Rescue Strategies in Anterior Circulation Stroke with Failed Mechanical Thrombectomy—A Retrospective Observational Study (RAFT)

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Abstract

Context: Recanalization failure rate in mechanical thrombectomy (MT) for large vessel occlusions is up to 30%. Outcome greatly depends on recanalization success and, thus, there is an urgent need to adopt new strategies to improve recanalization. Aims: To report on the feasibility, safety, and outcome of rescue strategies (stenting and/or angioplasty) in cases of failed MT for acute ischemic stroke (AIS) in anterior circulation. Materials and Methods: It was a retrospective observational study where patients undergoing MT were divided into two groups. The first group (MT-only) was of patients who had undergone only MT with the standard tools (stentriever and/or aspiration). The second group (MT-plus) consisted of patients who underwent a rescue procedure after failure of the standard MT. The two groups were compared based on the demographics, risk factors, stroke severity, and the extent of infarct on imaging. The angiographic findings, procedural details, periprocedural care, and angiographic and clinical outcome were also compared. Results: Out of 181 cases, 142 were in MT-only while 39 were included in MT-plus group. The two groups had comparable baseline stroke severity, extent of infarct on imaging and door to puncture time. The MT-plus patients had significantly longer time of onset and puncture to recanalization time. The clinical outcome was favorable in both groups with 57.7% and 59% patients achieving mRS 0–2 in MT-only and MT-plus groups, respectively. Successful recanalization was achieved in 80.3% and 89.7% in MT-only and MT-plus groups, respectively. There was no significant increase in symptomatic intracranial hemorrhage and mortality after rescue procedures. Conclusions: Rescue stenting and/or angioplasty after failed MT is a safe and effective recanalization method for AIS in anterior circulation without increasing mortality or morbidity.

Keywords: Acute ischemic stroke, angioplasty, carotid stenosis, intracranial atherosclerosis

INTRODUCTION

The evidence of benefit of mechanical thrombectomy (MT) in acute ischemic stroke (AIS) due to large vessel occlusion (LVO) is indisputable. The number needed to treat (NNT) to reduce disability by at least one level on modified Rankin scale (mRS) being 2.6 and NNT to achieve functional independence at 90 days being 5. [1] Based on this initial success, MT has also shown benefits even in the extended time window [2,3] and for the extended tissue window for selected patients. [4] Amongst the various factors affecting MT outcomes, one of the strongest predictor of good functional outcome is the degree of revascularization of the occluded arterial tree. [5,6] Despite the use of currently available MT tools in various combinations, failure rate of MT to achieve successful recanalization (modified thrombolysis in cerebral ischemia [mTICI] 2b-3) is about 30%. [7] Numerous factors lead to MT failure; intracranial atherosclerotic disease (ICAD), fibrin rich or calcific emboli and vessel dissection to name a few. [8] This calls for the development of rescue strategies for the improvement of recanalization rates in the MT failure cases. For acute myocardial infarction, primary percutaneous transluminal coronary angioplasty has been widely performed and recommended with favorable outcomes (level IA evidence). [9] Even before the advent of the MT trials, many preliminary studies assessing the efficacy of primary stent placement in the setting of proximal occlusive stroke have showed positive outcomes. [10–12] There have been many retrospective observational studies on rescue/bailout angioplasty and/or stenting for failed MT. [8,13–16] We chose to share our experience of bailout procedures for AIS due to anterior circulation LVO in a tertiary care center from southern India.

MATERIALS AND METHODS

Study Design

This was a retrospective observational study done on the data obtained from the prospectively maintained institutional
stroke registry. The study was approved by the institutional ethics committee.

