Optimal Risk Factor Management in the Patient After Coronary Revascularization

A Statement for Healthcare Professionals
From an American Heart Association Writing Group

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Revascularization with coronary artery bypass graft surgery (CABG) and percutaneous transluminal coronary angioplasty (PTCA) is well accepted as a method of relieving anginal pain and thus improving quality of life. In addition, CABG has been shown to improve survival in certain subgroups of patients with coronary disease, which has led to the widespread use of this procedure in revascularization. In 1991 407 000 bypasses and 303 000 PTCA procedures were performed.1 Currently, coronary atherectomy, various laser techniques, and coronary stents are being evaluated as additional approaches to revascularization.

While often effective, there is the risk of complications with CABG and PTCA. These procedures are also costly because they require skilled personnel, sophisticated equipment, and hospitalization. Thus, the probability of long-term success should be optimized for maximum patient benefit and the best use of healthcare resources. Short- and long-term failure rates for these procedures have been defined. Approximately 10% to 20% of CABG procedures in the United States are performed in patients who had previously undergone this procedure, in large part because of the closure of bypass grafts from thrombosis and accelerated atherosclerosis. Restenosis rates for PTCA and atherectomy at 6 months are about 40%.2,3 The patient who undergoes revascularization probably has atherosclerotic disease in other coronary arteries and other vascular beds (eg, cerebrovascular and peripheral arteries).

The renewed interest in preventive interventions in patients undergoing revascularization is derived from a variety of sources, including improved understanding of the role of risk factors in atherosclerotic and thrombotic diseases, results of clinical observations documenting the role of these risk factors in revascularization failure, the results of clinical trials that specifically tested the ability to prevent disease progression and recurrence, and evidence that such interventions are cost-effective and sometimes cost-reducing. This report summarizes these scientific data and makes recommendations for the assessment and treatment of risk factors following CABG, PTCA, and other revascularization procedures.

Can Atherosclerotic Progression and Its Complications Be Prevented After Revascularization?

Overview of the Pathogenesis of Bypass Graft Closure and Post-PTCA Restenosis

Saphenous Vein Bypass Graft Disease

Vein graft disease can be divided into three phases:

- An early (within 1 month) postoperative phase caused by technical factors and superimposed thrombotic occlusion.
- An intermediate phase (within the first postoperative year) characterized by intimal hyperplasia, resulting in narrowing of the graft lumen, which may also promote thrombosis.
- A late phase (after the first postoperative year) related to graft atherosclerosis and superimposed thrombosis similar to that affecting native coronary arteries.

Occlusion rates of 5% to 15% per distal anastomosis at 1 month after surgery and 15% to 25% at 12 months have been reported.5-7 At the end of 10 years up to 50% of vein grafts will become occluded.8

Post-PTCA Restenosis

Although the success rate of PTCA for dilating arterial stenoses is high, restenosis occurs in 40% to 60% of vessels, most frequently within the first 6 months after the procedure.9 Restenosis is incompletely understood but appears to involve at least three processes: (1) a phenomenon of recoil, (2) mural thrombosis organized by connective tissue, and (3) intimal hyperplasia as a response to the injury perpetuated until endothelialization takes place. The occurrence of restenosis has not been reduced by the substitution of lasers or atherectomy devices for angioplasty2,3,10,11 nor by the neutralization of growth factors, which appear to be responsible for smooth muscle cell proliferation.12 The possibility of reducing

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restenosis by using stents or by opening the artery as much as possible (maximum luminal gain aiming at less relative loss) is now being investigated. Early acute closure (within 24 hours of PTCA) is primarily mediated through thrombosis and is decreased by administration of aspirin and heparin. However, long-term administration of aspirin is not effective in preventing later restenosis.13

Thus, the role of thrombosis and progression of atherosclerosis through smooth muscle cell hyperplasia are thought to be particularly important in saphenous vein bypass grafts and post-PTCA arteries. The next section discusses the ability to modify these processes, thus preventing clinical events.

