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Preoperative Evaluation Prior to High-Risk Vascular Surgery

Santiago Garcia and Edward O. McFalls

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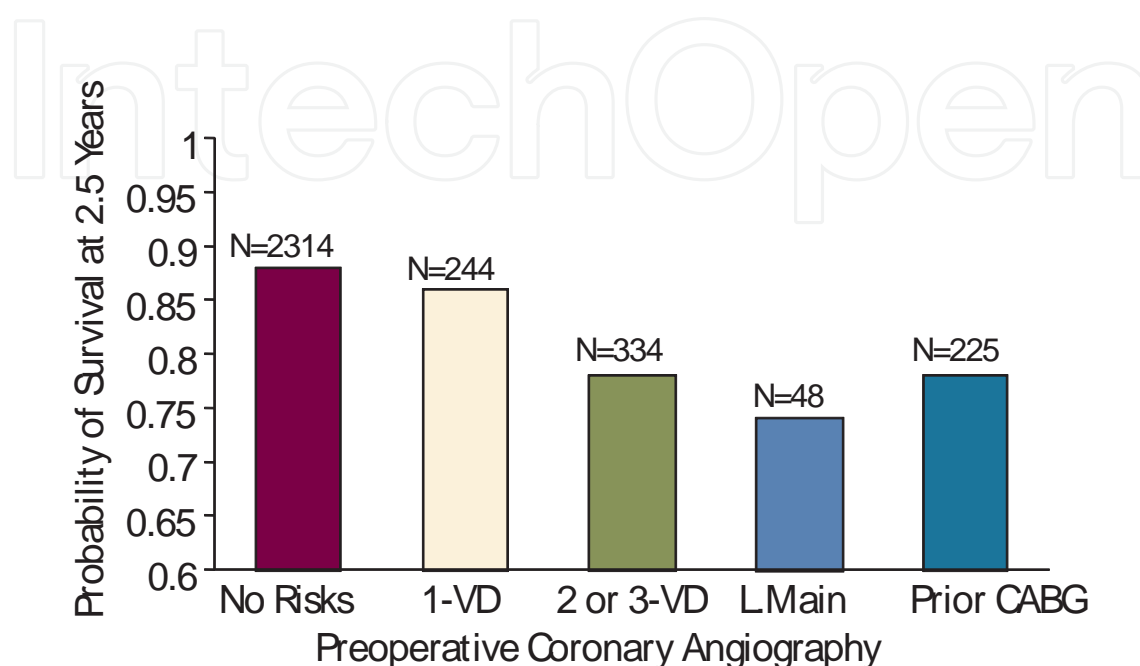
1. Introduction

The number of patients undergoing noncardiac surgery worldwide is growing, and annually 500,000 to 900,000 of these patients experience perioperative cardiac death, nonfatal perioperative myocardial infarction (PMI) or cardiac arrest [1]. Over 300,000 surgical revascularization procedures are performed in the US annually as part of the treatment of expanding abdominal aortic aneurysms, critical limb ischemia, and severe carotid disease [2].

The preoperative assessment of a patient in need of elective non-cardiac surgery is often a difficult task. Current guidelines consider vascular surgery a high-risk operation with an anticipated risk of major postoperative cardiac complications in excess of 5% [3]. Although the reasons relate, in part, to the hemodynamic stresses associated with aortic procedures, the prevalence of atherosclerotic coronary artery disease (CAD) in patients undergoing vascular surgery exceeds 50% and therefore, may require special attention in the preoperative period [4].

2. Pathophysiology of postoperative myocardial infarction

Unlike spontaneous myocardial infarction the majority of postoperative, or type 2, myocardial infarctions (PMI) are thought to result from an imbalance between oxygen supply and demand in the setting of severe, yet stable, coronary artery disease [5]. Several studies using continuous electrocardiographic monitoring in high-risk vascular patients undergoing surgery have shown that tachycardia-related ST-segment depression is common in the postoperative period and is associated with in-hospital as well as long-term mortality [6-7]. Peak troponin elevation correlates well with duration of ST-segment depression [8].

