Balloon Guide Catheter Is Beneficial in Endovascular Treatment Regardless of Mechanical Recanalization Modality

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Background and Purpose—Based on its mechanism, the use of balloon guide catheters (BGCs) may be beneficial during endovascular treatment, regardless of the type of mechanical recanalization modality used—stent retriever thrombectomy or thrombaspiration. We evaluated whether the use of BGCs can be beneficial regardless of the first-line mechanical endovascular modality used.

Methods—We retrospectively reviewed consecutive acute stroke patients who underwent stent retriever thrombectomy or thrombaspiration from the prospectively maintained registries of 17 stroke centers nationwide. Patients were assigned to the BGC or non-BGC group based on the use of BGCs during procedures. Endovascular and clinical outcomes were compared between the BGC and non-BGC groups. To adjust the influence of the type of first-line endovascular modality on successful recanalization and favorable outcome, multivariable analyses were also performed.

Results—This study included a total of 955 patients. Stent retriever thrombectomy was used as the first-line modality in 526 patients (55.1%) and thrombaspiration in 429 (44.9%). BGC was used in 516 patients (54.0%; 61.2% of stent retriever thrombectomy patients; 45.2% of thrombaspiration patients). The successful recanalization rate was significantly higher in the BGC group compared with the non-BGC group (86.8% versus 74.7%, respectively; $P<0.001$). Furthermore, the first-pass recanalization rate was more frequent (37.0% versus 14.1%; $P<0.001$), and the number of device passes was fewer in the BGC group (2.5±1.9 versus 3.3±2.1; $P<0.001$). The procedural time was also shorter in the BGC group (54.3±27.4 versus 67.6±38.2; $P<0.001$). The use of BGC was an independent factor for successful recanalization (odds ratio, 2.18; 95% CI, 1.54–3.10; $P<0.001$) irrespective of the type of first-line endovascular modality used. The use of BGC was also an independent factor for a favorable outcome (odds ratio, 1.40; 95% CI, 1.02–1.92; $P=0.038$) irrespective of the type of first-line endovascular modality used.

Conclusions—Regardless of the first-line mechanical endovascular modality used, the use of BGC in endovascular treatment was beneficial in terms of both recanalization success and functional outcome. **(*Stroke*. 2019;50:1490-1496. DOI: 10.1161/STROKEAHA.118.024723.)**

Key Words: balloon occlusion ■ endovascular treatment ■ stroke ■ thrombectomy

Endovascular treatment (EVT) is a standard therapy for acute intracranial large vessel occlusion.[1–4] A few technical considerations have been discussed among the scientific community to achieve a more effective and faster recanalization during EVT.[5,6] In in vitro models, balloon guide catheters (BGCs) were able to make a significant flow arrest or reversal,

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which led to reduced distal embolization of fragmented thrombi during stent retriever thrombectomy (SRT) procedures.[7,8] This suggested that BGCs might contribute to improved EVT results by reducing the number of thrombectomy device passes and ultimately making the final recanalization more successful.[9] A few clinical studies have shown that the use of BGCs was associated with higher recanalization success rates and shorter procedure times in SRT, one of the major first-line modalities for EVT.[9–13] The use of BGCs was also associated with better clinical outcomes in SRT.[10,13] As a result, the use of BGCs is recommended in SRT in current guidelines.[1]

Considering the mechanism of BGCs, the distal embolisms during thrombaspiration might also be reduced when BGCs achieve flow arrest or reversal. Procedural benefits have been reported for the combined use of BGCs and thrombaspiration from a single small case series.[14] Accordingly, we hypothesized that the use of BGCs would be helpful regardless of the first-line endovascular modality, SRT, or thrombaspiration used. We evaluated whether procedural and clinical outcomes would be better irrespective of the type of first-line endovascular modality used.

