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Combined surgical approach for carotid and coronary stenosis

Sixty-four patients and review of literature

S. BONARDELLI, N. PORTOLANI, G. A. M. TIBERIO, F. NODARI, M. DE LUCIA, G. QUARTIERINI
R. MAFFEIS, G. GHILARDI, R. LORUSSO*, C. LATINI*, M. ZOGNO*, S. M. GIULINI

Background. **The proper role of combined carotid endarterectomy (CEA) and coronary bypass (CABG) is still controversial. We contribute to the discussion through the critical evaluation of 64 consecutive patients, whose data have been collected in a prospective way.**

Methods. **Between 1990 and 1999, 64 patients presenting a critical coronary disease (unemendable by PTA) associated with severe carotid stenosis (≥70% if symptomatic, ≥80% if asymptomatic), underwent combined CEA-CABG. Cardiological symptoms were evident in 90.6% of cases. Therty-five patients (54.7%) had a three-vessel coronaropathy, 18 (28.1%) a two-vessel disease and 11 (17.2%) severe stenosis of the common trunk; furthermore 7 patients (10.9%) had a low ejection fraction (<50%). A positive neurologic history was present in 22 (44%) patients. Thirty-four patients (55%) had a carotid stenosis >90%; a significant disease of the contralateral carotid axis was observed in 53% of cases: stenosis >50% in 30 patients and thrombosis in 4. CEA was performed with somato-sensorial evoked potential monitoring.**

Results. **The hospital mortality rate was 6.2% (4 patients). The cause of death was cardiac in 2 cases (1 early bypass thrombosis and 1 irreversible coronary spasm) and related to a multiorgan failure in 2. The neurologic morbidity rate was 0%.**

Conclusions. **Our data highlight that in these high-risk patients the combined approach dramatically reduces the stroke risk although the mortality rate is still higher than that observed after CEA or CABG.**

KEY WORDS: Carotid stenosis, surgery - Coronary disease, surgery - Endarterectomy, carotid - Coronary artery bypass.

Simultaneous carotid endarterectomy (CEA) and coronary bypass (CABG) was first described in 1972 by Bernhard *et al.*[1] and advocated for patients with concomitant coronary and carotid critical disease, in order to reduce cardiac and neurologic complications these patients are subject to when the single pathologies are approached separately. Since then a broad range of perioperative results have been reported and the proper role of combined CEA and CABG is still controversial.

The present study contributes to the discussion through the critical evaluation of 64 severely compromised consecutive patients, whose data have been collected in a prospective way.

Authors' address: S. Bonardelli, Via Aperta 21, 25075 Nave (BS), Italy. E-mail: bonardel@master.cci.unibs.it

*From the Department of Medical and Surgical Sciences
Surgical Section
University of Brescia
*Cardiothoracic Surgery of Spedali Civili Hospital,
Brescia, Italy*

Materials and methods

In our center the simultaneous approach to carotid and coronary stenosis is indicated when the patient complies with the following selection criteria:

— critical symptomatic coronary disease that cannot be emended by percutaneous transluminal angioplasty (PTA) or:

— critical asymptomatic coronary disease, unemendable by PTA, exposed to a high risk of perioperative cardiac complications;

— concomitance of carotid stenosis >70% in neurologically symptomatic patients or

— carotid stenosis >80% in asymptomatic patients.

Between 1990 and 1999 we performed 64 combined procedures of CEA and CABG in 64 patients that complied with the above mentioned selection

TABLE I.—*Risk factors for cardiovascular pathologies.*

Parameters	No. of patients	%
Age	Mean: 71 years	Range: 57-82
Sex (M/F)	49/15	
Arterial hypertension	43/64	67.2
Dyslipidosis	37/64	57.8
Smoking	21/64	32.8
Diabetes	19/64	29.7
Familial vasc. pathol.	19/64	29.7

TABLE II.—*Preoperative cardiac status.*

Parameters	No. of patients	%
Clinical findings		
Previous MI with residual angor	33	51.6
Instable angina	25	39
Asymptomatic	6	9.4
Previous CABG	2	3.1
Coronarography		
Trivascular disease	35	54.7
Two vessels disease	18	28.1
Stenosis of the common trunk >70%	11	17.2
Ecocardiography		
Reduced ejection fraction <50%	7	10.9

criteria. These patients figure as 1.5% of the 4107 CABGs and 4.5% of the 1427 CEAs performed in the same period.

Forty-nine patients were male and 15 female, with a mean age of 71 years (57-82).

Arterial hypertension was present in 67% of the patients, dyslipidosis in 57%; the incidence of other risk factors, such as smoking, diabetes and a familial history of cardiovascular diseases was around 30% (Table I).

