AJNR Am J Neuroradiol 19:767–772, April 1998

Direct Percutaneous Transluminal Angioplasty for Acute Middle Cerebral Artery Occlusion

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PURPOSE: **We review our initial experience with direct percutaneous transluminal angioplasty (PTA) as a reperfusion treatment for acute occlusion of the middle cerebral artery.**

METHODS: **Ten patients in whom successful thrombolysis might not be expected because of the risk of hemorrhagic complications or reocclusion were treated with direct PTA. When early ischemic findings were present on the initial CT scans and/or when lenticulostriate arteries were involved, we performed direct PTA rather than thrombolytic therapy. Direct PTA was also performed when superselective local angiography via a Tracker catheter advanced just distal to the occlusion site showed the presence of a large embolus or high–grade stenosis suggestive of thrombosis. Angioplasty was performed with a Stealth balloon catheter with a maximum diameter of 2.0 to 2.5 mm. The balloon catheter was advanced into the site of occlusion and inflated to 2 atm initially, and subsequently up to 3 atm. Two to six inflations, each of 30 seconds' duration, were performed.**

RESULTS: **Although the rate of initial recanalization was 100% (10 of 10), reocclusion occurred in two patients with atherothrombotic M2 occlusion. The final angiographic success rate of direct PTA was 80% (8 of 10). There were no hemorrhagic or technical complications, and five of 10 patients showed marked clinical improvement. In two of seven patients with cardioembolic M1 trunk occlusion, crushed fragments of the embolus obstructed M2 portions after direct PTA, necessitating local thrombolysis.**

CONCLUSION: **Direct PTA may be performed safely as an alternative to thrombolytic therapy in patients with acute occlusion of the middle cerebral artery when early CT findings and/or lenticulostriate artery involvement are present or when superselective local angiography shows the presence of a large embolus or high–grade stenosis.**

In reperfusion therapy for acute middle cerebral artery (MCA) occlusion, successful thrombolysis is limited by two major difficulties: hemorrhagic complications (1–4) and recurrent ischemia due to reocclusion (5). In patients with embolic MCA trunk occlusion, the embolus is often so large as to be resistant to thrombolysis. Time–consuming thrombolytic therapy or use of high doses of thrombolytic agents may be associated with significant risk of hemorrhagic complications. For safety in such cases, mechanical crushing of the embolus and immediate recanalization by direct percutaneous transluminal angioplasty (PTA) might be preferable to time–consuming thrombolytic therapy or use of high doses of thrombolytic agents (6).

On the other hand, in patients with atherothrombotic MCA occlusion, the greatest problems of thrombolytic therapy are the low rate of recanalization (7) and the risk of reocclusion (5). Even after successful thrombolysis, most patients are left with a high–grade stenosis that may hinder subsequent recovery of the ischemic tissue and carry a risk of reocclusion. Recently, in patients with acute atherothrombotic stroke (5), as in patients with acute myocardial infarction (8–11), angioplasty has been performed after thrombolytic therapy to prevent reocclusion of the residual stenosis. In some of those patients, rapid recanalization by direct PTA may be preferable to thrombolytic therapy with its potential risk of rethrombosis. We present a retrospective review of our initial experience in 10 patients with acute MCA occlusion treated with direct PTA.

Received May 13, 1997; accepted after revision October 20.

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Methods

Fifty-seven patients with acute MCA occlusion were treated by reperfusion therapy over the past 5 years. Inclusion criteria

