ELSEVIER

European Journal of Cardio-thoracic Surgery 19 (2001) 619–626

EUROPEAN JOURNAL OF CARDIO-THORACIC SURGERY

www.elsevier.com/locate/ejcts

Should severe monolateral asymptomatic carotid artery stenosis be treated at the time of coronary artery bypass operation?☆

Mario Gaudino*, Franco Glieca, Nicola Luciani, Carlo Cellini, Mauro Morelli, Paola Spatuzza, Michele Di Mauro, Francesco Alessandrini, Gianfederico Possati

Department of Cardiac Surgery, Catholic University, Rome, Italy

Received 19 September 2000; received in revised form 21 January 2001; accepted 7 February 2001

Abstract

Objective: The optimal treatment of severe monolateral asymptomatic carotid artery stenosis (SMACS) in patients undergoing coronary artery bypass grafting (CABG) is still controversial. **Materials and methods**: This study is based on the in-hospital and mid-term (>5 years) clinical results of a cohort of 139 consecutive CABG patients with SMACS operated at our Institution between January 1989 and December 1995. In the first 73 patients (no carotid surgery group), the SMACS was left untouched at the time of coronary surgery, whereas in the remaining 66 (carotid endoarterectomy group), the carotid stenosis was treated either immediately before or concomitantly with the CABG procedure (depending on the severity of the anginal symptoms). **Results**: The overall preoperative characteristics of the patients were comparable. The in-hospital results were similar between the two groups with regard to mortality, stroke and major postoperative complications. However, at mid-term follow-up, significantly more patients of the no carotid surgery group suffered cerebral events (transient or permanent) ipsilateral to the SMACS or the lesion had to be operated on. **Conclusions**: The concomitant treatment (either staged or simultaneous) of SMACS at the time of CABG does not influence the in-hospital results, but confers significant neurological protection during the years after the operation.

Keywords: Carotid artery; Coronary surgery; Stroke

1. Introduction

The optimal treatment of severe monolateral asymptomatic carotid artery stenosis (SMACS) in patients undergoing surgical myocardial revascularization is far than established as, to date, no prospective randomized investigation has compared the results of medical versus surgical treatment of the carotid lesion in this subgroup of cases.

In an effort to contribute to the debate on this issue and to shed some new light on it, we herein review our experience in the treatment of coronary artery bypass (CABG) patients with SMACS.

2. Patients and methods

2.1. Preoperative carotid artery evaluation

As already described in details elsewhere [1], since 1988, all patients referred for CABG procedures at our institution are routinely submitted to a preoperative Echo-Doppler evaluation of the carotid vessels as part of a more complex screening protocol aimed at reducing the neurological risk in coronary surgery. Extracranial carotid arteries are evaluated by colour flow duplex scanning study; B-mode and colour flow images of the common, external and internal carotid arteries are obtained in longitudinal and transverse planes. The presence of plaques is noted and reduction in the cross-sectional area of the lumen is calculated. Doppler velocity spectra are recorded from each of these vessels, maintaining the angle of insonation as close to 60° as possible. The highest peak systolic velocity (PSV) and end-diastolic velocity (EDV) are calculated. According to the flow velocity criteria, the severity of internal carotid artery stenosis is graded as ≤50% when the PSV is ≤120 cm/s, between 50 and 80% when the PSV is >120 cm/s and ≥80% when the PSV is >120 cm/s and the EDV is >120 cm/s [2].

In patients with >80% stenosis, a preoperative carotid angiography is always performed.

☆ Presented at the 14th Annual Meeting of the European Association of Cardio-thoracic Surgery, Frankfurt, Germany, October 7–11, 2000.

* Corresponding author. Cattedra di Cardiochirurgia, Policlinico Universitario Agostino Gemelli, Largo A. Gemelli 8, 00168 Rome, Italy. Tel.: +39-06-305-8181; fax: +39-06-305-8181.

E-mail address: mgaudino@tiscalinet.it (M. Gaudino).

1010-7940/01/$ - see front matter
PII: S1010-7940(01)00665-0

2.2. Patient population

In this report, we focus on non-emergent patients submitted to primary isolated CABG procedures at our institution between January 1989 and December 1995, in whom the preoperative Echo-Doppler screening of the carotid arteries revealed a severe (>80%) asymptomatic internal carotid artery stenosis (SMACS). Cases undergoing other cardiac procedures, patients with moderate to severe ascending aorta disease (as previously defined, see [1]), with recent (<30 days) transmural myocardial infarction or chronic (>1 month) atrial fibrillation, and those who (for different reasons) could not be submitted to the complete preoperative evaluation were excluded from the data analysis in order to minimize potential confounding factors. Patient data were prospectively entered in a computerized database.

