JACC Vol. 14, No. 4
October 1989:1016–42

TASK FORCES

Task Force I: Determination of Prognosis in Patients With Ischemic Heart Disease

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I. Introduction

This report summarizes information regarding morbidity and mortality in ischemic heart disease as it relates to insurability and employability. *Insurability* requires the assessment and evaluation of risks that may relate to life, disability and health. *Employability* should consider three aspects: 1) the capability of the individual to perform the job, 2) the risk to the individual of performing the job, and 3) the risk to society if the individual is performing the job.

This report focuses primarily on the assessment of risk of patients with chronic ischemic heart disease, including definite or probable angina pectoris, previous myocardial infarction, cardiac arrest or documented significant coronary artery obstruction. It focuses primarily on chronic disease outcomes and does not address the early prognosis of patients presenting with acute myocardial infarction. In addition, the risk to society posed by ischemic heart disease events occurring on the job is considered for individuals without manifestations of coronary artery disease. Prognostic risk focuses primarily on survival, but also encompasses subsequent myocardial infarction. The effects of specific therapies on prognosis and changes in the natural history of the disease are also considered.

II. Sources of Information

Three types of studies that have recently been extensively reviewed (1) concern prognosis in patients with ischemic heart disease: 1) U.S. population statistics, 2) cohort or observational studies, and 3) randomized clinical trials.

U.S. population statistics. These data, obtained from national surveys, census figures and publications from the American Heart Association (2–5), provide limited information for the evaluation of specific individuals, and there are hazards in extrapolating results from specific studies to national statistics (6–8).

Cohort or observation studies. These studies define the population through community or regional surveillance. Findings from these studies can be extrapolated to the U.S. population because the study population is generally representative of the U.S. population as a whole. The findings from several large studies (the Framingham Study, Tecumseh Study, Chicago Peoples Gas Company Study, Minneapolis Professional and Business Men, U.S. Railroad Workers studies and the Chicago Western Electric Company study) largely agree with each other. The risk of developing coronary heart disease among asymptomatic individuals as it relates to the initial assessment has been defined by these studies. Estimates from the Framingham Study form the basis of the Coronary Risk Handbook (9).

Most of the detailed information regarding the assessment of risk of individual patients with manifest ischemic heart disease is derived from specific cohort studies of individuals with the disease. In general, these studies provide the most detailed assessment of the importance of characteristics influencing prognosis but suffer from the selection bias introduced from the enrollment process and criterion selection. The Coronary Artery Surgery Study (CASS) trial included a large collaborative patient registry of all individuals catheterized at participating centers (10). Collaborative registries of patients with acute myocardial infarction include the Myocardial Infarction Limitation of Size (MILIS) Study (11), the Multicenter Postinfarction Trial (MPIT) (12) and those coordinated at San Diego (13) and Stanford (14); however, this report focuses primarily on nonacute disease.

Voluntary collaborative registries include the National Heart, Lung, and Blood Institute-Percutaneous Transluminal Coronary Angioplasty (PTCA) registry of patients undergoing percutaneous transluminal coronary angioplasty (15). There are large regionally-based databases describing complete assessment and outcome of patients undergoing cardiac catheterization or other specific procedures at one or more institutions. These include the Duke Database for Cardiovascular Disease (16), the Seattle Heart Watch Study (17), the Cleveland Clinic Registry (18), the University of Alabama Registry (19) and the Emory University Registry (20). Prognostic studies of specific groups of patients undergoing tests or procedures include those from Cedars-Sinai Hospital (21).

