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Morphological and Clinical Analysis of Extra-Intracranial Bypass

1. Clinical and Angiographical Analysis

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Summary. In this morphological-clinical analysis it was possible to study the clinical and angiographical results of extra-intracranial bypass in a continued series. Small changes in management result from the indications in the groups with TIA's and completed strokes. Preoperative angiographical findings allow determination of the most favourable bypass-feeder taking into consideration age and morphology. From the postoperative dilatation of the donor artery conclusions may be drawn as to the indication for operation with respect to the angiogram and the choice of the branch of the superficial temporal artery.

Key words: Arterial bypasss - STA-MCA anastomoses – Superficial temporal artery - Angiographical study - Clinical analysis

Introduction

There are some controversies on the effect of extracranial-intracranial arterial bypass, especially on the criteria for the selection of the patients suitable for this surgery [1, 2, 8, 9]. Indications for this surgery arose from the types of clinical manifestations, angiographical and regional cerebral blood flow studies [1, 2]. One of the purposes of this report is to analyse the clinical cases selected by such criteria and to explore any further criteria indicating this surgery. The superficial temporal artery is commonly used as the donor artery for this operation because of its anatomical feasibility [2, 6]. We usually obtain anatomical information on this artery from preoperative angiographical examination. In spite of large numbers of operations, there have been few studies centered on the use of this artery point [5, 6]. In this paper we report on the morphological features of this artery on preoperative angiograms and the quality of postoperative bypass func-

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Table 1. Age distribution

	21–30 years	31–40 years	41–50 years	51–60 years	61–70 years	Total	Average age[a]
Male	1	3	9	16	7	36	51.7± 9.4 SD
Female	2	3	1	3	1	10	42.9±14.5 SD
Total	3	6	10	19	8	46	49.8±11.1 SD

[a] Significant difference between male and female ($P<0.05$)

Table 2. Preoperative angiographical diagnosis

Age group		MOS	BICO	ICO	ICS	MCO	MCS	MCB	WNL
Y	9	2	0	2	2	0	1	1	1
M	29	5	5	10	2	1	2	1	3
O	8	1	1	3	0	0	0	1	2
Total	46	8	6	15	4	1	3	3	6

BICO: Bilateral internal carotid occlusion
ICO: Internal carotid occlusion
ICS: Internal carotid stenosis
MCO: Middle cerebral occlusion
MCS: Middle cerebral stenosis
MOS: Multiple vessel occlusions and/or stenoses
MCB: Middle cerebral branch occlusion
WNL: Within normal limits

tion in patients with superficial temporal artery-middle cerebral artery (STA-MCA) anastomosis with special reference to change in the diameter of the donor artery.

Clinical Material and Methods

The series studied for this work consists of 46 patients operated on in the Neurosurgical Department, University of Munich, during 10 months between January and October 1977. These patients were elected by our own criteria [1, 2]. Transient ischemic attack (TIA), prolonged reversible-ischemic neurological deficit (PRIND) and completed stroke (CS) with mild neurological deficits were indicated for this surgery from the types of clinical manifestations. We operated on 36 men and 10 women with an average age of 52 and 43 years respectively (Table 1). They were divided into three age groups, "young" (under 40-years-old), "middle-aged" (41 to 60) and "old" (over 61). The preoperative angiographical examination showed an internal carotid occlusion in one third of the cases. It was remarkable that another third of the patients had several alterations in cerebral vessels, although no significant accumulation of multiple alterations of vessels could be observed in the older age group.

The statement (Table 2) "within normal limits" means that angiographically there were no significantly localized alterations of vessels in the sense of hemodynamically acting stenoses or occlusions. Together with the measurement of brain perfusion, which showed disturbance of blood supply in one cerebral hemisphere, we have previously explained the angiographical

Table 3. Type of clinical manifestation

Age group		TIA	PRIND	CS
Y	9	5	2	2
M	29	6	16	7
O	8	2	2	4
Total	46	13	20	13

TIA Transient ischemic attack
PRIND Prolonged reversible ischemic neurological deficit
CS Completed stroke

Table 4. Symptomalogical analysis

Age group		Hemiparesis and/or hemi-hypesthesia (H)	Aphasia (A)	H+A	Others
Y	9	3	1	4	1
M	29	8	0	16	5
O	8	3	1	3	1
Total	46	14	2	23	7

