perioperative risk, overall morbidity and mortality is not reduced and may be increased.[3]

The perioperative period can be viewed as a stress test, subjecting the body to neuroendocrine, hemodynamic, thermal, and coagulation changes. These stresses are thought to account for most perioperative myocardial infarctions. The preponderance of available data indicates that the postoperative period has the highest incidence of cardiac events.[4,5] Yet, we have invested relatively little effort and resources in postoperative research and management strategies. Therefore, we believe that the potential for novel discoveries and cost-effective therapies may be comparatively greater. One possible approach would use continuous 12-lead electrocardiographic monitoring in at-risk patients during the first 48 h after surgery. Systems are available with central alarm capabilities that can be used on a general surgical floor. Based on recent data showing that ischemia precedes postoperative cardiac events in most patients[4–6] and that there is an apparent threshold of 120 min of postoperative ischemia before development of major morbid events,[5,6] prompt ischemia detection should allow for timely intervention and a reduced incidence of postoperative infarction. Because postoperative ischemia also predicts long-term cardiac morbidity and mortality,[7,8] improved methods for ischemia detection could use the physiologic stress of the perioperative period as a "surgical stress test."

In summary, if we wish to reduce perioperative cardiac complications, we need to develop a comprehensive approach that deploys our resources throughout the perioperative period most effectively. We contend that systematic study and consideration to the relatively unexplored avenues of postoperative management should be made before we make additional and massive investments in approaches that have been in place for decades.

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In Reply:—I generally agree with the comments of Rosenfeld *et al.* and appreciate their clinical efforts to reduce adverse outcome *via* an integrated perioperative approach. They raise a number of specific issues that should be addressed.

There is no question that the development of a paradigm for cost-effective preoperative assessment of high-risk patients undergoing surgery is challenging. No one test can comprehensively model the myriad pathophysiologic changes that can lead to myocardial infarction. Therefore, an optimal paradigm must consider both the chronic and acute disease states of the patient, as well as the anticipated pathophysiologic changes that occur intraoperatively and postoperatively. Development of such a paradigm is possible using large-scale outcome studies that incorporate these physiologic and clinical factors to assess available technologies and routine and specialized testing for both efficacy and cost-effectiveness. However, Rosenfeld *et al.* question even the need for a paradigm. The solution of the problem of perioperative cardiac morbidity requires the development of perioperative monitoring and therapeutic techniques. However, without an appropriate preoperative paradigm, we cannot hope to develop comprehensive and cost-effective solutions for the following reasons:

First, the use of intensive monitoring and aggressive therapy for all 9 million patients at risk in the United States annually (with an additional 9 million throughout the world) is not a practical goal,

the cost incurred would be substantial.[1] Even if the cost per patient of such additional monitoring and therapy were only $500 per day (probably an underestimate), the resultant expense would be $18 billion annually worldwide.[2] Given that such monitoring and therapy may reduce perioperative cardiac morbidity by 50% (probably an overestimate) and that the health-care expenditure associated with perioperative cardiac morbidity is approximately $40 billion annually, at least $18 billion would be expended to save, at most, $20 billion. Perhaps a better approach would be to apply preoperative assessment strategies to identify those patients of the 18 million at highest risk for perioperative ischemia, who, once identified, would become the appropriate subset for intensive monitoring and aggressive therapy. For example, Hollenberg *et al.*[3] have identified five clinical factors that predict patients at highest risk for postoperative ischemia: left ventricular hypertrophy by electrocardiogram, history of hypertension, diabetes mellitus, definite coronary artery disease, and use of digitalis that is, the presence of four or five of these factors is associated with a 77% risk of postoperative ischemia.[3] Given that approximately 10% of the 18 million patients at risk belong to the group at highest risk for postoperative ischemia, applying the Hollenberg risk stratification paradigm will reduce the expenditure by 90%, from $18 billion to $2 billion, which appears to be cost-effective. Additionally, for certain subsets of patients, specialized testing may refine the highest risk subsets, as has been suggested by Eagle *et al.* and others.[1,2,4,5] Accordingly, preoperative stratification is not only useful but also necessary for the development of cost-effective approaches to managing a candidate population of 18 million patients per year.

Second, preoperative assessment may allow identification of patients who will benefit from angioplasty or coronary artery bypass surgery. Although several studies have concluded that mechanical revascularization may not reduce future risk (as suggested by Rosenfeld and colleagues), most studies suggest that successful revascularization reduces perioperative risk for subsequent noncardiac surgery.[1,2,4]

Third, there is no question that false-negative findings are a limitation of virtually all preoperative testing procedures: The occurrence of predictors usually is far greater than the occurrence of outcomes, resulting in universally low positive predictive values for nonroutine specialized testing. All predictors or screening tests have similar positive predictive limitations. For example, angina is a predictor of myocardial infarction; however, of the 5 million patients in the United States who experience angina annually, only 1.5 million have a myocardial infarction. This does not mean that preoperative predictors or screening tests are not useful, but rather, high-risk subsets of patients likely to benefit from such testing must be identified to develop cost-effective strategies.

In conclusion, the development of the optimal preoperative paradigm is difficult but necessary to delineate the highest-risk patient subsets, thereby providing the essential milieu for designing cost-effective diagnostic and therapeutic approaches.

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