Randomized controlled trials. These trials have evaluated not only the outcome of coronary bypass surgery and medical

0735-1097/89/$3.50

Table 1. Prognostic Characteristics From the Initial Assessment

Characteristics	Analysis	
	Univariate	Multivariate
Age	CA, CL, D, I, S	CA, D, S
Gender	CA, D, I	CA, D
Risk factors		
Smoking	CA, CL, D, I	CA
Hypercholesterolemia	D, I	
Hypertension	CA, CL, D, I, S, V	CA, CL, V
Diabetes	CL, D, S	CL
Symptoms		
Pain type	D, S	D
Duration	CL, D, S	CL
Course	CA, CL, D, V	CA, D, V
Nocturnal	D	
Frequency	D, S	S
Myocardial damage		
Congestive heart failure or class	CA, CL, D, S	CL, D, S
ST-T wave changes	CL, D, S, V	CL, D, S, V
Ventricular gallop	D, S	D
Cardiomegaly	CA, CL, D, S	CA, D, S
Premature ventricular complexes	D, S	D
History of myocardial infarction	CA, D, V	D, V
Q waves on electrocardiogram	CL, D, S	CL, D
Digitalis use	CA, S	
Diuretic use	CA, S	
Rales	D, S	
Heart murmur	D, S	
Left ventricular hypertrophy	CL, D, S	CL, S
Conduction abnormalities	CL, D, S	CL, D
Peripheral vascular disease	CL, D, E, S	CL, D

CA = Coronary Artery Surgery Study Trial and Registry (10,94–98); CL = Cleveland Clinic Registry (18,103); D = Duke University Database (16,99–101); E = European Coronary Surgery Study (90–93); I = Life Insurance Studies (1,104); S = Seattle Heart Center Watch Registry (17,22,102); V = Veterans Administration Cooperative Trial (87–89).

therapy but also changes in the natural history of ischemic heart disease. Assessments of prognosis provided by these studies are limited by selection bias introduced by who is enrolled in the trial and difficulties in generalizing beyond these subjects of patients. This report summarizes the three largest trials in patients with stable angina: the Veterans Administration Cooperative Trial, the European Coronary Surgery Study and the Coronary Artery Surgery Study.

III. Characterization of Prognosis

A. Prognostic Characteristics From the Initial Assessment

Table 1 shows significant prognostic variables from the initial assessment that have been found to be important in at least two of the seven major studies. Where the relation has been examined for the characteristic alone and found to be significant, an appropriate notation has been made in the univariate column. Where multivariate analyses have been performed including at least several of the characteristics (uncommon for the randomized clinical trials) and the characteristics have remained important, an appropriate notation has been made in the multivariate column. The prognostic evaluation of a patient with coronary artery disease begins with the physician's initial assessment. Decisions to perform noninvasive testing or cardiac catheterization should be considered in light of what these tests add to the physician's initial assessment.

Clinical perspective versus life insurance perspective on prognosis. Many different characteristics from the physician's initial assessment can be used to predict survival. Their importance as they relate to prognosis depends in part on how an individual's prognosis is considered. The prognostic risk from a life insurance perspective compares the risk of an individual with coronary artery disease with that which would be expected for an individual of similar age and gender. Clinicians generally consider the prognosis from the perspective of the importance of individual characteristics among patients with established disease. This difference in perspective regarding prognosis influences the importance assigned to characteristics from the initial assessment.

Factors affecting prognosis. Among patients with established coronary artery disease, clinical prognosis worsens with age. However, when considered from a life insurance perspective, the relation reverses (relative mortality in ischemic heart disease patients is considerably higher in younger than in older age groups) because the assigned risk of the individual with coronary artery disease is related to the expected risk in a comparable healthy population. Consequently, age is an important prognostic characteristic and of fundamental importance when considered from the life insurance perspective.

Other important prognostic characteristics from the initial assessment include the patient's gender, risk factors, symptoms, evidence of myocardial damage and evidence of associated vascular disease. The importance of gender is marginal in patients with established disease, although this characteristic is very important in operative mortality with coronary artery bypass grafting, most likely related to the smaller size of coronary vessels in women. Risk factors are particularly important in relation to the risk of development of coronary artery disease, but their contribution to prognosis is less important among patients with established disease (16,22). When examined by themselves, they clearly identify subgroups at higher risk, but when considered in conjunction with other characteristics, their contribution is less important. Similarly, psychological constructs such as the type A personality appear to be important in the development of the disease, but evidence of their importance as independent prognostic variables is not convincing.