Table 5. Number of cerebral ischemic attacks

Age group		1	2	3	Over 4
Y	9	1	7	0	1
M	29	9	11	4	5
O	8	4	2	0	2
Total	46	14	20	4	8

examination [1, 2] such that the hemodynamic assessment prevailed over the angiographical analysis. The clinical signs of the cerebrovascular disease (Table 3) were divided in TIA, PRIND and CS. In this series we did not operate on patients presenting with stroke in evolution or after CS with severe neurological deficit. Younger and middle-aged patients usually presented with TIA or PRIND symptoms whereas patients in advanced age presented more often with stroke together with mild neurological deficit. Analysis of the symptomalogy (Table 4) showed that often the typical stroke symptoms of hemiparesis and aphasia lead to other invasive diagnostic methods and raised the question as to whether surgery would be adequate. The elaboration of these cases with respect to the number of cerebral ischemic attacks prior to the introduction of adequate examination (Table 5) indicates the harmlessness with which the initial signs of stroke are still met. Less than one third of the patients presented with only one cerebral ischemic attack, therefore it is especially significant that, younger patients will have been asked for a thorough history only after the second stroke symptoms have occurred. Consequently, the interval between the appearance of the neurological deficit

Table 6. Interval from onset of neurological deficit to operation (32 days–15 years)

Age group		Months				
		2–3	4–6	7–12	Over 12	Unknown
Y	9	3	3	1	2	0
M	29	8	10	6	4	1
O	8	2	3	2	1	0
Total	46	13	16	9	7	1[a]

[a] Gradual onset

Table 7. Risk factors

Age group		Hyper-tension (%)	Arterio-sclerosis (%)	Hyper-lipidemia (%)	Diabetes mellitus (%)	Abnormal ECG (%)
Y	9	4[a]	3[a]	3	0	4
		(44)[b]	(33)[b]	(33)	(0)	(44)
M	29	20	22	11	5	16
		(69)	(76)	(38)	(17)	(55)
O	8	3	6	4	1	7
		(38)	(75)	(50)	(13)	(88)
Total	46	27	31	18	6	27
		(59)[b]	(67)[c]	(39)	(13)	(59)

[a] One renal hypertension
[b] Statistically significant correlation with abnormal ECG ($P<0.05$)
[c] Statistically significant correlation with hyperlipidemia ($P<0.05$)

and surgery (Table 6) is often very long. Nevertheless, 29 patients (63%) were operated upon within 6 months of the beginning of the symptoms.

Risk factors for arteriosclerotic changes (Table 7) were evenly distributed among these patients. In the middle-aged patients an increased incidence of hypertension could be observed, further signs of severe general arteriosclerosis in patients of middle or older age and particularly a regular and severe alteration of the ECG in older patients could also be noted. Changes in metabolism as a risk factor in these patients were negligible. Nineteen bypass operations have been effected in the right cerebral hemisphere, 20 in the left cerebral hemisphere and 7 were bilateral (Table 8). In 36 patients we used the parietal branch as a bypass-feeder and in 17 patients the frontal branch (Table 9).

The superficial temporal artery (STA) commonly divides into two main branches. Using the lateral view of angiograms, we classified STA into five types according to their branching level, low (L), middle (M), high (H), parietal (P) and frontal (F) types as shown in Fig. 1. The M type was defined so that the branching level of STA be situated within 5 mm perpendicular to the planum sphenoidale or its extension line, where we could most easily palpate STA transcutaneously. When STA branched more than 5 mm above or below this line, it was designated H type or L type, respectively. When one of the branches of STA was hypoplastic, namely less than 0.5 mm in diameter at its origin, it was designated P type or F type, according to which was the dominant branch.

