# CLINICAL CONCEPTS AND COMMENTARY

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# *Assessment of the Patient with Cardiac Disease*

## *An Anesthesiologist's Paradigm*

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THE stresses associated with surgery are extreme, ubiquitous, and persistent. Not surprising, therefore, is that approximately 5% of the worldwide surgical population—or 5 million patients annually—suffer some form of perioperative cardiac morbidity.[1-3] Identification of this group remains challenging, and even confusing, given the broad spectrum of approaches across institutions. In this brief report, the background of this problem is outlined, and an integrated—albeit personal—paradigm is suggested.

### Brief History of Preoperative Assessment

Perioperative myocardial infarction was identified as an important problem in the early 1950s; however, more than a decade passed before investigators attempted to identify subsets of high-risk patients (table 1).[1] Initially, preoperative risk assessment was based on data derived from the routine history, physical examination, and electrocardiogram—either used as individual risk factors or combined using multivariable analyses ("risk indices").[4-7] Thereafter, it was believed that routine testing was not adequately sensitive, and specialized testing was suggested, including stress electrocardiography, echocardiography, and scintigraphy.[8-11]

Finally, over the past decade, the role of preoperative chronic disease state, and therefore its assessment, was placed in perspective *via* clinical research, which demonstrated that intraoperative and particularly postoperative pathophysiologic changes also contributed to perioperative and long-term adverse cardiovascular outcomes.[12-17] The individual assessment measures and a suggested paradigm are presented in this article.

### Clinical Predictors and Risk Indices

Data obtained from routine testing, including history, physical examination, electrocardiogram, and chest radiograph, are readily available.[2,3] Early investigations identified only two risk factors consistently shown to be associated with adverse outcome: recent myocardial infarction and current congestive heart failure. Other factors, such as age and stable angina, remained controversial.[1] Consequently, a number of investigators suggested various indices derived from combinations of weighted variables.[3-7] Using more specific endpoints, several investigators developed indices specific to postoperative ischemia and 2- and 5-yr survival.[13,16] It now appears that risk indices have refined our approaches to assessment; however, they seem to be best used as initial screening tools within a more comprehensive paradigm, as described here.

#### *Specialized Testing*

Given the limitations of routine testing, specialized preoperative cardiac testing was initially suggested in the 1970s.[8-11] Several hundred studies have attempted to establish its utility; however, results have differed markedly across studies, making interpretation and rec-

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**Table 1. Chronology of the Most Important Findings of Outcome Studies Assessing Perioperative Cardiac Morbidity**

| YEAR | FINDING |
|---|---|
| 1952 | PERIOPERATIVE MI IDENTIFIED AS A PROBLEM |
| 1961-1976 | PREOPERATIVE PREDICTORS STUDIED: RECENT MI ESTABLISHED AS A RISK FACTOR |
| 1977-1982 | MULTIFACTORIAL APPROACH TO IDENTIFY PREOPERATIVE RISK FACTORS |
| 1982-1984 | SPECIALIZED PREOPERATIVE TESTS (EST, RN, DT) RECOMMENDED FOR DETERMINING RISK |
| 1985-1986 | INTRAOPERATIVE (DYNAMIC) RISK FACTORS IDENTIFIED: ECG, TEE ISCHEMIA |
| 1987 | POSTOPERATIVE (DYNAMIC) RISK FACTORS STUDIED |
| 1990 | POSTOPERATIVE ISCHEMIA: PRINCIPAL PREDICTOR OF IN-HOSPITAL OUTCOME |
| 1991 | ROUTINE USE OF DIPYRIDAMOLE THALLIUM SCINTIGRAPHY CHALLENGED |
| 1992 | POSTOPERATIVE ISCHEMIA: PRINCIPAL PREDICTOR OF LONG-TERM SURVIVAL |
| 1995 | β-BLOCKER AND $\alpha_2$ AGONISTS MITIGATE POSTOPERATIVE ISCHEMIA |
| 1996 | PERIOPERATIVE β-BLOCKERS SUBSTANTIALLY IMPROVE LONG-TERM SURVIVAL |
| 1997 | *AMERICAN COLLEGE OF PHYSICIANS–* NEW CLINICAL GUIDELINES MANDATED FOR PERIOPERATIVE β-BLOCKER USE |