**Prevention of Early Thrombosis in Saphenous Vein Bypass Grafts**

The importance of platelets in the pathogenesis of thrombosis following vein grafting or PTCA suggests that antiplatelet agents should inhibit early thrombotic graft occlusion of saphenous vein bypass grafts and post-PTCA coronary arteries. It should also decrease the frequency of late vein graft occlusive events related to thrombosis superimposed on intimal hyperplasia that occurs in the first postoperative year or on the atherosclerosis that occurs later. Studies of saphenous vein bypass grafts have demonstrated the importance of initiating platelet inhibitor therapy in the perioperative period, preferably before but not later than 48 hours after surgery.14,19 When therapy was started more than 48 hours after surgery, no reduction in the vein graft occlusion rate was observed. Recent studies from the Veterans Administration7 suggest that one dose of aspirin daily is as effective as aspirin given three times daily in reducing vein graft closure. In fact, 100 mg aspirin daily was as effective as higher doses.20 Preoperative administration of aspirin was associated with increased bleeding complications and no additional benefit in early vein graft patency when compared with aspirin started 6 hours after surgery.21

Trials comparing aspirin with aspirin plus dipyridamole have not shown an additional benefit of the latter.22,23 Likewise, there is only a statistically nonsignificant trend toward improved graft patency rate with sulfipyrazone. Ticlopidine (250 mg twice daily) may also reduce the incidence of vein graft occlusion but may have additional side effects.24 Ticlopidine may be useful for patients who are allergic to aspirin. Heparin and oral anticoagulants have some benefits for prevention of graft occlusion, but perioperative use of these agents may be undesirable because of the risk of bleeding during surgery.21 On occasion, a small percentage of people can develop neutropenia.

**Prevention of Early Thrombosis in Coronary Arteries After PTCA**

Thrombosis likely plays a major role among the multifactorial pathophysiological processes accounting for early occlusion after PTCA. Accordingly, in three prospective,13,25,26 and two retrospective27,28 angiographic studies, pretreatment with aspirin alone,13,27,28 aspirin plus dipyridamole,25,27,28 or ticlopidine alone25 significantly reduced the incidence of acute thrombotic occlusion and periprocedural Q-wave infarction in patients who underwent coronary angioplasty. A recent prospective study29 indicated that aspirin alone was as effective as the combination of aspirin and dipyridamole in reducing acute thrombotic occlusion. Importantly, in most studies heparin was used with the platelet inhibitors mentioned above.

**Prevention of Late Bypass Graft Closure and Post-PTCA Restenosis**

Internal mammary arteries used as vascular conduits have patency rates of approximately 90% at 10 years, which is considerably greater than those of vein grafts. Because of this high patency rate, it is difficult to demonstrate that interventions have an additional beneficial effect on internal mammary grafts.30 However, most patients receive saphenous vein grafts in addition to an internal mammary graft and thus still benefit from early institution of aspirin, smoking cessation, and treatment of lipid abnormalities.

Additional interventions may be effective when antiplatelet therapy with aspirin is started early after surgery and continued for at least 1 year afterward to improve graft patency. There is substantial evidence that the vein grafts are deleteriously affected by cigarette smoking. The frequency of graft atherosclerosis is increased in smokers31 with a significant association between smoking after the first operation and graft thrombosis as well.32 Vein graft stenosis and occlusion are related to levels of low-density lipoprotein (LDL) cholesterol and lipoprotein(a) and inversely related to levels of high-density lipoprotein (HDL) cholesterol.8,32,33 In patients with dyslipidemia, treatment with colesterol and niacin improves venous graft patency and lessens progression of native vessel disease.34

No intervention has been proven to be beneficial in avoiding post-PTCA restenosis. Evidence of the effectiveness of fish oil started 1 week before PTCA is conflicting.35 Restenosis may occur more frequently in patients with low HDL cholesterol,36,37 which suggests that lipid abnormalities may play a role in restenosis. Whether lipid-modifying drugs after restenosis is controversial.38,39 The literature on the effect of smoking on the outcome of PTCA is conflicting. Several studies have suggested that there is no relation between smoking and restenosis rates,40-42 but in two recent studies in which logistic regression analysis was used, continued smoking was found to be an independent predictor of restenosis.43,44 Given the known harm of smoking in patients with CHD, it is appropriate to strongly recommend smoking cessation to patients who undergo PTCA. The efficacy of calcium antagonists is unknown, although some physicians administer them for several months after PTCA.

Thus, available data support the following strategies to minimize occurrence of acute closure and restenosis after PTCA: administration of aspirin (and heparin) at the time of PTCA, long-term administration of aspirin (80 to 325 mg/d), and smoking cessation.

