurse.

Outcome Measures

Primary outcomes of the study were the safety and feasibility of patient participation in the early mobilization program. Safety was measured by the quantity and type of adverse events that occurred during early mobilization program sessions and the 30-day mortality rate. The feasibility of patient participation was measured by the following: early mobilization program sessions attempted, sessions where criteria to participate were met, sessions where criteria to participate were not met, and reasons why patients did not meet participation criteria. Secondary outcomes included the following: type of interventions utilized during sessions, number of sessions that included out-of-bed activity and walking ≥15.24 m (50 ft), average time from admission to out-of-bed activity and walking ≥15.24 m, Barthel Index (BI)[33] at discharge, and discharge destination from the acute hospital.

Data Analysis

Data were collected from retrospective chart review by 3 investigators (B.F.O., L.E.S., and M.L.A.). Microsoft Excel software (Microsoft Office 2010, Microsoft Corporation, Redmond, Washington) was used for data collection and analysis. Descriptive statistics are represented as number (percentages) and means (standard deviations) unless otherwise specified.

Results

Between January 2011 and May 2011, 40 patients were admitted to the neurosurgical ICU with a diagnosis of SAH. Fifteen patients were excluded because the SAH was determined to be caused by trauma (n=10) or arteriovenous malformation (n=1) or because care was withdrawn (n=4). The remaining 25 patients were included in the early mobilization program study. The majority of patients in the study were female (76.0%), and the mean age was 55.6 years (SD=11.8). Three patients (12%) were classified as poor grade SAH (Hunt and Hess grade IV/V), and the average hospital length of stay was 14.1 days (SD=4.4). Demographic and clinical characteristics are summarized in Table 2.

Three hundred thirty-two early mobilization program sessions were attempted. Patients met the criteria to participate in 286 sessions (86.1%). Patients did not meet criteria to participate in 46 sessions (13.9%) for the following reasons: Lindegaard ratio >3.0 or MCA MFV >120 cm/s (8.1%, 27 out of 332), MAP <80 mm Hg (1.8%, 6 out of 332), ICP >15 (1.8%, 6 out of 332), unable to open eyes in response to voice (0.9%, 3 out of 332), respiratory rate >40 breaths/min (0.6%, 2 out of 332), MAP >110 mm Hg (0.3%, 1 out of 332), and heart rate <40 bpm (0.3%, 1 out of 332). Patients classified as poor grade SAH met the criteria to participate in 62.5% (25 out of 40) of early mobilization program sessions attempted. Temporal trends of patient participation in the early mobilization program are shown in the Figure.

Adverse events occurred in 5.9% (17 out of 286) early mobilization training sessions for the following reasons: MAP <70 mm Hg (3.1%, 9 out of 286), MAP >120 mm Hg (2.4%, 7 out of 286), and heart rate >130 bpm (0.3%, 1 out of 286). Temporal trends of adverse events that occurred during early mobilization program sessions are shown in the Figure. The 30-day mortality rate for all patients was 0%. Adverse events occurred in 5.0% (2 out of 40) of early mobilization sessions for

Table 2.
Patient Demographic and Clinical Characteristics (n=25)[a]

Characteristic	Value
Female	19 (76.0)
Age (y), $\bar{X}$ (SD)	55.6 (11.8)
Ethnicity	
White, non-Hispanic	14 (56.0)
Asian	1 (4.0)
African American/black	7 (28.0)
Hispanic	3 (12.0)
Hunt and Hess grade	
I	1 (4.0)
II	10 (40.0)
III	11 (44.0)
IV	3 (12.0)
V	0 (0.0)
Poor grade SAH (Hunt and Hess grade IV/V)	3 (12.0)
Type of aneurysm treatment	
Endovascular coil embolization	19 (76.0)
Surgical clip ligation	4 (16.0)
No aneurysm identified	2 (8.0)
Clinical characteristics	
EVD	8 (32.0)
V-P shunt	4 (16.0)
Sonographic vasospasm	17 (68.0)
Decompressive hemicraniectomy	4 (16.0)
Ventilator greater than 2 days	4 (16.0)
mRS prior to event, median (range)	0 (0.1)
Hospital length of stay (d), $\bar{X}$ (SD)	14.1 (4.4)

[a] Values are number (percentage) unless otherwise indicated. SAH=subarachnoid hemorrhage, EVD=external ventricular drain, V-P shunt=ventriculoperitoneal shunt, mRS=modified Rankin Scale score.

patients classified as poor grade aneurysmal SAH.

