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Case Report

# Successful Rehabilitation Outcomes in a 93 Years Oldest-Old Patient after Left ACA and MCA Infarction: A Case Report

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# 93세의 초고령 좌측 전대뇌동맥, 중대뇌동맥 뇌경색 환자에 대한 초기 집중재활치료의 성공적인 재활 결과: 증례 보고서

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**Abstract**

As the geriatric population grows rapidly, the incidence of stroke is high in the elderly (age > 65 years) and peaks in the oldest old (age > 85 years). However, there is conflicting evidence regarding the effectiveness of rehabilitation in the oldest old stroke patients. We report the case of a 93-year-old man with hemiplegia, cognitive impairment, aphasia, and dysphagia after acute stroke. The patient underwent rehabilitation evaluation within 48 hours of disease onset and started early mobilization. After being transferred to the Department of Rehabilitation Medicine, he underwent eccentric biased strengthening exercises and customized treatment to prevent complications. After 4 months of intensive inpatient rehabilitation, his functional level (FIM total from 25 to 51), aphasia (AQ score from 5.9 to 12.4), and dysphasia improved. He could independently walk to the toilet using an anterior walker. Although aging progression is associated with reduced effectiveness of rehabilitation treatment, our case report suggests that early multidisciplinary intensive inpatient rehabilitation may bring significant functional benefits to the oldest-old population.

**Key Words**

Aged, 80 and over, Rehabilitation, Functional status

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## Introduction

Worldwide, the population over 65 is growing faster than any other age group. One in six people in the world will be over 65 (16%) by 2050, up from one in 11 in 2019 (9%).[1] Traditionally, the United Nations has used measures and indicators of population aging based largely or entirely on people's chronological age, defining older persons as those aged 60 or 65 or over.[2] As the oldest-old peoples represent the fastest growing population in developed countries, this group is further subdivided for both healthcare and research purposes: young-old ages 65-74, old-old ages 75-84, and oldest-old age 85 or older.[3] Age is the most significant non-modifiable risk factor for stroke. Stroke incidence increases progressively with age in people over 85.[4] Moreover, major geriatric problems, such as frailty, falls, osteoporosis, sarcopenia, and gait disturbance, are more prevalent and severe than in older adults over 85 years.[5] Owing to these characteristics in this population, the effectiveness of rehabilitation in oldest-old stroke patients remains controversial and conflicting evidence exists.

However, many studies demonstrated clear benefits of rehabilitation for functional recovery in the oldest-old patients. Intensive inpatient rehabilitation in stroke patients over 65 years can produce significant functional gains. In the parameters of cognitive tests and functional scores by Functional Independence Measure (FIM), there was no significant difference between the group in patients over 85 years and in the 75 to 84 groups. Along with the rehabilitation program, comprehensive geriatric assessment and specific modalities for older adults are important to maximize treatment effectiveness and could improve patients' functional recovery.[6-9] To expand the database in this area, we report successful rehabilitation outcomes in an oldest-old patient after left anterior cerebral artery and middle cerebral artery infarction who showed marked improvement in functional status, cognitive impairment, aphasia, and dysphagia after early intensive inpatient rehabilitation.

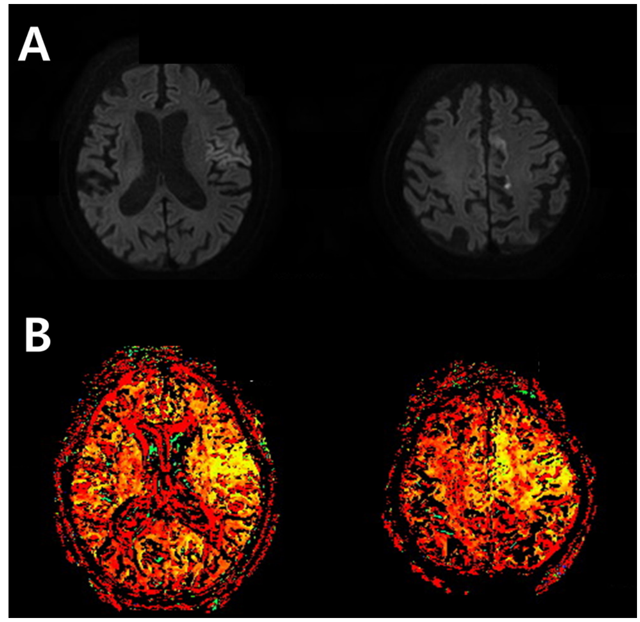


**Fig. 1.** Initial magnetic resonance imaging after ischemic stroke. (A) Axial diffusion-weighted imaging demonstrating diffusion restriction in the left anterior cerebral artery (ACA) and middle cerebral artery (MCA) territories. (B) Perfusion imaging showing a region of decreased perfusion within the left MCA and ACA territories

