Mechanical Thrombectomy of an Embolic Middle Cerebral Artery/M1 Occlusion: First-Pass Effect in Acute Large Vessel Occlusion

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Abstract

Complete or near-complete reperfusion of large vessel occlusion (LVO) is the goal of thrombectomy. Reperfusion of LVO in only one pass (first-pass reperfusion, FPR) is associated with a better clinical outcome, called first-pass effect (FPE), and it can be considered the goal of the endovascular treatment of LVO, when achievable.

We describe a representative case of FPE in a 77-year-old female patient with a cardioembolic acute occlusion of right MCA/M1, with atrial fibrillation that suspended anticoagulation before a scheduled surgery. After one-pass thrombectomy with a stent retriever and distal aspiration, reperfusion was achieved. First-pass reperfusion, with complete regression of neurological deficit and a good clinical outcome (FPE), is the topic of this chapter.

Keywords

Middle cerebral artery · First-pass effect · Reperfusion · Stent retriever · Large vessel occlusion · Thrombectomy

Abbreviations

ACA	Anterior cerebral artery
ASPECTS	Alberta Stroke Program Early CT Score
BGC	Balloon guide catheter
CT	Computed tomography
FPE	First-pass effect
FPR	First-pass reperfusion
ICA	Internal carotid artery
IV	Intravenous
LVO	Large vessel occlusion
MCA	Middle cerebral artery
mRS	Modified Rankin Scale
NIHSS	National Institute of Health Stroke Scale
p.m.	*Post meridiem*
PA	Posterior-anterior
PCA	Posterior cerebral artery
PO	Per os
TICI	Thrombolysis in Cerebral Infarction

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Patient

A 77-year-old woman with a history of atrial fibrillation and therefore anticoagulated with apixaban, biological aortic and mitral valve prosthesis, and moderate kidney insufficiency presented to another hospital with sudden left-hand hemiparesis. The neurological examination showed in addition hemihypoesthesia, gaze deviation to the right and left hemianopia. The NIHSS score was 20. The onset time was 4:45 p.m. She had suspended the apixaban intake before a planned dental surgery to avoid bleeding issues. The patient had a previous stroke during a heart surgery years ago with complete neurological recovery. Her condition according to the modified Rankin Scale (mRS) before this present stroke was rated 0.

Diagnostic Imaging

Admission non-contrast computed tomography (CT), 44 min after stroke onset, revealed a dense MCA sign and subtle loss of differentiation of the head of the caudate nucleus and putamen, consistent with ASPECTS 8. A chronic postischemic lesion existed in the right temporal lobe. CT angiography showed occlusion of the right MCA in the M1 segment (Fig. 1).

The patient was transferred to our hospital for endovascular therapy. Arrival at our center was 2 h after stroke onset.

Diagnostic angiography of the right common carotid artery confirmed the occlusion of the right MCA with good leptomeningeal collaterals from the right ACA and PCA (Fig. 2).

Treatment Strategy

This patient presented with a typical right MCA syndrome due to an acute cardioembolic occlusion of the right MCA/M1 segment. IV thrombolysis was not indicated because of previous oral anticoagulation. The management strategy consisted of urgent angiographic evaluation and endovascular revascularization of the right MCA. The endovascular treatment consisted of mechanical thrombectomy with stent retriever under manual distal aspiration with a standardized technique. We do not use balloon guide catheters (BGC) for the treatment of MCA occlusions.

Treatment

Procedure, 24.09.2020: urgent endovascular revascularization of a right-hand MCA/M1 occlusion with a combination of mechanical thrombectomy and aspiration

Anesthesia: general endotracheal anesthesia; 1× 500 mg ASA (Aspirin i.v. 500 mg, Bayer Vital) IV at the end of the procedure

Access: right femoral artery, 8F Radifocus Introducer II 10 cm (Terumo); *guide catheter:* 8F Guider Softip (Stryker); *diagnostic catheter:* 5F Optitorque S2 125 cm (Terumo); *aspiration catheter:* SOFIA Plus 6F 125 cm (MicroVention); *microcatheter:* Trevo Pro 18 MC (Stryker); *stent retriever:* pRESET 5/40 mm (phenox); *microguidewire:* pORTAL 0.014″ 200 cm (phenox)