Patients participated in the following interventions during the 286 early mobilization program sessions: bed mobility training (61.2%, 175 out of 286), transfer training (54.9%, 157 out of 286), therapeutic exercise (39.2%, 112 out of 286), gait training (36.3%, 104 out of 286), balance training (36.0%, 103 out of 286), and ADL training (17.8%, 51 out of 286). Participation in the early mobilization program was initiated a mean of 3.2 days (SD=1.3) after aneurysmal SAH. Sixty percent of the patients were discharged home, and the remaining 40% went to an inpatient rehabilitation facility. At discharge, the mean BI score was 59.8 (SD=35.5), and the median modified Rankin Scale score was 2, suggesting that disability was experienced in the majority of patients as a result of aneurysmal SAH.[34] Early mobilization program outcome data are summarized in Table 3.

Discussion

With evidence suggesting the safety, feasibility, and efficacy of early mobilization programs for various patient populations, we developed an early mobilization program for patients with aneurysmal SAH to prevent the complications associated with immobility and critical illness that lead to cognitive, psychological, neuromuscular, and functional decline. Participation in the early mobilization program was feasible soon after aneurysm treatment and until discharge from the hospital. Participation in the early mobilization program was initiated 3.2 days after aneurysmal SAH. Limited participation was observed on days 1 and 2 after aneurysmal SAH due the need for aneurysm treatment (Figure). Participation increased on day 3 and remained elevated until day 17 after aneurysmal SAH, which was consistent with average hospital length of stay (14.4 days).

The criteria for participation in the early mobilization program focused on ensuring neurologic and physiologic stability prior to the initiation of a session. The MCA MFV and Lindegaard ratio, predictors for the development of DCI,[30–32] were included in the criteria to participate in early mobilization program sessions. In this study, patients most likely did not meet the criteria to participate because the MCA MFV and Lindegaard ratio predicted an increased risk of DCI (8.1%). Overall, patients met the criteria for participation in the majority of early mobilization program sessions attempted (86.1%), which is consistent with participation rates in other early mobilization studies.[17,18] As a high participation rate was observed, future studies might include early mobilization in patients with predictors of DCI and a stable neurologic examination.

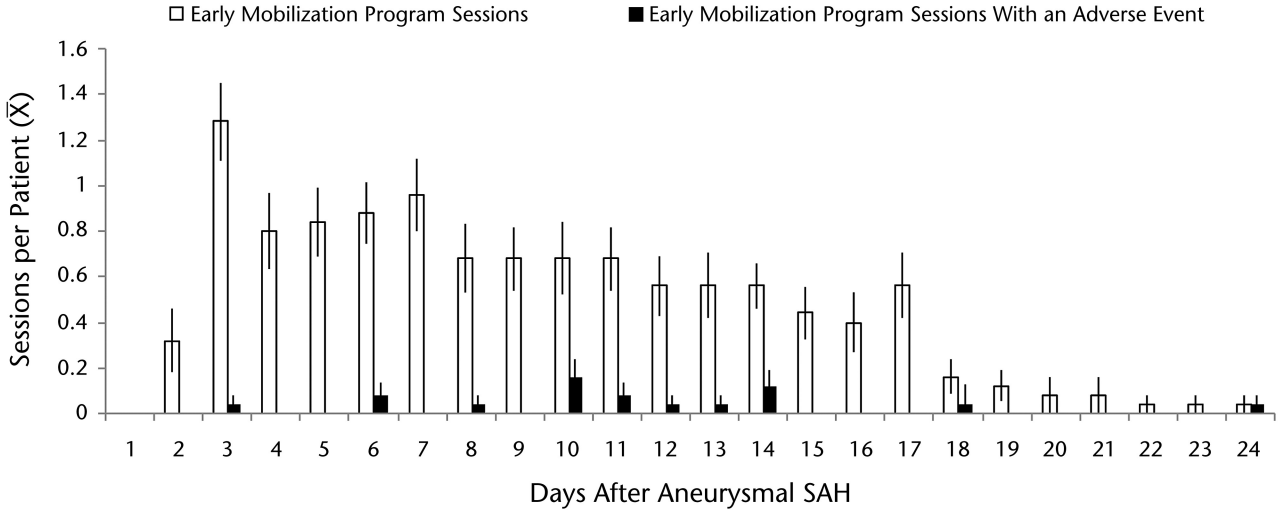

Figure.
Temporal distribution of the occurrence of early mobilization program sessions and adverse events during the early mobilization program. SAH=subarachnoid hemorrhage.

The 30-day mortality rate is lower than observed in aneurysmal SAH[1] because patients who had care withdrawn were excluded from the study. Because no patients in the study died within 30 days, the early mobilization program did not increase 30-day mortality in our study. Patients experienced minimal adverse events, which were attributed to the normal physiological changes associated with activity. Patients who experienced an adverse event were able to continue in the early mobilization program until discharge from the hospital. The rate of adverse events in this study (5.9%) is comparable to that in other early mobilization studies.[17,18]

The maintenance of patients within the established MAP parameters was challenging because of MAP variability associated with activity and positional changes. Adverse events most likely occurred during the early mobilization program sessions because the MAP trended below 70 mm Hg (3.1%) or above 120 mm Hg (2.4%). Adverse events occurred consistently between days 3 and 14 after aneurysmal SAH (Figure), when patients were at highest risk for DCI.[24] In all sessions where an adverse event occurred because the MAP trended below the threshold (70 mm Hg), patients were receiving training that focused on the transition to a more upright position (supine to head of bed 30°, head of bed 30° to sitting, sitting to standing). During the mobilization of patients with acute aneurysmal SAH, MAP should be closely monitored during transitions to more progressively upright positions, especially during the time when maintaining adequate CPP is a priority in patients at highest risk for DCI.