## Case Report

A 93-year-old man was admitted to the hospital via the emergency room with complaints of aphasia and right hemiplegia, and his initial NIHSS score was 22. He had a medical history of hypertension, diabetes mellitus, non-ST-segment elevation myocardial infarction, and severe aortic valve stenosis. However, he could walk without support and perform basic activities of daily living (ADL) independently. Initial brain magnetic resonance imaging showed small infarcts in the left anterior cerebral artery and middle cerebral artery territories and multifocal intracranial and neck arterial stenosis (Fig. 1). In the neurology department, he was administered tissue plasminogen activator after the failed intra-arterial thrombectomy. Nasogastric tube feeding was started to prevent aspiration pneumonia caused by post-stroke dysphagia, and an indwelling catheter was inserted for post-stroke urinary dysfunction. Ten days after the stroke, the patient was transferred to the rehabilitation department.

The patient complained of right-sided motor weakness with postural instability. He had impaired cognitive function and difficulty in verbal communication. On the day of admission, a neurological examination was conducted. Patient's initial and final functions were evaluated using the Korean version of the Berg Balance Scale (K-BBS) to assess balance, the Functional Ambulatory category (FAC) to assess ambulation ability, the Korean version of the Modified Barthel Index (K-MBI) and FIM to assess ADL, the Korean version of the Mini-Mental State Examination (K-MMSE) to assess cognitive function and Aphasia Quotient (AQ) to assess aphasia. These functional tests were performed approximately 1 week (when the patient was transferred to the rehabilitation department and first evaluated by the physiatrist) and 4 months (the patient was discharged) after stroke onset. On physical examination, the patient exhibited decreased muscle power. The Medical Research Council Scale for muscle strength was grade one for the right upper extremity and grade three for the right lower extremity. The patient's FAC score was zero, and he could not stand without manual support. The patient's K-MBI score was 5, indicating total dependency on daily activities of life. The K-MMSE and CDR scores were 11 and 2, respectively, indicating cognitive impairment. At the beginning of the program, the patient was diagnosed with global aphasia (AQ score= 5.9, 3.2%ile). A videofluoroscopic swallowing study was performed to assess the risk of aspiration, confirming a penetration-aspiration scale (PAS) score of 8 for small liquid volumes.

Along with the neurological examination, a comprehensive geriatric assessment was conducted. Multidimensional assessments were conducted to evaluate combined medical problems and related impairments such as sarcopenia, osteoporosis, and vitamin D deficiency. Handgrip strength, muscle mass, and physical performance were assessed to determine sarcopenia according to the Asian Working Group (AWG) for Sarcopenia 2019 criteria.[10] The patient's left-hand grip strength was 9.9 kg, which was low. Body mass index and skeletal muscle index were also measured and were normal values (21.4 and 8.9, respectively). Because the evaluation for his initial physical performance was limited due to hemiplegia after stroke, diagnosing sarcopenia could not be completed. However, based on the AWG criteria for "possible sarcopenia", defined by low muscle strength with or without reduced physical performance, his physical status could be classified as possible sarcopenia. Patient frailty was assessed using the Clinical Frailty Scale (CFS), which was assessed by interviewing the patient or their proxy, focusing on their health state before (i.e., 2 weeks before) the acute stroke. His CFS score was 8 points, and frailty was diagnosed when the score was 5 or more in previous studies,[11] so the patient could also be diagnosed with frailty. To determine vitamin D deficiency, blood tests were performed. The serum vitamin D level was 6.55 (normal range: 30-100), and based on the test results, 200,000 IU vitamin D3 was administered intramuscularly. For osteoporosis evaluation, bone mineral density was measured, which was at normal levels (T-score L1-L4 =0.3)

Early rehabilitation programs were initiated. The daily session included: 1) active range of motion exercise and mobility training, 2) robot-assisted gait training, 3) functional electrical stimulation, 4) ADL training, 5) speech therapy, 6) cognitive training, and 7) oromotor facilitation. The patient attended a 1-hour physical therapy and robot-assisted gait training session five times per week. A physical therapist managed this physical exercise program with the goals of improving range of motion, strength, static and dynamic standing, and gait endurance. Multimodal training included a combination of resistance exercise and eccentrically biased strengthening exercise. A Robot-assisted tilt-table stepping Erigo® (Hocoma AG, Switzerland) was used for early mobilization. After 3 months of improvement in the patient's functional level, a partial weight-bearing treadmill from Lokomat (Hocoma, Switzerland) was used to improve spatiotemporal gait parameters. Occupational therapy consisted of individual 30-minute sessions, 5 days per week, with the goal of enhancing ADL skills required for personal hygiene and feeding to strengthen right side fine motor function. Speech therapy and cognitive training were also performed (individual 30-minute sessions, 2 days per week). Oromotor facilitation programs such as thermal tactile stimulation and electrical stimulation of the suprahyoid or infrahyoid muscles were performed in individual 30-minute sessions for 5 days a week.

