Anesthesiology 2001; 95:1133–40

Coronary Artery Plaque Burden and Perioperative Cardiac Risk

Elisabeth Mahla, M.D., Martin N. Vicenzi, M.D.,* Brigitte Schröttner, M.D.,† Robert Maier, M.D.,‡ Kurt Tiesenhausen, M.D.,§ Norbert Watzinger, M.D.,‖ Rainer Rienmüller, M.D.,# Rita L. Moser, M.D.,** Helfried Metzler, M.D.††*

Background: **Electron-beam computed tomography–derived coronary calcium score correlates with the morphologic severity of coronary artery disease, reflecting both global atherosclerotic plaque formation and coronary artery luminal narrowing. The current study examines the impact of coronary atherosclerotic plaque burden, measured by coronary calcium score, on the potential for perioperative myocardial cell injury, as assessed by cardiac troponin T elevations in patients undergoing elective vascular surgery. The authors further investigated whether perioperative myocardial cell injury in those patients adversely affects noninvasive measures of left ventricular systolic function, such as ejection fraction and wall motion score.**

Methods: **Fifty-one consecutive patients scheduled for vascular surgery were enrolled in this prospective study. In addition to standard preoperative evaluation, including patient history and physical examination, electron-beam computed tomography scan, 12-lead electrocardiography, and transthoracic echocardiography were performed on the day before surgery. Subsequent evaluations on postoperative days 2 and 7 included transthoracic echocardiography and 12-lead electrocardiography. Cardiac troponin T determinations were performed on the day before surgery, immediately preoperatively, and on postoperative days 1, 2, 3, and 7.**

Results: **The median coronary calcium score of the 51 patients was 997.0 (25th percentile, 202.5; 75th percentile, 1,949.5). Cardiac troponin T elevations exclusively occurred in patients with a coronary calcium score greater than 1,000. The six patients (12%) with perioperative cardiac troponin T elevations had a 2.5-fold higher coronary calcium score than those without cardiac troponin T elevation ($P = 0.021$). In these patients, the ejection fraction decreased from 61 ± 10% to 52 ± 13% (mean ± SD) on postoperative day 2 and was 54 ± 16% on postoperative day 7 ($P = 0.022$).**

Conclusion: **A high electron-beam computed tomography coronary calcium score, reflecting substantial coronary plaque burden, carries an increased risk for myocardial cell injury after vascular surgery. In these patients, myocardial damage may result in deterioration of global systolic left ventricular function.**

ELECTRON-BEAM computed tomography (EBCT) is a highly sensitive and noninvasive technology for the detection and quantification of coronary artery calcium.[1,2] Calcification is an integral part of atherosclerotic plaque formation.[3] The EBCT-derived coronary calcium score correlates with the morphologic severity of coronary artery disease (CAD), reflecting both global atherosclerotic plaque burden[4–7] and the likelihood of significant coronary artery stenoses.[2,8–10] Thus, EBCT is currently under extensive evaluation for the early diagnosis of CAD in asymptomatic patients, for the noninvasive morphologic evaluation of symptomatic CAD, and for the prediction of subsequent myocardial ischemic events.[2,6–13]

Patients undergoing vascular surgery have only an 8% incidence of normal coronary angiograms and a 60% incidence of significant angiographic CAD[14] and are therefore at increased risk for perioperative cardiac morbidity.[15–17] This risk increases with preoperatively impaired left ventricular function.[18–20] Even asymptomatic perioperative ischemic events may herald adverse long-term cardiac outcome.[19,21–23] Perioperative stress has been clearly demonstrated to precipitate myocardial infarction in patients with chronic flow-limiting coronary stenoses.[24–27] Perioperative myocardial cell injury might, however, also arise from acute flow limitation, after stress induced plaque rupture and thrombosis in primarily nonstenotic coronary artery segments.[21,28] Cardiac troponins are established highly sensitive and highly specific biochemical markers for the detection of ischemic myocardial cell injury in surgical and nonsurgical patients.[16,17,29–32]

We examined the impact of coronary atherosclerotic plaque burden, measured by coronary calcium score, on the potential for perioperative myocardial cell injury, as assessed by cardiac troponin T (cTnT) elevations in patients undergoing elective vascular surgery. In addition, we investigated whether perioperative myocardial cell injury in those patients adversely affects noninvasive measures of left ventricular systolic function such as ejection fraction (EF) and wall motion score.