Our surgical strategy with regard to the treatment of SMACS changed almost in the middle of the study period: from the beginning, until January 1993, we adopted a watchful waiting policy and left the carotid stenosis untouched. From this date on, following the publication of the Veterans Administration Study [3], we started treating the carotid lesion (either immediately before or simultaneously with the CABG procedure). Of note, no change in the surgical team occurred between the two study periods.

This policy change gave us the possibility of comparing, in the present study, two groups of consecutive CABG patients with SMACS: one in which the carotid lesion was left untouched at the time of coronary surgery (no carotid surgery group, 73 patients) and another in which the carotid stenosis was treated either immediately before or simultaneously with the CABG operation (carotid endoarterectomy group, 66 patients).

The mean preoperative characteristics of patients of the two groups are summarized in Table 1; no major difference was evident between the no carotid surgery group and B, with the only exception of a superior number of smokers in the latter.

2.3. Surgical procedure

2.3.1. No carotid surgery group

In this group, surgical myocardial revascularization was performed using the standard technique. Hypothermic systemic perfusion and either cold crystalloid or isothermic hematic blood cardioplegia were used; the left internal mammary artery was nearly always used to revascularize the left anterior descending artery and additional venous or arterial conduits for the other target vessels. Proximal and distal anastomoses were always performed during a single period of aortic cross-clamping.

2.3.2. Carotid endoarterectomy group

In this group, simultaneous carotid endoarterectomy and CABG was performed in cases of unstable angina (46 patients), whereas a staged procedure (carotid endoarterectomy performed before myocardial revascularization) was adopted in patients with stable angina ($n = 20$). As described in detail elsewhere [1], this strategy was adopted to minimize the neurological risk, both in stable and unstable patients. During simultaneous operations, the carotid procedure was always carried out before median sternotomy; for both simultaneous and staged operations, an intraluminal carotid shunt was used. For patients submitted to the staged procedure, the mean interval between carotid and coronary operations was 13.5 ± 8.1 days. The CABG operation was performed according to the principles described for the no carotid surgery group. Hypothermic systemic perfusion and isothermic blood cardioplegia were always adopted.

2.4. Follow-up

All patients were regularly submitted to clinical examination at our institution 1 and 6 months after surgery, and then, every year thereafter. A stress myocardial scintigraphy and an Echo-Doppler evaluation of the carotid vessels were obtained in all cases 6 months postoperatively and every year thereafter.

2.5. Statistical analysis

The results are expressed as mean values ± SD unless otherwise indicated. Statistical analysis comparing two groups was performed with unpaired, two-tailed *t*-testing of the means or the χ^2 test for categorical variables. Freedom from transient ischaemic attack (TIA), freedom from stroke and freedom from TIA + stroke curves were obtained with the Kaplan–Meier method (SPSS software, Chicago, IL). The statistical significance was calculated

Table 1
Comparison between the preoperative characteristics of patients of the two groups

	No carotid surgery group	Carotid endoarterectomy group	*P* value
Number of patients	73	66	–
Mean age (years)	69 ± 5.2	71 ± 8.9	NS
Age > 70 years	28	25	NS
Male/Female	42/31	36/30	NS
Cardiac risk factors			
Diabetes	22	19	NS
Smoking	43	59	<0.0001
Dyslipaemia	55	20	NS
Hypertension	22	19	NS
Unstable angina	51	46	NS
Previous AMI[a]	41	37	NS
Three-vessel disease	59	48	NS
Left main disease	7	6	NS
Peripheral vasculopathy	16	13	NS

[a] AMI, acute myocardial infarction.

Table 2
Operative data

	No carotid surgery group	Carotid endoarterectomy group	*P* value
Aortic cross-clamp time (min)	66 ± 11	63 ± 9	NS
CPB time (min)[a]	73 ± 14	71 ± 11	NS
Bypass/patient	2.9 ± 0.3	2.8 ± 0.4	NS
Operative time (h)	4.2 ± 0.3	5.8 ± 0.4[b]	< 0.0001

[a] CPB, cardio-pulmonary bypass.
[b] Including only the 46 patients submitted to the simultaneous approach.

with the log-rank test. A *P* value of ≤0.05 was considered significant.

