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ORIGINAL ARTICLE

Early Progressive Mobilization of Patients with External Ventricular Drains: Safety and Feasibility

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Abstract

Background/Objective: Early mobilization of critically ill patients has been shown to improve functional outcomes. Neurosurgery patients with an external ventricular drain (EVD) due to increased intracranial pressure often remain on bed rest while EVD remains in place. The prevalence of mobilizing patients with EVD has not been described, and the literature regarding the safety and feasibility of mobilizing patients with EVDs is limited. The aim of our study was to describe the outcomes and adverse events of the first mobilization attempt in neurosurgery patients with EVD who participated in early functional mobilization with physical therapy or occupational therapy.

Methods: We performed a single-site, retrospective chart review of 153 patients who underwent placement of an EVD. Hemodynamically stable patients deemed appropriate for mobilization by physical or occupational therapy were included. Mobilization and activity details were recorded.

Results: The most common principal diagnoses were subarachnoid hemorrhage (61.4%) and intracerebral hemorrhage (17.0%) requiring EVD for symptomatic hydrocephalus. A total of 117 patients were mobilized (76.5%), and the median time to first mobilization after EVD placement in this group of 117 patients was 38 h. Decreased level of consciousness was the most common reason for lack of mobilization. The highest level of mobility on the patient's first attempt was ambulation (43.6%), followed by sitting on the side of the bed (30.8%), transferring to a bedside chair (17.1%), and standing up from the side of the bed (8.5%). No major safety events, such as EVD dislodgment, occurred in any patient. Transient adverse events with mobilization were infrequent at 6.9% and had no permanent neurological sequelae and were mostly headache, nausea, and transient diastolic blood pressure elevation.

Conclusion: Early progressive mobilization of neurosurgical intensive care unit patients with external ventricular drains appears safe and feasible.

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Introduction

Prolonged immobilization of critically ill patients in the intensive care unit (ICU) setting has been shown to be detrimental in terms of increasing ICU-acquired musculoskeletal weakness, de-conditioning, and development of delirium resulting in longer ICU stays, delayed hospital discharges, and long-term disability [1–4]. The evidence has shown early mobilization of critically ill patients to be safe, feasible, and beneficial [4–9]. Improved functional outcomes have been reported in hospitalized stroke patients who commence a program of earlier rehabilitation and mobilization [10–14]. Current evidence is limited as to whether similar benefits of early mobilization convey to neurosurgical patients who undergo placement of an external ventricular drain (EVD) for managing increased intracranial pressure (ICP) and hydrocephalus. The prevalence of ICU personnel routinely mobilizing this patient population as standard practice has not been described in the literature, and there are no evidence-based clinical practice guidelines clarifying the safety profile of mobilization of such patients. Patients with EVD may be particularly prone to delayed mobilization due to bed-rest orders [15–17]. Reported reasons for delaying mobilization in these patients are (1) fear of dislodging the EVD, (2) raised ICP during mobilization when the EVD is closed to drain, (3) causing intracranial vasospasm, (4) accidentally over-draining cerebral spinal fluid from the patient's EVD due to improper clamping during mobilization, and (5) lack of therapist experience with an EVD and working in a neurosurgical ICU [18].

There are no studies examining the optimal timing and safety of early mobilization of neurosurgery patients with EVD. The aim of our study was to bridge this gap in knowledge by describing timing, outcomes, and adverse events of first attempts at mobilization of patients with EVD by physical and occupational therapists at a single, academic tertiary care hospital.

