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Stent expansion and in-stent thrombus sign in the Trevo stent retriever predict recanalization and possible etiology during mechanical thrombectomy: A case series of 50 patients with acute middle cerebral artery occlusion

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Keywords

Stent retriever; Trevo; Stroke; Acute ischemic stroke; Mechanical thrombectomy

ABSTRACT

Background:

The interaction between the stent retriever and clot is a key factor for recanalization during mechanical thrombectomy.

Objective:

To evaluate the association between radiographically apparent features during thrombectomy and angiographic outcomes using the Trevo ProVue, which has a fully radiopaque strut.

Methods:

We retrospectively reviewed 50 patients with acute middle cerebral artery occlusion who were treated with the Trevo. Patients were divided into groups that achieved (1^{st}-pass recanalization group, n=21) or did not achieve (non-1^{st}-pass recanalization group, n=29) a modified Thrombolysis in Cerebral Ischemia score of 2b or 3 with the 1^{st}-pass procedure. Patients were also divided into a thromboembolic (n=49) and atherosclerotic (n=11) group by occlusion etiology. We evaluated radiographic findings of the Trevo strut, e.g., degree of stent expansion and filling defect of the thrombus in the strut (in-stent thrombus sign) during the 1^{st}-pass procedure among these groups.

Results:

The median stent expansion was significantly greater in the 1^{st}-pass recanalization than non-1^{st}-pass recanalization group (60% versus 34%; $P<0.01$), and in the thromboembolic than atherosclerotic group (45% versus 31%; $P<0.01$). The receiver operator characteristic curve shows moderate capacity of the prediction for recanalization and etiology, with an area under the curve of 0.83 and 0.73, respectively. The in-stent thrombus sign was significantly more common in the thromboembolic than atherosclerotic groups (86% versus 10%; $P<0.01$).

Conclusions:

Greater stent expansion was associated with recanalization after thrombectomy. The in-stent thrombus sign may be useful for etiology prediction. These radiographic findings could provide useful real-time feedback during procedure, reflecting the clot–stent interaction.

INTRODUCTION

Mechanical thrombectomy using a stent retriever has become the standard for managing acute ischemic stroke caused by large vessel occlusion in the anterior circulation.[1-5] The mechanism of clot retrieval using a stent retriever involves the following: once the stent retriever is deployed at the occlusion site, a variable degree of a clot apposition through the expanding stent strut occurs, and the entangled clot could be removed after a few minutes of temporary deployment. This clot–stent interaction is considered to be a factor influencing recanalization after the removing the stent retriever.[6-8] However, there have been few reports on a convenient method, available in routine clinical practice, for assessing this interaction.

The Trevo ProVue (Stryker, Kalamazoo, MI) is a stent retriever designed for mechanical thrombectomy, which is characterized by fully visible strut. Its unique full-length radiographic visibility can provide a certain degree of information from the occlusion site, allowing us to see the configuration of the radiopaque strut. However, there have been few studies evaluating the contribution of the Trevo's visibility.[9, 10] Assessing radiographic findings of the visible strut could help us to understand the clot–stent interaction within the vessel, and may have a potential to provide information about the recanalization and the characteristics of the occlusion.

The purpose of this study was to evaluate how the radiographic findings during mechanical thrombectomy could serve as a method to assess the clot–stent interaction within the vessel. We studied whether the radiographic findings of the Trevo's strut, such as the degree of stent expansion and the appearance of the thrombus in the strut, were associated with successful recanalization. In addition, we studied whether these findings were different between patients with thromboembolic and atherosclerotic occlusion.

METHODS

Patient Selection

We retrospectively reviewed 50 consecutive patients with acute occlusion in the M1 segment of the middle cerebral artery (MCA) who were treated with mechanical thrombectomy using the Trevo stent retriever at our institute between July 2015 and June 2017. In this period, the Trevo was used as the 1st-line device in all the patients. We analyzed prospectively maintained institutional databases to examine the procedural and clinical outcomes.

Our selection criteria for patients undergoing mechanical thrombectomy were as follows: 1) acute ischemic stroke caused by large vessel occlusion confirmed by magnetic resonance angiography (MRA); 2) a score of ≥6 on the Alberta Stroke Program Early Computed Tomography Score (ASPECTS) and on ASPECTS-diffusion weighted imaging; 3) a certain neurological deficit as defined by a National Institutes of Health Stroke Scale (NIHSS) ≥2; 4) <8 h from symptom onset; however, <24 h from the time the patient was last seen to be well in cases where the time of symptom onset was unknown. Intravenous tissue plasminogen activator (IV tPA) was administered after magnetic resonance imaging (MRI), according to the Japanese Guidelines for the Management of Stroke.[11]

Informed consent for procedure and research enrollment was obtained from each patient or a family member before performing the endovascular procedure. The study design was approved by the institutional review board, which was conducted in accordance to the Declaration of Helsinki.

