Combined Carotid Endarterectomy and Coronary Artery Bypass Grafting. Analysis of the Results

Márcio Luís Lucas, Telmo Pedro Bonamigo, Elton Luiz Schmidt Weber, Fernando Antônio Lucchese
Santa Casa de Porto Alegre - Porto Alegre, RS - Brazil

Objective

To evaluate the results of combined surgery (carotid endarterectomy and coronary artery bypass grafting) in patients with concomitant carotid and coronary artery disease.

Methods

The authors reviewed 49 different reports describing several aspects of the combined surgery in 4788 patients to analyze early events in the perioperative period.

Results

Overall stroke, acute myocardial infarction (AMI), and mortality rates were 4.3%, 2.2%, and 4.2%, respectively. Most recent papers (1990 to 2000) show significant lower incidence of strokes compared to those published earlier (1972 to 1989) (4.1% x 10.2%; $p < 0.05$). In this same survey, the incidence of postoperative stroke was higher in the series with a small sample ($n < 50$) than in those with a larger population ($n > 100$) (7.2% x 3.9%; $p < 0.05$), denoting the impact of surgeons' experience on postoperative results.

Conclusion

In sum, we believe that combined carotid endarterectomy and coronary artery bypass grafting is a safe and effective procedure when performed by experienced and qualified surgeons.

Key words

carotid endarterectomy, coronary artery bypass grafting, review

Mailing Address: Márcio Luís Lucas • Rua Independência, 44/905 – 92000-010 – Porto Alegre, RS - Brazil
E-mail: mlucasvasc@ig.com.br

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Indications for isolated coronary artery bypass grafting (CABG) and carotid endarterectomy (CE) are well established in current literature [1-4]. About 8% to 14% of patients undergoing CABG have significant carotid artery stenosis (> 70%), and nearly half the patients undergoing CE have some degree of heart disease [5-7], and the surgical management of these patients is controversial [8,9,10].

Several surgical tactics and techniques are available to treat patients with associated obstructive coronary artery disease and carotid artery disease. The most commonly described in literature are the *combined* approach (CE and CABG performed under the same anesthesia); the *simultaneous* approach (synchronous or concomitant), in which two surgical teams work at the same time; the *sequential* approach, in which either CE or CABG is peformed first in a single anesthetic period; the *staged* approach, with CE preceding CABG; and finally the *reverse staged* approach, addressing the coronary disease first and delaying the carotid endarterectomy for some days so the patient can recover from the first operation [11].

Although the superiority of combined *versus* staged approach has not yet been established, most vascular surgeons favor the combined approach [7].

This review aims at addressing aspects of patients' clinical profile, surgical indications, operative tactics and techniques, results and postoperative complications of combined surgery in patients with advanced atherosclerotic disease.

Methods

Patients' clinical profile

Most patients with atherosclerotic disease in two different arterial territories (carotid and coronary) are elderly individuals with risk factors for atherosclerotic disease, such as high blood pressure, smoking, dyslipidemia, and diabetes. The majority are obese, sedentary, have family history of coronary heart disease and past history of some kind of neurological or cardiovascular event. In short, these patients require extra care and close monitoring during the perioperative period, because they tend more to develop serious postoperative complications, such as stroke, acute myocardial infarction (AMI), and death.

Mean age of these patients is 65, with a 3:1 male-to-female prevalence [12,13]. Some studies have demonstrated that patients age 65 and above are more likely to develop postoperative stroke when compared to patients under 65 [7].

The frequency of each risk factor is shown in Table I[12-25]. The range of values shows the heterogeneity of samples from several studies, and high blood pressure and smoking were the most frequent factors. In addition, the degree of systemic atherosclerosis may also be shown by the frequency of peripheral artery disease in these patients [14,15].