Table 8. Side of operation

Age group		Right	Left	Bilateral
Y	9	6	2	1
M	29	10	13	6
O	8	3	5	0
Total	46	19	20	7

Table 9. Branch of STA used for anastomosis

Age group (patients)			Parietal branch	Frontal branch
Y	10	(9)	10	0
M	35	(29)	19	16
O	8	(8)	7	1
Total	53	(46)	36	17

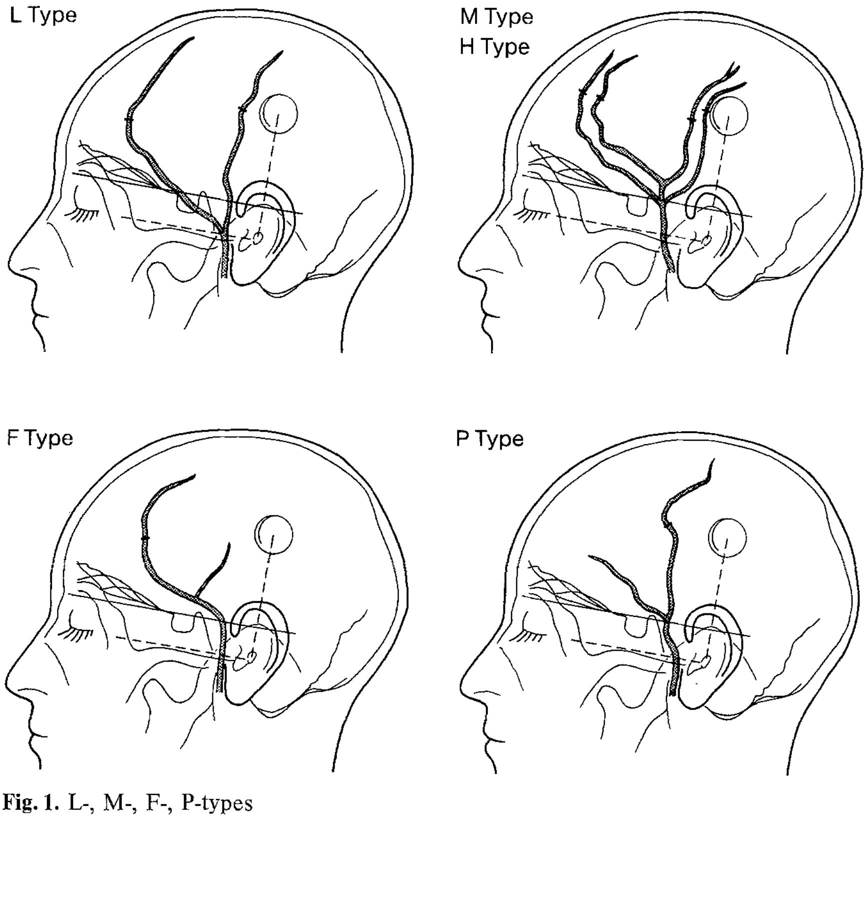


Fig. 1. L-, M-, F-, P-types

Table 10. Comparison of neurological status (I)

Preoperative status		Postoperative result		
		Asymptomatic (%)	Improved (%)	Unchanged (%)
TIA	8	6	0	2
		(75)	(0)	(25)
PRIND	12	7	3	2
		(58)	(25)	(16)
CS	9	0	7	2
		(0)	(78)	(22)
Total	29	13	10	6
		(45)	(34)	(21)

The diameter of the STA was measured with the aid of a micromeasure with a 0.2 mm scale and a magnifying glass on preoperative and postoperative angiographical lateral view films dipicting the STA most clearly. The diameter of STA was measured at two different sites, at its intersection with the planum sphenoidale or its extension, and at a preestimated level just proximal to the portion where anastomosis would be performed (Fig. 1). The absolute real value of the diameter was calculated using the magnification ratio of the angiogram.

The diameter of the parietal branch where it intersects this line was designated D_{p1}, of frontal branch D_{f1} and of nonbifurcated stem artery D_{s1}. The distal was the site where each branch would be anastomosed, 5 cm above external acoustic canal on the line perpendicular to orbitomeatal line (Fig. 1). Diameters of the parietal branch, frontal branch and stem artery were expressed as D_{p2}, D_{f2}, and D_{s2} respectively. When the difference in diameter of the two STA branches was over 0.1 mm at the distal site, STA were designated as "frontal dominant" or "parietal dominant" according to the dominancy in diameter.