Course of treatment: the endovascular procedure started 2 h 45 min after the stroke onset with a diagnostic angiography to confirm vessel occlusion and assess the collateral status as well as other possible occlusions or stenoses; an 8F sheath, 8F guiding catheter, and a 5F S2 diagnostic catheter from the aortic arch were used. After the diagnostic angiography, the 8F guiding catheter was advanced into the cervical segment of the ICA over a 0.035″ guidewire; the distal access catheter (DAC) for aspiration and the 0.021″ inner diameter microcatheter and a 0.014″ microguidewire were also coaxially advanced into the petrous ICA. Then a catheterization of the occluded right MCA was performed, with a passage through the M1 occlusion, further distally to the M2 segment (the angular gyrus artery of the MCA) with the microguidewire and the microcatheter, followed by the deployment of a stent retriever (pRESET 5/40 mm, phenox) at the level

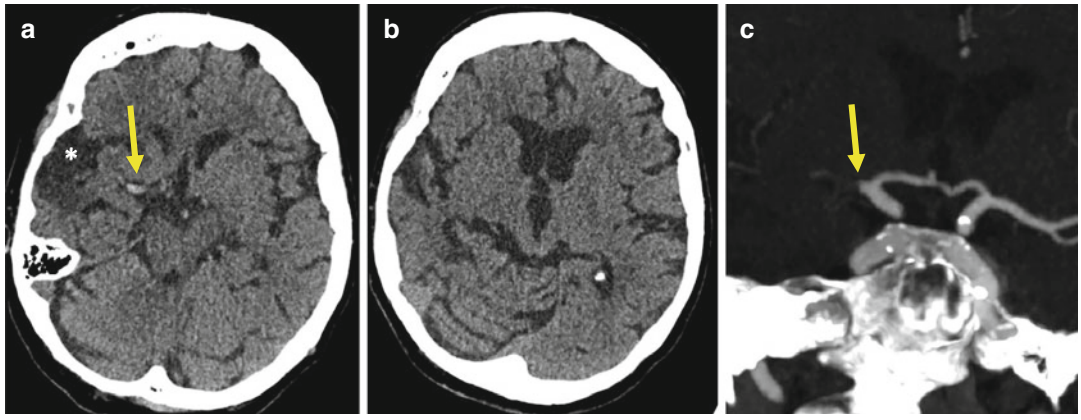

Fig. 1 Diagnostic imaging of a patient with acute MCA/M1 occlusion. Non-contrast CT, axial view, main trunk MCA level (**a**) and basal ganglia level (**b**) showing a dense MCA (arrow, **a**) and loss of grey-white matter differentiation of the right head of the caudate nucleus and putamen and a chronic ischemic lesion in the right-hand temporal lobe (asterisk, **a**). A CT angiography reconstruction at the ICA bifurcation level (coronal view (**c**)) showing the cut-off of the right MCA in the M1 segment (arrow, **c**)