Angiographic and Autopsy Data: In a landmark angiographic study Hertzer et al. showed that only 8% of patients with peripheral arterial disease in need of major vascular surgery have normal coronary arteries [4]. In the CARP trial, among 1048 patients undergoing coronary angiography within 6-months of a high-risk vascular operation, the extent and severity of CAD were predictors of long-term mortality (Figure 1) [9].

Reproduced from The American Journal of Cardiology 2008, 102: 809-13. VD= Vessel disease, CABG= coronary artery bypass grafting, L main= Left main

Figure 1. Extent of Coronary Artery Disease and Survival

The prevalence of angiographic chronic total occlusions in patients with PMI or cardiac death is 81% as opposed to only 29% of matched control patients without PMI or cardiac death [10]. On average patients with postoperative cardiac complications have 2 ±1.4 critical (>70%) coronary stenosis in contrast to patients without postoperative complications who have less disease burden (0.7 ±1.2). Two small autopsy studies reported conflicting data on the incidence of coronary plaque rupture in patients with fatal PMI [11-12]. Dawood et al. found plaque rupture in only 7% of 42 autopsied patients [11]. In contrast, Cohen et al. reported in a smaller study a higher incidence of plaque rupture (46%) [12]. Differences between studies could be explained on the basis of timing of the autopsy relative to occurrence of PMI.

Stepwise approach to preoperative risk assessment:

The approach to assessing the potential cardiac risk associated with any patient scheduled for elective non-cardiac operation includes the nature of the operation, the risk of associated coronary artery disease and the functional capacity of the patient. The initial evaluation requires an assessment of a prior history of cardiac problems and/or risk fac-

tors along with either classical angina or unusual symptoms such as shortness of breath or atypical chest pains. Attention should be given to clinical risk variables such as age >70 years, angina, history of congestive heart failure, prior myocardial infarction, prior cerebrovascular accident (CVA) or transient ischemic attack (TIA), history of ventricular arrhythmias, diabetes mellitus (particularly insulin dependent), and abnormal renal function (Creatinine >2.0 mg/dl) [13] (Table 1). The physical examination also provides key insight into high risk variable and include a chronic debilitated state, increased jugular venous distention, edema, S_3 gallop, significant aortic stenosis while the 12-lead electrocardiogram provides prognostic information related to the presence of abnormal Q-waves or heart rhythms other than normal sinus. Assessing the functional capacity of patients undergoing elective operations is an important ingredient to determining whether a patient can withstand the rigors of a prolonged operation. In those patients who are unable to achieve a 4-MET demand, a level compatible with routine daily activities, there is increased risk of postoperative events and additional testing may be warranted (i.e. stress test). The presence of multiple ischemic segments indicative of either multivessel coronary artery disease or left main disease is considered high risk and is associated with an increased risk of perioperative cardiac complications and reduced long-term survival [14]. Ultimately, a combined approach of utilizing clinical variables associated with stress-imaging tests is most cost-effective.

RCRI	Derivation set (2893)		Validation set (n=1422)	
	Events	Rate, 95% CI	Events	Rate, 95% CI
0	5/1071	0.5 (0.2-1.1)	2/488	0.4 (0.5-1.5)
1	14/1106	1.3 (0.7-2.1)	5/567	0.9 (0.3-2.1)
2	18/506	3.6 (2.1-5.6)	17/258	6.6 (3.9-10.3)
≥3	19/210	9.1 (5.5-13.8)	12/109	11 (5.8-18.4)

Table 1. The Revised Cardiac Risk Index (RCRI) can be used to risk-stratify patients prior to non-cardiac surgery with regard to the risk of serious cardiac complications. Adapted from Lee et al. Circulation 1999; 100:1043-1049.

3. Preventive therapies

Therapies that have been proven to reduce PMI among patients undergoing non-cardiac surgery include beta-blockers and statins.

Beta-blockers:

Mangano et al. reported a 6% absolute risk reduction in cardiac events at 6 months with atenolol among 200 male veterans undergoing noncardiac surgery [15]. Poldermans et al. reported a more dramatic 30% absolute risk reduction with bisoprolol among 173 patients undergoing vascular surgery with evidence of myocardial ischemia on stress test [16]. However, subsequent larger studies with metoprolol yielded negative results [17-19]

(Table 2). The landmark POISE trial, with over 8300 patients enrolled showed that although extended-release metoprolol 200 mg reduces PMI by 26%, it is associated with a higher risk of death and stroke. For every 1000 patients treated with extended-release metoprolol 15 non-fatal myocardial infarctions would be prevented but 5 strokes and 8 deaths would be caused by it [20]. Therefore, the POISE trial raised serious concerns about the safety of injudicious administration of high-dose beta-blockers in the perioperative period.