Methods

The data that support the findings of this study are available from the corresponding author on reasonable request. We retrospectively reviewed consecutive patients with acute stroke who underwent EVT in 17 comprehensive stroke centers between September 2010 and December 2015 in Korea. Patients who met all the following criteria were included in this study: (1) intracranial large vessel occlusion in the anterior circulation (intracranial internal carotid artery [ICA], M1, or proximal M2); (2) endovascular procedure using a modern, mechanical recanalization technique (SRT or thrombaspiration); (3) age ≥18 years; (4) initial National Institutes of Health Stroke Scale (NIHSS) score of ≥4; (5) time from onset to puncture ≤600 minutes; (6) modified Rankin Scale score before qualifying stroke of ≤1; and (7) available modified Rankin Scale score at 3 months after stroke onset. Patients with intracranial artery dissections were excluded, but those with tandem cervical ICA occlusions were included. Those with multifocal intracranial occlusions (bilateral or both anterior and posterior circulation) were not included.

The institutional review boards of all participating hospitals approved this study and waived the requirement of informed consent for study inclusion based on the retrospective study design.

Endovascular Procedure

For patients eligible for intravenous tissue-type plasminogen activator treatment, the full dose of tissue-type plasminogen activator (0.9 mg/kg) was administered. All endovascular procedures were performed under local anesthesia. Conscious sedation was allowed as necessary.

The SRT procedures were performed according to common recommendations.[6] An 8- or 9-F regular guide catheter or BGC (Cello [Medtronic, Dublin, Ireland]; Optimo [Tokai Medical, Aichi, Japan]) was used. The use of a BGC depended on the protocols of each participating site. Two types of stent retriever (SR)—Solitaire (AB or FR, Medtronic) and Trevo (XP or ProView; Stryker, Kalamazoo, MI)—were used for SRT. No distal access catheter was used in the study population because it had not yet been introduced during the study period. The SR was delivered and then deployed over the thrombus with a 0.021- or 0.027-in microcatheter. The SR was left deployed for a few minutes before retrieval. Then, the SR and microcatheter were carefully retrieved. For cases using BGCs, the balloon of the BGC was first inflated, then the SR and microcatheter were retrieved under constant aspiration with a 30- or 50-mL syringe through the BGC. This process was repeated until a modified Thrombolysis in Cerebral Infarction (mTICI) grade 2b or 3 was achieved.

The thrombaspiration procedures were performed according to previous reports, with little deviation.[6,15,16] A 6-F regular guide catheter (Shuttle Guiding Sheath; Cook Medical, Bloomington, IN) or 8- or 9-F BGC (Cello; Optimo) was used. The use of a BGC depended on the protocols of each participating site. Except for BGC use, thrombaspiration techniques were similar across all participating centers. After the guide catheter or BGC was optimally positioned in the distal cervical ICA, a large bore aspiration catheter (Penumbra Reperfusion Catheter [Penumbra, Alameda, CA]; Navien [Medtronic]; Revive IC [Codman, Raynham, MA]) was advanced as close as possible to the proximal end of the thrombus using a coaxial technique with a 0.021- to 0.027-in microcatheter over a microwire. Thrombaspiration was then performed with manual aspiration using a 50-mL syringe. Among aspiration catheters used, the Penumbra Reperfusion Catheter was predominantly used for thrombaspiration in all centers during the study period. For cases using BGCs, the balloon of the BGC was first inflated, then the aspiration catheter was cautiously retrieved under constant aspiration with a 50-mL syringe. This process was repeated until an mTICI grade 2b or 3 was achieved.

Whether or not to use the BGC in EVT was determined mostly by the internal protocol of each participating center. The timing to stop the SRT or the thrombaspiration attempts or to switch to another endovascular modality (SRT to thrombaspiration, vice versa, or a combination of both) was determined according to the operator's judgment, taking into consideration the occlusion pathogenesis, clinical or patient condition, and other relevant factors.

Data Collection and Assessment

Data, including clinical and laboratory findings and procedural details, were obtained from the prospectively maintained registries in each participating hospital, which were then entered into the predefined case report form. Case report forms were anonymized and sent to a core laboratory. Imaging data—initial noncontrast computed tomography with computed tomographic angiography or magnetic resonance images with magnetic resonance angiography, catheter angiograms during EVT, and follow-up computed tomography or magnetic resonance images—were also anonymized, then sent to the core laboratory as digital imaging and communication in medicine files.

