Evolution of Subarachnoid Hemorrhage Extension in Lobar Hemorrhage in the Early Chronic Phase and the Impact on Cerebral Amyloid Angiopathy Criteria

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Background: Subarachnoid hemorrhage extension (SAHE) in acute lobar hemorrhage (LH) is frequent. Little is known about the short- and medium-term radiological evolution of SAHE. Our aim was to study this evolution by magnetic resonance imaging (MRI). *Methods:* We performed an observational study and analyzed retrospectively MRIs of patients with LH with possible/probable/definite cerebral amyloid angiopathy (CAA), and compared initial MRI performed between 3 hours and 21 days after symptom onset with follow-up MRI performed between 2 and 12 months after initial MRI. *Results:* Twenty patients were analyzed. Initial MRI showed 11 of 20 patients (55%) with SAHE. Follow-up MRI showed, compared with initial MRI, an increase of 77% (45% versus 80%) of patients with chronic intrasulcal hemorrhage, an increase of 36% (22% versus 30%) of the number of lobes with chronic intrasulcal hemorrhage, and an increase of 37% (1.75 versus 2.4) of lobes with chronic intrasulcal hemorrhage seen per patient. All new chronic intrasulcal hemorrhages involved the brain lobe with initial LH except 1 lobe in 1 patient. Three patients switched from possible to probable CAA according to the modified Boston criteria after follow-up MRI due to chronic intrasulcal hemorrhage in the lobe involved by LH. In 6 patients, follow-up MRI showed more diffuse chronic intrasulcal hemorrhage than pre-existing combined SAHE and chronic intrasulcal hemorrhage in the LH lobe, or showed presence of chronic intrasulcal hemorrhage in the absence of initial SAHE and/or chronic intrasulcal hemorrhage in the LH lobe. *Conclusion:* In LH patients, presence of SAHE on initial MRI changes the modified Boston CAA criteria on follow-up MRI in a portion of patients. On follow-up MRI, SAHE/chronic intrasulcal hemorrhage extension or chronic intrasulcal hemorrhage appearance in the LH lobe is relatively frequent.
Key Words: Subarachnoid hemorrhage extension—lobar hemorrhage—cerebral amyloid angiopathy criteria—MRI—chronic intrasulcal hemorrhage.

Introduction

Subarachnoid hemorrhage extension (SAHE) in acute lobar hemorrhage (LH) is frequent. In 2 earlier reports, LH-related SAHE has been reported in 57% and 65% of LH patients.[1,2] SAHE is associated with death or worse functional outcome and seems to be a major cause of recurrent intrasulcal bleedings, and indicates sites with increased vulnerability for future LH (analyzed after a 2-year follow-up).[3] However, little is known about the short- and medium-term evolution of LH-related SAHE on magnetic resonance imaging (MRI) and how SAHE influences radiological criteria for cerebral amyloid angiopathy (CAA).

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Methods

We performed an observational study and analyzed retrospectively the MRI brain imaging of all patients with symptomatic acute LH recruited between January 2012 and September 2015 in our stroke center database with possible, probable, or definite CAA.

Exclusion criteria were as follows: recent trauma; anticoagulation treatment; pathological blood coagulation tests (activated partial thromboplastin time [aPTT] ratio = patient's aPTT/normal control aPTT > 1.2; or PTT < 75%) or platelet count ($<100 \times 10^9$/L); radiological imaging suggesting arteriovenous malformation, brain tumor, vasculitis, or cavernoma; and presence of movement artifacts on MRI.

In daily practice in our center, initial (acute–subacute) and follow-up (early chronic) brain MRIs in stroke (and thus also our LH) patients are performed randomly on 2 different MRI scans (1.5 T and 3 T). For this study, only patients who underwent initial and follow-up MRI on the same MRI scan using the same parameters were included.

