Emergency Microsurgical Embolectomy after Failure of Endovascular Recanalization for Embolic Occlusion of the Anterior Intracranial Artery

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Summary

Objectives: Although the first-line treatment option for ischemic stroke due to intracranial artery occlusion is endovascular recanalization, this type of endovascular treatment can be associated with failure of recanalization of the occluded artery. In case of failure of this approach, surgical embolectomy might be a final effective therapeutic option, if case selection is adequate. Here, we present the surgical results of microsurgical embolectomy of an intracranial artery occlusion after failure of endovascular recanalization.

Methods: Seven patients with acute occlusion of the distal internal cerebral artery (ICA) and the middle cerebral artery (MCA) were treated with microsurgical embolectomy. Occlusion occurred in the distal ICA in 3 patients and in the MCA in 4 patients. We investigated patients' clinical characteristics, admission time, occlusion time, and collateral flow.

Results: Two patients were men and 5 patients were women; their mean age was 68.4 years. The mean admission time was 112.9 min. Although recanalization was achieved intraoperatively in all patients, 1 elder patient died on the first postoperative day. The mean occlusion time was 6.8 h. The MCA conduction time was grade 1 in 1 patient, grade 2 in 1 patient, grade 3 in 1 patient, and grade 5 in 1 patient. At 6 months after the operation, 1 patient had grade 3 on the modified Rankin Scale and 5 patients had grade 2.

Conclusions: Microsurgical embolectomy may be an ultimate effective therapeutic option for recanalization in selected patients, especially in cases of failure of endovascular recanalization.

Key words: Ischemic stroke, Intracranial artery occlusion, Endovascular recanalization, Microsurgical embolectomy, Surgical outcome
Anterior İntrakranyal Arterin Embolik Oklüzyonunu için Endovasküler Rekanalizasyonun Başarılısını Sonrasında Acil Mikrocerrahi

Özet


Yöntem: Distal internal serebral arter (ICA) ve orta serebral arter (MCA) akut oklüzyonu olan 7 hasta mikrocerrahi embolektomi ile tedavi edildi. Tikanna üç hastada distal ICA, 4 hastada MCA’dan görülüdü. Hastaların klinik özellikleri, hastaneye geliş zamanları, oklüzyon süreleri ve kollateral akimlari yönleri ile araştırıldılar.

Sonuçlar: Hastaların ortalama yaş 68,4 olmak üzere ikisi erkek ve beş kadındı. Hastaneye geliş süreleri ortalama 112,9 dakika idi. Rekanalizasyon her hastaya uygulanmasına karşın bir yaşlı hastameliyat sonrası birinci günde kaybedildi. Ortalama oklüzyon zamanı 6,8 saatti. MCA kondüsyon zamanı 1 hastada derece1, 1 hastada derece 2, 1 hastada derece 3 ve 1 hastada ise derece 5 oldu. Operasyondan 6 ay sonra 1 hasta modifiye Rankin Skalasında derece 3 ve 5 hasta da derece 2 idi.

Yargı: Özellikle endovasküler rekanalizasyonun başarılı olduğu olgularında mikrocerrahi embolektomi, seçilmiş hastalarda, bir son etkili terapötik opsiyon olabilir.

Anahtar Kelimeler: İskemik inme; intrakraniyal arter oklüzyonu; endovasküler rekanalizasyon; mikrocerrahi embolektomi; cerrahi sonuçlar

INTRODUCTION

In 1956, Welch described the method of surgical middle cerebral artery (MCA) embolectomy for the first time(19). Since then, only a few authors have reported the outcome of emergency embolectomy as a treatment method for acute spontaneous occlusion of the internal cerebral artery (ICA) and of the MCA(3,8,10). These reports concluded that emergency embolectomy, as an ultimate procedure, can be a safe and useful treatment when performed 3–6 h after arterial occlusion and with additional medical treatment(3). However, emergency microsurgical embolectomy has not been performed widely since the introduction of local intra-arterial thrombolysis.

Since the recent introduction of endovascular embolectomy for the treatment of major artery occlusion, the treatment of ischemic stroke due to intracranial arterial occlusion is a primary domain of medical and endovascular strategies(3). However, these endovascular procedures cannot control all procedure-related complications. In cases of failure of endovascular revascularization, microsurgical embolectomy in the anterior circulation can be a final therapeutic option, if case selection is adequate. Here, we present the surgical results of emergency microsurgical embolectomy of acute ischemic stroke due to occlusion of a cerebral artery in cases of failure of endovascular recanalization.

