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Original Article

Incidence and Predictive Factors of Perioperative Cardiac Events in Patients Undergoing Noncardiac Major Vascular Surgery in Imam Reza University Hospital From December 2010 to December 2013

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ABSTRACT

Background: Cardiovascular morbidity and mortality represent a special concern in a patient with known or unknown cardiovascular disease undergoing high-risk noncardiac surgeries such as major vascular surgery.

Methods: Over a period of 36 months, from 2010 to 2013, we enrolled 65 patients in the Vascular Surgery Department of Imam Reza University Hospital. To assess the patients before major vascular surgery, we performed electrocardiography and echocardiography; and depending on these modality findings, some of the patients were candidated for the exercise test, thallium scan, and coronary angiography. During surgery, the patients had cardiac monitoring; and after surgery, they underwent cardiac monitoring, echocardiography, and cardiac troponin tests.

Results: In the entire study population, the prevalence rate of perioperative ischemia was 18.5%, myocardial infarctions 4.6%, and arrhythmias 6.4% and hypotension 9.2% in the operating room. The prevalence of death owing to cardiac events during surgery was 4.6% in the whole study population. Additionally, 27.7% of the patients had no perioperative cardiac events. In the comparison of the risk factors, hypertension (72.2% vs 57.4; P = 0.021), diabetes (50% vs 19.1%; P = 0.017), smoking (62% vs 40%; P = 0.05), and previous ischemic heart diseases (58.5% vs 31.5%; P = 0.042) were more common in the patients with cardiac events.

Conclusions: Perioperative cardiac assessments and cardiac risk factor modifications may be considered in major vascular surgery. Close cardiac monitoring during and after surgery plays a significant role in decreasing cardiac events. ***(Iranian Heart Journal 2020; 21(4): 6-13)***

KEYWORDS: Acute coronary syndrome, Major vascular surgery, Major cardiac events

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Atherosclerotic peripheral artery disease correlates strongly with the risk for major adverse cardiovascular events because it is frequently associated with coronary and cerebral atherosclerosis. Patients with peripheral artery disease and concomitant symptomatic cerebrovascular or coronary disease are at particularly high risk.

The costs of perioperative myocardial ischemic injury add substantially to total health care expenditures, with an average increased length of hospital stay of 6.8 days for patients with perioperative myocardial ischemic injury. Perioperative cardiovascular complications not only affect the immediate period but also may influence the outcome over subsequent years. The evidence base for managing patients with cardiovascular disease who are candidated for noncardiac surgery has grown in recent decades. The perioperative assessment and management of vascular patients are of utmost importance because patients with vascular disease have multisystem involvement, including cardiac, cerebrovascular, renal, and peripheral arterial diseases, as well as multiple other comorbid conditions. Consequently, they are at high risk for complications after surgery. A focused perioperative evaluation should identify potentially treatable risk factors so that complications can be minimized and optimal choices can be made regarding the timing of elective surgery. Six independent predictors of complications were identified and included in a revised cardiac risk index (RCRI): a high-risk type of surgery, a history of ischemic heart disease, a history of congestive heart failure, a history of cerebrovascular diseases, perioperative treatment with insulin, and a perioperative serum creatinine level of higher than 2 mg/dL, with increasing cardiac complication rates noted with an increasing number of risk factors. Patients can be stratified into low, intermediate, and high cardiovascular risk on the basis of having 0, 1, 2, 3, or more RCRIs.

