Level of mobility and time to first out of bed mobilization in a neurosurgical ICU - A Brief Report

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ABSTRACT

Background: Hospitalization in the Intensive Care Unit (ICU) can lead to long-term physical, cognitive, and psychological impairments, collectively named Post-Intensive Care Syndrome. Individuals with acquired brain injury are at high risk, yet data on ICU mobility in this population remain limited. Early mobilization may prevent complications and improve recovery, but is challenging in neurocritical care. **Objectives**: To describe the level of mobility in a neurosurgical ICU and explore factors associated with mobility outcomes. **Methods**: This single-center, retrospective observational study included adults hospitalized >24 hours in a neurosurgical ICU. Daily mobility was recorded using the ICU Mobility Scale (IMS). Primary outcome was the distribution of mobility levels. Secondary outcomes included frequency of out-of-bed mobilization, maximal IMS score, time from in-bed to out-of-bed mobility, and factors influencing these outcomes. **Results**: Among 160 individuals included (median age 51 years (Q1-Q3 41–61), 45% female), 2,692 patient-days were analyzed. Median IMS was 1 (0-1). Out-of-bed mobilization occurred on 17% of days and was achieved a median 4 days (2-7) after first in-bed mobility in 76% of cases. Median maximal IMS during ICU stay was 5 (3-5). A higher initial Glasgow Coma Scale score was associated with a shorter time to out-of-bed mobilization, and longer ICU stays were linked to delayed mobilization. **Conclusions**: Early mobilization in the neurosurgical ICU is often limited, with most achieving out-of-bed mobility before discharge despite low maximal mobility levels. Further studies on factors influencing mobility are needed to optimize the clinical impact of early mobilization in this population.

KEYWORDS: early ambulation; intensive care Unit; neurosurgery; retrospective study

Introduction

Hospitalization in the Intensive Care Unit (ICU) has long-term consequences on health status and quality of life, including physical impairment, pain, fatigue, cognitive, and psychological disorders. These chronic symptoms have been described as Post-Intensive Care Syndrome (PICS) [1]. People with acquired brain injury (ABI) are less represented in PICS studies, as it is difficult to separate issues induced by the ICU from those caused by the neurological condition [2]. Nevertheless, people with ABI who stayed in ICU have an even higher probability of presenting physical, cognitive and psychological symptoms at the chronic stage, than those not admitted to ICU.

In order to prevent the development of PICS, several strategies have been developed and incorporated in a "liberation from ICU" bundle of care of 6 categories: ABCDEF [3]. Early mobility and exercise are the fifth item of the bundle. They aim to prevent physical disorders, such as bed rest complications, as well as cognitive and psychological issues. Despite the known beneficial effects of early mobilization, implementing it can be challenging. Indeed, it depends on the number of available nurses and rehabilitation therapists, mobilization devices, adapted environment, and the presence of medical devices around the individual (ventilation, lines, etc.) [4]. Some additional specific difficulties are related to neuro-critical care, such as ensuring the best cerebral perfusion, presence of external ventricular drains and intracranial monitoring [2].

Several protocols have been created to guide early mobilization [5]. Based on the individual's stability, as assessed using a set of clinical indicators, mobility should be progressively implemented. Thus, these protocols allow the individualization of mobility levels. Studies of individuals with

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ABI have reported that early progressive mobilization likely has a positive effect on functional recovery [6, 7]. However, a very early (<24 h from admission) and intensive mobilization may have a negative effect on functional recovery, as found in people with stroke [8]. Even though early mobilization is feasible in neuro-critically ill individuals, including those with invasive devices, careful attention to timing, intensity, and dose is essential to avoid potential harm [9].

The primary objective of this observational study was to describe typical mobility levels in a neurosurgical ICU. Secondary objectives were to examine the frequency of out-of-bed (OOB) mobilizations and the maximal mobility achieved, the trajectory of mobility throughout the ICU stay, and potential non-modifiable factors influencing mobility.

Methods

This retrospective longitudinal observational study was conducted in a single neurosurgical ICU, covering a 6-month period from January 1 to June 30, 2024. Individuals were identified through electronic medical records.