Materials and Methods

After obtaining institutional review board approval from the University of Graz (Graz, Austria) and written informed consent, 55 consecutive patients scheduled for elective vascular surgery between January 1999 and June 2000 were enrolled in this prospective study. Inclusion criteria were elective abdominal aortic aneurysm resection, infrainguinal vascular surgery, or carotid endarterectomy with general anesthesia; sinus rhythm; left ven-

* Assistant Professor, ** Resident, †† Professor, Department of Anesthesiology and Intensive Care Medicine, † Resident, # Professor, Department of Radiology, ‡ Resident, ‖ Assistant Professor, Department of Cardiology, § Assistant Professor, Department of Surgery.

Received from the Departments of Anesthesiology and Intensive Care Medicine, Radiology, Cardiology, and Surgery, University of Graz, Graz, Austria. Submitted for publication January 31, 2001. Accepted for publication May 30, 2001. Support was provided solely from institutional and/or departmental sources.

Address reprint requests to Dr. Mahla: Department of Anesthesiology and Intensive Care Medicine, Auenbruggerplatz 29, University of Graz, A-8036 Graz, Austria. Address electronic mail to: elisabeth.mahla@kfunigraz.ac.at.

tricular EF greater than or equal to 40%; and surgery scheduled on Tuesday or Wednesday (for organizational reasons). Exclusion criteria were unstable coronary syndromes, decompensated congestive heart failure, and known or suspected aortic stenosis; preoperative renal dysfunction (creatinine concentration > 1.4 mg/dl); and repeat surgery during the study period.

The day before surgery, patients underwent a routine clinical evaluation, including a detailed medical history, physical examination, routine laboratory tests, 12-lead electrocardiogram, and chest radiograph. Definite coronary artery disease was defined by the presence of at least one of the following parameters: typical angina, atypical angina with stress-induced scintigraphic perfusion defects, inducible ischemia on dobutamine echocardiography, previous myocardial infarction, previous coronary artery bypass grafting, or percutaneous transluminal coronary angioplasty. Patients with definite CAD who were clinically stable on any chronic antianginal medication proceeded to surgery without a preoperative change of this medication and without further noninvasive testing. For the purpose of this study, the patients were perioperatively further evaluated as described in the following sections.

Electron-beam Computed Tomography

On the day before surgery, EBCT scans were performed with the Imatron Ultrafast Computed Tomograph C-150/C-150L (Imatron, San Francisco, CA) equipped with high-resolution detector rings. The exact location of the heart was determined by a preview scan in multislice mode with an exposure time of 50 ms. The EBCT study was performed in single-slice mode with an exposure time of 100 ms. To detect even minimal amounts of coronary calcium, images were obtained with a scan slice thickness of 1.5 mm instead of the usual 3–6 mm.[2] Fifty-five to 60 adjacent images were obtained from the level of the pulmonary trunk to the diaphragm to cover the whole heart. Electrocardiographic triggering was used to image the heart at the same time of the cardiac cycle (R-R interval 80%). All EBCT studies were performed at midinspiratory level. Coronary foci with a computed tomographic value greater than or equal to 130 Hounsfield units (HU) and an area of at least three coherent pixels, each greater than or equal to 1 mm^2, were defined to represent coronary artery calcium. The identification of coronary calcifications was performed semiautomatically on the Imatron Workstation using the Calcium Score Analyzing Program (Imatron). According to Agatston *et al.*,[1] the total coronary calcium score (dimensionless unit) was calculated by multiplying the lesion area (measured in square millimeters) by a density factor, rated 1 through 4, according to the maximum CT value density within that area (130–199 HU: density factor 1; 200–299 HU: density factor 2; 300–399 HU: density factor 3; and > 400 HU: density factor 4).