Cardiac history is important information in the preoperative evaluation of patients who will be submitted to a combined procedure. Acute myocardial infarction (AMI) rates prior to surgery may range from 41% to 67%[8,16]. Approximately 20% to 30% of the patients have congestive heart failure (CHF)[16,17], and between 20% and 67% have unstable angina[7,9]. Most patients with angina (70% to 75%) are in NYHA III and IV functional class (New York Heart Association)[12,15,16]. In the preoperative angiographic study, around 60% to 80% of the patients have left main and three-vessel CAD [10,18]. Ejection fraction lower than 50% may be present in up to 72% of the patients[18].

Table I – Variation in the frequency of risk factors for cardiovascular disease in patients who underwent combined surgery (CE + CABG)[12-25]

Systemic arterial hypertensionCigarette smoking	39% to 91%
Diabetes mellitus	26% to 81%
Diabete melito	8% to 48%
Obesity	up to 55%
Dyslipidemia	35% to 60%
Peripheral arterial disease	24% to 58%

In the neurological assessment, up to 70% of the patients may have prior symptoms[16], with transient ischemic attack (TIA), prolonged reversible ischemic neurological deficit (PRIND) and amaurosis fugax being found in 20% to 60%, up to 16% and 8% respectively[8,9,19]. Moreover, permanent stroke was previously diagnosed in about 20% of the patients in some series[16,18,26,27]. The degree of carotid lesion was also studied. Thus, is some studies, mean stenosis exceeded 85%[18,26]. Significant bilateral lesion was present in up to 60% to 90% of the cases[14,16]. Significant contralateral lesion was found in 20% to 40%[7,12], whereas total contralateral occlusion ranged from 10% to 48% in the operated patients[8,18]. In the study by Trachiotis and Pfister[18], the average for stenosis on the operated side in patients with bilateral lesion was 86.2% *versus* 81.5% on the opposite side, whereas in the Mackey et al[26] study these rates were 88.8% and 75.3%, respectively, emphasizing these patients potential for postoperative complications. Therefore, it is not uncommon for us to treat patients with bilateral carotid lesion, and the management of these patients must be well thought out. Most authors are reluctant to correct the bilateral carotid lesion together with the cardiac surgery, first performing the carotid endarterectomy on the side that most contributes to cerebral blood flow, that is, the less stenotic side. However, Dylewski et al[14] reported their experience with 33 patients who underwent simultaneous CABG and bilateral CE. Ninety-four per cent of the patients had right-side lesion and 91%, left-side lesion. Neither stroke nor AMI was found in this series, and both mortality and pulmonary complications were present in 6% and 12% of the patients, respectively

Surgical indication and technique

The occurrence of preoperative carotid lesion in patients with obstructive coronary artery disease was demonstrated by some studies. Therefore, screening programs in CABG candidates may identify from 2.8% to 8.7% of the patients with significant carotid lesion (≥ 75%)[28-33].

The frequency of combined surgeries (CABG + CE) among myocardial revascularization surgeries ranges from 0.7% to 4.2%[17,18] and is expanding in some centers as the effectiveness of this procedure is increasingly recognized, as well as the higher incidence in elderly patients with advanced atherosclerotic disease[7].

Recommendation for combined procedure presupposes the presence of unstable angina, significant left main lesion, hemodynamic instability, and multiple-vessel disease in patients with symptomatic carotid disease and significant stenoses or bilateral lesion[8]. This surgery is not indicated for patients with asymptomatic carotid lesion, because the risk for stroke is similar to the surgical risk[11]. Staged surgery is indicated for patients more hemodynamically stable and having single- or two-vessel disease[9]. This distinction, however, is not well defined. Some authors have demonstrated their experience with the combined surgery in often stable and neurologically asymptomatic patients. Deciding on the surgical option (staged or combined) depends on the patient's condition, as well as the surgeons' experience in performing one or the other. Ideally, surgical treatment of patients with both lesions should be elective; however, the incidence of urgent or emergency surgery ranges from 33% to 72%[7,14].

Most authors recommend that carotid surgery be performed in cases of significant unilateral lesion, previous neurological symptoms or the presence of ulcerated atheromatous plaque. Nevertheless, cutoff point for establishing significant lesion ranges from 70% to 80%[1,8,18]. Other indications, such as bilateral lesion ≥ 50%, unilateral lesion ≥ 50% with the other side occluded and presence of carotid bruit, are also taken into account by other authors[9,13,15,16,18,19,26,34,35].

