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ABSTRACT

BACKGROUND AND PURPOSE: Reocclusion after treatment is a concern in endovascular therapy for isolated intracranial atherothrombotic stroke-related large-vessel occlusion (AT-LVO). However, the optimal endovascular therapy technique for AT-LVO has not yet been investigated. This study evaluated the optimal endovascular therapy technique for AT-LVO in a real-world setting.

MATERIALS AND METHODS: We conducted a historical, multicenter registry study at 51 centers that enrolled patients with AT-LVO. We divided the patients into 3 groups based on the endovascular therapy technique: mechanical thrombectomy alone, percutaneous transluminal angioplasty (PTA), and stent deployment. Mechanical thrombectomy alone was classified into the mechanical thrombectomy-only group; PTA and mechanical thrombectomy–PTA, into the PTA group; and mechanical thrombectomy–stent deployment, mechanical thrombectomy–PTA–stent deployment, PTA–stent deployment, and stent deployment–only into the stent group. The primary outcome was incidence of reocclusion of the treated vessels within 90 days of endovascular therapy completion.

RESULTS: We enrolled 770 patients and analyzed 509 patients. The rates in the mechanical thrombectomy-only, PTA, and stent deployment groups were 40.7%, 44.4%, and 14.9%, respectively. Incidence rate of residual stenosis >70% of final angiography was significantly higher in the mechanical thrombectomy-only group than in the PTA and stent deployment groups (mechanical thrombectomy-only versus PTA versus stent deployment: 34.5% versus 26.3% versus 13.2%, $P = .002$). Reocclusion rate was significantly lower in the PTA group than in the mechanical thrombectomy-only group (adjusted hazard ratio, 0.48; 95% CI, 0.29–0.80). Of the patients, 83.5% experienced reocclusion within 10 days after endovascular therapy. Alarmingly, a substantial subset (approximately 62.0%) of patients experienced reocclusion within 2 days of endovascular therapy. Incidence of mRS scores of 0–2 ninety days after endovascular therapy was not significantly different among the 3 groups. Incidences of symptomatic intracranial hemorrhage, any other intracranial hemorrhage, and death were not significantly different.

CONCLUSIONS: Incidence rate of reocclusion was significantly lower in the PTA group than in the mechanical thrombectomy-only group. We found no meaningful difference in reocclusion rates between the stent deployment and mechanical thrombectomy-only groups. In Japan, glycoprotein IIb/IIIa inhibitors are not reimbursed. Therefore, PTA might be the preferred choice for AT-LVOs due to the higher reocclusion risk with mechanical thrombectomy-only. Reocclusion was likely to occur within 10 days, particularly within 2 days post-endovascular therapy.

ABBREVIATIONS: AT-LVO = atherothrombotic stroke-related large-vessel occlusion; DAPT = dual antiplatelet therapy; EVT = endovascular treatment; GP = glycoprotein; HR = hazard ratio; ICH = intracranial hemorrhage; LVO = large-vessel occlusion; MT = mechanical thrombectomy; PTA = percutaneous transluminal angioplasty; Stent = stent deployment; TAPT = triple antiplatelet therapy

Endovascular therapy (EVT) has become an established therapy for treating acute ischemic stroke caused by large-vessel occlusion (LVO).[1,2] Atherosclerosis is the second leading cause of LVO. Incidence of atherothrombotic stroke-related LVO (AT-

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SUMMARY

PREVIOUS LITERATURE: Atherosclerosis is the second leading cause of LVO. Incidence of AT-LVO is significantly higher in Asian groups. Patients with AT-LVO tend to be refractory to endovascular treatment due to atherosclerotic stenosis, which leads to vessel dissections and increased reocclusions after endovascular treatment. Owing to the specificity of the lesion, the optimal treatment for patients with AT-LVO remains unknown. In addition, glycoprotein IIb/IIIa inhibitors, which are indispensable for the treatment of AT-LVO, are not reimbursed in Japan.

KEY FINDINGS: We showed that reocclusion was lower in the percutaneous transluminal angioplasty group than that in the mechanical thrombectomy-alone group and was likely to occur within 10 days post-endovascular treatment for AT-LVO. Reocclusion is particularly prone to occur within 2 days post-endovascular treatment.

KNOWLEDGE ADVANCEMENT: Our findings based on a large multicenter real-world registry suggested the optimal endovascular treatment technique for AT-LVO and revealed a high incidence of reocclusion within 10 days, particularly within 2 days post-endovascular treatment. Further additional prospective studies are warranted to investigate the optimal endovascular treatment technique and antiplatelet agent use for AT-LVO.

LVO) is significantly higher in Asian groups, such as the Japanese population, compared with other groups,[3] making its treatment a global concern.[4] The etiology of AT-LVO can be categorized into 2 main mechanisms: acute in situ occlusion due to intracranial arterial atherosclerotic stenosis and embolic mechanisms originating from extracranial artery stenosis or occlusion. Thrombectomy is often the principal EVT for AT-LVO. Nevertheless, patients with AT-LVO tend to be refractory to EVT due to atherosclerotic stenosis, which leads to vessel dissections and increased reocclusion after EVT.[3-5] In particular, reocclusion after treatment is as high as 22.2%, so it is important to reduce reocclusion rates and improve treatment outcomes.[6] Owing to the specificity of the lesion, the optimal choice of EVT for AT-LVO also differs from that made for nonatherosclerotic etiologies.[7] However, with recent advancements in devices and antiplatelet agents, the optimal treatment for patients with AT-LVO remains unknown. Glycoprotein (GP) IIb/IIIa inhibitors, which can inhibit platelet aggregation capacity in a short time, are not reimbursed in Japan. However, dual antiplatelet therapy (DAPT) and loading doses are frequently used for percutaneous transluminal angioplasty (PTA) and stent deployment.

