Mechanical thrombectomy for vertebral and basilar artery occlusions: An institutional experience with 17 patients

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Abstract. Acute ischemic stroke of the posterior circulation as a result of vertebrobasilar artery occlusions is often associated with severe morbidity and mortality rates. Vertebrobasilar artery occlusion retrieval via mechanical thrombectomy (MT) is a novel treatment modality for occlusive strokes. Nevertheless, factors associated with positive outcomes have not yet been adequately investigated. Thus, the present study focused on factors associated with good prognosis following this type of treatment. The present study retrospectively analyzed a series of 17 patients with acute vertebral artery occlusions (VAOs) and basilar artery occlusions (BAOs) treated with MT. In all patients, information such as sex and age, time from admission to the onset of femoral artery access, the number of thrombi removed, the time of femoral artery access to recanalization, pre- and post-operative National Institutes of Health Stroke Scale (NIHSS) scores, pre- and post-operative thrombolysis in cerebral infarction, as well as modified Rankin scale scores were documented and analyzed. The analysis comprised of 11 patients with BAOs and 6 patients with VAOs. A recanalization rate of 70.6% was achieved with an overall good functional outcome of 58.8% at 90 days. Observationally, there was a notable improvement in outcomes when comparing the NIHSS prior to surgery with NIHSS at 1 week after the surgery. A lower NIHSS score prior to MT may be a good prognostic factor. An average time of ~5.5 h from patient admittance to recanalization with a 70.6% recanalization rate with an overall good functional outcome of 58.8% at 90 days suggested that, patients for whom the surgeries were performed within 5 h of admittance may still have hope for recanalization compared to an initial 1.5-h average time for recanalization.

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Abbreviations: AIS, acute ischemic stroke; BA, basilar artery; BAO, basilar artery occlusion; CT, computer tomography; CTA, computer tomographic angiography; LVO, large vessel occlusion; mRS, modified Rankin scale; MT, mechanical thrombectomy; NIHSS, National Institutes of Health Stroke Scale; t-PA, tissue plasminogen activator; TICI, thrombolysis in cerebral infarction; VBAO, vertebrobasilar artery occlusion; VA, vertebral artery; VAO, vertebral artery occlusion

Key words: basilar artery, occlusion, recanalization, prognosis, thrombectomy, vertebral artery

Introduction

Acute ischemic stroke (AIS) is one of the primary triggers of disability, as well as mortality worldwide with a substantial burden on health systems and families (1-3). AIS of the posterior circulation as a result of vertebrobasilar artery occlusions (VBAOs) constitutes 10-20% of all large vessel occlusions (LVOs) with a mortality rate of almost 90% and most frequently affecting the basilar artery (BA) (4-8). The posterior circulation mainly provides blood supply to the main parts of the brain, such as the brainstem, thalamus and cerebellum (9).

Intravenous tissue plasminogen activator (t-PA) administered within 4.5 h of the stroke is currently the recommend treatment for patients with thrombolytic ischemic strokes (10,11). Of note, mechanical thrombectomy (MT) for the treatment of acute thrombolytic ischemic stroke has exhibited favorable outcomes in both anterior and posterior LVOs (5,12-17). Almost all studies involving acute VBAO have focused primarily on prognostic factors, such as the severity of neurologic deficits, the time of onset to treatment, the location of the occlusion, the state of collaterals, treatment or management options, as well as timely reperfusion (18-21).

Prognosis is often poor with a high mortality rate when early reperfusion is not achieved in patients with basilar artery occlusion (BAO) (19,22). Thus, MT for patients with BAO has been shown to be associated with good clinical outcomes with a wide range of functional attainments (13,22). Although a few studies have demonstrated that flow reversal, as well as the patency of the vertebral arteries (VAs) may also affect the recanalization success, only a few studies have reported MT in vertebral artery occlusions (VAOs) (5,7,23,24). Factors associated with a good outcome have not yet been adequately investigated. Thus, the present study focused on factors associated with a good prognosis following MT.

Specifically, the precise association between reperfusion and outcome has not yet been fully established in patients with BAO and VAO. Thus, the present study describes the authors' institutional experience on MT for VAOs, as well as BAOs.