3. Results

3.1. Operative data

The operative data are summarized in Table 2. No significant differences were reported between the two groups, although, as obvious, patients of the carotid endoarterectomy group who underwent the simultaneous approach had a longer operative time.

3.2. In-hospital results

Mortality and morbidity data are shown in Table 3. Two in-hospital deaths occurred among the 139 patients (one for each group; *P* = NS), both non-cardiac or cerebral related (pulmonary embolism in the no carotid surgery group and acute respiratory distress syndrome in the carotid endoarterectomy group).

No significant difference between the two groups was found in terms of the incidence of major postoperative complications (myocardial infarction, renal insufficiency, revision for bleeding) and the mean stay in the intensive care and in-hospital (although patients of the carotid endoarterectomy group who underwent the simultaneous approach stayed longer in the intensive care).

The postoperative incidence of neurological events was similar between the no carotid surgery and carotid endoarterectomy groups. Two postoperative strokes (one in the no carotid surgery group and one in the carotid endoarterectomy group; *P* = NS) were reported; the first one was in the distribution of the normal carotid artery and followed the resumption of a regular cardiac rhythm after a prolonged period of postoperative atrial fibrillation, whereas in the second case (carotid endoarterectomy group), computed tomography (CT) brain scan demonstrated multiple ischaemic foci.

No postoperative TIA or intraoperative stroke or TIA occurred.

Finally, no difference in mortality or morbidity could be detected between patients of the carotid endoarterectomy group who underwent the simultaneous versus the staged approach.

3.3. Follow-up

During the follow-up, two patients of the no carotid surgery group and one of the carotid endoarterectomy group died from causes unrelated to the surgical strategy

Table 3
Postoperative mortality and morbidity in the two groups

	No carotid surgery group	Carotid endoarterectomy group	*P* value
Number of cases	73	66	–
Operative death	1	1	NS
Postoperative complications			
Postoperative AMI[a]	1	2	NS
Postoperative renal insufficiency	6	8	NS
Revision for bleeding[b]	2	2	NS
Intraoperative stroke	0	0	NS
Intraoperative TIA[c]	0	0	NS
Postoperative stroke	1	1	NS
Postoperative TIA	0	0	NS
Mean ICU stay (h)	23.1 ± 6.3	28.2 ± 3.3[d]	< 0.0001
Mean postoperative stay (days)	5.1 ± 1.3	5.4 ± 0.9	NS

[a] AMI, acute myocardial infarction.
[b] No bleeding complication occurred at the site of carotid surgery.
[c] TIA, transient ischemic attack.
[d] Including only the 46 patients submitted to the simultaneous approach.

Table 4
Mid-term neurological events in the two groups

	No carotid surgery group ($n = 70$)	Carotid endoarterectomy group ($n = 64$)	P value
Ipsilateral stroke	7	0	0.0270
Ipsilateral TIA[a]	10	1	0.0180
Ipsilateral stroke + TIA	17	1	< 0.0001

[a] TIA, transient ischemic attack.

used (heart failure in two cases and rupture of an abdominal aortic aneurysm in one).

As shown in Table 4, seven strokes ipsilateral to the carotid lesion occurred in patients of the no carotid surgery group, whereas no stroke episode was reported in the carotid endoarterectomy group ($P = 0.0270$). Three of the seven patients died from the stroke; in two cases, a TIA preceded the acute episode, whereas in all the others, it was unheralded. Ten patients of the no carotid surgery group (excluding the two who subsequently developed strokes) experienced ipsilateral TIA versus only one patient in the carotid endoarterectomy group; the overall incidence of ipsilateral neurological events (TIA + stroke) was 17/70 in the no carotid surgery group versus 1/64 in the carotid endoarterectomy group. These differences in the incidence of stroke, TIA and stroke + TIA were all statistically significant, as reassumed in Figs. 1–3.

Of note, as shown in Table 5, all 17 no carotid surgery group mid-term events occurred in cases who were either hypertensive ($n = 4$), dyslipaemic ($n = 8$), or both ($n = 5$).

During the follow-up, 17 patients of the no carotid surgery group were scheduled for carotid endoarterectomy (including the four who survived a stroke, ten who experienced a TIA and three asymptomatic patients); however, the carotid procedure could not be performed in four patients (due to asymptomatic progression to occlusion of the lesion in two instances, refusal of the patients in one other and the death of the patients while on the vascular waiting list in the 4th case). Thus, overall, 13 cases were operated on the carotid lesion after the CABG procedure (mean interval, 46.5 ± 11.1 months). Echo-Doppler follow-up demonstrated that the carotid stenosis increased in the years after surgery in 38 cases (24.2%), and in three instances, asymptomatically progressed to complete occlusion (leading to a total of five asymptomatic progressions to carotid occlusion).

