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ORIGINAL ARTICLE

Preoperative cardiac assessment in patients undergoing major vascular surgery

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The aim of this study was to evaluate the effectiveness of a preoperative standardized cardiac assessment in patients undergoing major vascular surgery. From January 2005 to December 2006, 1446 elective interventions for major vascular diseases (carotid stenosis, CS; abdominal aortic aneurysm, AAA; peripheral arterial obstructive disease, PAOD) were performed; 1090 out of these patients underwent preoperative diagnostic assessment on an outpatient basis. Thirty-day results in terms of cardiac mortality and morbidity rates were recorded. Patients suffered from a CS in 578 cases (53%), an AAA in 303 cases (27.8%) and a PAOD in 209 cases (19.2%). Four hundred thirty-two patients (39.6%) underwent further evaluation of cardiac functional capacity with non-invasive stress testing. Sixteen patients were successfully treated prior to vascular surgery. Thirty-day cardiac mortality and morbidity rates were 0.2% and 3.9%, respectively. A positive preoperative non-invasive stress testing did not affect 30-day cardiac outcomes. In conclusion, the use of an accurate preoperative cardiac assessment allowed us to obtain satisfactory perioperative results in patients undergoing major vascular surgery. Routine preoperative evaluation with non-invasive stress testing did not seem to improve perioperative cardiac results.

Key words: *cardiac risk; preoperative cardiac evaluation; major vascular surgery*

Introduction

Cardiac complications (myocardial infarction, acute congestive heart failure, pulmonary edema, fatal arrhythmias) represent the major cause of perioperative morbidity and mortality in patients undergoing major vascular surgery.[1–4] This is particularly related to the frequent association of systemic localizations of atherosclerosis (carotid bifurcation, abdominal aorta, peripheral arteries) with coronary artery disease (CAD).[5,6] It has also been demonstrated that history of CAD, congestive heart failure, cerebrovascular disease, diabetes mellitus and chronic renal failure increase perioperative cardiac mortality and morbidity rates.[7,8]

In order to reduce perioperative cardiac complications in patients undergoing major vascular surgery, an accurate cardiac assessment, consisting of electrocardiogram (ECG), cardiologist consultation, echocardiography and, in selected cases, non-invasive stress testing, has been advocated by several authors.[9–11] Non-invasive stress testing, is widely used in order to assess the risk of cardiac complications in the perioperative period, even if its predictive power is controversial;[10] furthermore, other authors suggested the use of preoperative cardiac testing only in patients considered at high surgical risk, omitting it in intermediate-risk patients.[12]

The demonstration of a poor cardiac functional capacity makes necessary the adoption of measures to reduce perioperative cardiac risk. Perioperative beta-blocker medical therapy is associated with a reduced risk of in-hospital death among patients undergoing major non-cardiac surgery.[13]

At the moment, there are no strong data to support prophylactic surgical or endovascular myocardial revascularization;[9,11,14] hence, myocardial revascularization prior to vascular surgery should be reserved for those few patients with unstable angina or stable angina with significant left main or three-vessel CAD[9] (American College of Cardiology/American Heart Association [ACC/AHA]

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guidelines) or for patients with proven ischemic heart disease subject to high-risk surgery (European Society of Cardiology [ESC] guidelines).[11]

The aim of this study was to evaluate the effectiveness of a preoperative standardized cardiac assessment in the reduction of perioperative cardiac morbidity and mortality rates in patients undergoing major vascular surgery in a single-center experience.

Methods

From January 2005 to December 2006, 1446 elective open and endovascular interventions for major vascular diseases (carotid stenosis, CS; abdominal aortic aneurysm, AAA; peripheral arterial obstructive disease, PAOD) were performed at our Institution; 1090 out of these patients underwent preoperative diagnostic and cardiac assessment on an outpatient basis. We excluded from our series all patients without a complete preoperative assessment (operation in emergency/urgency, direct admission at our Department, transfer from other Departments).

Data from all preoperative evaluations in an outpatient basis were prospectively collected in a dedicated database, which included demographic data, preoperative risk factors, and clinical and diagnostic assessment. All these patients underwent open or endovascular intervention and perioperative (<30 days) results in terms of overall and cardiac morbidity and mortality rates were recorded.