Materials and Methods

Study Patients

After Institutional Review Board approval, a retrospective electronic health record review was conducted to include all patients in the neurosurgical intensive care unit (NSICU) who underwent placement of an EVD at Mayo Clinic in Jacksonville, Florida, between January 1, 2013, and May 31, 2016. Patients were included in the study if they were deemed hemodynamically and medically/neurosurgically stable by the treating NSICU team physician and/or treating neurosurgeon and ICU rehabilitation services team. Candidates who met these criteria were considered for early functional mobilization by a physical or occupational therapist and able to actively engage in the evaluation or treatment session. All patients had active provider consults in place for physical or occupational therapy. Bedside nursing in the NSICU was actively involved in the safety monitoring of patient's symptoms as well as helping with EVD clamping of the drain as needed during mobility. Nursing was available immediately for the rehabilitation team in monitoring the patient clinically or with vital signs or symptoms change depending on the condition of the patient (in bed mobility or during ambulation). Per established standard of care, exclusion criteria included presence of a femoral sheath or recent removal of femoral vascular sheath, hemodynamic instability, active bleeding or angioedema, heart rate greater than 120 bpm, ICP higher than 25 mm Hg or as deemed unstable by the treating NSICU/neurosurgery team, a cerebral perfusion pressure lower than 50 mm Hg, resting heart rate of 50% age-predicted maximum or less, systolic blood pressure lower than 90 or higher than 180, diastolic blood pressure higher than 105, peripheral oxygen saturation of 90% or less, marked diaphoresis, facial pallor, intense anxious or painful facial expression (especially in patients who were aphasic), or active bleeding from lines, catheters, or wounds.

Once patients met inclusion criteria, the bedside nurse, per standard of care in the NSICU, would clamp the EVD before mobilization and therapy to avoid a potentially harmful cerebral spinal fluid siphoning [19].

Data Collection

Collected patient data included age, sex, principal diagnosis, survival to discharge, length of stay, discharge disposition, mobilized or reason not mobilized, completed mobilization activities, time from EVD placement to first mobilization, degree of required mobility assistance, and adverse events with mobilization. Mobilization activity events included transfer from supine position to sitting on the side of the bed, rising from sitting to standing by the side of the bed, transfer from the bed to a bedside chair, and ambulating any distance away from the bed.

Potential adverse event (AE) patient responses to mobilization included unstable ICP (defined as an ICP of 20 mm Hg or greater sustained 2 min or longer), cerebral perfusion pressure lower than 50 mm Hg, systolic blood pressure lower than 90 mm Hg or higher than 180 mm

Hg, diastolic blood pressure higher than 105 mm Hg, orthostatic systolic blood pressure drop of 20 mm Hg following any positional change, persistent saturation of peripheral oxygen less than 90%, increased headache, nausea, and emesis. Serious AE included EVD dislodgement or removal from the head or an event that leads to serious health deterioration such as patient collapse, syncope, elevated ICP episode requiring active NSICU team management, or major new neurological deficits (transient or permanent) and death.

Statistical Analysis

Continuous variables were summarized with the sample median and range. Categorical variables were summarized with number and percentage of patients. We estimated the proportion of patients who were mobilized and the proportion of patients who experienced AE, along with exact binomial 95% CIs. Statistical analysis was performed using R Statistical Software, version 3.2.3 (R Foundation for Statistical Computing).

Results

A total of 153 patients received EVDs during the study period. A summary of baseline characteristics and hospitalization information is provided in Table 1. Median age was 58 years (range, 23–95), and 94 patients (61.4%) were female. The most common principal diagnoses were subarachnoid hemorrhage (SAH) (61.4%) and intracerebral hemorrhage (17.0%). The majority of patients ($N=127$ [83.0%]) survived to discharge; median length of stay for these patients was 17 days (range, 2–106). A total of 117 patients (76.5%; 95% CI, 69.2–82.5%) were mobilized, and the median time from EVD placement to initial mobilization in these 117 patients was 38 h (range, 4–537). Mean time from EVD placement to initial mobilization was 83.0 h. Among the 36 patients not mobilized while an EVD was present, the most common reason was decreased patient responsiveness (23 [63.0%]). Initial patient mobilization data are summarized in Table 2.