Finally, clinical or scintigraphic evidence of myocardial ischaemia recurrence was detected in five patients of the no carotid surgery group versus two of the carotid endoarterectomy group ($P =$ NS).

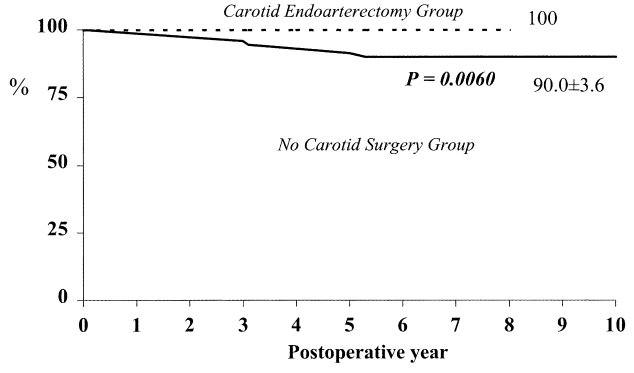

Fig. 1. Freedom from stroke during the years after surgery in the two groups.

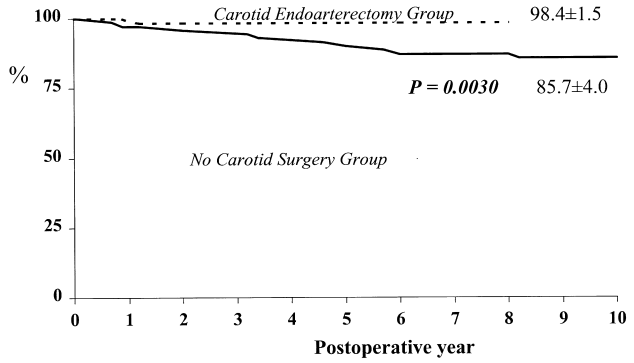

Fig. 2. Freedom from TIA during the years after surgery in the two groups.

4. Discussion

This study has two major methodological limits that must be acknowledged. First, although patient data were prospectively entered into a computerized database, the method used for data collection was, in fact, retrospective, with all the recognized bias related to this type of analysis. Second, and probably most importantly, the comparison of two consecutive groups of patients is by far less rigorous than a trial in which cases are randomly assigned to one or another treatment modality.

On the other hand, the rigorous preoperative evaluation to which all CABG patients are submitted at our institution [1]

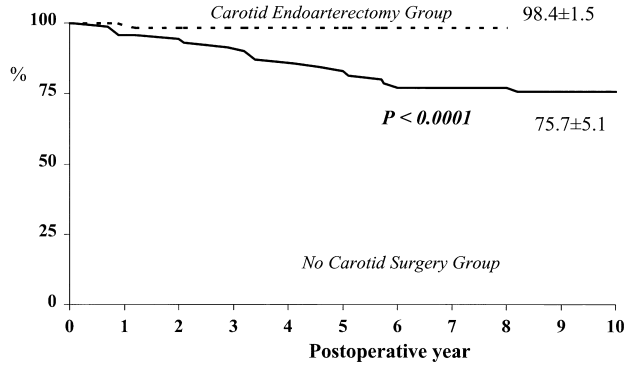

Fig. 3. Freedom from stroke + TIA during the years after surgery in the two groups.

Table 5
Distribution of mid-term neurological events in relation to dyslipidaemia and hypertension in no carotid surgery group

	Number of no carotid surgery group patients	Stroke	TIA[a]	Stroke + TIA
Hypertensive	8	1	3	4
Dyslipaemic	12	5	3	8
Hypertensive + dyslipaemic	13	1	4	5
Neither	37	0	0	0

[a] TIA, transient ischemic attack.

and the rigid criteria for patient enrolment should be able to minimize potential confounding factors in this series and to assure an acceptable homogeneity between the two groups (and, in fact, the preoperative characteristics of patients of the no carotid surgery group and B were comparable, see Table 1).

With these considerations in mind, the analysis of our data strongly suggests that the aggressive treatment of SMACS at the time of CABG surgery does not reduce the perioperative neurological risk. In fact, the incidence of both intra- and postoperative neurological events was similar between patients submitted to carotid endoarterectomy and CABG and to solo-CABG (see Table 3).