A patient may be evaluated by those in a number of healthcare systems before undergoing noncardiac surgery; he or she may be seen by a primary caregiver or a cardiologist. [1]

Clinical evaluations of patients may identify stable or unstable coronary artery disease (CAD). Patients with acute coronary syndromes such as unstable angina or the decompensated heart failure of an ischemic origin are at high risk of developing further decompensation or myocardial necrosis and death during the perioperative period. Such patients clearly warrant further evaluation and medical stabilization. If the patient does not have unstable symptoms, the identification of known or symptomatic stable CAD or risk factors for CAD can guide further diagnostic evaluations or changes in perioperative management. [2]

In determining the extent of the perioperative evaluation, it is important not to perform testing unless the results will affect perioperative management. These management changes include the cancellation of surgery for prohibitive risk compared with benefits, delays of surgery for further medical management, coronary interventions before surgery, the use of an intensive care unit, and changes in monitoring. Nonetheless, the potential benefits of perioperative coronary revascularization have been questioned, often limiting the need for extensive testing.

METHODS

Over a period of 36 months, from 2010 until 2013, we enrolled 65 patients in the Vascular Surgery Department of Imam Reza University Hospital. Major vascular surgery types consisted of carotid endarterectomy, abdominal aortic aneurysmectomy, aortoiliac bypass surgery, iliofemoral bypass, and femoropopliteal bypass surgical operations. We recorded the demographic data of the

patients and their past medical history of cardiac diseases (ie, CAD, valvular heart disease, heart failure, and arrhythmias) and cerebrovascular diseases and their risk factors such as diabetes mellitus, hypertension, dyslipidemia, and smoking. Every patient undergoing elective vascular surgery should undergo a perioperative assessment that includes a thorough history taking and a physical examination, a blood analysis, electrocardiography (ECG), and chest radiography. A complete blood count should be obtained to screen for the presence of infection, ensure an adequate red blood cell volume, and rule out a serious hematologic abnormality. Serum electrolytes should be evaluated and corrected when abnormalities exist. Of special importance are serum potassium, calcium, and magnesium levels because if abnormal and not corrected, they can lead to deleterious cardiac effects. Furthermore, because renal diseases are very prevalent in vascular patients and some vascular interventions such as the repair of an abdominal aortic aneurysm may compromise renal function, a baseline creatinine level should be obtained. All patients should also have serum glucose measured; and in diabetic patients, glucose levels should be tightly controlled before, during, and after interventions. The measures of coagulation such as the prothrombin time and the international normalized ratio should be determined to identify coagulation abnormalities. In patients taking warfarin or other anticoagulants, an appropriate anticoagulation scheme should be decided on before surgery.

We performed ECG and echocardiography for all the patients; and depending on these findings, we conducted the exercise test, thallium scan, and coronary angiography in some patients. During surgery, the patients had cardiac monitoring, and any ECG changes, the occurrence of arrhythmias, and blood pressure changes were recorded. After surgery, the patients underwent cardiac monitoring in the intensive care unit, and we conducted echocardiography for the detection of new or worsening regional wall motion abnormalities and the measurement of the left ventricular function and troponin levels.

Statistical Analysis

The data were summarized as the mean ± the standard deviation, the median, and the interquartile range or as percent frequencies. The comparisons between the 2 groups were made using unpaired *t*-tests and Mann–Whitney *U* tests or χ^2 tests, as appropriate.

The data were expressed as odds ratios (95% confidence intervals [CIs] and *P*-values), sensitivities, specificities, positive predictive values, negative predictive values, and likelihood ratios. A *P*-value of less than 0.05 was considered statistically significant. The analyses were performed with the SPSS software, version 24.

RESULTS

The study population consisted of 65 consecutively enrolled patients (48 males and 17 females; $P \leq 0.001$) who underwent major vascular surgery. The mean age was 65.01 ± 12.33 years, with the youngest patient being 30 years old and the oldest 89 years old.

Table 1: Characteristics of the study patients

Hypertension	61.5%
Diabetes mellitus	27.7%
Dyslipidemia	35.4%
Smoking	38.5%
Past history of cerebrovascular accidents	9.2%
Mean hemoglobin level before surgery	13.36 ±1.34 mg/dL
Mean serum creatinine level	1.10 ± 0.31 mg/dL
Mean systolic blood pressure	132.30 ± 16.00 mm hg
Mean diastolic blood pressure	80.53 ± 9.60 mm Hg

In addition, 38% of the patients had confirmed ischemic heart disease, 36.9%

had a past history of admission owing to acute coronary syndromes (unstable angina and ST-segment-elevation or non- ST-segment-elevation myocardial infarctions), 3.1% had valvulopathy, 10.8% had coronary artery bypass graft surgery, and 9.2% had arrhythmias.