Endovascular Procedures

Our endovascular procedures for mechanical thrombectomy have been previously reported.[10, 12] An intravenous heparin bolus was given after groin puncture and a nine-French balloon-guide catheter was navigated into the internal carotid artery. A microcatheter with a microguidewire was navigated into the portion distal to the occluded site, crossing the occlusion. The Trevo ProVue (4mm) and XP ProVue (4 or 6mm) stent retriever (both from Stryker, Kalamazoo, MI) were used as the 1st-line device.

The Trevo was deployed using the "Push and Fluff technique" described by Haussen et al.[13] After deployment of the Trevo, angiography was performed using the guiding catheter to obtain information about the occlusion. The Trevo was left in place for a few minutes. If a maximum of three passes of the Trevo failed to recanalize the occlusion, we attempted additional endovascular procedures, including aspiration using a Penumbra catheter (Penumbra Inc., Alameda, CA), a combined thrombectomy technique using both a stent retriever and an aspiration catheter, percutaneous transluminal angioplasty (PTA). For refractory occlusion due to the atherosclerotic etiology, intracranial stenting was not attempted, but emergent superficial temporal artery to middle cerebral artery (STA-MCA) bypass was attempted as a rescue surgical treatment. All the procedures in this study were performed by the 1st author (T.I.) together with some of the other authors.

Radiographic Assessment of Trevo's Strut during 1st-Pass Stent Deployment

All radiographic findings were assessed by using conventional 2D angiography with antero-posterior view during endovascular procedures. The degree of stent expansion was defined as the diameter of the stent strut at the occlusion site (Do) divided by the diameter of the stent strut at the nearby normal vessel (Dn) (Figure 1). Immediate flow restoration was defined as an anterograde flow that was seen on the angiography during deployment of the Trevo. The in-stent thrombus sign, which we propose here as a notable sign during mechanical thrombectomy, was defined as the filling defect in the strut as depicted by angiography during immediate flow restoration. Two experienced neurointerventionalists (T.I. and J.S.) reviewed the angiographic imaging separated individually with being blinded to the patients' subsequent imaging and clinical information.

Outcome Assessment

Successful recanalization was defined as a modified Thrombolysis in Cerebral Infarction (TICI) score of 2b or 3. Symptomatic intracranial hemorrhage was defined as subarachnoid hemorrhage or intracerebral hemorrhage combined with an increase in NIHSS score by 4 or more points from pre-treatment baseline, within 24 h of endovascular treatment. A favorable

outcome was defined as a modified Rankin Scale (mRS) score of ≤2 at 90 days.

Comparison of the 1st-Pass Recanalization Group with the Non-1st-Pass Recanalization Group

Patients were divided into a group that achieved a TICI 2b or 3 with the 1st-pass procedure (1st-pass recanalization group) and those who did not achieve this (non-1st-pass recanalization group). Baseline characteristics, radiological findings, and treatment results for each of the two groups were then compared.

Comparison of the Thromboembolic Group with the Atherosclerotic Group

Patients were also divided into a thromboembolic and an atherosclerotic group according to the etiology of the occlusion, and each of the two groups were then compared. Atherosclerotic etiology was defined as an occlusion revealing significant fixed focal stenosis at the occlusion site that was seen on the angiography after all the mechanical thrombectomy and thrombolysis procedures, and not showing improvement of the stenotic lesion on the routine follow-up MRA after the treatment (the next day and one week after). Significant stenosis was defined as >50% stenosis according to the Trial of Org 10172 in Acute Stroke Treatment (TOAST) classification.[14] The degree of the stenosis was determined with the Warfarin Aspirin Symptomatic Intracranial Disease criteria.[15] Thromboembolic etiology was defined as an occlusion that did not meet the definition of the atherosclerotic etiology and not be suggestive to be other etiologies like focal dissection.

Statistical Analysis

Descriptive statistics are presented as the median and interquartile range (IQR). Continuous variables were compared with Welch's two-sample *t*-test and discrete variables were compared with Wilcoxon's rank-sum test. The proportions of patients with each parameter were compared using Fisher's exact test. To evaluate the predictive capability of the variables, the receiver operating characteristic (ROC) curve was constructed and the area under the curve (AUC) was calculated. Statistical analysis was performed with free

open-source software (R3.1.1; R Foundation for Statistical Computing; http://www.r-project.org).

RESULTS

Patient Characteristics

Table 1 summarizes the baseline characteristics of the 50 patients (median age, 79 years) analyzed in this study. The median baseline NIHSS and ASPECTS score were 15 and 8, respectively. Eight patients (16%) received IV tPA before endovascular procedures. The median time from onset or last last-known well-being to groin puncture was 149 min. The etiology of the occlusion was thromboembolic in 39 (78%) and atherosclerosis in 11 patients (22%). There were no patients considered to have other etiologies like an occlusion due to focal arterial dissection.

Radiographic Assessment of Trevo's Strut during the 1st-Pass Stent Deployment

Radiographic findings during the 1st-pass procedure are summarized in Table 2, and representative cases are shown in Figure 1. In all 50 patients, the Trevo was used as a sole thrombectomy device for the 1st-pass procedure. The median degree of stent expansion was 40%. Immediate flow restoration was observed in 48 patients (96%). Among these 48 patients, the in-stent thrombus sign was observed in 34 patients (71%).