Two neuroradiologists independently assessed the images for the Alberta Stroke Program Early CT Score using a commercialized digital imaging and communication in medicine viewer (OsiriX; Pixmeo, Geneva, Switzerland).[17] The interrater agreement for Alberta Stroke Program Early CT Score was good (intraclass correlation coefficient, 0.657). The mTICI grade was assessed by 2 independent neurointerventionalists using catheter angiograms taken during EVT. By offering only initial and final angiograms to raters, they were also blind to whether a BGC was used in each case. The kappa coefficient for the dichotomized mTICI grade (0–2a versus 2b–3) was 0.813. All raters were blind to clinical information and findings on follow-up imaging. All discrepant cases were resolved by consensus.

Outcome Measurement

To evaluate endovascular benefits, we assessed the following endovascular results: successful recanalization, first-pass recanalization, number of passes of the thrombectomy devices, use of intra-arterial thrombolytics to resolve far distal artery occlusion that was newly observed after thrombectomy, and procedural time (puncture-to-recanalization time). Successful recanalization was defined as a final mTICI grade of 2b or 3 without further reocclusions during the procedure. The total number of device passes required to achieve successful recanalization was also counted. If the occlusion was successfully recanalized by a single pass of SRT or thrombaspiration, it was considered to be a first-pass recanalization.

Clinical outcomes included patients' functional outcomes, mortality, and the occurrence of symptomatic intracerebral hemorrhage. Favorable outcome was defined as a modified Rankin Scale score of 0 to 2 at 3 months after stroke onset. Mortality was also assessed by the modified Rankin Scale score at that time. The occurrence of intracerebral hemorrhage was assessed on follow-up computed tomography or magnetic resonance images obtained 24±6 hours after EVT. Intracerebral hemorrhage was regarded as symptomatic if the patient's NIHSS score increased to ≥4.

Statistical Analysis

Patients were assigned to the non-BGC group or the BGC group based on the use of a BGC during their procedure. Demographics, risk factors for stroke, severity of stroke, endovascular results, and clinical outcomes were compared between the non-BGC and BGC groups. The Mann-Whitney *U* test, χ^2 test, and Fisher's exact test were used for group comparisons. Each multivariable analysis for successful recanalization and favorable outcomes using binary logistic regression was performed. To determine whether the benefits afforded by BGCs were significant regardless of the type of first-line endovascular modality used, the type of first-line endovascular modality as a key variable was entered into the multivariable models in addition to variables with a *P*-value <0.20 in the univariable analyses. Using this process, we evaluated the use of BGCs as an independent factor contributing to successful recanalization or favorable outcomes, irrespective of the type of first-line endovascular modality used.

A *P* value <0.05 was considered statistically significant. All statistical analyses were performed using SPSS software (version 23; IBM, Armonk, NY).

Results

A total of 955 patients (mean age, 67.8±12.0 years; male patients, 53.1%) who met the inclusion criteria were analyzed. Median values for the initial NIHSS score and Alberta Stroke Program Early CT Score were 15.0 (interquartile range, 8.0–23.0) and 8.0 (interquartile range, 7.0–9.0), respectively. SRT was used as the first-line endovascular modality in 526 patients (55.1%), and thrombaspiration was used in 429 (44.9%). BGCs were used in 516 patients (54.0%). The initial NIHSS score was higher in the BGC group, which also had more distal ICA occlusions (Table 1). BGCs were more frequently used in SRT (61.2% versus 45.2%; *P*<0.001).