**Prevention of Atherosclerotic Progression in Native Coronary Arteries**

Serial coronary arteriography in patients with underlying coronary artery disease has been used in a number of clinical trials designed to determine whether specific interventions can prevent the progression of coronary atherosclerosis or even result in regression. Most of these studies have been directed toward interventions...
that lower total and LDL cholesterol. In addition, several of these interventions raised HDL cholesterol levels: diet, lipid-altering drugs, major lifestyle change, behavioral modification, and ileal bypass surgery. Studies on the ability of calcium entry blockers to prevent atherosclerosis have also been undertaken. Although a global scoring system by an arteriographic reading panel that gave an overall measure of atherosclerotic change was used in some trials,\textsuperscript{34,45} serial quantitative coronary arteriography provides a more reproducible and accurate method for following serial changes and is increasingly being used.

An overview of these trials\textsuperscript{46} demonstrates that progression can be slowed significantly, that regression can be demonstrated in a minority of patients, and that plaques prone to rupture can also be stabilized, preventing coronary events. The favorable serial changes in the coronary circulation correlate with the ability to both lower LDL cholesterol and raise HDL cholesterol. Furthermore, in the POSCH Trial, the global coronary change score, determined after repeat serial coronary arteriography 3 years after randomization, predicted subsequent coronary events.\textsuperscript{46} Finally, a 1-year lifestyle modification study\textsuperscript{47} revealed significant changes in the coronary circulation, supporting the view that diet and drug interventions can produce detectable improvement in underlying coronary atherosclerosis as early as 1 year after such interventions are initiated.

Prevention of Clinical Events With Specific Interventions

Following coronary artery bypass surgery, smoking cessation favorably alters morbidity and mortality. In the Coronary Artery Surgery Study, after 10 years of follow-up, survival was 80% among those who smoked at entry into the study but then stopped, compared with 69% among those who continued to smoke. Continued smoking imposed an almost twofold relative risk of death.\textsuperscript{48} After 10 years of follow-up, smokers were more likely to have angina, to be unemployed, to have greater limitation of activity, and to have more hospital admissions. Smokers had an average of 8.8 additional days in the hospital, compared with nonsmokers, with an estimated additional hospital care expenditure of over $4700 per smoker, an additional hospital expense of $1.80 per pack of cigarettes smoked.\textsuperscript{48}

A variety of drug and dietary interventions to lower LDL cholesterol and raise HDL cholesterol can reduce the likelihood of subsequent mortality and significant morbidity in patients with native coronary artery disease. Serum lipid—modifying drug and dietary interventions reduce the likelihood of myocardial infarction and reinfarction by approximately 25%. Total mortality is less affected, with a reduction in risk of approximately 10%, which is of borderline statistical significance. These studies lack sufficient statistical power to detect differences in total mortality rates.\textsuperscript{34,45,47-51}

Clinical events in patients in randomized lipid-lowering trials using serial coronary arteriography also showed a significant reduction in the likelihood of such events, especially when progression was decreased or regression took place; the benefit was often seen quite soon (ie, within 1 to 2 years of initiation).\textsuperscript{46,49} Finally, cholesterol-lowering drugs are cost-effective or even cost-saving when used in secondary prevention.\textsuperscript{21}

Assessment of Risk Factors in the Patient Undergoing Surgical or Nonsurgical Revascularization

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Assessment</th>
<th>Therapeutic Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevated LDL cholesterol</td>
<td>Fasting lipid profile</td>
<td>≤100 mg/dL (&lt;2.6 mmol/L)</td>
</tr>
<tr>
<td>Decreased HDL cholesterol</td>
<td>Fasting lipid profile</td>
<td>&gt;35 mg/dL (&gt;0.9 mmol/L)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>Blood pressures confirmed on two visits</td>
<td>≤140/90 mm Hg</td>
</tr>
<tr>
<td>Physical inactivity</td>
<td>Interview</td>
<td>&gt;20 min of physical activity or level walking, 1 1/2 to 2 mi/d, 3 times per week as a minimum</td>
</tr>
<tr>
<td>Smoking</td>
<td>Interview</td>
<td>Complete cessation</td>
</tr>
<tr>
<td>Obesity</td>
<td>Body weight for height</td>
<td>≤130% of ideal body weight</td>
</tr>
<tr>
<td>Diabetes</td>
<td>Fasting blood glucose</td>
<td>≤140 mg/dL</td>
</tr>
<tr>
<td>Stress</td>
<td>Interview</td>
<td>Improved coping skills</td>
</tr>
</tbody>
</table>

LDL indicates low-density lipoprotein; HDL, high-density lipoprotein.