The majority of patients (58/64) had been referred to a cardiologist for the symptoms related to the coronary obstructive disease and the carotid stenosis emerged from the clinical and instrumental routine for cardiac surgery. Five patients were recognized as having severe coronaropathy following preliminary routine for carotid surgical procedure. In 1 case of normal preoperative cardiological evaluation we observed a cardiorespiratory arrest during anaesthetic induction for CEA procedure. The patient underwent coronarographic investigation highlighting a severe asymptomatic "two vessels" disease; for this reason a combined procedure was programmed after about 1 month.

TABLE III.—*Neurologic and carotid status.*

Parameters	No. of patients	%
Clinical findings		
Previous TIA	18	28.1
Previous stroke	10	16.6
Asymptomatic	36	56.3
Carotid status		
ICA stenosis 70-80%	12	18.8
ICA stenosis 81-90%	18	28.1
ICA stenosis >90%	34	53.1
Contralateral ICA stenosis 50-60%	21	32.8
Contralateral ICA stenosis 61-70%	9	14
Contralateral ICA thrombosis	4	6.2

All the patients had a clinical evaluation of cardiac and cerebrovascular symptoms. The diagnosis of coronary stenosis was always confirmed by coronarography and completed by echocardiographic study of myocardial function. The diagnosis of carotid stenosis, based on echo-color Doppler scans, was confirmed by angiography of the epiaortic trunks extended to the intracranial circulation.

As summarized in Table II, 33 patients (51.6%) presented anamnestic myocardial infarction with residual angor, 25 (39%) unstable angina, whereas 6 (9.4%) were asymptomatic; 2 patients had already had a CABG. Instrumental investigation showed that 31 patients (54.7%) had a trivascular coronaropathy, 18 (28.1%) a two vessels disease and 11 (17.2%) were affected by severe stenosis of the common trunk; furthermore 7 patients (10.9%) had a left ventricle ejection fraction reduced of more than 50%.

From the neurologic point of view, 56% of the patients were asymptomatic, whereas 44% had a positive neurologic history: TIA in 18 cases and stroke in 10. Thirty-four patients (55%) had a carotid stenosis of more than 90%; a significant disease of the contralateral carotid axis was observed in 53% of cases: stenosis >50% in 30 patients and thrombosis in 4 (Table III).

Operative technique

Two surgical teams worked in close succession. CEA was performed at the time of vein harvest, followed by CABG with sternotomic approach and extra-corporeal circulation, the last procedure being the closure of the cervical incision. The CEA was always performed under systemic heparinization (10,000 IU) with longitudinal extension (over-

TABLE IV.—*Surgical procedures.*

Procedure	No. of patients	%
CEA+1 CABG	7	10.9
CEA+2 CABG	23	36
CEA+3 CABG	29	45.3
CEA+4 CABG	2	3.1
CEA+1 CABG+aortic valve replacement	2	3.1
CEA+3 CABG+mitral valve replacement	1	1.6

pass technique) and selective endoluminal shunting (8 cases), as indicated by the somatosensorial evoked potentials (SSEP) monitoring. The arterial closure was usually performed by primary suture but a precoagulated Dacron patch was used in 8 patients with internal carotid thinner than 3 mm.

The CEA was associated with a variable number of aorto-coronary bypasses. Three patients also had concurrent replacement of the aortic or mitral valve (Table IV).

Results

Four patients died (6.2%) within 30 days after the operation. The cause was an early coronary graft failure in 2 cases (primary in 1 case and consequent on an irreversible coronary spasm in the second) and a multiorgan failure in the remaining 2.

We did not observe neurologic complications except in 1 case of transient paresis of the 7th and 10th cranial nerve.

In 2 patients the sternal wound was revised: in 1 case for bleeding, in the second for septic dehiscence.

The average stay in the cardiosurgical intensive care unit was 1.5 days plus 5 days on the ward, before the usual period in cardiac rehabilitation centres. Only in 1 case was the postoperative course complicated by severe bilateral pneumonia, conditioning respiratory and renal failure associated with haemodynamic instability (repeated hypertensive crisis); anyway the outcome was positive and the patient discharged on postoperative day 30.

Discussion

The concomitance of atherosclerotic disease with a critical stenosis both on the coronary and the carotid circulation identifies a group of particularly compromised patients, exposed to an elevated surgical risk. In fact in these conditions the CEA related cardiac mortality, normally close to 1%, rises to an incidence comprised between 5 and 20% [1-10] and, in the same way, the incidence of stroke connected to CABG rises from 1-2% to 6-14%.[11-14] In recent years there has been a significant increase in the number of such patients and it is estimated that 10-20% of CABG candidates are also affected by carotid lesions requiring surgical correction.[5, 7, 14-18] This is partially justified by the broadening of surgical indication to more compromised patients but, above all, it is consequent on the diffusion of ultrasound study of epiaortic vessels, at present one of the fundamental components of the diagnostic screening preliminary to any cardiosurgical procedure, independently of the patient's age and neurological symptoms.