Preoperative diagnostic assessment

Regardless of the kind of vascular disease, all patients preoperatively underwent an extensive assessment of clinical history and a physical examination, a two-view chest X-ray, an ECG, laboratory tests including complete blood count, coagulative parameters and blood chemistries and a duplex ultrasound scanning of the indexed district. Moreover, all patients suffering from AAA or PAOD underwent duplex scanning of the supra-aortic vessels.

Patients assessed with CS preoperative underwent a computed tomography (CT) scan of cerebral parenchyma and CT angiography (CTA) of extracranial vessels. Degree of stenosis was determined by using the North American Symptomatic Carotid Endarterectomy Trial method.

Patients with AAA underwent CTA of the entire aorta to evaluate the presence of other aortic lesions and to determine the type of repair (assessment of criteria of feasibility for endovascular repair). In this subgroup, in patients with a history of chronic obstructive pulmonary disease or asthma, pulmonary functional capacity and response to bronchodilators were investigated and the presence of carbon dioxide retention through arterial blood gas analysis was evaluated.

In patients with PAOD, preoperative diagnostic evaluation was completed by CTA of the lower limbs, reserving the digital subtraction angiography in double projection in selected cases.

Finally, regardless of the response of ECG, all patients underwent cardiological consultation associated with an echocardiography with evaluation of left-ventricular ejection fraction (LVEF). Since most of the patients came from peripheral centers, the cardiologist recommended changes in medications, in order to obtain the best medical treatment in all patients, consisting of statins and antiplatelet agents in all patients and beta-blockers in selected cases. A resting heart rate of 60–65 beats/min was considered right.

Our series comprised patients undergoing carotid, aortic and peripheral surgery. On the basis of ACC/AHA and ESC guidelines,[9,11] patients undergoing open or endovascular carotid surgery should be considered at intermediate cardiac risk (between 1% and 5%) and patients undergoing open aortic and peripheral surgery should be considered at high cardiac risk (>5%); furthermore, patients undergoing endovascular aortic or peripheral surgery should be considered at intermediate cardiac risk (between 1% and 5%). The cardiologist performed the consultation before the surgeon had decided what was the kind of treatment for the patient (open or endovascular); hence, all patients subject to aortic or peripheral surgery have been considered at high surgical risk and the decision to make further preoperative tests was taken by the cardiologist on the basis of the results of history, physical examination, ECG and echocardiography.

In particular, the cardiologist suggested non-invasive stress testing in the presence of past or recent ischemic heart disease, compensated or prior heart failure, past or recent cerebrovascular disease, diabetes mellitus, chronic renal failure (history); alterations at cardiac auscultation (physical examination); significant arrhythmias, abnormal Q waves (ECG anomalies); and severe valvular diseases, abnormal areas of motility, LVEF less than 40% (echocardiographic anomalies). All non-invasive stress tests have been conducted after withdrawal of beta-blockers.

In patients with a negative cardiac stress test, surgery was performed without any other investigation. Patients with a positive stress test (a peak heart rate less than 85% of the maximum predicted at dobutamine stress echocardiography or reversible defects that involved more than 20% of myocardial segments at the radionuclide myocardial perfusion imaging) underwent new consultation and the cardiologist, also on the basis of the surgeon's decision, proposed higher levels of postoperative care in the intensive care unit (ICU) and further changes in medications with the adjunct of beta-blockers or suggested performing classical coronary angiography with possible therapeutic procedures (percutaneous transluminal coronary angioplasty [PTCA] or coronary artery bypass graft [CABG]). Coronary revascularization prior to vascular surgery was performed in patients subject to high-risk surgery, who had unstable angina or stable angina with three-vessel disease or a significant stenosis of the left main coronary artery.

In these patients the vascular intervention was consequently delayed. If PTCA was performed, patients received a single antiplatelet therapy (aspirin) for four weeks. If a stent was inserted, a dual antiplatelet therapy was administered (aspirin and clopidogrel) for four weeks (bare-metal coronary stents) or six months (drug-eluting coronary stents).

Definition of parameters

Our database included demographic data, preoperative risk factors, and clinical and diagnostic assessment. We used some criteria to define these parameters, as shown in Table 1.

Statistical analysis

Statistical analysis was performed by using SPSS 15.0 for Windows (SPSS Inc, Chicago, IL, USA). General characteristics, cardiovascular risk factors, results of preoperative diagnostic assessment and different surgical approaches for perioperative (<30 days) cardiac mortality and morbidity rates were analyzed and compared by χ^2 test or Fisher's exact test when necessary. Statistical significance was defined at the $P < 0.05$ level.