MATERIAL AND METHODS

Patient selection and outcome assessment

Between May 2009 and June 2012, 7 consecutive patients with acute occlusion of the distal ICA and MCA were treated with emergency microsurgical
embolectomy after failure of intra-arterial (IA) mechanical endovascular thrombolysis. The occlusion occurred in the distal ICA in 3 patients and in the MCA in 4 patients. As the endovascular recanalization of the occluded vessel that was attempted in all cases failed, we decided to perform emergency microsurgical embolectomy as an ultimate treatment attempt. All patients underwent microsurgical embolectomy within 8 h of the onset of symptoms of acute cerebral stroke in the anterior circulation. All patients exhibited severe neurological deficits, such as acute hemispheric symptoms, on admission. We investigated the patients' clinical characteristics, time between the onset of symptoms and admission, vessel occlusion time, collateral flow, and occlusion site. The collateral flow was evaluated using MCA conduction time (MCT), as described by Kakinuma et al. MCT was defined as the conduction of the contrast media to the insular portion of the MCA through the leptomeningeal collateral circulation from the anterior cerebral artery(7). The MCT of the patients was graded into the 5 following types: (1) grade 1: in the arterial phase, there was conduction not only to the insular portion of the MCA, but also to the proximal site of the M2; (2) grade 2: conduction to the insular portion of the MCA was present in the late arterial phase; (3) grade 3: conduction to the insular portion of the MCA was present in the capillary phase; (4) grade 4: conduction to the insular portion of the MCA was observed only in the venous phase; and (5) grade 5: no leptomeningeal anastomosis to the insular portion was observed on angiography. The surgical outcome was assessed 1 day and 6 months after the operation using the modified Rankin Scale (mRS)(18). Grade 0 on the mRS was defined as the absence of symptoms. Grade 1 was defined as no significant disability, despite the presence of some symptoms (the individual was able to carry out all his/her usual duties and activities). Grade 2 was defined as the presence of a slight disability (the patient was unable to carry out all previous activities, but was able to look after his/her own affairs without assistance). Grade 3 was considered moderate disability (the patient required some help, but was able to walk without assistance). Grade 4 was defined as moderately severe disability (the patient was unable to walk without assistance and could not attend to his/her own physical needs without assistance). Grade 5 on the mRS was defined as severe disability (the patient was bedridden, incontinent, and required constant nursing care and attention). Grade 6 was equivalent to death.

Surgical techniques
After preservation of the frontal and parietal branch of the superficial temporal artery (STA), a pterional approach was performed to allow STA–MCA bypass surgery in cases in which microsurgical embolectomy had failed. The sites of occluded artery were reconfirmed in the operative field via the visualization of an artery of dark-blue color. A small longitudinal arteriotomy was performed after temporary clipping of the proximal and distal part of the occluded site. The embolus was removed completely in all patients. After the complete removal of the clot, we performed irrigation of the arterial lumen using heparinized saline to facilitate the lysis of residual clots and prevent early rethrombosis. The sites of arteriotomy were closed using mini clips. Confirmation of arterial patency is essential and should be performed using a microdoppler device. The operative time from skin incision to removal of embolus was about 1 h.

RESULTS
Clinical data
The data of all patients are summarized in Table 1. Two of the patients were men and 5 were women; their mean age was 68.4 years (range, 61–79 years). The mean time between the onset of symptoms and admission was 112.9 min (range, 30–190
On admission, the Glasgow Coma Scale (GCS) score was 14 in 4 patients and 15 in 3 patients, and most of the patients exhibited severe hemiparesis of motor grade 1, with the exception of 1 patient with grade 3 (case 3). On admission, 5 patients exhibited grade 5 on the mRS, 1 patient was rated as grade 4, and 1 was rated as grade 3. The mean occlusion time was 6.8 h (range, 5.3–8.0 h). The MCT was grade 1 in 1 patient, grade 2 in 1 patient, grade 3 in 1 patient, and grade 5 in 1 patient, whereas 3 patients had occlusion of the distal ICA.

Surgical outcome

The surgical outcome in all patients is summarized in Table 2. Although complete recanalization was achieved intraoperatively in all patients, 1 elder patient died on the first postoperative day (case 6). In 5 patients, neurological improvement was obtained at postoperative day 1. All patients (with the exception of 1 patient who died) were transferred to a rehabilitation care unit after the operation and underwent physical rehabilitation therapy. At postoperative day 1, 4 patients showed grade 2 on the mRS and 2 patients were rated as grade 3. At 6 months after the operation, 1 patient showed grade 1 on the mRS and 5 patients were rated as grade 2. One patient showed no remarkable neurological change from grade 3 (case 3). There were no complications related to surgery during the intraoperative and postoperative courses, with the exception of 1 patient who developed a chronic subdural hematoma on the surgical side (case 2).

