www.jkns.or.kr 10.3340/jkns.2009.46.1.38 Print ISSN 2005-3711 On-line ISSN 1598-7876
J Korean Neurosurg Soc 46 : 38-44, 2009

Clinical Article

Silent Microbleeds and Old Hematomas in Spontaneous Cerebral Hemorrhages

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Objective : The authors studied the risk factors of silent cerebral microbleeds (MBs) and old hematomas (OHs) and their association with concurrent magnetic resonance (MR) imaging findings in the patients of intracerebral hemorrhages (ICHs).
Methods : From April 2002 to June 2007, we retrospectively studied 234 patients of primary hemorrhagic stroke. All patients were evaluated with computed tomography (CT) and 3.0-tesla MR imaging studies within the first week of admission. MBs and OHs were assessed by using T2*-weighted gradient-echo (GRE) MR imaging. The patients were divided into 2 groups, depending on whether or not they had two GRE lesions of chronic hemorrhages. A correlation between MBs and OHs lesions were also statistically tested. Lacunes and white matter and periventricular hyperintensities (WMHs, PVHs) were checked by T1- and T2-weighted spin-echo and fluid attenuated inversion recovery sequences. Variables on the clinical and laboratory data and MR imaging abnormalities were compared between both groups with or without MBs and OHs.
Results : MBs were observed in 186 (79.5%) patients and a total of 46 OHs were detected in 45 (19.2%) patients. MBs (39.6%), OHs (80.4%), and ICHs (69.7%) were most commonly located in the ganglionic/thalamic region. Both MBs and OHs groups were more frequently related to chronic hypertension and advanced WMHs and PVHs. The prevalence and number of MBs were more closely associated with OHs groups than non-OH patients.
Conclusion : This study clearly demonstrated the presence of MBs and OHs and their correlation with hypertension and cerebral white matter microangiopathy in the ICHs patients. Topographic correlation between the three lesions (MBs, OHs, and ICHs) was also noted in the deep thalamo-basal location.

KEY WORDS : Cerebral hemorrhage · Microbleed · Magnetic resonance imaging · Leukoaraiosis · Hypertension.

INTRODUCTION

The rupture of small artery or arteriole damaged by microangiopathy, a disorder frequently related to hypertension, is an important cause of spontaneous intracerebral hemorrhages (ICHs). With recent advances in magnetic resonance (MR) imaging technology, use of the gradient-echo (GRE) T2*-weighted images has facilitated detection of chronic hemorrhagic lesions in the brain owning to its great sensitivity to the local magnetic field inhomogeneity produced by iron content of hemosiderin[16,17,24,29]. Cerebral microbleeds (MBs) are defined as all discrete hypointense areas on T2*-weighted MR with GRE sequence. These lesions are not symptomatic clinically and are indicators of a bleeding prone microangiopathy histologically[17,22,27,30,34]. Retrospective and prospective studies indicated that MBs are strongly associated with development of ICH in hypertensive patients[7,13,25,32,34]. On the other hand, old hematomas (OHs), as resolved hemorrhagic scars from a prior cerebral bleeding, typically present an irregular hypointense area on the GRE MR images[10]. There has not been any previous reports addressing the prevalence of OHs and its association with MBs in clinical series of ischemic or hemorrhagic cerebral strokes. We have reviewed two-hundred-thirty-four patients with primary ICHs who underwent brain MR imaging study and evaluated the clinical and radiological characteristics and their relationship with cerebral MBs and OHs. Our major purpose was to determine the frequency of MBs and OHs and their diagnostic and clinical significance in the patients with spontaneous ICHs.

• Received : February 24, 2009 • Revised : June 9, 2009
• Accepted : July 8, 2009
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MATERIALS AND METHODS

Subjects

All were within first week of onset of acute neurological deficits and had corresponding acute hemorrhage lesions on brain computed tomography (CT) and MR imaging. Between April 2002 and June 2007, a total of 234 patients with ICHs and a history of previous ICH who underwent MR imaging scanning with 3.0-tesla system were retrospectively enrolled. These patients consisted of 115 men and 119 women (50.9%) with mean age of 61.1 ± 11.9 years (range, 29 to 86 years). The requirement for diagnosis of previous stroke was symptomatic episodes that had been diagnosed as stroke and had been treated. Sixty four (27.4%) patients had suffered from a prior brain stroke, that was diagnosed as ICH in 45 (19.2%) patients and cerebral infarction in 19 patients. For these patients with recurrent ICHs, the hematoma locations and intervals between the first and recurrent stroke were also inspected.