Table 1 Parameters used to elaborate the perioperative cardiac risk

Parameter	*Definition*
Sex	Male/female
Older age	>80 y
Smoking	Current or previous (within 10 y) smoker
Hypertension	A systolic blood pressure of 140 mmHg or greater, a diastolic blood pressure of 90 mmHg or greater or use of antihypertensive medications
Hypercholesterolemia	Total cholesterol serum level >200 mg/dL or low-density lipoprotein (LDL) cholesterol >140 mg/dL or use of statins
Diabetes mellitus	Fasting glucose of 126 mg/dL or greater or use of oral antidiabetics/insulin
Chronic obstructive pulmonary disease	Chronic parenchymal X-ray changes or pulmonary function tests less than 80% of predicted
Chronic renal failure	Creatinine serum level greater than 2.0 mg/dL
Coronary artery disease	History of at least one of the following: positive ECG changes consistent with myocardial ischemia, angina, myocardial infarction, PTCA and CABG
Myocardial infarction	History of previous myocardial infarction
PTCA	History of previous myocardial endovascular revascularization
CABG	History of previous myocardial surgical revascularization
Congestive heart failure	Presence of any of the following: history of congestive heart failure, pulmonary edema or paroxysmal nocturnal dyspnea, bilateral rales or S3 gallop at physical examination, pulmonary vascular redistribution at chest radiograph
Valvular heart disease	Presence of any of the following: echocardiographic features – aortic stenosis with a maximal jet velocity ≥2.5 m/s, mitral stenosis with a valve area ≤2 cm^2, aortic regurgitation with a grade ≥2/4, mitral regurgitation with a grade ≥2/4, patients who have undergone any intervention on a cardiac valve
Arrhythmia	Presence of any of the following: atrial fibrillation, high-grade atrioventricular block, ventricular or supraventicular ectopy
Implanted devices	Presence of a pace-maker or an implantable cardioverter defibrillator (ICD)
Positive stress testing	Poor cardiac functional capacity diagnosed at radionuclide myocardial perfusion imaging or dobutamine stress echocardiography or treadmill exercise test
Cardiac treatment	PTCA or CABG prior to vascular surgery

ECG, electrocardiogram; CABG, coronary artery bypass graft; PTCA, percutaneous transluminal coronary angioplasty

Table 2 Demographic data, preoperative risk factors and clinical assessment

	CS group (n = 578)	*AAA group* (n = 303)	*PAOD group* (n = 209)	*Total* (n = 1090)
Male sex	411 (71.1%)	272 (89.8%)	148 (70.8%)	831 (76.2%)
Median age (y)	73.1	72.5	70.1	72.4
Older age (>80 y)	131 (22.7%)	60 (19.8%)	31 (14.8%)	222 (20.4%)
Smoking	415 (71.8%)	278 (91.7%)	177 (84.7%)	870 (79.8%)
Hypertension	440 (76.1%)	208 (68.6%)	153 (73.2%)	801 (73.5%)
Hypercholesterolemia	315 (54.5%)	105 (34.7%)	118 (56.5%)	538 (49.4%)
Diabetes mellitus	143 (24.7%)	32 (10.6%)	69 (33%)	244 (22.4%)
Chronic obstructive pulmonary disease	199 (34.4%)	207 (68.3%)	75 (35.9%)	481 (44.1%)
Renal chronic failure	61 (10.6%)	30 (9.9%)	15 (7.2%)	106 (9.7%)
Coronary artery disease	127 (22%)	83 (27.4%)	61 (29.2%)	271 (24.9%)
Myocardial infarction	83 (14.4%)	52 (17.2%)	48 (23%)	183 (16.8%)
PTCA	39 (6.7%)	26 (8.6%)	20 (9.6%)	85 (7.8%)
CABG	41 (7.1%)	19 (6.3%)	21 (10%)	81 (7.4%)
Congestive heart failure	12 (2.1%)	18 (5.9%)	14 (6.7%)	44 (4%)
Valvular heart disease	65 (11.2%)	27 (8.9%)	21 (10%)	113 (10.4%)
Arrhythmia	99 (17.1%)	49 (16.2%)	39 (18.7%)	187 (17.2%)
Implanted devices	19 (3.3%)	7 (2.3%)	9 (4.3%)	35 (3.2%)

CABG, coronary artery bypass graft; PTCA, percutaneous transluminal coronary angioplasty; CS, carotid stenosis; PAOD, peripheral arterial obstructive disease; AAA, abdominal aortic aneurysm

Results

Study group

Patients were predominantly men (831, 76.2%), with a mean age of 72.4 years (range 32–92). They suffered from CS in 578 cases (53%), AAA in 303 cases (27.8%) and PAOD in 209 cases (19.2%). Demographic data, preoperative risk factors and clinical assessment are shown in Table 2.

