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Thrombolytic therapy for delayed, in-hospital stroke after cardiac surgery
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The endocardial RFA lesions develop progressively and were reported in animals 12 months after RFA [3]. The histopathologic mechanism of these lesions seems to be related to intimal hyperplasia of the endothelium of the exposed coronary artery with increased fibrous tissue formation in adventitia and media, caused by direct physical thermic effects of the RFA applications [3].

Development of coronary artery stenosis is considered to be a late complication of RFA [3]. The facts that the postoperative electrocardiogram was normal and that other coronary arteries remained normal in the second angiogram do reinforce this hypothesis. The electrical changes recorded perioperatively in some cases are likely to be related to transient thermic-induced irritability of the coronary artery leading to its spasm [3, 5]. Although risk factors that contribute to coronary artery involvement after RFA have yet to be defined, clinical and experimental data are needed to explain the mechanism of late coronary artery lesions. The proximity between the tip of the ablation probe and the coronary artery, as well as the cumulative energy exposure, might be considered risk factors [3].

Because of the fact that intraoperative RFA could be associated with serious complications, such as the one mentioned in this report, we believe the procedure should only be performed by trained and experienced surgeons. We have also modified our initial technique so that the RFA applications avoid causing a direct injury to the circumflex artery (Fig 1). We now perform one RFA application between the left pulmonary veins and the mitral annulus more distally over the atrioventricular groove after the terminal circumflex vessel has left the groove, thus avoiding the proximal part of the circumflex artery. In addition, using cold cardioplegia just before the RFA application, to minimize the thermic effect, seems to be a good tip for avoiding coronary artery injury. We have also changed the position of the second RFA application joining the isolation of the pulmonary veins to the anterior wall of the left atria to avoid any esophageal injury and reduced its power output to 100 W. We do not routinely perform angiography after intraoperative RFA, but it becomes a necessity in any patient presenting with angina after the procedure.

In conclusion, complications related to intraoperative RFA seem to be underreported and must be thought of. We believe that our modified technique of intraoperative RFA could help avoid serious complications such as coronary artery lesions and esophageal perforation.

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Thrombolytic Therapy for Delayed, In-Hospital Stroke After Cardiac Surgery

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Five patients who had delayed stroke after cardiac surgery underwent intraarterial administration of a fibrinolytic agent for thromboembolism (n = 4) or thrombosis (n = 1) of the cerebral artery. Complete recanalization of the occluded artery was obtained in 3 patients and partial recanalization in 2. Additional angioplasty for basilar artery stenosis was performed in 1 patient. No patients exhibited rebleeding into the pericardial space or wound bleeding. All patients survived with moderate or full functional recovery. Immediate cerebral angiography and local thrombolysis may improve functional outcome and survival in patients with postcardiotomy cerebral thromboembolism.

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Postoperative stroke is a devastating complication after cardiac surgery. Although the incidence is low, treatment of postoperative cerebral thromboembolism is challenging. We evaluated the results of aggressive strategy with early diagnosis and local administration of fibrinolytic agent for stroke after cardiovascular surgery.

We performed intraarterial thrombolysis for 5 in-hospital patients with delayed stroke after cardiovascular surgery. Stroke occurred 2 to 8 days (average, 6.8 ± 2.8 days) after surgery. All of these patients were free from neurologic deficits in the immediate postoperative period. Intracranial hemorrhage and completed cerebral infarction were

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excluded by computed tomography of the brain. Then cerebral angiography was performed immediately in all patients. Immediate cerebral angiography revealed cerebral embolism in 4 patients and cerebral thrombosis in 1 with occlusion of the major intracranial arteries. The average interval between onset of symptoms and cerebral angiography was 3.0 ± 0.7 hours (range, 2 to 4 hours) (Table 1). Local intraarterial administration of a thrombolytic agent through a catheter monitored by repeat angiography was carried out in all patients, and mechanical destruction of embolus was attempted in 1 patient. Recanalization of the occluded artery was obtained by intraarterial administration of urokinase in a total dose of 48 or 96×10^4 units. Complete recanalization of the occluded artery was achieved in 3 patients (60%) and partial recanalization in 2 (40%). Although a tiny hemorrhagic cerebral infarction, which had been detected by the computed tomography, occurred in 1 patient (patient 3), neurologic improvement was satisfactory. In patient 5, additional balloon angioplasty for residual stenosis of the basilar artery was performed 1 week after fibrinolytic therapy (Fig 1). Although 1 patient underwent resternotomy and refixation because of sternal dehiscence, no patients exhibited rebleeding into the pericardial space or wound bleeding. Blood transfusion was necessary in patient 5.