Postoperatively angiographical findings were available in 18 patients. Since STA-MCA anastomoses were performed bilaterally in 3 of them, 21 anastomoses were performed altogether. These postoperative control angiographies were performed on the 21 anastomoses, 6 to 12 months after surgery. The bypass function of STA-MCA anastomosis was assessed on the basis of postoperative angiographical findings as follows: bypass function was designated as "good" when sufficient flow through the bypass in more than 2 branches of the middle cerebral artery was depicted on the angiogram, as "poor" when little filling of the cortical branches was depicted in 1 to 2 branches and as "none" when no filling through the bypass was shown in the cortical branch.

In the study of preoperative to postoperative diameter changes of donor arteries, the magnification ratio of angiography was corrected using the distance between tuberculum sellae and torcular as a calibration length on a lateral view film. The change of diameter of STA was expressed as the dilatation ratio: the ratio of the postoperative to preoperative diameter of the STA branch, both measured at the same point.

Results of STA-MCA Bypass

In 29 patients we could effect a control with respect to the early postoperative phase 6 months after the bypass (Table 10). The criteria for this evaluation have been described earlier [1, 2, 3]. The improvement means improvement of a paresis for more than one degree. In these very strictly selected patients,

Table 11. Comparison of neurological status (II)

Age group		Postoperative result		
		Asymptomatic (%)	Improved (%)	Unchanged (%)
Y	8	5	1	2
		(63)	(13)	(25)
M	15	6	5	4
		(40)	(33)	(27)
O	6	2	4	0
		(33)	(67)	(0)
Total	29	13	10	6
		(45)	(34)	(21)

Table 12. Postoperative neurological status and bypass function

Bypass function		Neurological status		
		Asymptomatic	Improved	Unchanged
No	1	0	0	1 (PRIND × 1)
Poor	4	2 (TIA × 2)	0	2 (PRIND × 1, TIA × 1)
Good	13	7[a] (TIA × 3, PRIND × 4)	5[a] (PRIND × 1, CS × 4)	1 (CS × 1)
Total	18	9	5	4

[a] Each one was operated on bilaterally

especially with respect to CS, we now have an improvement of the symptoms or an asymptomatic course in the majority of the cases. In the mild deficits after CS an astonishing improvement rate of 78% could be noted. After TIA we saw the expected asymptomatic course in only 6 out of 8 cases, whilst 2 patients continued to have attacks. We will return to this point in the discussion. If we relate the neurological course to the age of the patients (Table 11) again the group of old patients is surprising since they showed a favourable outcome without any further symptoms of their cerebral perfusion disturbance or with improved pareses. In spite of an angiographically rather poor bypass the functional effect in young patients was also favourable with a mostly asymptomatic course. Comparing the angiographical bypass function with the postoperative clinical course naturally nothing could be changed in the state of the patient if the bypass was not functioning (1 patient out of the PRIND group). With a moderately filled bypass an asymptomatic outcome was obtained twice in TIA, whereas PRIND or TIA symptoms were followed up in two patients. In the good bypass group excellent outcome in TIAs and PRIND were observed, even the majority of the patients with CS and mild deficits showed an improvement of the symptoms (Table 12).

Table 13. Branching level of STA

Age group		Branching			No branching	
		H type (%)	M type (%)	L type (%)	F type (%)	P type (%)
Y	12	6 (50)	3 (25)	3 (25)	0	0
M	43	6 (14)	6 (14)	24 (56)	3 (7)	4 (9)
O	11	4 (36)	1 (9)	6 (55)	0	0
Total	66	16 (24)	10 (15)	33 (50)	3 (5)	4 (6)

Table 14. Combination of the type of branching level of bilateral STA in 22 patients

Combination of the type of branching level of STA	No. of cases
Symmetrical cases	11
L-L	8
M-M	2
H-H	1
Asymmetrical cases	11
L-H	4
L-M	3
M-H	1
No branching unilaterally	3

Results of Preoperative Analysis of STA

The result of the classification by branching level of STA is shown in Table 13. Over the entire group and in the middle-aged and old groups L type was the most common, while H type was the most common in the young group. In 7 (11%) of 66 STAs we had no branching type. Branching levels of bilateral STAs were compared in 22 cases (Table 14). In 11 cases the bilateral STAs belonged to the same type of branching; the other 11 cases had different types of STA branching levels. L-L type combination was most common. Of 8 cases with L-L type 7 belonged to the middle-aged group and the remaining 1 to the old group. The results of the study on the dominancy of branches of STA in 60 angiograms is shown in Table 15. No correlation was found between the age of patients and the dominancy of branch of STA. In each age group most STAs belonged equally to both proximal and distal levels. The diameters of two kinds of branches of STA were compared at distal levels. Frontal dominancy was noticed in the middle-aged and old groups. Table 16 shows the results of quantitative comparison of diameters of parietal branch and frontal branch. No statistically significant correlation was found between the diameter of either branches and age group. The diameter change of the parietal and frontal branches of STA along their course toward