The highest level of patient mobility activity achieved by the group was ambulation for 51 patients (43.6%), followed by transferring from supine to sitting for 36 patients (30.8%), from bed to a chair for 20 patients (17.1%), and from sitting to standing for 10 patients (8.5%). The peak distance mobilized during ambulation was 120 feet (range, 1–1080). AEs to mobilization were rare and transient (6.9%; 95% CI, 3.5–12.9%) and included diastolic blood pressure greater than 105 mm Hg (0.9%; 95% CI, 0.2–4.7%), increased headache (0.9%; 95% CI, 0.2–4.7%), nausea (0.9%; 95% CI, 0.2–4.7%), emesis (2.6%; 95% CI, 0.9–7.3%), and other AEs (1.7%; 95% CI, 0.5–6.0%). No EVD dislodgment occurred during patient mobilization.

Table 1 Baseline patient characteristics and hospitalization information

Variable	Summary ($N=153$)
Age at admission, median (range), year	58 (23–95)
Sex, female, no. (%)	94 (61.4)
Principal diagnosis, no. (%)	
SAH	94 (61.4)
ICH	26 (17.0)
Neoplasm	11 (7.2)
Infection	4 (2.6)
Other	18 (11.8)
Survived to discharge, no. (%)	127 (83.0)
Length of stay ($n=127$), median (range), days	17 (2–106)
Discharge disposition ($n=127$), no. (%)	
Home without HHC	38 (29.9)
Acute rehab facility	30 (23.6)
LTAC	16 (12.6)
Subacute rehab facility	12 (9.4)
Home with HHC	11 (8.7)
Other	20 (15.7)
Therapy ordered, no. (%)	
PT and OT	139 (90.8)
PT alone	14 (9.2)

HHC home health care, *ICH* intracerebral hemorrhage, *LTAC* long-term acute care facility; *OT* occupational therapy, *PT* physical therapy, *SAH* subarachnoid hemorrhage

Discussion

The primary finding of our study is that progressive functional mobilization by physical and occupational therapists of patients with a recently placed EVD can be achieved safely and earlier with a relatively low rate of AEs. The body of evidence over the past decade demonstrates the importance of early return to mobility activities on functional outcomes for immobilized hospital patients [4–6, 20]. Prolonged immobility of critically ill patients leads to prolonged length of stay (LOS), muscular weakness and atrophy, increased risk of deep vein thrombosis, and decreased functional independence. Early mobilization in the ICU setting reduces hospital LOS, increases strength, and optimizes return to functional independence [4, 6]. Despite this evidence, implementation of early ICU mobilization programs as a standard clinical practice has lagged [16, 21]; less than half of 500 U.S. ICUs surveyed have adopted the practice [21]. Likelihood of early patient mobilization does appear to increase when physical and occupational therapists are integrated into the ICU; this unit-based staffing model is found in only 1 in 3 U.S. ICUs surveyed [21]. Mobilizing patients is not the exclusive responsibility of rehabilitation personnel, however, and perceived barriers to early mobilization have been described across disciplines.

Table 2 Mobilization information

Variable	Summary ($N = 153$)
Mobilized by PT/OT, no. (%)	117 (76.5)
Reason not mobilized ($n = 36$), no. (%)	
Decreased responsiveness	23 (63.9)
Unstable intracranial pressure	4 (11.1)
Medically unstable	3 (8.3)
Withdrawal of care	3 (8.3)
Hemodynamically unstable, active bleeding, or angioedema	2 (5.6)
Femoral sheaths or recent removal of femoral sheaths	1 (2.8)
Time from EVD to first mobilization ($n = 117$), median (range), h	38 (4–537)
Least degree of mobility assistance with EVD in place ($n = 117$), no. (%)	
Complete independence	2 (1.7)
Modified independence	5 (4.3)
Supervision assistance	15 (12.8)
Minimal assistance	39 (33.3)
Moderate assistance	13 (11.1)
Maximal assistance	16 (13.7)
Total assistance	27 (23.1)
Highest level of mobility with EVD in place ($n = 117$), no. (%)	
Supine-to-sit	36 (30.8)
Sit-to-stand	10 (8.5)
Transferred to chair	20 (17.1)
Ambulated	51 (43.6)
Ambulation assistive device ($n = 51$), no. (%)	
Walker	33 (64.7)
None	18 (35.3)
Peak distance mobilized during ambulation with EVD in place ($n = 117$), median (range), ft	120 (1–1080)
Adverse response to mobilization ($n = 117$), no. (%)	
Any adverse events ($n = 117$)	8 (6.8)
Diastolic blood pressure > 105 mm Hg	1 (0.9)
Increased headache	1 (0.9)
Nausea	1 (0.9)
Emesis	3 (2.6)
Other	2 (1.7)