Almost full functional recovery was attained in 3 patients (60%) with complete recanalization and moderate disability remained in 2 patients (40%).

Comment

Acute occlusion of major cerebral arteries caused by thromboembolism induces large cerebral infarction accompanied by consequential severe, fatal swelling of the brain [1, 2]. Immediate restoration of cerebral blood flow within a short period after cerebral infarction may improve morbidity and mortality [3]. Intraarterial administration of a fibrinolytic agent has been shown to extend the window of therapy to 6 hours from onset of stroke. In the PROACT study, partial recanalization was significantly greater in a local administration of a pro-urokinase group than a placebo group, whereas the incidence of intracranial hemorrhagic deterioration was the same [4]. Several large series of patients treated by local thrombolysis with urokinase or tissue plasminogen activator reported complete or partial recanalization in 74% of the patients, higher than that of the intravenous administration, with a lower incidence of symptomatic intracranial hemorrhage than that reported for the intravenous thrombolysis [5]. These results suggest potential benefits and acceptable safety of intraarterial thrombolysis.

Use of fibrinolytic agents may induce hemorrhagic infarction, accompanied by acute expansion of the lesion and surrounding edema, resulting in functional deterioration and death. Interval between onset and reperfusion is an important predictor for hemorrhagic infarction.

Table 1. Clinical Findings of Patients

Patient/ Age/Sex	Surgery	Onset (Postoperative Day)	Onset Cerebral Angiography Interval (h)	Cerebral Angiography Findings	Dose of Urokinase	Cerebral Angiography Outcome	Complication	Additional Procedure	Disability
1/57/M	AVR + MVR	8	3	Left MCA embolus	48×10^4	CR	None	No	No
2/77/F	Double CABG	8	3	Left MCA embolus	96×10^4	CR	None	No	No
3/58/M	Double CABG	9	2	Left ICA embolus	96×10^4	PR	Hemorrhagic cerebral infarction	No	Moderate
4/64/F	Double OPCAB	2	3	Right ACA embolus	48×10^4	PR	None	No	Moderate
5/71/F	Triple CABG	7	4	Basilar artery thrombus	72×10^4	CR	Sternal dehiscence	PTA	Mild

ACA = anterior cerebral artery; AVR = aortic valve replacement; CABG = coronary artery bypass grafting; CR = complete recanalization; F = female; ICA = internal carotid artery; M = male; MCA = middle cerebral artery; MVR = mitral valve replacement; OPCAB = off-pump coronary artery bypass grafting; PR = partial recanalization; PTA = percutaneous transluminal angioplasty.

