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Functional Independence Through Compensatory Neurorehabilitation in a Young Adult After Severe Intracerebral Hemorrhage: A Case Report

[1]Ani Purwati*, [2]Farida Arisanti, [3]Dian Marta Sari
[1]Physical medicine and rehabilitation department, Hasan Sadikin General Hospital, Faculty of Medicine, Universitas Padjadjaran, Bandung*, Indonesia, email: anipurwati21@gmail.com
[2] Physical medicine and rehabilitation department, Hasan Sadikin General Hospital, Faculty of Medicine, Universitas Padjadjaran, Bandung, Indonesia; email: ridasanti78@gmail.com
[3] Physical medicine and rehabilitation department, Padjadjaran Teaching Hospital, Faculty of Medicine, Universitas Padjadjaran, Bandung, Indonesia, email: dr.dianrw@gmail.com
*Correspondence

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Abstract
Introduction: *Intracerebral hemorrhage (ICH) in young adults is associated with high morbidity and often involves extensive lobar bleeding requiring surgical intervention. Despite greater age-related neuroplasticity, functional recovery after craniotomy can vary, and rehabilitation outcomes in this population remain underreported* ***Objective:*** *To describe functional recovery following a structured rehabilitation program in a young adult after severe ICH and craniotomy* ***Methods:*** *A 39-year-old man with a large left frontotemporoparietal ICH with intraventricular extension underwent emergency craniotomy and hematoma evacuation. Two months later, he presented with severe right hemiplegia (Brunnstrom I), shoulder subluxation, poor functional speech, and total dependence in daily activities (Barthel Index 40/100). A 4-week goal-directed rehabilitation program was implemented, including endurance training, mobility control, compensatory use of the unaffected limb, cognitive stimulation, and caregiver education* ***Results and Discussion:*** *After 4 weeks, the patient achieved independent bed-to-sit transfers, increased unsupported sitting tolerance (10 to 60 minutes), partially comprehensible speech, and improved ADL independence using compensatory strategies. Barthel Index improved to 65/100; Brunnstrom stages improved (right 2–3; left 2–5).* ***Conclusion:*** *Meaningful functional gains can be achieved through endurance-focused and compensatory rehabilitation, even when motor recovery is limited.*

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Introduction

Intracerebral haemorrhage (ICH) accounts for approximately 15-20% of all stroke cases and remains associated with higher mortality and greater risk of long-term disability compared with ischaemic stroke (van Nieuwenhuizen *et al*., 2020). Survivors frequently experience persistent motor deficits, communication impairment, and reduced ability to perform activities of daily living (ADLs) (Egger *et* al., 2026). Despite advances in acute medical and neurosurgical management, functional recovery after severe ICH remains limited for many patients, and long term dependency is common.

Although ICH predominantly affects older adults, up to 10-14% of strokes are said to occur in individuals younger than 50, with an increasing number of cases being reported in low- and middle-income countries (Nehme & Li, 2026). Younger patients generally have fewer comorbidities and greater neuroplastic potential. However, functional outcomes in young adults with extensive lobar hemorrhage and intraventricular extension remain highly variable. In cases requiring craniotomy, survival may improve, but neurological deficits often persist (Zhang *et al*., 2021).

Motor recovery after ICH is strongly influenced by lesion characteristics and corticospinal tract (CST) integrity (Yasukawa, Uchiyama, Koyama, & Domen, 2025). Large cortical-subcortical involvement increases the likelihood of sustained motor impairment (Yasukawa *et al*., 2025). At the same time, recovery trajectories are not determined solely by impairment level restitution. Contemporary neurorehabilitation models emphasize task-oriented training and compensatory strategies to optimize activity and participation outcomes Early, structured rehabilitation is recommended to improve independence, prevent secondary complications, and enhance social reintegration (Kharchenko *et al*., 2025).