Thus, we conducted a post hoc study using a nationwide registry of patients with AT-LVO treated with EVT in a real-world setting to compare the prognosis of AT-LVO in the 3 different treatment categories.

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MATERIALS AND METHODS

Data Collection and Definitions

The data supporting the findings of this study are available from the corresponding author on request. Recovery by Endovascular Salvage for Cerebral Ultra-Acute Embolic and Atherothrombotic Stroke with LVO (RESCUE AT-LVO) was a historical multicenter registry study conducted in 51 facilities in Japan that enrolled patients with acute intracranial occlusion caused by intracranial or extracranial carotid atherosclerosis from January 2017 to December 2019. We showed the number of facilities performing EVT during a 2-year period stratified by the number of AT-LVO cases (0–4, 5–9, 10–19, 20–39, and ≥40). In this study, we investigated AT-LVO caused by in situ occlusion of the intracranial arteries. The eligibility criteria were as follows: 1) acute ischemic stroke with in situ occlusion of the intracranial artery; 2) EVT performed for intracranial occlusion within 7 days from the time the patient was last known well; 3) a final diagnosis of atherosclerotic disease;[8] and 4) occlusion site at the intracranial internal carotid artery, M1 or M2 segment of the MCA, basilar artery, or intracranial vertebral artery. Patients were excluded for the following reasons: 1) stenosis caused by a nonatherosclerotic etiology, such as Moyamoya disease, arterial dissection, or vasculitis; 2) multiple acute infarctions in multiple vascular territories, excluding artery-to-artery embolism due to cervical artery occlusion or stenosis; 3) EVT performed only for cervical lesions; and 4) artery-to-artery embolism due to occlusion or stenosis of the vertebral artery origin. On the basis of the eligibility and exclusion criteria, we have comprehensively assessed preoperative, intraoperative, and postoperative information and determined the lesions to be consistent with AT-LVO.

The patients were categorized into 3 groups based on the EVT technique: mechanical thrombectomy (MT), including local intra-arterial fibrinolysis and mechanical clot disruption; PTA; and stent deployment (Stent). MT alone was classified into the MT-only group; PTA and MT-PTA, into the PTA group; and MT-Stent, MT-PTA-Stent, PTA-Stent, and Stent-only into the Stent group.

This study was conducted in accordance with the Ethical Guidelines for Medical and Health Research Involving Human

Subjects in Japan. The study protocol was approved by the Institutional Review Board of the Hyogo College of Medicine (approval No. 3727) and all participating facilities. The requirement for written informed consent was waived because we used clinical information obtained from routine clinical practice. Clinical data were collected at each facility through chart reviews or contact with the patients or their relatives.

The collected variables included age, sex, mRS score before onset,[9] medical history, prior medication, initiating additional antiplatelet medication, vital signs, NIHSS score on admission,[10] laboratory data, imaging studies, use of rtPA, and time. Imaging studies evaluated the ischemic volume on admission using the ASPECTS and the occluded vessels. We evaluated the ASPECTS using DWI in MRI or noncontrast CT[11,12] and defined the ASPECTS of each patient as ASPECTS on noncontrast CT or ASPECTS on DWI. The degree of reperfusion by EVT was classified using the modified TICI grading system based on DSA findings immediately after EVT procedures.[13] The preoperative and postoperative stenosis rates of the lesion were determined using the Warfarin-Aspirin Symptomatic Intracranial Disease (WASID) criteria for intracranial stenosis.[14] Intraoperative complications encompassed vessel perforation, vessel rupture, vascular dissection, distal embolism, cholesterol crystal embolization, and puncture site complications.

We routinely performed noncontrast CT or MRI 24 (SD, 8) hours after EVT. To evaluate hemorrhagic complications, we defined any intracranial hemorrhage (ICH) as any new hemorrhage on imaging irrespective of symptoms and symptomatic ICH as any exacerbation of ≥4 points on the NIHSS score, according to the Heidelberg classification.[15] The presence of reocclusion was confirmed using DSA or MRI. When we used DSA, reocclusion was defined as modified TICI 0 or 1. When using MRI, the presence of reocclusion was confirmed using the modified Mori grade. Reocclusion was defined as a modified Mori grade of 0 or 1.

Outcomes

The primary outcome was incidence of reocclusion of the treated vessels within 90 days of EVT completion. The secondary outcomes were as follows: 1) incidence of modified TICI 2b–3 immediately after EVT, 2) incidence of mRS 0–2 ninety days after EVT, 3) incidence of any ICH within 90 days after EVT, 4) incidence of symptomatic ICH within 90 days after EVT, 5) incidence of death within 90 days after EVT, and 6) mRS score 90 days after EVT.

Statistical Analyses

We analyzed the characteristics of patients in the MT-only, PTA, and Stent groups. Categoric variables are expressed as frequencies and percentages, and continuous variables are reported as means (SD) or medians with interquartile range. Variables between patients with different groups were compared using ANOVA and the Kruskal–Wallis test, as appropriate, and categoric variables were analyzed using the χ^2 test. The cumulative incidence was calculated using the Kaplan-Meier method, and variances among the groups were evaluated using the log-rank test. The period until reocclusion of the treated vessel was identified as first-day reocclusion and was observed in the treated vessel, subtracting the day of the initial treatment and adding an extra day, within a timeframe of 90 (SD, 30) days after the initial treatment.