Illustrative cases

Case 2

A 61-year-old woman was admitted with sudden onset of right-sided weakness (motor grade 1/1) and dysarthria. The time between the onset of symptoms and admission was 60 min. Cranial magnetic resonance imaging (MRI) showed an acute cerebral infarction in the left MCA territory with a mild perfusion–diffusion mismatch. Perfusion MRI showed decreased cerebral blood flow (CBF) in the left MCA territory (Fig. 1A–C). Cerebral angiography showed a left M1 occlusion and MCT was grade 1 (Fig. 1D and E). Endovascular mechanical embolectomy with shuttle and a guiding catheter of a penumbra reperfusion catheter was performed. Although the endovascular procedure provided recanalization of the inferior division, it failed to recanalize the main upper division of the MCA (Fig. 1F). We performed an emergency microsurgical embolectomy using the left pterional approach. A left distal M1 occlusion was confirmed in the operative field (Fig. 1G). After small arteriotomy, the embolus was removed. Occlusion time was 8 h. The sites of arteriotomy were closed using mini clips (Fig. 1H). Her right-sided motor power recovered to a grade 3 at 1 day after operation. Postoperative angiography showed recanalization of the left MCA (Fig. 1I). Two weeks later, she complained of headache with progressively increasing severity. Cranial computed tomography (CT) showed an isodensity area over the left cerebral convexity, suggesting chronic subdural hematoma (Fig. 1J). After closed-system drainage of the hematoma was performed via a single burr hole, her headache disappeared. Her motor power gradually improved to a grade 4 at 6 months after operation.

Case 4

A 61-year-old woman was admitted with sudden onset of right-sided weakness (motor grade 1/1) and aphasia. The time between the onset of symptoms and admission was 90 min. MRI showed an acute cerebral infarction in the left MCA territory with a severe perfusion–diffusion mismatch (Fig. 2A and B). The perfusion defect on the time-to-peak maps involved the whole right MCA territory (Fig. 2C). Cerebral angiography showed an embolic left distal ICA occlusion (Fig. 2D). Vertebral angiogram showed mild
collateral vasculature to the left MCA territory from the posterior cerebral artery (PCA) branch (Fig. 2E). Because of the technical failure of endovascular mechanical embolectomy, she underwent an emergency microsurgical embolectomy. A left terminal ICA “T“ occlusion was confirmed in the operative field and the embolus was removed completely (Fig. 2F). Occlusion time was 5.3 h. Postoperative angiography showed recanalization of the left occluded ICA and mild M1 stenosis at the arteriotomy site (Fig. 2G). Her right-sided motor power recovered to a grade 3 at 1 day and to a grade 4 at 6 months after operation.

Case 6
A 79-year-old woman was transferred to our hospital with sudden onset of left-sided weakness (motor grade 1/2) and speech disturbance. She had been taking medicines for coronary heart disease, hypertension, diabetes mellitus, and rheumatoid arthritis for the past several years. The time between the onset of symptoms and admission was 190 min. Cranial perfusion CT performed at the initial hospital showed a large perfusion defect in the right MCA and PCA territory (Fig. 3A). Right ICA angiography showed an intraluminal embolus in the right carotid T segment. Left ICA angiography showed no collateral flow to the right side through the anterior communicating artery (Fig. 3B and C). After failure of IA mechanical and chemical thrombolysis with urokinase, her consciousness gradually deteriorated to a Glasgow Coma Scale (GCS) score of 10 (E2, V3, M5). We performed an emergency microsurgical embolectomy with decompressive craniectomy, and right terminal ICA occlusion was confirmed. The embolus was removed and the occlusion time was 7.5 h. However, postoperatively, her consciousness deteriorated to a GCS score of 7 (E2, V2, M3). A cranial CT showed diffuse acute cerebral infarction in the right cerebral hemisphere with midline shifting (Fig. 3D). The patient's family rejected all surgical treatment because of her old age and she died the following day.
### Table 1. Clinical Summary of Patients Who Received Microsurgical Embolectomy after Failure of Endovascular Recanalization