Inclusion criteria were age ≥ 118 years at ICU admission and hospitalization for >24 hours in the neurosurgical ICU during the study period. Individuals were excluded if they never regained any active mobility (i.e., death or discharge before reaching an IMS score of 1). Due to the retrospective design, detailed documentation of reasons for withholding mobilization sessions was unavailable.

Data were collected from medical records by 2 researchers. For each day of ICU stay, the maximum level of mobility was recorded using the validated French version of the ICU Mobility Scale (IMS) [10, 11].

The primary outcome was the distribution of observed mobility levels. Secondary outcomes were divided into descriptive and time-to-event outcomes. Descriptive outcomes included the number of days per individual with an IMS score greater than 1, and the highest IMS score achieved during the ICU stay. Time-to-event outcomes included several intervals covering the entire ICU stay: from ICU admission to the first IMS score of 1; from the first IMS score of 1 to the first IMS score >1; from the first IMS score >1 to the maximal IMS score; and from the latter to ICU discharge. Additional secondary outcomes were the adjusted odds ratio for out-of-bed mobilization and the adjusted hazard ratio for the time to first out-of-bed mobilization.

Baseline characteristics were collected to describe the sample and to identify potential covariates associated with mobility levels.

Statistical analysis was conducted using R software version 4.3.3. Descriptive results are presented as numbers and percentages for categorical variables, and as medians with interquartile ranges (Q1–Q3) for quantitative variables. Post hoc subgroup analyses were conducted across subgroups defined by the reason for ICU admission. Chi-squared tests were used to compare subgroups for qualitative variables, and Fisher's exact test was used when not applicable. For quantitative variables, the Kruskal-Wallis test was used. The occurrence of OOB mobilization during the stay was explored using logistic regression, and time to reach this outcome using Cox regression.

This study was conducted in accordance with the Helsinki declaration and current French law. It was approved by the research ethics committee *Comité Ethique de Recherche en Anesthésie et Réanimation* (CERAR), which waived the need for formal consent (IRB: 00010254 - 2025 – 035).

Results

Sample Characteristics

Over the 6-month study period, 207 adults were admitted to the ICU and remained hospitalized for >24 hours, meeting the eligibility criteria. Among them, 160 were included in the final analysis.

A total of 47 individuals were excluded because they never regained any active mobility during the study period. Among them, 35 died, and 12 were discharged to another unit. Their mobility remained null throughout the ICU stay, so they were excluded to present results concerning only potentially active individuals.

Baseline characteristics of the included sample are presented in Table 1. The median age was 51 years (Q1–Q3 41–61), with 72 women (45%). The population had a median Body Mass Index (BMI) of 24.9 (22.2–28.3), a median initial Glasgow Coma Scale (GCS) of 14 (8–15), and a median ICU length of stay (LOS) of 14 days (6–22). The main reasons for ICU admission were non-traumatic subarachnoid hemorrhage (SAH, n=50), traumatic brain injury (TBI, n=35), and intracerebral hemorrhage (ICH, n=19).

Seven participants (4%) died during their ICU stay despite having previously regained active mobility.

Global Mobility Outcomes

Mobility data were collected for a total of 2,692 patient-days, with less than 1% missing data. The distribution of IMS scores across all observed days is shown in Figure 1. The overall median IMS was 1 (0–1). Out-of-bed mobilization occurred on 452 patient-days, representing 17% of all observed days.

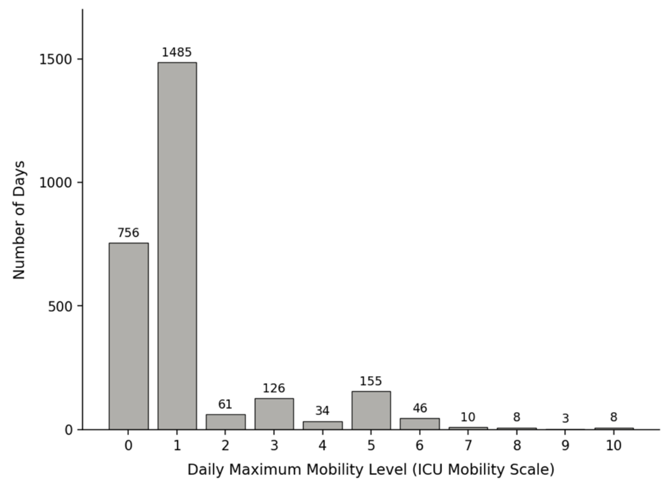

Figure 1 Mobility levels distribution

Regaining Active Mobility (IMS=1)

All 160 participants regained in-bed active mobility, which was a prerequisite for inclusion in the analysis. The median time from ICU admission to the first occurrence of IMS = 1 was 1 day (Q1–Q3 0–6).