Table 15. Comparison of diameters of two branches of STA

Age group		Parietal branch dominant (%)	Frontal branch dominant (%)	Equal[a] (%)
Y	12	5	2	5
		(42)	(17)	(42)
M	37	5	14	18
		(14)	(38)	(49)
O	11	1	3	7
		(9)	(27)	(64)
Total	60	11	19	30
		(18)	(32)	(50)

[a] Diameter difference of frontal and parietal branches

Table 16. Comparison of diameters of two branches of STA on their distal part

Age group		Parietal branch ± SD (mm)	Frontal branch ±SD (mm)
Y	12	1.2 ± 0.3	1.0 ± 0.4
M	39	1.1 ± 0.5	1.2 ± 0.5
O	11	1.1 ± 0.3	1.3 ± 0.4
Total	62	1.1 ± 0.4	1.2 ± 0.4

peripheral sites were studied using the percentage decrease in diameter expressed as $(D_{p1}-D_{p2}) \times 100/D_{p1}$ for the parietal branch, and $(D_{f1}-D_{f2}) \times 100/F_{f1}$ for the frontal branch. These results are shown in Table 17 with data of statistical analysis. The decrease rate of the parietal branch in H and M types of STA was larger than that in L type, and this difference was statistically significant (middle-aged group $P<0.001$, total $P<0.01$). The correlation between branching level and rate of decrease was not statistically significant for the frontal branch. In each type of branching level the rate of decrease in the old group was greater in the parietal branch than in the frontal branch, whereas in the young group it was greater in the frontal branch than in the parietal branch. The rate of decrease in the frontal branch was greater in the younger group in each type of branching level, while the decrease rate of the parietal branch was greater in the old group than that in the young group. These differences between age groups of the patients were not however statistically significant. The preoperative diameters of STA branches used for anastomoses were compared with those not used for anastomoses at the distal site of their course (Table 18). On both parietal and frontal branches, the branches chosen for anastomosis were much thicker than those not used for anastomosis ($P<0.001$ in parietal branch, $P<0.005$ in frontal

Table 17. Percentage decrease in diameter of StA in angiography

Age group	Parietal branch			Frontal branch		
	H plus M	L	P	H plus M	L	F
Y	$n=8$	$n=3$		$n=9$	$n=3$	
	26±15	14±21		34±28	27±20	
M	$n=12$	$n=20$	$n=4$	$n=12$	$n=20$	$n=3$
	44±22	19±26	20±14	25±23	26±17	45±32
O	$n=4$	$n=7$		$n=4$	$n=5$	
	33± 9	21±10		21±16	11±18	
Total	$n=24$	$n=30$		$n=25$	$n=28$	
	36±20	20±21		28±24	23±18	

Table 18. Comparison of diameters of two branches of STA

Branch of STA	Used as donor artery		Not used as donor artery	
	± SD	(mm)	± SD	(mm)
Parietal branch	$n=32$	1.2±0.3	$n=16$	0.7±0.3
Frontal branch	$n=17$	1.5±0.5	$n=30$	1.1±0.4

Table 19. Comparison of bypass function

Age group		Bypass function		
		No (%)	Poor (%)	Good (%)
Y	5	0	3	2
		(0)	(60)	(40)
M	12	1	1	10
		(8)	(8)	(83)
O	4	0	0	4
		(0)	(0)	(100)
Total	21	1	4	16
		(5)	(19)	(76)

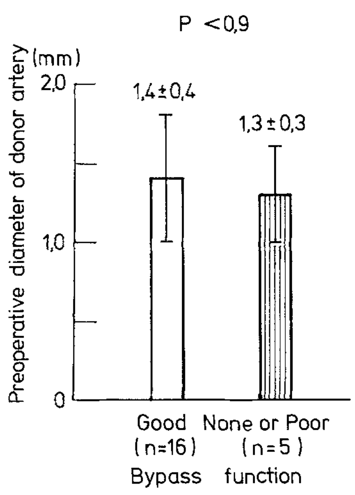
branch). Frontal branches were thicker than parietal branches for both those used ($P<0.002$) and those not used ($P<0.005$) as the donor artery.