This finding is in accordance with the results of Brener and associates who, in the only published study which compared the operative versus non-operative management of asymptomatic carotid stenosis in CABG patients (although not using a prospective randomized methodology), were unable to demonstrate any advantage related to the treatment of the carotid lesion [4]. Concordant with those observations, the majority of studies which evaluated the perioperative stroke incidence in CABG patients with asymptomatic carotid stenosis submitted only to myocardial revascularization found no evidence of increased neurological risk despite non-treatment of the carotid stenosis [5–7].

However, our data testifies also that surgical treatment of SMACS at the time of CABG confers substantial neurological protection in the years after surgery. In fact, during the follow-up periods, the incidence of neurological events (stroke + TIA) was significantly higher in the no carotid surgery group (see Table 4). The fact that a different aetiology of the event (cardioembolic, hypertensive) was not evident at the time of hospital admission in any of these cases strongly argues in favour of a carotid origin of the strokes.

In addition, the need for subsequent carotid endoarterectomy and, even more importantly, the asymptomatic progression to carotid occlusion, occurred with a concerning high frequency in the group of patients submitted to solo-CABG, with clinical and economic consequences that should not be underestimated.

To date, no study has compared the mid-term results of the surgical versus medical treatment of the carotid lesion at the time of coronary surgery in CABG patients with SMACS; moreover, if the early in-hospital results of this subset of cases treated with solo-CABG have been reported, only scant information exists on the fate of these patients in the years after isolated myocardial revascularization. In the only reports on this issue, Barnes and co-authors found that the presence of an untreated asymptomatic carotid stenosis is associated with a high risk of late neurological events (16.7% during a mean follow-up of 11.3 months) [5] and Brener and colleagues confirmed this finding, reporting a combined stroke + TIA incidence of 9% during a 3 year observation period, with nine of 44 patients necessitating a carotid endoarterectomy after the CABG operation [4].

Data obtained among non-cardiac surgery patients seems to suggest that the prophylactic treatment of asymptomatic carotid stenosis is able to confer a moderate but significant degree of neurological protection in the years after surgery when compared with the medical therapy. Apart from all previous studies with major methodological limits, the recent asymptomatic carotid atherosclerosis (ACAS) study demonstrated that, if the perioperative mortality and complication incidence is low, the endoarterectomy of asymptomatic carotid lesions is superior to medical treatment in terms of stroke prevention [8], and a recent meta-analysis which examined all published trials on this issue further supported this conclusion [9].

In addition, those studies which examined the natural history of unoperated asymptomatic carotid stenosis in non-cardiac surgery patients demonstrated that these type of plaques are associated with a substantial stroke risk (ranging from 2 to 5%/year) [10–12], with a non-negligible incidence of silent cerebral microembolization and stroke and with significant impairment of the cerebral autoregulation [13–15], so that they can not be merely considered innocent lesions.

These data are derived from the analysis of patients with isolated asymptomatic carotid stenosis, a subset of cases in whom the atherosclerotic process is less severe and diffuse than in patients with concomitant carotid and coronary disease. It seems then plausible that the clinical and economic benefits of prophylactic carotid endoarterectomy reported in this subset of patients can be even magnified in a cohort of cases in whom the vasculopathic process is more aggressive and generalized (such as CABG patients with coexistent carotid disease).

Of particular relevance is the finding that (as shown in Table 5) all no carotid surgery group mid-term cerebral

episodes occurred in patients who were hypertensive or dyslipaemic (or both). Indeed, it is known that dyslipaemia and hypertension are the most powerful predictors of progression of isolated carotid atherosclerosis [16,17] and, in fact, in our own series, they were strongly associated with the occurrence of stroke and TIA during follow-up in patients in whom the carotid lesion was left untouched at the time of myocardial revascularization. This observation seems to suggest that CABG patients with SMACS who are hypertensive and/or dyslipaemic represent a particular subgroup of cases at very high cerebrovascular risk.

In conclusion, our data show how the concomitant treatment (either staged or simultaneous) of SMACS at the time of CABG does not influence the in-hospital results, but confers significant neurological protection during the years after the operation. The prophylactic benefit of carotid surgery is particularly evident in hypertensive and dyslipaemic cases.

Although it seems clear that carotid surgery does not confer neurological protection in the perioperative period and the endoarterectomy could probably be safely delayed to after coronary surgery (and even during the rehabilitation period), it seems likely that logistic and economic considerations should favour the performance of the carotid operation during the same hospitalization.