The EBCT studies and the quantitative evaluation were performed by two radiologists blinded to all clinical data. The interobserver variability of the coronary calcium score in our institution is 5% (unpublished data), which is comparable to the available literature.[33]

Transthoracic Echocardiography

Serial standard two-dimensional and M-mode echocardiography (Sonos 5500; Agilent Technologies GmbH, Böblingen, Germany) was performed in all patients on the day before surgery and on postoperative days (POD) 2 and 7. Parasternal long- and short-axis views and apical two-, three-, and four-chamber views were obtained for the assessment of the following: (1) left ventricular EF, as a measure of global left ventricular systolic function using the Simpson method[34]; and (2) regional wall motion abnormalities, as a measure of regional left ventricular systolic dysfunction. The left ventricle was divided into 16 segments, and wall motion was scored on a five-point scale (with a score of 1 indicating normal contractility, 2 hypokinesis, 3 akinesia, 4 dyskinesia, and 5 aneurysm, respectively). The wall motion score was calculated by dividing the sum of all scores by the number of segments visualized.[34] The interobserver variability of these parameters in our institution is within a 10% range, which is in good agreement with the literature.[35] The echo tapes were evaluated by two independent cardiologists who were blinded to the patients' clinical, cTnT, and EBCT coronary calcium score data.

Twelve-lead Electrocardiogram and Cardiac Troponin T Assessments

Serial 12-lead electrocardiogram recordings were performed on the day before surgery and on POD 2 and 7. Morning venous blood samples for measurement of cTnT were drawn on the day before surgery, immediately before induction of anesthesia, and on POD 1, 2, 3, and 7. Serum cTnT was measured by a second-generation enzyme immunoassay (Troponin T STAT; Roche Diagnostics Ltd., Mannheim, Germany). The lower limit of detection in this assay is 0.01 ng/ml serum, and the threshold value for the diagnosis of myocardial cell injury is 0.1 ng/ml.[36] Patients with a cTnT increase greater than 0.1 ng/ml in at least one measurement were defined as cTnT-positive.

After surgery, the study patients underwent a daily clinical assessment for the evaluation of chest pain, shortness of breath, or pulmonary congestion by a research fellow.

Perioperative Management

Anesthetic management and perioperative care and intensive care unit referral were at the discretion of the attending physicians. Postoperative analgesia was provided with opioids and nonsteroidal antiinflammatory drugs. Preoperative cardiac medication was resumed as

soon as possible. Intraoperatively, all patients received 5,000 units of unfractionated heparin, administered intravenously before vascular clamping. Postoperatively, the surgeons individually determined further anticoagulatory management for the prevention of graft thrombosis. The perioperative hematocrit was maintained between 30 and 33%. The attending physicians were aware of the patients' preoperative echocardiographic data and the perioperative cTnT concentrations.

According to a prospectively defined protocol, any evidence of perioperative myocardial cell injury initiated an antiischemic and antithrombotic therapy in the following order:

1. β-adrenergic blocker therapy was resumed or initiated (orally and intravenously in patients who were unable to take oral medication) unless contraindicated by a heart rate less than 60 beats/min, signs of congestive heart failure, or a systolic blood pressure less than 100 mmHg. β-adrenergic blocker therapy was titrated to achieve a heart rate less than 80 beats/min.
2. Nitrates were administrated in patients with anginal pain and in case of a contraindication to β-adrenergic blockade and titrated to maintain a systolic blood pressure greater than 100 mmHg.
3. Intravenous aspirin was administered 6 h after surgery, unless contraindicated by major postoperative bleeding.
4. Intravenous continuous unfractionated heparin was administered in case of a contraindication to aspirin (major postoperative bleeding, active gastroduodenal ulcers) and in case of persistent myocardial ischemia with increasing cTnT concentrations. The dose of heparin was adjusted to achieve an activated partial thromboplastin time at 1.5 of normal.