**Patients**

Patients who had undergone endovascular intervention for anterior circulation AIS between October 2010 and January 2020 were enrolled from this database. Patients with posterior circulation stroke, incomplete details, or the ones lost to follow-up were excluded. Patients were divided into two groups. The first group (MT-only) consisted of those who underwent MT-only (using stentriever or aspiration in any combination). The second group (MT-plus) consisted of patients who had undergone a bailout/rescue procedure in the form of angioplasty and/or stenting in addition to the standard MT with either stent retrievers or aspiration catheters or both. Data from these were analyzed for various parameters like the demographic and clinical features like risk factors, severity of weakness as per the National Institute of Health Stroke Scale (NIHSS), and the extent of infarct on imaging [quantified using the Alberta stroke program Early CT score (ASPECTS)]. The angiographic findings, procedural details like door to recanalization time, number of passes, periprocedural care, and angiographic and clinical outcome were analyzed.

**Procedure**

The standard procedure for MT was followed for all patients. Initial passes were attempted using retrievable stents or aspiration catheters or a combination of both as a routine. The number of passes and the decision to switch over to a rescue procedure in case of a failed MT was left to the operator’s judgment. The balloon angioplasty was performed as the first rescue measure. If it failed to recanalize or if after initial recanalization the vessel recocluded, a stent was deployed. An appropriate stent was selected depending on the target vessel and lesion morphology. For intracranial stenting, a balloon-mounted drug eluting stent (coronary stent) was used and for an extracranial vessel, a self-expandable stent was used. After stenting, to patients who were not taking dual antiplatelets prior to stroke, injection tirofiban was given as a bolus based on weight followed by infusion for at least 12 h. 300 mg of aspirin and 300 mg of clopidogrel was loaded immediately orally followed by an oral maintenance dose. Computed tomography of brain was done 12–24 h after the procedure to assess the extent of reperfusion injury if any.

**Outcomes**

The radiological outcome was scored using the mTICI scale with successful recanalization defined as mTICI score of 2b or 3. The functional outcome was graded using the mRS score at three-month follow-up. Favorable clinical outcome was defined as an mRS score ≤2 at three months. Safety outcomes like mortality (during hospital stay or three-month follow-up), and symptomatic intracerebral hemorrhage (SICH), procedural complication like vessel perforation, and technical failure were also noted.

**Statistical analysis**

Baseline and periprocedural characteristics were compared between the “MT-plus” and “MT-only” groups using the Student’s t-test (normal distribution) or Mann–Whitney test (skewed distribution) for continuous variables and the Chi-squared test for categorical variables. Data was analyzed by Statistical Product and Service Solutions 22.0 (SPSS 22.0, IBM Corporation, Armonk, NY, USA).

**Result**

A total of 232 patients underwent MT during the study period. Out of which, 193 were in anterior circulation and 39 were in posterior circulation. Of the 193 cases, 12 cases (11 from MT-only group and 1 from MT-plus group) were excluded due to loss of follow-up or incomplete details. Out of 181 cases, 142 underwent MT while 39 required a rescue procedure in addition to MT (MT-plus). Majority of patients were male in both the groups with patients in MT-plus being significantly older (mean age of MT-only—48.9 ± 16.1 versus MT-plus—57 ± 12.7; P value—0.002) [Table 1]. There was statistically more number of patients with hypertension

| Table 1: Demographics and risk factors |
|---------------------------------------|
| MT-only (142) | MT-plus (39) | P |
| Demographic Variables | | |
| Age (mean±standard deviation) | 48.9±16.1 | 57±12.7 | 0.002 |
| Gender (n, %) | | |
| Male | 96 (67.6) | 32 (82.1) | 0.079 |
| Female | 46 (32.4) | 7 (17.9) | |
| Associated conditions/risk factors | | |
| Hypertension (n, %) | | |
| Yes | 32 (22.5) | 23 (59) | < 0.001 |
| No | 110 (77.5) | 16 (41) | |
| Diabetes (n, %) | | |
| Yes | 30 (21.1) | 23 (59) | < 0.001 |
| No | 112 (78.9) | 16 (41) | |
| Ischemic heart disease (n, %) | | |
| Yes | 33 (23.2) | 15 (38.5) | 0.056 |
| No | 109 (76.8) | 24 (61.5) | |
| Atrial fibrillation (n, %) | | |
| Yes | 8 (5.6) | 0 | 0.204 |
| No | 134 (94.4) | 39 (100) | |
| Rheumatic heart disease (n, %) | | |
| Yes | 39 (27.5) | 3 (7.7) | 0.010 |
| No | 103 (72.5) | 36 (92.3) | |
| Intracranial atherosclerosis (n, %) | | |
| Yes | 20 (14.1) | 17 (43.6) | < 0.001 |
| No | 122 (85.9) | 22 (56.4) | |
| Kidney disease (n, %) | | |
| Yes | 2 (1.4) | 1 (2.6) | 0.519 |
| No | 140 (98.6) | 38 (97.4) | |
| Dyslipidemia (n, %) | | |
| Yes | 16 (11.3) | 7 (17.9) | 0.282 |
| No | 126 (88.7) | 32 (82.1) | |
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Annals of Indian Academy of Neurology ¦ Volume 24 ¦ Issue 6 ¦ November-December 2021