Victims from cerebral hemorrhages by intracranial tumors, bleeding diathesis, traumatic brain injury, cerebral amyloid angiopathy (CAA), vascular malformation, hemorrhagic infarcts, cerebral autosomal dominant arteriopathy with subcortical infarcts and leukoencephalopathy, moyamoya disease, or brain aneurysm were excluded from this study, by reviewing medical records and interviewing patients of their family. Twenty-nine acute ICHs were located in the infratentorial region (5 in the brain stem, 24 in the cerebellum), 42 in the cortico-subcortical region, 65 in the thalamic region, and 98 in the basal ganglionic region. Acute symptomatic hematomas involved the cerebral cortex and white matter grouped as 'lobar' lesions and the other as 'deep' lesions.

Clinical and laboratory evaluations of stroke risk factors

Demographic and clinical data, including age, gender, hypertension, diabetes mellitus, dyslipidemia, previous stroke, smoking habit, cardiac disease, alcohol abuse, and current stroke medication were obtained. There were 136 (58.1%) patients with chronic hypertension and 26 (11.3%) with diabetic. Blood levels of total cholesterol (TC), high-density lipoprotein (HDLC), low-density lipoprotein (LDLC), and triglyceride (TG) were measured in a fasting state within 24 hours of hospitalization. Cigarette smoking and alcohol use were recorded and characterized as current or not. Habitual alcohol intake was considered if patients' alcohol consumption exceeded 100 gm of ethanol per week. The patient who had quit more than one year earlier was categorized into nonsmoker. 58 (24.8%) were alcoholics and 72 (30.8%) were smokers on admission. Cardiac disease was coded as present, if there was evidence of cardiac abnormalities known to be a source for cerebral embolism or evidence of coronary heart disease or signs of left ventricle hypertrophy. Chronic renal failure was assumed, when the patient's serum creatinine level was above 1.4 mg/dL. Urine microalbumin was quantatively measured and its reference value was lower than 29 mg/L. Eight patients have taken antiplatelet agents or anticoagulants on hospital admission.

Neuroradiological studies and evaluations

All patients underwent CT scan and MR images of the brain within the first week of hemorrhagic stroke. The ICH was verified and its volume was measured using a semiautomated process which consisted of tracing the perimeter of the appropriate hyperdense areas by a plain CT. All scans were evaluated by an experienced neuroradiologist without knowledge of the clinical and laboratory data.

All MRI studies were performed on a 3.0-tesla unit system (Signa Excite; GE Medical System, Milwaukee, WI, USA), and the whole brain was scanned with a section thickness of 5 mm and a 2 mm intersection gap. The MR imaging protocol included axial spin-echo T1-weighted (TR / TE, 600.0 / 11.0 msec), fast spin-echo T2-weighted (TR / TE, 4000.0 / 111.5 msec), fluid attenuated inversion recovery (FLAIR) (TR / TE, 8002.0 / 139.3 msec), and T2*-weighted GRE sequences. In order to enhance the susceptibility effect of hemosiderin deposits, the T2*-weighted GRE image was obtained in the axial plane with following parameters; TR / TE, 425 / 20 msec, 1 excitation, flip angle 15°, field of view 230 × 17.25 mm, matrix 512 or 256 × 160 pixels, axial slices 20[15].

