

Endovascular Treatment of Acute Vertebrobasilar Artery Occlusion: One Institution's Experience

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Abstract

Background: Acute vertebrobasilar artery occlusion (VBAO) is associated with high mortality and disability. Because of the poor efficacy of intravenous thrombolysis (IVT), greater attention has been directed to endovascular treatment (ET). Some randomized trials have demonstrated the effectiveness and safety of ET for anterior circulation infarction caused by proximal intracerebral artery occlusion. The improvement of these trials was attributed to the wider application of the Solitaire stent retriever. Stent retrievers work by temporarily deploying a stent that captures the thrombus and at the same time instantly restores blood flow. However, very few trials have addressed the effectiveness of ET for vertebrobasilar occlusion.

Methods: Between 2011 and 2015, our study included 14 patients who received ET for ischemic stroke caused by acute VBAO in our department. Clinical, imaging, and angiographic data were collected. Successful reperfusion was defined as Thrombolysis in Cerebral Infarction (TICI) grade $\geq 2b$. The modified Rankin scale (mRS) score was used to measure outcome.

Results: The median patient age, NIHSS score on admission, Glasgow coma score (GCS), and onset-to-treatment interval were 61.5 (range 43–77), 24.0 (range 6–30), 8.5 (range 4–15), and 561.5 min (range 120–1080), respectively. Recanalization was successful (TICI grade $\geq 2b$) in 12 of 14 patients (85.7%). One patient (7.1%) suffered a symptomatic intracerebral hemorrhage. At 3 months, 35.7% (5/14) overall had good and moderate outcome (mRS ≤ 3); 37.5% of patients treated with an SR procedure as the initial ET and 16.7% of patients treated with IAT as the initial ET had good outcome (mRS ≤ 2).

Conclusions: ET for acute VBAO is associated with a high successful recanalization rate. Among ETs, the SR procedure may be superior to IAT at improving clinical outcome. An SR procedure rather than IAT should be the initial modality in patients with acute vertebrobasilar occlusion who undergo endovascular treatment. Careful patient selection may be the key to improving good outcome rate.

Keywords: Acute vertebrobasilar occlusion; Ischemic stroke; Endovascular treatment; Stent retriever

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Introduction

Acute vertebrobasilar artery occlusion (VBAO) is associated with high mortality and disability [1]. The use of intravenous thrombolysis within 3–4.5 h of acute ischemic stroke is still the standard treatment [2]. Because of the narrow therapeutic

window and the poor efficacy of the intravenous thrombolysis (IVT) [3,4], greater attention has been directed to endovascular treatments ETs (including intra-arterial thrombolysis, mechanical thrombectomy, and stent implantation). ET has 2 advantages: firstly, it increases the percentage of candidates for recanalization treatment among patients with ischemic stroke and secondly,

it increases the rate recanalization success [5]. The MR CLEAN, EXTEND-IA, and ESCAPE randomized trials demonstrated that ET is effective and safe in patients with acute ischemic stroke caused by proximal intracerebral occlusion of the anterior circulation [6–8]. However, the evidence of its superiority over IVT in vertebrobasilar occlusion is insufficient.

We retrospectively studied 14 cases of acute VBAO treated with ET in our hospital from 2011 to 2015 and evaluated the efficacy and safety of endovascular treatment for vertebrobasilar occlusion.

Methods

Patients

Candidates for this study were consecutive patients with acute ischemic stroke who received ET for vertebral and/or basilar artery occlusion between 2011 and 2015 in our hospital. The baseline characteristics (**Table 1**) including age, gender, vascular risk factors (hypertension, diabetes mellitus, atherosclerosis, hyperlipidemia, history of tobacco use), and thrombolysis onset-to-treatment time were collected.

Clinical evaluation

The severity of acute ischemic stroke was evaluated by the National Institutes of Health Stroke Scale (NIHSS) and Glasgow Coma Scale (GCS) scores at the time of hospitalization (**Table 1**). The NIHSS scores at discharge were also recorded. Clinical evaluation was performed by neurologists.