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(\(P\) value < 0.001), diabetes (\(P\) value <0.001), coronary artery disease (\(P\) value—0.056), and ICAD (\(P\) value < 0.001) in MT-plus group and more number of patients with rheumatic heart disease (\(P\) value < 0.01) in MT-only group [Table 1]. As far as the baseline parameters [Table 2], there was no significant difference in the stroke severity as per the median NIHSS at presentation (\(P\) value—0.72) and ASPECTS score on imaging (\(P\) value—0.09) and door to puncture time (\(P\) value—0.218). The MT-plus patients had significantly longer time of onset (\(P\) value—0.019) and puncture to recanalization time (\(P\) value < 0.01). There was no difference on the primary outcome at the end of three months [Table 3] as per the mRS with 57.7% and 59% patients achieving mRS 0–2 in MT-only and MT-plus groups, respectively (\(P\) value—1.0). Similarly, successful recanalization (mTICI 2b-3) was achieved in 80.3% and 89.7% in MT-only and MT-plus groups, respectively, without any significant difference (\(P\) value—0.237). The rate of complications including SICH (\(P\) value—0.50) and large infarcts requiring decompression (\(P\) value—0.60) between the two groups were similar [Table 3]. There was no difference in the mortality (\(P\) value—0.48) both immediate and within three months between the two groups.

Of the 39 patients in the MT-plus group, 16 underwent angioplasty only and 23 underwent stenting. Twelve patients

### Table 2: Preprocedure and procedural parameters

|                        | MT-only (142) | MT-plus (39) | \(P\)  |
|------------------------|---------------|--------------|-------|
| **Preprocedure parameters** |               |              |       |
| Initial NIHSS* (\(n, %\)) |               |              |       |
| Minor                  | 0             | 0            | 0.728 |
| Moderate               | 53 (38.1)     | 17 (43.6)    |       |
| Moderate to severe     | 57 (40.1)     | 16 (41)      |       |
| Severe                 | 31 (21.8)     | 6 (15.4)     |       |
| ASPECTS†(\(n, %\))    |               |              |       |
| < 6                    | 9 (6.3)       | 6 (15.4)     | 0.096 |
| \(\geqslant 6\)        | 133 (93.7)    | 33 (84.6)    |       |
| Time from onset Median [IQR‡] | 120 [160]    | 240 [360]    | 0.019 |
| Door to puncture time median [IQR] | 60 [45]     | 75 [70]      | 0.218 |
| Puncture to recanalization time median [IQR] | 45 [35]     | 80 [40]      | <0.001 |
| Bridging intravenous thrombolysis | 29 (20.4) | 9 (23.1) | 0.824 |
| **Vessels occluded** |               |              |       |
| Only ICA§ Occlusion (\(n, %\)) | 27 (19)      | 17 (43.6)    | 0.002 |
| ICA+ACA/| MCA¶ (\(n, %\)) | 16 (11.3) | 8 (20.5) | 0.179 |
| Only MCA (\(n, %\)) | 99 (69.7)     | 14 (35.9)    | <0.001 |
| **Procedural details** |               |              |       |
| Stentriever (\(n, %\)) | 77 (54.2)     | 22 (56.4)    | 0.857 |
| Yes                    | 65 (45.8)     | 17 (43.6)    |       |
| No                     |               |              |       |
| Aspiration (\(n, %\)) |               |              |       |
| Yes                    | 11 (7.7)      | 6 (15.4)     | 0.210 |
| No                     | 131 (92.3)    | 33 (84.6)    |       |
| Combination (Stentriever+Aspiration) (\(n, %\)) | 43 (30.3) | 4 (10.3) | 0.013 |
| Yes                    | 99 (69.7)     | 35 (89.7)    |       |
| No                     |               |              |       |
| Additional intra-arterial fibrinolysis (\(n, %\)) | 15 (10.6) | 3 (7.7) | 0.767 |
| Yes                    | 127 (89.4)    | 36 (92.3)    |       |
| No                     |               |              |       |
| Direct angioplasty or stenting (\(n, %\)) | 0             | 6 (15.4) | < 0.001 |
| Yes                    | 142 (100)     | 33 (84.6)    |       |
| No                     |               |              |       |