The T2*-weighted GRE scans were evaluated for two parenchymal lesions of hypointensity, cerebral MBs and OHs. These were located and counted through the entire brain. Cerebral MBs were defined as a rounded area of homogenous signal loss with a diameter less than 5 mm. The corresponding areas with hypointensity at the globus pallidus and the dentate nucleus, likely representing calcification, and in the sylvian fissure or cerebral sulcus, likely due to a signal-void blood vessel, were checked on CT and disregarded. The other signal loss lesions with a maximum diameter of more than 7 mm were separately counted as OHs[10]. The OHs were considered as old scars from prior ICH and defined as irregularly shaped areas of hypointensity (linear, curvilinear, cystic, starlike, and so forth). Areas of supposedly parenchymal ischemic destruction, that is, lesions exhibiting signal isointensity with cerebrospinal fluid in their centers, were diagnosed as lacunes or

old infarcts. Lacunes were detected by their deep location, size less than 10 mm, and perilesional halo on FLAIR images ruling out the enlarged perivascular spaces and patchy leukoaraiosis. White matter and periventricular hyperintensity (WMH, PVH) defined as focal areas of increased signal intensity on FLAIR images and classified into three grades using a scoring system[7]. WMH, signal hyperintensity in the centrum semiovale of white matter, was graded as punctuate (grade 1), patchy / early confluent (grade 2), or confluent (grade 3). PVHs were specified as caps or lining (grade 1), bands (grade 2), or deeply extending into the white matter (grade 3). The grade 1 WMH and PVH of grade 1 and 2 were not regarded as advanced lesions because they probably represent normal anatomical variants (Fig. 1).

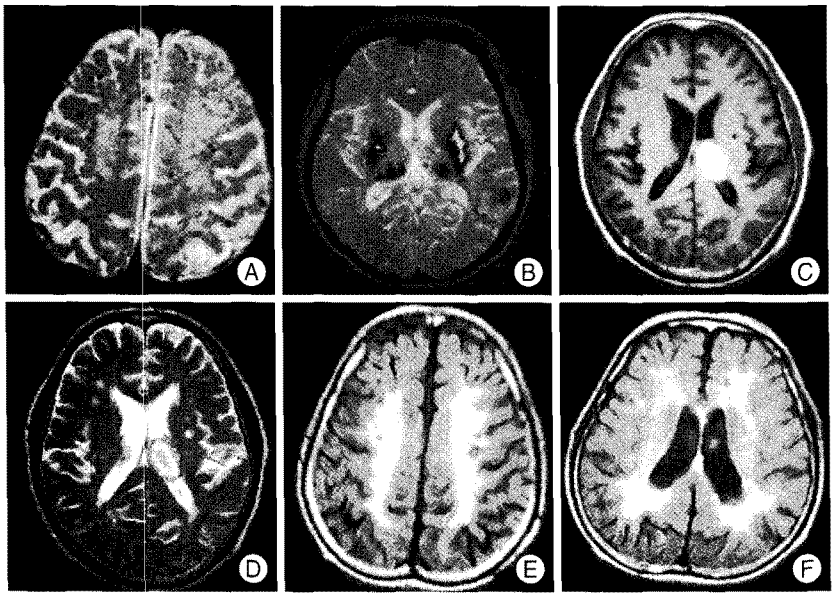

Fig. 1. Definitions and classifications of magnetic resonsance (MR) imgaing abnormalities in different patients of spontaneous intracerebral hemorrhages (ICHs). A numerous small round hypointense lesions, silent microbleeds, are detected by gradient-echo (GRE) sequence on the both cerebral hemispheres (A). Two old hematomas from prior ICHs, fluid-filled cavities with black rim, are clearly revealed in the both basal ganglia with GRE MRI (B). Lacuna shows the hypointensity on T1-weighted MR and the hyperintensity on T2-weighted MR imaging in this case of left thalamus hematoma (C and D). Advanced white matter hyperintensity (grade 3) and periventricular hyperintensity (grade 3) are shown on the fluid attenuated inversion recovery MR images (E and F).

Statistical data analysis

Patients were divided into four subgroups according to the presence or absence of cerebral MBs and OHs and investigated independently. Demographic and clinical data between MBs-present and MBs-absent groups were compared. Association between OHs and laboratory and MR findings was also examined statistically. Data for continuous variables are presented as mean ± SD unless otherwise specified. For comparison between MBs and non-MBs groups and between patients with and without OHS, we used the independent sample T test for continuous variables and the Pearson chi-square test for categorical variables. Topographic distribution between MBs, OHs and ICHs were also analyzed statistically. The level of significance was set at $p < 0.05$. All statistical tests were performed using SPSS version 10 (SPSS Inc., Chicago, IL, USA).