MI = myocardial infarction; EST = electrocardiographic stress testing; RN = radionuclear scintigraphy; DT = dipyridamole thallium scintigraphy; ECG = electrocardiography; TEE = transesophageal echocardiography.

ommendation difficult.[1-3] It is now understood that no one test can mimic all stress responses, thereby inherently limiting preoperative testing *per se*. The challenge, then, is to develop a preoperative assessment approach using specific testing tailored to the individual patient undergoing a specific procedure.

### *Exercise Treadmill Testing*

Increases in heart rate are common during and after surgery, with nearly one half of all perioperative ischemic events associated with tachycardia.[1] Thus, use of the exercise treadmill appears reasonable and is supported by several studies demonstrating that a positive ischemic response and low exercise capacity predict outcome following noncardiac surgery.[1-3] For example, early studies indicated that perioperative myocardial infarction occurred in 37% of vascular surgery patients who demonstrated a positive ischemic response, *versus* 1.5% of those who did not.[3] In contrast, however, other studies found that only routine 12-lead resting preoperative electrocardiographic results and the capacity to exercise were independent predictors of perioperative cardiac morbidity, and not any variable related to ischemia.[2,3] These results indicate that exercise tolerance may be more important than the ST response, suggesting that preoperative exercise stress testing should not be performed routinely but should be reserved for patients who satisfy standard medical criteria for specialized testing, such as new, unexplained chest pain.

### *Ambulatory Electrocardiography*

Several studies have suggested an association between ST-segment changes detected during normal daily activities and future cardiac events in patients with stable or unstable angina and prior or recent myocardial infarction.[1] In surgical patients, 18–40% of patients with or at risk for coronary artery disease have frequent ischemic episodes before surgery, with most (> 75%) being clinically silent.[12] Several investigators have suggested an association between these electrocardiographically silent changes with adverse outcome.[18] Others have found that preoperative ST-segment change was a univariate predictor of outcome-for it was outweighed by postoperative phenomena.[12,17] Thus, some controversy exists regarding this technology, and its precise role relative to other diagnostic tests remains undefined.

*Radionuclide Ventriculography*

Initial results in patients undergoing vascular surgery suggested preoperative gated-pooled-determined ejection fraction as an independent predictor of perioperative cardiac morbidity. However, a series of other studies failed to confirm these findings.[1-3] Subsequently, in a study of 457 patients undergoing abdominal aortic surgery,[10] a depressed ejection fraction (50%) predicted postoperative left-ventricular dysfunction, but not other cardiac complications. Thus, quantification of resting ejection fraction using radionuclide ventriculography appears to provide little incremental information beyond routine historical and physical findings, although exercise radionuclide ventriculography does appear to have prognostic value.

*Echocardiography*

Precordial echocardiography has been suggested for identification of high-risk subsets. However, in a study of 334 patients,[14] preoperative transthoracic echocardiography added little incremental information to routine clinical and electrocardiographic data for predicting ischemic outcomes (cardiac death, myocardial infarction, or unstable angina), and its results were only a univariate predictor of congestive heart failure and ventricular tachycardia. In multivariate analysis that included clinical information (*e.g.*, a history of congestive heart failure or coronary artery disease), none of the preoperative echocardiographic measurements were significantly associated with the outcomes of heart failure or ventricular tachycardia. Thus, until subsets of patients who may benefit are identified, the indications for preoperative echocardiography appear to be analogous to those in similar nonsurgical patients: evaluation of ventricular dysfunction, or evaluation of valvular function in patients with a murmur.

Stress echocardiography, on the other hand, may offer unique prognostic information. For example, in 136 patients undergoing vascular surgery, all 15 postoperative complications occurred in the 35 patients who had a positive response on dobutamine stress echocardiogram.[2] Other investigators subsequently confirmed that stress echocardiography using either dobutamine or dipyridamole offered useful prognostic information enabling treatment paradigms.[2,3] Thus, as with other newly introduced tests, these early positive findings using preoperative stress echocardiography in small populations suggest considerable promise, but until appropriate trials are completed, the results must be viewed cautiously.