Study	Patients	Intervention	Findings
Mangano et al. [15]	200 Male veterans undergoing non-cardiac surgery	Atenolol begun in hospital	Cardiac events at 6 months 0% (drug) vs. 8% (placebo)
Poldermans et al. [16]	173 patients with ischemia undergoing vascular surgery	Bisoprolol 30 days before surgery	Cardiac events 3.4 % (drug) vs. 34% (placebo)
Yang et al. [17]	496 vascular surgery patients	Metoprolol begun before surgery	Cardiac events 10.2% (metoprolol) vs. 12% (placebo) (p=NS)
Juul et al. [18]	921 patients with diabetes undergoing major non-cardiac surgery	Metoprolol XL 100 mg	21 % vs. 20% (p=NS)
Brady et al. [19]	103 patients without previous MI undergoing infrarenal vascular surgery	Oral metoprolol 50 mg bid	34 % vs. 30% (p=NS)
Devereaux et al. [20]	8351 undergoing non-cardiac surgery	Oral CR- metoprolol 200 mg/d for 30 days	5.8% (drug) vs. 6.9% (placebo). Reduction in MI but increased risk of stroke and mortality with metoprolol

Table 2. Summary of clinical trials assessing the role of beta-blockers prior to non-cardiac surgery.
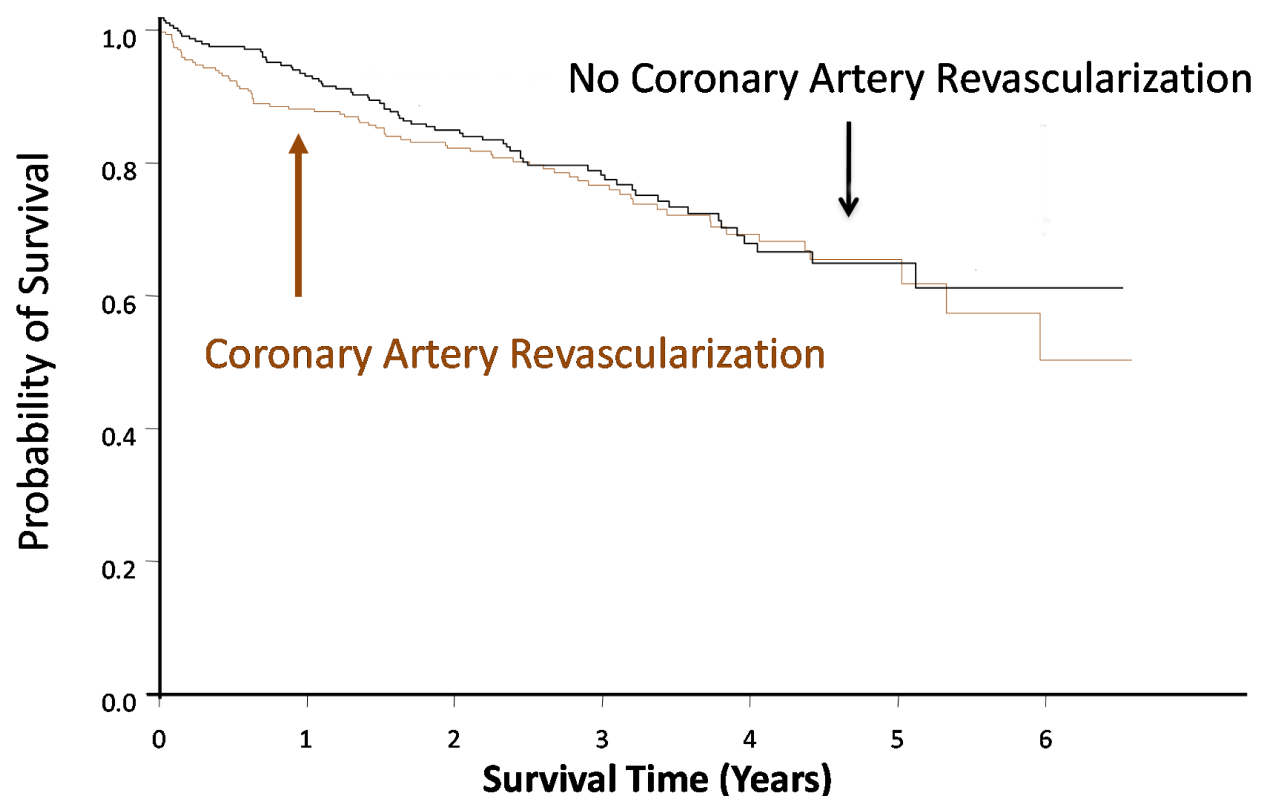
Statins:

In the Dutch Echocardiographic Cardiac Risk Evaluation Applying Stress Echocardiography (DECREASE-III) study high-dose fluvastatin reduced the composite of cardiovascular death and non-fatal myocardial infarction by 53% among 457 patients undergoing vascular surgery [21]. In a smaller trial involving 100 vascular patients randomly assigned to 20 mg of atorvastatin or placebo, statins reduced cardiac events from 26% to 8% at 6 months [22]. In a single center registry of patients undergoing vascular operations at our institution the use of perioperative statins was an independent predictor of long-term survival [23]. Statins may play a pivotal role in plaque stabilization by reducing circulat-

ing levels of inflammatory cytokines, increase expression of nitric oxide synthase, and reduced production of endothelin-1 and reactive oxygen species.
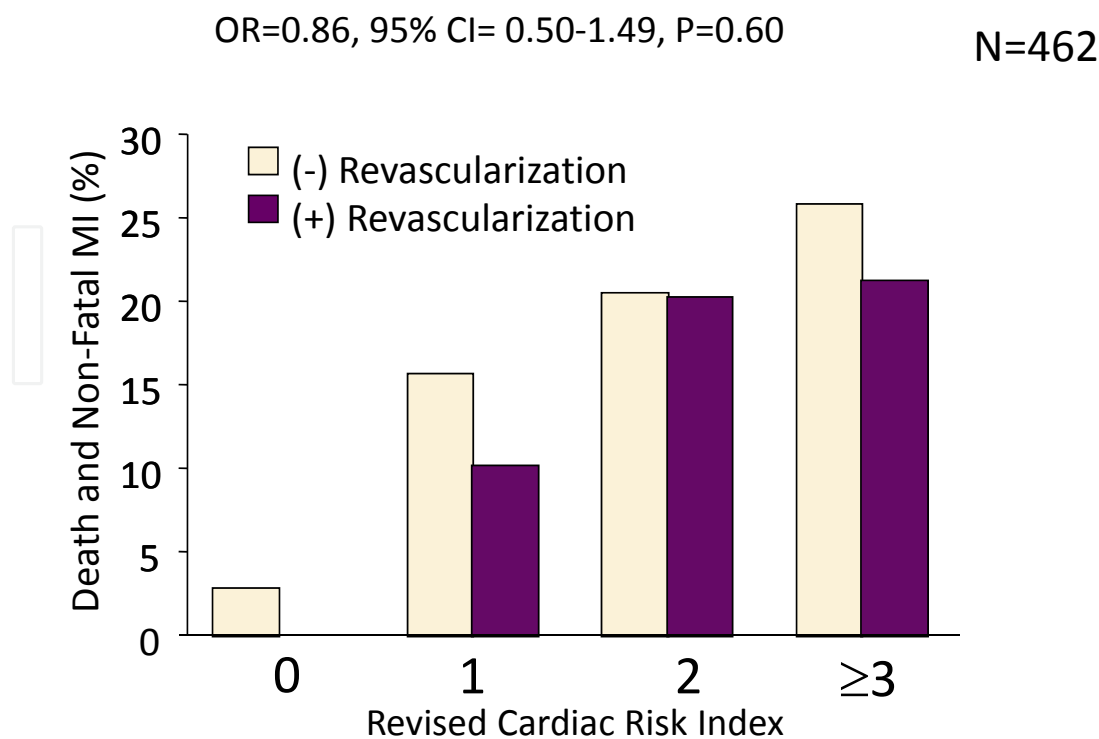
Role of coronary revascularization:

The Coronary Artery Prophylactic Revascularization trial (CARP) showed that a strategy of prophylactic revascularization was not superior to optimal medical therapy in preventing PMIs or improving long-term mortality among 510 Veterans undergoing elective major vascular surgery [24] (Figure 2). Despite high utilization rates of statins and beta-blockers in the CARP trial, 16% of patients suffered a PMI [24]. Moreover, among patients with multiple risk factors and/or evidence of myocardial ischemia on nuclear imaging test the incidence of PMI was 25% [25], which was unaffected by revascularization status (Figure 3). Similarly to CARP, the DECREASE-V pilot study failed to show any benefit with prophylactic revascularization among 101 patients with multivessel CAD and abnormal stress test prior to vascular surgery (death or MI at 1 year 49% vs. 44%) [26]. These high events rates despite optimal medical therapy highlight the need for additional interventions for risk reduction among high-risk patients.

Reproduced from The New England Journal of Medicine 2004; 351:1795-804

Figure 2. Primary Outcome of the Coronary Artery Revascularization Prophylaxis (CARP) Trial

OR=0.86, 95% CI= 0.50-1.49, P=0.60   N=462

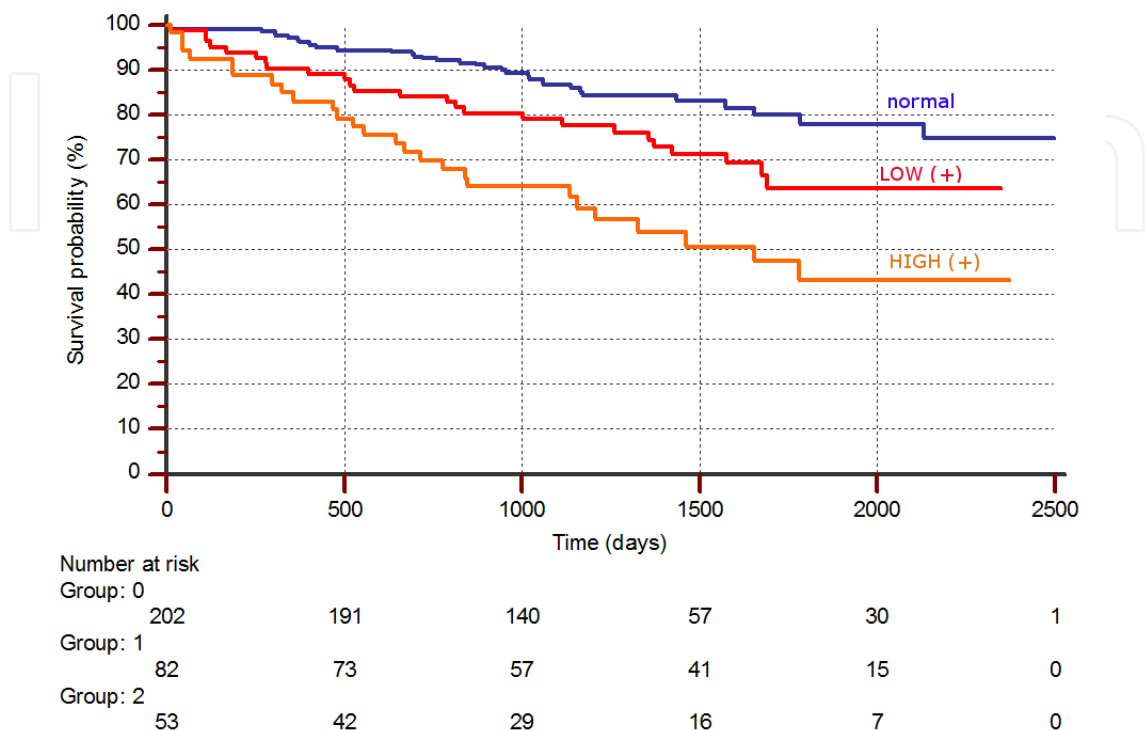Reproduced from Circulation: Quality and Outcomes. 2009; 2: 73-77. OR= Odds Ratio, CI=Confidence Interval

Figure 3. Impact of Revascularization According to Number of Risks Enumerated in the Revised Cardiac Risk Index

4. Diagnosis

A joint ESC/ACCF/AHA/WHF Task Force has redefined myocardial infarction as an event characterized by ischemic symptoms (i.e. chest pain or dyspnea), a typical rise and fall of cardiac biomarkers (preferably troponin) with at least one value above the 99th percentile of the upper reference limit, and electrocardiographic (ECG) changes consistent with myocardial ischemia or imaging evidence of new loss of viable myocardium (i.e. new perfusion defect) or wall motion abnormality [27].