EVD external ventricular drains, *OT* occupational therapy, *PT* physical therapy

Concerns of patient safety as a barrier to mobilizing critically ill patients are common [21–26]. One systematic review of 40 studies investigating perceived barriers to early ICU mobility listed "vascular access devices, tubes and drains" [26] as the second most commonly reported patient-related barrier, second only to patient hemodynamic instability as a reason for not initiating patient mobility [26].

Current evidence supporting early mobilization of patients with EVD's remains limited, and no evidence-based clinical practice guideline currently exists for mobilizing this patient population. In 2013, Hale et al. [18] used a cross-sectional, descriptive study design to look at practice patterns of Canadian physical therapists mobilizing patients with EVDs. A survey of 25 physical therapists working in neurointensive care centers in Canada found that 76% of therapists felt it was safe to mobilize patients with an EVD in place. Clinical experience and safety concerns were considered the most important factors in the progression of patient mobilization activities. The majority of the therapists ranked ICP as the determining factor whether to mobilize the patient or not. Experienced therapists were more likely to mobilize borderline stable patients compared to therapists with less experience [18].

In a 2016 quality improvement project, Shah et al. [27] reported that physical therapy intervention for patients with an EVD was safe and feasible. They included 90 patients evaluated for physical therapy with an average time between EVD placement and initiation of therapy of 8.3 days. The level of activity achieved by 81% of their patients was at least standing, and 54% of them were able to safely ambulate with an EVD in place. A total of 4 AEs were documented, including increased ICP, EVD dislodgement, and emesis [27].

Moyer et al. [15] prospectively assessed the feasibility, safety, and outcomes of an early mobility protocol for 26 patients with SAH and an EVD. Results were compared to a pre-intervention group of 19 similar SAH patients with EVD from the previous 12 months. Average number of days to onset of patient mobilization was significantly earlier in the post-intervention group than the pre-intervention group (6.5 vs. 18.7, $P<0.0001$). Of the 101 reported attempts at mobilization in the post-intervention group, 6 sessions were terminated due to increased lethargy, pain, elevated ICP, EVD malfunction, or hypotension. None of the post-intervention patients experienced catheter dislodgement or other major complications associated with mobilization. Discharge destination was more favorable in the post-intervention group, with more patients discharging home or to acute rehabilitation facilities than those in the pre-intervention group (63.2% vs. 88.5%, $P=0.018$) [15].

Key differences between prior reports and our study are in the timing of the onset of initial mobilization activities after EVD placement and the intensity of these activities performed by the patient. To our knowledge, no other study has reported on outcomes and intensity level during the patient's first effort at physical mobility greater than bed rest with an EVD in place. Patients in our study tolerated both an earlier onset and more progressive mobilization, up to and including ambulation, on the initial attempt at mobilizing out of bed. Mean time to initiation of mobilization after EVD placement was 3.5 days (83.0 h) as compared to those of Moyer et al. [15] (6.5 days) and Shah et al. [27] (8.3 days). The mean value is reported here to allow for direct comparison to these previous published results, although the calculation is inflated (skewed) by a solitary outlying value of 537 h. The median of 1.6 days (38 h) better represents the typical onset of patient mobilization from the time of EVD placement.