*National Institute of Health Stroke Scale, †Alberta Stroke Program Early CT score, ‡Interquartile range, §Internal carotid, ¶anterior cerebral artery, ¤middle cerebral artery
underwent stenting of the intracranial vessels and eleven underwent stenting of the extra cranial ICA [Table 4].

**Case**

Mr. AS, 54-year-old male without previous history of comorbid illness presented with left-sided weakness with slurred speech after waking up. He presented to the hospital after nine and half hours (570 min from onset). He had intermittent episodes of numbness of left upper limb since 2 days, which he passed off. On arrival, his NIHSS was 14/42. He underwent an MR perfusion imaging, which was analyzed by the rapid processing of perfusion and diffusion (RAPID) software (IschemaView, Menlo Park, CA, USA). It showed watershed and basal ganglia infarcts [Figure 1a and b] with tapering occlusion of right middle cerebral artery [Figure 1c and d] and a large area of diffusion/perfusion mismatch [Figure 1e]. The pre-procedure digital subtraction angiogram [Figure 2a] showed right MCA occlusion. He underwent MT with contact aspiration [Figure 2b and c] in the first pass followed by stentriever [Figure 2d and e]. After the second pass, there was a severe stenosis of middle segment of middle cerebral artery that got occluded during serial angiographic runs [Figure 2f]. Hence, a rescue procedure was done where in first there was balloon angioplasty [Figure 3a] of the middle cerebral artery followed by a drug-eluting balloon-mounted stent placement Figure 3b). Poststenting mTICI 3 flow was achieved [Figure 3c]. There was no increase in the size of infarct or any hemorrhage on the follow-up CT scan of the brain [Figure 3d and e]. Patient had an excellent recovery with 24 h NIHSS being 6. After 90 days, he achieved an mRS score of 0.

**DISCUSSION**

Our study shows that rescue strategies like balloon angioplasty

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**Table 3: Details of Outcome and complications**

| MT Only (142) | MT Plus (39) | P |
|---------------|--------------|---|
| **Radiological Outcome** | | |
| mTICI* Post (n, %) | | |
| Unsuccessful Recanalization | 28 (19.7) | 4 (10.3) | 0.237 |
| Successful Recanalization | 114 (80.3) | 35 (89.7) | |
| **Clinical Outcome** | | |
| 3 Month Outcome (n, %) | | |
| Good Outcome | 82 (57.7) | 23 (59) | 1.000 |
| Poor Outcome | 60 (42.3) | 16 (41) | |
| Death (n, %) | | |
| Yes | 25 (17.6) | 9 (23.1) | 0.488 |
| No | 117 (82.4) | 30 (76.9) | |
| **Complications** | | |
| SICH† (n, %) | | |
| Yes | 10 (7) | 4 (10.3) | 0.505 |
| No | 132 (93) | 35 (89.7) | |
| Decompression (n, %) | | |
| Yes | 20 (14.1) | 4 (10.3) | 0.607 |
| No | 122 (85.9) | 35 (89.7) | |

*modified thrombolysis in cerebral ischemia, †symptomatic intracranial hemorrhage