TABLE: Clinical and radiologic characteristics for 10 patients

Case	Age, y/Sex	Early CT Findings	Occlusion Site	Embolic Source	Time to Reperfusion, h	Post-CT Findings	Complications	Initial Symptoms	Outcome
1	66/M	I	R M2 (−)	· · ·	6.0	Sta	Reoc	Hemiplegia	F, T-cane
2	50/F	I, L, C	L M1 (+)	Af	4.0	Ext	Pete	Hemiplegia, motor aphasia	F, T-cane, aphasia
3	60/M	L, C	L M1 (+)	Af	3.5	Ext	Pete	Hemiplegia, motor aphasia	G, mild aphasia
4	80/M	I, L	L M1 (+)	Af	3.0	Sta	· · ·	Hemiplegia, global aphasia	E, full recovery
5	69/M	C	R M2 (−)	· · ·	6.0	Sta	Reoc	Hemiplegia, restless	F, T-cane
6	70/M	· · ·	L M1 (−)	· · ·	5.5	· · ·	· · ·	Hemiplegia, motor aphasia	E, full recovery
7	79/F	I, L	R M1 (+)	Mr	3.5	Sta	· · ·	Hemiplegia	F, T-cane
8	66/M	I, L, C	L M1 (+)	Af	4.5	Sta	· · ·	Hemiplegia, motor aphasia	G, mild aphasia
9	49/M	I, L, C	R M1 (+)	MSr, AR	2.0	· · ·	· · ·	Hemiplegia	G, mild hemiparesis
10	85/M	I, L	L M1 (+)	Af	4.0	Ext	Small	Hemiplegia, motor aphasia	F, wheel chair

Note.—I indicates loss of the insular ribbon; L, obscuration of the lentiform nucleus; C, cortical effacement; M1, M1 portion of the MCA; M2, M2 portion of the MCA; presence (+) or absence (−) of lenticulostriate artery involvement in parenthesis; Af, atrial fibrillation; Mr, mitral valve regurgitation; MSr, mitral valve stenosis with regurgitation; AR, aortic valve regurgitation; Ext, extravasation of contrast medium; Sta, stagnation of contrast medium; Reoc, reocclusion; Pete, petechial hemorrhage; small, small hemorrhage; E, excellent; G, good; F, fair; T-cane, walking with a T-cane.

for this treatment consisted of major arterial occlusion at angiography, consistent with clinical symptoms; absence of apparent computed tomographic (CT) hypodensity related to the ischemic events; and availability of informed consent from the patient or a family member. Early findings on the initial CT scans were defined according to the following characteristic changes: loss of the insular ribbon (ie, loss of definition of the gray–white interface in the lateral margins of the insula); obscuration of the margins of the lentiform nucleus; and cortical effacement (attenuation of the cortical sulci in the affected area) (4).

When early CT findings are present and/or lenticulostriate arteries are involved in ischemia, thrombolytic therapy may be associated with a significant risk of hemorrhagic complications (4).

After the demonstration of MCA occlusion on angiograms, a Tracker 18 catheter (Target Therapeutics; Fremont, Calif) was advanced across the occlusion site, using a guiding 6F catheter. Superselective local angiography via the Tracker catheter advanced just distal to the occlusion site demonstrated the extent of the arterial occlusion. When superselective local angiography shows the presence of a large embolus or high–grade stenosis suggestive of thrombosis, time–consuming thrombolytic therapy or use of high doses of thrombolytic agents may be expected, and we prefer direct PTA to thrombolytic therapy for these patients. During angiography, when we judged that use of thrombolytic agents might result in an unfavorable outcome, we explained the risk of thrombolytic therapy and recommended direct PTA to the patients or their family. After informed consent was obtained, angioplasty was performed. According to these criteria, 10 patients, eight men and two women, 49 to 85 years old (mean, 67 years), were treated with direct PTA over the last 3 years.

Angioplasty was performed with a Stealth angioplasty balloon catheter (Target Therapeutics) with a maximum diameter of 2.0 to 2.5 mm. Just before angioplasty, 5000 U of heparin was administered intravenously. An additional 1000 U of intravenous heparin was given at 1–hour intervals during the dilatation procedure. The balloon catheter was advanced into the occlusion site and inflated to 2 atm initially and subsequently up to 3 atm. Several inflations of 30 seconds each were performed until recanalization was established. After each inflation, repeated angiograms were obtained to assess the degree of recanalization. If recanalization was not achieved, the next inflation was performed in the same manner. After angioplasty, when complete recanalization was achieved and a cardiac source of the embolism was present, a diagnosis of embolism was made. On the other hand, when residual stenosis was present and a cardiac source of the embolism was absent, the diagnosis was thrombosis, and antiplatelet therapy with intravenous administration of sodium ozagrel (80 mg/d) was instituted for 7 days. Subsequently, ticlopidine hydrochloride (200 mg/d) was prescribed.

To assess the occurrence of extravasation of contrast medium, CT scans were obtained just after the completion of direct PTA. Follow–up CT scans were also obtained within 24 hours and again 3 to 7 days after onset. To evaluate the recanalized vessel, MR angiography was performed 3 months after onset.