In the cardiac assessment before surgery, 12.3% of the patients had abnormal chest X-rays (cardiomegaly, pulmonary venous hypertension, and pulmonary arterial hypertension), 40% had abnormal ECGs (30.80% with pathologic Q-waves and 20% with ST-T changes), 36.9% had abnormal echocardiographic findings (23.1% with wall motion abnormalities and 31.5% with left ventricular dysfunction), 6.2% had positive thallium gated single-photon emission computed tomography (SPECT) scans, and 9.3% had confirmed coronary artery involvement in coronary angiography.

Table 2: Cardiological assessments before surgery

Ischemic heart disease	38%
Admission owing to ACS	36.9%
Valvulopathy	3.1%
CABG	10.8%
Arrhythmias	9.2%
Abnormal CXR	40%
Abnormal ECG	30.8%
Abnormal echocardiography	36.9%
Positive thallium scan	6.2%
Coronary artery stenosis in angiography	9.2%

ACS, Acute coronary syndrome; CABG, Coronary artery bypass graft surgery; CXR, Chest X-ray; ECG, Electrocardiography

The prevalence of perioperative ischemia was 18.5%, myocardial infarctions 4.6%, and arrhythmias 6.4% and hypotension 9.2% in the operating room. The prevalence of death owing to cardiac events during surgery was 4.6% in the whole study population. Moreover, 27.7% of the patients had no perioperative cardiac events.

In the postoperative cardiac assessment, 46.2% of the patients had abnormal ECGs (33.80% with pathologic Q-waves and 35.4% with ST-T changes) (vs 40% in preoperative ECGs; $P \leq 0.001$), 40% had abnormal echocardiographic findings (27.7% with wall motion abnormalities and 35.5% with left ventricular dysfunction) ($P \leq 0.001$), and 4.6% had a postoperative rise in cardiac troponin levels. In the comparison of the patients who had abnormal cardiac assessments (ie, abnormal ECGs, abnormal echocardiographic findings, and abnormal thallium gated SPECT scans or angiographic finding) before surgery, the rate of cardiac events was 33.3%, as opposed to 23.7% in the patients who had normal cardiac evaluations ($P = 0.026$).

In the comparison of the risk factors between the patients with or without cardiac events, the prevalence of hypertension in the group with cardiac events (Group 1) was 72.2% versus 57.4% in the group without cardiac events (Group 2) ($P = 0.021$). Diabetes was detected in 50.0% in Group 1 and 19.1% in Group 2 ($P = 0.017$), dyslipidemia in 38.9% in Group 1 and 34.8% in Group 2 ($P = 0.468$), smoking in 62.0% in Group 1 and 40.0% in Group 2 ($P = 0.05$), and previous ischemic heart disease in 58.5% in Group 1 and 31.5% in Group 2 ($P = 0.042$).

Table 3: Comparisons of the risk factors between the 2 study groups

Risk Factor	Group 1	Group 2	*P*-value
Hypertension	72.2%	57.4%	0.021
Diabetes	50.0%	19.1%	0.017
Dyslipidemia	38.9%	34.8%	0.468
Smoking	62.0%	40.0%	0.05
Previous ischemic heart disease	58.5%	31.5%	0.042

DISCUSSION

Among our study population, comprised of 65 patients, cardiac events occurred in 27.7%, perioperative ischemia in 18.5%, myocardial infarctions in 4.6%, hypotension

and arrhythmias in the operating room in 6.4%, and death due to cardiac events during surgery in 4.6%.