Within the context of native coronary artery disease, other interventions have accomplished secondary prevention. The use of aspirin, beta blockers, and, most recently, angiotensin converting enzyme (ACE) inhibitors in postinfarction patients decreases subsequent mortality among patients with underlying coronary artery disease. Changes in lifestyle such as smoking cessation, exercise programs, and behavior modification are effective secondary prevention measures and should be used in the treatment of postrevascularization patients. Taken as a comprehensive program, a meta-analysis of trials of cardiac rehabilitation programs suggests a 25% reduction in coronary events from this intervention.\textsuperscript{52}

Evaluation of Risk Factors in the Patient Undergoing Revascularization

Serum Lipid Levels

Every patient with known coronary artery disease should have a complete lipid profile after an overnight fast, as should patients with clinical atherosclerosis of the aorta, arteries to the limbs, or carotid arteries. The profile should include measurements of total cholesterol, HDL cholesterol, LDL cholesterol, and total triglycerides, which should be made in a laboratory that participates in a suitable standardization program. LDL cholesterol can be accurately estimated in patients with triglyceride levels of less than 400 mg/dL (4.5 mmol/L) after direct measurement of total cholesterol, HDL cholesterol, and triglyceride (LDL-C = TC−HDL-C−TG/5). In patients with triglyceride levels greater than 400 mg/dL, direct measurement of LDL cholesterol by ultracentrifugation may be necessary. Following the general recommendations of the National Cholesterol Education Program Adult Treatment Panel II,\textsuperscript{53} two measurements of all fractions should be made 1 to 8 weeks apart.
Desirable levels of serum lipids in patients with established coronary artery disease are as follows: LDL cholesterol less than 100 mg/dL (2.6 mmol/L), HDL cholesterol greater than 35 mg/dL (0.9 mmol/L), and triglycerides less than 200 mg/dL. These can serve as one set of goals for therapy.53,54

**Blood Pressure**

Systolic and diastolic blood pressure should be measured in both the right and the left arm after the patient has rested quietly for 5 minutes. The patient should sit with his or her arm bared, supported, and positioned at heart level. The patient should not have smoked or ingested caffeine within 30 minutes before measurement. The appropriate cuff size should be used.55 Measurements should be made on a mercury sphygmomanometer, a recently calibrated aneroid manometer, or a validated electronic device. The disappearance of the sound (phase V) should be used for the diastolic reading. Two pressures separated by 2 minutes should be taken in succession and the average of both systolic and diastolic pressures calculated. If the first two readings differ by more than 5 mm Hg, additional readings should be obtained. Initial elevated levels should be confirmed on at least two subsequent visits. These general recommendations are in agreement with the 1993 Report of the Joint National Committee on Detection, Evaluation, and Treatment of High Blood Pressure.56 A confirmed systolic blood pressure of 140 mm Hg or diastolic blood pressure greater than 90 mm Hg deserves attention.

**Physical Inactivity**

Even modest levels of physical activity may offer benefit.57 The patient should be asked in some detail about his or her level of physical exertion in both occupational and nonoccupational activities before the onset of coronary symptoms. The patient should also be specifically asked to recall the frequency of physical activity during the previous week and amount of exercise engaged in during leisure time. Most patients with long-term coronary artery disease should be encouraged to participate in physical activity.58 However, exercise should be safe, as indicated by the patient's history or further testing (eg, exercise ECG). The treatment goal is difficult to define scientifically, but a level of exercise vigorous enough to make the patient breathe hard and/or sweat, performed at least three times per week, is a useful rule of thumb. An alternative approach for the patient with known coronary artery disease is level walking at a brisk pace for at least 1 1/2 to 2 miles a day, three times per week as a minimum (preferably daily).

**Smoking**

A thorough history of smoking should be obtained, including duration and frequency of past and current use of cigarettes or other forms of tobacco. This assessment of likelihood for recidivism in the patient who has recently quit smoking is important. Symptoms of nicotine withdrawal and the presence of other smokers at work and/or at home may lead to recidivism. Smoking or a high likelihood of recidivism is justification for further smoking cessation efforts.

