ORIGINAL

Significance and characteristics of patients with Ribbon-like signal hyperintensity after acute ischemic stroke

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Abstract : Objectives : We discovered a novel finding of ribbon-like signal hyperintensity of the cerebral cortex, named the ribbon sign, after reperfusion therapy. Herein, we report the significance and clinical characteristics of ribbon signs. Materials and Methods : Data from consecutive patients with acute ischemic stroke and anterior large-vessel occlusion were prospectively extracted from the Tokushima University Hospital Stroke Registry between January 2011 and March 2020. Diffusion-weighted imaging findings were retrospectively assessed in patients with acute ischemic stroke with large-vessel occlusion, with or without treatment. Results : A total of 140 patients (78 males, average age : 75.7 years) were enrolled in the study. Among the patients, 113 (80.7%) underwent reperfusion therapy. Eighty-one (57.9%) patients underwent successful recanalization. The ribbon sign was more common in patients with successful recanalization than in patients with unsuccessful recanalization (53.1% vs. 8.5%, respectively ; $p<0.01$). The ribbon sign is a specific finding after successful recanalization. Conclusions : Our study is the first to report that the ribbon sign is a specific finding in patients with acute ischemic stroke. The patients with extensive DWI lesion, including those in the cortex on adimisson, exhibited the ribbon sign after successful recanalization. J. Med. Invest. 73 : 36-43, February, 2026

Keywords **:** *ischemia, magnetic resonance imaging, outcomes assessment, thrombolytic therapy*

INTRODUCTION

The efficacy and safety of reperfusion therapy, including intravenous thrombolysis (IVT) and endovascular treatment (EVT), in patients with acute ischemic stroke (AIS) due to anterior large-vessel occlusion (LVO) have been established (1-8). A non-invasive intracranial vascular study is recommended during the initial imaging evaluation of patients with acute stroke. Diffusion-weighted imaging (DWI) lesions at onset have been accepted as the ischemic core in some clinical studies. However, whether DWI lesions at onset are already infarcted or potentially salvageable is debatable, particularly in cases where rapid reperfusion is possible.

We assessed magnetic resonance imaging (MRI) as first-line and post-treatment imaging in patients with AIS and discovered a novel finding of ribbon-like signal hyperintensity of the cerebral cortex, named the ribbon sign, after reperfusion therapy. Herein, we report the significance and clinical characteristics of ribbon signs after reperfusion therapy.

METHODS

Data from consecutive patients with AIS caused by anterior LVO were prospectively extracted from the Tokushima University Hospital Stroke Registry between January 2011 and March 2020. MRI was implemented as the first-line pretreatment imaging. Patients who fulfilled the following eligibility criteria were included : (a) imaging both within 24 hours of AIS onset and within 72 hours posttreatment ; (b) baseline magnetic resonance angiography to confirm an internal carotid artery (ICA) or middle cerebral artery (MCA) M1 (horizontal segment of MCA) occlusion ; (c) AIS confirmed by baseline MRI (Discovery 750 3T, GE Healthcare ; DWI : b=0–1000 s/mm^2 : 5-mm contiguous slices) ; and (d) clinical outcome obtained at 3 months after onset.

Data on clinical characteristics, including baseline demographics, baseline National Institutes of Health Stroke Scale (NIHSS) score, time from onset to MRI, lesion side, baseline DWI-Alberta Stroke Program Early Computed Tomography Score (DWI-ASPECTS), stroke subtype, type of reperfusion therapy, outcomes, and ribbon sign, were retrospectively collected. The ribbon sign was defined as ribbon-like signal hyperintensity of the cerebral cortex without white matter on DWI on the second MRI within 72 hours post-treatment. Cortical hyperintensity was limited to 1.5 times the thickness of a normal cortex and longer than 15 mm. The cerebral cortex in this study included the frontal lobe, temporal lobe, parietal lobe, and insular cortex.

