Clinical Article
J Korean Neurosurg Soc 62 (5) : 545-550, 2019
https://doi.org/10.3340/jkns.2019.0108
pISSN 2005-3711 eISSN 1598-7876

Initial Experience of ACE68 Reperfusion Catheter in Patients with Acute Ischemic Stroke Related to Internal Carotid Artery Occlusion

Hyoung-Gyu Jang,[1] Jung-Soo Park,[1] Jong-Myong Lee,[1] Hyo-Sung Kwak[2]

Department of Neurosurgery and Research Institute,[1] Clinical Medicine of Chonbuk National University-Biomedical Research Institute, Chonbuk National University Hospital, Jeonju, Korea
Department of Radiology and Research Institute,[2] Clinical Medicine of Chonbuk National University-Biomedical Research Institute, Chonbuk National University Hospital, Jeonju, Korea

Objective : Penumbra ACE68 reperfusion catheter is a new large bore aspiration catheter used for reperfusion of large vessel occlusion. The objective of this study was to investigate the efficacy of this catheter in comparison to that of previous Penumbra catheters in patients with acute ischemic stroke related to internal carotid artery (ICA) occlusion.

Methods : Data of all eligible patients who received endovascular treatment (EVT) for ICA occlusion using Penumbra aspiration catheters between January 2015 and December 2018 were retrospectively reviewed. After dividing into two groups according to use of penumbra ACE68, baseline characteristics of patients, successful recanalization rate, puncture to recanalization time, and switch to stent base technique rate were assessed. Successful recanalization was defined by a thrombolysis in cerebral infarction (TICI) score ≥2b and favorable functional outcome was defined according to modified Rankin scale (score, 0–2).

Results : ACE68 reperfusion catheter was used in 29 of 75 eligible patients (39%). The puncture to recanalization time was significantly shorter (26±18.2 minutes vs. 40±24.9 minutes, p=0.011) and the rate of switch to stent-based retrieval was significantly lower (3% vs. 20%, p=0.046) in ACE68 catheter group. Moreover, although not statistically significant, the successful recanalization rate was higher (83% vs. 76%, p=0.492) in ACE68 catheter group. Favorable functional outcome was observed in 48% of patients treated with ACE68 reperfusion catheter and in 30% of patients treated using other Penumbra systems (p=0.120). Baseline Alberta Stroke Program Early CT Scores ≥8 (odds ratio [OR], 9.74; 95% confidence interval [CI], 1.72–54.99; p=0.010) and successful recanalization (OR, 10.20; 95% CI, 1.13–92.46; p=0.039) were independent predictors of favorable outcome.

Conclusion : EVT using ACE68 reperfusion catheter can be considered a first-line therapy in patients with acute ICA occlusion as it can achieve rapid recanalization and reduce the frequency of conversion to stent-retrieve therapy.

Key Words : Stroke · Brain ischemia · Aspiration thrombectomy.

• Received : April 28, 2019 • Revised : June 8, 2019 • Accepted : June 18, 2019
• Address for reprints : **Jung Soo Park**
Department of Radiology and Research Institute, Clinical Medicine of Chonbuk National University-Biomedical Research Institute, Chonbuk National University Hospital, 567 Baekje-daero, deokjin-gu, Jeonju 54896, Korea
Tel : +82-63-250-1755, Fax : +82-63-277-3273, E-mail : nspark@jbnu.ac.kr, ORCID : https://orcid.org/0000-0002-4949-203X

INTRODUCTION

Since a series of reports published in 2015, endovascular treatment (EVT) has been considered a safe and effective treatment modality for large vessel occlusion in the anterior cerebral circulation in patients with acute ischemic stroke (AIS)[1,4,9]. Studies at that time were primarily performed using stent-retrievers, but with the development of newer thrombectomy devices, aspiration thrombectomy with large-bore aspiration catheters has recently emerged as another therapeutic option in treating patients with AIS. The ACE68 reperfusion catheter (Penumbra Inc., Alameda, CA, USA), a new large-bore flexible reperfusion catheter used for vessel recanalization, was launched in July 2016. The purpose of this study was to investigate the efficacy of the ACE68 reperfusion catheter in comparison to that of prior Penumbra catheters in patients with AIS related to internal carotid artery (ICA) occlusion.

