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Longitudinal Recovery After Arteriovenous Malformation-Related Hemorrhagic Stroke with Multidisciplinary Rehabilitation

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ABSTRACT

Recurrent hemorrhagic stroke caused by choroid plexus arteriovenous malformation (AVM) is exceptionally rare and frequently associated with severe neurological disability. We report a 22-year-old man in Georgia who developed recurrent intracerebral hemorrhage six years after prior Gamma Knife radiosurgery. Following emergency craniotomy and hematoma evacuation, he presented with right hemiparesis, dysarthria, dysphagia, cognitive impairment, and marked dependence in activities of daily living. A staged rehabilitation pathway included prolonged home-based therapy, structured multidisciplinary outpatient neurorehabilitation, and caregiver training. Functional status assessed by the Functional Independence Measure and Functional Assessment Measure (FIM+FAM) improved from 123 at rehabilitation initiation to 178 at follow-up. The patient regained substantial independence, resumed university studies, and successfully reintegrated into community life. This case demonstrates that meaningful long-term recovery after severe recurrent AVM-related stroke is achievable through timely surgery, coordinated multidisciplinary rehabilitation, and sustained family engagement, while highlighting the value of longitudinal functional outcome measurement in resource-limited healthcare systems.

KEYWORDS. Arteriovenous malformation; Caregiver training; Georgia; Hemorrhagic stroke; Stroke rehabilitation.

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INTRODUCTION

Hemorrhagic stroke in young adults is relatively uncommon and is frequently associated with structural cerebrovascular abnormalities, particularly cerebral arteriovenous malformations (AVMs). [1,2] AVMs involving the choroid plexus represent an exceptionally rare anatomical subtype reported only in limited clinical literature. [1] Rupture of such lesions may result in intracerebral hemorrhage with severe neurological deficits and long-term impairment affecting mobility, self-care, cognition, communication, and swallowing.[1,2]

Gamma Knife radiosurgery is an established treatment option for surgically challenging AVMs; however, hemorrhagic risk may persist until complete obliteration of the vascular nidus is achieved. [3,4] Recurrent hemorrhage following prior treatment therefore remains a clinically significant event that may markedly worsen functional prognosis and increase rehabilitation complexity. [2-4]

Coordinated multidisciplinary rehabilitation is a cornerstone of modern stroke care and has been consistently associated with improved functional recovery, independence, and community reintegration. [5-8] Active family caregiver participation may further strengthen continuity of therapy, particularly where formal long-term rehabilitation pathways remain limited, and families assume substantial responsibility for daily support. [9]

Georgia provides an informative example of a middle-income health system undergoing rehabilitation development. Recent policy reforms have expanded organized rehabilitation services, though access remains uneven, and specialist resources remain concentrated in major urban centers. [10-12] Within this context, we report a young adult with recurrent choroid plexus AVM-related hemorrhagic stroke who achieved marked long-term functional recovery following timely neurosurgical intervention, structured multidisciplinary rehabilitation, and sustained family engagement.

CASE

A 22-year-old male with a known history of choroid plexus arteriovenous malformation (AVM) was admitted in June 2022 after sudden severe headache followed by loss of consciousness. At age 16 (2016), he had experienced intraventricular hemorrhage secondary to AVM rupture, which was treated with

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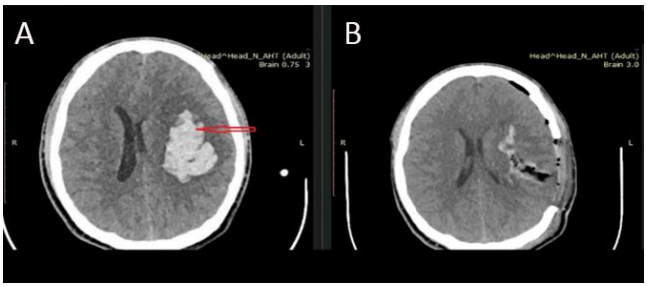
Gamma Knife radiosurgery. He subsequently remained neurologically stable for approximately six years.

Emergency non-contrast computed tomography (CT) of the brain demonstrated a large left parietotemporal intracerebral hemorrhage measuring approximately 45 mL, with intraventricular extension and an estimated 8 mm midline shift, indicating substantial mass effect. Emergency left craniotomy with hematoma evacuation was performed within 4 hours of symptom onset. Post-operative CT confirmed successful evacuation of the hematoma with reduction in mass effect (**FIG.1**).