Until a prospective randomized investigation on this issue is completed, the treatment of SMACS at the time of coronary surgery appears advisable in all patients, and mandatory in hypertensive and dyslipaemic cases.

References

[1] Gaudino M, Glieca F, Alessandrini F, Cellini C, Luciani N, Pragliola C, Schiavello R, Possati G. Individualized surgical strategy for the reduction of stroke risk in patients undergoing coronary artery bypass grafting. Ann Thorac Surg 1999;67:1246–1253.

[2] Roederer GO, Langlois YE, Jager KA, Lawrence RJ, Primozich JT, Phillips DJ. A simple spectral parameter for accurate classification of severe carotid disease. Bruit 1984;8:174–178.

[3] The Veterans Affairs Cooperative Study Group, Hobson 2nd RW, Weiss GD, Fields WS, Goldstone J, Moore WS, Towne JB, Wright CB. Efficacy of carotid endarterectomy for asymptomatic carotid stenosis. N Engl J Med 1993;328:221–227.

[4] Brener BJ, Brief DK, Alpert J, Goldenkranz RJ, Parsonnet V. The risk of stroke in patients with asymptomatic carotid stenosis undergoing cardiac surgery: a follow-up study. J Vasc Surg 1987;5:269–279.

[5] Barnes RW, Liebman PR, Marszalek PB, Kirk CL, Goldman MH. The natural history of asymptomatic carotid disease in patients undergoing cardiovascular surgery. Surgery 1981;90:1075–1083.

[6] Furlan AJ, Craciun AR. Risk of stroke during coronary artery bypass graft surgery in patients with internal carotid artery disease documented by angiography. Stroke 1985;16:797–799.

[7] Gerraty RP, Gates PC, Doyle JC. Carotid stenosis and perioperative stroke risk in symptomatic and asymptomatic patients undergoing vascular or coronary surgery. Stroke 1993;24:1115–1118.

[8] Executive Committee for the Asymptomatic Carotid Atherosclerosis Study. Endarterectomy for asymptomatic carotid artery stenosis. J Am Med Assoc 1995;273:1421–1428.

[9] Benavente O, Moher D, Pham B. Carotid endarterectomy for asymptomatic carotid stenosis: a meta-analysis. Br Med J 1998;317:1477–1480.

[10] Norris JW, Zhu CZ, Bornstein NM, Chambers BR. Vascular risks of asymptomatic carotid stenosis. Stroke 1991;22:1485–1490.

[11] The Asymptomatic Cervical Bruit Study Group, Mackey AE, Abrahamowicz M, Langlois Y, Battista R, Simard D, Bourque F, Leclerc J, Cote R. Outcome of asymptomatic patients with carotid disease. Neurology 1997;48:896–903.

[12] Muluk SC, Muluk VS, Sugimoto H, Rhee RY, Trachtenberg J, Steed DL, Jarret F, Webster MW, Makaroun MS. Progression of asymptomatic carotid stenosis: a natural history in 1004 patients. J Vasc Surg 1999;29:208–216.

[13] Orlandi G, Parenti G, Bertolucci A, Murri L. Silent cerebral microembolism in asymptomatic and symptomatic carotid artery stenosis of low and high degree. Eur Neurol 1997;38:39–43.

[14] Brott T, Tomsick T, Feinberg W, Johnson C, Biller J, Broderick J, Kelly M, Frey J, Schwartz S, Blum C, Nelson JJ, Chambless L, Toole J. Baseline silent cerebral infarction in the Asymptomatic Carotid Atherosclerosis Study For the Asymptomatic Carotid Atherosclerosis Study Investigators. Stroke 1994;25:1122–1129.

[15] Gratzl O, Rem J, Mueller HR, Radue EW, Mueller-Brand J. Cerebral blood flow and common carotid flow in neurologically asymptomatic carotid endarterectomy patients. Neurol Res 1990;12:26–28.

[16] Grotta JC, Yatsu FM, Pettigrew LC, Rhoades H, Bratina P, Vital D, Alam R, Earls R, Picone C. Prediction of carotid stenosis progression by lipid and hematologic measurements. Neurology 1989;39:1325–1331.

[17] Garvey L, Makaroun MS, Muluk VS, Webster MW, Muluk SC. Etiologic factors in progression of carotid stenosis: a 10-year study in 905 patients. J Vasc Surg 2000;31:31–38.