**Obesity**

An assessment of obesity in CABG patients has important implications for both in-hospital and follow-up periods. Obesity is associated with prolonged total bypass time.59,60 Through multivariate analysis obesity was found to be an independent risk factor for perioperative morbidity, including respiratory failure, leg wound complications, myocardial infarction, arrhythmias, and sternal dehiscence. With a mean follow-up time of 36.9 months, obese patients had a greater incidence of significant recurrent angina associated with further weight gain. Even mild obesity is associated with impaired lung function and increased alveolar arterial oxygen gradients in patients undergoing bypass surgery.61 Height and weight should be measured and recorded for all patients, and relative body weight should be correlated to tables of standard weight to height to calculate percent ideal body weight. Patients whose body weight is greater than 130% of ideal should be targeted for intensive diet and exercise intervention after revascularization.

**Diabetes Mellitus**

The effects of diabetes mellitus on the atherosclerotic process are multifactorial and result from lipid abnormalities, abnormalities of platelet function, and abnormalities of other metabolic pathways.62-64 Insulin resistance and compensatory hyperinsulinemia may be especially important mechanisms of the excess cardiovascular risk imposed on diabetic patients.65-69 Optimal control of glucose metabolism by itself may have a major impact on existing atherosclerosis. Moreover, diabetes appears to be an important risk factor for late cardiac mortality after bypass surgery.70 Many of the more important atherosclerosis intervention trials have specifically excluded persons with diabetes.71 A fasting serum glucose measurement should be obtained for each patient. A level greater than 140 mg/dL suggests glucose intolerance. Additional tests, such as a glucose tolerance test, may be used to better define the diagnosis in the postoperative period.

**Psychosocial Factors and Stress**

Modification of psychosocial factors may reduce the risk of subsequent events in patients with known coronary disease, although this issue remains highly controversial. The Recurrent Coronary Prevention Project, a study of 1000 type A men who had already experienced a myocardial infarction (MI), showed that type A behavior was substantially reduced by behavioral modification focused on time, urgency, and hostility.72 Furthermore, there was a 45% lower rate of recurrent cardiac events (fatal and nonfatal MIs) in the behavior modification group over the 3 years of the intervention, compared with those who had not received training in behavior modification. The Lifestyle Heart Trial demonstrated regression of coronary atherosclerotic lesions in a small group of intensively treated patients who received stress management training.73 Although the evidence showing intervention through stress modification to reduce risk in postintervention patients is preliminary, assessment for psychosocial factors seems appropriate. In addition to the accumulating evidence that such factors might play a role in the progression of
coronary artery disease, stress clearly affects the patient’s ability to comply with the overall postintervention regimen, to alter other risk factors, and to have an improved quality of life. Each patient should be assessed for level of perceived stress at home and at work. Also, the extent to which various demands and coping with these demands affect ability to alter other risk factors should be determined.

Optimal Timing of Risk Factor Assessment

Coronary risk factors should be assessed before or as part of surgical and nonsurgical interventions. If the patient is stable, risk factors should be modified before intervention. Because of the confounding effects of hospitalization, surgery, and perioperative care, an accurate assessment of lipid profiles, blood pressure, and blood sugar is not always possible after CABG or MI. However, attention to known risk factors in the stable patient before CABG or PTCA is both feasible and important. In patients whose risk factors have not been evaluated, all risk factors and the success or failure of previous modification efforts should be reassessed during postoperative follow-up and on an ongoing basis afterward. Current data suggest that blood lipids should be assessed 8 to 12 weeks after major surgical procedures and MI because total and LDL cholesterol levels may be depressed after these cardiac events and may return to baseline only after 2 to 3 months. Measurements made earlier than 2 to 3 months after CABG or MI should be viewed with this in mind.

Management and Follow-up of Risk Factors

Overview

Role of the Physician

Cardiovascular specialists should lead the effort to establish comprehensive and coordinated programs in risk factor modification. The opportunity and responsibility to promote good health as well as disease prevention lies with physicians and should not be delegated. All patients who undergo surgical and nonsurgical coronary revascularization come to the cardiovascular specialist with advanced disease for which risk factor modification has beneficial effects on long-term morbidity and mortality. The general population receives a variety of medical and nonmedical advice on the importance of coronary risk factor modification. The immediate and long-term importance of risk factor identification and modification must be stressed to patients with coronary artery disease and their families. Complete risk factor assessments, including a fasting lipid profile, should be performed in all first-degree relatives of patients with onset of coronary artery disease before age 55 through 60, including children older than 2 years. The cardiovascular specialist should take responsibility for carrying out these risk factor assessments, either personally or by other healthcare providers. The physician should not miss the opportunity to emphasize the importance of specific risk factor modification behaviors to individual patients. The physician should also try to ensure successful compliance. Patients and their families are likely to be more receptive to these concepts at the time of major interventions, when there is at least a temporary disruption in normal lifestyle.