The outcome at the end of the third month after onset was categorized as one of five possible classifications: excellent (full recovery to social life without neurologic deficit); good (partial recovery to social life or independent home life with self–care); fair (dependent home life requiring some assistance for daily life); poor (bedridden, either conscious or vegetative); or dead.

Results

The clinical and radiologic characteristics of the patients are shown in the Table. In all patients, neurologic examination revealed complete hemiplegia, and six patients with left MCA occlusion also had global or motor aphasia. The time from symptom onset to reperfusion ranged from 2 to 6 hours (average, 4 hours). Only one patient (case 6) with atherothrombotic M1 occlusion had neither early CT findings nor involvement of the lenticulostriate arteries. The other nine patients had early CT findings and seven patients also had lenticulostriate artery involvement. In seven patients, cardioembolism was diagnosed because of the presence of a cardiac source of an embolus and the confirmation of complete recanalization at post–PTA angiography or follow-up MR angiography. In two of these seven patients with cardioembolic M1 occlusion (cases 4 and 9), crushed fragments of the embolus obstructed the M2 portions after direct PTA, necessitating local thrombolysis.

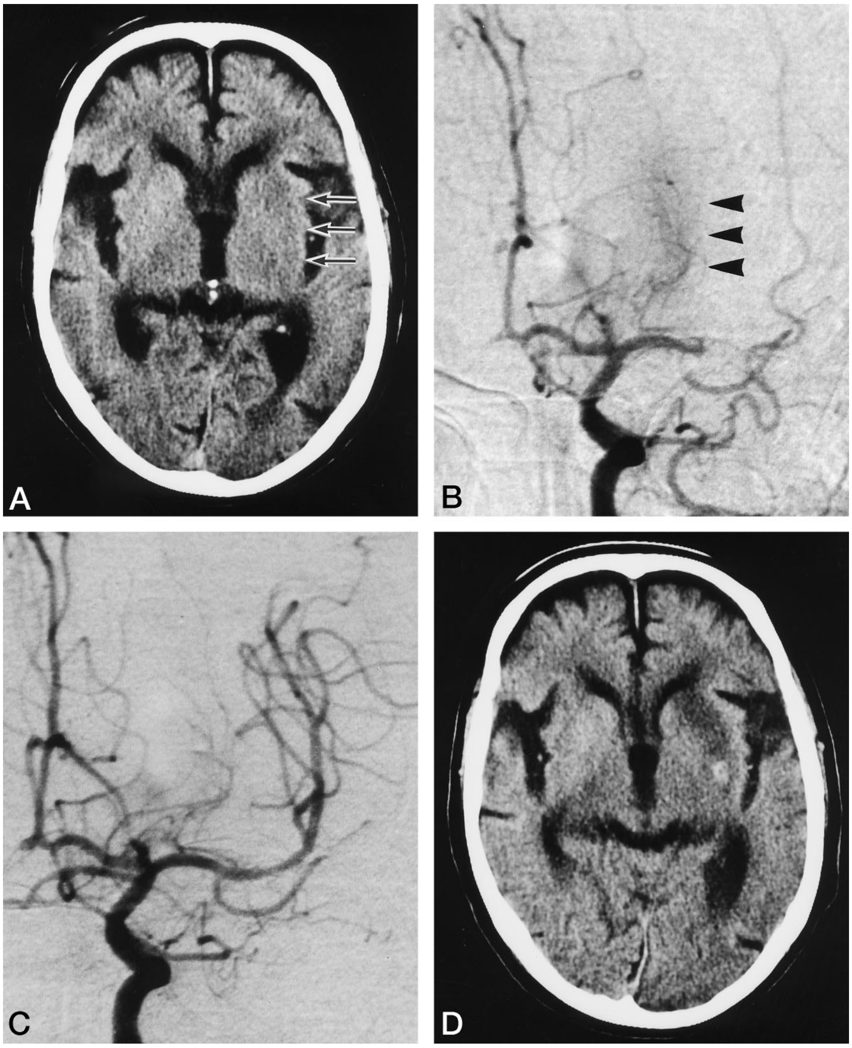

FIG 1. Case 10.