Patients who received EVT were required to have a mismatch between the severity of the clinical deficit and the infarct volume, as defined according to the following criteria : obtaining a score of 8 or higher on the NIHSS (scores range from 0 to 42, with higher scores indicating a more severe deficit) before March 2015, and having an infarct volume of 7 or higher on DWI-APECTS within 8 hours from onset ; having a score of 6 or higher on the NIHSS after March 2015, and having an infarct volume of 6 or higher

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on DWI-ASPECTS within 6 hours from onset. Some discretion of the neurointerventionalists was approved for the indication of EVT for the patients who did not match the criteria.

If eligible, patients received IVT (0.6 mg/kg alteplase) according to the Japanese-approved standard care protocol before EVT. All interventional procedures were performed by board-certified neurointerventionalists of the Japanese Society for Neuroendovascular Therapy. Successful reperfusion was defined as modified Thrombolysis in Cerebral Infarction Scale grade 2b or 3 after EVT and early neurological improvement was defined as a decrease of 4 points in the NIHSS score 24 hours (9) after IVT or medical therapy. Recanalization was defined as successful reperfusion and patency of the ipsilateral ICA and MCA on the second magnetic resonance angiography within 72 hours post-treatment.

Two neurologists with stroke expertise (Y.Y. and N.Y.) independently evaluated baseline DWI-ASPECTS on MRI at onset and the ribbon sign on MRI within 72 hours post-treatment. When the readers' assessments differed, a final consensus was reached by a third reader, a neuroradiologist (M.Y.).

The study protocol was approved by the Tokushima University Hospital Ethics Committee. Written informed consent was obtained from the patients.

Statistical analyses

Continuous variables were described as mean±standard deviation (SD) and compared using Student's t-test. The non-normally distributed variables (NIHSS score and DWI-ASPECTS) are described as medians and interquartile ranges. Categorical variables were compared using the χ^2 test or Fisher's exact test as appropriate. Additionally, the factors associated with the ribbon sign followed by LVO were analyzed using multiple logistic regression analysis. Differences were considered statistically significant at $p<0.05$. All statistical analyses were performed using GraphPad Prism version 9 (GraphPad Software, California, USA).

Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

RESULTS

Patients

During the study period, 221 patients were diagnosed with AIS due to anterior LVO. Among these patients, 70 (31.7%) were excluded due to the lack of MRI findings within 72 hours post-treatment. Among these, 11 patients were excluded due to missing outcomes 3 months after onset. Finally, a total of 140 patients were included in this analysis. The baseline clinical characteristics of the patients are presented in Table 1. The etiology of ischemic stroke was diagnosed as intracranial atherosclerotic disease or embolic stroke due to a cardiac source, another origin, or an unknown origin. A total of 113 (80.7%) patients underwent reperfusion therapy (IVT, n=21 [15.0%] ; EVT, n=42 [30.0%] ; combined IVT/EVT, n=50 [35.7%]). Recanalization was achieved in 81 (57.9%) patients. A total of 45 (32.1%) patients had a modified Rankin Scale (mRS) score of 0–2 and 95 (67.9%) had an mRS score of 3–6 at 3 months after onset. The ribbon sign was observed in 48 (34.3%) patients on the second MRI. Concordance between the two assessors was 87.1%, with substantial agreement, as indicated by kappa=0.715.

Table 1. Characteristics of the patients in this study

	Total (n = 140)
Age	75.7 ± 10.2
Sex (Male)	78/140 (55.7)
Lesion side (Left)	63/140 (45)
Initial NIHSS score	15 (10-19)
Time from onset to the first MRI	4.8 ± 7.6
DWI-ASPECTS	7 (6-9)
Time from onset to the second MRI	30.1 ± 15.5
Etiology	
ICAD	53 (37.9)
Embolic stroke	87/140 (62.1)
Reperfusion therapy	113/140 (80.7)
IVT	21/140 (15.0)
EVT	42/140 (30.0)
IVT/EVT	50/140 (35.7)
Recanalization	81/140 (57.9)
mRS score of 0–2	45/140 (32.1)
mRS score of 3–6	95/140 (67.9)
Ribbon sign	48/140 (34.3)

Data are presented as mean ± SD for age, time from onset to the first MRI, DWI-ASPECTS, and time from onset to the second MRI ; median and interquartile range for initial NIHSS score and DWI-ASPECTS ; and number of patients (%) for others.
SD, standard deviation ; NIHSS, National Institute of Health Stroke Scale ; MRI, magnetic resonance imaging ; DWI-ASPECTS, diffusion-weighted imaging–Alberta Stroke Program CT Score ; CT, computed tomography ; ICAD, intracranial atherosclerotic disease ; IVT, intravenous thrombolysis ; EVT, endovascular treatment ; mRS, modified Rankin Scale.