*Coronary Angiography*

Although previously successful myocardial revascularization appears to reduce risk for subsequent noncardiac surgery,[1-3] the efficacy of performing elective revascularization prior to surgery remains questionable. In fact, the incidence of complications following revascularization often is similar to that associated with the noncardiac surgical procedure. In many cases, therefore, the expected reduction in mortality rate afforded by revascularization is more than offset by the increase associated with the revascularization procedure itself. Routine angiography should be performed not in all high-risk patients undergoing noncardiac surgery, but only in those patients who warrant revascularization for medical reasons, independent of surgery.

*Thallium Scintigraphy*

Among the highest-risk patients undergoing noncardiac surgery are those with exercise limitations, including patients with peripheral vascular, orthopedic, or neurologic disease. As a result, a number of pharmacologic methods to model the effects of exercise have been developed, including those that induce coronary vasodilation (dipyridamole, adenosine) or increase heart rate (dobutamine, arbutamine, cold pressor). The most extensively investigated of these is dipyridamole thallium scintigraphy, with more than 1500 patients studied.[2,3,6-8] In the mid-1980s, the usefulness of scintigraphy was assessed in patients about to undergo vascular surgery. Nearly all perioperative adverse events were found to occur in patients with redistribution defects. Few if any events occurred in patients without preoperative redistribution abnormality (no defect or fixed defect). As a result, widespread use of dipyridamole thallium ensued, adding more than $500 million annually to national healthcare costs.[2,3] However, in the early 1990s, investigators formally challenged these findings in a prospective, triple-blinded study, assessing both adverse outcome and perioperative myocardial ischemia (through continuous electrocardiography and transesophageal echocardiography).[9] In contrast to previous findings,[2,3] no association between redistribution defects and adverse outcomes was found, with the majority of adverse outcomes occurring in patients without redistribution defects; nor was there an association between redistribution defects and perioperative ischemia—the majority of episodes occurred in patients without redistribution defects. These investigators suggested that in addition to coronary redistribution, other phenomena not simulated by dipyridamole might precipitate adverse events following surgery, such as increases in myocardial oxygen demand, atherosclerotic plaque instability, or thrombosis.

As a result of these findings, controversy arose and persisted until a larger scale study was performed in 1994.[10] In a study of 457 consecutive unselected patients undergoing abdominal aortic surgery, these investigators confirmed the early 1990 study,[9] demonstrating that thallium redistribution was not significantly associated with perioperative myocardial infarction, prolonged ischemia, or other adverse events (odds ratio, 1.1; confidence interval, 0.6–2.0; $P > 0.05$). Thus, these latter studies[9,10] suggest avoidance of routine use of thallium scintigraphy.

Since that time, studies have addressed quantification of results, finding improved predictive value if redistribution abnormalities occurred in multiple segments, differing views, or varied coronary artery territories. Similarly, subset identification using combinations of clinical and technical markers also appeared to enhance diagnostic paradigms.[11] Thus, it now is accepted that routine use of dipyridamole thallium in patients undergoing vascular surgery is not warranted. At the extremes of risk (no risk and extremely high risk) dipyridamole thallium scintigraphy does not appear to add significant predictive information. However, moderate-risk subsets, identified using clinical evaluation, may benefit from this technique, especially if scintigraphy is quantitated.

## A Suggested Paradigm for Preoperative Assessment

Based on these clinical research findings and other clinical experience, the following paradigm for preoperative assessment is suggested (fig. 1).

Initially, the presence of coronary artery disease is ascertained through routine testing, primarily history and electrocardiogram. If neither coronary artery disease nor its risk factors are present, then cardiac function is assessed using risk indices or other routinely derived measures. If the patient's functional status† is good, no preoperative cardiovascular testing is warranted and no special therapeutic considerations are necessary. If functional status is poor, despite the absence of cardiac disease or risk factors, then there is no need for preoperative cardiovascular testing, and the therapy should be modified to address other (noncardiac) organ dysfunction.