Diagnostic workup

Head CTs and/or MRIs were performed to confirm the diagnosis of posterior circulation infarction, and angiography was recommended to locate the occlusion, responsible arteries, collateral flow, and other vascular lesions that may affect patient management.

Cerebral angiography and endovascular treatment

Patients were taken to the intervention neuroradiology suite. Cerebral angiography was performed under general anesthesia. A 6 Fr femoral introducer was placed into the right femoral artery. After access was obtained, heparin (70 μ /kg) was given and a 5F diagnostic catheter was introduced into the left vertebral artery for angiography, then exchanged for a 6F guiding catheter (Neuron; Penumbra, Alameda, CA), permitting the delivery of a microcatheter (ev3, Plymouth, MN, USA) to the location of occlusion or stenosis by the coaxial-catheter technique. The treatment was given via the microcatheter. In the stent retriever procedure, after stent deployment, the deployed stent retriever was pulled back under continuous aspiration with a 50-mL syringe together with the microcatheter into the guiding catheter. Another angiogram was performed to evaluate post treatment flow. The degree of recanalization was assessed using the TICl scoring system (0: no perfusion; 1: penetration but no perfusion; 2a: partial perfusion with incomplete distal filling of <50% of the expected territory; 2b: partial perfusion with incomplete distal filling of 50% to 99% of the expected territory;

3: full perfusion with normal filling of the distal branches in a normal hemodynamic fashion) [9]. All patients received a CT scan to detect bleeding within 24 h.

Blood pressure management

Before ETs, BP should be maintained at or below 185/110 mm Hg. Maintain BP at or below 180/105 mm Hg during reperfusion therapy [2].

Follow up

Patients were followed up by phone interview or return visit. Outcomes were measured by neurologists using the modified Rankin scale (mRS) score (≤ 2 = good outcome; from >2 to ≤ 3 = moderate outcome; from $4 \leq$ to ≤ 6 = poor outcome; >6 = dead) [10] (**Table 1**).

Statistical analysis

Differences in clinical and radiological variables before and after ET were compared between patients with good outcome and patients with poor outcome. Univariate analysis was performed using the Mann–Whitney *U* test or Fisher exact test, where appropriate (**Table 2**). Forward stepwise logistic regression including all variables with $P < 0.1$ after univariate analysis was used to determine the predictors of clinical outcome. Statistical analysis was performed using SPSS 19.0 (IBM SPSS Statistics, Armonk, NY).

Results

The median age, NIHSS score on admission, and GCS score of our 14 patients (12 males, 2 females) were 61.5 (range 43–77), 24.0 (range 6–30), and 8.5 (range 4–15), respectively. In all, 87.5% of our patients had hypertension, 35.7% had diabetes and hyperlipidemia, 92.8% had atherosclerosis, and 57.1% had a history of smoking. The median time from symptom onset to treatment was 561.5 min (range 120–1080). The median procedure time was 132 min (range 70–240). Other demographic and clinical details are shown in **Table 1**.

Before treatment, vessel occlusion was complete (TICl=0) in 13 patients and incomplete (TICl=2a) in one patient (no. 10). The occlusion locations are listed in **Table 1**.

The ET procedure for each patient is shown in **Table 1**. The median number of Solitaire passes and median dose of recombinant tissue plasminogen activator (rt-PA) injected into the thrombus was 3 (range 1–5) and 27.5 mg (range 13–35), respectively.