Preoperative cardiac assessment

According to our decisional algorithm, 658 patients (60.4%) without anomalies at ECG, cardiological consultation and echocardiography underwent surgical vascular intervention without any other diagnostic assessments. The remaining 432 patients (39.6%) underwent further evaluation of cardiac functional capacity with a dobutamine stress echocardiography in 272 cases (63%), a radionuclide myocardial perfusion imaging in 140 cases (32.4%) and a maximal treadmill exercise test according to the Bruce protocol in 20 patients (4.6%).

Of these 432 patients, 326 (75.5%) had a negative test, while the remaining 106 patients (24.5%) had a positive one. In 73 (68.9%) out of these 106 patients, perioperative cardiological risk was judged acceptable by the consultant and beta-blocker medical therapy and postoperative ICU stay were suggested. In the remaining 33 patients (31.1%), a coronary angiography was performed; no significant CAD was diagnosed in 17 cases and the patients were operated on, while the remaining 16 patients had significant coronary artery lesions and were successfully treated (15 PTCA and 1 CABG) prior to vascular surgery (Table 3).

Operative management

Concerning the CS group, a standard carotid endarterectomy according to the technique of early distal control of the internal carotid artery[15] with extensive use of patch and selective use of shunt was performed in 552/578 cases (95.5%), while the remaining 26 patients (4.5%) underwent carotid artery stenting (CAS). For the AAA group, traditional open repair with a standard transperitoneal approach was carried out in 180/303 patients (59.4%), while in the other 123 cases (40.6%) AAA was excluded through the endovascular implantation of a stent-graft. Finally, in PAOD patients the endovascular approach was performed in 101/209 cases (48.3%).

Overall, 125 patients (11.5%) required a higher level of postoperative monitoring in ICU.

A beta-blocker therapy was continued in all patients who received it prior to the cardiological assessment. Furthermore, with regard to cardiac management, the surveillance for perioperative myocardial infarction was

Table 3 Preoperative cardiac assessment and operative management

	CS group (n = *578)*	*AAA group* (n = *303)*	*PAOD group* (n = *209)*	*Total* (n = *1090)*
Stress testing	135/578 (23.4%)	222/303 (73.3%)	75/209 (35.9%)	432/1090 (39.6%)
Positive stress testing	31/135 (23%)	56/222 (25.2%)	19/75 (25.3%)	106/432 (24.5%)
Coronary angiography	11/31 (35.5%)	17/56 (30.4%)	5/19 (26.3%)	33/106 (31.1%)
PTCA	4/31 (12.9%)	8/56 (14.3%)	3/19 (15.8%)	15/106 (14.1%)
CABG	1/31 (3.2%)	0	0	1/106 (0.9%)
Endovascular treatment	26/578 (4.5%)	123/303 (40.6%)	101/209 (48.3%)	250/1090 (22.9%)
Postoperative ICU	31/578 (5.4%)	73/303 (24.1%)	21/209 (10%)	125/1090 (11.5%)

CABG, coronary artery bypass graft; PTCA, percutaneous transluminal coronary angioplasty; CS, carotid stenosis; PAOD, peripheral arterial obstructive disease; AAA, abdominal aortic aneurysm; ICU, intensive care unit

obtained with the measurement of troponin T in the recovery room after operation and on the next two postoperative mornings; if indicated, the troponin T monitoring was continued. The diagnosis of myocardial infarction was determined by troponin T values combined with either changes on ECG or symptoms referred by the patient.

Early results (<30 days)

In our series, two open-treated patients died in the early postoperative period for an acute congestive heart failure with pulmonary edema. As a consequence, 30-day cardiac mortality rate was 0.2% (2/1090 patients). Analyzing the three categories of patients, there were no differences in terms of 30-day cardiac mortality risk (Table 4).