Nearly 44% of patients in our study were able to progress mobility to ambulation with an EVD in place on their first attempt at mobilizing out of bed; median peak distance achieved by this group was 120 feet. In contrast, the highest level of reported mobilization activity achieved by patients in the first phase of Moyer et al.'s [15] multiphase study was bedside activities limited to standing and lateral side stepping; the authors reportedly are collecting data examining patient tolerance to sitting in a bedside chair and ambulating in the hallway. According to Shah et al. [19], 54% of patients with an EVD did achieve ambulation; in contrast to our study, these instances of ambulation occurred over 149 consecutive sessions. No data were reported on mobility levels achieved during first mobilization. Delays in mobilizing patients with EVD combined with lower intensity levels of physical activity may increase risks of musculoskeletal weakness, de-conditioning, development of delirium, delayed hospital discharges, and long-term disability.

Our institution has an established standard of care model supporting the early initiation of progressive mobilization in stable patients who meet certain criteria including those with EVD; it is unclear how prevalent this practice is outside our own facility. Since 2010, a team of physical therapists, occupational therapists, and rehabilitation technicians has been integrated into the ICU areas. Institutions considering adoption of the procedure should be aware that increasing the physical activity of patients with EVDs to the point of mobilization may represent an advanced clinical practice pattern [28]. Higher acuity levels and relatively fewer number of cases' characteristic of this patient population dictate that the practice of mobilizing patients with EVDs be considered a low frequency-high risk practice, requiring thorough staff training to ensure competency to optimize patient safety. Mobility sessions must include clear, detailed collaboration by the patient's team of neurosurgeon, neurointensivist, and nursing staff prior to mobilization to ensure patient safety. Rehabilitation therapists must have full understanding of treatment precautions and contraindications and continuously remain alert to patient signs and symptoms indicating the need to modify or terminate treatment.

The main limitation of our study is the retrospective design of safety documentation in the electronic medical record which may introduce biases into data collection. However, it is our practice to prospectively evaluate patients eligible in our practice that are candidates for mobility who meet certain criteria. Also, the documentation of AE would occur during such events in the medical record as standard of care. Active tidaling measurement of ICP during patient mobilization is not practical for rehabilitation or nursing staffing, and thus, no real-time or near real-time monitoring of potential ICP numbers occurred during rehabilitation. These ICP data, however, would be problematic even if monitoring real-time since Valsalva used during standing up and other maneuvers in theory could increase ICP transiently higher than 20 mm Hg temporarily but are not clinically significant.

This is why we used clinical monitoring which our physician and NSICU team deemed the gold standard based on symptoms during mobility along with vital signs monitoring. Also, ICP and other vital signs are interrogated if a patient has symptoms during mobilization per standard of care in the ICU setting regardless of mobilization. Future research should focus on a prospective observational design in which physiologic variables and neurologic status changes can be collected or monitored during various mobility activities.

Conclusions

The results of our study indicate that 76.5% of patients who underwent placement of an EVD achieved early functional mobilization by physical or occupational therapy and tolerated a higher level of mobility activity on their first attempt, with a relatively low rate of transient AEs compared to current published evidence. These findings suggest that early functional mobilization of patients with EVDs by physical and occupational therapists is both safe and feasible. Given that patients with EVDs may be confined to bed rest due to fear of mobilization with an EVD in place, this can lead to delayed mobilization which can potentially lead to prolonged hospital LOS and negative impact on patient outcomes from deep vein thrombosis development. These data add to the limited body of available evidence on this topic and may help inform future clinical practice guidelines.

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Author Contribution

RAY and SMA participated in study design and performed data collection. WDF, SMB and CMS participated in study design. CCC, LWP, JLB, KLD, MHZC and DMS performed data collection. LNM participated in manuscript preparation. MGH participated in study design and performed primary data analysis. All authors participated in manuscript preparation and read and approved the final manuscript.

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Compliance with Ethical Standards

Conflict of interest

The authors declare that they have no conflict of interest.

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