Patients and methods

Patients. The present study retrospectively analyzed a series of 17 patients with acute VAOs and BAOs treated using MT at the Department of Neurosurgery, Jiangyin Hospital (Jiangyin, China) from January, 2017 to December, 2020. The study was approved by the Research Committee of Jiangyin Hospital. Patients, as well as relatives were made aware of the intention to include them in a study during follow-up visits at the outpatient department. Written informed consents, as well as consents for publication were obtained from all the patients and the hospital. In all patients, information such as sex and age, time from admission to the onset of femoral artery access, the number of thrombi removed, the time of femoral artery access to recanalization, pre- and post-operative National Institutes of Health Stroke Scale (NIHSS) scores, pre- and post-operative thrombolysis in cerebral infarction (TICI) scores, as well as modified Rankin scale (mRS) scores were documented and analyzed. All patient information obtained is presented in Table I.

Indications and contraindications. The indications for MT included the following: i) The clinical diagnosis was in line with AIS of the posterior circulation, the patients were hospitalized within 24 h of onset, and the presence of neurological deficits related to posterior circulation ischemia, such as dizziness, gaze disturbance, visual field defect, visual impairment, coma, etc.; ii) a cerebrovascular evaluation with computer tomographic angiography (CTA) revealed that the BA and/or VA was occluded, and a head computer tomography (CT) scan ruled out intracranial hemorrhage; iii) the patient's family agreed to an informed consent and signed the surgical consent form.

The contraindications for MT were the following: i) A head CT scan indicated the presence of intracranial hemorrhage or large-area cerebral infarction in the posterior circulation (>2/3 of the pons or midbrain volume or cerebellar hemisphere infarction); ii) a history of active bleeding or a tendency to hemorrhage; iii) severe disability, mRS score >2 points; iv) severe renal insufficiency; v) the patient had a clear history of allergies to contrast agents.

Pre-operative evaluation. After the patient was admitted to hospital, a neurologist completed a physical examination, a neurological functional assessmen.t as well as NIHSS scoring in the emergency room. The emergency physician also performed a head CT scan to rule out intracranial hemorrhage, as well as a head and neck CTA to identify BAO (Fig. 1A and B) and/or VAO. In addition, pre-operative magnetic resonance images (MRIs) were performed in all patients to detect brainstem infarction. In all patients, the pre-operative CTA revealed the presence of large vessel occlusion, such as the BAO or VAO. The time from admission to the onset of femoral artery puncture/accesses was documented prior to the commencement of endovascular surgeries.

Anatomical divisions of the vertebrobasilar artery. The VA is characteristically divided into four segments, namely V1-V4 (25,26) as follows: V1, also denoted as the pre-foraminal segment (starts from the subclavian artery to the transverse foramen of C6); V2, also denoted as the foraminal segment (starts from the transverse foramen of C6 to the transverse foramen of C2); V3, also denoted as the atlantic, extradural or extraspinal segment (starts from C2, where the artery loops, turns lateral and upwards into the transverse foramen and progresses via C1 to penetrate the dura; V4, also denoted as the intradural or intracranial segment (starts from the dura at the lateral border of the posterior atlanto-occipital membrane to their convergence on the medulla to constitute the BA) (25,26).

Endovascular procedures. All procures were performed under general anesthesia. The entire surgical procedures were carried out strictly as previously described by Luo *et al* (8). After securing the femoral artery access, a 6F/8F guide catheters were maneuvered into the BA or the VAs via the subclavian arteries and initial angiographies performed to determine the locations of the occlusions (Fig. 1C). Using a coaxial system, 0.21-inch microcatheters (Rebar microcatheter; Covidien; Medtronic) and 0.014-inch microguide wires (Transend; Stryker) were advanced into the thrombi as far as the distal ends of the occluded vessels. Angiographies were then performed to confirm that the distal vasculars were patent and no pathology was found in the lumen.

In all patients, Solitaire ABs or FRs (EV3 Neurovascular) were utilized for the MT. The solitaire devices were carefully maneuvered to the occluded segments via microcatheters and the stent retrievers were unsheathed to allow for complete expansion through the thrombi. The devices often created bypasses that restored blood flow across the occluded segments. Again, angiography was performed to determine the patency of the distal arteries, after which the fully deployed the solitaire devices were resheathed. Thrombectomies were performed via the withdrawal of the solitaire devices and the delivery microcatheters as a single unit. In the case that the angiography revealed that the occluded arteries were patent (Fig. 1D), and blood flow rates were basically normal (TICI 2b and above), the procedures were then completed.