Appendix A. Definitions

Postoperative myocardial infarction: was diagnosed on the basis of echocardiographical evidence of regional hypokinesia, MB fraction of >4% of the total hematic level of creatine kinase concentration and appearance of new Q waves on the electrocardiogram.

Postoperative renal insufficiency: was defined as a postoperative increase of the serum creatinine level ≥3 mg/dl with respect to the preoperative level.

Intraoperative stroke: was defined as a new focal neurological deficit or coma associated with CT demonstration of a recent ischaemic cerebral lesion which became evident at the moment of the awakening of the patient from the anaesthesia and lasted more than 24 h.

Intraoperative TIA: was defined as a new focal neurological deficit associated with normal brain scan which became evident at the moment of the awakening of the patient from the anaesthesia and lasted less than 24 h.

Postoperative stroke: was defined as a new focal neurological deficit or coma associated with CT demonstration of a recent ischaemic cerebral lesion and lasting more than 24 h which became evident after a normal awakening of the patient from the anaesthesia and a normal postoperative neurologic status.

Postoperative TIA: was defined as a new focal neurological deficit associated with normal brain scan and lasting less than 24 h which became evident after a normal awakening of the patient from the anaesthesia and a normal postoperative neurologic status.

Appendix B. Conference discussion

Mr Treasure (*London, UK*): This is a problem we all face. I have one question for you for clarification: because of the way your study was divided by a time policy in 1993, it seems to me that there were many more years of follow-up for group A during which they could manifest a stroke than there were for group B. Have you looked at the actual frequency of strokes/year to even that out?

Dr Gaudino: Yes. This is an obvious limitation of such a study; but even when looking at the actuarial incidence of stroke, there is still a statistical difference between the two groups.

Mr Treasure: Good. I have one other comment. Your conclusion, I would split it into two sentences. You see no immediate benefit from concomitant surgery in the immediate postoperative period. The other statement, that there is benefit to the patient from dealing with a carotid stenosis, supports the international stroke trials, but it is a separate statement, and it ought to be true irrespective of the timing of the carotid stenosis surgery, which is important in practical terms. I think you made that point, but I think that should be clear, that your conclusion bundles together two things which are, in fact, separate.

Dr Gaudino: Yes. It is obvious that the treatment of the carotid stenosis per se does not improve in-hospital outcome. You can leave the lesion untreated and the patient would have the same possibility to leave the hospital in good condition. But we think that when looking at the patient, at the globality of the patient, I mean, you must admit that you treat the coronary lesion, but you leave another lesion, which is probably as important, untreated.

Also, from an economic point of view, we have shown that the treatment of the carotid stenosis does not add any days of in-hospital stay. So, from an economical point of view, I guess this is cheaper than a second hospitalization.

Dr Von Oppell (*Cape Town, South Africa*): What techniques are you currently using in your carotid endarterectomy program; a patch technique, or an eversion technique? What are your thoughts in terms of the technique of carotid endarterectomy when doing 'prophylactic' surgery?

Dr Gaudino: Yes. Well, the question is not well addressed as, in our department, vascular surgeons usually perform the carotid endarterectomy. I can say that in our cases, they used an intravascular shunt for this kind of procedure, but I cannot go into that further in technical detail.

Appendix C. Editorial Comment

The study by M. Gaudino et al. is part of an ambitious institutional approach to prevent intra- and postoperative stroke and mortality in CABG. The authors routinely investigated, since approximately 1989, the carotid arteries in all CABG patients by duplex scanning; in addition, they analyzed routinely the ascending aorta quality in recent years with intraoperative echography, in order to propose an 'individualized' methodological approach to CABG patients with or without significant carotid disease [1]. The present study is intended to answer the question whether severe monolateral asymptomatic carotid stenosis should be treated 'at the time' of — either before or simultaneously with — CABG.

In order to answer this question — the title of their paper — the authors could have restricted their analysis to the operative results of their consecutive experience, concluding that the 'at the time' approach did not improve the outcome. However, the authors choose in favour of the 'at the time' of CABG approach on the basis of the documented worse long-term neurological complications in patients with CABG and no carotid surgery: quod not est demonstrandum!

There are no arguments to believe that the fate of an unoperated severe carotid lesion is going to be different in patients with no severe coronary artery disease or after CABG. Hence, it is surprising that in a study starting in the early nineties, including such an extensive preoperative and yearly follow-up protocol, no more attention was paid to the treatment of the residual carotid lesions. In addition, the well-known risk factors were apparently not controlled during the follow-up; we [2] and others documented that, after CABG, the known risk factors continue to influence the outcome.