FIGURE 1. Computed tomography scans of the brain



Explanations: (A) Pre-operative non-contrast CT demonstrating a large left parietotemporal intracerebral hemorrhage with intraventricular extension and midline shift. (B) Post-operative CT following emergency craniotomy showing hematoma evacuation and reduction of mass effect.

Following surgery, the patient remained in coma for approximately 14 days and subsequently required intensive and high-dependency medical care. He was discharged home in July 2022. Initial post-acute examination revealed right hemiparesis, dysarthria, mild dysphagia requiring dietary modification, cognitive impairment, and severe dependence in activities of daily living.

Given the severity of recurrent hemorrhagic stroke and marked neurological deficits, the early functional prognosis was guarded. Initial treatment goals included preventing complications, restoring safe swallowing, improving mobility, and improving communication and cognition to return to independence in daily activities.

As structured inpatient neurorehabilitation services were not readily available, a staged home-based rehabilitation program was initiated. In December 2023, the patient entered an intensive outpatient multidisciplinary rehabilitation program at Ken Walker University Clinic for Medical Rehabilitation. The treatment team included a rehabilitation physician, physiotherapist, occupational therapist, speech and language therapist, clinical psychologist, and neuropsychologist. Family caregivers received structured training to continue exercises, mobility practice, and repetition of functional tasks at home.

Functional recovery was assessed using the Functional Independence Measure and Functional Assessment Measure (FIM+FAM), a validated measure of motor, cognitive, communication, and psychosocial function in rehabilitation settings. [13] Assessments were performed at four time points: initiation of home-based rehabilitation (July 2022), admission to structured outpatient rehabilitation (December 2023), discharge from the intensive program (May 2024), and community follow-up (May 2025) (**TAB.1**).

TABLE 1. Functional recovery trajectory measured by Functional Independence Measure and Functional Assessment Measure (FIM+FAM)

Time point	Clinical phase	FIM+FAM score
July 2022	Initiation of home-based rehabilitation	123
December 2023	Admission to structured outpatient MDT rehabilitation	141
May 2024	Discharge from intensive outpatient MDT program	174
May 2025	Community follow-up	178

Abbreviations: FIM+FAM, Functional Independence Measure and Functional Assessment Measure; MDT, multidisciplinary team.

The FIM+FAM score improved progressively from 123 at rehabilitation initiation to 141 at outpatient admission, 174 at discharge, and 178 at follow-up, representing an absolute gain of 55 points. Clinically meaningful improvements were observed in mobility, self-care, communication, cognition, and swallowing. By the final follow-up, the patient had regained substantial independence in everyday activities, resumed university studies, and successfully reintegrated into community life (**FIG.2**).

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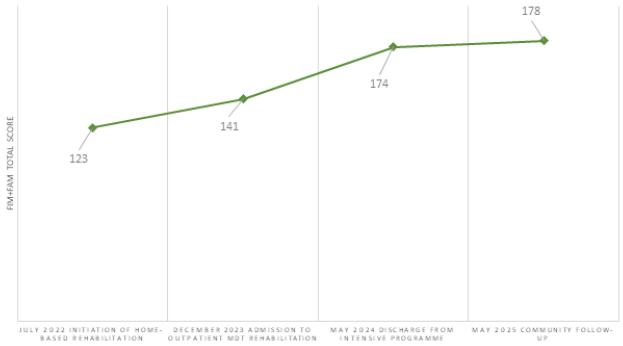
FIGURE 2. Functional recovery trajectory based on sequential Functional Independence Measure and Functional Assessment Measure (FIM+FAM) scores across rehabilitation phases



Overall, the rehabilitation trajectory demonstrated sustained gains from severe post-stroke dependence to near-complete functional independence. The combination of timely neurosurgical management, structured multidisciplinary rehabilitation, and active family participation appeared central to the favorable long-term outcome.

DISCUSSION

This case is noteworthy because it combines three uncommon and clinically important elements: recurrent hemorrhagic stroke caused by a rare choroid plexus arteriovenous malformation (AVM), severe initial neurological impairment, and substantial long-term recovery despite an initially guarded prognosis. The patient presented with large-volume intracerebral hemorrhage, intraventricular extension, prolonged coma, hemiparesis, dysphagia, cognitive dysfunction, and marked dependence in activities of daily living. Such features are commonly associated with poor neurological outcomes. [2] Nevertheless, functional status improved progressively from a FIM+FAM score of 123 to 178, representing a transition from severe dependence to near-complete independence.