At univariate analysis, in the AAA group, valvular heart disease and history of previous congestive heart failure represented factors significantly affecting 30-day cardiac mortality (Table 5). Multivariate analysis did not confirm the significance for any of the examined parameters. Moreover, at 30 days, 81 patients (7.4%) had a major complication, requiring a prolonged hospital stay or a re-intervention: 45 had at least one cardiac complication (22 myocardial infarctions requiring a PTCA in 11 cases, 16 episodes of atrial fibrillation and 7 of acute congestive heart failure) with a 30-day cardiac morbidity rate of 4.1% (Table 4). In the 22 patients with a postoperative myocardial infarction, none of the examined factors showed an increased risk at uni- and multivariate analysis.

Furthermore, the AAA group showed an increased risk of overall and cardiac 30-day morbidity rates with respect to other patients. In particular, univariate analysis showed that at ages older than 80 years, chronic renal failure and valvular heart disease significantly affect 30-day cardiac morbidity (Table 6); chronic renal failure and valvular heart disease maintained their significance also at multivariate analysis ($P = 0.01$, 95% CI: 1.3–12.1; $P = 0.002$, 95% CI: 1.8–15.5, respectively).

Discussion

Historically, many attempts to obtain a precise cardiac risk-score following major vascular surgery have been made;[7,16, 17] in these studies, history of CAD, congestive heart failure, cerebrovascular disease, diabetes mellitus and chronic renal failure increased the risk of perioperative cardiac adverse events. Also in our patients undergoing aortic surgery, several preoperative risk factors affected cardiac mortality and morbidity (valvular heart disease, history of previous congestive heart failure, age older than 80 years and chronic renal failure).

Table 4 Early results (<30 days)

	CS group (n = *578)*	*AAA group* (n = *303)*	*PAOD group* (n = *209)*	P	*Total* (n = *1090)*
Cardiac mortality	0	2 (0.7%)	0	NS	2/1090 (0.2%)
Cardiac morbidity	14 (2.4%) 7 myocardial infarction 6 atrial fibrillation 1 congestive heart failure	23 (7.6%) 9 myocardial infarction 9 atrial fibrillation 5 congestive heart failure	8 (3.8%) 6 myocardial infarction 1 atrial fibrillation 1 congestive heart failure	0.001*	45/1090 (4.1%)

CS, carotid stenosis; PAOD, peripheral arterial obstructive disease; AAA, abdominal aortic aneurysm; NS, non-significant
*Between AAA group and the other two groups

Table 5 AAA group: univariate analysis for cardiac mortality at 30 days

	AAA group (2 deaths) (%)	P
Sex		
Male	0.7	NS
Female	0	
Age (y)		
<80	0.4	NS
>80	1.7	
Smoking		
Yes	0.7	NS
No	0	
Hypertension		
Yes	1	NS
No	0	
Hypercholesterolemia		
Yes	1.9	NS
No	0	
Diabetes mellitus		
Yes	3.1	NS
No	0.4	
Chronic obstructive pulmonary disease		
Yes	0.5	NS
No	1	
Chronic renal failure		
Yes	3.3	NS
No	0.4	
Coronary artery disease		
Yes	1.2	NS
No	0.4	
Congestive heart failure		
Yes	5.6	<0.01
No	0.3	
Valvular heart disease		
Yes	3.7	0.04
No	0.4	
Arrhythmia		
Yes	0	NS
No	0.8	
Implanted devices		
Yes	0	NS
No	0.7	
Positive stress testing		
Yes	0	NS
No	0.6	
Cardiac treatment		
Yes	0	NS
No	0.5	
Endovascular treatment		
Yes	0	NS
No	1.1	

NS, non-significant; AAA, abdominal aortic aneurysm

Table 6 AAA group: univariate analysis for cardiac morbidity at 30 days

	AAA group (23 complications) (%)	P
Sex		
Male	7	
Female	9.7	NS
Age (y)		
<80	5.4	0.01
>80	15	
Smoking		
Yes	6.5	NS
No	16	
Hypertension		
Yes	6.7	NS
No	8.4	
Hypercholesterolemia		
Yes	4.8	NS
No	8.6	
Diabetes mellitus		
Yes	9.4	NS
No	7	
Chronic obstructive pulmonary disease		
Yes	7.7	NS
No	6.2	
Chronic renal failure		
Yes	20	0.005
No	5.8	
Coronary artery disease		
Yes	7.2	NS
No	7.3	
Congestive heart failure		
Yes	16.7	NS
No	6.7	
Valvular heart disease		
Yes	25.9	<0.001
No	5.4	
Arrhythmia		
Yes	8.2	NS
No	7.1	
Implanted devices		
Yes	14.3	NS
No	7.1	
Positive stress testing		
Yes	8.9	NS
No	4.8	
Cardiac treatment		
Yes	0	NS
No	6.1	
Endovascular treatment		
Yes	4.1	NS
No	9.4	