Treatment Results and Outcome

The treatment results and outcome are summarized in Table 2. Successful recanalization was achieved in 21 patients (42%) after the 1st-pass procedure and eventually in 45 patients (90%). Symptomatic intracranial hemorrhage occurred in one patient (2%). A favorable outcome at 90 days was obtained in 24 patients (48%).

Comparison of the 1st-pass Pass Recanalization Group with Non-1st-pass Recanalization Group

There were 21 patients in the 1st-pass recanalization group and 29 in the non-1st-pass recanalization group. There were no significant differences in the baseline characteristics between the two groups (Table 1).

In terms of radiographic findings during the 1st-pass procedure, there were significant

differences between the two groups in the degree of stent expansion (Table 2). The median degree of stent expansion was significantly greater in the 1st-pass recanalization group than in the non-1st-pass recanalization group (60% [IQR 48－69] versus 34% [23－42]; P<0.01) (Figure 2). The ROC curve showed moderate correlation between the stent expansion and recanalization based on the findings during 1st pass procedure (Figure 2). The AUC of the ROC curve was 0.83 (95% confidence interval [95% CI]: 0.71–0.96). At the calculated best cut-off value of 48%, the sensitivity and specificity were 76% and 86%, respectively. There were no significant differences in terms of immediate flow restoration (100% versus 93%; P=0.50) and the in-stent thrombus sign (71% versus 70%; P=1.00) (Figure 2).

Final successful recanalization was achieved in 24 patients (83%) in the non-1st-pass recanalization group by use of only the stent retriever in 14 patients (48%), aspiration catheter in four patients (14%), combined use of the stent retriever and aspiration catheter in three patients (10%), and PTA in three patients (10%). The rate of symptomatic intracranial hemorrhage and outcome at 90 days did not differ significantly differ between the two groups.

Comparison of the Thromboembolic Group with the Atherosclerotic Group

There were 39 patients in the thromboembolic group and 11 in the atherosclerotic group. In terms of baseline characteristics, there were significant differences in the demographic and clinical data and medical history between the two groups (Table 1). The median age was significantly higher in the thromboembolic group than in the atherosclerotic group (79 yeas in the thromboembolic group versus 70 years in the atherosclerotic group; P=0.01). The median ASPECTS score on admission was significantly lower in the thromboembolic group than in the atherosclerotic group (8 versus 10; P=0.03). Atrial fibrillation was detected significantly more common in the thromboembolic group than in the atherosclerotic group (67% versus 18%; P<0.01).

Regarding radiographic findings, there were significant differences between the two groups in the degree of stent expansion and the in-stent thrombus sign (Table 2). The median degree of stent expansion was significantly greater in the thromboembolic group than in the

atherosclerotic group (45% [IQR 33－63] versus 31% [20－40]; P<0.01) (Figure 2). The ROC curve showed moderate correlation between the stent expansion and etiology based on the findings during 1st pass procedure (Figure 2). The AUC of the ROC curve was 0.73 (95% CI: 0.58–0.88). At the calculated best cut-off value of 50%, the sensitivity and specificity were 44% and 100%, respectively. Although the rate of the immediate flow restoration was similar in the two groups (97% versus 91%; P=0.40), the in-stent thrombus sign was observed significantly more common in the thromboembolic group than in the atherosclerotic group (87% versus 10%; P<0.01) (Figure 2).

Although the rate of the 1st-pass recanalization was similar in the two groups (44% versus 36%; P=0.74), final successful recanalization was achieved more often in the thromboembolic group than in the atherosclerotic group (97% versus 64%; P<0.01). Among the 39 patients in the thromboembolic group, successful recanalization was achieved by use of the stent retriever in 38 patients (77%), aspiration catheter in four patients (10%), combined use of the stent retriever and aspiration catheter in three patients (7%), PTA in one patient (3%). Among the 11 patients in the atherosclerotic group, successful recanalization was achieved by use of the stent retriever in five patients (45%) and PTA in two patients (18%). In three of the four patients without successful recanalization in the atherosclerotic group, emergent STA-MCA bypass was performed as a rescue surgical treatment. The rate of symptomatic intracranial hemorrhage and outcome at 90 days did not significantly differ between the two groups.

DISCUSSION

Our study demonstrated that the radiographic findings of Trevo's visible strut expansion and the in-stent thrombus sign could serve as a convenient method for predicting recanalization as well as the characteristics of the occlusion. Our results showed that the degree of stent expansion was associated with recanalization after the procedure. In addition, the in-stent thrombus sign provided useful information for differentiation of the etiological characteristics of the occlusion. A combination of these radiographic findings during stent deployment could serve as convenient and useful real-time feedback during mechanical thrombectomy.