In the case that the angiography still revealed stenosis of the BA or VA and the anterior blood flow did not meet a TICI score of 2b, balloon angioplasty (GatewayTM, Boston Scientific Corporation) was then first performed. In the case that the angiography still revealed no patency, the stent placements were performed to ensure that the flow rates met the TICI score of ≥2b. In all patients who underwent the MTs, the number of thrombi removed were documented. In addition, the time from femoral artery puncture/access to the recanalization of the occluded arteries was documented.

Post procedure management, efficacy evaluation and follow-up. Heparin infusion was used during and immediately after the surgery. Intravenous tirofiban used during the surgery was also maintained after the surgery. Aspirin (300 mg) and clopidogrel (300 mg) were administered via the rectal route

Table I. Clinical data of the 17 patients with acute ischemic stroke in the posterior circulation who underwent emergency stent mechanical thrombectomy.

Patient no.	Sex	Age (years)	Location of lesion	NTR	DNT (Min)	TAR- (Min)	mTICI score		NIHSS score		mRS (90 days)
							Pre-op	Post-op	Pre-op	Post-op (1 week)	
1	M	46	Basilar artery	4	43	135	0	2b	10	6	2
2	M	65	Left vertebral artery (V1)	5	57	310	0	3	10	2	1
3	M	60	Left vertebral artery (V2)	4	47	340	0	1	25	-	6
4	M	54	Basilar artery	5	58	300	0	2a	17	-	6
5	M	56	Left vertebral artery (V1)	3	42	100	0	1	12	-	6
6	F	75	Basilar artery	2	97	100	0	3	25	8	3
7	F	74	Basilar artery	3	52	245	0	2a	20	-	6
8	M	64	Basilar artery	4	115	170	0	3	20	10	3
9	M	64	Left Vertebral Artery (V4)	2	31	180	0	3	16	3	2
10	M	75	Basilar artery	3	29	156	0	3	26	6	2
11	F	74	Basilar artery	3	51	188	0	3	19	3	1
12	M	47	Left vertebral artery (V1)	1	29	65	0	3	4	2	1
13	M	70	Basilar artery	3	361	135	0	3	16	2	1
14	M	57	Basilar artery	4	61	285	0	2a	17	10	4
15	M	54	Basilar artery	2	81	105	0	3	9	1	0
16	M	34	Right Vertebral artery (V1)	3	21	120	0	3	15	4	1
17	F	52	Basilar artery	2	43	91	0	3	12	3	1

DNT, time from admission to the onset of femoral artery access (puncture); NTR, number of thrombi removed; TAR, time of femoral artery access (puncture) to recanalization; NIHSS, National Institutes of Health Stroke Scale; mRS, modified Rankin scale; mTICI, modified thrombolysis in cerebral ischemia; min, minutes; pre-op, pre-operative; post-op, post-operative.