If coronary artery disease or its risk factors are present, functional status is assessed using any one of a number of measures. If functional status is good, conservative therapy is indicated, although preoperative cardiovascular testing may not be warranted. A conservative approach includes continuation of preoperative cardiovascular medications, intraoperative electrocardiographic monitoring, treatment of hemodynamic abnormalities and ischemic events, and more prolonged monitoring and therapy postoperatively if ischemic events occur. If functional status is equivocal or cannot be determined from history, then the presence of coronary disease or multiple risk factors warrants delay of surgery and performance of nonroutine testing. For patients who can exercise, electrocardiographic treadmill testing is recommended. For patients who cannot exercise, either dipyridamole thallium scintigraphy, stress echocardiography, or ambulatory (Holter) electrocardiography is appropriate. All seem to be equally prognostic. If test results are negative, conservative therapy is used. If test results are mild to moderately positive, aggressive therapy is instituted. An aggressive approach includes delay of surgery and optimization of cardiovascular medication (with addition of medications), intraoperative use of multiple-lead electrocardiography, transesophageal echocardiography, pulmonary artery monitoring (as indicated), and prolonged postoperative hemodynamic and ischemic monitoring over at least 24–48 h. If test results are strongly positive, then very aggressive therapy is performed. This approach includes preoperative delay of surgery with performance of coronary angiography; either aggressive medical therapy, angioplasty, or coronary revascularization; and performance of a lesser surgical procedure followed by prolonged postoperative intensive care monitoring. If the results of the functional assessment demonstrate impaired (moderate-to-severe) functional status, then no additional preoperative cardio-

† Functional status can be ascertained by any of a number of measures. See reference 3.