RESULTS

Table 1 shows regional differences in the distribution of the MBs, OHS, and ICHs. In 234 patients, MBs were observed in 186 (79.5%) patients and the number ranged from 1 to 106 (median 10). Among total of 1,986 MBs, 774 (39.0%) were located in the subcortex-cortex, 501 (25.2%) in the basal ganglia, 286 (14.4%) in the thalamus, 208 (10.5%) in the cerebellum, and 217 (10.9%) in the brain stem. A total of 45 lesions of OHs were detected in 45 (19.2%) patients. 29 (64.4%) patients had OHs in the basal ganglionic, 7 (15.6%) patients in the thalamic region, and 5 (11.1%) patients in the lobar region, and 4 (8.9%) patients in the infratentorial region. The gan-

Table 1. Distributions of microbleeds, old hematomas, and ICHs in specific brain regions

Locations*	No. of patients MBs / OHs / ICHs	No. of patients Total (%) MBS / OHs / ICHs	 Mean (range) MBs / OHs / ICHs
Lobar	164 / 5 / 42	774 (39.0) / 5 (11.1) / 42 (17.9)	4.72 (0-60) / 1 (0-1) / 1 (0-1)
Basal ganglia	165 / 29 / 98	501 (25.2) / 29 (64.4) / 98 (41.9)	3.04 (0-25) / 1 (0-1) / 1 (0-1)
Thalamus	143 / 7 / 65	286 (14.4) / 7 (15.6) / 65 (27.8)	2.0 (0-12) / 1 (0-1) / 1 (0-1)
Cerebellum	132 / 1 / 24	208 (10.5) / 1 (2.2) / 24 (10.3)	1.58 (0-28) / 1 (0-1) / 1 (0-1)
Brain stem	139 / 3 / 5	217 (10.9) / 3 (6.7) / 5 (2.1)	1.56 (0-13) / 1 (0-1) / 1 (0-1)
Total	186 / 45 / 234	1986 (100) / 45 (100) / 234 (100)	10.62 (1-106) / 1 (0-1) / 1 (0-1)

*A statistically significant between-group difference was observed with regard to the locations of MBs, OHs and ICHs ($p = 0.001$, chi-square test). MBs : microbleeds, OHs: old hematomas, ICHs : intracerebral hemorrhages

Table 2. Summary of 45 patients of recurrent ICHs

Variable	No. of patients (%)
Interval of recurrence (years)	
≤1	8 (17.8)
≤2	17 (37.8)
≤3	20 (44.4)
≤4	24 (53.3)
>4	21 (46.7)
Locations of ICHs (previous / present)	
BG / BG	11 (24.4)
BG / Thalamus	7 (15.6)
BG / Lobar	9 (20.0)
BG / Cerebellum	2 (4.4)
Thalamus / BG	4 (8.9)
Thalamus / Thalamus	2 (4.4)
Thalamus / Lobar	1 (2.2)
Lobar / BG	2 (4.4)
Lobar / Thalamus	1 (2.2)
Lobar / Lobar	2 (4.4)
Cerebellum / Thalamus	1 (2.2)
Brain stem / Thalamus	1 (2.2)
Brain stem / Lobar	2 (4.4)

BG : basal ganglia, ICH : intracerebral hemorrhage

glionic/thalamic locations of MBs (39.6%) and OHs (80.4%) are consistent with deep ICHs (69.7%). Their regional correlation was significant statistically (p = 0.001). For the patients of recurrent ICHs, the common patterns for recurrence were 'ganglionic-ganglionic in 11 cases (24.4%) and 'ganglionic-lobar' in 9 cases. Mean interval of recurrent ICH was 76.7 months and 17 (37.8%) patients had the second hemorrhage within 2 years after the first hemorrhagic attack (Table 2).