NS, non-significant; AAA, abdominal aortic aneurysm

In 1996, the ACC/AHA published the first clinical guidelines for preoperative cardiac risk stratification in patients undergoing non-cardiac surgery. These guidelines were recently updated in 2007.[9] Other societies published their own guidelines[11,18,19] and numerous discrepancies exist between them.[20]

In particular, comparing the most updated guidelines (ACC/AHA 2007 and ESC 2009),[9,11] there were no substantial differences in the stratification of the risk in major vascular surgery; in fact, both considered at high surgical risk all patients undergoing open aortic and peripheral surgery and at intermediate surgical risk all patients subject to carotid surgery (open or endovascular) or to endovascular aortic/peripheral procedures. Our approach did not substantially differ from these classifications, but our patients underwent cardiological consultation before the surgeons and the patients decided the best type of treatment and so we considered all patients suffering from aortic/peripheral diseases as high surgical risk patients. This represents a real problem in clinical practice, which is often omitted in the official guidelines.

Furthermore, ACC/AHA 2007 and ESC 2009 guidelines recommended the selective use of supplemental preoperative non-invasive cardiac testing in order to provide an objective measure of cardiac functional capacity, to identify the presence of significant myocardial ischemia and to evaluate the risk of perioperative cardiac adverse outcomes; however, some differences exist. In fact, American guidelines recommended the use of non-invasive stress testing in patients with active cardiac conditions and in patients subject to all vascular procedures with three or more clinical factors, and suggested its utilization in patients subject to all vascular procedures with at least one clinical factor. On the other hand, European guidelines recommended a supplemental stress testing in patients subject to high-risk surgery (open aortic and peripheral diseases) with three or more clinical factors and suggested its utilization in patients considered at intermediate risk (carotid procedures). Our data were prospectively collected from January 2005 to December 2006; hence, we could not follow any of these guidelines. However, our approach was quite similar to the recommendations and suggestions reported by ACC/AHA guidelines.

A particular key point is the need to perform a supplemental preoperative cardiac testing in patients subject to carotid surgery (considered in both guidelines at intermediate risk); the DECREASE (Dutch Echographic Cardiac Risk Evaluation Applying Stress Echo) II trial[12] demonstrated that cardiac testing could safely be omitted in intermediate-risk patients, provided that beta-blocker therapy aiming at tight heart rate control is prescribed. In our series, we performed 135 cardiac stress testings in the 578 patients subject to carotid surgery, and according to the conclusions of the DECREASE II trial, these further evaluations could have been avoided, saving time and economical resources. Furthermore, only 31/135 patients (23%) had a positive stress test and five patients (3.7%) underwent preoperative myocardial revascularization; in these five patients no perioperative cardiac complications occurred, but we cannot know what could have happened in these patients if left untreated. Hence, our experience supports the conclusions of this randomized trial.

Several authors[21–24] demonstrated that positive predictive value of stress testing is very poor (5–25%) and they concluded that its use in order to predict perioperative cardiac events is very limited. Our experience supports these conclusions; in our population study, a positive preoperative cardiac stress testing does not represent a risk factor for postoperative cardiac events and its positive predictive power is very low.

As a consequence, a positive preoperative non-invasive cardiac stress testing seems to support the value of appropriate perioperative medical therapies in order to lower the cardiac risk rather than extensive use of myocardial revascularization. The guidelines[9,11] suggested that beta-blockers should be given to patients undergoing major vascular surgery, but the most recent POISE trial[25] minimized the benefits resulting in the assumption of beta-blocker medical therapy in the perioperative period. In our experience, beta-blocker medical therapy and a high level of postoperative care in ICU is the most used approach in patients with poor cardiac functional capacity undergoing endovascular treatment.