Illustrative Cases

Representative cases of acute ischemia with anterior LVO are shown in Figures 1 and 2. Both were diagnosed with AIS and proximal MCA occlusion.

Case 1

In Case 1, the patient was treated conservatively without reperfusion therapy because of extensive ischemic lesions on DWI (DWI-ASPECTS=2) at 1.5 hours after onsets (Figure 1). The second DWI showed a massive ischemic lesion in both the cortex and white matter 27 hours after onset. There was no ribbon sign. Three months after onset, the patient had an mRS score of 4.

Case 2

In Case 2, the patient underwent reperfusion therapy with combined IVT and EVT. Although extensive ischemic lesions were observed on the first DWI (DWI-ASPECTS=4) 1 hour after onset (Figure 2), second MRI at 22 hours after onset showed a DWI lesion limited to the cerebral cortex and basal ganglia. We named a DWI lesion limited to the cerebral cortex the ribbon sign (Figure 2E and 2F). Three months after onset, the patient had an mRS score of 3.

Ribbon Signs Were Observed in Patients with AIS after Recanalization

We divided the patients with anterior LVO into two groups based on recanalization status after treatment (Table 2). The patients with recanalization had a higher proportion of left-side lesions (58.0% vs 32.2%, respectively, $p=0.0035$), higher initial

