Perioperative Complications After Vascular Surgery Are Predicted by the Revised Cardiac Risk Index But Are Not Reduced in High-Risk Subsets With Preoperative Revascularization

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Background—The Revised Cardiac Risk Index (RCRI) is useful for risk stratifying patients before noncardiac operations. Among patients with documented coronary artery disease who undergo vascular surgery, it is unclear whether preoperative revascularization reduces postoperative cardiac complications in high-risk subsets defined by the RCRI.

Methods and Results—The Coronary Artery Revascularization Prophylaxis Trial was a randomized, controlled trial that tested the long-term benefit of a preoperative coronary artery revascularization before elective vascular surgery. Using preoperative baseline characteristics to determine the RCRI, we tested the benefit of preoperative revascularization on death and nonfatal myocardial infarction in patients with multiple risks. Among 462 patients undergoing vascular surgery, there were 72 complications (15.6%) within 30 days postsurgery, including 15 deaths (3.2%) and 57 nonfatal myocardial infarctions (12.3%). The postoperative risk of death and nonfatal myocardial infarction after surgery increased according to the RCRI (odds ratio, 1.73; 95% CI, 1.26 to 2.38; \( P \leq 0.001 \)), with a rate of 1.6% in patients with no risk that increased to 23.4% in patients with \( \geq 3 \) risks. Preoperative revascularization had no influence on the incidence of complications in any risk subset (odds ratio, 0.86; 95% CI, 0.50 to 1.49; \( P = 0.60 \)). Among those individuals with \( \geq 2 \) risks who also demonstrated ischemia on a preoperative stress-imaging test (\( N = 146 \)), the incidence of events was 23% in patients with and without preoperative revascularization (\( P = 0.95 \)).

Conclusions—The risk of death and nonfatal myocardial infarction is accurately predicted by the RCRI in patients undergoing vascular surgery but is not reduced in any high-risk subset of the RCRI with preoperative coronary artery revascularization. (Circ Cardiovasc Qual Outcomes. 2009;2:73-77.)

Key Words: peripheral arterial disease ■ revascularization ■ outcomes

The Revised Cardiac Risk Index (RCRI) predicts the risk of perioperative complications in patients undergoing elective noncardiac operations.\(^1\) Its application has proved effective in risk stratifying patients who might benefit from perioperative \( \beta \)-blocker therapy\(^2\) and may optimize stratification of patients at intermediate risk who are scheduled for elective vascular surgery.\(^3\) On the basis of these considerations, the ACC/AHA Guidelines for preoperative risk assessment advocate use of the RCRI before making decisions about preoperative noninvasive stress imaging before vascular operations.\(^6\) Although the Coronary Artery Revascularization Prophylaxis (CARP) Trial showed no long-term survival benefit with a strategy of preoperative coronary artery revascularization before elective vascular surgery,\(^7\) the impact of preoperative revascularization on postoperative cardiac complications among high-risk subsets defined by the RCRI is unclear.\(^8\) Accordingly, we performed a post hoc analysis of baseline characteristics of all randomized CARP patients and tested whether the composite of death and nonfatal myocardial infarction (MI) was predicted by the RCRI at 30 days after vascular surgery. On the basis of treatment received as part of the randomization strategy, we then tested whether preoperative revascularization reduced the composite of death and nonfatal MI in patients with multiple risks defined by the RCRI.

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SUMMARY

- Guidelines for preoperative evaluation advocate the use of the Revised Cardiac Risk Index in making decisions about preoperative cardiac workup before vascular operations.
- Yet, it is unclear whether preoperative revascularization reduces postoperative cardiac complications in high-risk subsets, as defined by the Revised Cardiac Risk Index.
- In this multicenter randomized trial of patients with peripheral arterial disease undergoing vascular surgery, the Revised Cardiac Risk Index was predictive of the postoperative risk of death and nonfatal myocardial infarction.
- However, preoperative revascularization was not associated with a lower incidence of complications in any Revised Cardiac Risk Index subset.

Methods

The Cooperative Studies Program Evaluation Committee approved the scientific merit of the research program. The Human Rights Committee from the Hines Veterans Affairs Cooperative Studies Program Coordinating Center and the Institutional Review Board and Research and Development Committees from each Veterans Affairs Medical Center approved the study.