To assess the effects of the MT-only group compared with those of the other groups on primary and secondary outcomes, we used 2 statistical methods. First, we applied Cox proportional hazards models to estimate the primary and secondary outcomes as hazard ratios (HRs) with 95% CIs. Second, we used binary logistic regression models to estimate the modified TICI 2b–3 and mRS scores 0–2 at 90 days after EVT as ORs with 95% CIs. We constructed crude and adjusted models with adjustments for age, initial NIHSS score on admission, premorbid mRS score, ASPECTS before the procedure, onset to puncture (days), site of occlusion (anterior or posterior circulation), and use of IV rtPA. Subsequently, we compared the frequencies of the outcomes according to the technique using the χ^2 test.

We conducted subgroup analyses to evaluate the efficacy of PTA and Stent compared with the MT-only group in preventing reocclusion. Subgroups were defined by age (75 years of age or older or younger than 75 years of age), sex, the presence of anterior circulation, residual stenosis rate (≥70% or <70%), use of DAPT/triple antiplatelet therapy (TAPT), and administration of rtPA.

All statistical analyses were performed using JMP 16.0 (SAS Institute). All reported P values were 2-tailed, and P values < .05 were considered statistically significant.

RESULTS

Among the 783 enrolled patients in RESCUE AT-LVO, 514 were assigned to the intracranial group and 509 were included in this study (Fig 1). Among the 51 facilities, 47 facilities enrolled <19 patients (Fig 2). The distribution of each category was as follows: MT-only, 207 (40.7%); PTA, 226 (44.4%); and Stent, 76 (14.9%). The baseline characteristics were predominantly consistent across the different groups, with minor deviations in specific parameters (Online Supplemental Data).

Patients in the MT-only group had a higher rate of a medical history of ischemic heart disease than patients in the PTA and Stent groups (MT-only, 11.1%; PTA, 3.5%; and Stent, 7.9%). Occlusion of the M2 segment of the MCA was frequently observed in the MT-only group (MT-only, 16.4%; PTA, 4.4%; and Stent, 5.3%), and vertebral artery occlusion was frequently observed in the Stent group (MT-only, 4.8%; PTA, 5.8%; and Stent, 10.5%). Rate of puncture onset within 72 hours was not significantly different among the 3 groups (MT-only, 98.6%; PTA, 95.1%; Stent, 96.1%) (Online Supplemental Data).

Antiplatelet Therapy and Treatment Efficacy and Complications

The rates of antiplatelet therapy in the MT-only, PTA, and Stent groups were 54.6%, 76.1%, and 92.1% for the entire study period, respectively. Rate of antiplatelet therapy before onset was not significantly different among the 3 groups. However, the PTA and Stent groups had a higher rate of initiating additional antiplatelet medication than the MT-only group (MT-only, 38.7%; PTA, 70.4%; and Stent, 89.5%; $P < .0001$). Specifically, the initiation of additional antiplatelet medication was more frequent after onset–

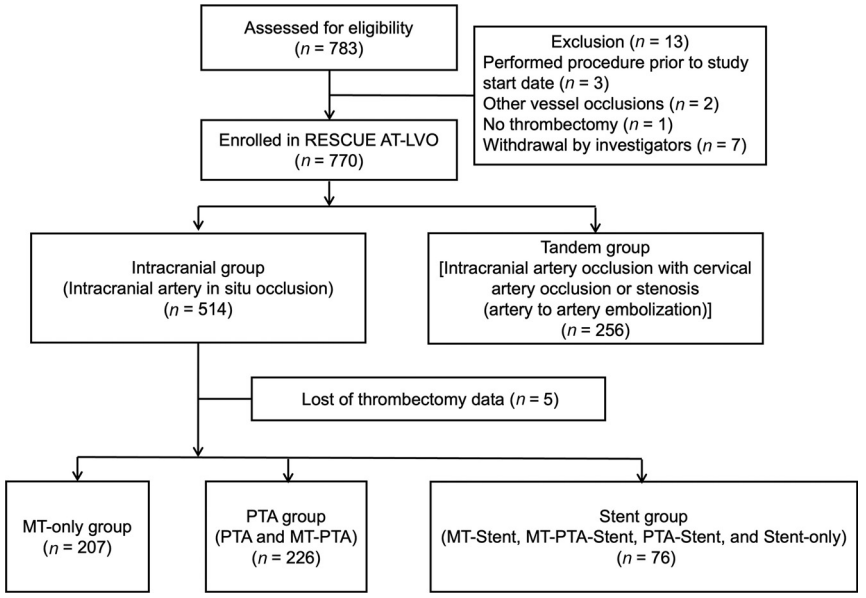

FIG 1. Study flow chart. RESCUE AT-LVO. MT-alone was classified into the MT-only group. PTA and MT-PTA were classified into the PTA group. MT-Stent, MT-PTA-Stent, PTA-Stent, and Stent-only were classified into the Stent group.

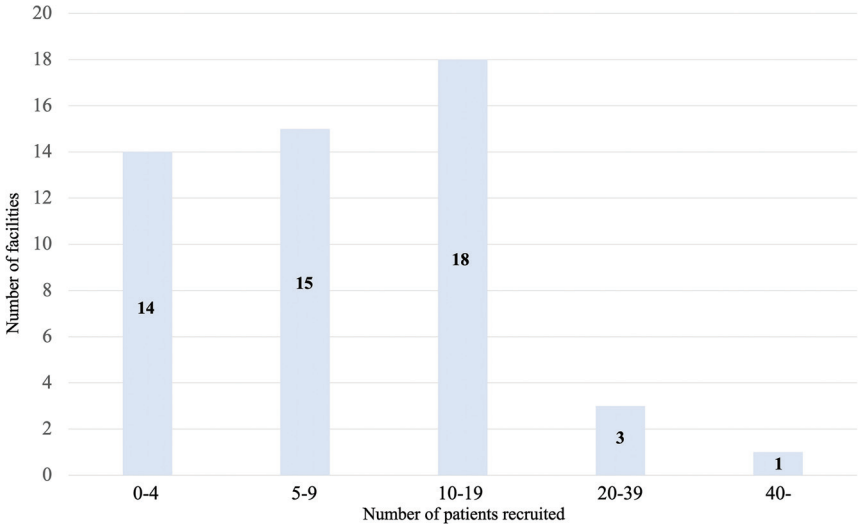

FIG 2. The number of recruited patients and the number of facilities.

