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Clinical Analysis of STA-SCA Bypass for Vertebrobasilar Occlusive Disease

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OGAWA, A., YOSHIMOTO, T. and SAKURAI, Y. *Clinical Analysis of STA-SCA Bypass for Vertebrobasilar Occlusive Disease.* Tohoku J. Exp. Med., 1991, **164** (3), 183-190 —— In order to clarify the effectiveness of extracranial- intracranial bypass in cases of vertebro-basilar occlusive disease, we investigated the operative complication, clinical course and follow-up study of 30 cases undergoing superficial temporal artery - superior cerebellar artery (STA-SCA) bypass surgery. Postoperative angiogram showed the patency of the anastomosess in all cases. No serious surgical complications were observed. The outcome on discharge was excellent, with no morbidity and one mortality which was due to cardiac infarction. In the follow-up study, there were four cases with ischemic symptoms, two with transient ischemic attack and two with completed stroke, one of which was a supratentorial infarction due to internal carotid artery occlusion and the other was a small infarction of pons. There were also two deaths due to cardiac infarction and diabetes mellitus. Favorable outcomes were obtained for the remaining cases. The present study suggests that, STA-SCA bypass, can be performed without surgical and systemic complications and used as an effective therapy for vertebrobasilar ischemia. ———— cerebral infarction ; EC-IC bypass ; surgical complication ; vertebrobasilar insufficiency

Various surgical methods were performed for intracranial revascularization in cases of occlusive cerebrovascular diseases of vertebrobasilar arterial system. However, the arterial pedicle in surgical revascularization must be anastomosed to a vessel distal to the occlusive lesion. For this reason, superficial temporal artery (STA) to superior cerebellar artery (SCA) bypass is most suitable method not only for vertebral artery lesion but also distal basilar artery lesion. Therefore, STA-SCA bypass is most frequently used method and we used this method bypass as the first choice for posterior fossa revascularization. Recently, we have reported that this surgical method is effective in improving cerebral blood flow and metabolism. In this report, in order to clarify the effectiveness of stroke prevention and the surgical risk, the operative complications, clinical course and follow-

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up result were investigated.

Case Material and Methods

Case materials

Thirty patients who underwent STA-SCA bypass were studied. Twenty six were male and four were female. Ages ranged between 41 and 71 (mean$\pm$S.D$=$ 60$\pm$7.2). Symptoms observed were transient ischemic attack (TIA) in 9 cases, reversible ischemic neurological deficit (RIND) in 6 cases, progressive stroke in two cases and minor completed stroke (mCST) in 13 cases. The vascular lesions revealed by cerebral angiography were occlusion of the basilar artery (BA) in 2 cases, stenosis in 11 cases, bilateral occlusion of vertebral artery (VA) in 7 cases, stenosis in 2 cases, and unilateral VA occlusion with contralateral VA stenosis in 8 cases. The outcomes on discharge from hospital and in the follow-up was classified into four categories: (i) good (return to normal social life); (ii) fair (return to social life is impossible, but unassisted daily life is possible); (iii) poor (bedridden); and (iv) dead. Follow-up study was done and recurrence in ischemic symptoms were investigated.

Surgical indication

Surgical indication was determined as follows: (i) Cases in TIA, RIND, progressing stroke or mCST of the posterior circulation in which there were no symptoms or only mild symptoms of neurological deficits preoperatively; (ii) cases in which there were no large infarction in computed tomography (CT) and/or magnetic resonance imaging; (iii) cases in which the symptoms could be explained in terms of the stenosis or occlusion detected in the intracranial VA and/or BA by four vessel angiography, and (iv) cases in which the possibility of embolism due to a cardiac or major vessel lesion could be excluded. Angiographical indication was determined as follows :(i) cases in which there was occlusion or more than 70% stenosis of the BA; (ii) cases in which there was more than 70% stenosis of bilateral VA; (iii) cases in which there was more than 70% stenosis of unilateral VA with contralateral VA occlusion; and (iv) cases in which there were poor collateral with the anterior circulation via the circle of Willis.