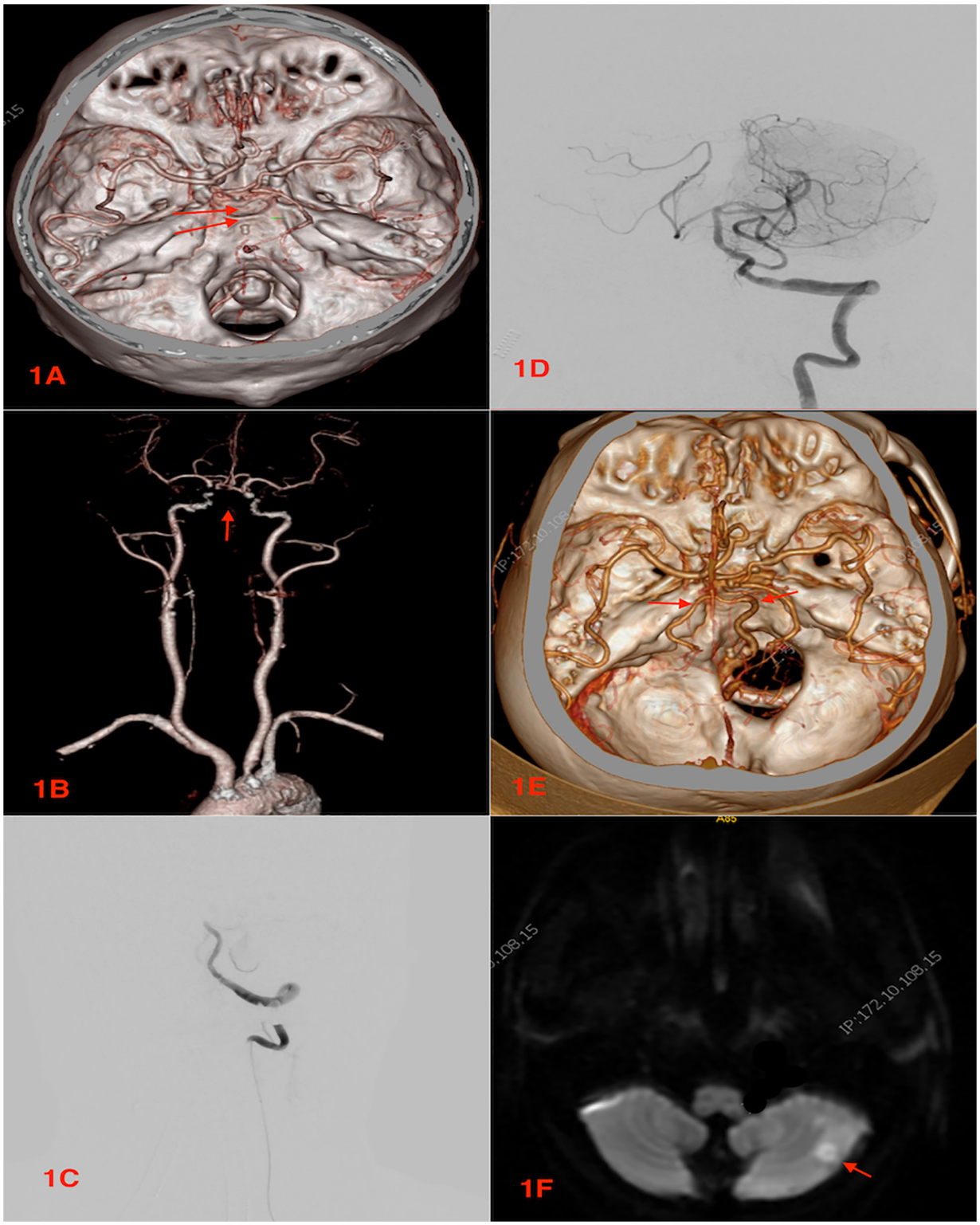

Figure 1. Images of one of the patients in the present study who underwent mechanical thrombectomy for basilar artery occlusion. (A-F) Pre-, intra- and post-operative images of the patient. (A and B) Pre-operative CTA images now showing no basilar artery. Red arrow indicates no basilar artery. (C) Intraoperative digital distraction angiography showing the acute occlusion of the basilar artery. (D) Intraoperative digital distraction angiography following thrombectomy showing the recanalization of the basilar artery. (E) Post-operative CTA showing the recanalized basilar artery. Red arrows indicate the basilar artery. (F) Post-operative magnetic resonance imaging showing an acute infarct in the cerebellar hemisphere. Red arrow indicates the infarction. CTA, computer tomographic angiography.

immediately after the surgery. All the patients were admitted to the intensive care unit (ICU) for monitoring and treatment, and transferred to the general ward after their conditions were stable. In all patients, immediate post-operative CT scans were performed to rule bleeding 24 h after the surgery. CTAs were also performed to confirm recanalization (Fig. 1E). In addition, post-operative MRIs were performed to assess infarctions following the procedure (Fig. 1F).

Furthermore, in all patients, the TICI grade was scored as follows (22,27): 0, no recanalization (no perfusion or anterograde flow beyond the occlusion site); 1, minimal recanalization (contrast medium passes the area of occlusion but fails to opacify the entire cerebral bed distal to the obstruction during the angiographic run); 2, partial recanalization (2a, partial filling, <50% of territory visualized; 2b, partial filling, ≥50% of territory visualized); and 3, complete recanalization (total reperfusion with normal filling). At the ICU, the NIHSS scores of all the patients were assessed 7 days after the surgery.

mRS was also used to evaluate the prognosis of the patients up to 90 days after the surgery. The mRS scores were assessed as follows (22,28): 0, no symptoms; 1, no clinically relevant disability; 2, slight disability (able to look after own affairs without aid but not to a full extent); 3, moderate disability (requires some aid but able to walk unaided); 4, moderately severe disability (unable to attend to own bodily needs or to walk without aid); 5, severe disability (requires constant nursing care); and 6, deceased.