A, CT scan on admission shows loss of the insular ribbon and obscuration of the lentiform nucleus (*arrows*).

B, Pretherapeutic angiogram shows occlusion of the left M1 trunk with stagnation of contrast medium in the dilated lenticulostriate artery (*arrowheads*), which might have been initially involved with ischemia.

C, Posttherapeutic angiogram after direct PTA shows complete recanalization of the left MCA.

D, Follow–up CT scan obtained the next day shows a low-density area only in the lenticulostriate artery territory with a small hemorrhage. The cerebral cortex appears normal.

However, thrombolysis of these small fragments was accomplished easily with small amounts of thrombolytic agents (case 4: urokinase, 120 000 U; case 9: tissue plasminogen activator, 1.8 mg).

Among the other three patients without a cardiac source of an embolus, two experienced recurrent ischemia subsequent to reocclusion and the rest showed residual stenosis suggestive of atherothrombosis. In the two patients with reocclusion, the stenotic sites involved the M2 portion of the MCA, and adequate arterial patency was not achieved because of the small diameter of the vessel.

Although the rate of initial recanalization was 100% (10 of 10), the final recanalization rate of direct PTA was 80% (8 of 10). While successful, recanalization did not always lead to clinical improvement; only five (50%) of the 10 patients showed marked clinical improvement (excellent or good outcome). CT scans just after direct PTA showed high-density areas in eight patients. In five of these, reabsorption of contrast medium and no evidence of hemorrhage were confirmed by follow–up CT scans. Although follow-up CT scans disclosed a small hemorrhage in one patient (case 10) and petechial hemorrhage in two patients (cases 2 and 3), none of the 10 patients incurred neurologic deterioration as a result of hemorrhagic complications.

Representative Cases

Case 10.—An 85–year–old man with nonvalvular atrial fibrillation presented with sudden onset of right hemiplegia and motor aphasia. A CT scan on admission revealed early findings, such as loss of the insular ribbon and obscuration of the lentiform nucleus (Fig 1A). Angiography showed complete occlusion of the left MCA trunk with stagnation of contrast medium in the dilated lenticulostriate arteries, suggesting that those arteries might have been initially involved in ischemia and that the use of thrombolytic agents might be associated with a high risk of hemorrhagic complications (Fig 1B). We diagnosed the condition as a cardioembolic stroke and selected rapid recanalization by direct PTA without thrombolytic agents, using a 2.0 mm × 1.5-cm Stealth balloon catheter with two inflations to 2 atm for 30 seconds. Angiography performed after the angioplasty revealed complete recanalization of the left MCA trunk (Fig 1C).