The authors felt that the Hobson study made them change their strategy; although appealing, none of the randomized trials on the operative versus non-operative treatment of isolated asymptomatic carotid stenosis (ACAS, ACST, VA) allow extrapolation to patients with synchronous treatment of severe asymptomatic unilateral carotid and severe coronary artery disease.

However, despite a mass of evidence accumulated already years beforehand in favour of the operative treatment of certain types of severe asymptomatic unilateral carotid disease, the authors refer to the data of the studies by Barnes and Brener on the late neurological outcome of untreated carotid lesions. However, as early as 1984, the Strandness group [3] produced good evidence of the increased medium-term stroke risk in the high grade asymptomatic carotid lesions graded by duplex criteria, as used in the present study; this was further convincingly documented by refining the selection criteria of the duplex studies in order to define the very high risk types of asymptomatic carotid stenoses, in which surgery was strongly indicated [4,5].

Since 1974, we tried to refine the selection of candidates for surgery with asymptomatic severe unilateral carotid disease — associated or not with coexistent coronary artery disease — by testing preoperatively their occlusion tolerance by carotid compression. In cases of occlusion intolerance, we strongly favoured surgery. Occlusion tolerance testing was done during preoperative EEG and/or OPG and/or, in recent years, transcranial cerebral Doppler examinations. Our data [6] based on these selection procedures in patients with synchronous carotid and CABG surgery revealed that in 73 patients operated upon for severe unilateral asymptomatic carotid disease, no ipsilateral TIAs or strokes occurred when we operated synchronously for patient convenience, i.e. when occlusion testing was tolerated; however, in the 28 patients not tolerating occlusion testing — those with presumed poor collateral circulation — one ipsilateral (related) stroke occurred; taken together, an incidence comparable with the Gaudino experience.

We strongly feel that in the early nineties, the poorer neurological follow-up in the no carotid endarterectomy group could have been predicted and should not be used, a posteriori, as the argument to favour the 'at the time' of CABG approach.

A final question not addressed in the previous and the present study by Gaudino is the incidence of and the

approach to the patients with unilateral occlusion of one carotid with or without a severe asymptomatic contralateral stenosis. Although they were evidently not included in the present analysis, no data allow to identify how these patients were categorized by Gaudino. They certainly represent a different risk group and their distribution should be mentioned. In our experience, the patients with severe unilateral stenosis and contralateral occlusion represented 17% of the synchronous operations.

Indeed, it has been documented that even patients with an isolated unilateral carotid occlusion present an increased ipsilateral stroke risk in their follow-up [7].

F. Vermeulen
St. Antonius Ziekenhuis,
Koekoekslaan 1, Nieuwegein,
NL-3435 CM,
The Netherlands

[1] Gaudino M, Glieca F, Allessandrini F, Cellini C, Luciani N, Pragioli C, Schiavello R, Possati G. Individualized surgical strategy for the reduction of stroke risk in patients undergoing coronary artery bypass grafting. Ann Thorac Surg 1999;67:1246–1253.

[2] Voors A, van Brussel B, Plokker H, Ernst S, Ernst N, Koomen E, Tijssen J, Vermeulen F. Smoking and cardiac events after venous coronary bypass surgery: a 15 year follow-up study. Circulation 1996;93:42–47.

[3] Roederer G, Langlois Y, Jager K, Primozich J, Beach K, Phillips D, Strandness E. The natural history of carotid arterial disease in asymptomatic patients with cervical bruit. Stroke 1984;15:605–613.

[4] Moneta G, Taylor D, Nicholls S, Bergelin R, Zierler E, Kazmers A, Clowes A, Strandness E. Operative versus non-operative management of asymptomatic high-grade internal carotid artery stenosis: improved results with endarterectomy. Stroke 1987;18:1005–1010.

[5] Moneta G, Taylor D, Zierler E, Kazmers A, Beach K, Strandness E. Asymptomatic high-grade internal carotid artery stenosis: is stratification according to risk factors or duplex spectral criteria possible? Vasc Surg 1989;10:475–483.

[6] Vermeulen F, Hamerlijnck R, Defauw J, Ernst S. Synchronous operation for ischemic cardiac and cerebrovascular disease: early results and long-term follow-up. Ann Thorac Surg 1992;53:381–390.

[7] Hennerici M, Hülsbömer H, Rautenberg W, Hefter H. Spontaneous history of asymptomatic internal artery occlusion. Stroke 1986;17:718–722.