Clinical and MR imging data of ICHs patients with respect to presence or absence of MBs are given in Table 3. Patients with MBs and those without MBs showed significant difference in age, hypertension, previous cerebral stroke, and levels of TC and LDLC. Subcortical and deep WMH was found in 194 (82.9%) patients; 39 had confluent, 59 had early confluent, and 96 had punctate abnormalities. Two-hundred-seventeen (91.6%) patients showed abnormal PVHs; 114 had caps, 50 had bands, and 53 had irregular types. Patients with MBs had higher prevalence of severe WMH and PVH, OHs, and lacunes compared to those without it. Other variables on CT and MR images were not significantly different between MBs and non-MBs groups.

Table 3. Demographic, clinical, and radiological variables for 234 ICH patients with or without microbleeds

Variable	With MBs (n = 186)	Without MBs (n = 48)	p Value
Demographic			
Age (years)	62.63 ± 11.75	54.94 ± 10.22	0.001
Male sex	90 (48.4)	25 (52.1)	0.648
Risk factors			
Hypertension	117 (63.2)	19 (39.6)	0.003
Previous stroke	62 (33.3)	2 (4.2)	0.001
Antithrombotic therapy	8 (4.3)	0 (0)	0.156
Diabetes mellitus	23 (12.4)	3 (6.3)	0.229
Smoking	44 (23.7)	14 (29.2)	0.430
Alcohol intake	56 (30.1)	16 (33.3)	0.666
Creatinine (>1.4 mg / dL)	27 (14.6)	6 (12.5)	0.711
Total cholesterol (mg / dL)	202.36 ± 41.84	188.27 ± 33.89	0.032
HDL-cholesterol	58.98 ± 23.10	56.15 ± 15.00	0.431
LDL-cholesterol	129.84 ± 37.99	116.26 ± 34.45	0.029
Triglyceride (mg / dL)	88.77 ± 72.38	102.04 ± 104.35	0.316
Urine microalbumin	221.26 ± 588.18	190.83 ± 481.46	0.851
Radiology			
Sites of ICH			0.559
Lobar, n (%)	32 (17.2)	10 (20.8)	
Deep, n (%)	154 (82.8)	38 (79.2)	
Advanced WMH, n (%)	89 (47.8)	9 (18.7)	0.001
Advanced PVH, n (%)	48 (25.8)	5 (10.4)	0.002
Lacunae, n (%)	154 (82.4)	32 (66.7)	0.017
OHs, n (%)	44 (23.7)	1 (2.1)	0.001
Old Infarcts, n (%)	18 (9.6)	1 (2.1)	0.068

Value are given as n (%). ICH : intracerebral hemorrhage, HDL : high density lipoprotein, LDL : low density lipoprotein, MBs : microbleeds, OHs : old hematomas, WMH : white matter hyperintensity, PVH : periventricular hyperintensity

Table 4 shows the comparison of demographic variables, vascular risk factors, and severity of MBs and WM changes on MRI between patients with and without OHS. OHs were more frequently counted in the patients with chronic hypertension and were closely associated with presence and frequency of MBs and advanced WMH and PVH. The percentage of patients who received an antithrombotics therapy was also higher in the OHs groups. However, other associated risk factors was similar in both groups, and the location of ICHs, hematoma volume and territorial infarction that did not differ between both groups statistically significantly. Lacunes were detected in 42 of 45 (93.3%) patients with OHs and 144 of 189 patients (76.2%) without OHs.

DISCUSSION

The advent of MR imaging with GRE sequence in ischemic and hem-

Table 4. Clinical and morphological characteristics of ICH patients with and those without old hematomas