The study design has been previously described.7,8 In brief, patients undergoing vascular surgery were screened at 18 Veterans Affairs Medical Centers (March 1999 through February 2003) during the enrollment period for the randomization process. Patients were considered eligible for the study if they were scheduled for a vascular operation for either an expanding abdominal aortic aneurysm or arterial occlusive disease of the lower extremities. Inclusion criteria for cardiac risks were the presence of multiple accepted cardiac risks or, with indeterminate number of risks, an abnormal preoperative stress imaging test.8,9 Patients were excluded from consideration of randomization if they required an urgent vascular operation or had a severe comorbidity. A baseline screening form was completed after randomization and included all clinical variables and baseline laboratory results. By study design, all randomized patients had undergone preoperative coronary angiography and had significant coronary artery disease (CAD) that was amenable to revascularization. The decision for preoperative coronary artery revascularization was randomly assigned. The revascularization strategy, either with coronary artery bypass grafting versus percutaneous coronary intervention, was left at the discretion of the local site. The trial was completed before use of drug-eluting stents. The RCRI was enumerated in each patient and included the following variables: a history of CAD (angina, prior MI, pathological q waves, or treated ventricular arrhythmias), history of cerebrovascular disease (prior stroke or transient ischemic attack), history of congestive heart failure, insulin-dependent diabetes mellitus, serum creatinine >2.0 mg/dL, and an abdominal operation.1 Only those vascular operations involving an intra-abdominal approach were considered high risk in the present cohort.

Of 510 patients who were randomized into the CARP Trial, 462 underwent their intended vascular operation and comprise the present cohort. Of the 258 patients assigned to revascularization, 225 (87%) underwent the planned vascular operation, as did 237 of the 252 patients (94%) assigned to no preoperative revascularization. Of the 33 patients assigned to revascularization who did not undergo vascular surgery, 18 declined the surgery, 10 died after uncomplicated coronary artery bypass grafting or percutaneous coronary intervention, and 5 developed a severe coexisting condition. Of the 15 patients assigned to no revascularization who did not undergo vascular surgery, 9 declined, 1 died after urgent coronary artery bypass grafting, and 6 developed a severe comorbid condition. The study end point was the composite of death and nonfatal MI within 30 days of vascular surgery. After surgery, blood for cardiac enzymes was collected and an ECG was performed each day for 4 days in all patients and assessed at local sites for the presence of a perioperative MI. A perioperative MI after vascular surgery was defined by an elevation of the locally measured cardiac enzymes above the normal reference value in association with a clinical correlate of myocardial ischemia.10 The specific cardiac biomarker was troponin I or T in 431 (93%) and creatine kinase (CK) MB-fraction mass in 31 (7%) patients. By study design, an end-point committee, independent of the CARP investigators, reviewed all source documents and confirmed the presence of all end points, including a perioperative MI.11 As part of this analysis, patients were grouped according to their RCRI without knowledge of their outcomes, and intergroup differences in complications were determined by logistic regression analyses and backward elimination. Odds ratio (OR) estimates and 95% CIs were obtained for risk variables in the model, including the impact of coronary artery revascularization and perioperative therapy on reduction of death and nonfatal MI in each group. Data are expressed as means and SDs and intergroup differences are considered significant at the P<0.05 level. The authors had full access to and take full responsibility for the integrity of the data. All authors have read and agree to the manuscript as written.

Results

Of 5859 patients scheduled for vascular surgery, 4669 (80%) were initially excluded. The main reasons for exclusion were insufficient cardiac risks (1654 patients), an urgent need for vascular surgery (1025 patients), prior coronary artery bypass grafting or coronary intervention without ischemia (626 patients), and a severe coexisting illness (731 patients). The patient’s decision not to participate and ineligibility due to participation in other research studies accounted for 633 exclusions. Of the patients who underwent coronary angiography without any clinical exclusions, 680 patients were excluded for reasons that were specified in the protocol. The primary reason was either nonobstructive CAD (363 patients) or CAD that was not amenable to revascularization (215 patients). Other anatomic reasons for exclusion included left main disease (54 patients), severe aortic stenosis (8 patients), and left ventricular ejection fraction <20%. Refusal to participate accounted for 29 exclusions.