Out-Of-Bed Mobility (IMS>1)

Overall, 122 participants (76%) achieved at least one OOB mobilization during their ICU stay. Among these, the median number of OOB days was 2 (Q1–Q3 1–4). The median time from first in-bed active mobility (IMS = 1) to the first OOB mobilization was 4 days (2–7) (See Supplemental File).

Maximal Level of Mobility

The median maximal IMS achieved during the ICU stay was 5 (Q1–Q3 3–5), corresponding to an active transfer from bed to chair. Among the 122 participants who achieved at least one OOB mobilization, this maximal level was reached within a median of 0 days (0–4) following the first OOB mobilization.

Of the 115 participants who achieved OOB mobility and survived their ICU stay, discharge from the ICU occurred a median of 3 days (1–6) after

Table 1 Participant's characteristics according to reason for admission

Variable	SAH (n=50)	TBI (n=35)	ICH (n=19)	BT (n=17)	IS (n=13)	Other* (n=26)	*p value*
Age	52 (40-60)	46 (27-57)	55 (34-64)	54 (48-63)	59 (48-66)	50 (46-60)	0.08†
Female sex, n (%)	34 (68)	5 (14)	7 (37)	8 (47)	4 (31)	14 (54)	**<0.01‡**
BMI	25 (22-29)	25 (22-28)	23 (22-27)	25 (23-34)	25 (25-28)	25 (22-31)	0.59†
ASA score	2 (1-2)	2 (1-2)	1 (1-3)	2.5 (2-3)	2 (2-3)	2 (2-3)	0.62†
GCS initial	15 (14-15)	8 (6-13)	12 (11-15)	14 (11-15)	13 (10-14)	15 (8-15)	**<0.01†**
DMV	0 (0-3)	7 (1-24)	3 (0-8.5)	0 (0-7.5)	0 (0-6)	0 (0-5)	**<0.01†**
ICU LOS	17 (9-21)	15 (7-28)	10 (6-19)	15 (7-28)	10 (5-14)	7 (3-18)	0.06†

Data are median (Q1-Q3)
Bold indicates significant differences between subgroups
ASA: American Society of Anesthesiologists
BMI: Body Mass Index
BT: Brain Tumor
DMV: Duration of Mechanical Ventilation
GCS: Glasgow Coma Scale
ICH: Intracerebral Hemorrhage
ICU: Intensive Care Unit
IS: Ischemic Stroke
LOS: Length of Stay
SAH: Subarachnoid Hemorrhage
TBI: Traumatic Brain Injury
*: intracranial infection; chronic subdural hematoma; spine surgery
†: Kruskal-Wallis Test
‡: Chi-square test

Table 2 Mobility outcomes according to reason for admission

Variable	SAH (n=50)	TBI (n=35)	ICH (n=19)	BT (n=17)	IS (n=13)	Other* (n=26)	*p value*
OOB during stay, n (%)	43 (88)	24 (69)	17 (90)	12 (71)	11 (85)	15 (58)	**<0.01º**
Number of OOB days	3 (1-5)	2 (0-3)	1 (0-2)	1 (0-2)	2 (1-4)	1 (0-3)	**<0.01†**
IMS max during stay	5 (3-6)	3 (1-5)	5 (3-5)	3 (1-4)	5 (3-5)	3 (1-5)	**<0.05†**
Days from:							
- Admission to IMS=1	0 (0-1)	6 (1-16)	1 (0-5)	0 (0-4)	0 (0-1)	1 (0-3)	**<0.01†**
- IMS=1 to IMS>1	3 (2-8)	5 (4-6)	4 (3-7)	3 (1-6)	4 (4-6)	3 (2-5)	0.58†
- IMS>1 to IMS max	3 (0-7)	0 (0-2)	0 (0-1)	0 (0-1)	2 (0-5)	1 (0-2)	**<0.05†**
- IMS max to discharge	3 (1-8)	3 (2-5)	2 (0-6)	3 (0-13)	2 (0-3)	4 (1-7)	0.36†