Controversial data exist also about benefits of myocardial revascularization in reducing perioperative cardiac adverse events in patients undergoing major vascular surgery;[9,11,12] ACC/AHA 2007 guidelines stated that coronary revascularization before non-cardiac surgery is useful in patients with stable angina and significant left main coronary artery stenosis or a three-vessel disease or in patients with unstable angina, while ESC 2009 guidelines recommended a prophylactic myocardial revascularization prior to high-risk surgery in patients with proven ischemic heart disease and not in patients at intermediate risk. In our series, about one-third of patients (33/106, 31.1%) with positive stress testing underwent coronary angiography; one of the treated patients had a postoperative myocardial infarction, while in the untreated group no cardiac complications occurred. So, preoperative coronary revascularization did not seem to be useful for reducing perioperative cardiac risk.

In the AAA subgroup, endovascular techniques allow the treatment of patients whose co-morbidities make conventional open repair difficult or high risk. For this reason, patients with a positive test could be treated with endovascular treatment when anatomically feasible. In our experience, endovascular treatment reduced cardiac morbidity rates compared with open surgical repair, even if these differences did not reach the statistical significance. However, this should encourage many surgeons to stress the indications for endovascular treatment.

Finally, this study has some limits: our results were carried out on a small monocentric sample size and we analyzed a heterogeneous population including patients undergoing vascular interventions at different levels of perioperative cardiac risk; in fact, patients undergoing abdominal aortic surgery showed higher cardiac morbidity and mortality rates than the other two groups. Furthermore, our overall 30-day outcomes in terms of mortality and major morbidity seemed to be better than others reported in previously published series. Maybe our good 30-day outcomes suffered from a selection bias; in fact, in our series we enrolled only the patients completely assessed in the preoperative period on an outpatient basis and we excluded all patients without a complete preoperative assessment. The strict respect of the worldwide accepted indications and the close collaboration with cardiologists and internists in the selection and the care of our patients may have contributed to our very good results in this subset of patients as well.

So, in conclusion, in our experience the use of an accurate preoperative cardiac assessment allowed us to obtain satisfactory perioperative results in patients undergoing major vascular surgery. Patients with AAAs represented a subgroup with higher perioperative cardiac morbidity rates. Routine preoperative evaluation with non-invasive stress testing did not seem to improve perioperative cardiac results in any subgroup treated for vascular diseases. However, the selective use of stress testing made it possible to identify a subgroup of higher risk patients who could benefit from coronary angiography and possible treatment of their CAD.

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References

1 Mackey WC, O'Donnell TFJ, Callow AD. Cardiac risk in patients undergoing carotid endoarterectomy: impact on perioperative and long-term mortality. *J Vasc Surg* 1990;**11**:226–33

2 Krupski WC, Layug EL, Reilly LM, *et al.* Comparison of cardiac morbidity rates between aortic and infrainguinal operations: two-year follow-up. Study of Perioperative Ischemia Research Group. *J Vasc Surg* 1993;**18**:609–15

3 L'Italien GJ, Cambria RP, Cutler BS, *et al.* Comparative early and late cardiac morbidity among patients requiring different vascular surgery procedures. *J Vasc Surg* 1995;**21**:935–44

4 Devereaux PJ, Goldman L, Yusuf S, *et al.* Surveillance and prevention of major perioperative ischemic cardiac events in patients undergoing noncardiac surgery: a review. *CMAJ* 2005;**173**:779–88

5 Aronow WS, Ahn C. Prevalence of coexistence of coronary artery disease, peripheral arterial disease, and atherothrombotic brain infarction in man and women >62 years of age. *Am J Cardiol* 1994;**74**:64–5

6 Sukhija R, Aronow WS, Yalamanchili K, *et al.* Prevalence of coronary artery disease, lower extremity peripheral arterial disease, and cerebrovascular disease in 110 men with an abdominal aortic aneurysm. *Am J Cardiol* 2004;**94**:1358–9

7 Lee TH, Marcantonio ER, Mangione CM, *et al.* Derivation and prospective validation of a simple index for prediction of cardiac risk of major noncardiac surgery. *Circulation* 1999;**100**:1043–9

8 Kertai MD, Boersma E, Bax JJ, *et al.* Comparison between serum creatinine and creatinine clearance for the prediction of postoperative mortality in patients undergoing major vascular surgery. *Clin Nephrol* 2003;**59**:17–23