Successful recanalization was more often achieved in the BGC group (86.8% versus 74.7%; *P*<0.001; Table 2). Furthermore, first-pass recanalization was more frequent (37.0% versus 14.1%; *P*<0.001), and the number of thrombectomy device passes was significantly fewer in the BGC group (overall mean, 2.5±1.9 versus 3.3±2.1; *P*<0.001). The procedural time was shorter in the BGC group (overall mean, 54.3±27.4 versus 67.6±38.2 minutes; *P*<0.001). Intra-arterial thrombolytics, such as urokinase, were more frequently used in the non-BGC group (12.1%) than in the BGC group (3.5%; *P*<0.001) to recanalize far distal branch occlusions that were observed after the initial mechanical recanalization procedure. All these endovascular benefits were significantly observed in the thrombaspiration subgroup and the SRT subgroup (Table I in the online-only Data Supplement). The type of first-line endovascular modality used was not associated with successful recanalization. In multivariable analysis, use of BGC was an independent factor for successful recanalization (odds ratio, 2.18; 95% CI, 1.54–3.10; *P*<0.001) irrespective of the type of first-line endovascular modality used (Table 3).

The use of BGC was also an independent factor for favorable outcome (odds ratio, 1.40; 95% CI, 1.02–1.92; *P*=0.038; Table 4) after adjusting for the type of first-line endovascular modality used and other variables.

Table 1. Comparison of Clinical Variables Between Patients Treated Without and With BGCs

	Non-BGC (n=439)	BGC (n=516)	*P* Value
Age, y	67.6 (±11.7)	67.9 (±12.3)	0.696
Sex, male	237 (54.0)	270 (52.3)	0.649
Hypertension	269 (61.3)	320 (62.0)	0.841
Diabetes mellitus	113 (25.7)	127 (24.6)	0.109
Dyslipidemia	117 (26.7)	147 (28.5)	0.562
Smoking	158 (36.0)	162 (31.4)	0.149
Coronary artery disease	68 (15.5)	84 (16.3)	0.790
Atrial fibrillation	216 (49.2)	288 (55.8)	0.044
Initial NIHSS score	15.0 (8.0; 22.0)	16.0 (8.0; 24.0)	0.001
ASPECTS	8.0 (7.0; 9.0)	8.0 (7.0; 9.0)	0.325
Occlusion of distal ICA	103 (23.5)	167 (32.4)	0.002
Tandem occlusion	45 (10.3)	57 (11.0)	0.753
Carotid angioplasty and stenting	27 (6.2)	29 (5.6)	0.783
Use of intravenous tPA	218 (49.7)	263 (51.0)	0.697
Onset-to-puncture time, min	310 (±132)	310 (±146)	0.949
First-line endovascular modality			<0.001
Stent retriever thrombectomy	204 (46.5)	322 (62.4)	
Thrombaspiration	235 (53.5)	194 (37.6)	

Values in parentheses represent the SD (±), number of patients (%), or first and third quartiles. ASPECTS indicates Alberta Stroke Program Early CT Score; BGC, balloon guide catheters; ICA, internal carotid artery; NIHSS, National Institutes of Health Stroke Scale; and tPA, tissue-type plasminogen activator.

Table 2. Univariable Comparison of Endovascular Treatment Results and Clinical Outcomes Between Patients Treated Without and Those Treated With BGCs

	Non-BGC (n=439)	BGC (n=516)	*P* Value
Endovascular results			
Successful recanalization	328 (74.7)	448 (86.8)	<0.001
First-pass recanalization	62 (14.1)	191 (37.0)	<0.001
Number of endovascular device passes	3.3 (±2.1)	2.5 (±1.9)	<0.001
Use of IA thrombolytics after mechanical procedure	53 (12.1)	18 (3.5)	<0.001
Puncture-to-recanalization time, min	67.6 (±38.2)	54.3 (±27.4)	<0.001
Clinical outcomes			
Favorable outcome*	225 (51.3)	290 (56.2)	0.134
Symptomatic ICH	31 (7.1)	30 (5.8)	0.507
Mortality	48 (10.9)	49 (9.5)	0.519

Values in parentheses represent the SD (±) or number of patients (%). BGC indicates balloon guide catheter; IA, intra-arterial; and ICH, intracerebral hemorrhage.