The AVERT trials have demonstrated the benefits of early mobilization in patients with stroke but did not include patients who were admitted to the ICU.[19–22] While receiving the highest level of monitoring in a neu-

Table 3.
Early Mobilization Program Outcomes (n=25)[a]

Outcome	Value
Early mobilization program sessions	286 (100.0)
Sessions including out-of-bed activity	167 (58.4)
Sessions including walking ≥15.24 m (50 ft)	51 (17.8)
Sessions per patient, X̄ (SD)	11.4 (4.3)
Days from subarachnoid hemorrhage to initial early mobilization program session, X̄ (SD)	3.2 (1.3)
Days from admission to out of bed, X̄ (SD)	5.4 (4.2)
Days from admission to walking ≥15.24 m, X̄ (SD)	10.7 (6.2)
Modified Rankin Scale score at discharge, median (range)	2 (1.5)
Barthel Index at discharge, X̄ (SD)	59.8 (35.5)
Patients discharged home	15 (60.0)
Patients discharged to an inpatient rehabilitation facility	10 (40.0)

[a] Values are number (percentage) unless otherwise indicated.

rosurgical ICU, patients in this study participated in complex functional training during early mobilization program sessions. The majority of early mobilization program sessions included out of bed activity (58.4%) and in 17.8% of the sessions, patients walked ≥15.24 m. Patients were more likely to be discharged home (60.0%) than to an inpatient rehabilitation facility (40.0%). Although the outcomes of this study cannot be compared with the findings of studies showing patients with stroke who are mobilized sooner are more likely discharged home,[35] they do support the need to determine the effects of early mobilization on the outcomes of patients with aneurysmal SAH.

The majority of patients were classified as having a Hunt and Hess score between I and III (Tab. 2). The exclusion of patients who had care withdrawn contributed to the low incidence of poor grade aneurysmal SAH in this study. In patients with poor grade aneurysmal SAH, adverse events occurred in 5.0% of the sessions, which was less than the overall adverse event rate observed in the study (5.9%). Patients with poor grade aneurysmal SAH participated in 62.5% of the early mobilization sessions compared with an overall participation rate of 86.1% for the study, suggesting that there might be a lower participation rate in the early mobilization of patients with poor grade aneurysmal SAH due to problems with neurologic and physiologic stability.

Limitations

This study has several limitations. It examined the results of an early mobilization program in a relatively small sample of patients with aneurysmal SAH. Although several patients were excluded because care was withdrawn, a larger sample of patients might have increased the number of those with poor grade aneurysmal SAH included in our study. In addition, this study was a retrospective analysis of an early mobilization program in patients with aneurysmal SAH that did not allow for an outcome comparison.

Conclusion

The results of this retrospective study suggest that an early mobilization program for patients with SAH is safe and feasible.

All authors provided concept/idea/research design. Dr Olkowski, Dr Slotnick, and Dr Arcaro provided writing and data analysis. Dr Olkowski, Dr Devine, Dr Slotnick, and Dr Arcaro provided data collection and project management. Dr Devine, Dr Veznedaroglu, Dr Liebman, and Dr Binning provided study participants. Dr Devine provided facilities/equipment, institutional liaisons, and consultation (including review of manuscript before submission).

This study was approved by the Capital Health Institutional Review Board.

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Appendix 1.

Criteria to Participate in Early Mobilization Program Sessions[a]

- Secured aneurysm or no underlying aneurysm identified
- Lindegaard ratio ≤3.0 or MCA MFV ≤120 cm/s
- Mean arterial pressure ≥80 and ≤110 mm Hg
- Heart rate ≥40 and ≤130 bpm
- Respiratory rate ≤40 breaths/min
- Pulse oximetry ≥88%
- Intracranial pressure ≤15 mm Hg
- No evidence of seizure activity
- Stable neurologic examination
- Able to open eyes in response to voice
- Ability to move one extremity on command

[a] MCA=middle cerebral artery, MFV=mean flow velocity.

Appendix 2.

Adverse Events During Early Mobilization Program Sessions

- Mean arterial pressure <70 and >120 mm Hg
- Heart rate <40 or >130 bpm
- Respiratory rate <5 or >40 breaths/min
- Pulse oximetry <88%
- Intracranial pressure >15 mm Hg
- Fall
- Acute change in neurologic presentation