These particularly fragile patients challenge the surgeon with problems related to their critical physiopathology, surgical timing and indication.

If the neuroendocrine solicitations connected to the surgical trauma and the sudden pressure alterations (consequent on carotid baroceptor stimulation or anesthesiologic manoeuvres during carotid cross-clamping) explain the increased cardiac risk during CEA,[13] in case of CABG the physiopathology of cerebral ischemic damage seems more complex and varied. The presence of critical carotid stenosis is generally considered a major risk factor for perioperative stroke and mortality. This evaluation has been strengthened by recent multicentric studies highlighting the stroke preventive role of CEA.[19-21] Other factors must however be carefully considered. The concomitance of severe lesions in different vascular districts represents an index of particularly severe atherosclerotic disease that, involving even the cerebral vasculature, increases the risk of haemorrhage, watershed ischemia or embolism.[7, 8, 22-28] The detachment of embolic material from the aortic arch and the proximal epiaortic trunks has been held responsible for CABG related ischemic events (20-60% of the total) affecting cerebral hemispheres vascularized by carotid arteries affected by low-grade stenosis.[18, 28-30] The embolic event can also originate from the pump-oxygenator system of the extracorporeal circulation.[17, 31] The fundamental role of an effective anaesthesiologic and resuscitation assistance has been underlined in

TABLE V.—*Literature results: postoperative morbidity.*

Authors	No. of patients	Neurologic complications (%)		AMI (%)
		Permanent	Reversible	
Rizzo 1992 [29]	127	7 (5.5)	n.a.	3 (2.3)
Vermeulen 1992 [34]	230	13 (5.6)	7 (3)	4 (1.7)
Nastasic 1993 [35]	40	—	—	n.a.
Wareing 1993 [36]	33	—	—	n.a.
Chang 1994 [37]	189	2 (1)	4 (2.1)	n.a.
Halpin 1994 [38]	133	2 (1.5)	2 (1.5)	6 (4.5)
Mackey 1996 [31]	100	9 (9)	2 (2)	6 (6)
Daily 1996 [39]	100	—	n.a.	1 (1)
Chiesa 1997 [17]	64	1 (1.5)	—	—
Hertzer 1997 [40]	304	13 (4.3)	n.a.	n.a.
Jahangiri 1997 [41]	64	1 (1.5)	2 (3.1)	—
Takach 1997 [26]	255	10 (3.9)	n.a.	12 (4.7)
Trachiotis 1997 [27]	88	3 (3.4)	2 (2.2)	—
Terramani 1998 [42]	30	—	—	1 (3.3)
Darling 1998 [43]	470	5 (1)	1 (0.2)	n.a.
Plestis 1999 [44]	213	6 (2.8)	5 (2.3)	5 (2.3)
This study	64	0	0	0
Total	2504	72/2504	25/1718	38/1468
%		3.26	1.4	2.2

n.a.=not available.

TABLE VI.—*Literature results: postoperative mortality.*

Authors	No of patients	Mortality				Others
		%	Cardiac	Neurolog.	MOF	
Rizzo 1992 [29]	127	5.5	7	0	0	0
Vermeulen 1992 [34]	230	3.5	4	1	3	0
Nastasic 1993 [35]	40	5	2	0	0	0
Wareing 1993 [36]	33	9	2	0	0	1
Chang 1994 [37]	189	2.1	3	1	0	0
Halpin 1994 [38]	133	1.5	0	2	0	0
Mackey 1996 [31]	100	8	4	2	2	0
Daily 1996 [39]	100	4	4	0	0	0
Chiesa 1997 [17]	64	9.4	6	0	0	0
Hertzer 1997 [40]	304	5.3	6	2	4	4
Jahangiri 1997 [41]	64	0	0	0	0	0
Takach 1997 [26]	255	3.9	7	2	0	1
Trachiotis 1997 [27]	88	3.4	1	2	0	0
Terramani 1998 [42]	30	0	0	0	0	0
Darling 1998 [43]	470	2.4	9	1	0	0
Plestis 1999 [44]	213	5.6	10	2	0	0
This study	64	6.2	2	0	2	0
Total	2504		67	15	11	6
%			2.7	0.6	0.4	0.2

MOF: multiple organ failure.

a recent publication by the Texas Heart Institute [26] demonstrating that perioperative variables such as haemodynamic stability and cardiac arrhythmia during CABG as well as pathologic states such as congestive cardiopathy, directly correlate to the occurrence of cerebrovascular morbidity. Furthermore Ricotta *et al.*[7] in a logistic regression analysis found the risk of stroke during CABG independently associated with concomitant valve replacement and redo CABG. The absence of neurologic complications in our 64 patients leads us to consider as marginal the role of the above mentioned pathogenetic alternatives and the removal of the carotid stenosis offers itself the best protection from cerebral damage, whenever the surgical and anaethesiologic procedures are correctly performed.