Data were collected by a research fellow. The patients were monitored until hospital discharge, and a telephone interview was performed to assess 30-day perioperative cardiac morbidity. Perioperative cardiac morbidity was prospectively defined as the occurrence of myocardial infarction, significant dysrhythmias, or congestive heart failure. Myocardial infarction was diagnosed by a typical increase and gradual decrease of cTnT greater than 0.1 ng/ml in combination with at least one of the following: (1) development of new Q waves greater than or equal to 0.04 s and greater than or equal to 1 mm deep in at least two contiguous leads; (2) new and persistent ST-segment or T-wave changes in two or more contiguous leads; (3) the development of postoperative akinesis or dyskinesis in any segment that was found to be normal or hypokinetic on preoperative echocardiography. Significant dysrhythmia was defined as high-grade atrioventricular block, symptomatic ventricular dysrhythmias, and supraventricular dysrhythmias with uncontrolled ventricular rate. Congestive heart failure was defined as the occurrence of clinical and radiographic evidence of pulmonary congestion with the appearance of cardiomegaly on chest radiograph and a typical response to treatment with diuretics.

Statistical Analysis

Data from the 51 patients who completed the study were included in the final analysis. Data from the four dropouts were excluded. All continuous variables were tested for their normal distribution and were compared by repeated-measures analysis of variance or, in case of non-normal distribution (coronary calcium score, cTnT), by rank sum analysis of variance. The main effects group (between factor, levels: cTnT-positive, cTnT-negative) and time (within factor, levels: preoperatively, POD 2, and POD 7), as well as their interaction, were analyzed.

The correlation of coronary calcium score and EF was assessed by multiple linear regression. The distribution of categoric dependent variables (risk factors for CAD, β-adrenergic blockers, aspirin) was analyzed in contingency tables by chi-square tests, followed by Fisher exact test whenever possible. Normally distributed continuous data are expressed as mean ± SD, and non-normally distributed data are expressed as median and 25th and 75th percentiles. For categoric data, count and percentage are provided. Differences were considered significant at $P < 0.05$. All tests were corrected for multiple comparisons. For effects over time, the inherent correlation of the repeated measures was accounted for. The data were analyzed on a personal computer by StatView 4.5 (Abacus Concepts, Berkeley, CA).

Results

Demographic data of all study patients separated by their perioperative cTnT concentrations are summarized in table 1. Fifty-five patients were initially enrolled to provide final data of 51 patients. Four patients were excluded because of uninterpretable postoperative echocardiographic recordings (n = 2) and repeat surgery (n = 2) during the study period.

A total of 306 cTnT determinations was performed during the perioperative period. Six patients (12%) developed perioperative cTnT elevations greater than 0.1 ng/ml, occurring preoperatively in one and postoperatively in five other patients. Two of these six patients presented with persistent electrocardiogram and echocardiographic evidence of ischemia and were diagnosed with asymptomatic perioperative non–Q-wave infarction on POD 2 after aortic abdominal aneurysm and infrainguinal surgery, respectively. Two patients (4%) with a history of congestive heart failure developed decompensated heart failure on POD 3 and 7 after carotid endarterectomy and infrainguinal surgery, respectively, occurring without cTnT elevations. Another patient developed pneumonia and

Table 1. Demographic Data of All Study Patients and Separated by Their Perioperative Cardiac Troponin Concentrations