*Favorable outcome was defined as a modified Rankin Scale score of 0 to 2 at 3 mo after endovascular treatment.

Discussion

In this study, the use of BGCs was associated with successful recanalization, and this benefit was seen independent of the type of first-line endovascular modality used, whether SRT or thrombaspiration. Moreover, the use of BGCs simplified and shortened the recanalization procedure by increasing the proportion of first-pass recanalization, lowering the number of passes required, and reducing the need for adjunctive intra-arterial thrombolytics for distal emboli after mechanical recanalization procedure. Importantly, the use of BGCs was also associated with favorable outcome independently of the type of first-line endovascular modality used.

These kinds of endovascular and clinical benefits have been demonstrated in a few previous clinical studies, in all of

Table 3. Univariable and Multivariable Analyses for Successful Recanalization

	Univariable Analysis			Multivariable Analysis	
	Failed Recanalization (n=179)	Successful Recanalization (n=776)	*P* Value	*P* Value	Odds Ratio (95% CI)
Age, y	67.7 (±15.5)	67.8 (±11.8)	0.936		
Sex, male	83 (46.4)	424 (54.6)	0.047	0.055	1.40 (0.99–1.98)
Hypertension	116 (64.8)	473 (61.0)	0.350		
Diabetes mellitus	50 (27.9)	190 (24.5)	0.340		
Dyslipidemia	48 (26.8)	216 (27.8)	0.894		
Smoking	55 (30.7)	265 (34.1)	0.429		
Coronary artery disease	28 (15.6)	124 (16.0)	0.999		
Atrial fibrillation	86 (48.0)	418 (53.9)	0.184	0.020	1.51 (1.07–2.13)
Initial NIHSS score	15.0 (8.0; 22.0)	15.0 (7.0; 23.0)	0.840		
ASPECTS	8.0 (7.0; 9.0)	8.0 (7.0; 9.0)	0.001	<0.001	1.25 (1.10–1.42)
Occlusion of distal ICA	58 (32.4)	212 (27.3)	0.197	0.083	0.71 (0.48–1.05)
Tandem occlusion	13 (7.3)	89 (11.5)	0.108	0.930	0.97 (0.45–2.09)
Carotid angioplasty and stenting	3 (1.7)	53 (6.8)	0.007	0.021	5.18 (1.18–21.1)
Use of intravenous tPA	81 (45.3)	400 (51.5)	0.136	0.203	1.25 (0.89–1.75)
First-line endovascular modality			0.454		
Stent retriever thrombectomy	94 (52.5)	432 (55.7)		0.500	1.13 (0.80–1.60)
Thrombaspiration	85 (47.5)	344 (44.3)			Reference
Use of balloon guide catheter	68 (38.0)	448 (57.7)	<0.001	<0.001	2.18 (1.54–3.10)

Values in parentheses represent the SD (±), number of patients (%), or first and third quartiles. ASPECTS indicates Alberta Stroke Program Early CT Score; ICA, internal carotid artery; NIHSS, National Institutes of Health Stroke Scale; and tPA, tissue-type plasminogen activator.