Data are median (Q1-Q3)
Bold indicates significant differences between subgroups
BT: Brain Tumor
ICH: Intracerebral Hemorrhage
ICU: Intensive Care Unit
IMS: ICU Mobility Scale
IS: Ischemic Stroke
OOB: Out of Bed
SAH: Subarachnoid Hemorrhage
TBI: Traumatic Brain Injury
*: intracranial infection; chronic subdural hematoma; spine surgery
†: Kruskal-Wallis Test
º: Fisher exact test

the first day on which maximal mobility was achieved. For 69 participants (60%), the maximal mobility level was reached or maintained on the day of ICU discharge, or the day preceding it.
Detailed mobility outcomes stratified by reason for ICU admission are presented in Table 2.

Factors Associated with achieving OOB mobilization

In the univariate analysis, participants admitted for SAH or ICH were significantly more likely to achieve at least one OOB mobilization during their ICU stay. These associations remained significant in multivariate logistic regression analysis (Table 3), with odds ratios of 4.54 (95% CI 1.49–18.07) for SAH and 6.04 (95% CI 1.26–45.17) for ICH.

Factors Associated with time to first OOB mobilization

No significant difference was observed in the time between regaining in-bed active mobility (IMS = 1) and the first OOB mobilization across admission subgroups.
In the multivariate analysis (Table 4), a higher GCS score at admission was associated with a shorter time to OOB mobilization [JR3.1](OR 1.07; 95% CI 1.01–1.13). In contrast, a longer ICU length of stay was associated with a longer delay to OOB mobilization (OR 0.98; 95% CI 0.96–0.99). A trend toward longer delays was also observed in females and in participants admitted for SAH; these variables were correlated in the study population.

Table 3 Logistic regression to explain probability of out of bed mobilization

	Univariate analysis		Multivariate analysis	
Variables	OR (95% CI)	*p value*	OR (95% CI)	*p value*
Age	1.00 (0.98-1.03)	0.71	1.01(0.98-1.04)	0.55
Sex (Female)	1.04 (0.50-2.21)	0.91	0.79 (0.32-1.95)	0.61
BMI	1.02 (0.96-1.09)	0.60	–	–
ASA score	0.94 (0.67-1.36)	0.74	–	–
GCS initial	0.98 (0.89-1.07)	0.67	0.99 (0.87-1.11)	0.82
ICU LOS	1.06 (1.02-1.10)	**<0.001**	1.05 (1.01-1.10)	**<0.05**
DMV	1.01 (0.99-1.04)	0.59	–	–
Reason for admission				
SAH	5.26 (1.71-17.70)	**<0.001**	4.54 (1.49-18.07)	**<0.05**
IS	4.03 (0.85-29.59)	0.11	3.47 (0.68-26.72)	0.17
ICH	6.23 (1.29-44.65)	**<0.05**	6.04 (1.26-45.17)	**<0.05**
BT	1.76 (0.49-6.89)	0.40	1.48 (0.37-6.23)	0.58
TBI	1.60 (0.56-4.66)	0.38	1.08 (0.31-3.64)	0.97

Data are median (Q1-Q3)
Bold indicates significant differences between subgroups
ASA: American Society of Anesthesiologists
BMI: Body Mass Index
BT: Brain Tumor
CI95: 95% Confidence Interval
DMV: Duration of Mechanical Ventilation
GCS: Glasgow Coma Scale
ICH: Intracerebral Hemorrhage
ICU: Intensive Care Unit
IS: Ischemic Stroke
LOS: Length of Stay
OR: Odds Ratio
SAH: Subarachnoid Hemorrhage
TBI: Traumatic Brain Injury