Prung et al [3] showed that the in-hospital cardiac mortality rate was high among their patients who underwent vascular surgery and experienced clinically significant perioperative myocardial infarctions.

Krupski et al [4] compared the differences in perioperative cardiac ischemic events between 140 patients undergoing major vascular surgery. Adverse cardiac outcomes occurred in 20 of 81 (25%) patients who had infrainguinal procedures compared with 4 of 48 (8%) patients who had aortic operations ($P = 0.04$). A history of diabetes and definite CAD were independently associated with adverse outcomes after both types of peripheral vascular operations.

Subramaniam et al [5] reported that in their diabetic patients, continuous insulin infusions reduced perioperative myocardial infarctions after vascular surgery. Likewise, in our study, diabetes mellitus was a risk factor for perioperative cardiovascular events.

In a study by de Liefde et al [6] on 665 consecutive patients with peripheral arterial disease undergoing elective major vascular surgery, perioperative complications were defined as the occurrence within 30 days after surgery. Patients with a hypertensive response during a preoperative exercise test showed a higher risk of early perioperative thrombectomy than those with a normal blood pressure response. Further, patients with a hypotensive response showed an increased risk of perioperative myocardial infarctions and cardiac complications than normotensive patients. Accordingly, de Liefde and colleagues concluded that patients with an abnormal blood pressure response had more cardiovascular complications in elective major vascular surgery.

In an investigation by Desai et al, [7] 577 patients underwent noncardiac vascular surgery, 302 (52%) were treated with statins. Perioperative myocardial infarctions occurred in 18 of the 302 (6%) patients treated with statins and in 38 of the 275 (14%) patients not treated with statins ($P = 0.001$). Desai and coworkers concluded that patients undergoing noncardiac vascular surgery treated with statins had a 57% less chance of having perioperative myocardial infarctions or death at 2 year's follow-up after controlling for other variables. In the comparison between their study and ours, the incidence of myocardial infarctions was higher in their study despite statin therapy.

Farkouh et al [8] allocated 173 patients to subgroups of 60 patients with overt CAD and 106 patients without overt CAD. There were no significant differences in terms of perioperative death, myocardial infarctions, or stroke between the subgroups at 30 days after surgery. The 5- and 10-year Kaplan–Meier survival rate after surgery was 77% and 51% in those without overt CAD and 54% and 24% in those with overt CAD ($P < 0.001$), respectively. For both groups, survival was significantly poorer than that expected for an age- and gender-matched group. The 5-year cumulative incidence of cardiac events was greater in those with overt CAD (50% vs 28%; $P = 0.003$). In their multivariable analysis, age, CAD, and diabetes were the independent predictors of death. Farkouh and colleagues concluded that while coronary events were the most important causes of long-term morbidity and mortality after peripheral vascular surgery, patients without overt CAD were at significant risk for long-term cardiac events.

Shrikhande et al [9] reviewed 736 patients undergoing 897 infrainguinal arterial reconstruction procedures. The patients were divided into 2 groups: Group 1 contained 54 patients with an ejection fraction of less than 35%, and Group 2 comprised 216 patients with an ejection fraction of 35% or higher. The outcomes evaluated were major adverse

clinical events, defined as postoperative myocardial infarctions, arrhythmias, and congestive heart failure. Perioperative mortality occurred in 20.3% of the patients (11/54) in Group 1 and 10.6% (23/216) in Group 2 (P = 0.068). Group 1 had a trend toward a greater incidence of major adverse clinical events than Group 2. Two-year survival for Group 1 was 61.7%, whereas survival for Group II was 78.4% (P = 0.0085). Shrikhande and coworkers concluded that a low ejection fraction predicted a significantly shortened 2-year survival after infrainguinal arterial reconstruction and a trend toward increased perioperative complications; thus, this was another factor to be considered in choosing open versus endovascular options.