After assessment of risk, the role and responsibility of the cardiovascular specialist is to emphasize the importance of nonpharmacologic intervention, to develop with the patient the overall treatment, to establish treatment goals, and to provide a means for monitoring or follow-up. The physician’s involvement in the intervention plan is crucial to its implementation; the patient needs to understand the entire treatment plan, both nonpharmacologic and pharmacologic, as well as the role of other healthcare professionals.

Role of Other Healthcare Professionals

Counseling can entail a considerable amount of time, including multiple inpatient sessions and follow-up with the patient and family members. A multidisciplinary team of nurses, registered dietitians, and exercise physiologists has the advantage of offering specific skills in counseling, nutrition, exercise, and smoking cessation. The team requires coordination, usually with the help of a team leader, and benefits from communication between the physician, team members, and the patient about the overall treatment plan and goals.

Role of the Family

The patient usually does not eat, smoke, exercise, or take medications in isolation but usually as part of a family unit. Family members are valuable members of the intervention team and need to encourage the patient toward treatment goals. It may be necessary to include the family in the intervention by changing family eating, smoking, or exercise habits in order for the patient to continue interventions initiated in the hospital. Such interventions are usually valuable for family members because they often share the patient’s risk factors. Screening for risk factor aggregation in siblings and children will further encourage modification of lifestyle for the patient and family.

Role of the Primary Care Provider

The revascularization procedure brings the patient in contact with the inpatient team for a relatively brief period. It is likely that long-term follow-up of these interventions will be performed by the primary care physician. Consultation notes or referral letters from the cardiovascular specialist should describe the treatment plan to reduce risk factors, the goals of interventions, steps taken in the hospital, and the need for follow-up.

Role of Health Insurers, Employers, and Government Agencies

Support is required for posthospitalization risk factor management programs, including cardiac rehabilitation programs, smoking cessation programs, lipid profile testing, diet and drug therapies to reduce blood pressure and serum lipids, and public education programs. Continued reinforcement of these principles is important to improve success rates and help reduce the otherwise negative impact of recurrent disease on healthcare expenditures and disability benefits.

Specific Nonpharmacologic Interventions

Fat-Modified Diet

Because most patients with coronary artery disease have an LDL cholesterol level greater than 100 mg/dL...
(2.6 mmol/L) and the diet recommended for all Americans is a fat-modified diet, steps should be taken to implement the Step II diet recommended by the National Cholesterol Education Program. The Step II diet limits saturated fat to less than 7% of calories, total fat to less than 30% of calories, and dietary cholesterol to less than 200 mg/d. Several strategies foster implementation of this diet:

1. The inpatient diet should be consistent with the Step II diet.
2. A registered dietitian (RD) or other qualified nutritional counselor should meet with the patient and the family member who shops and cooks for the family. An assessment of the family’s current eating patterns may be helpful in counseling.
3. Literacy-appropriate brochures or other written materials should be given to the patient and family to help them make correct food choices.
4. The cardiovascular specialist should recommend to the primary care physician long-term follow-up of recommended dietary changes by an RD or qualified nutritionist. The RD may also supervise additional dietary changes.

**Blood Pressure Control**

The patient who had hypertension before a coronary event may benefit from continued intervention consistent with the Fifth Joint National Committee Report. Nonpharmacologic interventions should focus on restriction of dietary sodium and weight reduction. Several specific strategies can be recommended:

1. The inpatient diet should be consistent with a moderate sodium restriction (2 to 3 g of sodium per day), with greater restrictions if necessary for control of heart failure, etc.
2. An RD or other qualified nutritional counselor should meet with the patient and key family members to give advice about low-salt diets, avoidance of excessive alcohol intake (more than 1 oz [30 mL] per day), and caloric restriction.
3. Literacy-appropriate brochures or other written materials should be available to help the patient understand the importance of salt restriction, avoidance of excessive alcohol intake, and weight loss.
4. Initiation of phase I cardiac rehabilitation and referral to an outpatient cardiac rehabilitation exercise program should emphasize regular, safe physical activity.