Results of Angiographical Assessment of Bypass Function

The bypass function was assessed angiographically for the three age groups as shown in Table 19. Bypass function in all 4 anastomoses in patients in the old

Table 20. Preoperative angiographical diagnosis and bypass function (21 bypasses in 19 cases) 19 cases

Bypass function	Preoperative angiographical diagnosis		
	Within normal limits	Stenotic lesion	Obstructive lesion
No 1	0	1	0
Poor 4	2	2	0
Good 16	0	3	13
Total 21	2	6	13



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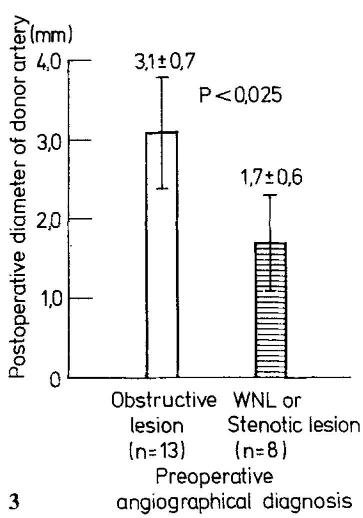

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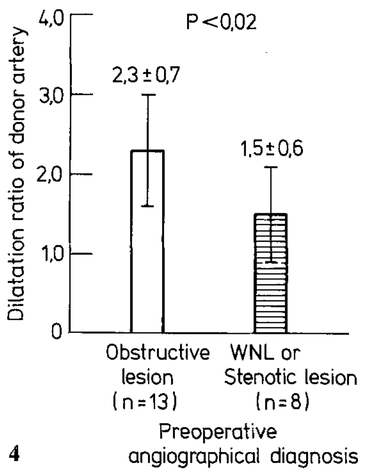
Fig. 2. Preoperative diameter of donor artery

Fig. 3. Postoperative diameter of donor artery

group and 10 of 12 patients of middle-aged group were good. On the other hand 3 of 5 anastomoses in the young group had poor function. Table 20 shows the results of the postoperative angiographical studies of the bypass function of 21 STA-MCA in 19 cases relative to preoperative angiographical diagnoses. The only 1 of 21 bypasses with no postoperative function occurred in a patient with stenotic lesion on the side of anastomosis. In 16 of 2 1 bypasses (76%) good function was ascertained. The remaining 4 bypasses (19%) showed poor function. As shown in Table 20, 13 of the 16 STA-MCA anastomoses whose function was judged "good", had been performed on the grounds of complete obstructive lesions in the proximal middle cerebral arteries or internal carotid arteries on the side of anastomosis. On the contrary 3 of 5 anastomoses with poor or no function had been operated on for stenotic lesion of the internal carotid artery on the side of the anastomosis, all of which were in the distal part of the internal carotid artery, namely the internal carotid siphon.



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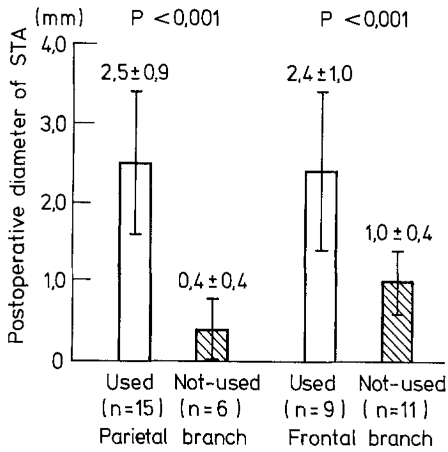

