ORIGINAL ARTICLE

Carotid stenosis and coronary artery bypass grafting

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Summary

Objective: To identify carotid stenosis (CS) prevalence and potential mortality predictors in individuals undergoing elective coronary artery bypass grafting (CABG). **Methods:** Cohort study including 393 scheduled for CABG. All patients underwent a color Doppler ultrasound study of the carotid arteries prior to CABG and were assessed for morbidity and mortality over the hospitalization. CS was considered clinically relevant when if ≥ 50%. Significance was set at $p < 0.05$. Logistic regression was used to define mortality independent predictors. **Results:** CS prevalence was 17.4%. Following logistic regression analysis, CS ≥ 50% ($p = 0.001$) and chronic renal failure (CRF) ($p = 0.03$) remained as mortality independent predictors. **Conclusion:** CS showed a high prevalence in the study sample and together with CRF was a mortality independent factor.

Keywords: Carotid arteries; atherosclerosis; coronary artery disease; coronary artery bypass grafting.

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Introduction

Significant disease in the carotid artery causes a four-fold increase in stroke perioperative risk[1]. The identification of a carotid stenosis (CS) previously to a carotid artery bypass graft (CABG) surgery can change the surgical management and reduce morbidity from stroke[2,3] and mortality with acceptable risks and cost[4,5]. To date, information is still insufficient to declare carotid endarterectomy previously or simultaneously with CABG is superior in patients with coronary artery disease (CAD) to prevent a postoperative CABG[6-12].

Carotid ultrasound has been considered an effective and widely accepted screen tool for carotid disease examination, being conducted rapidly and safely[13].

In view of the lack of data about the matter, the current study aimed to evaluate by color Doppler carotid ultrasound the CS prevalence in patients who will undergo an elective CABG. Secondarily, the ultrasound can identify associated factors that could be death predictors postoperatively over the hospitalization period.

Methods

This is a contemporary cohort study of 393 consecutive patients admitted to the Institute of Cardiology of Rio Grande do Sul to undergo a CABG and invited to participate in a CS screen preoperatively. The primary endpoint was death.

All patients signed an informed consent and the study was approved by the Institute Research Ethics Committee. The data collection was started in May 2007 and closed in April 2008.

Sample size calculation

Considering a beta error 20% and an expected CS frequency 6.3%, 393 individuals would be required to reach the statistical difference ($p < 0.05$) concerning the mortality independent predictors.

Patients

The specific criteria for surgery indication were observed[14].

Patients who did not agree to participate in the study or those with a concomitant surgery indication (CABG and carotid endarterectomy) were excluded.

Study proceedings

All patients underwent a color Doppler ultrasound of the carotid arteries.

Color Doppler ultrasound

The ultrasound studies were carried out by three physicians specialized in vascular ultrasonography, blinded to any patient's clinical history or physical examination data and who adopted the same criteria to diagnose CS in an ultrasound apparatus (GE Logiq 500; General Electric Medical Systems, Milwaukee, WI).

The stenosis was identified and rated by the following parameters: linear stenosis and stenosis area.

Statistical analysis

Continuous variables were expressed as mean ± standard deviation (SD) and compared by the two-sided Student's *t* test. The two-sided Mann-Whitney U test was used for variables with non-normal distribution. Qualitative variables were expressed as numbers and percentage. The median was used for variables with non-normal distribution.

Either the chi-squared or the Fisher's exact test was used to compare categorical variables in univariate analysis: patients without CS or CAD *versus* patients with coexisting CS and CAD.

The odds ratio (OR) and its 95% confidence interval (CI) were calculated for each risk factor, with a corresponding p-value, thus determining correlation limits with a 5% error.

Baseline differences across the groups regarding demographic variables were determined by multivariable analysis in order to evaluate which independent risk factors were associated with CS and CAD.

The variables selected by univariate analysis with $p \leq 0.20$ underwent multivariate analysis by using the logistic regression method to determine death independent predictors.

A p-value < 0.05 was considered significant.

Results

In the 393 patients included in the study, the patients' mean age (± SD) was 62.4 ± 9.4 (ranging from 38 to 85 years); out of them, 65.3% (257) were male and 94.1% (370) were Caucasian. Clinical characteristics and the sample baseline comorbidities, separated by the presence of CS, are listed in Table 1.

All surgeries were performed with cardiopulmonary bypass and elective. There were concomitant procedures in 12.7% (50). Transoperative complications were seen in 2.5% (10) of cases.