Our study showed that a greater degree of stent expansion was significantly associated with the success of recanalization after the procedure (Figure 2). It has been reported that the clot–stent interaction, i.e., the degree of integration of the stent strut into the clot, was an important factor in successful recanalization after mechanical thrombectomy using a stent retriever.[6-8] However, these previous studies evaluated the clot–stent interaction by cone-beam computed tomography imaging, because most stent retrievers did not have sufficiently radiopaque struts. The Trevo ProVue stent retriever is a fully radiopaque stent retriever, and its visibility may provide additional information that was difficult to be obtained from other less visible stent retrievers. The degree of stent expansion in the "visible" Trevo stent retriever could predict recanalization after the pass in our study. This result suggested that the degree of stent expansion could be used as a surrogate marker for the clot–stent interaction. The clot–stent interaction offering from the degree of stent expansion may have the potential assessing the clot composition, i.e., hard or soft thrombus. Therefore, assessing the degree of the stent expansion by seeing the visible Trevo strut could be a simple and convenient tool for predicting recanalization during mechanical thrombectomy.

We found that the in-stent thrombus sign provided information about the characteristics of the occlusion. The in-stent thrombus sign was observed in most of the patients with thromboembolic occlusion; in contrast, most patients with atherosclerotic occlusion did not show the in-stent thrombus sign (Figure 2). In this study, we propose that the in-stent thrombus sign, which we define as a filling defect in the strut observed by angiography

during immediate flow restoration, may reflect integration of the thrombus in the stent retriever into the stent strut.

Intracranial atherosclerotic disease is particularly common in Asian patients, and underlying atherosclerotic stenosis can be a hidden cause of refractory occlusions after mechanical thrombectomy procedures.[16-18] In our study, a markedly high rate of final successful recanalization was achieved in patients with thromboembolic occlusion, with the use of adequate additional endovascular procedures for those patients with refractory occlusions. Although the rate of final successful endovascular recanalization of patients with atherosclerotic occlusion was not as high, early detection of the underlying atherosclerotic stenosis contributed to prevention of excessive use of unnecessary endovascular procedures and facilitated switching to adequate procedures, such as PTA or bypass surgery. Intracranial stenting may be a valid alternative for treatment of atherosclerotic stenosis, but we did not perform emergent stenting because there were no approved devices for acute-stage cerebral ischemia in our country. Consequently, the clinical outcomes in our study were considered to be comparable with those of recent randomized controlled trails.[1-5]

Based on these results, we propose three patterns of radiographic findings during stent deployment that can be used as a convenient approach for predicting recanalization and the characteristics of the occlusion (Figure 3). First, findings of great stent expansion with the in-stent thrombus sign might indicate that the stent retriever caught the thromboembolic clot sufficiently well, and consequently, successful recanalization can be expected after the pass (Pattern 1). Second, findings of poor stent expansion with the in-stent thrombus sign might suggest that the stent retriever did not catch the thromboembolic clot sufficiently well, for some reasons (e.g., a hard clot) (Pattern 2). If recanalization is not achieved in such cases, another approach using aspiration catheter may be a reasonable option for the next pass. Third, findings of poor stent expansion without the in-stent thrombus sign might suggest that the occlusion was not due to a thromboembolic clot, but rather due to atherosclerotic stenosis (Pattern 3). If recanalization is not achieved in such cases, early switching to PTA or bypass surgery may be a reasonable option for the next procedure. Therefore, the visibility of the Trevo may also facilitate deciding on the next procedure, and may thereby further enhance

the final clinical outcome. Not only the Trevo but also other stent retrievers which has visible marker, such as the Solitaire Platinum (Medtronic, Dublin, Ireland), may have potential to work similarly.

Limitations

There are some limitations to this study. First, it involved a retrospective analysis of a case series containing variable baseline characteristics, lack of blinding and procedural variation between the groups. Second, the small sample size had low power to detect significant differences. Third, the radiographic findings were assessed by using one image obtained from 2D angiography. Therefore, further larger scale studies are needed to clarify and support our results regarding radiographic findings during mechanical thrombectomy using a stent retriever.

CONCLUSIONS

Our study showed that greater stent expansion was associated with recanalization during mechanical thrombectomy using a stent retriever. The results suggested that the degree of stent expansion could be used as a surrogate marker for the clot–stent interaction, which may have the potential assessing the clot composition. In addition, in-stent thrombus sign may be useful for differentiation of the etiological characteristics of the occlusion. These radiographic findings during stent deployment could serve as convenient and useful real-time feedback during mechanical thrombectomy.

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Competing Interests Statement

The authors have no personal, financial, or institutional interest in any of the drugs, materials, or devices described in this article.

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FIGURE LEGENDS

Figure 1. Representative cases

(A) A representative case showing great stent expansion with in-stent thrombus sign. An angiographic image during the deployment of the Trevo shows 86% stent expansion with the in-stent thrombus sign. Recanalization was achieved after the pass with retrieving a soft clot.

(B) A representative case showing poor stent expansion with in-stent thrombus sign. An angiographic image during the deployment of the Trevo shows 23% stent expansion with the in-stent thrombus sign. Recanalization was not achieved after the pass without retrieving any clot. After an additional procedure using an aspiration catheter, recanalization was achieved with retrieving a hard clot.