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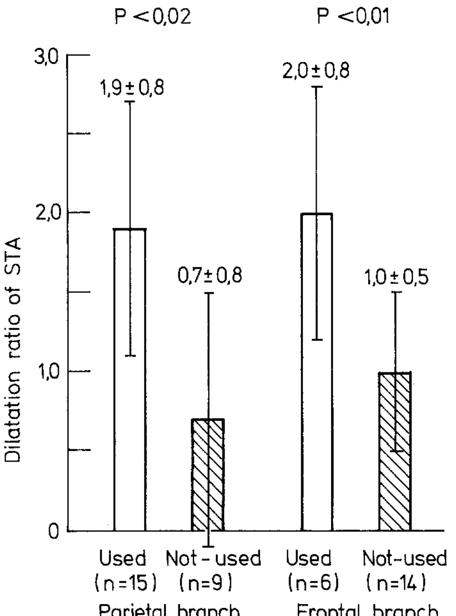
Fig. 4. Dilatation ratio of donor artery

Fig. 5. Postoperative diameter of STA

Figure 2 shows the relationship between the function of anastomoses and the preoperative diameter of the branches of the STA used for STA-MCA bypasses. There was no significant difference in the preoperative diameter of the branches of STA used for anastomosis between anastomoses with good bypass function and those with poor or no bypass function ($P<0.9$). The mean values of the post-operative diameter of the donor artery in relation to preoperative angiographical diagnosis are shown in Fig. 3. The postoperative mean diameter of the donor artery was larger ($P<0.025$) in anastomoses performed for obstructive lesions in the middle cerebral artery or in the internal carotid artery on the side of anastomoses (3.1 ± 0.7 SD mm) than in those cases without complete occlusive lesions (1.7 ± 0.6 SD mm). As shown in Fig. 4, the mean dilatation ratio of the donor artery was also determined relative to preoperative diagnosis. It was also significantly larger ($P<0.02$) for anastomoses carried out for complete occlusive lesions (2.3 ± 0.7 SD) than for those without complete occlusive lesions (1.5 ± 0.6 SD). Postoperative diameters were compared according to the branches of STA used and not used for anastomoses. Both in parietal and frontal branches of the STA, the postoperative diameter was larger ($P<0.001$) in the used branches than that in unused branches, as shown in Fig. 5.

As shown in Fig. 6, the dilatation ratio for the branches of STA was compared between branches used and not used for anastomosis. The ratio was larger both in the parietal branch ($P<0.02$) and in the frontal branch ($P<0.01$) used for anastomosis than in branches not used for anastomosis.

The postoperative diameters of the donor artery of STA-MCA anastomosis were compared between anastomoses with good bypass function and those with poor or no function, as shown in Fig. 7. The diameter of the donor artery in anastomoses with good bypass function was larger than that in those with poor or no function, both in parietal branches ($P<0.05$) and in frontal branches



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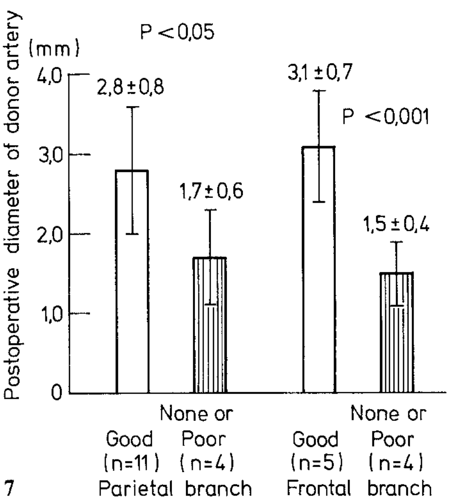

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Fig. 6. Dilatation ratio of STA

Fig. 7. Postoperative diameter of donor artery

Table 21. Dilatation ratio of donor artery

Donor artery	Bypass function			
	Good ± SD		None or Poor ± SD	
Parietal branch	$n=11$	2.2±0.7[a]	$n=4$	1.2±0.6
Frontal branch	$n=5$	2.2±0.7	$n=1$	1.0
Total	$n=16$	2.2±0.7[b]	$n=5$	1.2±0.5

[a] $P<0.05$
[b] $P<0.01$

($P<0.001$). Table 21 shows the results of the comparison of the dilatation ratio of the donor artery between anastomoses with good bypass function and those with poor or no bypass function. The dilatation ratio of the donor artery was also larger in bypasses with good bypass function than those in bypasses with poor or no bypass function. Lastly, the mean dilatation ratio of the donor artery was compared according to the age of the patient. It was 1.5±0.7 SD in the young group, 2.0±0.8 SD in the middle-aged group and 2.3±0.8 SD in the old group. The dilatation ratio tended to be larger in the older age group but was not significant statistically ($P<0.3$).