In the present cohort, the specific risks defined by the RCRI included abdominal surgery (N=274; 59%), history of ischemic heart disease (N=188; 41%), prior congestive heart failure (N=45; 10%), known cerebrovascular disease (N=93; 20%), insulin-dependent diabetes mellitus (N=90; 20%), and baseline creatinine >2.0 mg/dL (N=17; 4%). Of 462 patients undergoing their intended vascular operation, 231 (50%) had 2 or more cardiac risks and they had a higher prevalence of multivessel CAD, left ventricular dysfunction, diabetes mellitus, and renal failure (Table 1).

At 30 days after vascular surgery, there were 72 complications (15.6%) including 15 deaths (3.2%). Sixty-four patients had a documented MI and 57 were nonfatal (12.3%). The composite of death and nonfatal MI after surgery increased from 1.6% in patients with no risks to 23.4% in patients with ≥3 risks (Figure). By logistic regression analysis, the RCRI was an independent predictor of the composite of death and nonfatal MI at 30 days (OR, 1.73; 95% CI, 1.26
to 2.38; \( P<0.001 \)). Perioperative use of antiplatelet agents and \( \beta \)-blockers within 24 hours of vascular surgery was similar in all risk subsets.

Prophylactic coronary artery revascularization did not reduce the complication rate in any RCRI subset (Table 2) and by logistic regression analysis, did not alter the risk of perioperative death and nonfatal MI (OR, 0.86; 95% CI, 0.50 to 1.49; \( P=0.60 \)). There was no interaction between treatment assignment and RCRI subgroup (\( P=0.74 \)). When considering only those patients with multiple risks who had evidence of ischemia on a preoperative stress-imaging test (\( N=146 \)), death or nonfatal MI occurred in 16 of 52 (23.5%) patients who did not undergo preoperative revascularization compared with 18 of 78 patients (23.1%) who underwent preoperative revascularization (\( P=0.95 \)).

### Discussion

The principal finding of this analysis of the CARP Trial is that the composite of death and nonfatal MI after vascular surgery is predicted by RCRI but is not reduced in any
The number of clinical risks defined by the RCRI predicted the composite of perioperative death and nonfatal myocardial infarction (MI) in all patients undergoing vascular surgery (OR, 1.73; 95% CI, 1.26 to 2.38; P < 0.001).

high-risk subset with preoperative coronary artery revascularization. Nearly 1 in 4 patients in the highest RCRI risk subset had an adverse postoperative event, but even those patients with an abnormal preoperative stress-imaging test did not benefit from preoperative revascularization. These data are consistent with the main results of the CARP Trial and provide additional support that a strategy of prophylactic revascularization does not improve outcomes in high-risk patients who are scheduled for vascular surgery.

Clinical variables that comprise the RCRI include a history of ischemic heart disease, congestive heart failure, cerebrovascular disease, insulin-treated diabetes, creatinine >2.0 mg/dL, and need for a high-risk operation. In the derivation and validation of the index, complication rates in patients with 0, 1, 2, or ≥3 RCRI variables were 0.4%, 1%, 7%, and 11%. Application of this risk index may be an important means of selecting patients at intermediate risk who may benefit from additional preoperative testing, such as noninvasive stress-imaging tests. It also has utility in risk stratifying those patients who might benefit from perioperative β-blocker therapy. In the present cohort from the CARP Trial, the composite of death and nonfatal MI after vascular surgery was highly dependent on the RCRI obtained from baseline characteristics, as noted by the incremental complication rate from 1.6%, 13.0%, 20.4%, and 23.4% in patients with 0, 1, 2, or ≥3 RCRI variables. This demonstrates that the risk index is generalizable to even those patients who have documented CAD who undergo vascular surgery, which is considered high risk.

According to the current ACC/AHA Guidelines on preoperative management, noncardiac surgical procedures with anticipated event rates ≥5% are considered to be high-risk operations. Current guidelines incorporate the RCRI into the stepwise approach to management of these patients with poor or unknown functional class (step 5). Under the assumption that the perioperative event rate is <5%, as might be assumed when the RCRI is ≥2, the recommendations are to proceed with noncardiac surgery without additional testing but with the option of administering tight heart-rate control. On the basis of the findings of our analysis of the CARP Trial, in which all patients had significant CAD and all underwent vascular surgery, a RCRI cutoff of ≥1 may be more appropriate to identify high-risk vascular patients (event rate >10%) who may benefit from intensive pharmacological therapy before their planned operation.