<table>
<thead>
<tr>
<th>Case</th>
<th>Age (years)</th>
<th>Sex</th>
<th>Admission time after onset (min)</th>
<th>On admission</th>
<th>Occlusion time (h)</th>
<th>Occlusion site Side Artery</th>
<th>MCT</th>
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<tbody>
<tr>
<td>1</td>
<td>75</td>
<td>M</td>
<td>30</td>
<td>GCS 14</td>
<td>Motor grade HP G1/1</td>
<td>mRS G5</td>
<td>Lt distal ICA NA</td>
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<tr>
<td>2</td>
<td>61</td>
<td>F</td>
<td>60</td>
<td>GCS 14</td>
<td>Motor grade HP G1/1</td>
<td>mRS G5</td>
<td>Lt MCA G1</td>
</tr>
<tr>
<td>3</td>
<td>74</td>
<td>F</td>
<td>180</td>
<td>GCS 15</td>
<td>Motor grade HP G3/3</td>
<td>mRS G3</td>
<td>Rt MCA G2</td>
</tr>
<tr>
<td>4</td>
<td>61</td>
<td>F</td>
<td>90</td>
<td>GCS 15</td>
<td>Motor grade HP G1/1</td>
<td>mRS G5</td>
<td>Lt distal ICA NA</td>
</tr>
<tr>
<td>5</td>
<td>65</td>
<td>M</td>
<td>60</td>
<td>GCS 15</td>
<td>Motor grade HP G1/3</td>
<td>mRS G4</td>
<td>Lt MCA G5</td>
</tr>
<tr>
<td>6</td>
<td>79</td>
<td>F</td>
<td>190</td>
<td>GCS 14</td>
<td>Motor grade HP G1/2</td>
<td>mRS G5</td>
<td>Rt distal ICA NA</td>
</tr>
<tr>
<td>7</td>
<td>64</td>
<td>F</td>
<td>180</td>
<td>GCS 14</td>
<td>Motor grade HP G1/1</td>
<td>mRS G5</td>
<td>Lt MCA G3</td>
</tr>
</tbody>
</table>

GCS, Glasgow Coma Scale; mRS, Modified Rankin Scale; MCA, Middle cerebral artery conduction time; M, Male; F, Female; HP, Hemiparesis; G, Grade; Lt, Left; Rt, Right; ICA, Internal carotid artery; MCA, Middle cerebral artery; NA, Not available.
Table 2. Surgical Outcome of all Patients

<table>
<thead>
<tr>
<th>Case</th>
<th>Motor Grade POD 1</th>
<th>Motor Grade At 6 months</th>
<th>mRS POD 1</th>
<th>mRS At 6 months</th>
<th>Complication</th>
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<td>3/4</td>
<td>4/4</td>
<td>G2</td>
<td>G2</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>3/3</td>
<td>4/4</td>
<td>G3</td>
<td>G2</td>
<td>C-SDH</td>
</tr>
<tr>
<td>3</td>
<td>3/3</td>
<td>3/3</td>
<td>G3</td>
<td>G3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>3/3</td>
<td>4/4</td>
<td>G2</td>
<td>G2</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>4/4</td>
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<td>6*</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>Death</td>
</tr>
<tr>
<td>7</td>
<td>3/3</td>
<td>4/4</td>
<td>G2</td>
<td>G2</td>
<td></td>
</tr>
</tbody>
</table>

*The patient corresponding to case 6 died on the first postoperative day.

POD 1, postoperative day 1; mRS, Modified Rankin Scale; G, Grade; C-SDH, Chronic subdural hematoma; NA, Not available

Figure 1: Cranial magnetic resonance imaging (MRI) showing an acute cerebral infarction in the left middle cerebral artery (MCA) territory with a mild perfusion–diffusion mismatch (A and B). Perfusion MRI showing decreased cerebral blood flow (CBF) in the left MCA territory (C). Cerebral angiography showing a left M1 occlusion and an MCA conduction time (MCT) of grade 1 (D and E). Angiography after endovascular mechanical embolectomy showing a recanalization of the inferior division, and failure of recanalization of the main upper division of the MCA (F). Intraoperative photography showing a left distal M1 occlusion (G). The sites of arteriotomy were closed using mini clips (H). Postoperative angiography showing recanalization of the left MCA (I). Two weeks later, the patient complained of headache with progressively increasing severity. Cranial computed tomography (CT) obtained 2 weeks after the operation showing a chronic subdural hematoma over the left cerebral convexity (J).
Figure 2: Cranial magnetic resonance imaging (MRI) showing an acute cerebral infarction in the left middle cerebral artery (MCA) territory with a severe perfusion–diffusion mismatch (A and B). Perfusion defect on the time-to-peak maps involving the whole right MCA territory (C). Angiography showing an embolic left distal internal cerebral artery (ICA) occlusion and mild collateral vasculature to the left MCA territory from the posterior cerebral artery (PCA) branch (D and E). Intraoperative photography showing a left terminal ICA “T” occlusion (F). Postoperative angiography showing recanalization of the left occluded ICA and mild M1 stenosis at the arteriotomy site (G).