Although this definition is useful for distinguishing spontaneous coronary events (Type I MI) from events that arise at the time of coronary revascularization (Type 4 and 5 MIs), it does not take into account unique features of perioperative myocardial infarctions after noncardiac operations. First, the majority of coronary events that occur in the post-operative period are clinically silent as a result of sedation and analgesia. In a post-hoc analysis of the POISE trial 65.3% of all patients with an MI did not have any ischemic symptoms [28]. Second, the ECG is insensitive, relative to cardiac troponins, to detect myocardial ischemia in the post-operative period [29]. Finally, after vascular surgery the presence of ischemic ECG changes does not provide additional prognostic information regarding long-term mortality over and above that provided by a single peak troponin I measured within 48 hours after vascular surgery [30].

Our group, and others [31], has shown that cardiac troponins measured after surgery are independent predictors of 30-day and long-term mortality [32] (Figure 4).

Group 0 (blue) normal, Group 1 (red) cTnI > 99th percentile but < 3 URL, Group 2 (orange) cTnI ≥ 3 URL. Adapted from Journal of Vascular Surgery. In Press.

Figure 4. Kaplan-Meier estimates of mortality after vascular surgery relative to peak cardiac troponin I levels within 72 hours post-surgery

Taken together, these observations emphasize the importance of widespread utilization of cardiac troponin in the perioperative period for the surveillance of myocardial infarction and risk-stratification.

5. Treatment

Although robust data from randomized clinical trials is lacking small studies have shown that interventions aimed at improving oxygen delivery and minimizing myocardial oxygen consumption are beneficial in this setting. The main goals of therapy are to prevent, or minimize, wide fluctuations in blood pressure and heart rate through beta-blockade, analgesia, and fluid administration with the intention to preserve optimal coronary perfusion pressure during diastole.

Martinez et al. randomized 80 patients with prolonged (≥ 20 minutes) ischemia after vascular surgery to beta-blockers, aspirin, nitrates and optimization of oxygen supply-demand balance

or control. At 6 months, patients treated for ischemia had lower mortality relative to control patients (8% vs. 20%). In the post-operative period treated patients had lower median troponin values when compared to controls (3.3 ng/ml vs. 8.5 ng/ml) [33].

Anemia is an independent predictor of mortality after non-cardiac surgery in the elderly [34]. Blood transfusion improved survival in critically ill patients with CAD and hemoglobin < 10% [35]. This benefit was not seen among patients without CAD or among patients with a hematocrit > 25% with some studies reporting increased mortality and nosocomial infections associated with blood transfusions in [36].

Cardiac evaluation:

Although there is no consensus in the community with regard to the type (invasive angiography vs. imaging) and timing (in-hospital vs. 4-6 weeks after discharge) of cardiac evaluation after a PMI registry data suggest that only a minority of patients with elevated biomarkers receive cardiac work-up after the event [37].

Given the high-risk of bleeding immediately after non-cardiac surgery the use of emergency coronary angiography and stenting is usually reserved for patients with hemodynamic instability, ST-elevation or inability to control ischemic symptoms with medications. Among patients with coronary stents it is important to consider stent thrombosis in the differential diagnosis if ischemic symptoms develop after non-cardiac surgery, particularly if antiplatelet agents have been prematurely discontinued prior to the operation [38,39]. These patients have a high mortality rate and emergency coronary angiography with revascularization is appropriate.

6. Conclusions

Improving outcomes in this high-risk group of patients undergoing vascular surgery will require a paradigm shift from widespread use of cardiac imaging and procedures in the preoperative phase to rapid detection and management of cardiac complications in the post-operative setting with routine surveillance of cardiac troponins and targeted interventions.

Acknowledgements

Author details

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