Variable	Overall	cTnT Negative	cTnT Positive
No. of patients	51	45	6
Age (yr; mean ± SD)	68.9 ± 7.9	68.2 ± 8.0	73.7 ± 5.8
Gender (male/female)	34/17	31/14	3/3
Medical history; n (%)			
CAD	28 (55)	24 (86)	4 (14)
Previous myocardial infarction	12 (24)	9 (75)	3 (25)
CABG/PTCA	4 (8)	3 (75)	1 (25)
Previous congestive heart failure	2 (4)	2 (100)	0
Cardiac risk factors; n (%)			
Hypertension	29 (57)	25 (86)	4 (14)
Diabetes (medically treated)	14 (27)	11 (79)	3 (21)
Cholesterol >240 mg%	23 (45)	21 (91)	2 (9)
Current smoking	22 (43)	21 (95)	1 (5)
Concomitant medication; n (%)			
β-adrenergic blockers	10 (20)	8 (80)	2 (20)
ACE inhibitors	19 (37)	16 (84)	3 (16)
Nitrates	12 (24)	10 (83)	2 (17)
Statins	18 (35)	15 (83)	3 (17)
Aspirin	39 (76)	35 (90)	4 (10)
Heparin	8 (16)	6 (75)	2 (25)
Type of surgery; n (%)			
Abdominal aortic aneurysm	16 (31)	13 (81)	3 (19)
Infrainguinal	23 (45)	21 (91)	2 (9)
Carotid endarterectomy	12 (24)	11 (92)	1 (8)
Duration of surgery (min; mean ± SD)	144 ± 67	141 ± 69	172 ± 52
Duration of hospital stay (days; mean ± SD)	17 ± 7	16.4 ± 6.9	21.7 ± 8.5

CAD = coronary artery disease; CABG = coronary artery bypass grafting; PTCA = percutaneous transluminal coronary angioplasty; ACE = angiotensin-converting enzyme.

acute renal failure after late (POD 8) surgical reexploration, and one patient had wound infection. No significant dysrhythmias were observed, and there was no death from cardiac or noncardiac causes.

Preoperative Electron-beam Computed Tomography Coronary Calcium Score and Perioperative Cardiac Troponin T

The prevalence of coronary calcification by preoperative EBCT was 100%. Coronary calcium scores ranged from 6 to 5,540 (fig. 1). In 39 patients (76%), the coronary calcium score was greater than or equal to 200, and in only three patients (6%) it was less than 10. The median coronary calcium score of the total study population was 997.0 (25th percentile, 202.5; 75th percentile, 1,949.5).

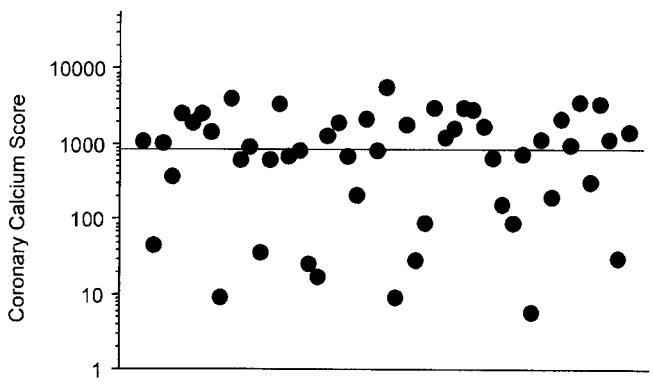

Fig. 1. Univariate scattergraph of the coronary calcium score (y-axis, log 10) of the 51 study patients. The straight line indicates the median.

The six cTnT-positive patients had a substantially (2.5-fold) higher median coronary calcium score than the 45 cTnT-negative patients (2,080 *vs.* 810; $P = 0.021$; fig. 2). Although there were no cTnT elevations in patients with a coronary calcium score less than or equal to 1,000 (n = 26), perioperative cTnT elevations occurred in 6 of the 25 patients (24%) with a coronary calcium score greater than 1,000. The patients suffering from perioperative myocardial infarction had a coronary calcium score of 1,205 and 1,434, respectively.

