Introduction

Cerebral fat embolism should be considered in the differential diagnosis of patients who present with impaired consciousness and hypoxia following a fracture. The diagnosis is based on the patient's history, physical examination, and the imaging findings. A 75-year-old woman presented at our hospital with progressive impaired consciousness and hypoxia following a femoral trochanteric fracture resulting from a fall. Adrenal insufficiency, ammonia-related encephalopathy, drug-induced encephalopathy, myxedema coma, and pulmonary embolism were considered in the differential diagnosis, but a definitive diagnosis could not be reached and cerebral fat embolism was considered the diagnosis by exclusion. MRI of the brain obtained on admission, including diffusion-weighted imaging (DWI) and fluid-attenuation-inversion recovery (FLAIR) showed no abnormalities. MRI susceptibility-weighted imaging (SWI), which enables detection of fat embolization, performed on day 5 after admission was diagnostic for cerebral fat embolism. We hypothesized that although SWI is reported as important in the diagnosis of cerebral fat embolization, it is underutilized for this purpose. In this study, we review previous reports in which cerebral fat embolism was identified by SWI, and determine whether any of these diagnoses were confirmed based on the SWI findings, rather than by DWI or FLAIR.

Case presentation

A 75-year-old woman with independent activities of daily living and an age-appropriate cognitive level prior to hospitalization was found collapsed on the ground in front of her home after returning home by car. Her past medical history included surgery for left renal cancer that is in remission and a vertebral compression fracture. Medications included sodium alendronate and calcium preparations. When the ambulance arrived,

she had a normal level of consciousness and complained of left hip pain, but developed a progressive loss of consciousness on the way to the local hospital. On arrival at that hospital, the patient's level of consciousness was E4V3M5 on the Glasgow Coma Scale (GCS) and oxygen saturation was 80% breathing ambient air. CT obtained on arrival revealed a trochanteric fracture of the femur (Figure 1). On the same day, the patient was transferred to our hospital for further investigation of hypoxemia and progressive loss of consciousness. On admission to our hospital, she had a GCS score of E4V3M5, body temperature of 37.1°C, oxygen saturation of 92% with oxygen supplied at 4 L/min through a mask, heart rate of 107 bpm, and respiratory rate of 29 breaths/min. On physical examination, there was no quadriplegia, the pupils were equal with no ocular deviation, and there was no rash on the skin of the extremities or trunk.

Chest examination revealed bilateral rattling, and diminished respiratory sounds at both lung bases. Heart rate and rhythm were regular, with no heart murmurs. The plantar reflex produced flexion on both sides.

Investigation

The patient’s condition in the emergency room suggested pulmonary embolism. Contrast-enhanced CT showed no embolus (Figure 2), and chest radiograph revealed bilateral dorsal infiltration (Figure 3) and thickening of the interlobular septal wall at the apex of the lung (Figure 4). DWI and FLAIR MRI of the brain were also obtained on the day of admission, but showed no abnormal findings (Figure 5-a and 5-b).

The laboratory results were as follows: white blood cell count, 18.73 × 10^3/μL; hemoglobin, 14.0 g/L; platelet count, 104 × 10^3/μL; aspartate aminotransferase, 42 U/L (normal range: 13–30 U/L); alanine aminotransferase, 32 U/L (normal: 7–23 U/L); lactate dehydrogenase (LDH), 209 U/L (normal: 124–222 U/L); alkaline phosphatase, 60 U/L (normal: 38–113 U/L); γ-glutamyl transpeptidase, 31 U/L (normal: 9–32 U/L); serum

protein, 6.6 g/dL (normal: 6.6–8.1 g/dL); serum albumin, 3.6 g/dL (normal: 4.1–5.1 g/dL); C-reactive protein, 0.686 mg/dL (normal: 0.00–0.14 mg/dL); serum creatinine, 0.87 mg/dL (normal: 0.46–0.79 mg/dL); blood urea nitrogen, 25.0 mg/dL (normal: 8–20 mg/dL); sodium, 134 mEq/L (normal: 138–145 mEq/L); potassium, 5.3 mmol/L (normal: 3.6–4.8 mmol/L); chloride, 102 mmol/L (normal: 101–108 mmol/L); phosphate, 3.8 mg/dL (normal: 2.7–4.6 mg/dL); calcium corrected for albumin, 9.2 mg/dL (normal: 8.8–10.1 mg/dL); glucose, 196 mg/dL (normal: 73–109 mg/dL). Arterial blood gas results (4 L/min on oxygen) were pH, 7.484; $PaCO_2$, 35.1 mmHg; PaO_2, 65.7 mmHg; SaO_2, 93.7%; and HCO_3, 25.3 mmol/L.