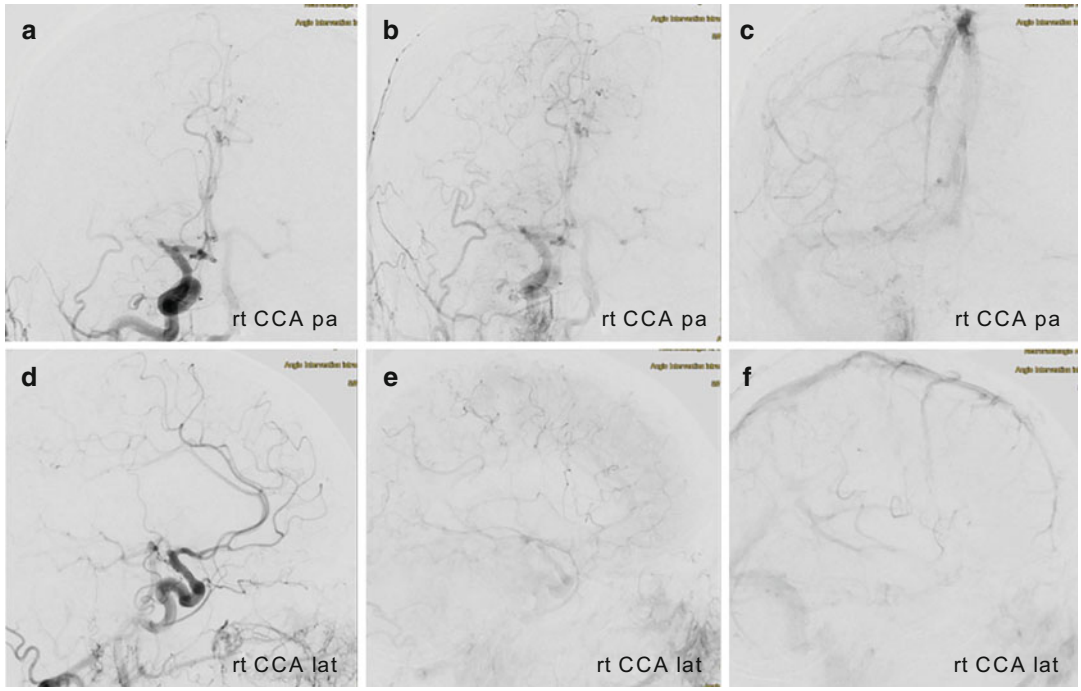

Fig. 2 Diagnostic angiography in a patient with acute right MCA syndrome. Selective angiogram of the right common carotid artery with PA view (**a**, **b**, **c**) and lateral view (**d**, **e**, **f**) from early arterial (**a**, **d**), parenchymatous (**b**, **e**), and venous phase (**c**, **f**) demonstrating the leptomeningeal collaterals from the ACA supplying in the retrograde direction the territory of the occluded MCA vessel

of thrombus. After an incubation period of 3 min, the microcatheter was advanced from a position of the microcatheter tip 5 mm proximal to 5 mm distal to the proximal marker of the pRESET ("pinching") to close the proximal ring of the stent retriever partly. The pRESET was slowly

withdrawn for thrombectomy under proximal aspiration with a 6F SOFIA Plus (MicroVention). A VacLok AT Vacuum Pressure Syringe (Merit Medical) was connected to the SOFIA Plus catheter and aspirated continuously during the thrombectomy maneuver. The SOFIA Plus catheter was advanced while the pRESET stent retriever was pulled back. After the withdrawal of the stent retriever, the SOFIA Plus catheter was left in the M1 segment under continuous aspiration for 20 s and was then pulled back to the petrous ICA. Gentle contrast medium injection confirmed the recanalization and reperfusion of the right MCA and its supply territory 3 h 27 min after the stroke onset (Fig. 3). The thrombus was captured in the stent retriever (Fig. 4).

Duration: 1st–4th DSA run: 40 min; fluoroscopy time: 33 min

Complications: none

Postmedication: 1× 500 mg ASA IV after the procedure, 1× 100 mg ASA PO daily for 6 days; 2× 5 mg apixaban (Eliquis, Bristol-Myers Squibb) PO daily was started on day 6 after the stroke

Clinical Outcome

Immediately after the endovascular procedure, the patient was extubated. Cranial CT obtained the next day showed acute ischemic lesions of the right caudate nucleus and putamen and the chronic ischemic lesion of the right temporal lobe (Fig. 5a). The follow-up magnetic resonance imaging (MRI) after 4 days (Fig. 5b) showed no hemorrhagic transformation of the acute ischemic changes with an unchanged ASPECTS of 8. Cardioembolic origin as etiology was confirmed. The patient was discharged home on day 4 post-stroke without a neurological deficit (NIHSS 0, mRS 0).

