Changes in Quadriceps Muscle Thickness, Disease Severity, Nutritional Status, and C-Reactive Protein after Acute Stroke

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Background: Lower leg muscle wasting is common in stroke patients; however, patient characteristics in the acute phase are rarely studied. This study aimed to examine the relationship between changes in quadriceps muscle thickness and disease severity, nutritional status, and C-reactive protein (CRP) levels after acute stroke. *Methods:* Thirty-one consecutive patients with acute intracerebral hemorrhage or ischemic stroke had quadriceps muscle thickness measured in the paretic and nonparetic limbs within 1 week after admission (first week) and 2 weeks after the first examination (last week) using ultrasonography. We also determined the relationship between the percentage change in muscle thickness and disease severity, nutritional status, and CRP levels on admission. *Results:* There was a significant correlation between changes in muscle thickness for both paretic and nonparetic sides and National Institutes of Health Stroke Scale (NIHSS) scores (paretic limb: $r = -.46$, $P = .01$; nonparetic limb: $r = -.54$, $P = .002$, respectively); however, there was no significant correlation with nutritional status on admission. Quadriceps muscle thickness was reduced more in the CRP-positive (≥.3 mg/dL) patients than in the CRP-negative (<.3 mg/dL) patients in the nonparetic limb (positive: −21.4 ± 12.1, negative: −11.4 ± 16.4%; $P = .039$), but not in the paretic limb (positive: −23.4 ± 9.0, negative: −19.1 ± 15.7; $P = .27$). *Conclusions:* A high NIHSS score and a positive CRP on admission were both significantly correlated with decreased quadriceps muscle thickness after acute stroke. Nutritional status on admission was not correlated with changes in quadriceps muscle thickness for these patients. **Key Words:** Muscle wasting—nutritional status—C-reactive protein—ultrasonography.

Introduction

Stroke-related muscle wasting is one of the factors that affect the occurrence of poststroke physical disability.[1,2] In particular, lower leg muscle wasting often leads to patients being unable to walk without assistance.[3,4] Therefore, lower leg muscle wasting is a therapeutic target, and many physicians and researchers have been trying to increase muscle mass and muscle strength, and enhance physical performance after stroke.[5-8]

A decrease in lower leg muscle mass is often observed in the acute phase after stroke and is usually not recovered.[3] A previous study reported a decrease in quadriceps muscle thickness during the acute phase in patients with nonambulatory stroke.[4] The factors that influence

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stroke-related muscle wasting include denervation, impaired feeding, inflammation, and immobilization.[9-11] In particular, admission disease severity, nutritional status, and C-reactive protein (CRP) as an inflammation marker were indicators of poor outcome for patients with nonambulatory stroke[12-17]; however, no studies have evaluated the factors related to lower leg muscle wasting in the acute clinical phase.

The purpose of the present study was to investigate the relationship between changes in quadriceps muscle thickness and disease severity, nutritional status, and CRP levels after acute stroke.

Materials and Methods

Participants and Study Design

A total of 214 consecutive patients admitted to the Department of Neurosurgery, Itami Kousei Neurosurgical Hospital, Japan, between June 2014 and December 2014, with a diagnosis of intracerebral hemorrhage and ischemic stroke were eligible for inclusion if the time from onset of stroke to hospital admission was less than 48 hours. A total of 178 patients were excluded because of mild stroke (National Institutes of Health Stroke Scale [NIHSS] score ≤4), premorbid modified Rankin Scale score of 3 or lower, mechanical ventilation over 24 hours, or refusal to participate in the study. The study was approved by the Itami Kousei Neurosurgical Hospital Research Ethics Committee. All patients or their relatives provided informed consent.

All subjects received standard care from ward and rehabilitation staff. We defined standard care as conventional therapy consisting of mobilization and a conventional rehabilitation approach to improve the patients' independence in activities of daily living at a frequency of 5 times a week (each session lasted between 40 and 60 minutes). The time to first mobilization was determined by physicians and matched to each patient's condition. There was no detailed mobilization protocol defining the type or amount of exercise,[18] and all mobilizations were adjusted according to the patients' needs and abilities. All patients were mobilized out of bed several times per day, but neither time nor duration of mobilization was recorded.

Measurements and Procedures

The thickness of the quadriceps muscle, including the rectus femoris and the vastus intermedius, was determined using B-mode ultrasound (US) imaging (LOGIQ P5; GE Healthcare Japan, Tokyo, Japan) with an 8-MHz transducer. Measurements were obtained with the subjects in the supine position with the hips and knees extended and the transducer positioned midway between the anterior superior iliac spine and the proximal end of the patella.[19,20] Quadriceps muscle thickness was examined in the paretic and nonparetic limbs within the first week after admission (first) and 2 weeks after the first-week examination (last). The reliability of the US technique for measuring muscle thickness of the quadriceps femoris muscle in patients with stroke has previously been established.[20] All the measurements were conducted with single examiner who was well trained about US measurements.

Age, sex, type of stroke (intracerebral hemorrhage or ischemic stroke), side of disorder (paralyzed side), time to first measurement from admission, and time to first mobilization from admission were obtained from the medical records. The NIHSS score on admission was measured for disease severity. Time from admission to first nutritional therapy (oral feeding or nasogastric tube feeding), body composition on admission, serum albumin level on admission, Geriatric Nutritional Risk Index (GNRI),[21] which was calculated from weight, and serum albumin were measured for nutritional status. CRP levels on admission were also measured for inflammation status.

Statistical Analysis

All data were expressed as means ± standard deviation. Quadriceps muscle thickness was compared between the paretic and nonparetic sides with 2-way factorial analysis of variance. The correlations between percentage change in quadriceps muscle thickness and age, NIHSS score, time to first mobilization, nutritional status (time to first feeding, body mass index, serum albumin, and GNRI) were calculated using Spearman's method. To study the effects of CRP level at admission on the changes in muscle thickness, we divided all the subjects into 2 groups—CRP positive (CRP ≥ .3 mg/dL) and CRP negative (CRP < .3 mg/dL)—and compared these parameters.

All tests were performed at a significance level of P less than .05. Analyses were performed with statistical software (SPSS 20; IBM, Chicago, IL).

Results

A total of 36 patients were included in the study. Two patients were excluded from analysis because one of them died and one was discharged early to a rehabilitation hospital. Three patients were also excluded from analysis because they withdrew during the measurement period. Finally, we analyzed 31 patients. One patient developed pneumonia, 4 patients developed unexplained fever, and 6 patients were able to walk 50 m unassisted during the measurement period. The clinical characteristics of the subjects are summarized in Table 1.

Table 2 shows the quadriceps muscle thickness in the paretic and nonparetic limbs. Within-group comparisons revealed that muscle thickness in both the paretic and nonparetic limbs was significantly different (paretic limb: –5.9 mm, 95% confidence interval [CI] = –7.4 to –4.3, $P < .001$; nonparetic limb: –4.5 mm, 95% CI = –6.1 to –2.8, $P < .001$). Between-group comparisons also revealed