Surgical method

With the exception of four cases in which the right STA could not be used as the donor due to arteriosclerosis or hypoplasia, the anastomosis was performed on the right side. The head was placed in a vertex down position such that the temporal base was perpendicular. A craniotomy was performed extending anteriorly from the central portion of the zygomatic arch and posteriorly to pyramidal ridge. The temporal base was drilled out until it was flat. Drainage veins from the temporal lobe were always preserved. In order to extent the operative field without retraction, a large gerform was placed between the middle fossa and the temporal lobe on both side. The tentorium was cut extensively along the pyramidal ridge. The SCA and the perforating arteries were then dissected and a rubber sheet was laid down. A collagen sheet was placed under the rubber sheet such that the operative field made as shallow as possible. Immediately before the temporary- occlusion of the SCA, 10 mg/kg of mannitol (20%), 10 mg/kg of vitamin E and 10 mg/kg of phenytoin (Suzuki et al. 1987; Uenohara et al. 1988; Yoshimoto et al. 1988) were administered. The anastomosis was done with 10-0 nylon, and two stay sutures with 7-8 stitches on each side were set.

Results

The outcome at the time of discharge from hospital was good for all patients

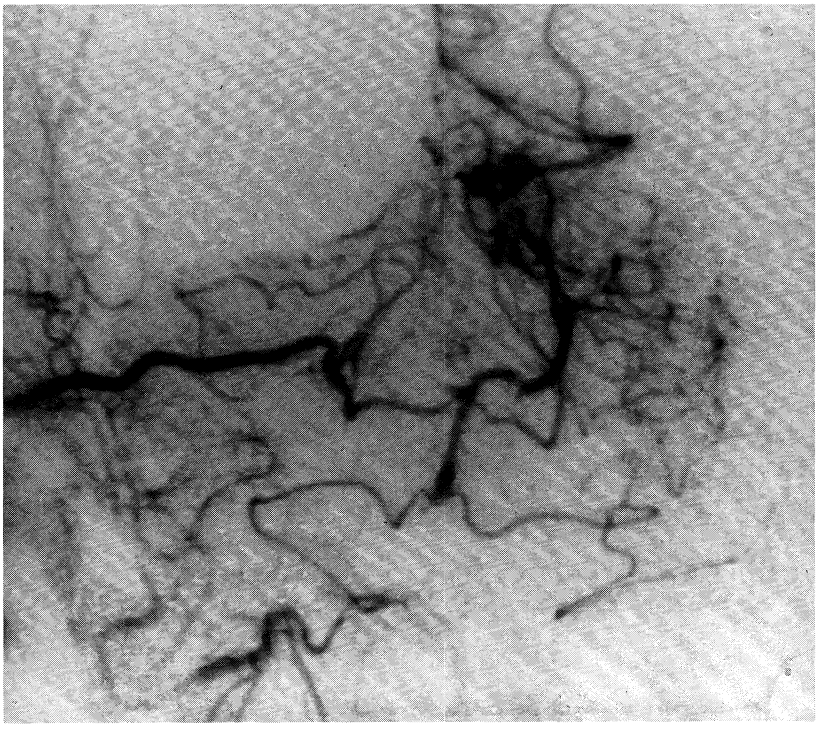

Fig. 1. Representative postoperative selective external carotid angiogram demonstrating patency of an superficial temporal artery to superior cerebellar artery anastomosis.

except one, who had been recovering well from the surgery but died of cardiac infarction prior to discharge (Table 1). There were no cases showing aggravation of neurological symptoms as a result of the surgery. In postoperative CT scans, three cases had subarachnoid hemorrhages confined to the crural cistern at the anastomosis. There were also 9 cases with diplopia due to the trochlear nerve palsy, but all were transient and recovered within 3 months. Three cases also had cerebrospinal fluid otorrhea, but improved without further treatment. There were no cases with swelling, edema or hematoma of the temporal lobe and postoperative angiography showed patency in all cases (Fig. 1).

Follow-up study was possible in all patients 6 to 74 months after surgery (mean of 32 months). The outcome was good in 25 cases, fair in one, poor in one, and two were dead. The deaths were due to a diabetic coma one year after surgery in one case and due to cardiac infarction 2 years and 5 months after surgery in the other case. The one fair case was due to the hemiparesis caused by small infarction of the pons 4 months after surgery. The one poor outcome was due to a supratentorial infarction caused by occlusion of the internal carotid artery (ICA) one year 3 months after surgery. Two of the 25 patients in good

TABLE 1. *Clinical summary of the patients treated by superficial temporal artery to superior cerebellar artery anastomosis*