In some series, CABG was preceded by CE under the same anesthesia without extracorporeal circulation (ECC)[7,9,12,17,26,36]. Still, Khaitan et al[13] have reported good results with the combined procedure using ECC. These authors have noted that longer ECC time was associated with increased morbidity and mortality rates and prolonged intensive care unit (ICU) stay. Conversely, ECC did not significantly affect morbidity and mortality rates in the study of Schwartz et al[37] Minami et al[8] have likewise analyzed the effect of ECC on combined surgery in 340 patients, to check whether this approach could provide some degree of neuroprotection, reducing postoperative complications. The rationale was that the hypothermia caused by ECC would decrease oxygen delivery to the brain, as well as attenuate production of anoxic brain metabolites. The results obtained by these authors, however, may be compared to those of other researchers who did not use ECC during CE.

Decision regarding which patients should be referred to combined surgery, as well as how it should be performed, has been largely debated. Some authors have shown that CABG without concomitant management of significant carotid lesion may have neurological complications ranging from 7% to 61% plus 1.6% and 23% for transient and permanent lesions, respectively[38]. Risk of perioperative stroke increases nearly three-fold in patients with history of cerebrovascular ischemia[31]. With the combined approach, these rates drop to around 10% for neurological lesions[26,27,39-44]. Other major risk factors for neurological damage following CABG include advanced age and prolonged ECC time[45]. However, AMI incidence after CE varies widely. For patients with no history of cardiac symptoms, the incidence is as low as 1%, whereas for patients with history of cardiac symptoms these rates may be as high as 7% a 17%[46].

The rationale for combined surgery indication is three-fold: first, undiagnosed carotid artery disease may be an aggravating factor for perioperative neurological damage in patients who undergo CABG; therefore, management of carotid lesion prior to ECC decreases such risk. Second, the sequential procedure, CE followed by CABG, would lead to an increase in cardiovascular morbidity and mortality, because ischemic heart syndromes are the primary complications in patients submitted to management of carotid disease. Finally, by proposing surgical treatment for only one arterial territory (carotid or coronary), the risk exists that an stable condition becomes unstable[45].

The literature has shown that a carotid disease greatly increases the likelihood of stroke following CABG[28,47,48]. Therefore, CE should precede CABG in both the combined and the staged approach, depending on patient condition, availability of surgical teams, and local surgical experience. To clarify what would be the best approach to treat these patients, Borger et al[5] published a meta-analysis of sixteen studies comparing the results of combined and staged surgeries. This meta-analysis found that the combined group (n = 844) had stroke (6% x 3.2%) and mortality (4.75% x 2.9%) rates significantly higher compared to those of the staged group (n = 920). However, incidence of AMI in the combined group (4.6%) did not greatly differ from those of the staged group (5.1%). Such results are probably due to the higher severity of the diseases associated to the group of patients who underwent combined procedure in these studies.

In their study, Coyle et al[10] identified higher rates of morbidity and mortality (stroke and death) after combined surgery when compared to staged surgery. It should be remembered that neurologically symptomatic patients with higher degree of carotid stenosis, hypertension, smoking habits, angina and three-vessel disease, were more prevalent in the combined group, when compared to the staged group. These findings show the higher gravity

of the condition of patients who underwent combined procedure in most studies. Moreover, a randomized study to determine whether there are differences in outcomes between both surgeries is needed. Such study would require the involvement of several institutions so that a reliable population sample size may be obtained.

According to the calculations of Borger et al[5], to an incidence of final outcome (for example, stroke) of 7.5%, we would need a sample of 1500 patients per group in order to detect a relative risk decrease of 33% with an alpha level of 0.05. Similarly, Barnes et al[49] reviewed 1483 patients with asymptomatic carotid artery disease, sudivided in both procedures. This study found lower AMI (3.8% x 11.8%) and mortality rates (4.7% x 11.1%) in the combined group; however, stroke incidence in the combined group (2.8%) did not show a statistically significant difference from the staged group (3.15), and these results differ from those obtained by Borger et al's meta-analysis[5].