Results

Demographic and preoperative evaluations. A total of 17 patients were included in the present analysis. Among these, 13 patients were males while 4 were females. Their ages ranged from 34-75 years, with an average age of 60 years. The time from the onset of admission to the femoral artery puncture/access was 3.0-8.0 h, with an average time of 5.5 h. The basic clinical information of the 17 patients is presented in Table I. In all the patients, pre-operative MRIs did not reveal brainstem infarction subsequent to their surgeries.

Anatomical distribution of lesions. Out of the 17 patients, 11 patients had BAOs while 6 patients had VAOs (Table II). In addition, out of the 6 patients with VAOs, five occlusions were observed on the left side, while one occlusion was observed on the right side. Furthermore, out of the out of the 6 patients with VAOs, four occlusions were observed at the V1 segment of the VA, one at the V2 segment and one at the V4 segment. Thus, in the present study, there were more patients with BAOs than VAOs. More patients also had V1 occlusions compared to V2 and V4 occlusions. No patient had a V3 segment occlusion.

Operative outcomes. After 1-7 times of MT with Solitaire AB, 70.6% (12/17) of the patients achieved complete recanalization (TICI 2b or 3); 17.4% (3/17) achieved partial recanalization (TICI 2a), while 11.7% (2/17) of the patients achieved minimal recanalization (TICI 1). Out of the 11 patients with BAOs, 72.7% (8/11) achieved a successful recanalization (TICI 2b or 3), while out of the 6 patients with VAOs, 66.7% (4/6) achieved a successful recanalization (mTICI 2b or 3). No notable differences in recanalization (TICI 2b or 3) were observed between the patients with BAO and VAOs (Table II). The average time from femoral artery puncture/access to recanalization was 172 min. No notable differences were observed between the time from femoral artery puncture/access to recanalization and prognosis. This may be due to the small sample size of the study. All the 12 patients who achieved successful recanalization of the arteries (TICI 2b or 3) survived after their surgery. Out of the 3 patients who achieved partial recanalization (TICI 2a), 1 patient had severe stenosis of the BA with acute occlusion and balloon dilation at the stenotic portion resulted in rupture and bleeding of the BA and subsequently in mortality after the surgery.

Table II. Stratification of patients as per the type of artery occluded, recanalization rate and the functional outcomes of patients.

Artery occluded	No. of patients	mTICI score		mRS score at 90 days		
		1-2a	2b or 3	0-2	3-5	6
BA	11	3	8	6	3	2
VA	6	2	4	4	-	2
Total	17	5	12	10	3	4

BA, basilar artery; VA, vertebral artery; mTICI, modified thrombolysis in cerebral ischemia; mRS, modified Rankin scale.

The other 2 patients had larger areas of cerebral infarctions after the surgery, and decompressive craniostomies were performed to allow for brain expansion, as well as brain hernias and 1 patient succumbed. The 2 patients with TICI 2a who succumbed had occlusions in the BA. The 2 patients who achieved minimal recanalization (TICI 1) succumbed immediately after their surgeries. These 2 patients had occlusions in the V1 and V2 segments of the VA. All the deceased patients succumbed immediately after the surgeries (<24 h). The average number of thrombi removed was three. In addition, the average time from femoral artery puncture/access to recanalization was 178 min. Thus, an average time of ~5.5 h from patient admittance to recanalization with a 70.6% recanalization rate with an overall good functional outcome of 58.8% at 90 days suggests that, patients whose surgeries were performed within 5 h of admittance still have hope for recanalization compared to an initial 1.5 h average time for recanalization.

Efficacy evaluation and follow-up outcomes. The average NIHSS score prior to surgery was 15.3, while the average NIHSS score at 1 week after the surgery was 4.5. Observationally, there was a marked improvement in patient outcomes when comparing the NIHSS before surgery to the NIHSS at 1 week after the surgery. The prognoses of the patients were assessed at 90 days post-surgery using the mRS. A good prognosis was defined as a mRS score ≤2 (Table II). It was observed that (Table I) 41.17% (7/17) of the patients had mRS scores of 0 and 1 (good prognosis). In addition, 29.41% (5/17) of the patients had mRS scores of 2 and 3 (mild to moderate disability). Furthermore, 5.8% (1/17) of the patients had mRS scores of 4 and 5 (severely disability), and 23.53% (4/17) of the patients had a mRS score of 6 (deceased).