**Table 4: Details of the Stents used for rescue procedure**

| Stent name | Number |
|------------|--------|
| Extra cranial carotid stents | |
| XACT® carotid stent system | 8 |
| Protégé® Rx carotid stent system | 1 |
| C Guard™ EPS | 2 |
| Intracranial Stents | |
| Stent retrievers (detached) | 2 |
| Balloon mounted drug eluting stents (Coronary) | 9 |
| Leo stent | 1 |
and/or stenting are feasible and effective recanalization methods for failed MT, without increasing SICH, morbidity, and mortality when compared with the cases where MT is successful. Even though the MT-plus patients had a comparative disadvantage of having a longer time of onset and significant delay in the recanalization time as compared to MT-only group, there was no difference in the outcome. These findings once again highlight that successful recanalization is one of the most important predictors of better outcome regardless of the method. For tandem occlusions, the results of the thrombectomy in TANdem occlusions collaboration showed that emergent carotid stenting with antithrombotic agents and intracranial thrombectomy showed better recanalization and good outcome compared to other strategies. Pretreatment intravenous thrombolysis or periprocedural use of unfractionated heparin was not associated with increased risk of hemorrhagic complications.\[17\] Similar findings were also noted in other observational studies.\[18,19\]

The SAMMPRIS and VISSIT trials that provide the best available evidence of endovascular treatment for ICAD, found no benefit of elective endovascular stenting for ICAD stenosis compared with best medical treatment as secondary stroke prevention.\[20,21\] The major concern raised was regarding increased incidence of intracranial hemorrhage. However, for treatment of acute strokes with intracranial occlusions, several studies from pre-MT period and observational studies after the advent of MT have supported primary stenting as a safe and effective method.\[10–12,22\]

The preliminary evidence after the advent of MT, in favor of rescue stenting came from the South Korean study where they found that permanent stenting may be a rescue modality for stentriever-failed anterior circulation LVO.\[13\] Similarly, Chang et al. showed that rescue stenting was independently associated with good outcomes. The most dreaded complication when stenting in the setting of AIS is the associated bleeding risk when using antiplatelet therapy. This study also showed that concomitant use of antiplatelets does not increase symptomatic intracranial hemorrhage or mortality.\[16\] Yang et al. in their multicenter retrospective study from China showed that for patient with atherosclerotic LVO in anterior circulation, primary angioplasty treatment showed favorable independent outcome at 90 days and lower rate of asymptomatic intracranial hemorrhage.\[14\]

In 2019, a meta-analysis of eight studies across America, Europe, and Asia showed that rescue stent procedure seemed reasonable as a last resort following failed thrombectomy.\[8\] There is an ongoing international randomized control trial. The results from this trial may help to clarify the role of stenting as a bail out procedure for AIS in anterior circulation.

The reasons for MT failure are varied and many times it is often not possible to clearly classify the underlying pathology. ICAD seems to be one of the most prevalent causes for unsuccessful MT especially in Asian population. However, the same can be caused by residual adherent or calcified thrombi or dissections that may also be associated with failed MT.\[13\] Since there are no criteria to distinguish between these causes, the decision to switch over to an alternative method may be delayed thereby increasing the puncture to recanalization time.

In our observation, presence of warning symptoms in the form of TIAs or strokes in the same vascular territory prior to the bigger stroke may be an indicator of an underlying stenosis. Similarly, a tapering occlusion of the vessel rather than an abrupt cutoff or an mTICI 2b-3 flow with the stentriever in the vessel and no flow after it is retrieved may also point to an underlying ICAD and help the interventionist to make a decision for an early switch over to a rescue strategy.
As a rescue measure, angioplasty and/or stenting appears to be a safe and efficacious option for failed MT procedures in the anterior circulation as a last resort. Further randomized studies are needed to overcome the limitations of the retrospective and observational evidence to conclusively recommend these strategies in the guidelines. Till then, the decision to use bail out procedure has to be individualized.

Acknowledgements
We thank Ms Delitia Manuel for her help with the statistical analyses.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

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