MATERIALS AND METHODS

Patient enrollment

The Institutional Review Board of Chonbuk National University Hospital approved this retrospective study. Clinical and radiological records of patients with acute ICA occlusion treated with EVT using Penumbra aspiration catheters between January 2015 and December 2018 were retrospectively analyzed. A total of 488 patients with AIS were treated with EVT over the study period. Among them, we included patients whose initial occlusion site was between the proximal ICA and the ICA terminus. Patients with middle or anterior cerebral occlusion who did not show ICA occlusion were excluded from the study. Patients who did not use the penumbra aspiration catheters as first-line EVT were also excluded. Our final sample consisted of 75 patients with ICA occlusion treated with EVT using Penumbra reperfusion catheters as first-line therapy. All patients were initially evaluated by brain computed tomography (CT), and angiographic status of patients was routinely assessed by 3-dimensional CT angiography or magnetic resonance (MR) angiography. Inclusion criteria for EVT were an initial National Institutes of Health Stroke Scale (NIHSS) score ≥4, no evidence of intracerebral hemorrhage, and a large vessel occlusion, including ICA, on CT or MR angiography. A brain CT scan was routinely performed immediately after the EVT.

EVT

All eligible patients received 0.9 mg/kg of intravenous recombinant tissue plasminogen activator (tPA) within 4.5 hours of symptom onset. After femoral artery puncture, a 100-cm 8 Fr guide catheter (Guider Softip; Stryker, Natick, MA, USA) was introduced to the cervical portion of ICA through a coaxial system, which was assembled by combining the outermost 80-cm 8 Fr shuttle sheath (Shuttle-SL; Cook, Bloomington, ID, USA). After the ICA occlusion site was defined by angiography, a Penumbra aspiration catheter was introduced to the face of the clot triaxially over a Rebar 18 microcatheter (EV3, Irvine, CA, USA) and Synchro 0.014-inch guidewire (Stryker, Freemont, CA, USA) under roadmap guidance. Before February 2018, the 5MAX, 4MAX or 054 reperfusion catheters were used; subsequently, ACE68 reperfusion catheter was used as the first option for ICA occlusion. The microcatheter and wire were removed and a 20-mL syringe was connected to the proximal hub of the reperfusion catheter. Continuous manual aspiration was performed, maintaining the vacuum state between the tip of catheter and the thrombus, while gently withdrawing the Penumbra catheter through the guide catheter. If recanalization was not achieved applying this technique 3–5 times, a Solitaire stent retrieval system (Covidien, Irvine, CA, USA) was used.

Clinical and radiologic analysis

Patients demographic, clinical, and angiographic data were retrospectively analyzed. The NIHSS and modified Rankin scale (mRS) scores were assessed on admission and a favorable functional outcome was defined as a mRS score of ≤2 at 3 months. Initial Alberta Stroke Program Early CT Scores (ASPECTS) were collected and the degree of vessel occlusion after EVT was defined by the thrombolysis in cerebral infarction (TICI) scale; successful recanalization was defined as TICI ≥2b. Procedure-related symptomatic hemorrhage was defined as the presence of hemorrhage after EVT with any increase in the NIHSS compared to baseline on admission.

Statistical analysis

SPSS ver. 20.0 (IBM SPSS, Chicago, IL, USA) was used for statistical analysis. All patients were divided into two groups according to use of ACE68 reperfusion catheter. Continuous

 https://doi.org/10.3340/jkns.2019.0108

variables were expressed as means with standard deviation or medians with interquartile range (IQR), while categorical data were expressed as counts and percentages. Independent t-test was used to analyze differences in continuous variables and Pearson's chi-squared test was used for categorical variables. Multivariable logistic regression analyses were performed to identify independent predictors of favorable functional outcome. Statistically significant differences were defined by $p<0.05$.

RESULTS

The study sample included 33 male (44%) (mean age, 72.9±11.6 years). The median NIHSS score at admission was 13 (range, 4–20) and median ASPECTS score was 8 (range, 2–10). Twenty-nine patients (39%) were treated with EVT using the ACE68 reperfusion catheter and 46 patients (61%) with 5MAX, 4MAX, or 054 reperfusion catheters. The median onset to door time was 97 minutes (range, 10–752 minutes).