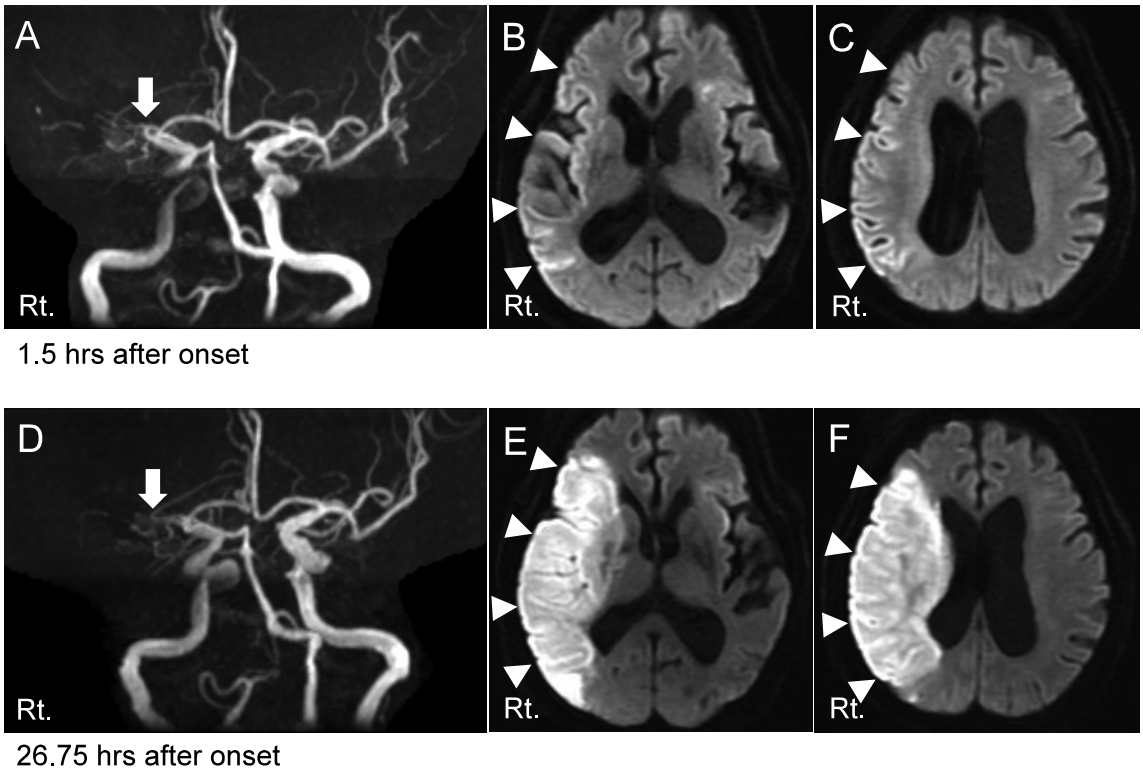

Figure 1. A : MRA showing occlusion of the right MCA at the stem 1.5 hours after onset (arrow). B, C : DWI showing slight hyperintensity in the right MCA territory (arrowhead). D : MRA shows occlusion of the right MCA at the stem 26.75 hours after onset (arrow). DWI showing bright hyperintensity in the right MCA territory without recanalization of the MCA (arrowhead).
MRA, magnetic resonance angiography ; MCA, middle cerebral artery ; DWI, diffusion-weighted imaging.

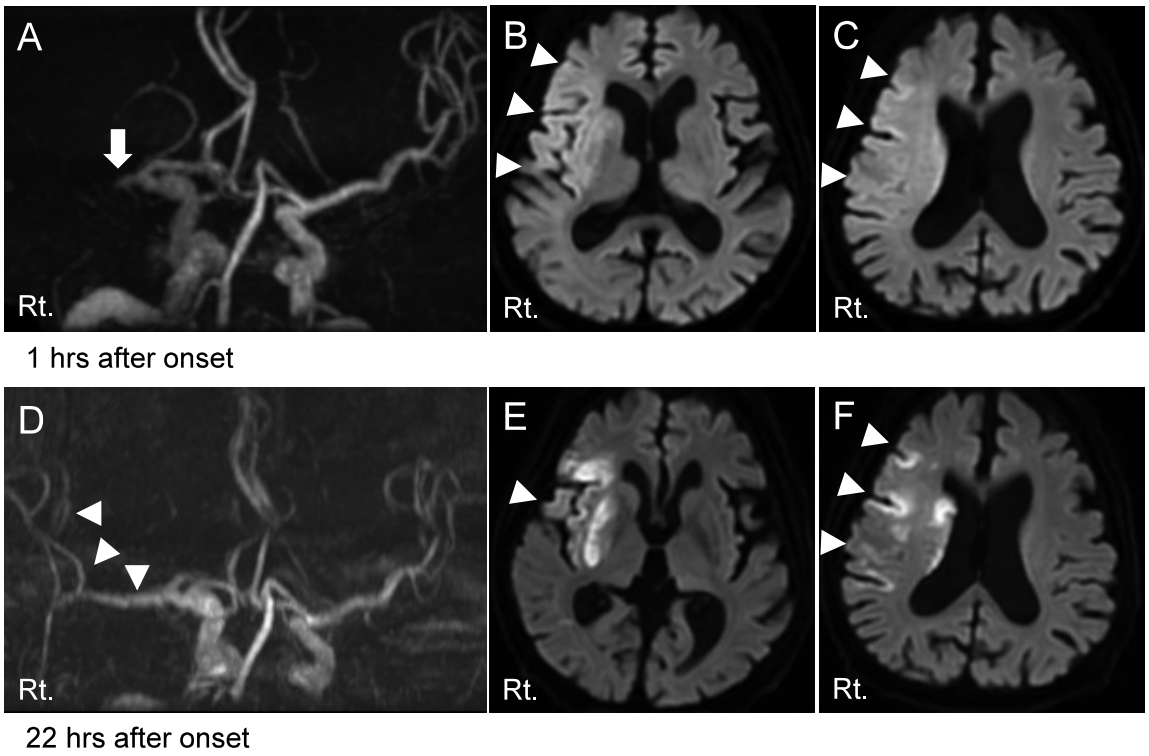

Figure 2. A : MRA shows occlusion of right MCA at the stem 1.0 hour after onset (arrow). B, C : DWI shows a slight hyperintensity at the right MCA territory (arrow head). D : MRA shows recanalization of right MCA at the stem 22 hours after onset (arrow head). E, F : DWI shows a bright hyperintensity at the cortex and basal ganglia of right MCA territory with recanalization of MCA (arrow head).
MRA, magnetic resonance angiography ; MCA, middle cerebral artery ; DWI, diffusion-weighted imaging.