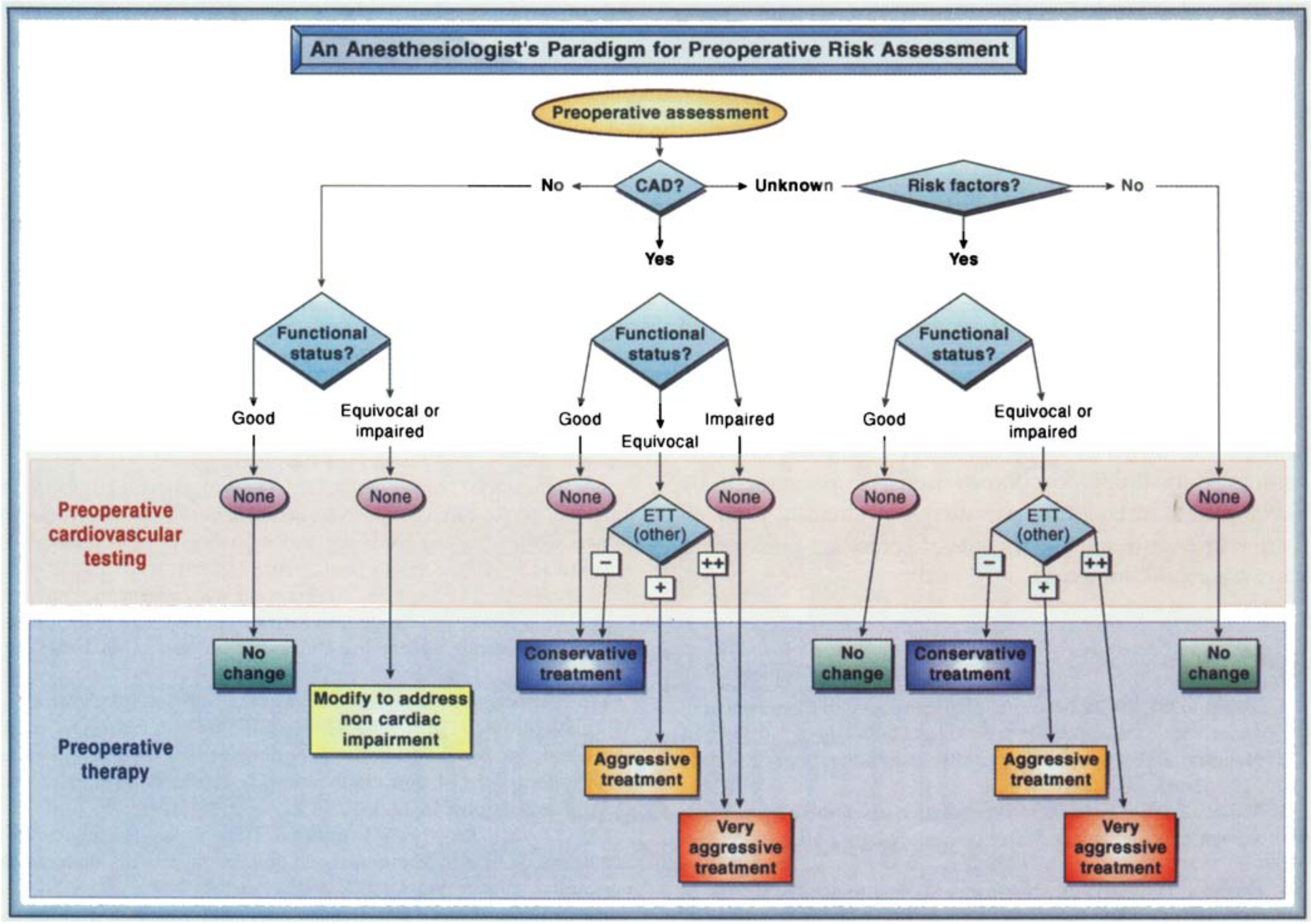


**Fig. 1. Suggested paradigm for selection of preoperative tests and therapy. Key are the presence of coronary artery disease (or risk factors) and the patient's functional capacity. Minus sign = negative result on electrocardiographic treadmill testing (ETT); single plus sign = moderately positive result; double plus sign = strongly positive result; CAD = coronary artery disease; ETT (other) = aside from ETT, another stress test may be substituted such as dipyridamole thallium scintigraphy or stress echocardiography, depending on the ability to exercise, as well as the underlying pathophysiology (stable *vs.* unstable *vs.* rest *vs.* Prinzmetal's angina).**

vascular testing is warranted, and very aggressive therapy is instituted.

If coronary artery disease is not known, and if no risk factors are present, then no preoperative cardiovascular testing is performed and no modification of the therapeutic approach is instituted.

If coronary artery disease is not known and if multiple risk factors are present, then functional status is appraised. If functional status is good, no testing and conservative therapy is recommended. If functional status is impaired or cannot be discerned, nonroutine testing is performed and, if negative, warrants conservative therapy; if positive, testing requires aggressive therapy; and if very positive, it necessitates very aggressive therapy, as outlined previously. Finally, if functional status is poor, no additional nonroutine testing is performed, but either aggressive or very aggressive therapy is indicated, depending on functional status, as described previously.

## Conclusions

Perioperative cardiac morbidity remains a challenging problem. Basic to its solution is the delineation of possible causes. The complex and myriad responses, manifested differently among patients, make comprehensive identification of the at-risk patient difficult. Accordingly, the preoperative testing procedure has inherent limitations. For example, patients with coronary artery disease or risk factors who have a normal or only mildly impaired testing response may develop a serious adverse cardiac outcome as a result of intraoperative and postoperative events. Likewise, patients with a moderately abnormal preoperative test response may undergo a relatively benign intraoperative and postoperative course and develop no adverse cardiac events.

To address this conundrum, a paradigm has been suggested, using diagnostic and therapeutic approaches based on clinical screening for disease state and functional capacity. Specialized (and costly) testing is used conservatively, that is, only if it is clear that the additional information provided by the proposed test will likely have an impact on outcome.

Finally, the anesthesiologist must recognize her or his unique experience and skill in caring for the patient undergoing surgery. Thus, the anesthesiologist must assume responsibility for comprehensive assessment by developing and enacting paradigms, evaluating their effectiveness, and seizing the opportunity to be the primary medical caregiver.

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