The rarity of recurrent hemorrhage after prior radiosurgical treatment further increases the clinical relevance of this report. AVMs are a recognized cause of hemorrhagic stroke in younger adults, while choroid plexus AVMs remain particularly uncommon lesions described mainly in isolated reports. [1,2] Gamma Knife radiosurgery is an established treatment option for surgically challenging AVMs; however, hemorrhage risk may persist until complete obliteration of the nidus is achieved. [3,4] This case therefore reinforces the importance of long-term neurological follow-up after treatment of complex AVMs. The rehabilitation trajectory is equally noteworthy.

During the prolonged home-based phase, functional gains were modest, whereas a more pronounced improvement was observed during the subsequent intensive outpatient multidisciplinary phase. During the home-based rehabilitation phase, the FIM+FAM score improved by 18 points, whereas a further 33-point gain occurred following admission to structured multidisciplinary rehabilitation over approximately five months. This pattern is consistent with existing evidence that coordinated stroke rehabilitation, adequate therapy intensity, goal-directed practice, and interdisciplinary management improve recovery in mobility, self-care, communication, and participation. [6-8,13,14] Although spontaneous neurological recovery and younger age may have contributed, the temporal association between organized rehabilitation and accelerated functional gains is clinically persuasive.

Published reports of AVM-related hemorrhagic stroke have predominantly focused on acute neurosurgical management, hemorrhage control, and radiological outcomes, whereas detailed longitudinal rehabilitation trajectories are reported far less frequently. Functional recovery is often described narratively, without serial standardized outcome measures or extended community follow-up. In this context, the present case adds clinically relevant evidence by documenting sequential improvement in FIM+FAM across multiple rehabilitation phases, culminating in a return to university studies and successful community reintegration. The report is further strengthened by its setting within a middle-income health system undergoing rehabilitation development, where coordinated multidisciplinary care and caregiver involvement may be especially influential.

Another important message concerns the role of family caregivers. In many health systems with limited long-term rehabilitation capacity, family members become the practical extension of the rehabilitation team. Caregiver training in this case supported

continuation of exercises, task-oriented practice, and reinforcement of therapeutic goals between formal sessions. The existing literature suggests that caregiver-mediated rehabilitation may enhance patient outcomes when accompanied by adequate education and professional guidance. [9] This case supports that view.

Beyond the individual patient outcome, the report also has health-system relevance. Comparative analyses using the World Health Organization Systematic Assessment of Rehabilitation Situation framework indicate that many middle-income countries continue to face structural barriers to the integration of rehabilitation, including workforce shortages, fragmented financing, and uneven geographic access. [10-12] This case illustrates what may be achievable when organized multidisciplinary rehabilitation services become available within an emerging health system.

Several limitations should be acknowledged. As a single case report, causal relationships between specific interventions and outcome cannot be definitively established. Recovery may partly reflect natural neurological improvement, patient motivation, family support, and the favorable influence of younger age. [13] Nevertheless, detailed longitudinal functional documentation offers meaningful clinical insight into recovery after severe recurrent AVM-related hemorrhagic stroke.

Overall, this case corroborates current evidence that timely acute management followed by structured multidisciplinary rehabilitation can substantially improve stroke outcomes. It further adds that even rare and severe recurrent AVM-related stroke in a young adult may be followed by excellent long-term recovery when specialist rehabilitation and sustained family engagement are available.

CONCLUSIONS

Severe recurrent choroid plexus arteriovenous malformation (AVM)-related hemorrhagic stroke does not necessarily result in permanent profound disability. This case demonstrates that timely neurosurgical intervention followed by coordinated multidisciplinary rehabilitation and sustained family caregiver participation may lead to substantial long-term functional recovery, even after major neurological injury.

Beyond the individual clinical outcome, this report highlights the importance of accessible, structured rehabilitation services within middle-income health systems, where organized multidisciplinary care may significantly influence independence, participation, and community reintegration after stroke.

Clinicians should consider early referral to rehabilitation, active caregiver education, and continuity of therapy across care settings. Further research should examine how multidisciplinary rehabilitation pathways and family-supported practice may optimize outcomes after severe stroke in resource-constrained settings.