On the initial MRI, the presence of SAHE in the (sub)acute phase was analyzed on Fluid Attenuated Inversion Recover (FLAIR) sequence (seen as hyperintensity) and T2*-weighted imaging (seen as hypointensity). To avoid a large amount of false-negative (for acute SAHE) patients on FLAIR imaging (related to decreasing sensitivity of FLAIR imaging over time in subarachnoid hemorrhage), only patients with initial MRI performed within 21 days after symptom onset were included.[4-6] Because our primary goal was to study the radiological short- to medium-term evolution of SAHE (and thus not to study the disease progression of suspected CAA over time), only patients with follow-up MRI performed between 2 months and 1 year after the initial MRI were included. When several control MRIs were performed within this time window, only the most recent was analyzed. Control MRI was performed simply because of follow-up reasons and thus not because of new symptoms. Analyzed parameters included age, sex, history of arterial hypertension, delay between symptom onset and initial MRI, and delay between initial and follow-up MRIs.

On the initial MRI, we scored the following: predominantly involved brain lobe for acute symptomatic LH, the presence of SAHE, acute intraventricular hemorrhage, chronic LH, the localization and the number of lobes involved for SAHE, the localization and the number of lobes involved for chronic (i.e., FLAIR hypointense and T2*-weighted hypointense) intrasulcal hemorrhage, the presence and the number of cortical–subcortical microbleeds (further simply called microbleeds) on T2*-weighted imaging (called innumerable if >25), and Boston and modified Boston criteria for CAA.

On follow-up MRI, we scored the following: the presence of new (asymptomatic) LH, the localization and the number of lobes involved for chronic intrasulcal hemorrhage, the presence and the number of microbleeds on T2*-weighted imaging (called innumerable if >25), and Boston and modified Boston criteria for CAA.

Results

Twenty patients were included, 11 men and 9 women, with a mean age of 72 (range 49-90). Apart from one 49-year-old patient with histologically proven CAA, all patients were over 55 (range 61-90). Ten patients had history of arterial hypertension. Mean delay between symptom onset and initial MRI was 4.65 days (range 1-21, including 12 patients in whom MRI was performed ≤3 days after symptom onset). None of the patients had hyperacute MRI within the 3-hour time window. Eleven patients had 3 T MRI scan and 9 patients had 1.5 T MRI scan.

On the initial MRI, the predominantly involved brain lobe for acute LH was frontal in 9 of 20 patients, temporal in 5 of 20, parietal in 4 of 20, and occipital in 2 of 20. SAHE was present in 11 of 20 patients (55%, all involving the same lobe as the LH within 2 patients involving a supplementary adjacent brain lobe), with a total of 13/160 lobes (i.e., 160 = 20 patients with each 8 brain lobes) involved by SAHE. LH-associated acute intraventricular hemorrhage was present in 2 of 20 patients. Chronic intrasulcal hemorrhage was seen in 9 of 20 patients (45%) with a total of 35/160 lobes (22%) involved, with a mean of 1.75 lobes involved (range 1-8) per patient. Some patients had in certain lobes both (acute) SAHE and chronic intrasulcal hemorrhage. Microbleeds were seen in 12 of 20 patients (ranging from 1 to innumerable). On initial MRI, according to the Boston criteria, 2 of 20 patients had definite CAA, 3 of 20 probable CAA, and 15 of 20 possible CAA. According to the modified Boston criteria (taking into account chronic intrasulcal hemorrhage but not SAHE), 2 of 20 patients had definite CAA, 10 of 20 probable CAA, and 8 of 20 possible CAA.

Follow-up MRI was performed after a mean of 127 days (range 61-355) after the initial MRI. On the follow-up MRI, 1 of 20 patients showed a new (asymptomatic) LH. The number of microbleeds was unchanged in all patients. Chronic intrasulcal hemorrhage was seen in 16 of 20 patients (80%) with a total of 48/160 lobes (30%) involved, with a mean of 2.4 lobes (range 1-8) involved per patient. One patient (lacking SAHE) had new chronic intrasulcal hemorrhage in a lobe initially not involved by LH or chronic intrasulcal hemorrhage, corresponding probably to CAA disease progression. After follow-up MRI, according to the Boston criteria, 2 of 20 patients had definite CAA, 4 of 20 probable CAA, and 14 of 20 possible CAA. According to the modified Boston criteria, 2 of 20 patients had definite CAA, 14 of 20 probable CAA, and 4 of 20 possible CAA.

Thus, 1 of 20 patients switched from possible to probable CAA (according to both the Boston and the modified