before EVT (MT-only, 13.0%; PTA, 20.4%; and Stent, 26.3%; $P < .0001$) and during EVT (MT-only, 9.2%; PTA, 38.9%; and Stent, 54.0%; $P < .001$) (Table 1). Moreover, the PTA and Stent groups had a higher rate of initiating additional antiplatelet medication during EVT with aspirin and clopidogrel compared with the MT-only group (aspirin: MT-only, 7.3%; PTA, 30.1%; Stent, 46.1%; $P < .001$; clopidogrel: MT-only, 6.3%; PTA, 24.3%; Stent, 40.8%; $P < .001$). The use of DAPT or TAPT was also more frequent in the PTA and Stent groups compared with the MT-only group (DAPT/TAPT: MT-only, 28.5%; PTA, 62.2%; Stent, 76.3%; $P < .001$) (Table 2).

Residual stenosis >70% was higher in the MT-only group than in the PTA and Stent groups (MT-only, 34.5%; PTA, 26.3%; Stent, 13.2%; $P < .002$). Intraoperative complication rate increased approximately twice for the PTA group and thrice for the Stent group compared with the MT-only group (MT-only, 4.8%; PTA, 9.3%; and Stent, 14.5%; $P = .03$). A distal embolism was more frequent in the PTA group (MT-only, 0%; PTA, 1.3%; Stent, 7.9%; $P < .001$). However, the rates of other intraoperative complications were not significantly different among the 3 groups (Table 1).

Outcomes

Reocclusion occurred in 80 (15.7%) patients. The cumulative incidence rates of reocclusion in the MT-only, PTA, and Stent groups were 20.3% (42), 10.2% (23), and 18.4% (14), respectively. Cumulative incidence rate of reocclusion was lower in the PTA group than in the MT-only group (adjusted HR, 0.48 [95% CI, 0.29–0.80]) (Table 3).

Of the 79 patients, 66 (83.5%) experienced reocclusion within 10 days following EVT; specifically, 49 of 79 (62.0%) patients experienced reocclusion within 2 days (Fig 3*A*). A modified TICI 2b–3 was achieved in 420 (82.5%) patients. Among these patients, modified TICI 2b–3 was more frequent in the PTA and Stent groups than in the MT-only group (adjusted OR, 1.87 [95% CI, 1.12–3.11] and 2.83 [95% CI, 1.20–6.71], respectively) (Table 3). A total of 190 patients (39.8%) achieved an mRS score of 0–2 at 90 days after EVT (Table 3 and Fig 4). Incidence of mRS scores of 0–2 at 90 days after EVT was not significantly different among the 3 groups (Table 3). The cumulative incidences of symptomatic ICH, ICH, and death were not significantly different among the groups (Table 3 and Fig 3*B–D*). The distribution of mRS scores at 90 days was also not significantly different among the 3 groups (Fig 4).

Subgroup Analyses

In subgroup analyses, PTA was associated with significantly fewer cases of reocclusion compared with the MT-only group in the following groups: patients 75 years of age and older, male patients, patients with anterior circulation occlusion, those with residual stenosis <70%, those without the use of DAPT/TAPT, and patients treated with rtPA. However, these differences were not significant (Fig 5).

DISCUSSION

Our study showed that reocclusion rate was lower in the PTA group than in the MT-only group. In addition, all 3 groups had a

Table 1: Antiplatelet therapy and treatment efficacy and complications

	MT-Only	PTA	Stent	*P* Value
No. of patients (No.) (%)	207 (40.7)	226 (44.4)	76 (14.9)	NA
Antiplatelet, therapy (No.) (%)	112 (54.6) ($n = 205$)	172 (76.1)	70 (92.1)	<.001
Before onset (No.) (%)	46 (22.4) ($n = 205$)	46 (20.5) ($n = 224$)	10 (13.5)	.26
After onset (No.) (%)	80 (38.7)	159 (70.4)	68 (89.5)	<.001
After onset, before EVT (No.) (%)	27 (13.0)	46 (20.4)	20 (26.3)	<.001
During EVT (No.) (%)	19 (9.2)	88 (38.9)	41 (54.0)	<.001
Just after EVT (No.) (%)	34 (16.4)	25 (11.1)	7 (9.2)	<.001
Residual stenosis (WASID) (%) (median) (IQR)	64 (50–80) ($n = 200$)	57 (40–71) ($n = 224$)	47 (20–61)	<.001
Residual stenosis (WASID) >70%, (No.) (%)	69 (34.5) ($n = 200$)	59 (26.3) ($n = 224$)	10 (13.2)	.002
Intraoperative complications (No.) (%)	10 (4.8)	21 (9.3)	11 (14.5)	.03
Vessel perforation	3 (1.5)	4 (1.8) ($n = 225$)	0 (0)	.51
Vessel rupture	0 (0)	1 (0.4) ($n = 225$)	1 (1.3)	.29
Vascular dissection	5 (2.4)	9 (4.0) ($n = 225$)	5 (6.6)	.25
Distal embolism	0 (0)	3 (1.3) ($n = 225$)	6 (7.9)	<.001
Cholesterol crystal embolization	0 (0)	0 (0)	0 (0)	NA
Puncture site complications	2 (1.0)	4 (1.8) ($n = 225$)	1 (1.3)	.77

Note:—IQR indicates interquartile range; WASID, Warfarin–Aspirin Symptomatic Intracranial Disease; NA. not applicable.