With respect to the surgical procedure itself, some points may be addressed regarding several techniques used in said studies. A great number of authors use intraoperative electroencephalographic monitoring to show potential changes secondary to cerebral hypoperfusion, using shunt from the moment such changes are seen[8,12,16,36.] Moreover, hypothermia (temperature between 27 ºC and 30 ºC) and hemodilution (hematocrit between 20% and 25%) seem to play a role in neuroprotection during CEE. However, hypothermia may sometimes mask potential electroencephalographic ischemic changes, delaying judicious use of internal shunt intraoperatively[8]. This device may be used at the surgeon's discretion[7], or be based on the presence of contralateral occlusion[15]. Some authors do not routinely use either electroencephalographic (EEG) monitoring or shunting[13], while others always do[17,18]. Dylewski et al[14], contrary to the conventional technique for carotid endarterectomy, performed the bilateral eversion technique in 33 patients, and obtained stroke and AMI rates of zero percent and mortality rate of 6.1%.

Use of patch angioplasty is not consensual; some authors use this technique routinely[8,15], while others use it only when the diameter of the internal carotid is lower than 4 mm[15,17]. Primary arteriography with no patch is the procedure of choice in other papers[7,9,13].

Factors that determine the length of surgery, such as ECC time, clamping time, and number of grafts for patient also may affect results. ECC time is an important risk predictor for postoperative complications, ranging from 72 to 129 minutes.[13,18] Aortic clamping time ranges from 32 to 44 minutes[10,14], and number of grafts may vary from 2.9 to 4 per patient[8,36].

Results

Some papers evaluated postoperative outcomes in combined CE/CABG with regard to length of hospital stay, ICU stay, pulmonary and renal complications, infections, survival and absence of long-term neurocardiovascular events. However, the most discussed and presented data were postoperative rates of stroke, AMI, and mortality.

Compiling data from 49 papers with over fifteen patients each (total of 4788 patients) reporting the experience of several centers in combined surgery, we have found rates of stroke between 0 and 13.3%, AMI between 0 and 10.4%, and mortality between 0 and 11.5%. Global incidence of stroke, AMI, and mortality was 4.3%, and 2.2%, respectively. A recent study by Brown et al[50], involving ten US states, assessed the results of 226 combined procedures (CE + CABG) in patients with mean age of 72.2 Rates of stroke (12%) and mortality (6.7%) were higher than those found in most papers we reviewed, although these values still fall into the variations stated previously. Based on these results, Brown et al[50] emphasize that judgment must be exercised in indicating combined procedure, since most patients reviewed by these authors were asymptomatic in terms of cerebrovascular disease, and that postoperative stroke symptoms were mostly unrelated to the cerebral hemisphere corresponding to the operated side[50] .

To assess how date of publication affected morbidity and mortality results, we divided the papers into two groups: the "old", consisting of 27 papers published between 1972 and 1989, and the "new", consisting of 23 papers published between 1990 and 2000. Mean age of each group was 62.2 and 68.6 years, respectively. Stroke and AMI rates were 10.2% and 4.1%; and 2.5% and 2.1%, respectively. As for mortality, rates were 5.4% for the "old" group and 3.8% for the "new" group. Using the chi-square test (x^2), considering $p < 0.05$ statistically significant, we have found that postoperative stroke was significantly higher in the "old" group, even though patients' age in this group was considerably lower than in the "new" group ($p < 0.05$). No difference was found between groups regarding mortality and postoperative AMI (tab. II).

In a recent systematic review, Naylor et al[51] analyzed the results of simultaneous surgery in 94 papers, in a total of 7863 procedures. Rates of stroke, AMI, and death found by these authors were 4.6%, 3.6%, and 4.6%, respectively. Analysis of results according to publication date (1972-1992 vs. 1993-2002), showed a decrease in death rate (5.2% vs. 4.4%), stroke (6.5% vs. 3.3%), and AMI (4.3% vs. 3.4%); combined rates of stroke/death/AMI was significantly higher in the first group (13.8% vs. 8.6%; $p = 0.03$)[51].