The presence of significant myocardial damage has been found in all studies to be an important predictor of outcome.

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Table 2. Prognostic Characteristics: Treadmill Exercise Testing

Characteristic	Studies (reference no.)		
	Univariate Analysis	Multivariate Analysis	Add to Cardiac Catheterization
ST segment change	23, 24, 27, 105–111	23, 94, 105	105
Treadmill angina	23, 24, 105–107	105	105
Treadmill time or stage	23, 94, 105, 107, 109–112	94, 105, 107, 113	94, 105, 113
Maximal heart rate	23, 94, 105, 111, 114	23, 94	94
Ventricular arrhythmias	23, 105, 115, 116	23	—
Anginal heart rate	117	—	—
Exertional hypotension	24, 118	—	—

In essence, this characteristic reflects the presence and extent of previous myocardial infarction and is often associated with symptoms of congestive heart failure.

Anginal symptoms identify individuals with myocardium at risk, and their tempo reflects the severity of the risk. Longstanding angina reflects longstanding coronary artery disease and, because the disease is progressive in nature, suggests a worsening anatomic severity.

B. Prognostic Characteristics Elicited by Noninvasive Testing

Noninvasive testing has been able to identify high and low risk subgroups of patients with chronic coronary artery disease. In general, studies are relatively small in size and, to provide sufficient events, have often combined end points to include not only death but also myocardial infarction and coronary artery bypass grafting.

The treadmill exercise test. This test has been the most carefully studied and excellent reviews are available (23–26). The studies cited in Table 2 indicate that among the many exercise variables evaluated, the most important prognostic indicators are maximal exercise capacity, increases in systolic blood pressure, and ST segment displacement (depression and elevation) (27). Although uncommon, exertional hypotension and ventricular tachycardia also identify a high risk subgroup of patients. The magnitude of the additional prognostic information provided by exercise testing is considerable in relation to the initial assessment and comparatively modest where catheterization has been performed (28,29).

Nuclear studies. Important prognostic characteristics obtained with radionuclide angiography and with thallium scintigraphy are shown in Tables 3 and 4, respectively. The radionuclide exercise ejection fraction appears to be the most important prognostic variable. In patients with a normal rest ejection fraction, the change in ejection fraction with exercise and the peak exercise ejection fraction provide virtually identical prognostic information. Perfusion defects in the distribution of two or more coronary arteries, and perhaps the quantitative estimate of the magnitude of hypoperfusion or the uptake of thallium in the lung appear to be the most important thallium prognostic variables. The contributions of radionuclide angiography and thallium scintigraphy to prognostic assessment are similar.

Ambulatory electrocardiography. This has also been performed in large series of patients with acute myocardial infarction and chronic angina. In patients with acute myocardial infarction, two large observational studies (11,12) have shown that frequent premature ventricular complexes on a predischarge 24 h ambulatory ECG are predictive of impaired prognosis independently of left ventricular function. Similar observations have been made in patients with

Table 3. Prognostic Characteristics: Radionuclide Angiography

Characteristic	Studies (reference no.)	
	Univariate Analysis	Multivariate Analysis
Exercise ejection fraction	119, 120	120
Change in ejection fraction	121	
Rest ejection fraction	119–121	119
Angina		
ECG changes		
Wall motion abnormalities	120	
Exercise time	120	
Rest end-diastolic volume	119	

Table 4. Prognostic Characteristics: Thallium Scintigraphy

Characteristic	Studies (reference no.)	
	Univariate Analysis	Multivariate Analysis
Transient defects	21, 122–124	21, 122, 124
Total or fixed defects	21, 122, 125	123
Degree of hypoperfusion	21	21
Lung thallium uptake	126	126
Exercise ST changes	124, 126	124, 126
Heart rate changes	124	124
Exercise ventricular arrhythmia	124	