Table 2: Detailed antiplatelet therapy after onset

	MT-Only	PTA	Stent	*P* Value
No. of patients (No.) (%)	207 (40.7)	226 (44.4)	76 (14.9)	NA
Antiplatelet therapy after onset (No.) (%)	80 (38.7)	159 (70.4)	68 (89.5)	<.001
Aspirin (No.) (%)	68 (32.9)	149 (65.9)	63 (82.9)	<.001
Before EVT (No.) (%)	25 (12.1)	50 (22.1)	24 (31.6)	<.001
During EVT (No.) (%)	15 (7.3)	68 (30.1)	35 (46.1)	<.001
Just after EVT (No.) (%)	28 (13.5)	31 (13.7)	4 (5.3)	<.001
Clopidogrel (No.) (%)	55 (26.6)	122 (54.0)	55 (72.4)	<.001
Before EVT (No.) (%)	21 (10.1)	42 (18.6)	19 (25.0)	<.001
During EVT (No.) (%)	13 (6.3)	55 (24.3)	31 (40.8)	<.001
Just after EVT (No.) (%)	21 (10.1)	25 (11.1)	5 (6.6)	<.001
Prasugrel (No.) (%)	3 (1.5)	9 (4.0)	6 (7.9)	<.001
Before EVT (No.) (%)	1 (0.5)	1 (0.4)	1 (1.3)	<.001
During EVT (No.) (%)	2 (1.0)	6 (2.6)	5 (6.6)	<.001
Just after EVT (No.) (%)	0 (0)	2 (0.9)	0 (0)	<.001
Cilostazol (No.) (%)	13 (6.3)	41 (18.1)	13 (17.1)	<.001
Before EVT (No.) (%)	5 (2.4)	12 (5.3)	1 (1.3)	<.001
During EVT (No.) (%)	1 (0.5)	19 (8.4)	9 (11.8)	<.001
Just after EVT (No.) (%)	7 (3.4)	10 (4.4)	3 (4.0)	<.001
Ozagrel sodium (No.) (%)	3 (1.5)	20 (8.9)	6 (7.9)	<.001
Before EVT (No.) (%)	0 (0)	1 (0.4)	0 (0)	<.001
During EVT (No.) (%)	2 (1.0)	19(8.4)	5 (6.6)	<.001
Just after EVT (No.) (%)	1 (0.5)	0 (0)	1 (1.3)	<.001
DAPT or TAPT (No.) (%)	59 (28.5)	141 (62.4)	58 (76.3)	<.001

Note:—NA indicates not applicable.

high incidence of reocclusion within 10 days of EVT. A substantial subset (approximately 62.0%) encountered reocclusion within 2 days. In the PTA and Stent groups, a high percentage of patients received antiplatelet drugs administered immediately before or during EVT. This finding suggested that AT-LVO was suspected, and drugs were administered immediately before or during the procedure. Regarding intraoperative complications, rate increased by approximately twice for the PTA group and thrice for the Stent group compared with the MT-only group. In contrast, symptomatic ICH, ICH, and death rates were not significantly different among the 3 groups.

AT-LVO can be an occult cause of reocclusion following MT.[3] In a recent study using stent retrievers as first-line treatment, there was no difference in the first-pass effect between the AT-LVO and other groups, but there was a noteworthy difference in the final modified TICI (80.0% versus 92.5%; adjusted OR, 0.21 [95% CI, 0.09–0.50]), suggesting that the AT-LVO group is more likely to experience reocclusion during the procedure.[16] Some studies have indicated that PTA and/or Stent is safe and yields positive results in patients with AT-LVO.[17,18] These results are consistent with the findings of our present study. In addition, the restenosis rates after balloon angioplasty for symptomatic intracranial artery stenosis are 6.3% with the use of a drug-coated balloon and 31.3% with the use of a conventional balloon.[19] Therefore, we believe that the use of drug-coated balloons will improve the outcomes of patients with AT-LVO in the future. Our study found that >70% residual stenosis was higher in the MT-only group than in the PTA and Stent groups. Considering the higher reocclusion rate in the MT-only group, additional procedures, including PTA or Stent, may yield greater benefits for patients with severe stenosis after recanalization with MT-only.

In the present study, we did not observe a considerable difference in reocclusion rates between the Stent and MT-only groups. The primary reason, which may be subject to selection bias, is that the Stent group comprised patients with refractory occlusion or dissection who had undergone rescue stent placement. This bias may have influenced the results. It has been suggested that even in difficult-to-treat cases, stent placement can potentially achieve treatment outcomes comparable with those of MT-only.[20] A secondary consideration is that platelet aggregation screening is not universally conducted across all institutions, and these data were not collected in this study. Additionally, in Japan, GP IIb/IIIa inhibitors such as abciximab, eptifibatide, and tirofiban are not reimbursed. This policy applies to all formulations,