Discussion

The general aspect of this study is concentrated on morphological and clinical analysis, although some questions related to the functional outcome of the cerebral circulation remain unanswered. In comparison with earlier evaluations [1, 2, 7, 8] a well-functioning bypass in old patients is remarkable. With respect to the general arteriosclerotic process of the vessel walls one would not have expected such good functioning of the bypass in older age. This well working bypass in our old patients seems to have a significance for the neurological status. In the early postoperative course of the disease in the old patient and in CS with mild deficits we have mainly seen a good outcome with improvement of the symptoms. But this is only one aspect of the bypass function, the prophylactic effect however cannot be evaluated from the early postoperative course. The assessment of the hemodynamics and the effective demand of cerebral perfusion based on the angiogram is obviously difficult. We refer to the poor bypass results in stenoses and we would like to draw attention to the fact that stenoses, especially within the area of the carotid siphon, are obviously not a very suitable indication for a sufficient bypass. A morphologically impressive bypass was realized in complete occlusions of important cerebral arteries responsible for cerebral perfusion. Compared to earlier studies [1, 2] the reappearance of TIAs after surgery requires further consideration since reappearance may lead to another pathophysiological state. One has to ask if these patients symptoms were caused by microemboli rather than by a hemodynamically effective vascular process.

The interpretation of the preoperative angiographical findings on the STA gives information concerning the branching level, the type of the STA and the dominating branch of the vessel. The evaluation of the artery diameter at two definite points will assist in determining the usefulness of the vessel for the bypass connecting the STA to the middle cerebral artery. It is quite striking that the frontal branch dominates in our middle-aged and old patients. This would correspond to known observations of the senile ectasia of this vessel [5, 6]. At a high branching level of the STA a greater decrease in the parietal branch has been observed especially in old age, while in the young the frontal branch showed this greater decrease. Consequently in old age the frontal branch would be preferable as bypass, in younger subjects maybe the parietal branch. When designating the artery branches to be used as feeders in the bypass operations it is obvious that the surgeon chooses the branch of largest diameter. However in practice a reserved use of the frontal branch showing the largest diameter has been made probably with regard to the existing natural collaterals connecting the frontal branch via the ophthalmic artery to the ocular and cerebral vessels [4, 10]. Here it is the surgeon's decision either in favour of a more morphological consideration (choosing the frontal branch with its wider diameter) or a more functional dynamic consideration sparing the stronger frontal branch and an already existing natural collateral feeding [4, 10, 11].

In the postoperative angiographical observation it has long since been proved [2, 7] that the caliber of the donor artery of the extra-intracranial bypass increases in the course of time after the operation. But what does this increase depend on? Can we, from the answer to this question, draw any conclusions with respect to the indication or to the technique of anastomosis? Our measurements showed that the bypass function does not depend on the preoperative caliber of the donor artery. The bypass function, the postoperative diameter of the donor artery depend obviously on the preoperatively verified hemodynamic disturbance. We obtain a morphologically good bypass in complete arterial occlusions, but not in arterial stenoses. The morphological bypass function does not depend on the selection of the branch: frontal and parietal donor branches show significantly large diameters and a high ratio of dilatation. We have not found a clear dependency of vessel dilatation of the donor artery upon the age of the patient. One could expect that younger vessels would have a higher tendency to dilatation than old arteriosclerotic vessels. But this is not true for the branches of the STA particularly in connection with a bypass.

Conclusions

From the clinical point of view the findings indicate a continued use of bypass surgery considering the clinical course in patients after TIA, PRIND and CS with mild neurological deficit. Due to a restriction of the cases of CS we now have a more favourable clinical outcome and a better bypass function than expected in this group from earlier studies. Transient ischemic attacks as a result of hemodynamically relevant alterations can obviously be influenced by the bypass operation. Our results also indicate that in older patients a morphologically impressive extra-intracranial bypass can be realized provided that the preoperative angiographical findings are closely examined. The morphological point of view concerning the preoperatively small diameter of chosen branch is not decisive in the choice of the donor artery. It is possible, therefore, that functional criteria can be taken into consideration.

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