The main postoperative complications were: cardiogenic shock in 0.7% (3), vasopressor use for more than 48 hours in 4.0% (16), mechanical ventilation for over 48 hours in 3.5% (14), sepsis in 2.2% (9), respiratory infection in 3.8% (15), and urinary tract infection in 1.2% (5).

CS prevalence ≥ 50% was 17.4% (76) of the total study patients. Out of these, 12.0% (47) of patients had CS between 50 and 69% and 7.4% (29), CS ≥ 70%.

Medical and family history had the following distribution: cardiovascular disease (CVD) family history in 81.7% (321), left coronary trunk (LCT) stenosis in 34.4% (135), obesity in 32.1% (126), *diabetes mellitus* in 28.4% (112), peripheral obstructive arterial disease (POAD) in 23.4% (92), chronic obstructive pulmonary disease (COPD) in 12.4% (71) and CRF in 6.9% (27). Although differences

Tabela 1 – Clinical characteristics and baseline comorbidities regarding the carotid stenosis degree

General characteristics	Carotid stenosis		
	≥ 50% (n = 76)	< 50% (n = 317)	p
Age (years±SD)	62.5 ± 7.9	62.3 ± 9.7	0.88
Gender male	67.1	65.9	0.89
Caucasian ethnicity	96.1	93.4	0.81
Carotid murmur	35.5	10.4	< 0.0001
Risk factors: n (%)			
Systemic arterial hypertension	81.6	84.2	0.60
Diabetes	28.9	28.3	0.88
Smoking	17.1	18.0	1.00
Obesity (BMI ≥ 30 kg/m²)	80.3	65.0	0.01
BMI (kg/m² ± SD)	27.2 ± 3.3	28.1 ± 4.4	0.04
Waist circumference (cm±SD)	91.2±10.8	94.9±12.5	0.12
CVD family history	78.1	82.0	036
Low physical activity	80.3	81.1	0.87
Dyslipidemia	31.6	25.9	0.31
Comorbidities			
Peripheral obstructive arterial disease	23.7	23.3	1.00
LCT lesion	73.7	63.7	0.10
CRF (creatinine ≥1.5 mg/dL)	6.6	6.9	0.57
Chronic obstructive pulmonary disease	15.6	11.4	0.31

SD, standard deviation; BMI, body mass index; CVD, cardiovascular disease; LCT, left coronary trunk; CRF, chronic renal failure

across many variables concerning the CS degree have been observed, they were not shown statistically significant, except for the physical examination finding of a carotid murmur (p < 0.001).

Considering the CS degree: 77.1% (303) of the patients had a stenosis < 50%, 12.0% (47) had a stenosis between 50% and 69%, 7.1% (28) had a stenosis between 70% and 99%, and 0.3% (1) had an internal carotid artery (ICA) occlusion. The examination was normal in 3.6% (14) of the sample. Regarding the gender, 67.1% (51) of patients with a stenosis ≥ 50% were male.

The carotid murmur was detected in 35.5% (27) of the patients with CS and in 10.4% (33) of those with CS lower than 50%. The odds ratio (OR) for patients with a carotid murmur was 3.8 times (95% CI = 2.32-8.47; p < 0.0001) as high for significant CS.

The overall mortality was 8.1% (32) and 17.4% (p = 0.001) of patients had CS ≥ 50%.

In univariate analysis, the OR for neurological endpoints and mortality for a SC degree ≥ 50% was 4.2 (95% CI = 1.1-15.3) for psychomotor agitation; 0.3 (95% CI = 0.07-1.5) for stroke and 3.7 (95% CI = 1.7-7.9) for death (Table 2).

No predictors for stroke occurrence were identified in univariate analysis; for mortality, the predictors were as follows: CS ≥ 50% (OR = 3.7; p = 0.001, 95% CI = 1.7-7.9); CRF (OR = 0.3; p = 0.05, 95% CI = 0.1-0.9); obesity (OR = 2.1; p = 0.11; 95% CI = 0.8-5.3); and low physical activity (OR = 0.4; p = 0.16; 95% CI: 0.7-8.1).

After multivariate analysis, CS ≥ 50 (OR = 12.3; p = 0.001; 95% CI = 1.6-7.6) and CRF (OR = 3.7; p = 0.03; 95% CI = 1.0-9.6) remained as mortality independent predictors (Table 3).