**Physical Activity**

The return to usual (or greater) levels of physical activity has important physical, psychological, occupational, and social consequences for the typical patient with coronary artery disease. Cardiac rehabilitation programs appear to be associated with reduced recurrence of cardiac events and death and should be incorporated into the overall risk reduction program. A phase I cardiac rehabilitation program should be initiated while the patient is in the hospital. Referral to phase II and III programs or recommendation to the primary care physician for referral is encouraged. The cardiac rehabilitation program should be relatively convenient for the patient. Close contact with the primary care physician about the patient’s progress should be maintained.

**Smoking Cessation**

Smoking cessation is by far the most effective means of reducing the risk of recurrent infarction, decreasing this risk by at least 50% in a short period of time. Initiation of a smoking cessation program while the patient is in the hospital takes advantage of heightened awareness of risk and vulnerability. This opportunity should be taken to induce smoking cessation in both the patient and family members. Several steps should be taken:

- The patient should be prohibited from smoking, and family members should be restricted from smoking in patient areas while the patient is in the hospital. Ideally, all hospitals should be smoke-free.
- Regardless of the patient’s professed intention to quit smoking, a nurse or other counselor should speak with the patient and key family members while the patient is in the hospital. The goal should be a smoke-free home and work environment.
- Literacy-appropriate written materials or brochures should emphasize both the importance of smoking cessation and techniques to prevent recidivism.
- Follow-up by the primary care physician or a trained smoking cessation counselor or enrollment in a formal program should be recommended to prevent recidivism.

**Weight Reduction**

As part of the dietary advice to the obese patient to reduce fat and sodium, specific additional nutritional recommendations about weight loss should be made. Increased caloric expenditure through a cardiac rehabilitation program should also be emphasized.

**Stress Reduction**

Specific interventions to reduce strain or negative reactions to stress are not well established. In general, the patient may be advised to do the following:

- Avoid stress by changing conditions that bring on stress.
- Develop a plan to relieve unavoidable stress (eg, physical activity).
- Seek professional counseling (the primary care physician may make a referral).

**Specific Pharmacologic Interventions**

Drug therapy is an integral part of the proper management of patients undergoing surgical and nonsurgical revascularization. The goals of treatment are fourfold:

1. To prevent early graft and post-PTCA closure
2. To prevent late graft closure and post-PTCA restenosis
3. To slow, halt, or, preferably, reverse atherosclerotic progression in arteries that have not undergone revascularization
4. To prevent new or recurrent coronary events

**Platelet-Active Drugs**

Aspirin (100 to 325 mg/d) markedly reduces early vein graft occlusion when administered perioperatively. Aspirin with heparin is of benefit in the prevention of early post-PTCA occlusion. Because of its proven efficacy in preventing coronary and cerebrovascular events, aspirin therapy should be continued indefinitely.
Lipid-Lowering Drugs

In patients with abnormal lipid levels, combination therapy with older compounds such as niacin and resins or the use of newer HMG-CoA reductase inhibitors is indicated to slow progression and possibly cause regression of coronary atherosclerosis. In the long term these agents may reduce the risk of coronary events. The goal of lipid-lowering therapy should be an LDL cholesterol level less than 100 mg/dL (2.6 mmol/L) and an HDL cholesterol level greater than 35 mg/dL (0.9 mmol/L). It may be advisable to reduce triglyceride levels to less than 200 mg/dL as well.

Blood Pressure — Reducing Drugs

In patients whose blood pressure remains at or above 140/90 mm Hg over a 3- to 6-month period despite successful implementation of lifestyle modifications, antihypertensive medications should be started, especially in patients with end organ damage and/or other known risk factors for cardiovascular disease. Initial drug therapy is monotherapy. Diuretics and β blockers are the two classes of drugs preferred for initial drug therapy. ACE inhibitors, calcium antagonists, α receptor blockers, and the α-β blockers should be reserved for special indications or when diuretics and β blockers have proved unacceptable or ineffective.56

Other Classes of Drugs

β Blockers, ACE inhibitors, and anticoagulants reduce cardiovascular complications in subgroups of patients with coronary artery disease. β Blockers reduce the risk of all-cause mortality and coronary mortality, including sudden cardiac death and nonfatal MI in postinfarction patients. ACE inhibitors reduce the risk of these same complications in postinfarction patients with left ventricular dysfunction. Warfarin in a lower dose (international normalized ratio [INR] of about 2) has recently been shown to reduce thromboembolic complications, including embolic stroke, in patients with atrial fibrillation and possibly in those with significant left ventricular dysfunction. It is reasonable to assume that patients who have undergone CABG or PTCA and who have evidence of either heart failure or atrial fibrillation would benefit from treatment with ACE inhibitors or low-dose warfarin, respectively.