Table 4 Cox regression to explain time from $IMS = 1$ to $IMS > 1$

	Univariate analysis		Multivariate analysis	
Variables	HR (95% CI)	*p value*	HR (95% CI)	*p value*
Age	1.01 (0.99-1.02)	0.10	1.01 (0.99-1.02)	0.12
Sex (Female)	0.83 (0.57-1.19)	0.31	0.67 (0.43-1.04)	0.08
BMI	1.01 (0.99-1.04)	0.31	–	–
ASA score	1.02 (0.89-1.18)	0.78	–	–
GCS initial	1.06 (1.01-1.11)	**<0.05**	1.07 (1.01-1.13)	**<0.05**
ICU LOS	0.98 (0.96-0.99)	**<0.01**	0.98 (0.96-0.99)	**<0.01**
DMV	0.98 (0.97-0.99)	**<0.05**	–	–
Reason for admission				
SAH	0.67 (0.37-1.22)	0.19	0.56 (0.30-1.06)	0.08
IS	0.69 (0.32-1.51)	0.35	0.53 (0.23-1.22)	0.13
ICH	0.81 (0.40-1.62)	0.54	0.59 (0.28-1.22)	0.15
BT	0.66 (0.30-1.46)	0.31	0.84 (0.37-1.88)	0.67
TBI	0.65 (0.34-1.25)	0.20	0.76 (0.37-1.56)	0.46

Bold indicates significant differences between subgroups
ASA: American Society of Anesthesiologists
BMI: Body Mass Index
BT: Brain Tumor
CI95: 95% Confidence Interval
DMV: Duration of Mechanical Ventilation
GCS: Glasgow Coma Scale
HR: Hazard Ratio
ICH: Intracerebral Hemorrhage ICU: Intensive Care Unit
IS: Ischemic Stroke
LOS: Length of Stay
IMS: ICU Mobility Scale
SAH: Subarachnoid Hemorrhage
TBI: Traumatic Brain Injury

Discussion

Key findings

In this single-center retrospective observational study, mobility levels were recorded over 2,692 patient-days in 160 participants. The median IMS was 1 (Q1–Q3 0–1). Out-of-bed mobilization, defined as IMS>1, occurred on 452 days (17%) and was achieved by 122 participants (76%) after a median of 4 days (2–7) after the first active in-bed mobility. The median maximal IMS reached during the ICU stay was 5 (3–5).

Comparison with previous studies

The majority of observed mobility days corresponded to the low mobility levels, with IMS scores of 0–1 accounting for 82% of observations. This finding is consistent with previous ICU studies reporting globally low mobility levels [12, 13].

In our study, the time between the first active in-bed mobilization and the first out-of-bed mobilization was 4 days (Q1–Q3 2–7), which is in line with comparable studies [12, 14]. These findings are noteworthy, as longer delays might be expected in critically ill individuals in the neurosurgical ICU due to specific concerns such as impaired consciousness, agitation, elevated intracranial pressure, or the presence of external ventricular drainage.

Our results help address the existing gap in recommendations for early mobilization in this specific population [9]. Current guidelines advocate for early mobilization within 24 h following TBI or intracerebral hemorrhage, and within 24–48 h after aneurysmal subarachnoid hemorrhage. However, these recommendations provide limited guidance regarding mobilization intensity, as "early mobilization" generally refers to progressive, protocolized mobility. The only explicit recommendation concerns non-traumatic subarachnoid hemorrhage, for which out-of-bed mobilization should be initiated 48 h after aneurysm treatment, provided that intracranial pressure is controlled, external ventricular drainage is secure, and symptomatic vasospasm is absent. In our study, participants were mobilized out of bed after a median of 3 days (Q1–Q3 2–8) following the recovery of active mobility. This observation aligns with existing recommendations and supports recent evidence [15] suggesting that early mobilization remains controversial due to potential risks related to vasospasm and delayed cerebral ischemia.

Finally, the median maximal mobility level observed in our cohort (IMS 5, Q1–Q3 3–5) appears substantially lower than that reported in non-neurological ICUs [12, 13, 14]. An IMS ≥ 8 at ICU discharge has been proposed as a predictor of discharge to home [16], yet this level of mobility was observed in fewer than 1% of patient-days in our study. This difference is likely attributable to neurological impairments affecting both motor and cognitive functions, in addition to common ICU-related complications such as ICU-acquired weakness.