After 4 months of intervention, the patient showed significant improvement in functional status, independence in performing ADLs, cognition, aphasia, and oromotor

**Fig. 2.** A view of a patient walking independently using an anterior walker.

**Table 1.** Rehabilitation Outcomes

| | Before intervention | After intervention |
|---|---|---|
| K-MMSE | 11 | 19 |
| MBI | 5 | 27 |
| FIM Total | 25 | 51 |
| FIM Motor | 19 | 33 |
| FIM Cognition | 6 | 18 |
| AQ | 5.9 | 12.4 |
| FAC | 0 | 3 |
| BBS | 0 | 22 |

K-MMSE: Korean Mini-Mental State Examination, MBI: Modified Barthel Index Score, FIM: Functional Independence Measure, AQ: Aphasia Quotient, FAC: Functional Ambulatory Category, BBS: Berg Balance Scale

function. The K-BBS and FAC score improved from 0 to 22 and 0 to 3, respectively. The patient could walk approximately 50 m with an anterior walker (Fig. 2). The K-MBI score was from 5 to 27. The patient's MMSE score increased from 11 to 19. The total FIM score also improved from 25 to 51, and on the subscales, the FIM-motor score improved from 19 to 33, and the FIM-cognition score improved from 6 points to 18 points.

Although he had persistent difficulty with verbal communication, his AQ score increased from 5.9 (3.2%ile) to 12.4 (6.8%ile) (Table 1). Moreover, as speech comprehension improved with recovery, his aphasia was reclassified as Broca's aphasia. With improvement in oromotor performance, the transition to general oral diet with liquid thickener feeding were successfully applied. After 4 months of comprehensive rehabilitation, the patient was discharged home.

## Discussion

Age represents the most significant non-modifiable risk factor for stroke.[12] Indeed, 75% of stroke patients are older than 65 years, and stroke incidence increases progressively with age, peaking in people over 85.[3] Although stroke incidence is increasing in the oldest-old population, previous studies have shown more pessimistic results regarding the effectiveness of rehabilitation treatments in oldest-old patients.[13-18]

Stroke patients aged > 80 years had a worse prognosis than patients < 80 years; pre-stroke hospitalization was a major predictor.[13] Patients with stroke aged > 80 years had a higher risk-adjusted mortality rate, more extended hospital stays, and less likely to be discharged to their original residence. This may be because of sociodemographic factors and existing frailty, severe stroke paralysis, dysphagia, and urinary incontinence in the oldest-old.[14] Higher severity of stroke in oldest-old patients is due to an increase in anterior circulation infarction and cardiac embolism due to arterial fibrillation with increasing age.[17] Poor prognosis after stroke in the oldest-old due to altered metabolism, lower medication compliance, and higher-drug interactions due to polypharmacy, in addition to the reasons mentioned above. In addition, active administration of thrombolytic therapy is difficult because of limited information on its feasibility and safety in the oldest-old.[15]

For the above reasons, the oldest-old patients have a high risk of stroke, but their prognosis is poor. Hence, doctors are reluctant to apply active rehabilitation treatment to the oldest-old patients and are pessimistic about the effectiveness of rehabilitation treatment. It is believed that the effect of rehabilitation is small because the deterioration of physical and cognitive functions due to aging lowers the ability of the oldest-old to adapt to internal and external environmental changes.[16] This difference is also seen in older stroke patients who are discharged from rehabilitation programs at a lower rate than younger patients.[18]

In contrast, other studies[19-21] emphasized that rehabilitation may be practically effective for the oldest patients, although less often than for younger patients. Old is associated with complications, such as pressure sores and infections, but argue that intensive inpatient rehabilitation can provide significant functional benefits for all stroke survivors, regardless of age.[20] The same degree of functional recovery in older and younger patients after high-intensity multidisciplinary neurorehabilitation programs.[21]

These studies lead to a similar conclusion as this case study in which a 93 year- old stroke survivor benefited from early, organized intensive inpatient rehabilitation. We conducted multidisciplinary rehabilitation considering the vulnerability of the oldest-old patients. The rehabilitation program was largely divided into treatments to improve exercise function and prevent complications.

