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Evaluation of Cerebral Reserve Capacity with Acetazolamide Test on Internal Carotid Occlusive Lesions

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Abstract Cerebral blood flow and cerebral vascular reserve were measured using a stable xenon enhanced computed tomography (Xe-CT) with acetazolamide test. Five normal male adults and ten male patients with occlusive lesion of internal carotid artery were studied. Vascular reserve was 18 ± 13 ml/100g/min in the normal control, and 10 ± 10 ml/100g/min in the affected side of the patients. Vascular reserve tended to be lower in the affected side than in the normal control. In the patient with "steal phenomenon", vascular reserve increased after the bypass surgery. Xe-CT with the acetazolamide test is useful to identify candidates for bypass surgery.

Key Words : Cerebral vascular reserve, Cerebral blood flow, Acetazolamide, Cerebral ischemia

Introduction

Multicenter cooperative studies have failed to identify cases in which bypass procedures have improved the clinical outcome, so it has become important to find ways of selecting proper candidates for bypass surgery¹⁾. Acetazolamide (Diamox[®]) is a potent cerebral vasodilator and is useful in evaluating vascular reserves (Diamox test)²⁾. The purpose of this study is to evaluate the Diamox test for identifying candidates for bypass surgery.

Material and Methods

Cerebral blood flow (CBF) was measured using a stable xenon-enhanced CT method (Xe-CT) before and after intravenous administration of 1 gm of Diamox. The Xe-CT consists of Siemens medical CBF imaging software with a Somatom

DR 3 CT scanner. The CBF of the middle cerebral arterial region was evaluated one month after an ischemic attack or operation. We studied five normal male adults averaging 31 years, five males averaging 52 years with occlusion of internal carotid artery (ICA) and five males averaging 60 years with stenosis of ICA (Table 1). There was one asymptomatic patient, two with transient ischemic attacks (TIA), three with a reversible ischemic neurological deficit (RIND), and four with minor stroke. Surgery was applied in two superficial temporal artery-middle cerebral artery anastomoses, two carotid endarterectomies, and one vein graft bypass.

Results

Diamox increased CBF (ml/100g/min) from 65.3 ± 12.0 to 83.7 ± 12.9 (Δ CBF 18 ± 13) in the normal control (n=10), from 47.8 ± 8.9 to 57.7 ± 12.7 (Δ CBF 10 ± 10) in the affected

side of the patients with occlusive lesion of the ICA (n=10), and from 48.0 ± 13.2 to 61.2 ± 10.6 (Δ CBF 13 ± 9) in the contralateral side (Table 1). The increase was statistically significant in each group ($p < 0.02$), and there was no significant difference among these groups. The Diamox reactivity tended to be lower in the affected side than in the normal control. In one patient with the "steal phenomenon", the CBF decreased from 48.3 to 39.2 in the affected side and increased from 49.7 to 58.1 in the contralateral side after Diamox loading (Fig.1).

In the operation group (n=5), the preoperative Diamox test showed that the CBF of the affected side increased from 47.2 ± 7.6 to 54.4 ± 13.9 and contralaterally from 46.9 ± 9.4 to 61.1 ± 11.9 . Postoperatively the CBF before and after Diamox loading was 44.2 ± 13.2 and 53.2 ± 6.6 in the affected side, and 46.3 ± 13.0 and 61.2 ± 13.6 contralaterally. There was no significant difference between the preoperative reactivity and the postoperative reactivity. In the "steal phenomenon" case the CBF increased from 45.1 to 61.3 in the affected side and from 52.8 to 78.6

contralaterally, according to the postoperative Diamox test (Fig.1). The grasping power improved from 15kg to 25kg.

Discussion

In the early stage of bypass surgery, a postoperative increase in the resting CBF of the ischemic brain was expected. But it was observed only in selected patients³. In general, the resting CBF was not significantly changed by the operation², so several authors have recently used the loading tests of hypotension, CO₂ inhalation and acetazolamide administration^{2,4,5}.

Acetazolamide inhibits the action of carbonic anhydrase, which induces tissue acidosis with resultant cerebrovascular dilatation. In a past report, the mean CBF increased about 30% from the resting CBF after an intravenous dose of 1g acetazolamide². In our normal control, the CBF increased about 28%.