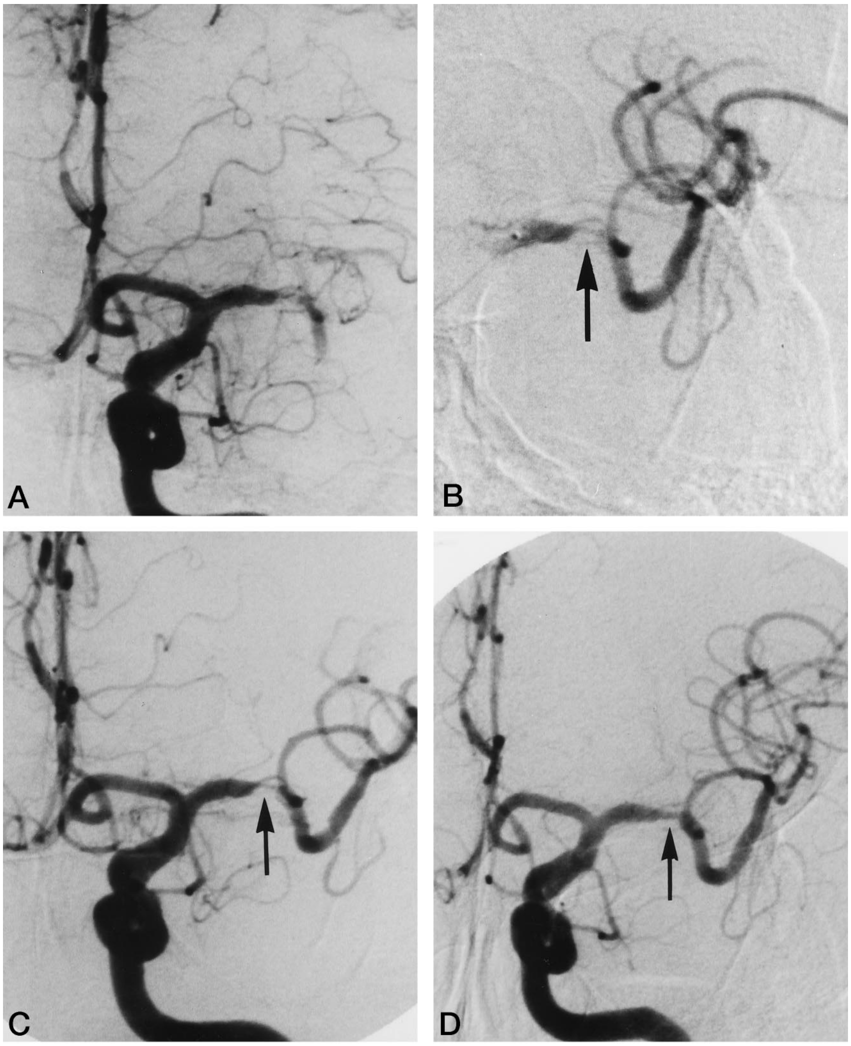

FIG 2. Case 6.

A, Pretherapeutic angiogram shows occlusion of the left M1 trunk.

B, Superselective local angiogram via Tracker 18 catheter shows severe stenosis of the left M1 trunk just proximal to the bifurcation (*arrow*).

C, Angiogram after the first inflation of a Stealth balloon catheter shows slow filling of the MCA divisions and branches, with residual severe stenosis of the M1 trunk (*arrow*).

D, Angiogram after completion of direct PTA shows enlargement of the luminal diameter of the stenotic portion (*arrow*) with excellent filling of the MCA divisions and branches.

Although the territory of the lenticulostriate arteries could not escape cerebral infarction with small hemorrhage, a follow–up CT scan the next day revealed neither cerebral edema nor a low-density area in the cerebral cortex (Fig 1D). The patient had persistent right hemiplegia, but his speech function recovered well.

Case 6.—A 70–year–old man was brought to our hospital by his wife who noticed that he had shown right-sided hemiplegia and motor aphasia on awakening that morning. A CT scan on admission revealed neither hemorrhagic density nor early findings of ischemia. Angiography demonstrated left MCA occlusion (Fig 2A). Local angiography via a Tracker 18 catheter revealed severe stenosis of the main trunk just proximal to the MCA bifurcation (Fig 2B). Direct PTA was performed immediately using a 2.0 mm × 1.5-cm Stealth balloon catheter with three inflations to 2 atm for 30 seconds each. There was still severe residual stenosis after the first inflation of the balloon catheter, which presumably flattened the superimposed thrombus on the stenotic lesion (Fig 2C). Angiography performed after the angioplasty showed enlargement of the luminal diameter of the stenotic portion with excellent filling of the MCA divisions and branches (Fig 2D). The patient recovered well, and he was normal neurologically without hemiparesis or motor aphasia the following morning. Follow–up CT revealed no abnormal areas.

Discussion

The primary goal of thrombolytic therapy should be the rapid restoration of the blood supply prior to endothelial damage. Prediction of endothelial damage is one of the most important concerns when deciding whether to perform thrombolytic therapy. Since extravasation of contrast medium indicates a disrupted blood–brain barrier, extravasation on contrast-enhanced CT scans is the most useful finding for evaluating the degree of endothelial damage and for predicting hemorrhagic complications (4, 12). In patients with MCA occlusion, early CT findings of ischemia, such as loss of the insular ribbon (13), obscuration of the lentiform nucleus (14), and cortical effacement, are reflections of acute edema by increased capillary permeability. These findings are also useful in evaluating endothelial damage (15, 16). Yokogami et al (4) reported a significant correlation between early CT findings on initial CT scans and extravasation on contrast-enhanced CT scans. When early CT findings are present, endothelial damage has already been initiated, and thrombolytic therapy may be associated with significant risk of hemorrhagic complications.