Evidence supporting rehabilitation effectiveness after stroke continues to expand (Lee, Choi, & Jeoung, 2022; Okuda & Aoike, 2021). However, detailed reports describing structured neurorehabilitation in young adults with severe ICH following surgical management remain limited. In particular, there is insufficient literature examining how compensatory strategies and endurance-focused activity training may support ADL independence when voluntary motor recovery is minimal.

This report describes a dissociation between persistent motor impairment and meaningful functional improvement over a nine-month follow up in a young adult with severe intracerebral hemorrhage. Early CT findings were used to anticipate limited corticospinal recovery and to guide rehabilitation goal setting. Based on this prognostic consideration, the rehabilitation strategy shifted early toward activity-level training and compensatory approaches. The longitudinal observation highlights how imaging findings and functional assessment can be integrated to support individualized neurorehabilitation planning. This case report was prepared in accordance with the CARE guidelines.

Case Report

Case Presentation

A 39-year-old male presented with sudden loss of consciousness due to spontaneous left frontotemporoparietal ICH and intraventricular hemorrhage (IVH) due to hypertension. CT imaging revealed extensive hematoma with ventricular extension and bilateral lacunar infarcts. Emergency craniotomy, decompression, and hematoma evacuation were performed within 12 hours of onset. The large left frontotemporoparietal intracerebral hemorrhage with intravetricular extension in CT imaging suggested

significant corticospinal tract involvement, indicating a poor prognosis for motor recovery.

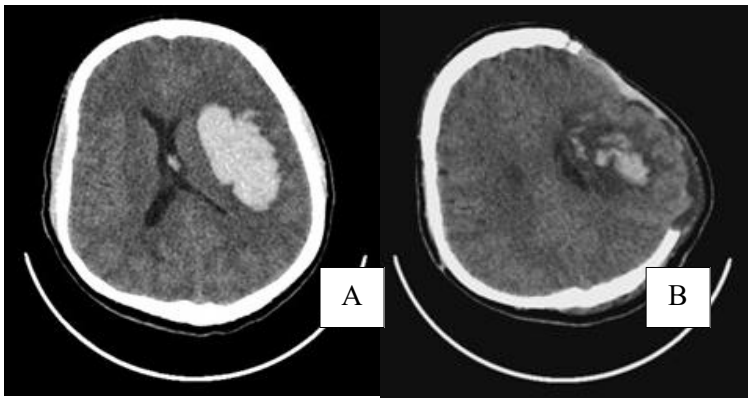

Figure 1. CT scan images. (A) Pre-operative, showing left frontotemporoparietal ICH and intraventricular extension. (B) Post-operative, after craniotomy, decompression and evacuation.

The patient was unconscious for 12 days and was discharged at 18 days post-onset with right hemiplegia (Brunnstrom stage 1, MMT 1/5), shoulder subluxation, unintelligible speech, and complete ADL dependency (Barthel Index 40/100).

Treatment

At two months post-onset, the patient was admitted to an inpatient postacute neurorehabilitation program due to persistent severe functional deficits. At admission, he demonstrated limited unsupported sitting tolerance (10 minutes), poor endurance, right hemiplegia (Brunnstrom stage 1; MMT 1/5), shoulder subluxation, dysarthric and partially unintelligible speech, and complete dependence in basic activities of daily living (Barthel Index 40/100).

Rehabilitation was delivered by a multidisciplinary team consisting of a physiatrist, physiotherapist, occupational therapist, and speech therapist. The program was conducted five days per week for four consecutive weeks, with each session lasting 90-120 minutes. Additional task-oriented practice was incorporated into daily nursing routines to enhance repetition and functional carryover. The timing and intensity of the program were aligned with evidence supporting structured post-acute rehabilitation following intracerebral hemorrhage (Ahmed, Liu, Nanavati, & Lin, 2024; Okuda & Aoike, 2021; Zheng, Zhu, Cadilhac, & Luo, 2025).