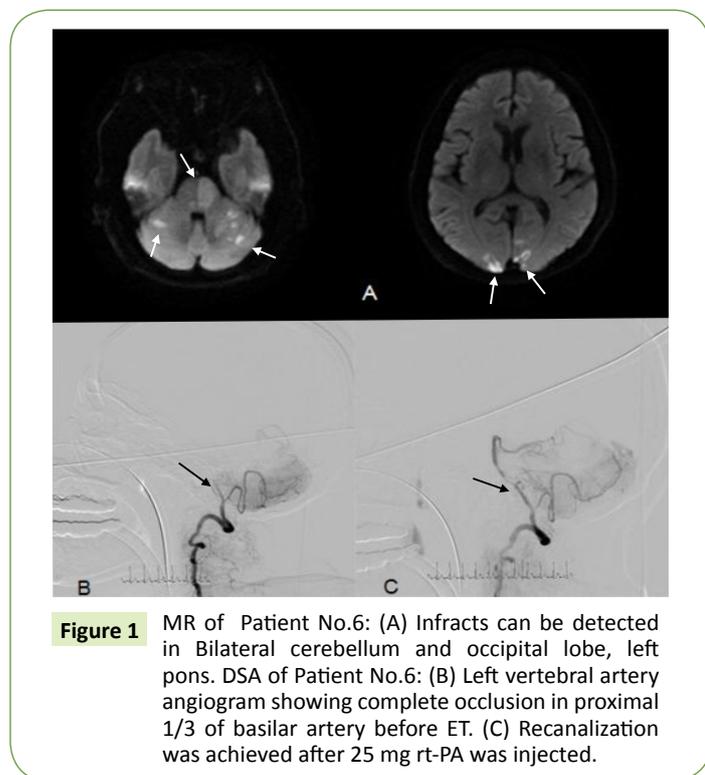
Recanalization (TICl $\geq 2b$) was successful in 12 of our 14 patients (85.7%), with the TICl score of 3 in 7 patients and 2b in 5. The TICl scores after an SR procedure (as the initial modality) in 8 patients were 3 in 5 patients (62.5%) and 2b in 2 patients (25.0%) and, after IAT (as the initial modality) in 6 patients, they were 3 in 2 patients (33.3%) and 2b in 3 patients (50.0%).

No procedure-related complications occurred. Postprocedural hemorrhage was radiologically detected by CT in 3 patients (Nos. 4, 6, and 10). According to the PROACT II criteria [11], postprocedural hemorrhage was asymptomatic in 2 patients (Nos. 4 and 10) and symptomatic in 1 patient (No. 6). Two of

Table 1. Overview of Patient Data and Clinical Outcome.

Case No.	Age/ Gender	Vascular Risk factors	NIHSS Before Treatment	G-CS	IV rt-PA	Onset to ET Time(min)	Side of occlusion	Endovascular treatment	Procedure Time(min)	TICI Pre/ post	HT	NIHSS Discharge	mRS (3 months)
1	77/M	2	30	5	No	530	wBA	IA rt-PA(35mg)	225	0/2b	No	30	6
2	71/F	4	30	5	No	120	dBA	IA rt-PA(18mg)	165	0/3	No	dead	-
3	70/M	3	22	4	No	270	dBA	IA rt-PA(30mg)	210	0/2a	No	-	-
4	47/M	2	24	11	No	810	dBA	IA rt-PA(25mg)	70	0/2b	Yes	19	6
5	49/M	3	6	13	No	330	dLVA to pBA	IA rt-PA(30mg)	190	0/3	No	2	2
6	71/M	2	26	5	No	780	mBA	IA rt-PA(25mg)	210	0/2b	Yes	30	6
7	57/M	2	9	14	No	593	V3-V4 LVA	Solitaire AB→IA rt-PA(30mg)	110	0/3	No	3	2
8	62/M	2	25	7	73.4mg	480	pBA	Solitaire AB→PTA→Winspan Stent	97	0/3	No	17	4
9	43/M	4	27	4	No	660	dLVA,dRVA,wBA	Solitaire AB→IA rt-PA(13mg)	83	0/3	No	20	5
10	51/M	5	10	15	No	960	V3-V4 LVA,V4 RVA	Solitaire AB→PTA→Winspan Stent	92	2a/3	Yes	7	2
11	76/M	5	16	10	No	215	BA	Solitaire AB	75	0/2b	No	3	2
12	76/F	4	30	6	No	660	dRVA,BA	Solitaire AB	114	0/2b	No	dead	-
13	52/M	2	6	14	No	1080	dLVA,dRVA,pBA	Solitaire AB	240	0/0	No	30	6
14	61/M	3	24	12	63mg	480	dLVA,pBA	Solitaire AB	150	0/3	No	15	3