Table 2. Characteristics of the patients with or without recanalization

	Recanalization – (n = 59)	Recanalization + (n = 81)	P value
Age	74.0 ± 10.7	77.0 ± 9.8	0.0894
Sex (Male)	33/59 (56.0)	45/81 (55.6)	> 0.9999
Lesion side (Left)	19/59 (32.2)	47/81 (58.0)	0.0035
Initial NIHSS score	13 (8-18)	15 (11-23)	0.0214
Time from onset to the first MRI	7.3 ± 10.5	3.0 ± 3.4	0.0008
DWI-ASPECTS	7 (6-9)	7 (6-9)	0.8834
Time from onset to the second MRI	33.1 ± 18.0	27.9 ± 12.9	0.0451
Etiology			0.0535
ICAD	28/59 (47.5)	25/81 (30.9)	
Embolic stroke	31/59 (52.5)	56/81 (69.1)	
Reperfusion therapy	36/59 (61.0)	77/81 (95.1)	< 0.0001
IVT	7/59 (11.9)	14/81 (17.3)	
EVT	18/59 (30.5)	24/81 (29.6)	
IVT/EVT	11/59 (18.6)	39/81 (48.1)	
mRS score of 0–2	8/59 (13.6)	37/81 (45.7)	< 0.0001
mRS score of 3–6	51/59 (86.4)	44/81 (54.3)	
Ribbon sign	5/59 (8.5)	43/81 (53.1)	< 0.0001

Data are presented as mean±SD for age, initial NIHSS score, time from onset to the first MRI, DWI-ASPECTS, and time from onset to the second MRI ; median and interquartile range for initial NIHSS score and DWI-ASPECTS ; and number of patients (%) for others.
SD, standard deviation ; NIHSS, National Institute of Health Stroke Scale ; MRI, magnetic resonance imaging ; DWI-ASPECTS, diffusion-weighted imaging–Alberta Stroke Program CT Score ; CT, computed tomography ; ICAD, intracranial atherosclerotic disease ; IVT, intravenous thrombolysis ; EVT, endovascular treatment ; mRS, modified Rankin Scale.

NIHSS scores (15 vs 13, respectively, p=0.0214), earlier evaluation of the first MRI after onset (3.0±34 vs 7.3±10.5, respectively, p=0.0008) and earlier evaluation of the second MRI after treatment (27.9±12.9 vs 33.1±18.0, respectively, p=0.0451). Among the patients with recanalization, 77 (95.1 %) received reperfusion therapy (IVT, n=14 ; EVT, n=24 ; combined IVT/EVT, n=39). Four (4.9%) experienced spontaneous recanalization. The patients who underwent recanalization had more favorable outcomes at 3 months after onset (37 [45.7%] vs. 8 [13.6%], p<0.0001) and a higher incidence of the ribbon sign (43 [53.1%] vs. 5 [8.5%], p<0.0001) than those who did not undergo recanalization. Multiple logistic regression analysis revealed that the ribbon sign was significantly associated with recanalization (odds ratio=13.28, 95% confidence interval=3.999 to 53.42).

The Ribbon Sign Was Associated with Lower DWI-ASPECTS

To analyze the characteristics of the ribbon sign, we divided the patients with recanalization into two groups according to the status of the ribbon sign (Table 3). The patients with ribbon signs had lower DWI-ASPECTS than those without ribbin signs (6 vs 9, respectively). Despite the low ASPECTS, the rates of reperfusion therapy (93% vs. 97.4%, p=0.6184) and favorable outcomes (44.2% vs. 44.7%, p>0.9999) did not differ between the two groups. In patients with reperfusion therapy, the patients with ribbon sign had the same outcome as the patients without ribbon sign despite the massive primary ischemic damage.