In a study by Garcia et al [10] on 462 patients undergoing vascular surgery, there were 72 complications (15.6%) within 30 days after surgery, including 15 (3.2%) deaths and 57 (12.3%) nonfatal myocardial infarctions, which is similar to our study

Asopa et al [11] used a prospectively collected vascular surgery database to identify 412 consecutive patients who had lower extremity bypass surgery. The prevalence of cardiac events in their study was more common than that in our study, and hypertension was a risk factor for cardiac events.

McCann et al [12] reported their observations on a consecutive series of 50 patients who underwent continuous perioperative ECG monitoring with a microprocessor-based ECG ischemia monitor. Thirty-eight percent of the patients were found to have episodes of ischemia; most of these episodes were painless and would not, otherwise, have been recognized. Ischemia was most prominent in the postoperative rather than the perioperative or intraoperative phase. Tachycardia was often associated with ischemia. Significantly more cardiac-related morbidity and deaths occurred in patients who were documented to have silent myocardial ischemia. In fact, no cardiac events occurred in the 31 patients without ischemia.

In an investigation by Pasternack et al, [13] a group of 385 patients undergoing peripheral vascular surgery was studied long-term as well as short-term to determine whether perioperative monitoring for silent ischemia could identify patients at significantly increased risk of late cardiac deaths or late cardiac complications as well as patients at increased risk of perioperative myocardial infarctions. Their multivariate logistic regression analysis of the patients' perioperative and postoperative characteristics showed that the presence of a total perioperative percent time ischemic of 1% or greater and age were the only significant predictors of perioperative myocardial infarctions.

Ashton et al [14] studied 1487 men older than 40 years undergoing major, nonemergent, noncardiac operations. Myocardial infarctions were established by at least 2 of the following criteria: the development of new Q-waves, typical changes in the level of creatine kinase MB, and positive technetium pyrophosphate scintigraphy. Ashton and coworkers concluded that CAD was the major risk factor for perioperative myocardial infarctions.

In a study by McFalls et al, [15] a 4-year follow-up of patients who had undergone elective vascular procedures was carried out. A total of 115 consecutive patients underwent surgery, and the authors determined vital status at 4 years post-surgery for all the patients. Their results showed that cardiac mortality was the major cause of late death among the patients undergoing elective vascular surgery. McFalls and colleagues concluded that although the perioperative indicators of symptomatic CAD identified those individuals at an increased risk of mortality in the first postoperative year, the extent of vascular disease at presentation

might be a more important determinant of long-term survival.

In the VISION Pilot Study [16] in 2011 in 5 hospitals in Canada, China, Italy, Colombia, and Brazil, during the first 30 days after surgery, 6.3% (99% CI: 3.9 to 10.0) of the patients suffered a major vascular event (10 vascular deaths, 16 nonfatal myocardial infarctions, and 1 nonfatal stroke). That study suggested that major perioperative vascular events were common, that the RCRI underestimated risk, and that monitoring troponins after surgery could help physicians to avoid missing myocardial infarctions.

In their investigation, Faggiano et al [17] showed that the number of major cardiac perioperative complications decreased over time. In particular, the in-hospital mortality rate was 0.9% in the latter period, compared with 3.4% in the years 2000 to 2002, and these data suggested the significant benefit of an intensive cardiac preoperative evaluation in reducing the incidence of perioperative and postoperative cardiac morbidity and mortality.

CONCLUSIONS

In our study, performed on 65 patients, cardiac events occurred in 27.7%, perioperative ischemia in 18.5%, and myocardial infarctions in 4.6%. Moreover, intraoperative cardiac events (arrhythmias and hypotension) happened in 6.4% of the patients, and the prevalence of death owing to cardiac events during surgery was 4.6%. Furthermore, cardiac events in major vascular surgery were more common among patients with hypertension, diabetes, and smoking, as well as those with a past history of cardiac disease. Thus, we recommend cardiac evaluation for all patients undergoing major vascular surgery and a better control of such risk factors as hypertension and diabetes.

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Conflict of Interest: None

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