(C) A representative case showing poor stent expansion without in-stent thrombus sign. An angiographic image during the deployment of the Trevo shows 20% stent expansion without the in-stent thrombus sign. Recanalization was achieved after the pass without retrieving any clot. Residual stenosis was considered underlying atherosclerotic stenosis.

Do=the diameter of the stent strut at the occlusion. Dn=the diameter of the stent strut at the nearby normal vessel.

Figure 2. The degree of stent expansion and the in-stent thrombosis sign according to the 1st-pass recanalization and etiology of the occlusion

(A) Box-and-whisker plots show that the degree of stent expansion was significantly greater in the patients with than those without recanalization.

(B) The ROC curve between the % stent expansion and recanalization shows moderate capacity of the prediction.

(C) The bar graph shows that the in-stent thrombus sign was observed similarly in the patients with and those without successful 1st-pass recanalization.

(D) Box-and-whisker plots show that the degree of stent expansion during the 1st-pass procedure was slightly but statistically significantly greater in the patients with thromboembolic occlusion than those with atherosclerotic occlusion.

(E) The ROC curve between the % stent expansion during the 1st-pass procedure and etiology

shows moderate capacity of the prediction.

(F) The bar graph shows that the in-stent thrombus sign was observed significantly more common in patients with thromboembolic occlusion than in those with atherosclerotic occlusion.

ROC=receiver operator characteristic.

Figure 3. Three patterns of radiological findings during stent deployment

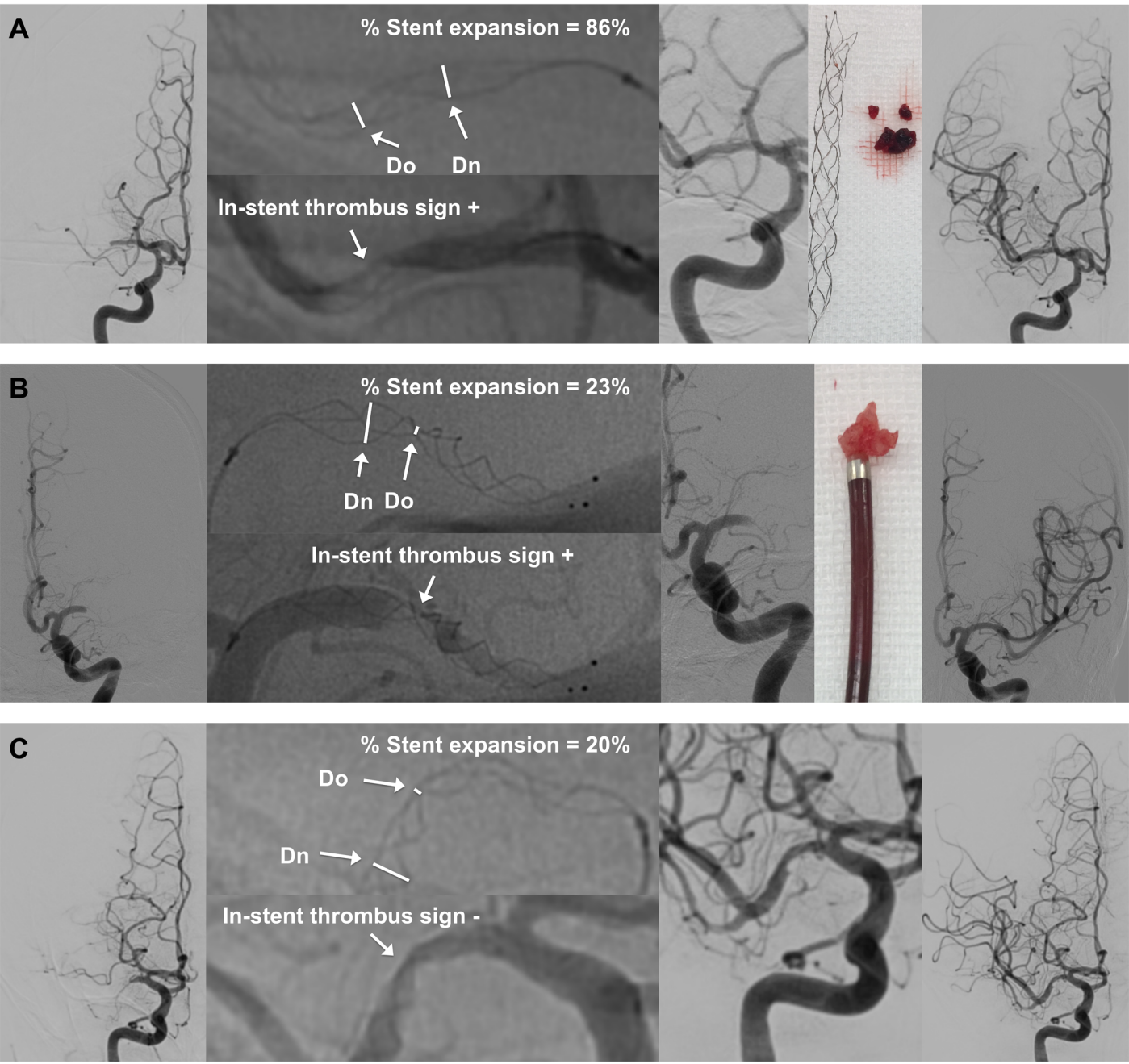
(A) Pattern 1: Great stent expansion with the in-stent thrombus sign.