Goal setting

Goals were established collaboratively using a patient-centered approach guided by the International Classification of Functioning, Disability and Health (ICF) framework. Short-term goals included improving sitting tolerance, transfer ability, and initiation of self-care tasks. Long-term goals focused on maximizing independence in basic ADLs through compensatory strategies, improving functional communication, and ensuring caregiver competence in safe assistance. Functional progress was monitored using serial motor examination and the Barthel Index. This structured, goal-directed approach is

consistent with contemporary stroke rehabilitation guidelines emphasizing task-specific and measurable outcomes (Lee *et al*., 2022;).

Rehabilitation Intervention

The rehabilitation strategy emphasized a compensatory neurorehabilitation approach tailored to the patient's severe persistent hemiplegia. Interventions focused on task-specific training using the unaffected limb for ADLs, progressive sitting balance and transfer training to enhance trunk control and endurance, structured speech stimulation to improve functional communication, and caregiver-assisted practice to promote carryover outside therapy sessions. Functional independence was prioritized over motor restitution given the minimal voluntary motor recovery at this stage.

Results and Discussion

Outcome

Outcome were assessed using both clinician-reported measures such as Barthel Indeks, Brunnstrom stages, MOCA and patient-centered functional observations. After one month of the structured rehabilitation program, the patient achieved meaningful functional improvement despite the affected limbs. The patient achieved independence in bed-to-sit transfers, tolerated unsupported sitting from 10 to 60 minutes, improved partially intelligible speech, and performed basic ADLs independently using the left hand. Barthel Index increased to 65/100. The patient and family reported meaningful improvement in independence following rehabilitation. The patient expressed increased confindence in perfoming daily activities such as eating and dressing using the unaffected limb. Caregivers noted reduced physical assistance needs and improved communication ability, which facilitated better social interaction at home.

Figure 2. Functional task performance after rehabilitation demonstrating compensatory left-hand use and improved postural endurance. (A) Dressing. (B) Eating. (C) Sitting without support. (D) Standing-up.

Table 1

Clinical Course, Rehabilitation Gap, and Structured Intervention Timeline

Timeline	Event/Intervention	Clinical Status	Intervention	Findings	Clinical Significance
Day 0	Onset of ICH + IVH	Loss of consciousness	-	CT: left frontotemporoparietal ICH, IVH, lacunar infarcts	Extensive cortical-subcortical involvement
Hour 12	Craniotomy, decompression, evacuation	ICU	Emergency craniotomy, decompression, hematoma evacuation	Hematoma evacuated	Life saving surgical management
Day 1-18	Acute hospital stay	Unconscious to conscious	Acute medical stabilization	Persistent right hemiplegia, aphasia	Severe motor and language impairment
Day 19-59 (At home, pre-rehab)	Discharged from acute hospital; home care with family	Conscious, severe right hemiplegia, aphasia	No structured rehabilitation	Bedbound most of the time, limited sitting tolerance, fully dependent on caregiver for ADL; no structured rehabilitation yet	Prolonged inactivity; risk of deconditioning
Day 60	Rehab admission	Severe hemiplegia, poor endurance	Baseline rehabilitation assessment	Barthel 40/100	Severe functional dependency
Day 60-90 (Week 1-4 of rehab)	Intensive rehab program	Gradual improvement	5 session/week; 100 minutes/session; total 8 -9 hours/week: 40 min endurance and mobility 30 min ADL retraining 20 min speech/cognitive 10 min caregiver training and daily home program	Gradual improvement in sitting tolerance, transfer ability, speech	Early shift to activity level training
Month 6 (July 2025)	Follow-up evaluation	Improved mobility, ambulatory with quadripod	Outpatient review	Independent ADL; ambulation with quadripod; Brunnstrom LE 5, UE 3, Barthel 80-85	Functional independence despite limited UE recovery
Month 9 (September 2025)	Extended follow-up	Functional stabilization phase	Reassessment	Independent ADL, ambulation with quadripod + SAFO; MoCA 17/30; Barthel 85-90	Functional stabilization phase

Footnote: Outcomes assessed by attending physiatrist and multidisciplinary rehabilitation team.