Table 5. Prognostic Characteristics: Cardiac Catheterization

	Studies	
	Univariate Analysis	Multivariate Analysis
Ventricular function		
Ejection fraction	CA, D, I, S	CA, D, S
LV score or wall motion abnormalities	CA, CL, D, S	CA, CL, D
Anatomy		
Left main disease	CA, D, I, V	CA, D, V
Number of diseased vessels	CA, CL, D, E, I, S, V	CA, CL, D, S
Proximal LAD	CA, D, S	CA, D
Other proximal disease or jeopardy score	CA, D	CA, D
Mitral regurgitation	CA, D, S	CA, D, S
LVEDP	CL, D, S	CL, D, S

CA = CASS Trial and Registry (10,94–98); CL = Cleveland Clinic Registry (18,103); D = Duke University Database (16,99–101); E = European Coronary Surgery Study (90–93); I = Life Insurance studies (1, 104); LAD = Left anterior descending coronary artery; LV = Left ventricular coronary artery; LVEDP = Left ventricular end-diastolic pressure; S = Seattle Heart Center Watch Registry (17, 22, 102); V = VA Trial (87–89).

congestive heart failure (30), but this relation has not been found in patients with angina requiring cardiac catheterization (31). Premature ventricular complexes occur more frequently in patients with reduced left ventricular function, and their prognostic information overlaps with measurements of left ventricular function (31). Evidence of silent ischemia has also been shown to be related to prognosis, although the data are not fully developed.

Exercise echocardiography. This study may also identify patients with a poor prognosis through assessment of wall motion changes, however, the data are not fully developed.

C. Prognostic Characteristics From the Cardiac Catheterization

Prognostically important characteristics from cardiac catheterization are shown in Table 5. Information from the physician's initial assessment and cardiac catheterization is shown in Table 6.

The prognostically most important characteristics from the catheterization reflect left ventricular function and coronary anatomy. Left ventricular function is usually expressed as the ejection fraction. Anatomic characteristics reflecting myocardial jeopardy include the degree of left main stenosis, the number of significantly diseased major coronary vessels and the presence of proximal disease in the major coronary arteries, particularly of the left anterior descending coronary artery. The severity of mitral regurgitation and elevated left ventricular end-diastolic pressure are also prognostically important.

Important characteristics from the initial assessment combined with the cardiac catheterization are shown in Table 6. The most important predictors of survival are left ventricular function and coronary anatomy. Patients with unstable angina or poor left ventricular function and severe congestive heart failure have an especially unfavorable prognosis. The presence of other vascular disease, mitral regurgitation and age have also been found to be significant predictors of outcome when considered with information from cardiac catheterization. When examined by themselves, risk factors clearly identify subgroups at higher risk but when considered in conjunction with the characteristics shown in Table 6, their contribution is less important. The importance of gender is marginal in patients with established disease.

Prognostic estimates are most discriminating when all characteristics are considered. For example, consider the prognosis of two patients with three vessel disease and a normal ejection fraction. One is 64, has frequent angina, resting ST depression, peripheral vascular disease, previous myocardial infarction, an ejection fraction of 51% and a 95%

Table 6. Summary of Important Prognostic Characteristics: Initial Assessment and Catheterization

	Studies	
	Univariate Analysis	Multivariate Analysis
Age	CA, CL, D, I, S	CA, CL, D, S
Gender	CA, D, I	CA, D
Risk factors	CA, CL, D, I, S, V	CA, CL, V
Symptoms	CA, CL, D, S, V	CA, CL, D, S, V
Myocardial damage	All	All
Vascular disease	CA, CL, D, E, S	CA, CL, D, E
Conduction abnormalities	CL, D, S	CL, D, S
Anatomy	All	All
LV function	CA, CL, D, I, S, V	CA, CL, D, S, V
Mitral regurgitation	CA, D, S	D, S

CA = Coronary Artery Surgery Study Trial and Registry (10,94–98); CL = Cleveland Clinic Registry (18,103); D = Duke University Database (16, 99–101); E = European Coronary Surgery Study (90–93); I = Life Insurance studies (1,104); LV = left ventricular; S = Seattle Heart Center Watch Registry (17,22,102); V = Veterans Administration Trial (87–89).