Table 2 – Occurrence of neurologic endpoints and mortality over stenosis carotid degree

Clinical endpoint	Stenosis degree				OR	p	95% CI
	≥ 50	%	< 50	%			
Psychomotor agitation	4	8.2	4	2.1	4.2	0.03	1.1-15.3
TIA	2	4.3	0	-	0.1	0.04	0.1-0.2
Cognitive change	8	16.7	10	5.2	3.5	0.01	1.3-9.5
Stroke - 1.7%	3	4.3	4	2.1	0.3	0.15	0.07-1.5
Death - 8.1%	14	17.4	18	5.7	3.7	0.001	1.7-7.9

OR, odds ratio; CI, confidence interval; TIA, transient ischemic attack

Table 3 – Mortality independent predictors in patients with a CABG indication

Variable	OR	95% CI	p
Carotid stenosis ≥50%	12.3	1.6-7.6	0.001
Chronic renal failure	3.7	1.0-9.6	0.03
Obesity	1.9	0.2-1.3	0.17
Low physical activity	1.8	0.7-8.3	0.15

CABG, coronary artery bypass grafting; OR, odds ratio; CI, confidence interval. Controlled variables: age, diabetes, systemic arterial hypertension, low physical activity, obesity, cardiovascular disease family history, peripheral obstructive arterial disease, and smoking.

Discussion

CS had a high prevalence (17.4%) and was a mortality independent predictor together with CRF in 393 patients with CAD undergoing elective CABG. CS prevalence was high if compared with other studies involving patients with DAC in which the rate was 6% to 15%. This value is higher than that expected perhaps because it was a higher risk population seen in a tertiary cardiology center where high complexity cases are referred to receive care[15-18].

Another major aspect demonstrated was that patients with a carotid murmur had a risk 3.8 times as high to be found with a CS, stressing the physical examination importance, although sensitivity for carotid murmur diagnosis has been low (34%). The carotid murmur is the most available physical examination data in clinical practice, although it has an important limitation: according to the NASCET study[19], a carotid murmur had a sensitivity 63% and a specificity 61%. The authors concluded it should not be overestimated because of its low specificity and as the sensitivity is low, the murmur will not be found in up to one-third of patients with CS ≥ 70%.

Regarding risk factors for carotid disease in patients with severe coronary disease, we found no statistically significant difference for gender, age, smoking status, dyslipidemia, hypertension, acute myocardial infarction (AMI) and/or stroke.

The screening, in turn, can also be helpful in the diagnosis and follow-up in cases with conservative treatment indication because CS, per se, is a risk marker, especially for vascular death. The presence of CS can change the surgical management with acceptable risks and cost, with these being similar both in concomitant surgeries and carotid revascularization with subsequent CABG, even in asymptomatic patients.

We believe the CS investigation by ultrasound is valid in all patients possibly undergoing CABG, in agreement with Fukuda *et al.*[2]. If a CS is found, a CABG should be scheduled for a concomitant treatment with the carotid disease or for a further treatment.

Carotid ultrasound was the study chosen by us, as it is a non-invasive subsidiary method generally employed in screening carotid atherosclerotic disease. It has sensitivity and specificity similar to that of angiography[20]. The latter is carrying on as the standard method and golden standard for cerebrovascular assessment in symptomatic people, but because of its high cost, and risk for stroke and other complications[21], the exclusive use of non-invasive studies has been advocated.

By comparing patients with a preserved renal function at the carotid surgery, those with renal failure have similar stroke and perioperative death rates, but higher rates of heart events[22]. Renal dysfunction is significantly associated with increased mortality and morbidity following CABG and requires careful consideration regarding the risk-benefit binomial when the surgery is indicated[23].

CRF is associated with an increased atherosclerosis risk in these patients, but CABG offers more benefits for severe CAD patients than only drug therapy. Recent evidence suggests internal mammary use in this surgery is especially better for those on hemodialysis[24] without DM[25]. Moreover, long-term survival of patients with a satisfactory course over the postoperative hospital period is favorable[26].

The pursuit for reduced morbidity, mortality, and cost should include the part concerning the investigation[27]. Thus, the efforts for a judicious use of diagnostic methods and the consequent reduction of cost and resulting complications would contribute to a more satisfactory treatment[28].

Conclusion

CS prevalence was high in our study, suggesting we had a high-risk population that can benefit from a previous diagnosis of the disease. Also CS and CRF were independent predictors of postoperative death in patients undergoing elective CABG.

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