Differential diagnosis

The following causes of impaired consciousness were considered: 1) adrenal insufficiency, 2) ammonia-related encephalopathy, 3) drug-induced encephalopathy, and 4) myxedema coma. However, the patient's serum cortisol (62.0 μg/dL), serum ammonia (26 μg/dL, normal: 12–66 μg/dL), TSH (2.64 μIU/mL, normal: 0.61–4.23 μIU/mL), and FT4 (1.11 ng/dL, normal: 0.77–1.59 ng/dL) were normal, and encephalopathy-causing drugs were not administered. Therefore, the possibility of the above-mentioned diseases was considered low. Pulmonary embolism was considered as the cause of hypoxia, but no embolus was detected on contrast-enhanced CT (Figure 2).

We then added cerebral fat embolism as a differential diagnosis, considering the causes of hypoxia and impaired consciousness in a unified manner. However, cerebral fat embolism generally has an incubation period of hours to days from fracture to onset, whereas the time from fracture to onset of symptoms in the present case was less than 30 minutes. Nevertheless, we believed that we should not dismiss cerebral fat embolism as a possible diagnosis based on the short incubation period alone. On day 5 of hospitalization, an

additional MRI of the brain was obtained (Figure 6), including SWI, which revealed numerous areas of low intensity scattered throughout both hemispheres (Figure 6-c), suggesting a diagnosis of fat embolism. The final diagnosis was fat embolism, based on the SWI findings.

Treatment

There is no definitive treatment for cerebral fat embolism syndrome from a bone fracture, and therapy is largely supportive while the embolism resolves spontaneously. We provided supportive care for our patient, including fluid resuscitation and oxygenation.

Outcome and follow-up

Bipolar hip arthroplasty was performed for the left hip fracture on day 11 after admission. Follow-up MRI including SWI was performed on day 24. SWI at that time showed dispersed areas of residual low intensity in both hemispheres (Figure 7). The patient's level of consciousness resolved spontaneously along with the natural course. On day 9 after admission, her level of consciousness had returned to normal compared to the prehospital level, oxygenation returned to normal on day 13, and the patient was transferred to a rehabilitation hospital on day 56.

Discussion

A 75-year-old woman was admitted to our hospital with impaired consciousness and oxygenation after fracturing her left femur in a fall. The SWI findings enabled a definitive diagnosis after diffusion and FLAIR MRI of the brain failed to reach a definitive diagnosis. SWI is an MRI technique that was first reported in 2004[1]. It uses differences in magnetic susceptibility among tissues to generate contrast.

In clinical terms, SWI is more sensitive than T2WI for imaging microbleeds because of its superior ability to detect iron and blood components. The usefulness of SWI imaging for cerebral fat emboli was first reported in 2009[2].

We hypothesized that although numerous studies since 2009 have reported the usefulness of SWI for detecting cerebral fat embolization, this ability may not be well known. To investigate our hypothesis, we analyzed case reports and case series gained from PubMed research that included cerebral fat embolization and asked the following questions: (1) How many reports of cerebral fat embolization have included SWI findings? and (2) How many cases of cerebral fat embolization were definitively diagnosed by SWI alone, rather than by DWI or FLAIR imaging?

We performed a filtered search for "within 5 years" and "case report" using the keywords "cerebral fat embolism" and "MRI" in a PubMed search. Of 42 cases of cerebral fat embolism included in 39 papers[3–41], we analyzed 33 cases[3–17,19–26,28–30,32,34,37,39,40] after excluding the following: (1) cases not available (n = 2)[27,35], (2) not a case report (n = 1)[33], (3) not in English (n = 1)[18], (4) not cerebral fat embolism (n = 3)[36,38,41], (5) diagnosis obtained by CT instead of MRI (n = 1)[32], and (6) MRI contraindicated due to a magnetic implant (n = 1)[31]. Of the 33 cases, SWI of the brain was acquired in 10 cases[4,5,10,12,17,25,34,36,37,41].

In all 33 cases, no diagnosis was confirmed solely by the SWI findings in the case that DWI or FLAIR failed to indicate a diagnosis. In one study, the findings of SWI were reported but not those of DWI or FLAIR[25].

Our research has some limitations. First, it is possible that some studies may have included SWI in the imaging protocol but not published the findings. Second, we are unable exclude the possibility that some diagnoses could have been obtained by SWI imaging in the absence of abnormalities on DWI or FLAIR, but

not reported explicitly in the paper.

Our investigation revealed that SWI was acquired in only 30.3% (10/33) of definitive diagnoses of cerebral fat embolism, despite the known diagnostic ability of SWI in this regard. In the present patient, DWI and FLAIR showed no abnormalities and a diagnosis of cerebral fat embolism was confirmed by SWI. Of the 33 cases included in this analysis, none reached a diagnosis of cerebral fat embolism based on the SWI findings alone in the absence of abnormalities on DWI or FLAIR. In this regard, the present case is extremely rare and appears to be unique.

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Author 2: Mitsushige Nishimura M.D. collected and analyzed the data.

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