The principal new finding of our study is that none of the high-risk subsets defined by the RCRI demonstrated a benefit of coronary artery revascularization, including those individuals with multiple risks who had evidence of ischemia on preoperative stress imaging. These data support the findings of the main randomized trial that preoperative coronary artery revascularization does not improve long-term survival after vascular surgery. It also supports the findings from the DECREASE-V pilot study, in which a strategy of preoperative revascularization does not reduce the composite of death and nonfatal MI, even among patients with high-risk stress-imaging test results.

Table 2. Postoperative Complication Rates Are Shown According to the Preoperative Revascularization Status for Each Risk Subset

<table>
<thead>
<tr>
<th>Risks</th>
<th>Preoperative Coronary Revascularization</th>
<th>No Preoperative Coronary Revascularization</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>26</td>
<td>36</td>
<td>0.99</td>
</tr>
<tr>
<td>1</td>
<td>79</td>
<td>80</td>
<td>0.36</td>
</tr>
<tr>
<td>2</td>
<td>84</td>
<td>83</td>
<td>0.99</td>
</tr>
<tr>
<td>≥3</td>
<td>33</td>
<td>31</td>
<td>0.77</td>
</tr>
</tbody>
</table>

RCRI includes the following variables: history of coronary artery disease with angina or prior myocardial infarction, prior stroke, prior congestive heart failure, insulin-dependent diabetes, abdominal aortic surgery, and serum creatinine >2.0 mg/dL. Preoperative coronary revascularization was performed according to the assigned treatment as determined by the randomization process of the CARP trial. Complication refers to the composite of death and nonfatal myocardial infarction within 30 days of vascular surgery.

Limitations

Certain limitations of the present analysis should be noted. It is possible that we have been overly conservative in estimating the RCRI, because only those patients with documented CAD defined by a history of cardiac events were given a risk score. In addition, although vascular surgery is considered a risk, we considered only those individuals who underwent an abdominal aortic operation as the highest risk. By excluding study patients that did not undergo their planned vascular operation, we might have underestimated the early mortality hazard associated with coronary revascularization, which was higher for patients assigned to a strategy of prophylactic revascularization. Patients included in this post hoc analysis were part of a randomized clinical trial and, therefore, were selected on the basis of predetermined inclusion and exclusion criteria. Because CARP was conducted at Veterans Affairs hospitals, the study cohort was predominantly male.

Conclusions

In summary, the utility of the RCRI as an estimate of risk for perioperative death and nonfatal MI is generalizable to
patients undergoing vascular surgery who have significant CAD on preoperative coronary angiography. Preoperative coronary artery revascularization did not reduce the composite of death and nonfatal MI in any high-risk subset of the RCRI, and these findings are consistent with the observations from the CARP Trial.

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**Disclosures**

Dr Garcia is a recipient of the Society for Cardiac Angiography and Interventions/Cordis Fellowship Program Award. Dr Littooy has served as an expert witness in malpractice lawsuits involving vascular surgery cases. Dr Larsen has received research grants as part of the ACUITY and AIM HIGH trials. The remaining authors report no conflicts.

**References**


**CLINICAL PERSPECTIVE**

It is unclear whether preoperative coronary revascularization reduces postoperative cardiac complications in high-risk patients undergoing vascular surgery as defined by the Revised Cardiac Risk Index (RCRI). Using preoperative baseline characteristics to determine the RCRI, we validated the RCRI in patients undergoing vascular surgery and evaluated the benefit of preoperative revascularization on death and nonfatal myocardial infarction among patients with varying risk. The postoperative risk of death and nonfatal myocardial infarction after surgery increased according to the RCRI (odds ratio, 1.73; 95% CI, 1.26 to 2.38; *P*<0.001), with a rate of 1.6% in patients with no risk that increased to 23.4% in patients with ≥3 risks. However, preoperative revascularization was not associated with the incidence of complications in any risk subset (odds ratio, 0.86; 95% CI, 0.50 to 1.49; *P* = 0.60). Therefore, we conclude that the risk of death and nonfatal myocardial infarction is accurately predicted by the RCRI in patients undergoing vascular surgery but is not reduced by preoperative coronary artery revascularization among any RCRI risk subset.
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