The overwhelming majority of references used in this review are from the English literature. In Brazil, little has been published on the subject. Fichino et al[52] reported their outcomes after combined surgery in thirty patients. No perioperative AMI was found; two patients had TIA (6.6%) and two others died (6.6%) of stroke and low cardiac output. In the group of 46 patients operated by

Table II – Complications following combined surgery (CE + CABG) in 49 published papers with more than fifteen patients each

Groups	Papers(n)	Patients(n)	Age (years)[a]	Stroke (%)	AMI (%)[b]	Deaths(%)
"old" (1972-1989)	26	1801	62.2	10.2	2.5	5.4
"new" (1990-2000)	23	2987	68.6*	4.1*	2.1	3.8
p			0.02	0.02	0.421	0.338
Total	49	4788	65.2	4.3	2.2	4.2

[a]Available data in twenty-two papers, fifteen of which are "new". bAvailable data of thirty-six papers, sixteen of which are "new".
** Statistically significant difference when groups are compared (p < 0.05; chi-square test)*

Souza et al[53], between January 1979 and November 1994, neither stroke nor AMI was found, and the four deaths (8.6%) were due to: low cardiac output/respiratory failure (n = 1), rupture of the descending aorta (n = 1), death during lower extremity revascularization surgery (n = 1), and multiple organ failure.

Such results may reflect refinements in surgical and anesthetic techniques, as well as qualified training of vascular and cardiac surgeons, anesthetists, and intensivists in the management and approach of patients undergoing combined surgery. This analysis, however, is not free from bias regarding selection of patients, and there may be differences in demographic, clinical, and angiographic characteristics of patients comprising each group. Still, these overall results lend some credence tocombined surgery, which has acceptable mortality and morbidity rates for such a major surgery and has been increasingly performed by cardiovascular surgeons.

Similarly, Rizzo et al[16] reviewed sixteen papers covering over fifty patients; the papers were published between 1979 and 1992 (total of 1815 patients) and found global rates of stroke, AMI, and mortality of 5.6%, 3%, and 4.8%, respectively. These values are similar to ours, although we compiled only one of the papers included in this review.

Mean hospitalization following combined surgery may range from 10.3 to sixteen days,[26,36] and mean ICU stay, from 3.6 to four days[13,18]. Respiratory complications occurred in up to 12% of the patients[14], acute renal failure in 6%[14,36], bleeding requiring surgical reintervention in 5%[36]; wound infection and hematoma in 4%[10,36]; low cardiac output syndrome (LCOS) from 0.6% to 4%[8,36], arrhythmias in up to 33%, and atrial fibrillation from 0 to 34%[15].

Another interesting piece of data was the frequency of contralateral stroke, which may account for up to 50% of all postoperative stroke, emphasizing the likelihood of other causes for these neurological complications, such as aortic or cardiogenic embolism, intracranial hemorrhage, and reduced cerebral perfusion associated with arterial hypotension[27].

Stroke-free rates range from 67% and 96.4%[7,26], and AMI-free rates range from 60% to 84%[7,16]. In some papers, the ten-year incidence of contralateral stroke after surgery is 11.8%, and ipsilateral stroke, 9.3%[8]. The two-year, three-year, five-year, and ten-year survival rates may be as high as 94.2%, 81%, 78.9%, and 56.1%, respectively[10,12]. Late mortality is attributed mainly to cardiac events (62%), caused primarily by left ventricle dysfunction, reoperation, advanced age, and history of AMI[16].

To evaluate the influence of the authors' combined surgery experience on postoperative results, we further divided the results of the 49 papers into three groups, according to the number of patients of the studied paper. The first group is composed of papers with less than fifty patients; the second, with fifty to 99 patients; and the third with a hundred or more patients each (Table III). From this perspective, as the study population sample increases, the occurrence of the most feared complication following the combined surgery – stroke – significantly decreases from 7.2% in the group of less than fifty patients to 3.9% in the groups with a hundred or more patients each ($p < 0.05$). Said difference was not found regarding the incidence of postoperative AMI and death.