Case			Symptom	Vascular lesion	Surgical complication	Patency	Outcome on discharge	Outcome in follow-up
1	51	M	TIA Prog.	blt. VA occl.	Transient IV palsy	Yes	G	G (6 y 3 m)
2	53	M	TIA Prog.	lt. VA occl. rt. VA sten. (95%)	SAH Transient IV palsy	Yes	G	G (4 y 11 m)
3	54	M	TIAs	blt. VA occl.		Yes	G	G (4 y 10 m)
4	45	M	TIAs mCST	proxy. BA sten. (80%)		Yes	G	G (4 y 10 m)
5	52	M	TIAs	proxy. BA occl.	CSF otorrhea	Yes	G	G (4 y 9 m) (TIA : 4 m)
6	56	M	RIND	proxy. BA sten. (80%)	Transient IV palsy	Yes	G	G (4 y 7 m)
7	58	F	TIA RIND	proxy. BA sten. (80%)		Yes	G	G (4 y 11 m)
8	65	M	mCSTs	mid BA sten. (80%)	Transient IV palsy	Yes	G	G (4 y 3 m)
9	69	F	TIAs	mid BA sten. (90%)	Transient IV palsy	Yes	G	G (4 y 1 m)
10	57	M	RIND mCST	proxy. BA sten. (70%)		Yes	G	G (3 y 11 m)
11	70	M	TIA	mid BA sten. (95%)	SAH	Yes	G	G (3 y 6 m)
12	53	M	TIA	lt. VA occl. rt. VA sten. (80%)	Transient IV palsy	Yes	G	G (3 y 6 m)
13	41	M	mCST	blt. VA occl.	Transient IV palsy	Yes	G	G (3 y 1 m) (TIA : 9 m)
14	60	M	mCST	blt. VA occl.	CSF otorrhea	Yes	G	G (2 y 8 m)
15	70	F	TIAs	mid BA sten. (90%)		Yes	G	G (2 y 5 m)
16	55	M	TIAs RIND	proxy. BA occl		Yes	G	G (2 y 4 m)
17	58	M	TIAs	lt. VA sten. (90%) rt. VA sten. (95%)		Yes	G	G (2 y 3 m)

18	67	M	RIND mCST	blt. VA occl	Transient IV palsy	Yes	G	G (2 y 3 m)
19	63	M	mCST	lt. VA sten. (70%) rt. VA occl.	CSF otorrhea	Yes	G	G (1 y 7 m)
20	60	M	TIA RIND	blt. VA occl	Transient IV palsy	Yes	G	G (1 y 5 m)
21	61	M	RINDs	lt. VA occl. rt. VA sten. (95%)		Yes	G	G (1 y 1 m)
22	61	M	mCST	blt VA occl.		Yes	G	G (11 m)
23	63	M	TIAs mCST	lt. VA sten. (90%) rt. VA occl.		Yes	G	G (6 m)
24	71	M	TIAs	lt. VA sten. (90%) rt. VA occl.		Yes	G	G (5 m)
25	59	M	Prog. mCST	lt. VA sten. (90%) rt. VA sten. (90%)	Transient IV palsy	Yes	G	G (4 m)
26	64	M	TIAs	lt. VA occl. rt. VA sten. (90%)		Yes	G	F (3 y 4 m) (CST : 3 m) (pontine infarction)
27	53	M	mCST	lt. VA occl. rt. VA sten. (90%)		Yes	G	F (2 y 6 m) (CST : 1 y 8 m) (ICA occl.)
28	66	M	mCST	proxy. BA sten. (70%)	SAH	Yes	G	D (2 y 3 m) (MI)
29	57	M	mCST	distal BA sten. (70%)		Yes	G	D (8 m) (DM)
30	57	M	RIND	proxy. BA sten. (95%)		Yes	D (MI)	—

M, male ; F, female ; TIA, transient ischemic attack ; RIND, reversible ischemic neurological deficit ; Prog., progressing stroke ; CST, completed stroke ; mCST, minor completed stroke ; lt., left ; rt., right ; blt., bilateral ; VA, vertebral artery ; BA, basilar artery ; occl, occlusion ; sten, stenosis ; SAH, subarachnoid hemorrhage ; CSF, cerebrospinal fluid ; MI, myocardial infaction ; DM, diabetes mellitus ; ICA, internal carotid artery ; G, good ; F, fair ; P, poor ; D, dead ; y, years ; m, months.

condition during the follow-up period experienced TIA, but the remaining 23 had no ischemic symptoms.