Out of the 11 patients with BAOs, 54.5% (6/11) achieved a good functional outcome (mRS 0-2), while out of the 6 patients with VAOs, 66.7% (4/6) achieved a good functional outcome (mRS 0-2). The overall good functional outcome in the patients was 58.8% (10/17) as per the mRS score range of 0-2 (Table II).

In addition, a mortality rate of 23.53% was observed and the causes of death were as a result of intraoperative procedural complications. At 2 years of follow-up, the patients with favorable outcomes revealed no further neurological deficits and massive improvements in their quality of life. No patients were lost during follow-up.

Discussion

The effectiveness of MT in posterior circulation stroke is still confronted with uncertainty, notwithstanding the successful outcomes in large vessel anterior circulation stroke (6,12,15,16,18,29). Overall, out of the 17 patients in the present study, BAOs were observed in 64.7% (11/17) of the patients, while in 35.3% (6/17) of the patients had VAOs. Furthermore, 70.6% of the patients achieved recanalization (TICI 2b-3), with 41.17, 29.41 and 29.41% of the patients attaining a good prognosis, mild to moderate disability and severely disability, respectively as per the mRS scores. The overall good functional outcome of the patients was 58.8% (10/17) as per the mRS score range of 0-2. The patients were predominantly males with a mean age of 60 years.

Sonig *et al* (30) reported a series of 12 BAOs treated with retrievable MT and achieved a successful recanalization (TICI 2b or 3) of 91.7% (11/12) in their patients with a median mRS scores 2 at discharge and 1 at last follow-up. In addition, Kang *et al* (31) demonstrated a successful reperfusion of 90.3% in patients with acute BAOs who underwent MT with retrievable stents and achieved a favorable functional outcome of 46.9% (mRS 0-2) of their patients. Furthermore, Gory *et al* (22) attained 72.2% effective recanalization (TICI 2b or 3) or reperfusion in their patients with a favorable functional outcome of 34% (mRS 0-2) and a 2-5% risk of hemorrhage. Baik *et al* (18) achieved an overall successful reperfusion rate of 78% with a favorable clinical outcome of 37% in their patients.

In the present study, out of the 11 patients with BAOs, 72.7% (8/11) achieved a successful recanalization (TICI 2b or 3) with a good functional out of 54.5% (6/11) as per the mRS score range of 0-2. In addition, out of the 6 patients with VAOs, 66.7% (4/6) achieved a successful recanalization (TICI 2b or 3) with a functional out of 66.7% (4/6) as per the mRS score range of 0-2. None of the patients presented with bilateral VAOs or tandem VA-BA occlusions. Tandem VA-BA occlusions although rare, have been reported in 16-20% of patients with acute VBAOs (6,18,32).

The initial symptomatology of the patients with neurological deficits related to posterior circulation ischemia, was dizziness, gaze disturbance, visual field defect, visual impairment or coma. A CT scan and CTA were the initial radiological modalities use in assessing the patient at the emergency after clinical assessments. A CT scan was used to rule out intracranial hemorrhage, while CTA was used to detect the BA and VA occlusions. Nevertheless, magnetic resonance diffusion weighted image is often the 'gold standard' radiological modality for the detection of ischemic changes in patients with LVO in the posterior circulation (5,33). Intraoperatively, angiographies are utilized to confirm occlusions, as well as to assess the patency of distal arteries.

The NIHSS is a beneficial and realistic means of assessing stroke severity in patients (5,34). It is devised to evaluate stroke symptoms associated with the anterior circulation with more emphasis on the limb, as well as speech impairments and less focus on cranial nerve symptomatology (5,35). Nevertheless, patients with LVO in the posterior circulation can have an NIHSS score of 0, with symptoms such as headaches, vertigo, as well as nausea only in the prodromal period. Furthermore, the baseline NIHSS score signifies a clinical evaluation of the collateral state, as well as thrombus severity (5,19). Thus, a low NIHSS score upon admission may be due small thrombi or good collaterals leading to positive outcomes following MT (5). Gory *et al* (36) observed that patients who present with a high NIHSS score had a poorer prognosis compared to patients with mild-to-moderate deficits at the time of treatment, notwithstanding recanalization and thus, they proposed an NIHSS cut-off value of 13. The present study revealed that the average NIHSS score prior to surgery was 15.3, while the average NIHSS score at 1 week after the surgery was 4.5. Thus, observationally, there was a notable improvement in outcomes when comparing the NIHSS before surgery to the NIHSS at 1 week after surgery. These findings are therefore consistent with those of the previous studies mentioned above.