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proximal left anterior descending coronary artery lesion. The other is 51, has infrequent angina, no peripheral vascular disease or previous myocardial infarction, an ejection fraction of 64% and a distal 75% left anterior descending coronary artery lesion. Expected survival on medical therapy is quite different. Five year estimates from the Duke Database (32) are 42% for the first patient and 92% for the second.

IV. Effects of Therapy on Prognosis

Studies of prognosis in ischemic heart disease must consider the ameliorating effects of therapy, including medical therapy, coronary artery bypass grafting, coronary angioplasty and changes over time in the natural history of the disease.

A. Medical Therapy

The influence of risk factor modification and drug therapy on the prognosis of patients with established disease has been reviewed (1,33). In general, serum cholesterol, hypertension and particularly smoking behavior worsen the prognosis of patients with manifest ischemic heart disease. However, the influence of these characteristics on *recurrent* cardiac events is modest compared with their influence on the incidence of *initial* coronary events (34–41). Although therapy directed at modifying these risk factors remains a prudent recommendation, definitive demonstration of substantially improved survival with risk factor modification in patients with chronic stable angina is limited (40).

Trials of drug therapy in modifying medical prognosis have been largely limited to patients with acute myocardial infarction or unstable angina. Evidence for an improved outcome, due to beta-blocker therapy, is more convincing after acute myocardial infarction (42–44) than in chronic angina (26,45,46). Two studies (47,48) have shown dramatic benefit of aspirin therapy in patients hospitalized with unstable angina. Some benefit for calcium channel blocker therapy may also be present (49). Vasodilator therapy may also improve survival in patients with congestive heart failure including some patients with coronary artery disease (50,51). The evidence for the use of antiarrhythmic therapy is controversial.

B. Coronary Artery Bypass Graft Surgery

The value of surgery in modifying prognosis has been excellently reviewed (1,52–54). In general, the magnitude of the improvement in prognosis is greatest in patients with anatomically extensive disease (left main disease and three vessel disease) or high risk based on clinical evaluation. Improvement is sustained in the first 7 to 8 years after surgery, diminishing thereafter as grafts become occluded (55,56,57). The influence of repeat bypass grafting on prognosis is unknown at present. The improved patency of internal mammary artery grafting compared with saphenous vein bypass procedures may improve or extend survival benefits with surgery (58,59).

Primary characteristics influencing operative mortality include age, body size (identified by gender in many studies), hypertension, prior coronary artery bypass grafting, history of smoking, left ventricular function, extent of anatomical disease, the presence of unstable angina or recent myocardial infarction, cerebral or peripheral vascular disease, and renal or pulmonary dysfunction (60–62) (Hammermeister KE. Seattle Heart Watch 1988 [personal communication]. Pryor DB. Duke Database 1988 [personal communication]). Long-term outcome after coronary artery bypass grafting is influenced by the same characteristics that define the risk in medically-treated patients except that coronary anatomy is much less important.

C. Coronary Angioplasty

The value of angioplasty in modifying prognosis in patients with coronary artery disease is unknown (63,64). The major limitation with respect to long-term prognosis appears to be restenosis occurring within 6 months in approximately one-third of treated patients (65,66).

D. Changes in the Natural History of Ischemic Heart Disease

There is overwhelming evidence that the natural history of coronary artery disease in the United States is improving over time. A recent comprehensive review describes a 42% decline in the age-adjusted mortality rates in the U.S. population between 1963 and 1985 (67). Outcomes have improved for patients with acute myocardial infarction (34,68) and those undergoing coronary artery bypass surgery (69). Improvements for patients with chronic stable angina treated medically are more modest (34,69,70).