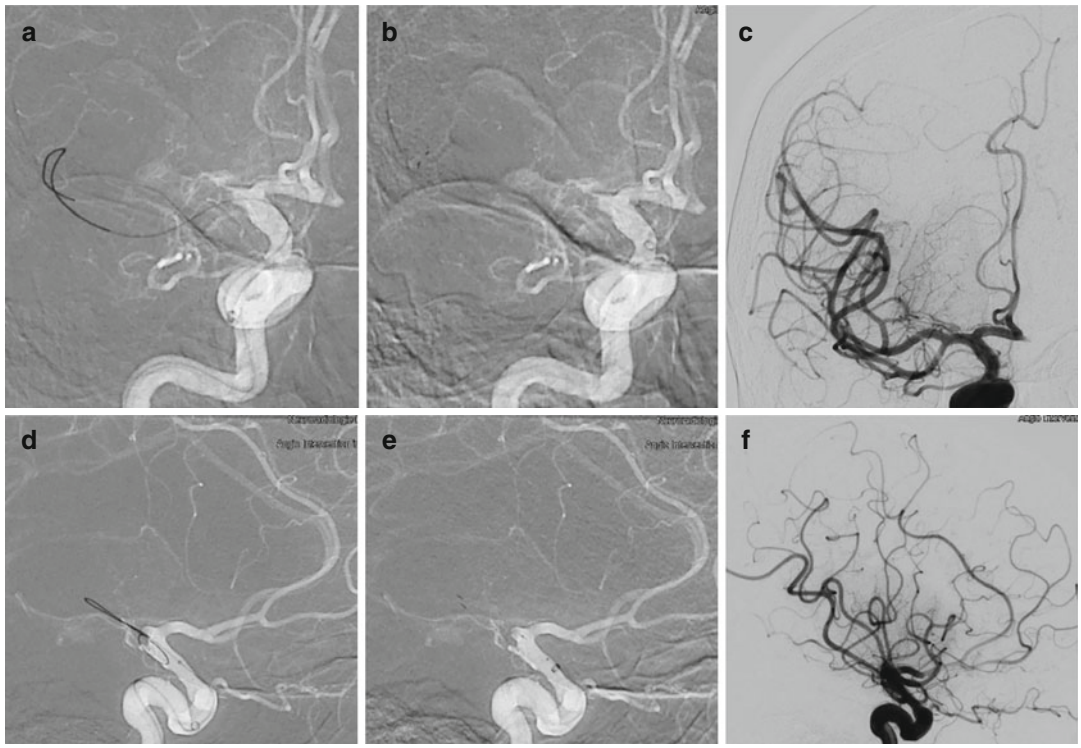

Fig. 3 Mechanical thrombectomy for an acute right MCA occlusion. Road map images of the M1 occlusion and catheterization with the microwire (**a**, **d**), followed by the deployment of a pRESET 5/40 stent retriever into the right-hand M1- and M2 segment (**b**, **e**). The angiogram obtained after the first pass of a pRESET 5/40 stent retriever (**c**, **f**) shows complete recanalization of M1 occlusion and reperfusion of the entire right-hand MCA territory

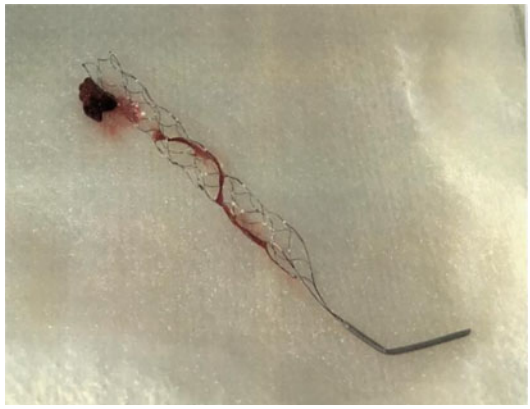

Fig. 4 Thrombus intermingled with the pRESET 5/40 stent retriever

Follow-Up Examination

At the 30- and 90-day neurological evaluation, the patient showed no neurological deficit (NIHSS 0, mRS 0). The patient was maintained under anticoagulation with apixaban.

Discussion

We presented a patient with an acute cardioembolic M1 occlusion, treated with mechanical thrombectomy (mTE) that achieved complete reperfusion in only one pass and associated an excellent clinical outcome, representing first-pass reperfusion and a first-pass effect.

The goal of thrombectomy in acute ischemic stroke is to achieve reperfusion as early as possible to maximize the probability of an excellent functional clinical outcome (Powers et al. 2019). Although sufficient reperfusion, measured after endovascular treatment as a TICI score $\geq$ 2b in the angiography, was the initial goal, a near-complete reperfusion TICI 2c or complete reperfusion (TICI 3) are associated with better clinical outcomes (Goyal et al. 2019; Liebeskind et al. 2019).

Achieving complete reperfusion with a single thrombectomy device pass is defined as first-pass reperfusion (FPR), and it is associated with significantly higher rates of good clinical outcome (Zaidat et al. 2018; Nikoubashman et al. 2019; Bai et al. 2021a), representing the first-pass effect (FPE). FPE is also associated with lower use of healthcare resources and lower estimated costs (Zaidat et al. 2020), and therefore it should be pursued as the new goal of the endovascular treatment of LVO with thrombectomy devices. A FP reperfusion (FPR) does not guarantee an excellent clinical outcome, as the clinical outcome depends on several factors (e.g., basal ASPECTS, time to reperfusion, patient's age, and previous functional status of patients) (Mohammaden et al. 2021; Serna Candel et al. 2021). As the term was first described by Zaidat et al. (2018), FPE was defined as near-complete or complete reperfusion, including TICI 2c and TICI 3. Also, a modified FPE (mFPE) was described by a successful reperfusion $\geq$TICI 2b after the first-pass (Zaidat et al. 2018). Other authors have considered FPE only with a complete reperfusion TICI 3 (Nikoubashman et al. 2019). The term was also described as an efficacy measure for new devices for LVO recanalization (Zaidat et al. 2018).