Table 4. Univariable and Multivariable Analyses for Favorable Outcome

	Univariable Analysis			Multivariable Analysis	
	Unfavorable Outcome (n=440)	Favorable Outcome (n=515)	*P* Value	*P* Value	Odds Ratio (95% CI)
Age, y	71.0 (±10.6)	64.9 (±12.5)	<0.001	<0.001	0.95 (0.94–0.97)
Sex, male	211 (48.0)	296 (57.5)	0.003	0.505	0.89 (0.62–1.26)
Hypertension	293 (65.6)	296 (57.5)	0.004	0.996	0.98 (0.71–1.36)
Diabetes mellitus	140 (31.8)	100 (19.4)	<0.001	<0.001	0.50 (0.36–0.71)
Dyslipidemia	111 (25.2)	153 (29.7)	0.128	0.432	1.21 (0.83–1.71)
Smoking	127 (28.9)	193 (37.5)	0.006	0.408	1.16 (0.79–1.68)
Coronary artery disease	71 (16.1)	81 (15.7)	0.929		
Atrial fibrillation	241 (54.8)	263 (51.1)	0.269		
Initial NIHSS score	17.0 (10.0; 24.0)	14.0 (7.0; 21.0)	<0.001	<0.001	0.89 (0.86–0.92)
ASPECTS	7.0 (8.0; 9.0)	7.0 (8.0; 9.0)	<0.001	<0.001	1.38 (1.21–1.57)
Onset-to-puncture time, min	310 (±134)	310 (±144)	0.949		
Occlusion of distal ICA	150 (34.1)	120 (23.3)	<0.001	0.083	0.74 (0.53–1.04)
Use of intravenous tPA	207 (47.0)	274 (53.2)	0.060	0.305	1.18 (0.87–1.60)
Tandem occlusion	53 (12.0)	49 (9.5)	0.209		
Carotid angioplasty and stenting	20 (4.5)	36 (7.0)	0.129	0.413	1.33 (0.69–2.59)
Successful recanalization	313 (71.1)	463 (89.9)	<0.001	<0.001	4.19 (2.75–4.40)
First-line endovascular modality			0.171		
Stent retriever thrombectomy	253 (57.5)	273 (53.0)		0.241	0.99 (0.82–1.10)
Thrombaspiration	187 (42.5)	242 (47.0)			Reference
Use of balloon guide catheter	226 (51.4)	290 (56.3)	0.134	0.038	1.40 (1.02–1.92)

Values in parentheses represent the SD (±), number of patients (%), or first and third quartiles. ASPECTS indicates Alberta Stroke Program Early CT Score; ICA, internal carotid artery; NIHSS, National Institutes of Health Stroke Scale; and tPA, tissue-type plasminogen activator.

which SRT was used.[10–13,18] Our study is distinguished from those previous studies by virtue of being the largest study population to date and by incorporating 2 major mechanical modalities, SRT and thrombaspiration.

Considering the mechanism of BGC action, BGCs may play a beneficial role not only in SRT but also in thrombaspiration, which is one of the main mechanical recanalization modalities. Among many strategies for achieving successful recanalization or making procedures more efficient, BGCs are a frequently considered options.[5,6] The most likely mechanism of BGC contributing to the improvement in endovascular results of mechanical recanalization is the prevention of distal embolism formation.[7,12,13] This mechanism has been well demonstrated experimentally. BGC can prevent distal embolisms, which develop during extraction of thrombi by causing antegrade flow arrest or its reversal. Dislodgement of thrombi during extraction might be a common problem both in SRT and thrombaspiration procedures.[19–21] Therefore, the prevention of distal embolism formation during endovascular procedures might be helpful not only in SRT but also in thrombaspiration. In addition, BGC decreases the systemic pressure impacting the clot, which is theoretically likely to increase the efficacy of the devices used during SRT and thrombaspiration procedures.

Based on these observations, we explored the role of BGC in mechanical recanalization in a unique way. First, our population has a balanced composition of 2 mechanical recanalization modalities, SRT and thrombaspiration. Thus, the beneficial effects of BGCs found in our study might be able to be applied to the general mechanical recanalization procedure, instead of being limited to 1 specific mechanical recanalization modality. Second, to determine whether the benefits afforded by BGCs were significant regardless of the type of first-line endovascular modality used, we strategically performed multivariable analyses by adding the type of first-line endovascular modality as a key variable. As a result, the use of BGC was an independent factor for successful recanalization and favorable outcome, even after adjusting the type of first-line endovascular modality used. In other words, the use of BGC could be beneficial in the thrombaspiration arm and in the SRT arm.