Discussion

Although these recommendations have been aimed at patients who have undergone revascularization, they are clearly appropriate for all patients with established coronary artery disease and other atherosclerotic diseases. All such patients need intervention in basic pathophysiological processes, namely smooth muscle cell proliferation and thrombosis. Thus, although CABG and PTCA patients are particularly prone to these pathological processes, these processes also play a role in atherosclerotic disease of the native coronary arteries as well as cerebral and peripheral arteries. The goal of treating all patients with coronary artery disease should be the prevention of sequela of these two pathological processes. Thus, the recommendations given here should be extended to myocardial infarction patients or those patients who have been diagnosed with coronary artery disease and in whom medical therapy has been elected.

These recommendations are supported by scientific literature and are quite straightforward. Frequently risk factors are not assessed as part of the revascularization process. Little attention is paid to these interventions by the physician performing revascularization, and revascularization units are not organized to provide services in these areas. Follow-up recommendations often overlook these prognostically important interventions. The goal of this report is to clarify both the rationale and the means by which appropriate interventions can be carried out. These are consistent with providing optimal care to the patient who has undergone revascularization.

Recommendations for Further Research

Model Systems

Model systems that identify risk factors and initiate nonpharmacologic and pharmacologic interventions should be tested for cost-effectiveness and impact on patients’ quality of life. A variety of strategies might be investigated, including the use of other technologies such as telecommunications and computers.

Vascular Biology of Revascularization

A great deal of research on saphenous vein grafts is ongoing, including investigation of preservation before implantation to prevent early thrombotic occlusion and studies to better understand late intimal hyperplasia and possible preventive strategies.

Additional research is ongoing regarding restenosis after angioplasty, atherectomy, and other invasive approaches to open stenotic coronary arteries through interventional catheter techniques. Such research can be broadly divided into the following four categories:

- Interventional technology (e.g., use of stents)
- Antithrombotic approaches to prevent thrombus formation and therefore subsequent organization (i.e., clinical trials are currently under way with monoclonal platelet antibodies, antithrombin agents, such ashirudin and hirulog, etc)
- Drug approaches designed to inhibit the ability of smooth muscle cells to undergo intimal hyperplasia (thus far this approach has failed, but new drugs are being tested)
- Gene therapy for early repair of damaged endothelium to prevent intimal hyperplasia

Gene therapy for the coronary endothelium is an exciting experimental approach. Viruses that have been genetically altered to incorporate metabolic inhibitors of smooth muscle cell proliferation are being studied in the hope that they can be introduced locally by catheters at the site of endothelial damage, thereby inhibiting the subsequent excessive reparative process that appears to underlie intimal hyperplasia.

Progression of Atherosclerosis in the Native Arteries

A great deal of additional research is being directed toward the prevention of atherosclerosis and the potential regression of existing atherosclerosis. The role of estrogen replacement therapy in postmenopausal women with underlying atherosclerosis is being ex-
plored to see if it will effectively decrease the rate of progression of underlying atherosclerosis and decrease the resultant clinical events. The potential benefits of antioxidants, both in the form of vitamins such as vitamin E, vitamin C, and beta carotene, as well as drugs such as probucol, are being actively investigated in clinical trials. The potential value of ACE inhibitors in the prevention of coronary events in affected individuals is also being studied. Research continues on the potential role of Lp(a) in the pathogenesis of atherosclerosis, and interventional studies directed toward lowering this risk factor are under way. Numerous transgenic animal models that overexpress various apolipoproteins and other gene products are being developed to better understand lipoprotein metabolism and to evaluate new therapeutic approaches.

It is beyond the purview of this report to review all of the experimental approaches under way today to further enhance our ability to prevent the problems of restenosis, bypass graft closure, and progression of underlying atherosclerosis. At present, however, risk factor identification and modification remains the most important approach.

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