The frequency of FPR varies amongst studies between 19% and 69.2% (Bai et al. 2021b; Serna Candel et al. 2021), probably due to differences in applied techniques, patient characteristics, or LVO location. Location of the occlusion determines the frequency of FPR, being ICA occlusion is a location influencing the possibility of achieving FPR (Bai et al. 2021b) negatively. For M1 occlusions, FPR has ranged between 22% and 69% (Serna Candel et al. 2021).

Thrombectomy with stent retriever under aspiration has shown higher (Brehm et al. 2019) or similar FPR rates (Ducroux et al. 2020) than direct aspiration.

Independent predictors of FPE in the literature were: use of balloon guide catheter (BGC), better collateral grade (Jadhav et al. 2019; Srivatsa et al. 2020; Serna Candel et al. 2021), site of occlusion with ICA-terminus occlusion as less predictor, and M1 occlusion as more predictor of FPE (Zaidat et al. 2018; Jadhav et al. 2019; Di Maria et al. 2021), older age, female gender, lower systolic blood pressure, presence of atrial fibrillation, a higher DWI-ASPECTS at admission, local anesthesia, and combined first-line device strategy

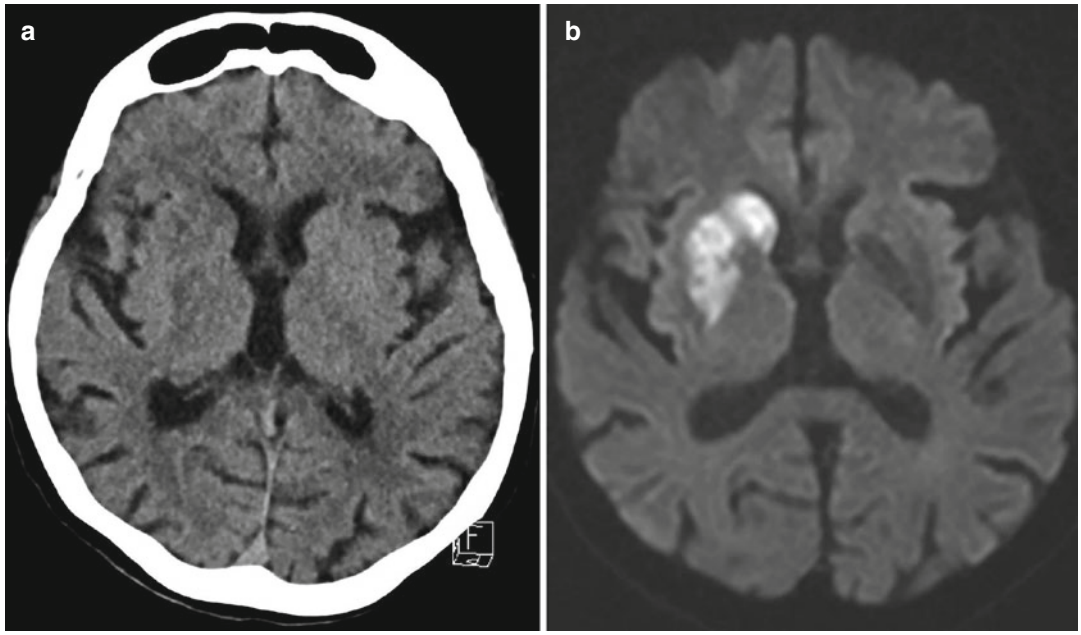

Fig. 5 Follow-up CT and MRI examinations after an acute right M1 occlusion, treated with mechanical and aspiration thrombectomy. Cranial CT 24 h after endovascular treatment with acute ischemic changes of the right caudate nucleus and putamen and a chronic ischemic lesion in the right temporal lobe (**a**). Follow-up MRI 4 days after the endovascular treatment without hemorrhagic transformation of the ischemia (**b**)

with thrombectomy and aspiration (Jadhav et al. 2021; Di Maria et al. 2021; Bai et al. 2021b).

FPE has been reported to be an independent factor for a favorable clinical outcome (Zaidat et al. 2018; Nikoubashman et al. 2019), with rates of 90-day better clinical outcome of 61.3% by FPE TICI $\geq$ 2c (Zaidat et al. 2018) and rates of 67% by FPE TICI 3 (Nikoubashman et al. 2019) and is associated with lower mortality rate, reduced hemorrhagic transformation, and procedural complications (Ducroux et al. 2020).