M=Male, F=female, GCS=Glasgow coma score, IV rt-PA=intravenous recombinant tissue plasminogen activator, ET=Endovascular treatment, wBA=whole basilar artery, dBA=distal basilar artery, dLVA=distal left vertebral artery, pBA=proximal basilar artery, dRVA=distal right vertebral artery, IA rt-PA(Dose)=intra-arterial recombinant tissue plasminogen activator, PTA=percutaneous transluminal angioplasty, HT=Hemorrhagic transformation, TICI=Thrombolysis in Cerebral Infarction, mRS=modified Rankin Scale.



these patients with hemorrhage were treated with IAT and one was treated with SR (**Figure 1**).

NIHSS score improvement (mean 5.4 [range 2–14]) occurred in 8

of our 14 patients (57.1%) at discharge. Among these 8 patients, 6 were treated with SR and 2 with IAT. The NIHSS score did not change in 3 patients and deteriorated in 1 patient. Three patients died in the hospital. At 3 months, outcome was good in 28.6% (4/14) of patients and moderate in 35.7% (5/14). Outcome was good in 37.5% of patients treated with an SR procedure as the initial ET and 16.7% of patients treated with IAT as the initial ET. The overall mortality rate was 50.0% (7 of 14) at 3 months.

In univariate analysis, 2 clinical factors were identified as predictors of good or moderate clinical outcome: lower NIHSS score on admission ($p=0.029$) and higher GCS score ($p=0.012$; see Table 2). Because of the small sample size, only clinical outcome variables with a probability value <0.05 in univariate analysis and other variables identified as predictors of outcome in previous studies were entered into multivariate analysis. In multivariate analysis including age, NIHSS on admission, GCS, symptom onset-to-treatment time, and initial treatment, only higher GCS ($OR=12.73$, $p=0.044$) was identified as a predictor of good or moderate clinical outcome.

Discussion

Early recanalization is the primary goal of endovascular treatment and a strong predictor of outcome in endovascular treatment of vertebrobasilar occlusion [10]. In Lindsberg's study and the Basilar Artery International Cooperation Study (BASICS), the rate of recanalization due to IVT was 53% and 67%, respectively [12,13]. Our study demonstrated that ET can achieve recanalization more frequently than IVT in VBAO.

Table 2. Univariate Analysis of Clinical and Imaging Parameters on Outcome in VBAO.

	Total(n=14)	Good or moderate outcome,mRS=0-3(n=5)	Poor outcome,mRS=4-6(n=9)	P
Age	61.6±11.9	58.8±10.7	63.2±12.8	0.518
Gender(male)	12(85.7)	4(100)	8(80.0)	0.604
Initial systolic blood pressure(mm Hg)	163.2±22.9	155.8±18.4	167.3±25.0	0.522
Post operation systolic blood pressure(mm Hg)	142.1±23.0	144.4±23.0	140.9±30.3	0.689
Diabets	5(35.7)	2(40.0)	3(33.3)	0.622
Hyperlipidemia	5(35.7)	3(60.0)	2(22.2)	0.203
History of smoking	8(57.1)	4(80.0)	4(44.4)	0.238
NIHSS on admission	20.4(6-30)	10.0(6-24)	24.4(6-30)	0.029
GCS	9.0(4-15)	12.8(10-15)	6.8(4-11)	0.012
IV t-PA	2(14.3)	1(20.0)	2(22.2)	0.604
Onset to treatment time	564.9±288.5	515.6±287.0	598.9±289.9	0.518
Responsible vessel				0.375
VA	2	2	0	
BA	7	1	6	
VA+BA	5	2	3	
Procedure time	145.1±60.8	123.4±46.5	157.1±66.8	0.364
Initial modality				0.198
IAT	6	1	5	
SR	8	4	4	