Perioperative Left Ventricular Function and Cardiac Troponin T

A total of 153 perioperative echocardiographic recordings was performed. The preoperative EF of the 51 patients was 57 ± 10%. No difference in the EF was observed between cTnT-positive and -negative patients ($P = 0.910$). However, there was a decrease of the EF over time ($P = 0.049$) and a different time course (interaction, $P = 0.022$). Namely, in cTnT-negative patients, the EF remained unchanged compared with the preoperative EF, but in cTnT-positive patients the EF decreased from 61 ± 10% to 52 ± 13% on POD 2 and was 54 ± 16% on POD 7 (fig. 3).

The preoperative wall motion score (1.2 ± 0.34) was similar in cTnT-positive and -negative patients (fig. 4).

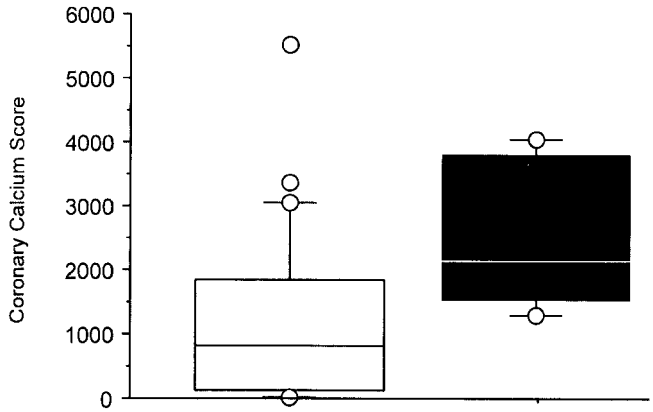

Fig. 2. Box and whisker plots illustrating the distribution of the coronary calcium score (y-axis) in cardiac troponin T (cTnT)-negative (white box) and cTnT-positive patients (black box; x-axis). The line in the box indicates the median. The box reaches from the 25th to the 75th percentile. The whiskers range from the 10th to the 90th percentile. Data points above and below are outliers.

Wall motion score increased in both groups during the observation period ($P = 0.003$) but did not differ between the groups ($P = 0.564$), and the time course was similar (interaction, $P = 0.333$).

Preoperative Electron-beam Computed Tomography Coronary Calcium Score and Perioperative Left Ventricular Function

There was no correlation between preoperative coronary calcium score and preoperative EF ($r^2 = 0.013$). Similarly, no correlation could be demonstrated between preoperative coronary calcium score and EF on POD 2 ($r^2 = 0.039$) and POD 7 ($r^2 = 0.029$).

Discussion

The results of the current investigation demonstrate a 100% prevalence of coronary artery calcification in a group of consecutive patients scheduled for elective vascular surgery. Our findings are in line with those of Hertzer *et al.*,[14] demonstrating a 92% incidence of various angiographic coronary artery stenoses in this patient population. Mangano *et al.*[15] reported a 50% incidence of clinical CAD in patients having at least one traditional risk factor in addition to vascular surgery. These patients have a 20–30% incidence of chronic flow limiting coronary artery stenoses, evidenced by preoperative dobutamine stress echocardiography.[24–26]

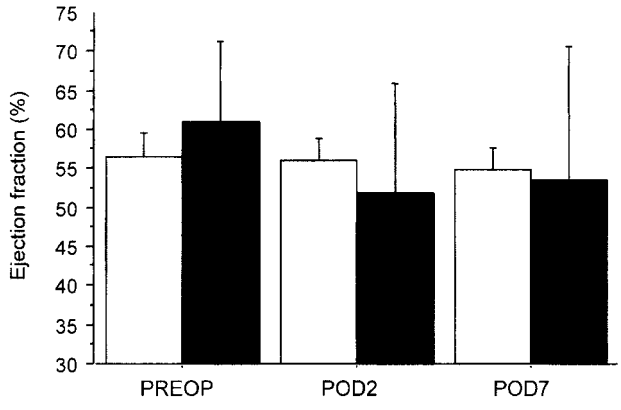

Fig. 3. Perioperative changes of the ejection fraction (y-axis, mean ± 95% confidence interval) in cardiac troponin T (cTnT)-negative (white bars) and cTnT-positive (black bars) patients. The x-axis depicts the observation points. PREOP = the day before surgery; POD = postoperative day.