Table 3: Outcomes

Variables	Incidence (No.) (%)	Crude HR (95% CIs)	*P* Value	Adjusted HR (95% CIs)	*P* Value
Reocclusion (No.) (%)					
MT-only	42 (20.3)	Reference			
PTA	23 (10.2)	0.48 (0.29–0.80)	.005	0.48 (0.29–0.80)	.005
Stent	14 (18.4)	0.88 (0.48–1.61)	.68	0.89 (0.48–1.65)	.72
Modified TICI 2b–3 (No.) (%)					
MT-only	158 (76.3)	Reference			
PTA	193 (85.4)	1.81 (1.11–2.96)	.02	1.87 (1.12–3.11)	.02
Stent	69 (90.8)	3.06 (1.32–7.09)	.01	2.83 (1.20–6.71)	.02
mRS score 0–2 at 90 days (No.) (%)					
MT-only ($n = 190$)	70 (36.8)	Reference			
PTA ($n = 214$)	88 (41.1)	1.19 (0.80–1.79)	.38	1.35 (0.85–2.15)	.21
Stent ($n = 73$)	32 (43.8)	1.34 (0.77–2.32)	.30	1.31 (0.70–2.46)	.39
Any ICH (No.) (%)					
MT-only	13 (6.3)	Reference			
PTA	13 (5.8)	0.91 (0.42–1.96)	.81	0.89 (0.40–1.97)	.77
Stent	2 (2.6)	0.41 (0.09–1.84)	.25	0.50 (0.11–2.24)	.36
Symptomatic ICH (No.) (%)					
MT-only	3 (1.5)	Reference			
PTA	4 (1.8)	1.22 (0.27–5.44)	.80	0.90 (0.17–4.74)	.91
Stent	1 (1.3)	0.91 (0.09–8.74)	.93	1.07 (0.11–10.8)	.95
Death (No.) (%)					
MT-only	15 (7.3)	Reference			
PTA	14 (6.2)	0.78 (0.38–1.63)	.51	0.73 (0.34–1.57)	.43
Stent	4 (5.3)	0.69 (0.23–2.09)	.51	0.38 (0.09–1.68)	.20

including IV and oral. However, DAPT or loading doses are frequently used for PTA and stent replacement. These may affect the interpretation of reocclusion rates and the generalizability of the findings of this study. We consider the use of antiplatelet agents in patients with AT-LVO essential for preventing reocclusion. If a patient presents with a score that predicts AT-LVO, antiplatelet agents should be administered as soon as possible to reduce reocclusion.[21]

The new ANGEL-REBOOT trial, a randomized controlled study examining the effectiveness of angioplasty as a secondary intervention in patients with AT-LVO, has been fully registered, and its findings are anticipated (NCT05122286). This trial, formally known as a Randomized Study of Bailout Intracranial Angioplasty Following Thrombectomy for Acute Large-Vessel Occlusion, aims to provide new insights into this treatment approach. Our study included the largest registry of patients who underwent EVT for AT-LVO in a real-world setting.

Some limitations of this study should be considered when interpreting our findings. First, we did not have a standardized EVT protocol specifying balloon and stent sizes and length or perioperative antiplatelet therapy, so these decisions were left to the discretion of the physician in charge. Consequently, selection bias might have occurred. The Stent group included patients with refractory occlusion or dissection who underwent rescue stent placement. Second, this study lacked a core laboratory. Typically, a core laboratory provides standardized, unbiased analysis and interpretation of clinical data, particularly in studies involving complex imaging or procedural outcomes. The absence of such facilities may lead to variability in data interpretation and can potentially affect the overall reliability and validity of the study.

Third, reocclusion was assessed without a standardized imaging follow-up protocol. Evaluations were primarily based on symptom deterioration or incidental findings of occlusion on follow-up MRI. This approach may have led to an underestimation of asymptomatic reocclusion. Fourth, we systematically registered patients with AT-LVO at 51 centers, and this study is, to the best of our knowledge, the largest study to evaluate the outcomes of EVT for AT-LVO. However, the sample size was significantly small to evaluate the outcomes in the different groups. Further large-scale studies are required to accurately assess the optimal EVT technique for AT-LVO. Finally, this registry study was conducted in Japan, where GP IIb/IIIa inhibitors are not reimbursed. In addition, the risk of bleeding events differs among ethnicities.[22] Thus, the generalizability of our findings to the rest of the world should be carefully considered.

CONCLUSIONS

Reocclusion rate is lower with PTA than with MT-only. We did not observe a difference in reocclusion rates between the Stent and MT-only groups. In Japan, where GP IIb/IIIa inhibitors are not reimbursed, DAPT or loading doses are frequently used for PTA and stent replacement. PTA may be considered a first-line strategy for AT-LVOs because reocclusion is more likely to occur if the procedure is terminated with MT alone. Randomized controlled trials are necessary to accurately determine the optimal EVT technique for AT-LVO. Reocclusion is likely to occur within 10 days of EVT in patients with AT-LVO. It is especially prone to occur within 2 days post-EVT. The preoperative and intraoperative administration of antiplatelet agents should occur soon as possible to reduce reocclusion.

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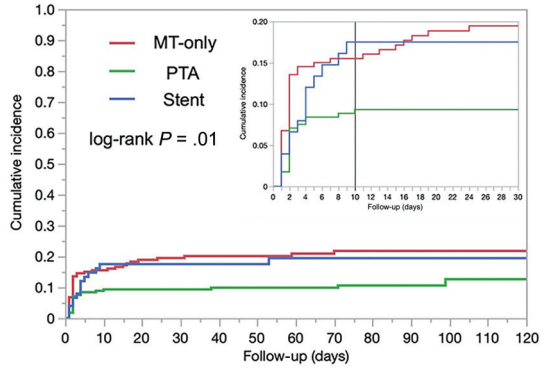
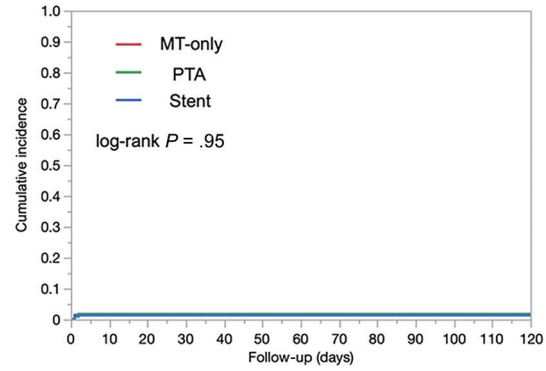