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SUPPLEMENTARY MATERIALS

N/A

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INFORMED CONSENT

Written informed consent was obtained from the patient and family caregivers for publication of this anonymized case report, including relevant clinical information and imaging. All reasonable efforts were made to protect patient identity and confidentiality.

REFERENCES

1. Zhao P, Maragkos GA, Livingstone KS, Kearns KN, Park MS. Choroid plexus arteriovenous malformations: a systematic review. J Cerebrovasc Endovasc Neurosurg. 2023;25(4):373-379. doi:10.7461/jcen.2023.E2023.02.002.
2. Burkhardt JK, Fröhlich S, Rohde V. Surgical management of cerebral arteriovenous malformations. Curr Opin Neurol. 2017;30(6):597-606. doi:10.1097/WCO.0000000000000486.
3. Karlsson B, Lax I, Söderman M. Risk for hemorrhage during the 2-year latency period following Gamma Knife radiosurgery for arteriovenous malformations. Int J Radiat Oncol Biol Phys. 2001;49(4):1045-1051. doi:10.1016/S0360-3016(00)01432-2.
4. Maruyama K, Kawahara N, Shin M, Tago M, Kishimoto J, Kurita H, Kawamoto S, Morita A, Kirino T. The risk of hemorrhage after radiosurgery for cerebral arteriovenous malformations. N Engl J Med. 2005;352(2):146-153. doi:10.1056/NEJMoa040907.
5. Langhorne P, Bernhardt J, Kwakkel G. Stroke rehabilitation. Lancet. 2011;377(9778):1693-1702. doi:10.1016/S0140-6736(11)60325-5.
6. Pollock A, Baer G, Campbell P, Choo PL, Forster A, Morris J, Pomeroy VM, Langhorne P. Physical rehabilitation approaches for the recovery of function and mobility after stroke. Cochrane Database Syst Rev. 2014;(4):CD001920. doi:10.1002/14651858.CD001920.pub3.
7. Winstein CJ, Stein J, Arena R, Bates B, Cherney LR, Cramer SC, Deruyter F, Eng JJ, Fisher B, Harvey RL, Lang CE, MacKay-Lyons M, Ottenbacher KJ, Pugh S, Reeves MJ, Richards LG, Stiers W, Zorowitz RD. Guidelines for adult stroke rehabilitation and recovery. Stroke. 2016;47(6):e98-e169. doi:10.1161/STR.0000000000000098.
8. Veerbeek JM, van Wegen E, van Peppen R, van der Wees PJ, Hendriks E, Rietberg M, Kwakkel G. What is the evidence for physical therapy poststroke? A systematic review and meta-analysis. PLoS One. 2014;9(2):e87987. doi:10.1371/journal.pone.0087987.
9. Bakas T, Clark PC, Kelly-Hayes M, King RB, Lutz BJ, Miller EL. Evidence for stroke family caregiver and dyad interventions. Stroke. 2014;45(9):2836-2852. doi:10.1161/STR.0000000000000033.
10. Kleinitz P, Sabariego C, Llewellyn G, Madden RH, Meyer T, Gutenbrunner C, Reinhardt JD. Integrating rehabilitation into health systems: a comparative study of nine middle-income countries using WHO's Systematic Assessment of Rehabilitation Situation (STARS). PLoS One. 2024;19(2):e0297109. doi:10.1371/journal.pone.0297109.
11. World Health Organization Regional Office for Europe. Georgia adopts its first national rehabilitation strategy. World Health Organization Regional Office for Europe. Published 2023. Accessed April 22, 2026. https://www.who.int/europe.
12. Aladashvili G, Kirvalidze M, Tskitishvili A, Chelidze N, Tvildiani N, Pkhakadze G, Bossert TJ, Lunze K, Nadareishvili I. Strengthening health workforce in Georgia: identifying gaps and integrating evidence-based strategic planning. Int J Health Plann Manage. 2025;40(4):993-1001. doi:10.1002/hpm.3922.
13. Teasell R, Hussein N, Foley N, Cotoi A, Sequeira K, Meyer M, Yao J, Richardson M, Allen L, Salter K. Evidence-based review of stroke rehabilitation. Top Stroke Rehabil. 2014;21(6):463-488. doi:10.1310/tsr2106-463.
14. Lohse KR, Lang CE, Boyd LA. Is better? Using metadata to explore dose-response relationships in stroke rehabilitation. Stroke. 2014;45(7):2053-2058. doi:10.1161/STROKEAHA.114.004695.