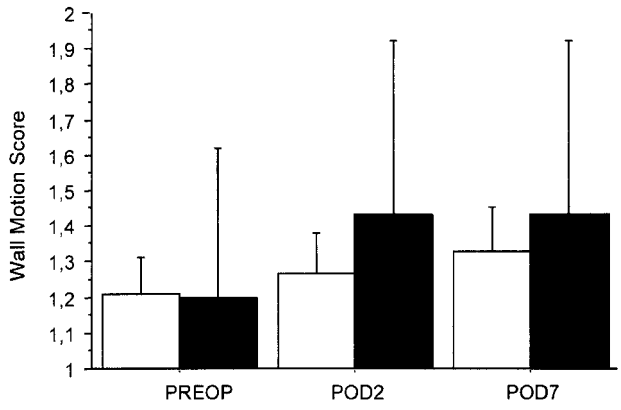

Fig. 4. Perioperative changes of the wall motion score (y-axis, mean ± 95% confidence interval) in cardiac troponin T (cTnT)-negative (white bars) and cTnT-positive (black bars) patients. The x-axis depicts the observation points. PREOP = the day before surgery; POD = postoperative day.

In our study population, a high preoperative EBCT coronary calcium score was associated with an increased risk of perioperative myocardial cell injury. Coronary artery calcification is part of the atherosclerotic plaque formation.[3–5] EBCT is an acknowledged yet not commonly available technology for the measurement of coronary calcium.[1,4] Histopathologic[4,5] and intracoronary ultrasound investigations[6,7] have demonstrated a close correlation between coronary artery calcium and global atherosclerotic plaque formation. Furthermore, there is angiographic evidence of an association between coronary calcium scores and the likelihood of significant coronary artery stenoses.[2,3,8–10]

The individual coronary calcium scores of our study patients varied within a wide range, similar to those reported previously in patients undergoing EBCT for evaluation of CAD.[6,8–10] Seventy-six percent of our patients had a coronary calcium score indicating at least nonobstructive CAD.[9] Fifty percent of our patients had a coronary calcium score greater than 1,000, suggesting substantial atherosclerotic plaque burden with significant angiographic coronary stenoses and total occlusion, respectively.[6–10] Perioperative myocardial cell injury occurred in 25% of these patients.

These findings are in line with previous investigations, suggesting an association between perioperative myocardial infarction and both the functional and anatomic severity of CAD.[24–26,28,37] Major vascular surgery precip-

itates postoperative ischemic events in approximately 50% of patients with chronic flow-limiting coronary stenoses, evidenced by preoperative stress echocardiography.[24–26] Furthermore, there is angiographic and histopathologic evidence that perioperative myocardial infarctions may also occur distal to noncritical stenoses, probably because of plaque rupture. Perioperative stress might induce plaque transformation and thrombosis in primarily nonstenotic coronary artery segments.[21,28,37] Finally, the cardiologic literature suggests that acute myocardial infarction is the peak clinical expression of systemic coronary artery disease activity.[38]

Electron-beam computed tomography coronary calcium score is unable to identify vulnerable soft plaques directly, but a clear correlation between calcified and noncalcified, potentially vulnerable plaques has been demonstrated recently.[7]

The association between high coronary calcium scores and perioperative myocardial cell injury in our study population is in line with the recent cardiologic literature, supporting the relation between high coronary calcium scores and subsequent acute ischemic events.[11–13] However, currently a clearly defined coronary calcium score cut point does not exist.[2,9,11–13]

As a measure of global atherosclerotic plaque burden, coronary calcium score may more comprehensively reflect the true severity of coronary artery disease affecting perioperative cardiac morbidity rather than a technology merely assessing coronary artery luminal narrowing. The lack of a generally accepted cut point currently precludes the definition of a positive predictive value for adverse cardiac outcome and the comparison with acknowledged methods for preoperative cardiac risk assessment.