The baseline characteristics of included patients are described in Table 1. No significant differences were found in any baseline

Table 1. Baseline characteristics according to using the ACE68 reperfusion catheter

Variable	ACE68 reperfusion catheter (n=29)	Other Penumbra catheters (n=46)	*p*-value
Age (years)	73.0±13.6	72.8±10.2	0.930
Men	11 (40)	22 (48)	0.401
Occlusion site, Rt ICA terminus	17 (59)	23 (50)	0.466
Baseline NIHSS score	14 (11–16)	12 (10–16)	0.565
Baseline ASPECTS	9 (7–10)	8 (6–10)	0.490
Onset to door time (minutes)	98 (57–182)	78 (41–124)	0.127
Risk factors			
Hypertension	15 (52)	29 (63)	0.332
Diabetes	7 (24)	10 (22)	0.809
Hyperlipidemia	3 (10)	3 (7)	0.552
Smoking	3 (10)	8 (17)	0.401
Atrial fibrillation or cardiac disease	10 (34)	19 (41)	0.555
Previous stroke	8 (28)	10 (22)	0.564

Values are presented as mean±standard deviation, number (%), or median (interquartile range). Rt : right, ICA : internal carotid artery, NIHSS : National Institutes of Health Stroke Scale, ASPECTS : Alberta Stroke Program Early CT score

Table 2. Imaging and clinical outcomes according to using ACE68 reperfusion catheter

Variable	ACE68 reperfusion catheter (n=29)	Other Penumbra catheters (n=46)	*p*-value
Onset to puncture time (minutes)	230 (163–300)	183 (145–250)	0.119
Puncture to recanalization time (minutes)	20 (15–25)	35 (22–48)	0.011
TICI ≥2b	24 (83)	35 (76)	0.492
Switch to stent based retrieve	1 (3)	9 (20)	0.046
Symptomatic hemorrhage	4 (14)	11 (24)	0.286
Discharge NIHSS score	7 (5–15)	10 (5–15)	0.432
Favorable functional outcome (mRS 0–2)	14 (48)	14 (30)	0.120

Values are presented as number (%) or median (interquartile range). TICI : thrombolysis in cerebral infarction, NIHSS : National Institutes of Health Stroke Scale, mRS : modified Rankin scale

data, including NIHSS score, ASPECTS score, and onset to door time, between patients who were treated with ACE68 reperfusion catheter and the rest of patients. Table 2 shows the EVT-related parameters and clinical outcome. Significant differences were detected in puncture to recanalization time (20 minutes [IQR, 15–25] vs. 35 minutes [IQR, 22–48], p=0.011) and the number of switches to the stent-retrieve as a second-line therapy (1 of 29 [3%] vs. 9 of 40 [20%], p=0.046) between ACE68 reperfusion catheter group and other Penumbra catheters group. Other parameters, such as onset to puncture time, rate of TICI ≥2b, rate of symptomatic hemorrhage after EVT, and favorable functional outcome, did not show significant differences. In multivariate logistic analysis ASPECTS score ≥8 and successful recanalization were identified as independent predictors of favorable functional outcome (Table 3). Although the use of ACE68 reperfusion catheter had no statistical significance as an independent predictor, more patients showed favorable functional outcome in ACE68 reperfusion catheter group (14/29 [48%] vs. 14/46 [30%]).

DISCUSSION

Since several randomized trials have demonstrated the efficacy and safety of EVT in patients with AIS caused by large vessel occlusion, this treatment modality has played an important role in the treatment of AIS[1,2,4,9]. Early EVT studies were mainly based on stent-retrievers, such as Trevo and Solitaire; subsequently, equivalent safety and efficacy of EVT have been reported in studies using aspiration catheters[5,10,11]. However, in EVT using aspiration catheters, the catheter should have sufficient inner diameter of the lumen for suction, and the navigation of catheter to the occlusion site may be more difficult than that of the stent-retriever, especially in tortuous vessels. Recently, better recanalization rate and a shorter procedure time have been achieved by using new generation of easy-to-track and large-bore aspiration catheters[3,6].