When deciding whether to perform thrombolytic therapy, another important issue is to confirm whether the lenticulostriate arteries are involved in ischemia (4, 15, 17, 18). Because these arteries are terminal vessels with poor collaterals, thrombolytic therapy for patients with MCA trunk occlusion involving the lenticulostriate arteries may be associated with a high risk of hemorrhagic complications, particularly in patients with embolic MCA occlusion. As shown by Yokogami et al (4), when the lenticulostriate arteries are involved in ischemia and early CT findings are present, thrombolytic therapy for MCA occlusion may result in an unfavorable outcome with hemorrhagic complications. In such cases, the use of thrombolytic agents should not be recommended. However, conservative treatment often leads to extended space-occupying cerebral edema or massive intracerebral hemorrhage due to late spontaneous recanalization subsequent to severe endothelial damage (19). Even if most of the ischemic tissue cannot escape cerebral infarction, therapeutic recanalization might be effective if recanalization could be performed without hemorrhagic complications prior to severe endothelial damage. Rapid recanalization using a balloon catheter without thrombolytic agents may reduce the frequency of serious hemorrhagic complications and may improve clinical outcome. In our study, most of the patients had early CT findings and involvement of the lenticulostriate arteries. However, none of these patients treated with direct PTA showed neurologic deterioration from hemorrhagic complications, suggesting the safety of direct PTA. As a matter of course, adequate control of blood pressure is also necessary to prevent hemorrhagic complications. In patients with MCA occlusion, when the lenticulostriate artery involvement and early CT findings are present, direct PTA may be preferable and may be an alternative to thrombolytic therapy.

Unlike in Caucasian populations, in the Japanese, atherothrombotic MCA occlusion is a frequent occurrence (20–22). Angiography may show only total occlusion, and it is difficult to distinguish embolic from atherothrombotic MCA occlusion. Whether an intrinsic stenosis is present or absent (ie, thrombotic or embolic occlusion), direct PTA may be effective in widening the stenotic site. In case of atherothrombotic stroke, it is difficult to determine the degree of stenosis versus the degree of superimposed thrombus by angiography alone. In some cases, thrombolytic therapy may reduce the overall degree of stenosis because of dissolution of the superimposed thrombus while in other cases thrombolytic therapy alone may fail to recanalize the occluded artery. Even if successful thrombolysis were performed, severe residual stenosis leaves the risk of reocclusion. Direct PTA may initially flatten the superimposed thrombus on the stenotic lesion and then the force of the more pronounced dilatation may reduce the degree of stenosis. Therefore, angioplasty may be preferred to recanalize the occluded artery and to avoid reocclusion. As for direct coronary angioplasty in cases of acute myocardial infarction (8–11), direct PTA may be a preferred treatment in some patients with evolving cerebral infarction.

The potential risks associated with direct PTA include arterial rupture, spasm, and distal embolization (5, 23–26). Tsai et al (5) stressed the importance of underdilating the stenosis to minimize these risks, because cerebral blood flow may be restored to normal with 50% of the normal vessel diameter. We also set the initial goal of angioplasty at 50% stenosis, keeping the dilatation force within 2 to 3 atm to prevent arterial rupture or spasm. Selecting an appropriate diameter for the balloon catheter as equal to the average inside diameter of the normal artery and underdilating the stenosis by using minimum dilatation force may provide successful PTA of the MCA. In this study, however, two patients with atherothrombotic M2 occlusion experienced neurologic deterioration due to reocclusion after initially successful direct PTA with neurologic improvement. Because of the small diameter of the M2 portion of the vessel, sufficient arterial patency was not achieved with the minimum dilatation force of 2 to 3 atm. In these cases, emergency bypass surgery might be considered during temporary recanalization after direct PTA. Although distal embolization by crushed fragments is a noteworthy complication of direct PTA for cerebral embolism (6), thrombolysis of these small fragments is likely to be easier with small amounts of thrombolytic agents, as in our cases 4 and 9.

Conclusion

The preliminary results from this study suggest that direct PTA may be performed safely as an alternative to thrombolytic therapy in some patients with acute MCA occlusion. Further experience will be required to draw conclusions concerning the usefulness of direct PTA for patients with acute ischemic stroke. We believe that direct PTA may be one of the therapeutic strategies available for acute MCA occlusion.

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