First, in exercise therapy, the early start of joint movement and the type of exercise were considered. Previous literature[22] illustrated that post-acute rehabilitation is a major component of stroke unit care and he safety and efficacy of early mobilization, which refers to rehabilitative intervention aimed at getting patients out of bed within the first 24 to 72 hours after acute stroke. This case was evaluated by a physiotherapist to plan rehabilitation interventions and early mobilization within 48 hours of admission to the stroke unit. After discharge from the stroke unit, this oldest-old patient was immediately transferred to the rehabilitation department based on previous evaluation. The type of exercise was also determined based on previous studies. Eccentrically biased training seems superior to conventional weight training at increasing torque at high contraction velocities to preserve functional capacity in older adults.[23] Hybrid training, combining voluntary and electrical muscle contractions, is effective to increase muscle mass and force on the lower extremities in the oldest-old.[24] For eccentric biased strengthening exercise and hybrid training of electrical muscle contractions, the Erigo-FES (Hocoma AG, Switzerland) was used in this case patient. The patients attended a robot-assisted gait training session, five times a week for 30 min per day. Tilted to 80°, this robotic device helped promote body verticalization and cyclic movement training together with muscle contraction and produce flexion and extension of joints. In addition, multimodal training such as resistance exercise, balance training are recommended in previous studies to improve sarcopenia in patients with stroke.[9] Especially, it is known that chair-stand exercise which repeats low-intensity, slow movements could improve sarcopenia and ADL in stroke patients.[25,26] Our patient was also instructed to perform chair-stand exercises in the hospital room. Besides, treadmill intervention with body weight support were shown to have effect on spatiotemporal gait parameters especially on step length in older adults with stroke.[6] Using Lokomat (Hocoma, Switzerland), the patient attended a partial body weight supported treadmill training five times a week for 30 min per day.

Second, the risk was assessed, and customized treatment was implemented to prevent complications. The most common medical complication after acute ischemic stroke are aspiration, musculoskeletal pain, urinary infection and depression, which may affect functional outcome.[27] In particular, swallowing disorders in the oldest-old are associated with an increased risk of developing pneumonia and mortality. When the patient was transferred to the rehabilitation department, he presented with a delirious mental status, which could increase aspiration risk. For the first 2 weeks, liquid food was administered via nasogastric tubes. A videofluoroscopy swallowing study confirmed a PAS score of 8, aspiration from small liquid. Indirect oromotor facilitation training, such as thermal tactile stimulation, electrical stimulation of the suprahyoid or infrahyoid muscles, and strengthening of the tongue or pharyngeal muscles, was performed in individual 30-minute sessions for 5 days per week. With improvement in oromotor performance, the transition to oral feeding has been successfully applied. A follow-up study after 2 months showed no aspiration when swallowing small amounts of liquid and aspiration when swallowing large amounts of liquid. Because liquid swallowing is amount-dependent, the patient was instructed to consume small amounts and increased oral intake with caution. After discharge, the patient was discharged with a general diet with liquid thickener and there were no complications.

In addition, to prevent the complication of stroke in oldest-old patients, multidimensional evaluation of metabolic changes, such as sarcopenia, frailty, osteoporosis, and vitamin D deficiency, should be performed.[5] According to the AWG for Sarcopenia 2019 criteria,[10] diagnosing sarcopenia requires measurements of both muscle quality and quantity and defines persons with low muscle mass, low muscle strength, and low physical performance. Low muscle strength is defined as handgrip strength < 28 kg for men and < 18 kg for women. and his left-hand grip power was 9.9kg, which indicated low muscle strength. The patient's body mass index and skeletal muscle index were within normal ranges, and physical activity measurement was limited due to post-stroke hemiplegia, but ‘possible sarcopenia’ could be diagnosed. Patients' frailty was diagnosed through CFS. To determine nutritional status, body mass index and serum albumin were measured (21.4 and 5.0, respectively) and were within normal ranges. The patient's nutritional status was within the normal range at the time of admission, but weakness and sarcopenia were already confirmed, so attention was paid to diet and nutrition intake during the rehabilitation treatment period.

Especially, vitamin D deficiency results in abnormalities in calcium, phosphorus, and bone metabolism. A previous study[28] suggested that all adults aged 50-70 and over 70 years require at least 600 and 800 IU/d of vitamin D, respectively, to maximize bone health and muscle function; among those aged 65 and older, 800 IU/d vitamin D is required for fall and fracture prevention. Moreover, measuring serum 25-hydroxy vitamin D levels using a reliable assay is the initial diagnostic test in patients at risk for deficiency. On the day of admission, blood tests were performed to determine serum vitamin B12, vitamin D, calcium, iron, and other trace mineral levels. The serum vitamin D level was 6.55 (normal range: 30-100). Based on the test results, 200,000 IU of vitamin D3 was administered intramuscularly.

After 4 months of multidisciplinary rehabilitation, the patient showed significant improvement without serious complications in functional status, cognition, aphasia, and oral motor skills.

In conclusion, this case report suggests that although advancing age is associated with reduced effectiveness of the rehabilitation process, early rehabilitation along with multidisciplinary geriatric assessment can produce significant functional improvement regardless of age. Given the variety of clinical features of oldest-old patients, large-scale clinical studies are needed to develop effective rehabilitation approaches to facilitate reconditioning stroke patients and reduce associated sequelae.

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