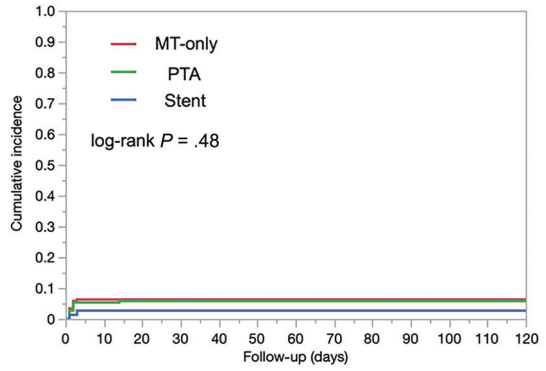
Follow-up days	0	2	5	10	90
MT group					
Number at risk, *n*	207	178	174	158	74
Cumulative events, *n*	0	28	31	32	42
Cumulative incidence, %	0	13.6	15.0	15.5	20.3
PTA group					
Number at risk, *n*	226	210	205	197	97
Cumulative events, *n*	0	16	19	21	23
Cumulative incidence, %	0	7.1	8.4	9.3	10.2
Stent group					
Number at risk, *n*	76	69	63	60	26
Cumulative events, *n*	0	5	10	13	14
Cumulative incidence, %	0	6.6	13.4	17.5	18.4

A



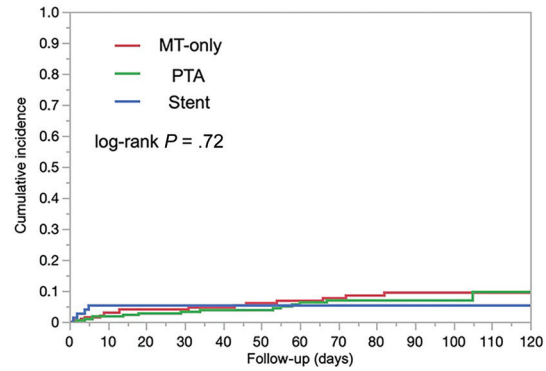
Follow-up days	0	2	5	10	90
MT group					
Number at risk, *n*	207	203	200	185	88
Cumulative events, *n*	0	3	3	3	3
Cumulative incidence, %	0	1.5	1.5	1.5	1.5
PTA group					
Number at risk, *n*	226	221	220	214	105
Cumulative events, *n*	0	4	4	4	4
Cumulative incidence, %	0	1.8	1.8	1.8	1.8
Stent group					
Number at risk, *n*	76	73	72	72	31
Cumulative events, *n*	0	1	1	1	1
Cumulative incidence, %	0	1.3	1.3	1.3	1.3

B



Follow-up days	0	2	5	10	90
MT group					
Number at risk, *n*	207	194	189	175	83
Cumulative events, *n*	0	12	13	13	13
Cumulative incidence, %	0	5.8	6.3	6.3	6.3
PTA group					
Number at risk, *n*	226	213	212	206	99
Cumulative events, *n*	0	12	12	12	13
Cumulative incidence, %	0	5.3	5.3	5.3	5.8
Stent group					
Number at risk, *n*	76	73	71	71	31
Cumulative events, *n*	0	1	2	2	2
Cumulative incidence, %	0	1.3	2.7	2.7	2.6

C



Follow-up days	0	2	5	10	90
MT group					
Number at risk, *n*	207	194	189	175	83
Cumulative events, *n*	0	12	13	13	15
Cumulative incidence, %	0	0.5	1.5	3.0	7.3
PTA group					
Number at risk, *n*	226	225	223	216	106
Cumulative events, *n*	0	1	2	4	14
Cumulative incidence, %	0	0.4	0.9	1.8	6.2
Stent group					
Number at risk, *n*	76	74	72	72	31
Cumulative events, *n*	0	2	4	4	4
Cumulative incidence, %	0	2.6	5.3	5.3	5.3

D

FIG 3. Cumulative incidences of outcomes. *A*, Reocclusion. *B*, Symptomatic ICH. *C*, Any ICH. *D*, Death.

Neurosurgical Hospital; Takanori Sano, Japanese Red Cross Ise Hospital; Hiroshi Yamagami, National Hospital Organization Osaka National Hospital; Shinzo Ota, Brain Attack Center Ota Memorial Hospital; Hiroyuki Ohnishi, Ohnishi Neurologic Center; Kyoichi Watanabe, Okayama City Hospital; Yoshiki Yagita, Kawasaki Medical School Hospital; Yoshifumi Tsuboi, Kawasaki Saiwai Hospital; Yukiko Enomoto, Gifu University Hospital; So Tokunaga, National Hospital Organization Kyusyu Medical Center; Keisuke Imai, Japanese Red Cross Society Kyoto Daiichi Hospital; Naoki Tokuda, Japanese Red Cross Society Kyoto Daini Hospital; Seigo Shindo, Japanese Red Cross Kumamoto Hospital; Hiroyuki Ikedam, Kurashiki Central Hospital; Masaru Hirohata, Kurume University Hospital; Hitoshi Hasegawa, Niigata University Medical & Dental Hospital; Yukako Yazawa, Kohnan Hospital; Nobuyuki Sakai, Kobe City Medical Center General Hospital; Masato Inoue, National Center for Global Health and Medicine; Kanta Tanaka, National Cerebral and Cardiovascular Center Hospital; Keigo Shigeta,