Figure 3: Cranial perfusion computed tomography (CT) showing a large perfusion defect in the right middle cerebral artery (MCA) and in the posterior cerebral artery (PCA) territory (A). Angiography showing an intraluminal embolus in the right carotid T segment and no collateral flow to the right side through the anterior communicating artery (B and C). Postoperative cranial CT showing diffuse acute cerebral infarction in the right cerebral hemisphere with midline shifting (D).
DISCUSSION

Approximately 85% of all stroke cases are ischemic in origin and about half are due to large cerebral artery occlusion (ICA, MCA, and basilar artery), primarily because of embolism from the heart or great vessels\(^{(15)}\). The prognosis following stroke due to large arterial occlusion is poor, with mortality rates of 50, 30, and 90%. The majority of those who survive have significant residual neurological sequelae. Revascularization has been shown to have a significant impact on prognosis of ischemic stroke\(^{(1,12)}\). Since the mid-1990s, the most common strategy for reperfusion in cases of embolic stroke is the recanalization of the occluded artery via intravenous (IV) thrombolysis with the recombinant tissue plasminogen activator (rt-PA), which limits the size and impact of the stroke\(^{(1,2)}\). However, a minority of all ischemic stroke patients actually undergo thrombolytic therapy, primarily because of its narrow treatment time window (less than 3 h)\(^{(1,9)}\). This narrow time window has recently been extended to 4.5 h\(^{(1,5)}\). The efficacy of this treatment is also particularly limited in large arterial occlusions, with reported revascularization rates of ~10% for ICA bifurcation and ~30% for proximal MCA occlusion\(^{(14)}\).

Endovascular mechanical embolectomy is another treatment option for major artery occlusion. This procedure can be performed up to 8 h after symptom onset\(^{(1)}\). Mechanical embolectomy is a useful technique for restoring blood flow in patients with large-vessel occlusion, and the devices involved in this procedure can be used alone or in combination with either IV or IA rt-PA\(^{(1)}\). Expanding the time window for treatment up to 8 h after stroke onset should dramatically increase the number of patients that are eligible for recanalization therapy\(^{(11)}\). Moreover, mechanical embolectomy is particularly efficient in patients who are ineligible for thrombolysis or in whom thrombolytic therapy has failed.

Some patients present beyond 3 h after stroke or are ineligible to undergo IV or IA thrombolysis due to intracranial hemorrhage. In addition, acute distal ICA occlusion has a low rate of recanalization, even with endovascular treatment\(^{(8)}\). In such cases, some authors have suggested that microsurgical embolectomy is an alternative treatment option for major artery occlusion\(^{(8)}\). Microsurgical embolectomy has been performed sporadically for acute MCA occlusion since the late 1950s\(^{(1,3,8,10)}\). However, surgical embolectomy fell rapidly out of favor with the advent of chemical thrombolysis and the failure of the Extracranial–Intracranial Bypass Study Group trial\(^{(17)}\). However, more recent studies reported a moderate success using surgical embolectomy as a salvage procedure in patients in whom fibrinolytic therapy for embolic ischemic stroke failed\(^{(6,13)}\). In a series of 26 cases analyzed by Sakai et al., 14 patients underwent surgical embolectomy within 24 h after the onset of symptoms without any reported complications\(^{(13)}\).

To date, emergency surgical embolectomies performed as an ultimate treatment for large artery occlusion are considered rather aggressive and are, therefore, controversial, as there are only a few reported series of surgical embolectomies\(^{(3)}\). Etminan et al. suggested most of the prognostic factors after surgical embolectomy based on the review of the literature. These factors were occlusion time, collateral flow, occlusion site, and occlusion pathogenesis\(^{(3)}\).