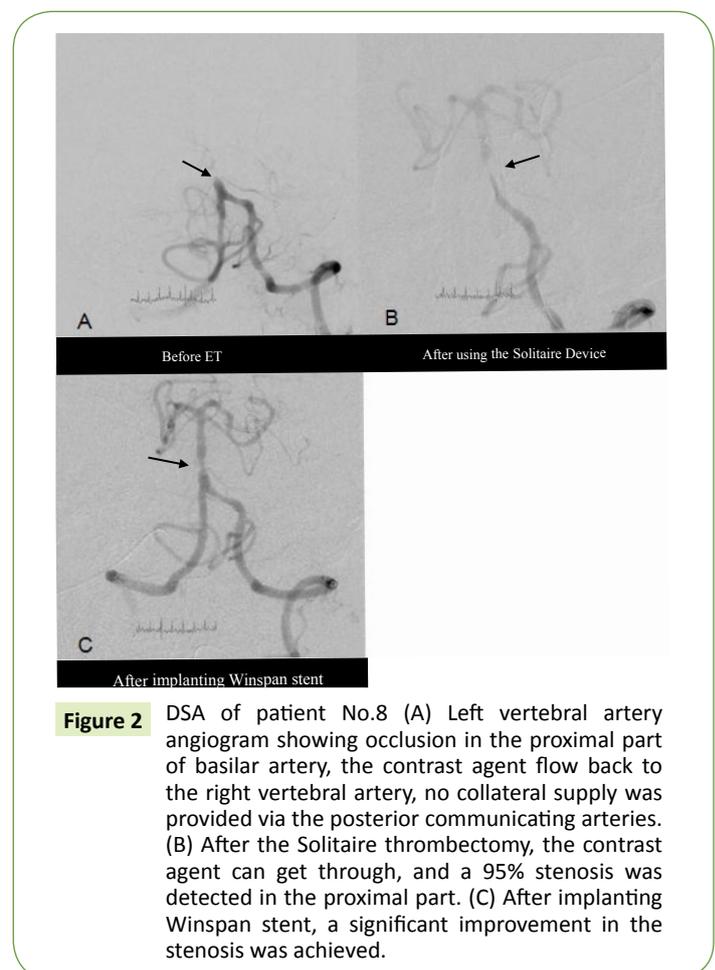
Data are shown as n (%), mean±standard deviation or mean(range), IV t-PA=intravenous recombinant tissue plasminogen activator, GCS= Glasgow coma score, VA=Vertebral artery, BA=Basilar artery, IAT=Intra-arterial thrombolysis, SR=Stent retriever.

Initially, only IAT was used. Gradually, as stent retriever use became more common, IAT was used in conjunction with SR or was replaced by it.

In Lindsberg's systematic analysis and the BASICS study [12,13], the recanalization rates in patients treated with IAT were respectively 65% and 72%, while the good outcome rates were respectively 24% and 17.4%. The results of other clinical studies were not as definitive. The efficacies of IAT and IVT seem to be similar. However, if the patients miss the window of therapeutic opportunity for IVT, IAT and other modalities of endovascular should be considered because of the comparatively wider time window [14].

A stent retriever can provide good flow restoration in its role as a temporary intracranial bypass and remove the thrombus [15]. Stent retrievers such as Solitaire were shown to be superior to the first-generation Merci stent retriever and are widely used nowadays [6]. In trials investigating ETs for proximal intracerebral occlusion of anterior circulation (such as MR CLEAN), most of the patients in the ET group were treated with Solitaire stent retrievers. Comparing these trials with previous trials (such as IMS-III), the improvement in results was attributed to the wider application of the Solitaire stent retriever [6–8]. In recent small sample studies of vertebrobasilar occlusion treated by a SR procedure, the good outcome rate ranged from 28.6% to 50% [15–18]. In line with previous studies, our study demonstrated that the Solitaire stent retriever may improve clinical outcome in patients with acute VBAO.