Clinical implications

The delay between regaining active mobility and the first OOB did not significantly differ across pathology subgroups, with a median of 4 days (Q1–Q3 2–7). However, multivariable analysis suggested a trend toward longer delays in participants with SAH. This finding is likely related to vasospasm and the constraints imposed by its monitoring and treatment. Nevertheless, the median delay in the SAH subgroup remained short, at 3 days (Q1–Q3 2–8), suggesting that early mobilization before the onset of vasospasm may be feasible in carefully selected individuals.

Overall, these results support the applicability of progressive early mobilization across neurological pathologies, with relatively uniform implementation when appropriate safety criteria are met. In this context, we encourage the systematic use of the safety checklist proposed in the guidelines by Olkowsky et Shah [9].

A decrease in maximal IMS was observed in 46 participants (40%) prior to ICU discharge, as the highest level of mobility achieved during the ICU stay was not achieved again in the 48 hours preceding discharge. In some cases, this decline may reflect secondary clinical deterioration occurring later during the ICU stay. However, it is also likely to be partly attributable to organizational factors, such as limited ICU resources or suboptimal interdisciplinary coordination. These findings highlight that the organization and continuity of early mobilization programs should be a specific focus in ICU settings to ensure consistent implementation and to allow individuals to fully benefit from their maximal functional capacities [17, 18].

Study limitations

No *a priori* sample size calculation was performed, which may have affected the statistical power of the study. In addition, the study sample excluded individuals with the lowest level of mobility (IMS 0). This exclusion should be considered when interpreting the results, as it likely leads to an underestimation of the overall severity of mobility impairment in individuals in the neurosurgical ICU.

The use of the maximal mobility level achieved during the ICU stay also represents a potential limitation. Although this metric may better reflect functional potential than mobility at ICU transfer, which can be influenced by logistical or organizational constraints, it does not capture temporal fluctuations in mobility or episodes of secondary clinical deterioration. As a result, maximal IMS may overestimate functional status in a subset of participants.

Furthermore, the absence of detailed reporting on factors specific to participants with acquired brain injuries may limit the interpretation of mobility outcomes. Variables such as polytrauma, the presence of external ventricular drainage, vasospasm, or cognitive impairments could have provided a more comprehensive understanding of determinants of mobility.

Finally, post hoc subgroup analyses should be interpreted with caution. These analyses were exploratory in nature, and the performance of multiple comparisons increases the risk of type I error.

Perspectives

Future research should aim to better identify the determinants of mobility outcomes in more homogeneous neurosurgical ICU populations. A more detailed characterization of modifiable and non-modifiable factors would improve the understanding of mobility trajectories and help tailor mobilization strategies to specific individual profiles.

The prognostic value of mobility outcomes in individuals in the neurosurgical ICU warrants further investigation. Demonstrating associations with functional recovery, discharge destination, and long-term outcomes would enhance the clinical relevance of mobility assessment in this population and contribute to a better understanding of the effects of early mobilization on recovery.

Finally, well-designed efficacy studies are needed to better evaluate the impact of early mobilization in individuals in the neurosurgical ICU. Assessing its effects on functional outcomes, complications, and recovery trajectories would help define optimal timing, intensity, and individual selection.

Conclusion

In this retrospective observational study of 160 individuals in the neurosurgical ICU who regained active mobility, median IMS was 1 (Q1–Q3 0–1) over 2,692 patient-days. Out-of-bed mobilization was achieved by 76% of participants within a median of 4 days (2–7). Future studies in this population should investigate determinants of mobility, the prognostic value of mobility outcomes, and the effects of early mobilization on recovery.

Statement and declaration

Authors' contribution

HDN: Conceptualization; Methodology; Investigation; Formal Analysis; Writing Original Draft
AL: Investigation; Writing Original Draft
CC: Investigation; Writing Original Draft
VD: Supervision; Conceptualization; Methodology
AJ: Supervision; Conceptualization; Methodology; Formal Analysis; Writing Original Draft
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Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Competing Interests

The authors declare that they have no conflicts of interest.

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