Prevention of distal embolism formation through flow arrest or reversal is one of the key mechanisms of BGCs.[7] Less distal embolization might partially explain a wide range of benefits seen with the use of BGCs in our study; for example, by inhibiting inaccessible distal artery occlusion, final reperfusion grade can be improved (more successful recanalization; from mTICI grade 2a to 2b or from 2b to 3) or by making it unnecessary to perform additional recanalization procedures to recanalize newly observed distal artery occlusions (ie, a fewer number of device passes, a higher rate of first-pass recanalization, and shorter procedural times seen in the BGC group). To explore a more direct effect that could be associated with the lower occurrence of distal embolization seen with the use of BGCs, we also assessed the use of adjuvant intra-arterial thrombolytics to resolve distal artery occlusions newly observed after the initial mechanical recanalization procedure. In fact, it is not practically possible to discriminate between the embolization of clots missed in the artery distal to the original occlusion site during extraction of the occluding clot and in situ fragmentation occurring just after the initial extraction of the thrombi. Due to limitation, we propose that the lowered need for adjuvant intra-arterial thrombolytics after the mechanical recanalization procedure might be one of the relevant findings supporting less distal embolism formation with the use of BGCs.

This study had a few limitations associated with its retrospective design. First, one of most serious concerns is the possibility that the recanalization procedures could be different in each participating center. However, mechanical recanalization procedures seemed to not be significantly different across participating centers. The SRT technique was mostly based on common recommendations as described above and was performed with a limited number of different SRs. As for thrombaspiration, all thrombaspiration procedures were performed with manual aspiration using a 50-mL syringe, thus endovascular results might be different according to effects seen with the use of aspiration pumps. However, final successful recanalization rates using SRT and thrombaspiration were not significantly different, even with the manual aspiration used in thrombaspiration. Cautiously, we think that technical heterogeneity might not be an issue in this study population, which had a homogeneous thrombaspiration procedure.

Combination of both endovascular modalities (use of an aspiration catheter in conjunction with a SR) could affect endovascular results. However, such a combination technique was never used as the first-line endovascular modality in this study population. In other words, the combination technique was used only in the failure of the first-line SRT or thrombaspiration. In addition, to change the first-line endovascular modality to the other alternative one or to the combination of them might also affect endovascular results. However, on the analyses performed excluding the patients with switching to the alternative modality or to the combination of them (12.4% of all patients), study results were not significantly changed (Tables II through IV in the online-only Data Supplement). Based on those findings, we did not adjust such a crossover. The first-pass recanalization, which could represent the pure effect of BGC on the first-line endovascular modality, was significantly associated with the use of BGC in the original study population.

The decision to use BGCs in EVT was determined mostly by the internal protocols of each center. However, regardless that their internal protocols did not recommend the use of BGC, operators in some participating centers used a BGC in the case of large clot burden. This might lead to more distal ICA occlusion and higher initial NIHSS score in the BGC group, which might reflect the real-world practice better. Interestingly, despite those unfavorable conditions, the use of BGC was significantly associated with more successful recanalization and favorable outcome, which might be one of indirect findings that support the benefits of BGC. Furthermore, most clinical variables, including stroke risk factors, seemed relatively well balanced between the non-BGC and BGC groups.

Finally, it is possible that operators' proficiency affected the use of BGC and treatment outcomes. Experienced operators might be more likely to choose the use of BGC than inexperienced ones. And endovascular and clinical outcomes might be affected by the proficiency independent of the use of BGC. Although none of the reliable ways to quantify the proficiency seems possible, it might be considered as a confounder.

Conclusions

The use of BGCs in mechanical recanalization procedures was significantly associated with successful recanalization. Furthermore, this benefit was consistent regardless of the type of first-line endovascular modality used, whether SRT or thrombaspiration. The use of BGCs could simplify and shorten EVT procedures by reducing the number of device passes required, increasing first-pass recanalization rates, and lowering the need for adjuvant intra-arterial thrombolytics after the mechanical recanalization procedure. Also, the use of BGCs was significantly associated with favorable outcomes, regardless of the type of first-line endovascular modality used.

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Disclosures

Dr D.J. Kim is a consultant at Stryker Pacific Limited. The other authors report no conflict.

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