Although some series of microsurgical embolectomy generally suggest a 6 h time window for surgical intervention\(^{(3,6,13)}\), studies of endovascular embolectomy performed up to 8 h after symptom onset in patients with acute arterial occlusion
demonstrated a significant reduction in mortality and morbidity after successful recanalization\(^4,16\). The majority of reports did not demonstrate a significant difference in surgical outcome between early (lesser than 6 h) or delayed (greater than 6 h) surgical embolectomy\(^3\). This most likely reflects the great heterogeneity within the reported patient populations, as patients also profit from surgical treatment beyond this time frame if they display good collateral flow on the initial angiography. In our study, although occlusion time was greater than 6 h in 5 patients, neurological improvement was achieved in 3 patients. Therefore, it should be emphasized that the occlusion time is not a definite limitation for surgical embolectomy.

Sufficient collateral flow, as evidenced in pretreatment angiography, seems to be a good predictor of positive outcome and infarct size\(^3,7\). Kakinuma et al.\(^7\) proposed a grading scale of MCT to assess collateral flow as a predictor of the outcome of microsurgical embolectomy. Although cohort MCT for microsurgical embolectomy for MCA occlusion did not predict the therapeutic effect of the procedure, the MCT in patients with medical treatment for MCA occlusion correlated with the incidence and extent of low-density areas on CT. The authors concluded that MCT can predict infarct size, the quantity of residual blood flow, and the clinical course in patients with MCA occlusion. Therefore, MCT might predict neurological outcome in microsurgical embolectomy, and good or moderate collateral flow should be considered as an important variable for decision making in microsurgical embolectomy. In our study, MCT was checked in 4 patients with MCA occlusion. It seemed that there was no significant relation between MCT and the surgical outcome of embolectomy. However, our sample size was small, and the result is not applicable to all patient populations. We also need to generate a more accurate grading system that can evaluate the collateral flow.

Patients with occlusion of the proximal M1 had significantly worse neurological outcomes than patients treated for M2 occlusion\(^6\). Etminan et al. stated that the only independent outcome predictor in surgical embolectomy was occlusion site\(^3\). Those authors assumed that patients with distal ICA and proximal M1 occlusion would probably have worse clinical outcome because of the increased number of perforating arteries at those sites. However, in our study, it seemed that there was no significant difference in surgical outcome between MCA and ICA occlusion, with the exception of the patient with ICA occlusion who died (case 6). Occlusion time in the ICA occlusion group was shorter than that observed in the MCA occlusion group (6.4 vs. 7.0 h). We cannot rule out the possibility that this occlusion time influenced the surgical results of the 2 groups. Prognosis seemed to be better in cases with a small admission time after the onset of symptoms. However, a larger sample size is also needed to supplement our cases. In our series, 1 patient died on the first postoperative day (case 6). She was the oldest patient in the series (79 years). Further, she had a history of many diseases and had been taking several medicines for many years. Her occlusion time was also relatively long. These disadvantageous factors might have contributed to the fatal surgical result.

It seems that patients with embolic occlusion of intracranial vessels that originated from atheromatous emboli of the aorta had a worse clinical outcome than patients with vessel occlusion that originated from fibrin–platelet clots\(^3,7\). Some authors explained this observation based on the more friable consistency and the increased risk of fragmentation of atheromatous emboli and subsequent emboli migration during intraoperative manipulation\(^3\).
Etminan et al. concluded that emergency embolectomy is effective and can achieve good recovery in patients via a review of the literature\(^3\). Kim et al. insisted that microsurgical embolectomy can be performed safely with lower morbidity for several reasons (even after intravenous or intra-arterial thrombolytic therapy)\(^8\): first, microsurgical embolectomy is not performed through the neural tissue; rather, it is performed through the subarachnoid space. The risk of procedure-related brain parenchymal hemorrhage is, therefore, very low. Second, recent advances in microsurgical techniques have made it possible to perform microsurgical embolectomy safely. Third, the conventional large skin-and-bone flap is not necessary in this procedure; microsurgical embolectomy can be performed through a minimal skin incision and craniotomy.

**CONCLUSION**

Emergency microsurgical embolectomy may be an alternative option for recanalization in selected patients with large-vessel acute ischemic stroke, especially in the case of failure of endovascular revascularization. Physicians should always pay attention to the types of hemodynamic changes that occur in acute ischemic stroke cases and be aware of the proper and rapid treatment options that are available among the various treatment modalities, which depend on the progress of the acute ischemic stroke. In addition, stroke care has become a multidisciplinary effort, via a collaboration between neurological, neurosurgical, radiologically, and critical-care teams. These improvements in care have resulted in greater access to stroke treatment and improvement in the outcome of patients with ischemic embolic stroke.

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