The Ribbon Sign Was Observed in Patients with Low ASPECTS after Recanalization

Patients with low ASPECTS were selected and divided into two groups based on the recanalization status after treatment (Supplementary Table 1). The patients with recanalization had higher ASPECTS than those without it (5 vs 3, p=0.0132). Sixteen (84.2%) patients with recanalization underwent reperfusion therapy (IVT, n=2 ; EVT, n=5 ; combined IVT/EVT, n=9). The patients with recanalization had a more favorable outcome (mRS 0–3) at 3 months after onset (9 [47.4%] vs. 1 [7.1%], p=0.0209) and a higher incidence of the ribbon sign (16 [84.2%] vs. 1 [7.1%], p<0.0001) than those without it.

The Ribbon Sign Tended to Be Associated with Reperfusion Therapy and Favorable Outcome in Patients with Low ASPECTS

To analyze the characteristics of the ribbon sign in patients with low ASPECTS, we divided patients with recanalization into two groups based on the status of the ribbon sign (Supplementary Table 2). The patients with ribbon signs had higher DWI-ASPECTS than those without them (5 vs 4, p=0.0315). The rate of reperfusion therapy tended to be higher in the patients with ribbon signs than in those without them (82.4% vs. 37.5%, p=0.0501). The patients with ribbon signs had more favorable outcomes at discharge (41.2% vs. 6.3%, respectively, p=0.0391) and at 3 months (47.1% vs. 12.5%, p=0.0570) than those without them.

DISCUSSION

The effectiveness of reperfusion therapy for anterior LVO is well established (1-8). We implemented MRI as the first-line pretreatment imaging. Using MRI, we demonstrated several findings of AIS (10, 11). In the era of mechanical thrombectomy, most patients receiving reperfusion therapy achieve successful

Table 3. Characteristics of the patients with recanalization with or without the ribbon sign

	Ribbon – (n = 38)	Ribbon + (n = 43)	P value
Age	77.6 ± 8.6	76.4 ± 10.8	0.5985
Sex (Male)	23/38 (60.5)	22/43 (51.2)	0.5024
Lesion side (Left)	22/38 (57.9)	25/43 (58.1)	> 0.9999
Initial NIHSS score	15 (11-21)	16 (11-24)	0.5683
Time from onset to the first MRI	3.1 ± 3.7	2.8 ± 3.2	0.7321
DWI-ASPECTS	9 (7-9)	6 (5-7)	< 0.0001
DWI positivity in the cortex	16/38 (42.1)	42/43 (97.7)	< 0.0001
Time from onset to the second MRI	28.8 ± 14.6	26.9 ± 11.2	0.5175
Etiology			0.8116
ICAD	11/38 (28.9)	14/43 (32.6)	
Embolic stroke	27/38 (71.1)	29/43 (67.4)	
Reperfusion therapy	37/38 (97.4)	40/43 (93.0)	0.6184
IVT	4 /38 (10.5)	10/43 (23.3)	
EVT	14/38 (36.8)	10/43 (23.3)	
IVT/EVT	19/38 (50.0)	20/43 (46.5)	
mRS score of 0–2	17/38 (44.7)	19/43 (44.2)	> 0.9999
mRS score of 3–6	21/38 (58.2)	24/43 (55.8)	

Data are presented as mean±SD for age, initial NIHSS score, time from onset to the first MRI, DWI-ASPECTS, and time from onset to the second MRI ; median and interquartile range for initial NIHSS score and DWI-ASPECTS ; and number of patients (%) for others.
SD, standard deviation ; NIHSS, National Institute of Health Stroke Scale ; MRI, magnetic resonance imaging ; DWI-ASPECTS, diffusion-weighted imaging–Alberta Stroke Program CT Score ; CT, computed tomography ; ICAD, intracranial atherosclerotic disease ; IVT, intravenous thrombolysis ; EVT, endovascular treatment ; mRS, modified Rankin Scale.

recanalization. We noticed that some patients who received reperfusion therapy had a ribbon-like signal hyperintensity in the cerebral cortex on DWI after successful recanalization. We named this the ribbon sign and retrospectively analyzed the incidence and characteristics of AIS. Among the patients with successful recanalization, 53.1% had the ribbon sign. Only 8.5% of the patients without recanalization had a ribbon sign. Therefore, the ribbon sign is a characteristic finding in patients with AIS and anterior LVO after successful recanalization.