Variable	With OHs (n = 45)	Without OHs (n = 189)	p value
Demographic			
Age (years)	61.44 ± 9.63	60.96 ± 12.37	0.775
Male sex	22 (51.1)	92 (48.7)	0.769
Risk factors			
Hypertension	39 (86.7)	97 (51.6)	0.001
Duration (years)	6.59 ± 5.60	2.85 ± 4.49	0.001
Antithrombotic therapy	4 (8.9)	4 (2.1)	0.046
Diabetes mellitus	8 (17.8)	18 (9.5)	0.113
Smoking	10 (22.2)	48 (25.4)	0.658
Alcohol intake	14 (31.1)	58 (30.7)	0.956
Creatinine (>1.4 mg/dL)	7 (14.0)	26 (14.2)	0.970
Total Cholesterol (mg/dL)	200.20 ± 43.69	199.27 ± 40.02	0.890
HDL-cholesterol	59.09 ± 20.81	58.24 ± 21.96	0.817
LDL-cholesterol	126.00 ± 38.89	127.34 ± 37.41	0.833
Triglyceride (mg/dL)	92.39 ± 71.01	91.25 ± 81.59	0.933
Urine microalbumin	215.48 ± 271.19	214.27 ± 590.99	0.995
Cardiac disease	2 (4.4)	14 (7.4)	0.479
Radiology			
Site of ICH			0.090
Lobar, n (%)	12 (26.7)	30 (15.9)	
Deep, n (%)	33 (73.3)	159 (84.1)	
Hematoma volume	19.28 ± 23.84	16.92 ± 18.47	0.473
Presence of MBs	44 (97.8)	142 (75.1)	0.001
Number of MBs	14.5 ± 13.09	9.48 ± 14.02	0.036
Advanced WMH, n (%)	30 (66.7)	68 (36)	0.001
Advanced PVH, n (%)	20 (44.4)	33 (17.5)	0.001
Lacunes, n (%)	42 (93.3)	144 (76.2)	0.524
Old infarction, n (%)	2 (4.4)	17 (9.0)	0.218

Value are given as n (%). OHs : old hematomas, HDL : high density lipoprotein, LDL : low density lipoprotein, ICH : intracerebral hemorrhage, MBs : microbleeds, WMH : white matter hyperintensity, PVH : periventricular hyperintensity

orrhagic stroke patients has drawn attention to focal areas of signal loss, such as MBs and OHs, which were suggested to indicate hemosiderin deposits following earlier bleeds[7]. In this study, MBs were detected in 79.5% of spontaneous ICHs patients. Moreover, OHs were found in 19.2% of these patients. With regard to their distribution, as shown in ours, some reports suggested that regions with the greatest number of MBs could be the sites of future bleeding and rehemorrhage in given patients[22,27,30,34].

The frequencies of MBs in the earlier investigations on ICHs cases that used lower tesla MRI or conventional MR sequences are much lower than those in our study. Reported detection rates were less than 50% in their different stroke populations[16,23,34]. First, this difference could be explained by the fact that utilization of MR scanner with different field strength may lead to difference of sensitivity in detecting cerebral MBs. Second, the prevalence of hypertension (58%) in our patients with ICHs was somewhat high as compared with previous study groups[26,33]. Third, the observation of previous brain strokes in more than one forth in this series is striking. Because it has been well-known that the subsequent increased vascular vulnerability can induce the stroke recurrence, this would also affect the higher prevalence rate of MBs in present study. Interestingly, 70% of our patients with recurrent strokes were hemorrhagic type. This finding is in line with the fact that the incidence of recurrence rate of hemorrhagic stroke is higher in the Asian populations than in the western people[1,4].

Baseline and radiographic characteristics of ICHs patients with regarding the presence or absence of MBs are demonstrated in Table 3. Being accordance with reported results[3,24,25,31,34], cerebral MBs have been associated with older age, hypertension, white matter disease, lacunar infarct, and former hemorrhagic stroke in this analysis. However, unlike other studies on the relationship between MBs and acute primary ICH[7,12,18,23,35], our study suggested that higher levels of both TC and LDLC was more commonly associated with the MBs groups than non-MBs patients. Although its role as a cause of cerebral stroke still remains uncertain, a few authors mentioned that lowering of serum TC may increase the risk of MBs and occurrence of cerebral hemorrhages[12,18,23,35]. Radiologically, the hyperintense lesions clearly defined on FLAIR MR imaging usually involved the subcortical and deep periventricular regions. Recently, some researchers speculated that severe degrees of WMH and PVH might be risk factors for the development of hemorrhagic or ischemic cerebral stroke[6,24,28,29]. In present study, their presence was more prominent in the patients with MBs, and MBs were also strongly correlated with increasing grades of WMHs and PVHs. As like cerebral MBs, the WMH and PVH has been shown to be frequently related to lacunes and hypertension on lots of investigations[3,6,21,33]. MBs, lacunes, and WMHs are all MR markers of microangiopathy in the brain and are evidences the simultaneous negative effects of hypertension. These also reflect vessel vulnerability that can predispose to subsequent endothelial rupture in the environment of long-