Vorstrup et al. used the acetazolamide test to select cerebrovascular-insufficient patients for bypass surgery². They reported

Table 1 Summary of 10 patients with internal carotid arterial occlusive lesion

Case No.	Age	Sex	Clinical Diagnosis	Cerebral Blood Flow (ml/100g/min)								Operative Methods	Clinical Result
				Preoperative state				Postoperative state					
				Affected		Contralat.		Affected		Contralat.			
				Rest	DIAMOX	Rest	DIAMOX	Rest	DIAMOX	Rest	DIAMOX		
Stenosis group													
1	60	M	min st	48.3	39.2	49.7	58.1	45.1	61.3	52.8	78.6	STA-MCA	improve
2	69	M	TIA	34.7	42.9	38.2	44.3	33.8	51.5	31.4	47.9	CEA	unchange
3	50	M	RIND	50.7	52.6	44.7	58.3	42.4	48.7	39.9	47.0	CEA	unchange
4	56	M	min st	50.3	61.0	46.5	58.7	—	—	—	—	—	—
5	63	M	min st	55.0	67.2	61.8	70.6	—	—	—	—	—	—
Occlusion group													
6	51	M	TIA	47.2	70.0	40.2	74.4	33.9	45.9	42.1	63.3	STA-MCA	unchange
7	51	M	min st	53.8	78.8	62.1	71.5	66.0	58.7	65.2	68.7	Vein graft	improve
8	28	M	asympt	62.6	65.1	67.8	72.7	—	—	—	—	—	—
9	59	M	RIND	39.2	50.6	34.1	54.0	—	—	—	—	—	—
10	58	M	RIND	35.8	49.8	34.4	49.2	—	—	—	—	—	—

CBF of normal control group (n=10) increased from 65.3 ± 12.0 to 83.8 ± 12.9 by acetazolamide 1g I.V.

CBF was measured in the middle cerebral arterial region.

RIND : reversible ischemic neurological deficit

min st : minor stroke TIA : transient ischemic attack

asympt : asymptomatic CEA : carotid endarterectomy

STA-MCA : superficial temporal artery-middle cerebral artery

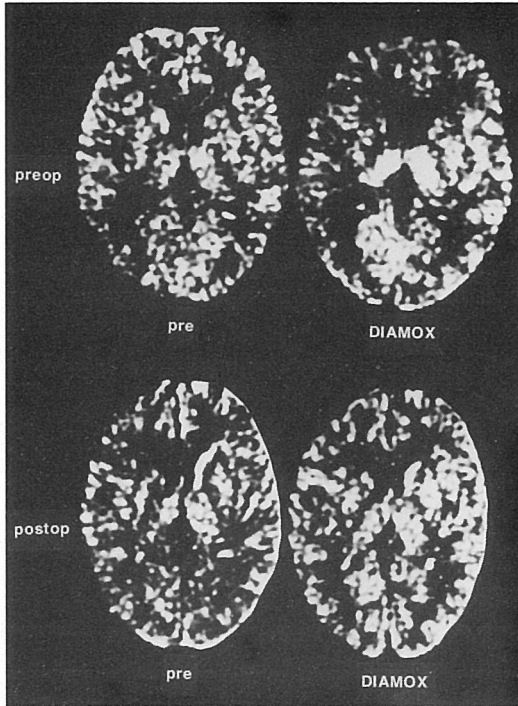


Fig. 1 A 60 y.o. man suffered minor stroke with motor aphasia and right hemiparesis due to a severe stenosis of left ICA. Double STA-MCA anastomoses were performed at the chronic stage. In Xe-CT, preoperative resting flow was within normal range but the Diamox test revealed "steal phenomenon" (upper). After bypass, right hemiparesis improved while "steal phenomenon" disappeared (lower).

that acetazolamide increased the side-to-side asymmetry of CBF in selected patients, and the asymmetry reduced after bypass surgery. Schmiedek et al. also reported that a small preoperative cerebrovascular reserve capacity (CRC), indicated by the acetazolamide test, improved postoperatively while preoperative high CRC was unchanged⁹. These results were not supported in our study, significantly.

In our study, the vascular reserve in the affected by occlusive ICA lesions was statistically good. For this reason, there was no significant change before and after the by-

pass surgery. But the vascular reserve varied in individual cases, and there was one "steal phenomenon" case. The reserve of this patient increased after the bypass surgery. The result agreed with the result reported by Vorstrup et al. that the only patients with a "steal phenomenon" improved in focal CBF after bypass surgery²).

Thus the acetazolamide test can detect a difference of vascular reserve. When there are large numbers of patients who should be graded by the acetazolamide test, patients with some ranges of reactivity, for example, "steal phenomenon" should be selected for bypass surgery.

In conclusion, Xe-CT with the acetazolamide test can identify candidates for bypass surgery.

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