These findings are similar to those of Takach et al[54], who found rates of stroke significantly higher in the group operated between 1975 and 1985, when compared with the group operated between 1986 and 1996 (5.4% x 1.9%; $p < 0.05$). For these same authors, postoperative AMI and death rates showed no significant difference between groups. However, in our analysis, we made no distinction regarding the number of patients operated and the period of study. Thus, a study consisting of 49 patients operated over a one-year period could belong to the same group of another study that evaluated 150 patients operated over a three-year period, because both are equivalent in terms of the number of patients operated by year of study, which, in this instance, is approximately fifty patients/year.

Table IV shows results regarding demographics and clinical data, as well as postoperative outcomes, of recent studies performed with a hundred or more patients. These are the results of 1663 patients operated in different centers, whose demographic, clinical and angiographic characteristics are presented. It can be noted that the incidence of stroke, AMI, and death in the immediate postoperative period ($\leq$ thirty days) is 4.6%, 5.0% and 1.7%, respectively, similar to that found in the broader analysis (n = 4.788) shown previously. It can also be noted that vascular and cardiovascular surgeons tend to

operate elderly patients more often, since mean age in the study of Rizzo et al[16] and Khaitan et al[13] ranged from 65 to 69.2 years, respectively.

As previously stated, neurological symptoms, bilateral carotid artery disease, left main coronary trunk involvement, and multiple-vessel lesion are more severe and, as shown in Table IV, their frequency varies considerably. Mean global rates of these characteristics were 44.3%, 42.6%, 28% and 89%, respectively, meaning that nearly half of the operated patients have prior neurological symptoms and bilateral carodid artery disease, whereas, on average, one third of the sample has left main coronary artery, and a great part of the patients have multiple-vessel disease.

Conclusions

The incidence of concomitant carotid and coronary disease is a frequent finding in patients with advanced atherosclerotic disease secondary to numerous cardiovascular risk factors, such as high blood pressure, cigarette smoking, dyslipidemia, obesity, and diabetes. Screening for carotid artery disease in candidates for CABG is an important tool in surgical planning, since several papers have shown that carotid disease increases the risk for neurological complications following CABG, and that, when CE is performed before CABG, there may be significant impact on long-term postoperative results. Among the different approaches for the operative management of the associated disease, combined surgery (simultaneous) has proved to be safe and effective, with acceptable morbidity and mortality rates. Combined procedure allows a single anesthetic and hospitalization to treat two diseases associated with high morbidity and mortality rates, decreasing the risks posed by delayed treatment and reducing hospital costs.

Although combined surgery has been increasing in number annually, some studies, such as that of Borger et al's[5] show that optimal results are attained by the staged procedure; however, it must be remembered that gravely ill, higher risk patients may be more prevalent in the combined group and that no totally randomized trial has been carried out to clarify which procedure is the best.

Management of patients with associated disease should be individualized and well-thought out; however, some clinical conditions merit underscoring:

Table III – Results after combined surgery (CE + CABG) depending on numbers of patients for study

Patients/group	Papers (n)	Total patients.	Stroke (%)	AMI (%)	Deaths (%)
n < 50	13	362	26 (7.2)#	7 (2.1)*	15 (4.1)
50 ≤ n <100	17	1189	53 (4.4)	15 (1.7)**	63 (5.3)
n > 100	19	3237	128 (3.9)	51 (2.4)***	124 (3.8)
Total	49	4788	207 (4.3)	73 (2.2)	202 (4.2)

**n = 329; **n = 862; e ***n = 2129, due to lack of available data in the papers.*
 # Statistically significant difference when compared to groups (p < 0,05; chi-square test)

Table IV - Results of combined surgery from recent papers with a hundred or more patients each