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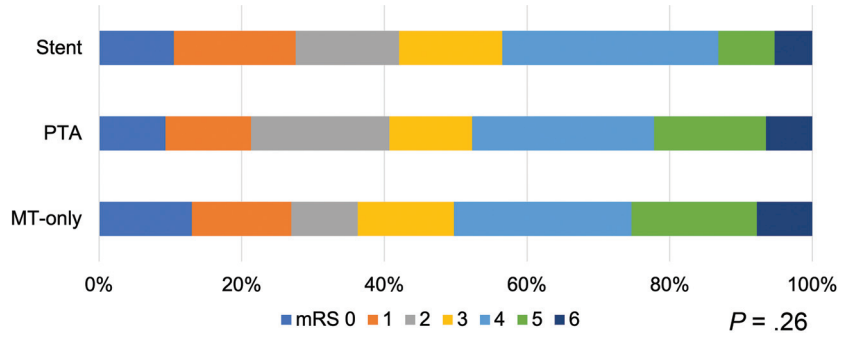

	mRS at 90 days	0	1	2	3	4	5	6
MT-only (*n* = 193)	*n* (%)	25 (13,0)	27 (14.0)	18 (9.3)	26 (13.5)	48 (24.9)	34 (17.6)	15 (7.8)
PTA (*n* = 216)	*n* (%)	20 (9.3)	26 (12.0)	42 (19.4)	25 (11.6)	55 (25.5)	34 (15.7)	14 (6.5)
Stent (*n* = 76)	*n* (%)	8 (10.5)	13 (17.1)	11 (14.5)	11 (14.5)	23 (30.3)	6 (7.9)	4 (5.3)

FIG 4. Distribution of mRS scores at 90 days.

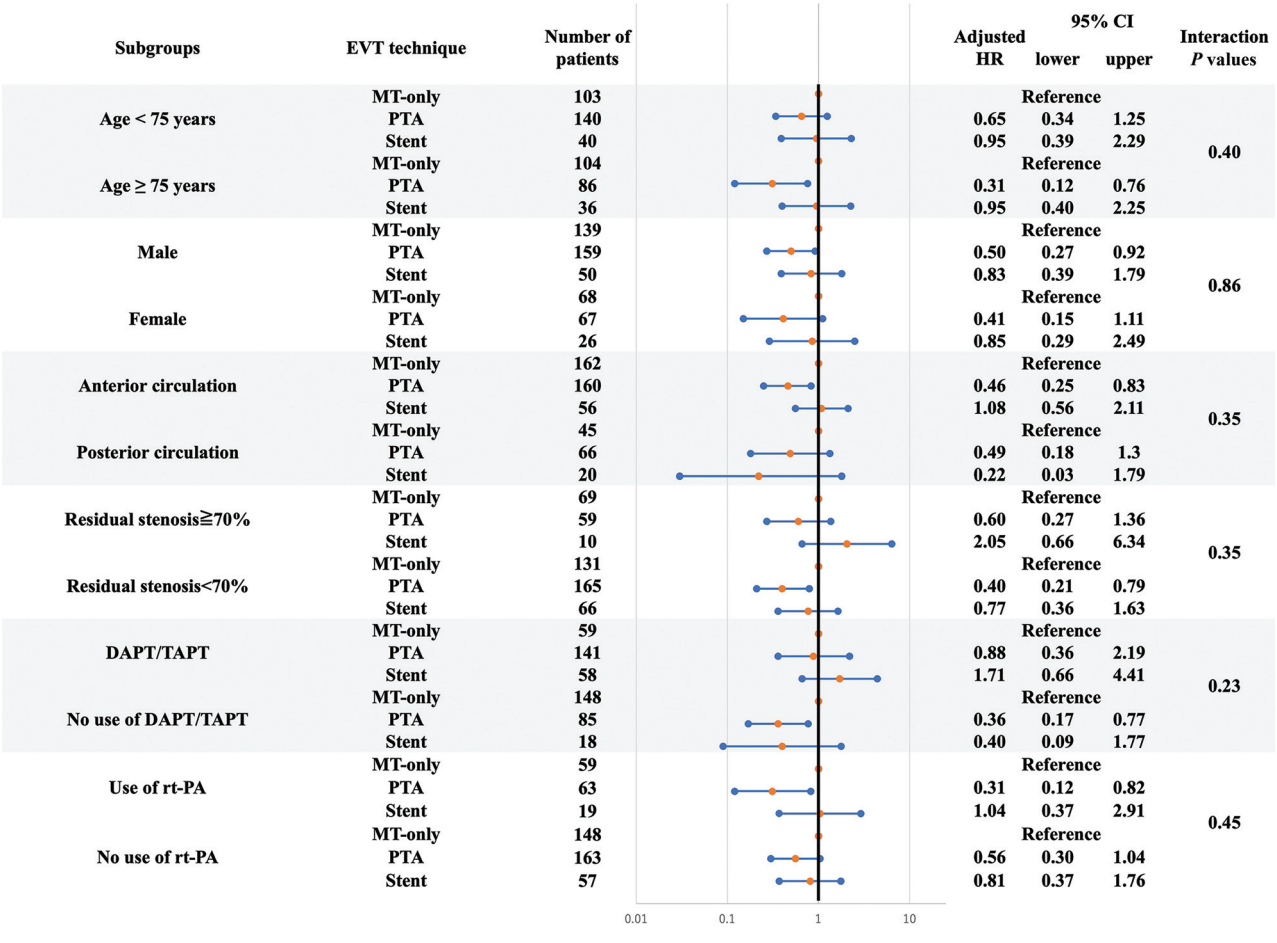

FIG 5. Subgroup analyses of reocclusion.

Masafumi Morimoto, Yokohama Shintoshi Neurosurgical Hospital; Takuya Kanamaru, NTT Medical Center Tokyo; Makoto Nakajima, Kumamoto University Hospital; Shinichiro Yoshida, Fukuoka Neurosurgical Hospital).

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