(B) Pattern 2: Poor stent expansion with the in-stent thrombus sign.

(C) Pattern 3: Poor stent expansion without the in-stent thrombus sign.

PTA=percutaneous transluminal angioplasty.

Figure 1



Degree of stent expansion (%) = [1- (Docclusion/Dnormal)] x 100

In-stent thrombus sign = Filling defect of the thrombus in the strut

Figure 2

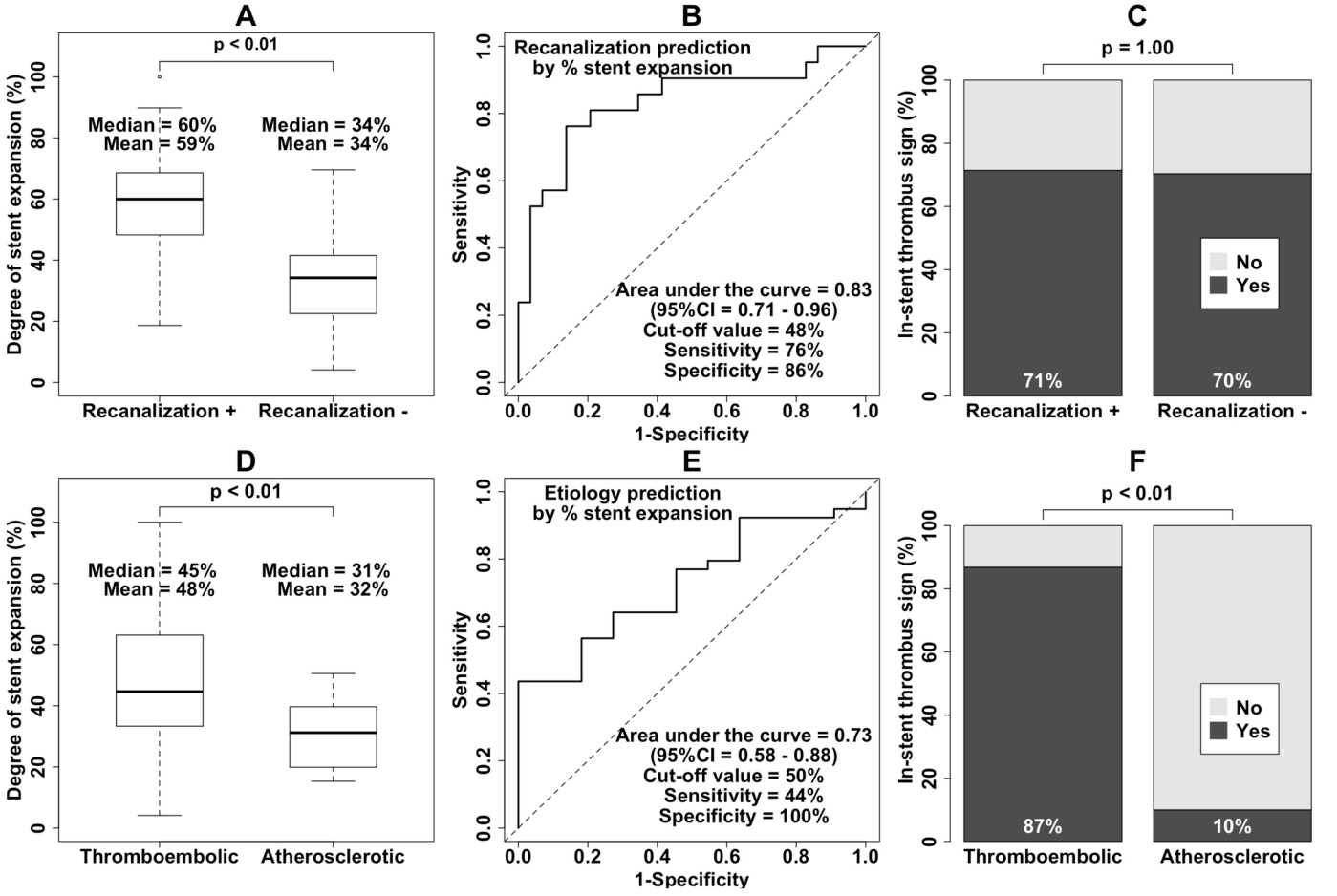

A
p < 0.01
Median = 60%
Mean = 59%
Median = 34%
Mean = 34%
Degree of stent expansion (%)
Recanalization +
Recanalization -
B
Recanalization prediction
by % stent expansion
Sensitivity
1-Specificity
Area under the curve = 0.83
(95%CI = 0.71 - 0.96)
Cut-off value = 48%
Sensitivity = 76%
Specificity = 86%
C
p = 1.00
In-stent thrombus sign (%)
No
Yes
71%
70%
Recanalization +
Recanalization -
D
p < 0.01
Median = 45%
Mean = 48%
Median = 31%
Mean = 32%
Degree of stent expansion (%)
Thromboembolic
Atherosclerotic
E
Etiology prediction