In the treatment for acute vertebrobasilar occlusion with underlying atherosclerotic stenosis, angioplasty and stent placement are usually performed following thrombolysis or thrombectomy rather than alone [19,20] (**Figure 2**). In the study by Shi et al., 9 patients underwent emergency stent placement



following inadequate recanalization after thrombolysis [19]. The recanalization rate was 88.9% and good outcome rate was 44.4%. In the report by Beheme et al., 6 of 7 patients were treated with

a combination of stent placement and mechanical thrombectomy [21]. Recanalization was achieved in all cases. Outcome at discharge was good in 2 patients and poor in 3 [21]. From the evidence provided by recent studies, we believe that patients with acute vertebrobasilar occlusion based on atherosclerotic stenosis may benefit from angioplasty and stent placement, but stronger evidence from RCTs is still needed.

Factors other than recanalization success can predict the outcome of vertebrobasilar occlusion, such as age, vascular risk factors, NIHSS score on admission, GCS score, the length and location of the occlusion, the symptom-to-treatment time, collateral flow, blood pressure, anesthesia, aspiration via the guide, pretreatment size of infarct [22–29]. In this study, only GCS score could be identified as a predictor of outcome, while other factors identified in previous studies as predictors of outcome (i.e., age, NIHSS score on admission, blood pressure and symptom onset-to-treatment time) did not have great impact on outcome. This reflects a major limitation of our study, which is its small sample size. Though lower GCS was a negative prognosticator in our study, coma should not be a contraindication for ET. In general, most VBAO patients are comatose at the time of treatment [12]. In the BASICS study, the good outcome rate of patients with coma, tetraplegia, or locked-in state on admission was reached in 17% after IAT [13]. Notably, the good outcome rate will be lower if recanalization is not achievable in VBAO patients with severe deficits.

Recent studies have shown disparity between technological improvements in the procedure and ability to select the appropriate patients for the procedure [30]. Recanalization was frequently futile. To decrease the frequency of futile recanalization, patient selection should be emphasized in the future studies. A study on the data from the BASICS demonstrated that the prognosis of patients with acute basilar artery occlusion was poor beyond

9h [31]. Though no window of opportunity for vertebrobasilar recanalization has been established, shorter onset-to-treatment time remains an important inclusion criterion. Multimodal imaging is also important for patient selection in ET for VBAO since the time window is not well established. For example, diffusion weighted image (DWI)- perfusion weighted image (PWI) mismatch can identify the infarct core and ischemic penumbra in the posterior circulation [32]. Recent trials indicated that patients with small infarct core caused by large vessel occlusion can benefit from an SR procedure [8]. Thus, VBAO patients with small infarct core may be candidates for SR procedures.

In our study, 3 patients developed postprocedural intracranial hemorrhage, the main complication of reperfusion therapy [26]. Among them, 1 patient (7.1%) developed symptomatic postprocedural hemorrhage. In line with the results of previous studies [12,13,15–18], our study demonstrated that endovascular treatment is safe in patients with vertebrobasilar occlusion.

This study has limitations. First, the sample size is so small that it is hard to get revealing answers. Second, its retrospective nature led to non-randomized treatment allocation and incompleteness of data, e.g., accurate puncture-to-recanalization time. However, our study contributes evidence of the efficacy of ET for acute VBAO even though this evidence remains insufficient.

In conclusion, the success rate of endovascular treatment for acute vertebrobasilar occlusion was high, and SR (compared to IAT) may have greater efficacy and safety. The current study demonstrated that SR (as an initial modality) is preferable to IAT in patients with acute vertebrobasilar occlusion who undergo endovascular treatment. Recanalization was frequently futile, and careful patient selection may be the key to improve the good outcome rate. Our results need to be confirmed by further studies.

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