Different technical solutions have been suggested in the surgical approach to associated coronary and carotid lesions: CEA and CABG can be performed in two different stages, within a few days interval (sequential approach, CEA first and then CABG or *vice versa*), or during the same procedure (combined approach); in this case CEA is performed during the vein harvest, prior to cardiopulmonary bypass or any off-pump cardiac procedure. It is difficult to compare the different timing because the literature shows a consistent bias since the more compromised patients are often selected for the combined approach.[18, 26, 32] Nevertheless, a meta analysis on 56 publications carried out by Moore *et al.*[33] on behalf of the American Heart Association has demonstrated that when CEA comes before CABG, the sequential and combined approach have a similar rate of neurologic complications but the incidence of myocardial infarction and mortality is greater ($p<0.01$ and $p<0.02$, respectively) in sequentially treated patients. Furthermore, if CABG comes before TEA sequential treatment has a higher stroke incidence.

The results of the combined approach, as reported by a series of recent papers, are summarized in Tables V and VI.[34-44] The risk of debilitating stroke and mortality ranges around 3 and 4%, respectively. A careful examination of these results suggests some considerations. First of all, it should be hightlighted that cardiac mortality represents 67% of the total and that this value rises to 78% when considering the role of an even transitory pump insufficiency in determining, maintaining or precipitating the complex physiopathology of mul-

tiple organ failure. This is confirmed by our experience, in which all the major complications are due to cardiac mortality or to MOF. Anyway the 2 cardiac deaths are consequent on a coronary graft failure and not on per- or immediately postoperative ischemic complications, which never occurred. It is also evident that the risk of neurologic complications is correlated to the degree and to the clinical relevance of the carotid stenosis. Infact the best results are obtained in patients with asymptomatic carotid stenosis, as was highlighted by Terramani *et al.*[42] that, reporting their own experience and extrapolating the results of other 9 authors, showed an incidence of perioperative stroke and mortality lower than 2 and 3%, respectively, on a sample of 569 patients, with neither morbidity nor mortality in the experience of 5 out of the 10 surgical groups, counting 137 patients. Likewise Chang [37] reports a 1% rate of invalidating stroke and a 2% incidence of mortality in a highly select group of 189 patients, the majority of which were neurologically asymptomatic (82%) and affected by monolateral carotid disease (89%). When in the presence of severe bilateral carotid stenosis or neurologically symptomatic patients, neurologic morbidity and mortality seem to be markedly higher in the different published experiences. Machey [31] reports an 8% mortality rate and a 9% incidence of stroke in a group of 100 patients, of whom 57 were neurologically symptomatic and 61 had a severe contralateral carotid stenosis. In a group of 99 patients with similar distinctive features Hertzer *et al.*[45] recorded a mortality rate of 6% and a 7% incidence of invalidating stroke reaching 21% in patients with symptomatic bilateral carotid stenosis. Similarly Rizzo [29] reports a 15% incidence of stroke in patients with contra lateral carotid thrombosis, which increases to 19% in case of anamnestic stroke. Our experience does not confirm this data and major neurologic complications did not occur, even in the case of severe symptomatic bilateral carotid involvement. We believe that intraoperative monitoring of cerebral response to carotid cross clamping indicating the insertion of a temporary endoluminal shunt is of paramount importance, especially in high risk conditions. In our experience intraoperative SSEP monitoring [46] has proved to be extremely reliable with an absence of ischemic cerebral complications in the 64 cases we presented in this paper and a stroke incidence of 0.8% in the 1363 "pure" CEAs performed in the same period.

Theoretically the role of minimally invasive endovascular procedures on the carotid bifurcation could be highlighted in this particular subgroup of patients. Anyway until the results of large trials are available, carotid angioplasty and stenting must be considered as an experimental procedure: results from 36 world leading centres performing 5210 procedures on a selected group of 4757 patients [47] show a combined stroke (minor and major) and procedure-related death rate of 5.07% which compares poorly to the results (obtained on a selected high-risk group of patients) of the great majority of the above mentioned series (Tables V, VI).

Conclusions

The simultaneous approach to carotid and coronary stenosis seems to be an effective option in reducing the elevated surgical risk of patients affected by multi-district critical stenosis, for whom an alternative to CABG does not exist. In particular our data highlight that in CABG candidates the concomitant CEA dramatically reduces the stroke risk; *vice versa*, we cannot evaluate the effect of CABG in reducing the risk of myocardial infarction in CEA candidates, as our experience includes only 6 such patients.

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