Next, we analyzed patients with successful recanalization and divided them into two groups : with or without the ribbon sign. The patients with ribbon signs had a lower DWI-ASPECTS (6 vs 9, respectively) and a higher rate of DWI positivity in the cortex (97.7% vs 42.1%) than those without them. In other words, patients with extensive DWI lesions, including those in the cortex, exhibited the ribbon sign after successful recanalization. Due to the differences in patient characteristics before reperfusion therapy, there was no difference in functional outcomes between the two groups. The ribbon sign is limited to the cortex, which may indicate DWI reversal of the white matter after reperfusion therapy. In patients with low ASPECTS, the ribbon sign tended to be associated with reperfusion therapy and favorable outcomes.

DWI is widely used to evaluate the ischemic core (12, 13). The sub-analysis of the Diffusion and Perfusion Imaging Evaluation for Understanding Stroke Evolution 2 study demonstrated that the region of DWI reversal is transient and results in abnormalities in fluid-attenuated inversion recovery. However, whether DWI precisely reveals the ischemic core is controversial (14-17). Reversible acute DWI lesions are found in half of the patients treated with intravenous tissue-type plasminogen activator within 4.5 hours and DWI reversal is associated with good clinical outcomes (18). Gray matter and white matter may have differential vulnerabilities to acute ischemia. A previous study demonstrated that white matter is more prone to DWI reversal than gray matter (19). Consistent with this finding, the ribbon sign, which is limited to the gray matter, may indicate a DWI reversal in the white matter. In this study, the ribbon sign tended to be associated with reperfusion therapy and favorable outcome in patients with low ASPECTS. In the era of EVT, patients with LVO experience faster reperfusion than those treated with IVT alone. In animal studies, DWI reversal was associated with limited necrosis of the brain tissue (16). Therefore, the initial DWI lesion may contain viable brain tissue. Although the ribbon sign is not the same as DWI reversal, it may indicate incomplete infarction in the cerebral cortex and white matter after revascularization therapy. Further studies are needed to elucidate the clinical significance of the ribbon sign and its relationship with clinical outcomes.

Cortical laminar necrosis is a finding similar to the ribbon sign. However, cortical laminar necrosis differs from the ribbon sign in three points (20-22). First, it is high-signal lesions on T1-weighted images, but on DWI after cerebral infarction. Second, it appears about 2 weeks after the ictus and is prominent at 1-2 months. The ribbon sign is defined as ribbon-like signal hyperintensity of the cerebral cortex without white matter on DWI on the second MRI within 72 hours post-treatment. Third, it occurs regardless of whether reperfusion therapy was performed or not. The ribbon sign is associated with reperfusion therapy.

Our study has a limitation. This is a retrospective study. The patients with low ASPECTS may not have been treated with EVT. This may have biased our results toward favorable outcomes and caused some overestimation of the patients with low

ASCPECTS after recanalization.

Our study is the first to report that the ribbon sign is a specific finding after successful recanalization in patients with AIS. The ribbon sign appeared frequently in patients with large DWI lesions, including the cortex, after recanalization.

DECLARATIONS OF INTERESTS

None.