V. Consideration of Occupations Posing a Risk to Society

Clinicians are frequently asked to "certify" that it is appropriate for an individual with ischemic heart disease to return to work. Such decisions are especially important in public safety officers, firefighters, pilots, critical process operators (e.g., nuclear power plant operators) and professional drivers. A significant cardiac event such as cardiac arrest or myocardial infarction occurring at a "critical" time in such occupations may adversely affect not only the individual but also the public or coworkers. In "certifying" whether it is appropriate for such individuals to work, the physician should consider not only the risk to the individual, but also the risk to society.

Prognostic concerns about coronary heart disease have led to the mandatory retirement of individuals with demonstrated disease, as well as individuals without manifest disease. These two groups will be considered separately with respect to both the risk to the individual and the risk to society.

A. Asymptomatic Individuals Without Manifest Coronary Disease

In general, there is no convincing evidence that employment in a specific occupation worsens an individual's risk for the occurrence of a cardiac event. A possible exception is firefighting, which entails bursts of heavy physical activity and exposure to heat and psychological stress. The risk of cardiac events in individuals without manifest coronary disease can be estimated with use of standard risk factor equations such as the Coronary Risk Handbook (9) based on the Framingham Study.

Epidemiologic studies suggest that habitual physical exercise may offer some protection against primary or secondary events of coronary heart disease and associated mortality but "falls short of proving" (71) this. The evidence also suggests that the effect of exercise training is outweighed by the other risk factors. There has also been some demonstration that emotional stress and sudden bursts of activity may increase the risk of sudden death, particularly in sedentary individuals (72,73).

Risk factor profiling using techniques such as the Coronary Risk Handbook are accurate and well substantiated. Screening programs to detect individuals without manifest coronary disease should consider such strategies rather than relying solely on individual characteristics such as age, gender, smoking, and others. Exercise testing can further improve the identification of individuals with one or more risk factors (74–77) and can be applied economically to specific occupations (78). In some cases, such as for airline pilots, it may be appropriate to consider further evaluation with radionuclide procedures or coronary angiography, or both, for individuals at increased risk (79–84).

B. Symptomatic Individuals

Whether it is appropriate for symptomatic individuals to return to occupations posing a risk to the public is often difficult to determine. From a prognostic standpoint, the goal is to determine whether the job is likely to place the individual under a stress that would otherwise be unlikely to occur. However, it is difficult to duplicate or simulate on-the-job conditions, such as those encountered in firefighting (85,86), in a standard ECG stress laboratory.

The decision should also consider the status of the patient's disease. The risk of death or infarction is substantially higher in individuals with manifest or symptomatic coronary disease than in those without manifest disease. The prognostic value of silent ischemia, defined as ST segment depression without chest pain, in patients without manifest coronary artery disease is unknown. For certain groups of patients, such as those with unstable angina, return to work is clearly inappropriate in a setting where the occurrence of a significant cardiac event would place the public at risk. In contrast, individuals without clinical or angiographic evidence of myocardial ischemia after coronary artery bypass grafting have an excellent prognosis (82).

Table 7. Prognostic Characteristics Classified by Pathophysiologic Construct and Weighted According to Power in Predicting Prognosis for Patients With Manifest Coronary Artery Disease

Pathophysiologic Construct	Weight
Myocardial function	
Congestive heart failure	++++
Functional class	+++
Diuretic use	++
Digitalis use	++
Cardiomegaly	+++
S_3 gallop	+++
Prior myocardial infarction	++
Exercise systolic pressure	+++
Exercise capacity	++++
Ventricular arrhythmias	++
Ejection fraction	++++
Wall motion score or assessment	++++
Left ventricular end-diastolic pressure	++
Myocardial jeopardy	
Angina frequency	+
Duration of angina	+
Level of exercise inducing ischemia	+++
Degree of exercise induced ST segment depression	+++
Exercise systolic pressure	+++
Presence and extent of reversible thallium uptake	+++
Number and distribution of coronary vessels with obstruction	+++
Myocardial ischemia	
Rest or nocturnal angina	+++
Progressive angina	++
Unstable angina	+++
Failure of angina to respond to nitroglycerin	++
ST segment depression on rest ECG	+++

VI. Conclusions

1. Variables from the clinical assessment, noninvasive tests and cardiac catheterization that are important for estimating prognosis include descriptors of myocardial function, myocardial jeopardy and myocardial ischemia (Table 7).