Discussion

For intracranial vascular reconstruction in cases of occlusive cerebrovascular diseases of the vertebro-basilar artery system, the possibilities of the usage of the STA or the occipital artery (OA) as a donor artery and the posterior cerebellar artery (PCA) (Sundt and Piepgras 1985), SCA (Ausman et al. 1979, 1982), anterior inferior cerebellar artery (AICA)(Ausman et al. 1981) or the posterior inferior cerebellar artery (PICA)(Khodadad 1981 ; Roski et al. 1982 ; Olteanu-Nerbe et al. 1985 ; Hopkins et al. 1987) as a recipient artery. A variety of surgical methods are therefore available depending upon the combination of vessels to be used (Ausman et al. 1990). However, AICA is a thin vessel and is inappropriate as a recipient. The OA-PICA bypass is suitable only for lesions lying the proximal VA from the PICA and its use is therefore infrequent (Khodadad 1981). Moreover, the incidence of atheroscrelosis on the PCA is high and the portion used for anastomosis lies deep, making this vessel somewhat unsuitable. For these reasons, STA-SCA bypass is a most frequently used method and we used this method as the first choice for posterior fossa revascularization (Ogawa et al. 1987).

In the follow-up study, the recurrence of ischemic symptoms was confirmed in four cases. Two were cases of completed stroke, one of which was a supratentorial infarction due to ICA occlusion (case 27, ref. Table 1) and the other was a small infarction of the pons (case 26). Other two were cases of TIA (cases 5 and 13). It has been reported that about one third of cases with vertebrobasilar TIA experience completed stroke within several years following TIA (Archer and Hornstein 1977 ; Cartlidge et al. 1977 ; Caplan 1983). And infarction occurred much more frequently in patient with vertebro-basilar ischemia compared to patients with carotid TIA. Although the follow-up period in the present study was relatively short, the only one case with small pontine infarction experienced an aggravation of symptoms due to the disorder of the posterior circulation and there was no cases of widespread infarction in the posterior fossa.

There were two deaths during the follow-up period, one of which was due to cardiac infarction and one of which was due to diabetes mellitus. Cardiac infarction is the most common cause of death in the natural course of vertebrobasilar ischemia and it is the most common systemic complication in vascular reconstruction in the posterior fossa (Cartlidge et al. 1977 ; Caplan 1983). These facts emphasize the importance of treating ischemic heart disease prior to surgery.

Hopkins and Budny (1989) collected previously reported cases (Ausman et al. 1984 ; El-Fiki et al. 1985 ; Sundt and Piepgras 1985 ; Hopkins et al. 1987) of STA-SCA and STA-PCA bypass and reported a high incidence of surgical complications — with a mortality rate is 14% and serious complications in 20%. They note that one of the frequent serious complications is hematoma and/or edema

caused by temporal lobe retraction. We use a surgical technique which minimizes the extent of temporal lobe retraction. That is, we put the temporal base perpendicular with the vertex down position and sufficiently drill out of the base. Veins are thereby preserved and a large gerform is laid down on both side of the operative field in the temporal base. The tentorium is cut extensively in order to make the operative field shallow. We have found that this technique prevent the emergence of serious operative complications.

Recently we have reported that this surgical method is effective in improving cerebral blood flow and metabolism (Ogawa et al. in press). We therefore conclude that STA-SCA bypass, which can be performed without operative and systemic complications, is an effective therapy for vertebrobasilar ischemia.