by % stent expansion
Sensitivity
1-Specificity
Area under the curve = 0.73
(95%CI = 0.58 - 0.88)
Cut-off value = 50%
Sensitivity = 44%
Specificity = 100%
F
p < 0.01
In-stent thrombus sign (%)
No
Yes
87%
10%
Thromboembolic
Atherosclerotic

Figure 3

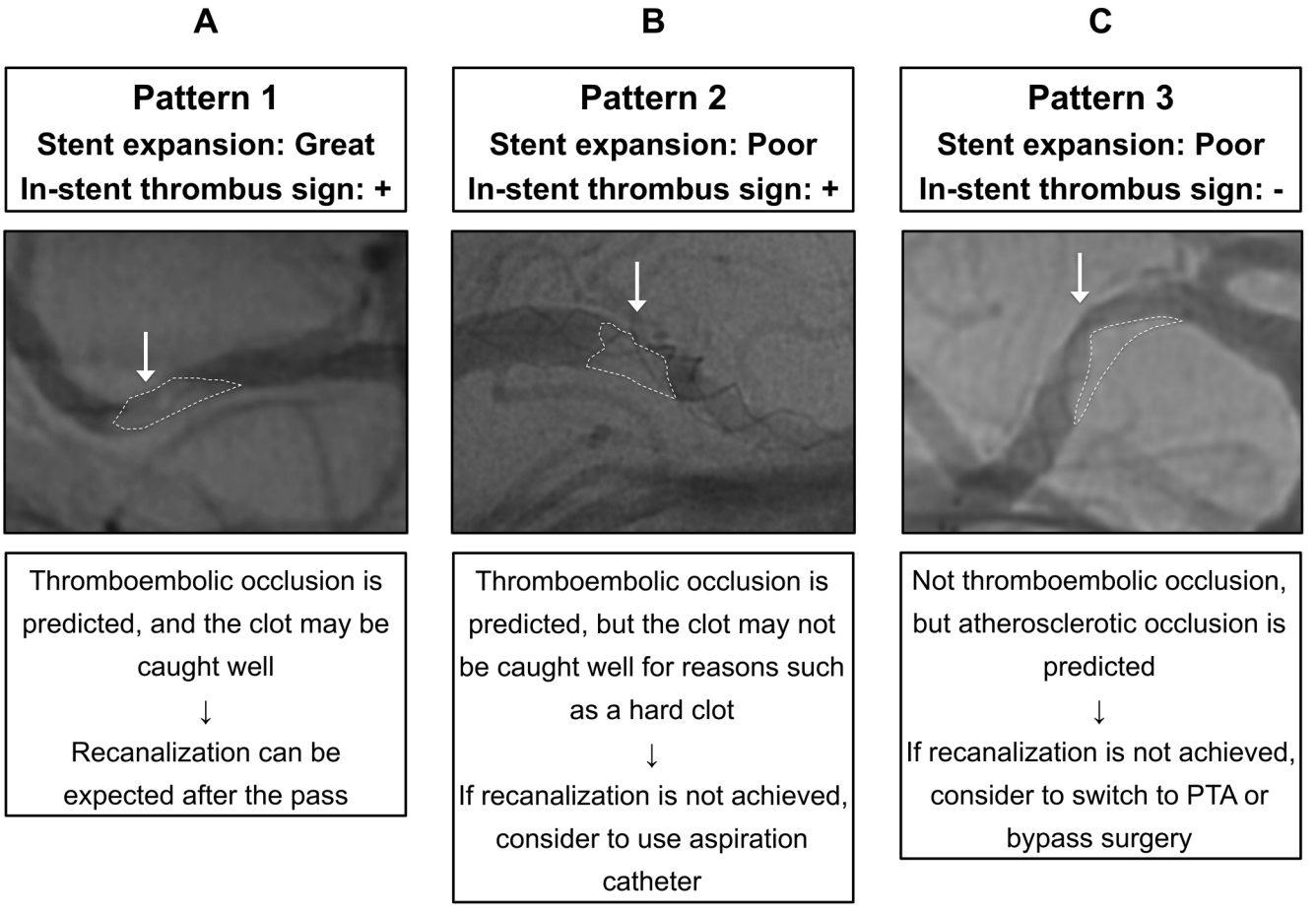

A
B
C
Pattern 1
Stent expansion: Great
In-stent thrombus sign: +
Pattern 2
Stent expansion: Poor
In-stent thrombus sign: +
Pattern 3
Stent expansion: Poor
In-stent thrombus sign: -
Thromboembolic occlusion is predicted, and the clot may be caught well
↓
Recanalization can be expected after the pass
Thromboembolic occlusion is predicted, but the clot may not be caught well for reasons such as a hard clot
↓
If recanalization is not achieved, consider to use aspiration catheter
Not thromboembolic occlusion, but atherosclerotic occlusion is predicted
↓
If recanalization is not achieved, consider to switch to PTA or bypass surgery