2. Prognosis can be estimated from the clinical examination (history, physical examination, ECG, chest roentgenogram) combined when indicated with one or more noninvasive studies (e.g., exercise test, radionuclide angiography, myocardial imaging or echocardiography) and does not usually require cardiac catheterization except when dictated by regulations or recommendations.

3. Most occupations do not increase the risk of coronary events. In patients with manifest coronary disease, continued employment should be permitted when patients are functionally able to perform the job.

4. Prognosis should be estimated for occupations in which sudden disability might endanger others. For patients with manifest disease, this evaluation should occur at yearly intervals, or more frequently if required by regulation or recommendation. The cost effectiveness of these approaches needs to be evaluated.

5. Prognosis should also be estimated for patients in occupations requiring sudden or sustained high level physical effort or exposure to extremes of hot or cold or to hypoxia, hypercarbia, carbon monoxide or stimuli producing sudden bursts of autonomic activity.

6. Prognosis need not be estimated for individuals without manifest coronary disease, except perhaps for those with occupations in which sudden disability might endanger others. In the latter group, noninvasive assessment may be of value. In some instances, cardiac catheterization may be required to satisfy regulations or recommendations.

7. Although the advisability of return to full-time work of individuals with manifest coronary disease can usually be established a priori, a trial work period may sometimes be necessary.

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Task Force II: Determination of Occupational Working Capacity in Patients With Ischemic Heart Disease

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Introduction

The physical, metabolic and cardiovascular demands of occupations in industrialized countries have substantially declined during the past century. Many jobs that once required substantial physical effort are now performed by machines, robots or computers. This decrease in job-related energy demand is especially apparent in occupations performed by people over age 40, who, given some seniority, rarely perform physical tasks exceeding a peak energy expenditure of 5 kcal/min or 3.5 METs, where 1 MET = energy expenditure sitting at rest (1). Nonetheless, the physical stress of employment is still the greatest challenge to the cardiovascular system of many patients with ischemic heart disease.

For many sedentary jobs posing limited psychological or environmental demands, the adequacy of the patient's physical working capacity can be assessed by a medical history, physical examination and symptom-limited exercise testing. However, as the physical demands of the job tasks increase to include exercise of widely varying intensities and types, or substantial psychological or environmental stress, assessment of physical working capacity becomes more complex.

In patients with ischemic heart disease, the focus of occupational work evaluation is to determine whether or not the increase in cardiac demands produced by physical, psychological and environmental stressors will exceed the threshold for a "safe working capacity." The challenge to the physician is to obtain an accurate, valid and reliable determination of this capacity.

Factors Influencing Metabolic and Cardiovascular Demands During Work

Physical exertion increases metabolic and cardiac demands roughly in proportion to the absolute intensity of the exertion. The magnitude of effort required for a particular task by an individual is related to the individual's physical working capacity. Therefore, the metabolic and cardiac demands on an individual are related to characteristics of the task, such as the work intensity, type of work, size of muscle mass involved, work-rest cycle and environmental conditions as well as characteristics of the patient including cardiovascular function, skeletal muscle training and psychological factors (2).

1. Types of Exercise Encountered in Occupational Tasks

Occupational tasks require different types of exertion, performed singly and in combination, and vary in the number and mass of muscle groups involved. The major types of exercise usually performed are *dynamic* (isotonic) and *static* (isometric), or a combination of both dynamic and static exertion.