The Penumbra ACE68 reperfusion catheter, a new large bore aspiration catheter available for vessel recanalization, was launched in July 2016. The ACE68 reperfusion catheter has an distal inner lumen diameter of 0.068, which is 0.012 in more than that of its predecessors, such as 5MAX or Penumbra 054, and translated to a gain in cross sectional area of approximately 58%[6]. Besides, The ACE68 reperfusion catheter has several features to improve trackability. Its triple wire coil reinforcement on proximal shaft advances pushability for navigation while maintaining kink resistance. Distal portion of the catheter, it has 16 transitions to enable smooth force transmission and minimize kinking. And the beveled catheter tip also imiproves navigation.

Table 3. Variable associated with favorable functional outcome (mRS 0–2 at 3 months)

Variable	Univariate analysis		Multivariate analysis	
	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Age <80	0.29 (0.75-8.70)	0.027	4.24 (0.98-18.30)	0.053
Baseline NIHSS score <15	1.12 (0.42-2.95)	0.823		
ASPECTS ≥8	10.50 (2.23-49.42)	0.003	9.74 (1.72-54.99)	0.010
Onset to recanalization time <6 hours	0.75 (0.23-2.45)	0.636		
Use of ACE68 reperfusion catheter	2.13 (0.82-5.58)	0.123	2.80 (0.85-9.22)	0.091
Successful recanalization (TICI 2b, 3)	12.66 (1.57-102.12)	0.017	10.20 (1.13-92.46)	0.039
Hypertension	0.57 (0.22-1.47)	0.241		
Diabetes	0.89 (0.29-2.76)	0.843		
Hyperlipidemia	0.83 (0.14-4.84)	0.833		
Smoking	0.95 (0.25-3.60)	0.943		
Atrial fibrillation or cardiac disease	1.04 (0.40-2.72)	0.932		
Previous stroke	0.39 (0.12-1.34)	0.136	1.19 (0.25-5.71)	0.831

OR : odds ratio, CI : confidence interval, NIHSS : National Institutes of Health Stroke Scale, ASPECTS : Alberta Stroke Program Early CT score, TICI : thrombolysis in cerebral infarction

 https://doi.org/10.3340/jkns.2019.0108

In our study, EVT using ACE68 reperfusion catheter group showed a significantly shorter procedure time (20 mintutes [IQR, 15–25] vs. 35 minutes [IQR, 22–48], p=0.011) and lower rate of switch to stent retriever as second-line therapy (1 of 29 [3%] vs. 9 of 46 [20%], p=0.046) compared with other Penumbra catheters group. These results are presumed to be related to the larger distal lumen diameter of ACE68 reperfusion catheter in order to aspirate ICA thrombus and, despite its size, superior trackability compared with prior versions, especially at the tip[3,6].

In previous studies, an initial high ASPECTS, the presence of successful recanalization, short time interval from symptom onset to recanalization were found to be independent predictors of favorable functional outcome[7,8,12]. In our study, multivariate logistic regression analysis demonstrated that successful recanalization (odd ratio [OR], 10.20; 95% confidence ratio [CI], 1.13–92.46, p=0.039) and initial ASPECTS score ≥8 (OR, 9.74; 95% CI, 1.72–54.99; p=0.010) were independent predictor of favorable functional outcome. Moreover, although not statistically significant, we found a tendency to more favorable functional outcome in the group treated by EVT with ACE68 reperfusion catheter (14 of 29 [48%] vs. 14 of 46 [30%], p=0.120; OR, 2.80; 95% CI, 0.85–9.22; p=0.091).

The ultimate goal of EVT in patients with AIS is to improve the clinical outcome. For that, first and foremost, rapid and sufficient recanalization of the occluded vessel is essential. Our study demonstrated that EVT using ACE68 reperfusion catheter can achieve rapid recanalization. Additionally, the successful recanalization rate (24 of 29 [83%]) was comparable to that of previous studies using stent-retrievers[1,2,4,9]. Furthermore, the frequency of conversion to stent-retriever is significantly reduced, which could be a cost saving as well as a time saving effect. Considering these observations, EVT using ACE68 reperfusion catheter as a first-line option may be a reasonable choice for achieving ultimate goal of EVT in patients with AIS related to ICA occlusion.