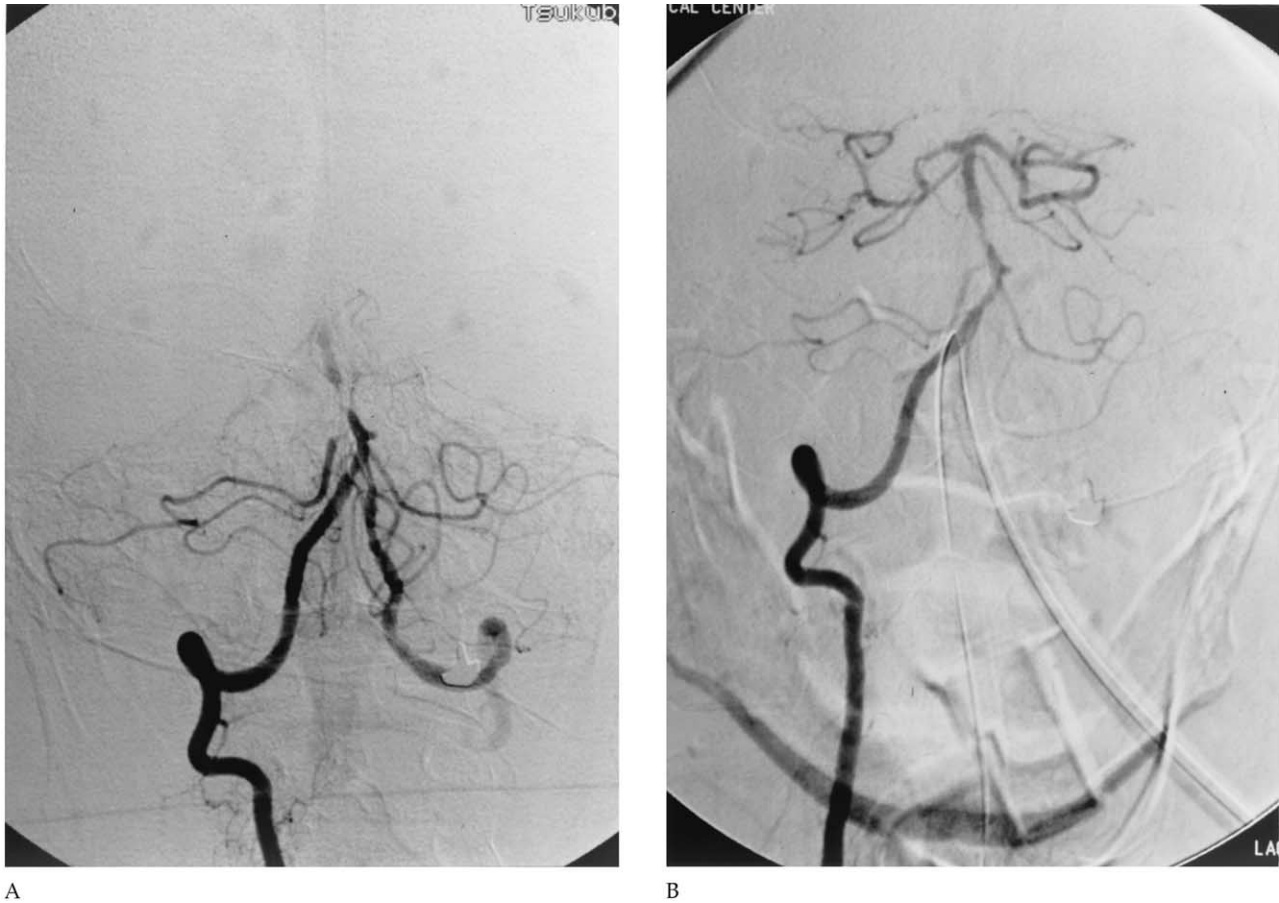


Fig 1. Cerebral angiogram in patient 5 (A) before local thrombolysis and (B) after local thrombolysis.

Because the interval between the onset and angiography was short in our patients, neurologic improvement was marked because of early recanalization of the occluded cerebral artery. Although 1 patient showed a small hemorrhagic infarction on computed tomography, brain swelling was minimal and moderate functional recovery was obtained.

Another concern of using a fibrinolytic agent is the risk of rebleeding from the surgical wound. Moazami and colleagues [6] reported the effectiveness of intraarterial thrombolysis in 13 cardiac surgery patients with recanalization and neurologic improvement rates of 46% and 38%, respectively, and no patient exhibited surgical wound rebleeding. In local thrombolysis, the dose of the fibrinolytic agent could be reduced to the minimum amount required to recanalize the target arteries. Direct intervention to the occluded cerebral artery is also possible when immediate cerebral angiography can be performed, as in patient 4. In patient 5, delayed additional angioplasty was also efficacious.

In conclusion, local thrombolytic therapy for cerebral thromboembolism may reduce mortality and improve

functional prognosis without serious complications in patients after cardiovascular operations.

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