Table 2
Impairment Level and Activity Level Outcomes Over 9 Months

Domain	Baseline	After 1 Month	July 2025 (6 Months)	September 2025 (9 Months)	Interpretation
Transfer Ability	Dependent	Independent	Independent	Independent	Functional mobility gained
Sitting tolerance	10 min	60 min	≥ 60 min	≥ 60 min	Improved endurance
Sitting to standing	unable	able with assist	Independent with device	Independent with device	Increase mobility level
Right UE	Brunnstrom 2	No change	Brunnstrom 3	Brunnstrom 3	Minimal motor recovery
Right LE	Brunnstrom 2	Brunnstrom 3	Brunnstrom 5	Brunnstrom 5	Favorable lower limb recovery
Ambulation	Unable	Unable	Short distance with quadripod	Quadripod + SAFO	Compensatory gait pattern
ADL (Barthel Index)	40/100	65/100	80 - 85	85 - 90	Functional independent achieved
Speech	Unintelligible	Partial functional speech	Functional communication	Functional communication	Communication recovery
MoCA Score	8/30	10/30	10/30	17/30	Delayed cognitive improvement

Discussion

The present case involved a large frontotemporoparietal hemorrhage with intraventricular extension, followed by surgical evacuation and a prolonged period of impaired consciousness. Lesions of this extent are consistently associated with unfavorable early motor outcomes, particularly when cortical motor areas and subcortical white matter tracts are affected. Intraventricular extension and large hematoma volume have repeatedly been identified as negative prognostic indicators, likely reflecting more extensive tissue disruption and secondary injury processes (Magid-Bernstein *et al*., 2022).

Motor recovery after intracerebral hemorrhage (ICH) is influenced by corticospinal tract (CST) integrity. In this patient, the persistence of Brunnstrom stage 1 in affected upper limb two months after onset suggests substantial CST involvement. Previous evidence indicates that corticospinal tract lesion load, when combined with baseline clinical severity, significantly improve outcome prediction in ICH patients. In cases with extensive CST damage, limited voluntary motor return and early plateau are commonly observed (Yasukawa *et al*., 2025).

Although decompressive surgery reduces mass effect and improves survival, it does not restore axonal continuity once descending pathways are structurally compromised (Yasukawa *et al*., 2025; Zhang *et al*., 2021). The persistent upper limb paralysis in this case therefore likely reflects underlying CST disruption rather than insufficient rehabilitation exposure. This interpretation is consistent with current mechanistic models of post-stroke motor recovery.

A notable feature of this case is clear dissociation between motor recovery and functional improvement. Despite minimal change at level particularly in upper limb motor function, the patient demonstrated a 25-point increase in the Barthel Index over a four-week rehabilitation period. Such improvement suggests that functional gains occurred primarily at the activity level rather than through restitution of motor impairment. Contemporary neurorehabilitation frameworks emphasize that meaningful independence can be achieved through compensatory strategies, task adaptation, and optimized use of preserved systems. In the present case, the unaffected limb was incorporated into self-care training, and environmental structuring facilitated safe task performance despite persistent hemiplegia (Xiong *et al*., 2025). The patient reported subjective improvement in independene and communication ability, particularly in perfoming self-care tasks using compensatory strategies.

From an International Classification of Functioning, Disability, and Health (ICF) perspective, recovery does not require parallel improvement across all domains. While body structure and function impairments remained largely unchanged, activity-level performance improved substantially. This dissociation represents the central clinical insight of the present report, functional independence can progress even when neurological motor restitution is limited. Such a pattern has been described in prior rehabilitation literature, in which activity-focused interventions yield measureable function gains despite stable impairment-level findings (Lee *et al*., 2022). The present case provides a practical illustration of this principle in a young adult with severe ICH.