Table 1. Baseline characteristics

	All	1st-pass procedure			Etiology of the occlusion		
	(n=50)	Recanalization + (n=21)	Recanalization - (n=29)	P Value	Thromboembolic (n=39)	Atherosclerotic (n=11)	P Value
Demographics and clinical data							
Age (years)	79 (73 − 85)	81 (75 − 85)	76 (71 − 83)	0.09	79 (74 − 85)	70 (64 − 78)	0.01
NIHSS score on admission	15 (7 − 22)	13 (11 − 22)	15 (7 − 21)	0.93	17 (10 − 23)	8 (7 − 20)	0.28
ASPECTS score on admission	9 (8 − 10)	9 (8 − 10)	9 (7 − 10)	0.82	8 (7 − 10)	10 (9 − 10)	0.03
IV tPA administration	8 (16%)	2 (10%)	6 (21%)	0.44	5 (13%)	3 (27%)	0.35
Time from symptom onset to groin puncture (min)	149 (77 − 317)	230 (98 − 280)	126 (76 − 323)	0.42	137 (72 − 255)	320 (117 − 489)	0.22
Medical history							
Hypertension	32 (64%)	16 (76%)	16 (55%)	0.15	25 (64%)	7 (65%)	1.00
Diabetes mellitus	10 (20%)	6 (29%)	4 (14%)	0.29	6 (15%)	4 (36%)	0.20
Dyslipidemia	7 (14%)	4 (19%)	3 (10%)	0.43	6 (15%)	1 (9%)	1.00
Atrial fibrillation	28 (56%)	15 (71%)	13 (45%)	0.09	26 (67%)	2 (18%)	<0.01
Etiology of the occlusion							
Thromboembolic	39 (78%)	17 (81%)	22 (76%)	0.74	39 (100%)	0 (0%)	-
Atherosclerotic	11 (22%)	4 (19%)	7 (24%)	0.74	0 (0%)	11 (100%)	-

Data are median (interquartile range), n (%).

NIHSS=National Institutes of Health Stroke Scale. ASPECTS=Alberta Stroke Program Early Computed Tomography Score. IV tPA=intravenous tissue plasminogen activator.

Table 2. Findings during the 1st-pass procedure and treatment results

	All (n=50)	1st-pass procedure			Etiology of the occlusion		
		Recanalization + (n=21)	Recanalization - (n=29)	P Value	Thromboembolic (n=39)	Atherosclerotic (n=11)	P Value
Findings during the 1st-pass procedure							
Degree of stent expansion (%)	40 (30－58)	60 (48－69)	34 (23－42)	<0.01	45 (33－63)	31 (20－40)	<0.01
Immediate flow restoration	48 (96%)	21 (100%)	27 (93%)	0.50	38 (97%)	10 (91%)	0.40
In-stent thrombus sign	34/48 (71%)	15/21 (71%)	19/27 (70%)	1.00	33/38 (87%)	1/10 (10%)	<0.01
Treatment results							
1st-pass recanalization (TICI 2b/3)	21 (42%)	21 (100%)	0 (0%)	-	17 (44%)	4 (36%)	0.74
Final successful recanalization (TICI 2b/3)	45 (90%)	21 (100%)	24 (83%)	0.07	38 (97%)	7 (64%)	<0.01
Procedures achieving successful recanalization (TICI 2b/3)							
Stent retriever	35 (70%)	21 (100%)	14 (48%)	<0.01	30 (77%)	5 (45%)	0.06
Aspiration catheter	4 (8%)	-	4 (14%)	-	4 (10%)	0 (0%)	0.56
Combined use of stent retriever and aspiration catheter	3 (6%)	-	3 (10%)	-	3 (7%)	0 (0%)	1.00
PTA	3 (6%)	-	3 (10%)	-	1 (3%)	2 (18%)	0.12
Emergent STA-MCA bypass	3 (6%)	0 (0%)	3 (10%)	0.25	0 (0%)	3 (27%)	<0.01
Symptomatic intracranial hemorrhage	1 (2%)	0 (0%)	1 (3%)	1.00	1 (3%)	0 (0%)	1.00
Favorable outcome (mRS 0-2 at 90 days)	24 (48%)	11 (52%)	13 (45%)	0.77	18 (46%)	6 (55%)	0.74
Death (mRS 6 at 90 days)	3 (6%)	1 (5%)	2 (7%)	1.00	3 (8%)	0 (0%)	1.00

Data are median (interquartile range), n (%).

TICI=modified Thrombolysis in Cerebral Infarction score. PTA=percutaneous transluminal angioplasty. STA-MCA=superficial temporal artery to middle cerebral artery. mRS=modified Rankin Scale score.