9 Fleisher LA, Beckman JA, Brown KA, *et al.* ACC/AHA 2007 guidelines on perioperative cardiovascular evaluation and care for noncardiac surgery: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to Revise the 2002 Guidelines on Perioperative Cardiovascular Evaluation for Noncardiac Surgery): developed in collaboration with the American Society of Echocardiography, American Society of Nuclear Cardiology, Heart Rhythm Society, Society of Cardiovascular Anesthesiologists, Society for Cardiovascular Angiography and Interventions, Society for Vascular Medicine and Biology, and Society for Vascular Surgery. *Circulation* 2007;**116**:e418–99

10 Falcone RA, Nass C, Jermyn R, *et al.* The value of preoperative pharmacologic stress testing before vascular surgery using ACC/AHA guidelines: a prospective, randomized trial. *J Cardiothorac Vasc Anesth* 2003;**17**:694–8

11 Poldermans D, Bax JJ, Boersma E, *et al.* Guidelines for pre-operative cardiac risk assessment and perioperative cardiac management in non-cardiac surgery: the Task Force for Preoperative Cardiac Risk Assessment and Perioperative Cardiac Management in Non-cardiac Surgery of the European Society of Cardiology (ESC) and endorsed by the European Society of Anaesthesiology (ESA). *Eur Heart J* 2009;**30**:2769–812

12 Poldermans D, Bax JJ, Schouten O, *et al.* for the Dutch Echocardiographic Cardiac Risk Evaluation Applying Stress Echo Study Group. Should major vascular surgery be delayed because of preoperative cardiac testing in intermediate-risk patients receiving beta-blocker therapy with tight heart rate control? *J Am Coll Cardiol* 2006;**48**:964–9

13 Lindenauer PK, Pekow P, Wang K, *et al.* Perioperative beta-blocker therapy and mortality after major noncardiac surgery. *N Engl J Med* 2005;**353**:349–61

14 McFalls EO, Ward HB, Moritz TE, *et al.* Coronary-artery revascularization before elective major vascular surgery. *N Engl J Med* 2004;**351**:2795–804

15 Pratesi C, Dorigo W, Innocenti AA, *et al.* Reducing the risk of intraoperative neurological complications during carotid endarterectomy with early distal control of the internal carotid artery. *Eur J Vasc Endovasc Surg* 2004;**28**:670–3

16 Goldman L, Caldera DL, Nussbaum SR, *et al.* Multifactorial index of cardiac risk in noncardiac surgical procedures. *N Engl J Med* 1977;**297**:845–50

17 Detsky AS, Abrams HB, McLaughlin JR, *et al.* Predicting cardiac complications in patients undergoing noncardiac surgery. *J Gen Intern Med* 1986;**1**:211–9

18 Snow V, Barry P, Fihn SD, *et al.* Evaluation of primary care patients with chronic stable angina: guidelines from the American College of Physicians. *Ann Intern Med* 2004;**141**:57–64

19 Snow V, Barry P, Fihn SD, *et al.* Primary care management of chronic stable angina and asymptomatic suspected or known coronary artery disease: a clinical practice guideline from the American College of Physicians. *Ann Intern Med* 2004;**141**:562–7

20 Gordon AJ, Macpherson DS. Guideline chaos: conflicting recommendations for preoperative cardiac assessment. *Am J Cardiol* 2003;**91**:1299–303

21 Urbinati S, Di G, Andreoli A, *et al.* Preoperative non-invasive coronary risk stratification in candidates for carotid endarterectomy. *Stroke* 1994;**25**:2022–7

22 Baron JF, Mundler O, Bertrand M, *et al.* Dipyridamole-thallium scintigraphy and gated radionuclide angiography to assess cardiac risk before abdominal aortic surgery. *N Engl J Med* 1994;**330**: 663–9

23 Leppo J, Plaja J, Gionet M, *et al.* Noninvasive evaluation of cardiac risk before elective vascular surgery. *J Am Coll Cardiol* 1987;**9**:269–76

24 Hanson P, Pease M, Berkoff H, *et al.* Arm exercise testing for coronary artery disease in patients with peripheral vascular disease. *Clin Cardiol* 1988;**11**:70–4

25 Deveraux PJ, Yang H, Yusuf F on behalf of POISE Study Group. Effects of extended-release metoprolol succinate in patients undergoing non-cardiac surgery (POISE trial): a randomised controlled trial. *Lancet* 2008;**371**:1839–47