Solitaire thrombectomy for AIS treatment is instinctively practical, very auspicious, and is already used in several institutions (37-39). Miteff *et al* (37) revealed that Solitaire thrombectomy attained a high rate of recanalization which translated into the good prognosis of patients with acute stroke caused by proximal occlusion within the cerebral arteries. Using Solitaire AB, Luo *et al* (8) achieved an overall recanalization rate of 89.9%, and 36.2% of their patients achieved a favorable outcome at 90 days. Furthermore, other studies have demonstrated that, on average, ~81% of patients often attain a recanalization rate of ~30%, attaining favorable outcomes at 90 days (13,37,40). The present study used Solitaire AB or FR to treat 17 patients with BAOs and VAOs and attained a 70.6% recanalization rate with an overall good functional outcome of 58.8% at 90 days; these finding are comparable to those of the aforementioned previous studies. The average number of thrombi removed in the present case series was three.

Luo *et al* (8) indicated that the collateral status prior to MT, as well as the baseline NIHSS score were independent predictors of mortality at 90 days in patients with acute posterior circulation stroke who underwent Solitaire AB thrombectomy. Studies have demonstrated that the reperfusion time is one of the key predictors of a good prognosis of patients with anterior circulation, as well as posterior circulation stroke (5,12-14,41). Nevertheless, other studies have not found any link between the reperfusion time and good prognosis of patients with posterior circulation strokes (5,19,42,43). Baik *et al* (18) observed a poor outcome despite the good recanalization rate, which may have been due to the longer procedural time.

Baik *et al* (18) observed a mortality rate of 21%. Luo *et al* (8) observed a mortality rate of 24.6% at 90 days. Similar studies observed mortality rates ranging from 21-33% at 90 days (5,22,30,31). The present study observed a mortality rate of 23.53% and the causes of death were intraoperative procedural complications. The present study anticipated a better prognosis and less or no mortality in patients with VAOs, as there are two VAs and the patent one can compensate

the occluded one, as compare to BAOs. Comparatively, MT often results in higher recanalization rates than t-PA therapy; however, better outcomes with MT are not always exhibited (12,18,44). The present study had certain limitations as this was a retrospective study with small case series, which did not allow for satisfactory conclusions, as a detailed statistical analysis could not be performed for the majority of variables; thus, statistical analyses were not performed. In addition, the study was conducted in a single hospital. Thus, further prospective studies with larger sample sizes and several hospitals are warranted to arrive at satisfactory conclusions.

In conclusion, the present study observed a notable improvement in patient outcomes comparing the NIHSS before surgery to the NIHSS at 1 week after surgery. Thus, a lower NIHSS score prior to MT may be a good prognostic factor. Herein, recanalization rate of 70.6% with an overall good functional outcome of 58.8% at 90 days was attained, which is comparable to that of previous studies (as those aforementioned). An average time of ~5.5 h from patient admittance to recanalization with a 70.6% recanalization rate and an overall good functional outcome of 58.8% at 90 days suggests that, patients whose surgeries are performed within 5 h of admittance, still have hope of recanalization compared to the initial 1.5 h average time for recanalization.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Authors' contributions

XY, YF, JJ, ZX, WM and SAR were involved in the conception and design of the study, in data acquisition and follow-up, and in the editing of the manuscript. SAR was involved in the preparation of the manuscript. All authors have carefully reviewed the manuscript and have read and approved the final version. XY and WM confirm the authenticity of all the raw data.

Ethics approval and consent to participate

The present study was approved by the Ethics Committee of Jiangyin Hospital [Approval no. 2016ER (058)] and written informed consent was obtained from all participants. All methods were performed in accordance with the relevant guidelines and regulations.

Patient consent for publication

Written informed consents as well as consents for publication were obtained from all the patients and the hospital.

Competing interests

All authors declare that they have no competing interests.

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