Author (reference)	Year	Patients (n)	Mean age (years)	Symptoms neurological (%)	Disease bilateral (%)	Main trunk left (%)	Lesion 3 vessels (%)	AVC (%) permanent	IAM (%)	Deaths (%)
Rizzo *et al*.[16]	1992	127	65	86 (68)	75 (59)	48 (37)	?	7 (5.5)	6 (4.7)	7 (5.5)
Vermeulen *et al*.[12]	1992	230	65.2	108 (47)	92 (40)	67 (29)	185 (80)	13 (5.6)	4 (1.8)	8 (3.5)
Chang *et al*.[19]	1994	189	66	51 (25)	?	?	?	2 (1.0)	?	4 (2.0)
Coyle *et al*.[10]	1995	110	66.5	59 (53.6)	?		96 (87.3)*	12 (10.9)	1 (0.9)	8 (7.3)
Akins *et al*.[7]	1995	200	67	85 (42)	44 (22)	86 (43)	130 (65)	8 (4)	5 (2.5)	7 (3.5)
Mackey *et al*.[26]	1996	100	68	57 (57)	61 (61)	?	?	9 (9)	6 (6)	8 (8)
Daily *et al*.[36]	1996	100	68	21 (21)	51 (51)	20 (20)	76 (76)	0 (0)	1 (1)	4 (4)
Takach *et al*.[54]	1997	255	65.6	93 (36.5)	83 (32.6)	75 (29.4)	?	10 (3.9)	12 (4.7)	10 (3.9)
Khaitan *et al*.[13]	2000	112	69.2	21 (19)	25 (22.3)	25 (21)	93 (77)	7 (5.8)	?	7 (5.8)
Minami *et al*.[8]	2000	340	65.3	156 (45.6)	151 (44.4)	33 (9.7)	?	11 (3.2)	2 (0.6)	9 (2.6)
TOTAL		1663		737 (44.3)	582 (42.6)	354 (28)	484 (75.4)	77 (4.6)	83 (5.0)	72 (4.3)
Variation		100-340	65-69.2	19-68%	22-61%	9.7-43%	65-80%	0-10.9%	0.6-6%	2-6%

**The authors did not state which patients had only three-vessel or left main artery disease*

• *Asymptomatic carotid bruit:* CABG seems to be the treatment of choice; however, when carotid stenosis is critical (90%), combined surgery is indicated.

• *Previous stroke:* in the presence of a major carotid lesion (80%) and unstable angina, sequential surgery is indicated. Yet, in the presence of unstable angina, multiple-vessel disease or left main trunk lesion, combined surgery may be the best choice.

• *Previous TIA:* in the case of critical carotid artery lesion, the combined surgery is suggested; otherwise, CABG should be performed first.

• *Previous carotid surgery (restenosis of the carotid artery):* when lesion exceeds 50%, sequential surgery is the choice[45].

The classical indication for combined surgery has usually been for patients with unstable angina and multiple-vessel disease associated with significant carotid lesion (symptomatic). While there are some controversial techniques, such as on-pump carotid endarterectomy, the use or not of patches and bypasses, the use of heart perfusion pumps, as well as other means in an attempt to decrease damage and postoperative complications, we believe that a total morbidity and mortality rate (occurrence of stroke, acute myocardial infarction, and death) around 10% to 12% is acceptable, since, according to our analysis, postoperative stroke, AMI, and mortally rates are about 4.3%, 2.2%, and 4.2%, respectively.

Another interesting piece of information is that isolated post-CABG stroke may be as high as 2% to 3%, and isolated post-CE stroke may be as high as 2% to 3%; hence, mortality for this outcome in surgeries, if performed isoladedly, would be between 4% and 6%, close to the rates found in our analysis of combined procedure (4.3%).

In sum, although seemingly safe and effective, combined surgery in patients with symptomatic atherosclerotic disease in both the carotid and coronary artery territories should be recommended and performed by well-trained, dedicated, skilled surgeons, anesthetists, and clinicians, supported by a qualified paramedic team, in an attempt to ensure the best results for patients always.

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