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AUTHORS' CONTRIBUTIONS

TM participated in the conception, design, data acquisition, and drafting of the article. SS, MK, IY, MI, KS, YK, KK, YY, and NY. participated in data acquisition, analysis, and interpretation. MH, YI, and YT critically reviewed the manuscript for intellectual content and approved its submission for publication.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

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Supplementary Table 1. Characteristics of the patients with low ASPECTS with or without recanalization

	Recanalization – (n = 14)	Recanalization + (n = 19)	P value
Age	71.8 ± 13.1	75.9 ± 11.7	0.0894
Sex (Male)	10/14 (71.4)	10/19 (52.6)	0.3441
Lesion side (Left)	3/14 (21.4)	8/19 (42.1)	0.2783
Initial NIHSS score	17 (12-19)	17 (13-26)	0.3048
Time from onset to the first MRI	5.9 ± 7.1	3.4 ± 3.4	0.1900
DWI-ASPECTS	3 (3-5)	5 (4-5)	0.0132
Time from onset to the second MRI	29.0 ± 18.0	28.6 ± 8.9	0.1287
Etiology			> 0.9999
ICAD	3/14 (21.4)	5/19 (26.3)	
Embolic stroke	11/14 (78.6)	14/19 (73.7)	
Reperfusion therapy	10/14 (71.4)	16/19 (84.2)	0.0035
IVT	2/14 (14.3)	2/19 (10.5)	
EVT	2/14 (14.3)	5/19 (26.3)	
IVT/EVT	0/14 (0)	9/19 (47.4)	
mRS score of 0–3	1/14 (7.1)	9/19 (47.4)	0.0209
mRS score of 4–6	13/14 (92.9)	10/19 (52.6)	
Ribbon sign	1/14 (7.1)	16/19 (84.2)	< 0.0001

Data are presented as mean±SD for age, initial NIHSS score, time from onset to the first MRI, DWI-ASPECTS, and time from onset to the second MRI ; median and interquartile range for initial NIHSS score and DWI-ASPECTS ; and number of patients (%) for others.
SD, standard deviation ; NIHSS, National Institute of Health Stroke Scale ; MRI, magnetic resonance imaging ; DWI-ASPECTS, diffusion-weighted imaging–Alberta Stroke Program CT Score ; CT, computed tomography ; ICAD, intracranial atherosclerotic disease ; IVT, intravenous thrombolysis ; EVT, endovascular treatment ; mRS, modified Rankin Scale.

Supplementary Table 2. Characteristics of the patients with low ASPECTS with or without the ribbon sign

	Ribbon – (n = 16)	Ribbon + (n = 17)	P value
Age	71.9 ± 12.6	76.4 ± 11.9	0.3027
Sex (Male)	12/16 (75.0)	8/17 (47.1)	0.1571
Lesion side (Left)	4/16 (25.0)	7/17 (41.1)	0.4646
Initial NIHSS score	17 (12-21)	17 (14-24)	0.6950
Time from onset to the first MRI	5.7 ± 6.9	3.3 ± 3.2	0.1874
DWI-ASPECTS	4 (3-5)	5 (4-5)	0.0315
DWI positivity in the cortex	16/16 (100)	17/17 (100)	> 0.9999
Time from onset to the second MRI	34.3 ± 17.0	27.5 ± 9.2	0.1287
Etiology			> 0.9999
ICAD	4 /16 (25.0)	4/17 (23.5)	
Embolic stroke	12/16 (75.0)	13/17 (76.5)	
Reperfusion therapy	6/16 (37.5)	14/17 (82.4)	0.0501
IVT	2/16 (12.5)	2/17 (11.8)	
EVT	2/16 (12.5)	5/17 (29.4)	
IVT/EVT	2/16 (12.5)	9/17 (41.2)	
mRS score of 0–3	2/16 (12.5)	8/17 (47.1)	0.0570
mRS score of 4–6	14/16 (87.5)	9/17 (52.9)	

Data are presented as mean±SD for age, initial NIHSS score, time from onset to the first MRI, DWI-ASPECTS, and time from onset to the second MRI ; median and interquartile range for initial NIHSS score and DWI-ASPECTS ; and number of patients (%) for others.
SD, standard deviation ; NIHSS, National Institute of Health Stroke Scale ; MRI, magnetic resonance imaging ; DWI-ASPECTS, diffusion-weighted imaging–Alberta Stroke Program CT Score ; CT, computed tomography ; ICAD, intracranial atherosclerotic disease ; IVT, intravenous thrombolysis ; EVT, endovascular treatment ; mRS, modified Rankin Scale.