Our study has several limitations. First, it lacks a prospective design. Second, the relatively small sample size precluded the attainment of statistical significance. Third, we lack another treatment modality, such as stent retriever, to be used in the control group. Finally, we used intravenous tPA only patients within 4.5 hours of symptom onset. The use of tPA may have affected successful recanalization rate.

CONCLUSION

Based on the results of this study, ACE68 reperfusion catheter may be considered as a first-line option when planning aspiration thrombectomy in patients AIS related to ICA occlusion. It can provide rapid revascularization with satisfactory recanalization rate and reduce the frequency of conversion to stent-retriever. Moreover, it may provide more opportunities to get a favorable outcome.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

INFORMED CONSENT

Informed consent was obtained from all individual participants included in this study.

AUTHOR CONTRIBUTIONS

Conceptualization : HSK
Data curation : HGJ
Formal analysis : HGJ
Methodology : JSP, HSK
Project administration : JSP
Visualization : JSP, JML
Writing - original draft : HGJ
Writing - review & editing : JSP, JML

References

1. Berkhemer OA, Fransen PS, Beumer D, van den Berg LA, Lingsma HF, Yoo AJ, et al. : A randomized trial of intraarterial treatment for acute ischemic stroke. **N Engl J Med 372 :** 11-20, 2015
2. Campbell BC, Mitchell PJ; EXTEND-IA Investigators : Endovascular therapy for ischemic stroke. **N Engl J Med 372 :** 2365-2366, 2015
3. Frei D, Gerber J, Turk A, McPherson M, Heck D, Hui F, et al. : The SPEED study: initial clinical evaluation of the penumbra novel 054 reperfusion catheter. **J Neurointerv Surg 5 Suppl 1 :** i74-i76, 2013

4. Goyal M, Demchuk AM, Menon BK, Eesa M, Rempel JL, Thornton J, et al. : Randomized assessment of rapid endovascular treatment of ischemic stroke. **N Engl J Med 372 :** 1019-1030, 2015
5. Jankowitz B, Aghaebrahim A, Zirra A, Spataru O, Zaidi S, Jumaa M, et al. : Manual aspiration thrombectomy: adjunctive endovascular recanalization technique in acute stroke interventions. **Stroke 43 :** 1408-1411, 2012
6. John S, Hussain MS, Toth G, Bain M, Uchino K, Hui FK : Initial experience using the 5MAX ACE reperfusion catheter in intra-arterial therapy for acute ischemic stroke. **J Cerebrovasc Endovasc Neurosurg 16 :** 350-357, 2014
7. Ozdemir O, Giray S, Arlier Z, Bas DF, Inanc Y, Colak E : Predictors of a good outcome after endovascular stroke treatment with stent retrievers. **ScientificWorldJournal 2015 :** 403726, 2015
8. Powers WJ, Derdeyn CP, Biller J, Coffey CS, Hoh BL, Jauch EC, et al. : 2015 American Heart Association/American Stroke Association focused update of the 2013 guidelines for the early management of patients with acute ischemic stroke regarding endovascular treatment: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. **Stroke 46 :** 3020-3035, 2015
9. Saver JL, Goyal M, Bonafe A, Diener HC, Levy EI, Pereira VM, et al. : Stent-retriever thrombectomy after intravenous t-PA vs. t-PA alone in stroke. **N Engl J Med 372 :** 2285-2295, 2015
10. Turk AS, Frei D, Fiorella D, Mocco J, Baxter B, Siddiqui A, et al. : ADAPT FAST study: a direct aspiration first pass technique for acute stroke thrombectomy. **J Neurointerv Surg 6 :** 260-264, 2014
11. Turk AS, Spiotta A, Frei D, Mocco J, Baxter B, Fiorella D, et al. : Initial clinical experience with the ADAPT technique: a direct aspiration first pass technique for stroke thrombectomy. **J Neurointerv Surg 6 :** 231-237, 2014
12. Yang Y, Liang C, Zhang Q, Shen C, Ma S, Mao J, et al. : Analysis of prognostic factors of endovascular therapy in 59 patients with acute anterior circulation stroke: a retrospective cohort study – observational. **Int J Surg 16 :** 36-41, 2015

 https://doi.org/10.3340/jkns.2019.0108