References

1) Archer, C.R. & Hornstein, S. (1977) Basilar artery occlusion: Clinical and radiological correlation. *Stroke*, **8**, 383-390.
2) Ausman, J.I., Lee, M.C., Chater, N. & Latchaw, R.E. (1979) Superficial temporal to superior cerebellar artery anastomosis for distal basilar artery stenosis. *Surg. Neurol.*, **12**, 277-282.
3) Ausman, J.I., Diaz, F.G., de los Reyes, R.A., Pak, H., Patel, S. & Boulos, R. (1981) Anastomosis of occipital artery to anterior inferior cerebellar artery for vertebrobasilar junction stenosis. *Surg. Neurol.*, **16**, 99-102.
4) Ausman, J.I., Diaz, F.G., de los Reyes, R.A., Pak, H., Patel, S., Mehta, B. & Boulos, R. (1982) Posterior circulation revascularization. Superficial temporal artery to superior cerebellar artery anastomosis. *J. Neurosurg.*, **56**, 766-776.
5) Ausman, J.I., Diaz, F.G., de los Reyes, R.A., Pearce, J.E. & Shrontz, C.E. (1984) Extracranial-intracranial anastomosis in the posterior circulation. In: *Vertebrobasilar Arterial Occlusive Desease. Medical and Surgical Management*, edited by R. Berguer & R.B. Bauer, Raven Press, New York, pp. 313-319.
6) Ausman, J.I., Diaz, F.G., Vacca, D.F. & Sadasivan, B. (1990) Superficial temporal and occipital artery bypass pericles to superior, anterior inferior, and posterior inferior cerebellar arteries for vertebrobasilar insufficiency. *J. Neurosurg.*, **72**, 554-558.
7) Caplan, L.R. (1983) Bilateral distal vertebral artery occlusion. *Neurology*, **33**, 552-558.
8) Cartlidge, N.E.F., Whisnant, J.P. & Elveback, L.R. (1977) Carotid and vertebral-basilar transient cerebral ischemic attacks. A community study, Rochester, Minnesota. *Mayo Clin. Proc.*, **52**, 117-120.
9) El-Fiki, M., Chater, N.L. & Weinstein, P.R. (1985) Extracranial-intracranial arterial bypass for vertebrobasilar insufficiency. In: *Cerebral Revascularization for Stroke*, edited by R.F. Spetzler, L.P. Carter, W.R. Selman & N.A. Martin, Theme-Straton, New York, pp. 483-489.
10) Hopkins, L.N. & Budny, J.L. (1989) Complications of intracranial bypass for vertebrobasilar insufficiency. *J. Neurosurg.*, **70**, 207-221.
11) Hopkins, L.N., Martin, N.A., Hadley, M.N., Spetzlar, R.F., Budny, J. & Carter, L.P. (1987) Vertebrobasilar insufficiency. part 2: Microsurgical treatment of intracranial vertebrobasilar disease. *J. Neurosurg.*, **66**, 662-674.
12) Khodadad, G. (1981) Short- and long-term results of microvascular anastomosis in the vertebrobasilar system, a clinical analysis. *Neurol. Res.*, **3**, 33-65.
13) Ogawa, A., Sakurai, Y., Kayama, T., Sato, S. & Suzuki, J. (1987) Revascularization for vertebro-basilar occlusive disease. In: *Controversies in EIAB for Cerebral Is-*

chemia, edited by R. Gagrialdi & L. Benbenuti, Mondzzieditore, Berogna, pp. 489-498.
14) Ogawa, A., Kameyama, M., Muraishi, K., Yoshimoto, T., Ito, M. & Sakurai, Y. Cerebral blood flow and metabolism following STA-SCA bypass for vertebrobasilar occlusive disease. *J. Neurosurg.*, in press.
15) Olteanu-Nerbe, V., Schimidek, P. & Marguth, F. (1985) Extra-intracranial bypass surgery for vertebrobasilar insufficiency due to obstructive vertebral artery and vertebral-basilar artery junction disease. *Neurol. Res.*, **7**, 93-97.
16) Roski, R.A., Spetzler, R.F. & Hopkins, L.N. (1982) Occipital artery to posterior inferior cerebellar artery bypass for vertebrobasilar ischemia. *Neurosurgery*, **10**, 44-48.
17) Sundt, T.M., Jr. & Piepgras, D.G. (1985) Extracranial intracranial bypass grafting: Posterior circulation. In: *Neurosurgery*, edited by R.H. Wilkins & S.S. Rengachary, McGraw-Hill, New York, pp. 1281-1292.
18) Suzuki, J., Abiko, H., Mizoi, K., Oba, M. & Yoshimoto, T. (1987) Protective effect of phenytoin and its enhanced action by combined administration with mannitol and vitamin E in cerebral ischemia. *Acta Neurochir.*, **88**, 56-64.
19) Uenohara, H., Imaizumi, S., Suzuki, J. & Yoshimoto, T. (1988) The protective effect of mannitol, vitamin E and glucocorticoid on ischemic brain injury: Evaluation by chemiluminescence, energy metabolism and water content. *Neurol. Res.*, **10**, 73-83.
20) Yoshimoto, T., Ogawa, A. & Suzuki, J. (1988) Acute stage revascularization under administration of new cerebral protective agent "Sendai Cocktail". In: *Advances in Surgery for Cerebral Stroke*, edited by J. Suzuki, Springer-Verlag, Tokyo, pp. 559-562.