At the initiation of rehabilitation, unsupported sitting tolerance was limited to approximately 10 minutes. This marked reduction likely reflected cardiovascular deconditioning following prolonged immobilization. Post-stroke reductions in aerobic capacity and orthostatic tolerance are well documented and are known to constrain participation in task-oriented therapy (Souza *et al*., 2024). Tilt-table sessions were

introduced early as a graded orthostatic adaptation strategy. Beyond facilitating safe verticalization, such interventions may support autonomic recalibration and improve tolerance to upright positioning. Progressive increases in unsupported sitting duration were then incorporated into functional task training. Improvements in standing tolerance and general endurance enabled longer engagement in grooming and feeding activities. In this context, endurance training functioned as a prerequisite for activity participation rather than as an isolated fitness goal. Current stroke rehabilitation recommendations emphasize aerobic conditioning as a key component of comprehensive recovery programs (Souza *et al*., 2024).

The functional gains observed in this case therefore likely reflect improved systemic capacity, which in turn permitted more sustained participation in daily tasks. Upper and lower limb recovery followed different trajectories in this patient. While upper extremity motor return remained minimal, the lower extremity demonstrated partial recovery sufficient to support assisted mobility training. The divergence may be explained by neuroanatomical organization of descending motor pathways. Distal upper limb function is highly dependent on intact corticospinal projections originating from lateral motor cortex regions. In contrast, lower extremity and axial control involve more bilateral and polysynaptic contributions, including reticulospinal pathways (Ruigrok, 2023).

When CST integrity is substantially compromised, upper limb recovery is therefore more limited. Whereas lower limb function may demonstrate partial compensatory improvement via alternative descending systems. This mechanistic distinction likely accounts for the observed plateau in upper extremity function alongside modest gains in mobility-related activities. Cognitive impairment was prominent during the early rehabilitation phase, with Montreal Cognitive Assessment (MoCA) scores improving from 8 to 17 over time. Although still below normative threshold, this change indicates measureable cognitive recovery beyond the acute stage. ICH-related cognitive deficits are often linked to frontal-subcortical circuit disruption and secondary injury processes (Magid-Bernstein *et al*., 2022; Mai, Joundi, Katsanos, Selim, & Shoamanesh, 2025). Emerging evidence suggests that functional recovery particularly in cognitive and participation domains, may continue beyond the early months, with measureable improvement reported between 3 and 12 months post-hemorrhage (Morotti *et al*., 2024).

In this case, structured cognitive stimulation and communication-oriented interventions were integrated into the rehabilitation program. Even modest cognitive gains appeared to facilitate improved engagement in therapy sessions and greater social interaction. Prior literature supports early integration of cognitive and language-focused therapy to enhance participation outcomes, even when motor recovery is limited (Brady, Myzoon, & Vandenberg, 2022). These findings suggest that cognitive recovery trajectories may extend beyond the period of motor plateau, underscoring the importance of continued stimulation and longitudinal follow up in young ICH survivors.

The rehabilitation approach in this case aligns with established clinical practice guidelines for stroke rehabilitaiton, which emphasize early, structured, task-oriented, and multidisciplinary interventions. The observed functional improvements support the effectiveness of these guideline-based strategies, even in cases with limited motor recovery.

Conclusion

This case demonstrates that meaningful functional independence may be achieved after severe intracerebral hemorrhage despite limited recovery of upper limb motor function. In this young adult with extensive lobar involvement and intraventricular extension, early imaging findings suggested substantial corticospinal tract compromise and a guarded prognosis for motor restitution. Recognizing this prognostic context, rehabilitation goals were strategically redirected towards activity-level training, endurance conditioning, and compensatory task adaptation rather than impairment-focused motor recovery alone.

Over nine months of follow up, sustained improvement in mobility, self-care performance, and communication was observed, while upper extremity motor return remained modest. This dissociation between motor impairment and functional outcome highlights the importance of early recognition of corticospinal tract injury and timely transition toward activity-focused rehabilitation strategies. Individualized, prognosis-informed neurorehabilitation planning may optimize participation and independence, even in cases of severe ICH with limited neurological restitution.

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