lasting uncontrolled hypertension. Therefore, with the reduction of severity of white matter damage and degree of microhemorrhage, the lowering the arterial blood pressure should be considered as the key issue in the management strategies for the prevention of occurrence and recurrence of the spontaneous ICHs.

By MR scanning with high resolution GRE images, the OHs in brain parenchyme were nicely revealed and differentiated from the MBs in 45 patients of ICHs had previous hemorrhagic events. Clinically, their incidence was more closely related with the chronic hypertension and concurrent treatment with antithrombotics in this study. This marker for stroke recurrence can offer further evidence of severe microangiopathy with enhanced vessel fragility. In addition, reviews on literature have suggested that survivors of ICHs have a higher risk of rehemorrhage than of ischemic stroke[2]. Consequently, we have to follow-up the ICH patients thoroughly, and arterial hypertension is needed to be controlled strictly and continuously to decrease the blood flow and damage to penetrating arterioles and then to prevent recurrent hemorrhage. As the second issue in clinical practice of stroke, even with its smaller sample size of antithrombotics user, it can be better not to prescribe the antiplatelet or anticoagulants for ICHs patients based on our results. However, currently, whether the presence of OHs will increase the risk of antithrombotic-related ICH is still inconclusive[2], so that more prospective data are required in order to confirm the predictability of MBs and OHs for this complication, as they are more relevant to the actual brain hemorrhagic lesion load. On comparison of MR abnormalities between the patients with and without OHs, the former had more advanced grades of PVHs and WMHs than the later. This finding was a unique in present anaylsis because the arteriosclerotic necrosis in the brain vessels is the major pathology in subcortical regions of hyperintensities, under cumulative hemodynamic stress induced by a chronically high blood pressure. However, we need more studies in the near future to define the potential role of white matter lesions in ICHs, as indicators of possible recurrence of brain hemorrhage. In the previous studies on ICHs, it has been reported that the hematoma was larger at the second bleeding and the clinical impact of the recurrent hematoma was more severe. In contrast with those[1], there was no statistical difference in the clot volume between the OHs and non-OHs groups. Finally, the presence and number of MBs were more significantly correlated to the OHs patients in this investigation, therefore cerebral MBs seem to have a predicting value of ICHs recurrence. We also showed topographic correlation between MBs and OHs in the basal ganglionic/thalamic region, where symptomatic ICHs and their recurrence are most commonly observed. The most common pattern of ICHs recurrence was ganglionic-ganglionic in the present data. Earlier studies have reported that the main topographic patterns of cerebral rebleeding were the ganglionic-ganglionic and lobar-lobar[8,9,11,19,20]. The former pattern is likely the result of chronic hypertension whereas the later probably results from CAA. But, because the patients of CAA were not recruited for this study, the result was different from the prior reports.

CONCLUSION

Our findings suggest that cerebral MBs and advanced WMHs, direct and indirect markers of hypertension-induced microangiopathy on MR imaging, could be potential risk factors for the development of spontaneous symptomatic ICHs. Both lesions may deserve to be treated as a "silent ICH" in the dyslipidemic and elderly patients with hypertension. Second, we showed that the patients of prior ICHs, demonstrated by OHs on GRE MRI, were closely related to long-standing hypertension, antithrombotics medication, and presence and frequency of MBs and severe types of WMHs and PVHs. Third, regional correlation in the brain between the three cerebral hemorrhages, MBs, OHS, and ICHs, was also noted in the basal ganglionic and thalamic location. With well-designed prospective studies, we can exactly determine the diagnostic and prognostic potentiality of MBs and OHs in the brain and assess the individual's risk of the occurrence and recurrence of spontaneous ICHs.

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