In our patients with EBCT evidence of CAD, perioperative myocardial cell injury was associated with an asymptomatic postoperative decrease of a previously normal EF, as measured by serial transthoracic echocardiography, albeit the mean EF remained greater than 50% in cTnT-positive and -negative patients. Left ventricular EF and wall motion score are the echocardiographic parameters of global and regional systolic function.[34] An impaired left ventricular EF reflects the severity of underlying CAD and adversely affects long-term prognosis.[39] Recently, Misov *et al.*[40] reported increased troponin concentrations in nonsurgical patients with congestive heart failure and severely limited left ventricular EF.

Clinical signs and a history of congestive heart failure are correlated with perioperative and long-term ischemic cardiac events, particularly in patients scheduled for vascular surgery.[15,18–20,22,23] However, there may be discordance between clinical symptoms and cardiac performance.[41] The incremental prognostic value of preoperative transthoracic echocardiography for the prediction of postoperative ischemic events is controversial.[18,20] Serial perioperative echocardiographic evaluations of a potential relation between myocardial ischemia and perioperative left ventricular systolic impairment have, to our knowledge, not yet been performed.

Although our results do not necessarily apply to patients with preoperatively impaired cardiac function, they support the concept that ischemia is one potential cause of postoperative congestive heart failure, as has been previously suggested by Lopez *et al.*[23] This is in contrast to Mangano *et al.*,[15] who could not identify ischemia as a potential cause of postoperative congestive heart failure, albeit at a time when troponin determinations were not available.

The overall 12% incidence of perioperative cTnT elevations in our study population is low compared with the previously reported 20–30% incidence of troponin elevations after a variety of noncardiac surgical procedures both in patients with definite CAD and those at risk for it.[16,17,29,30] With respect to the "redefinition of myocardial infarction"[32] and the prognostic impact of even asymptomatic perioperative troponin elevations, even a 12% incidence is substantial and needs further consideration.

Limitations to the Study

First, only patients with a preoperatively normal left ventricular EF were eligible for inclusion. This does not reflect the entire range of patients scheduled for vascular surgery.[19,20] A worse outcome could be expected in patients who had a preoperatively impaired systolic function.[18–20]

Second, the 4% incidence of perioperative myocardial infarction by traditional criteria in our study is low. This may be because the attending physicians were not blinded to perioperative cTnT concentrations, and thus any cTnT increase initiated immediate antiischemic and antithrombotic therapy by a strict protocol. This management is based on the previous knowledge that asymptomatic minor myocardial cell injury may precede symptomatic cardiac morbidity.[17,23,29] Although it is tempting to speculate that the antithrombotic[42] and antiinflammatory effects[21,43] of aspirin could have decreased the incidence of perioperative myocardial cell injury, the number of patients in our study is not sufficient to prove this speculation.

Third, only 20% of the patients were treated with β blockers. This reflects an underuse of β-adrenergic blockers in our institution despite available recommendations.[44] Forth, the total number of patients included in our EBCT study is too small for positioning this novel technology in preoperative cardiac risk evaluation.

In conclusion, a high EBCT coronary calcium score, reflecting substantial coronary plaque burden carries

an increased risk for myocardial cell injury after vascular surgery. In these patients, myocardial damage may result in deterioration of global systolic left ventricular function.

The authors thank Eva Herk (Technical Assistant, University of Graz, Graz, Austria) for data collection.

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