Size of retriever matters regarding FPR. The standard dimensions for stent retrievers are 4 mm diameter and 20 mm length ("4/20"). They can be increased to 5/30, 5/40, and even 6/30. From a technical standpoint any combination of 4, 5, and 6 mm diameter with 20, 30, and 40 mm length can be combined. A higher frequency of FPR with longer stents has been described in ICA, M1, and M2 occlusions (Zaidat et al. 2019; Haussen et al. 2019; Serna Candel et al. 2021) without safety concerns. Possible explanations for higher rates of FPR with longer stent retrievers are:

- Longer stent retrievers offer a longer working length, which potentially offers a larger surface for device integration in the clot and uniform distribution of forces during traction, as proximal and distal parts of the stent retriever are non-working (Haussen et al. 2019).
- Using longer stent retrievers allows some degree of imprecision of placement (Ospel et al. 2019) by the inexperience of operators. It allows for engagement of the entire thrombus in vessel tortuosity/elongation cases when tension causes a proximal dislocation of the stent retriever by deployment or if patients without general anesthesia move and make deployment imprecise.
- A longer stent retriever, with a distal segment beyond the clot in M2, could help to anchor the stent retriever if the operator prefers to remove the microcatheter before the aspiration through a distal access catheter during the thrombectomy (Kurre et al. 2013).
- The retriever placed distal to the thrombus could help sweep along a clot that does not

integrate into the struts. Also, when a push-and-fluff technique is used for better wall apposition resulting in device foreshortening on active deployment, a longer retriever offers higher security to cover the whole clot (Haussen et al. 2015).

The use of BGC was reported to be a predictor of FPR (Zaidat et al. 2018; Jadhav et al. 2019; Bai et al. 2021b) and reducing distal emboli. The use of a BGC did not affect angiographic outcomes in other reported studies (Mokin et al. 2020; Di Maria et al. 2021), and a high frequency of FPR without distal emboli can also be achieved without it (Serna Candel et al. 2021). No BGC was used in the case report we presented. We almost always try to advance the aspiration catheter (e.g., SOFIA) up to the M1 segment. We withdraw the stent retriever inside the SOFIA and leave the said catheter in the M1 segment under aspiration. Then, always under continuous aspiration, we remove the SOFIA catheter minimizing the risk of emboli displacement into new territories as we avoid the loss of engagement of the clot during retrieval (Kurre et al. 2013). Sometimes, we remove the stent retriever and the SOFIA at the same time under aspiration. Thrombus is retrieved within the stent retriever or the SOFIA, after removal, or in both devices. Positioning a BGC high enough in the ICA can be difficult or time-consuming in patients with significant vessel elongation, increasing the risk of complications. If the position of the BGC is not high enough, the SOFIA could be too short to be advanced up to the intracranial ICA bifurcation. We agree that using a BGC may help reduce distal emboli, but in our experience, the same effect is achieved with a distal aspiration, avoiding the fiddly handling and additional costs of a BGC.

FPR and FPE represent new concepts to measure the efficacy of techniques and devices for the endovascular treatment of acute LVO. However, the final goal remains to achieve the quickest and highest grade of recanalization and reperfusion with a negligible risk of target vessel injury and distal emboli.

Take-Home Messages

- First-pass reperfusion (FPR) is the angiographic term of achieving reperfusion, independent of the clinical outcome.
- First-pass reperfusion (FPR) is a new measure for thrombectomy devices.
- FPE is defined as achieving a near-complete (TICI 2c) or complete reperfusion (TICI 3) in a single pass of thrombectomy and is an independent predictor of good clinical outcome. Modified FPE is to achieve successful reperfusion $\geq$ TICI 2b in only one pass.
- FPE is also associated with lower healthcare resources use and estimated costs, and therefore it should be pursued as the new goal of the endovascular treatment of LVO with thrombectomy devices.
- Independent predictors of FPE described are: use of balloon guide catheter, better collateral grade, site of occlusion with ICA-terminus occlusion as less predictor and M1 occlusion as more predictor of FPE, advanced age, female gender, lower systolic blood pressure, a higher DWI-ASPECTS at admission, local anesthesia, and combined first-line device strategy with thrombectomy and aspiration.
- Longer size of stent retrievers is associated with a higher FPR for LVO.

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