The American Heart Association’s Science Advisory Committee was charged by the AHA’s Board of Directors to make recommendations about how practice, education, basic and clinical research, and research training in vascular disease can be fostered in medical institutions, where specialists from a variety of disciplines are involved in patient care, educational activities, and research relevant to diseases of the vascular system. For this purpose, the Science Advisory Committee appointed the Task Force on Vascular Medicine, after consultation with council chairs, to provide representation of key disciplines concerned with vascular diseases. This is the report of the task force as approved by the Science Advisory Committee.

It is the conclusion of the Task Force on Vascular Medicine that the vascular system should be viewed as a single system rather than as a set of different vascular beds. This concept, based on solid foundations of vascular biology, has important implications for the delivery of optimal care to the patient with vascular disease. Currently, depending on symptoms, the patient with vascular disease is referred to specialists in cerebrovascular, coronary artery, or peripheral vascular disease. However, by treating the circulation as a single system, the complementary skills of these various practitioners would be integrated to provide coordinated, comprehensive care for such patients. If the vascular system were regarded as a single system, the expertise of clinicians, educators, and clinical and basic researchers could be harnessed to ensure continued advances in vascular biology and medicine and the application of these advances to diagnosis, prevention, and treatment, which would benefit both individual patients and society.

The Problem

More than 70 million Americans—more than one in four—have some form of cardiovascular disease such as angina, heart attack, stroke, hypertension, intermittent claudication, aneurysm, Raynaud’s disease, or other less common conditions. Cardiovascular diseases cause almost as many deaths as accidents, cancer, infections, and all other diseases combined. The vascular complications of hypertension, obesity, diabetes, and, in postmenopausal women, hormonal changes, all of which increase the risk of myocardial infarction, call for an integrated approach to prevention and treatment.

In 1990 diseases of the heart and vascular system were responsible for the deaths of more than 900 000 Americans, or for about 43% of all deaths. The economic cost of these diseases in the United States in 1993 is estimated to be more than $117 billion. This figure includes physician and nursing services, hospital and nursing home services, the cost of medication, and lost productivity due to disability.

In the United States 571 000 operations were performed on the vascular system in 1985. In addition to surgical treatment of the epicardial coronary arteries, these operations included 107 000 carotid endarterectomies, 72 000 popliteal and tibial artery bypasses, 55 000 angiographic procedures, 33 000 abdominal aortic aneurysm repairs, and 30 000 aortoiliacofemoral reconstructions. In addition to surgical treatment of varicose veins, 6 million episodes of deep vein thrombosis and 500 000 episodes of pulmonary embolism with 50 000 deaths were recorded in 1989.

In 1989 in the United States there were 400 000 first strokes and 100 000 recurrent strokes. Brain infarction due to thromboembolism is the most common type of stroke, particularly in the elderly. In one population aged 55 years and older, the proportion of thromboembolic strokes increased from 71% in 1945 through 1949 to 81% in 1980 through 1984.

The incidence of arterial disease in the large leg arteries increases dramatically with age. A series of noninvasive tests on a population of 624 men and women in Southern California (average age, 66 years) showed that 11.7% had arterial disease of the large leg arteries (almost half of these subjects also had disease of the smaller arteries) and 16% had isolated disease of the small leg arteries. Although fewer than 10% of people with small leg artery disease develop critical limb ischemia, those who have diabetes are five times more likely to have amputations than nondiabetics. When Raynaud’s disease and phenomenon and the lymphedemas are also considered, it is evident that diseases of the heart and blood vessels are the major cause of death and disability in the Western world and are responsible for a substantial component of the cost of health care.

Hence, a well-coordinated multidisciplinary effort to focus attention on atherosclerotic and nonatheroscle-
rotic vascular disease is warranted. Multidisciplinary programs could serve as centers for the training of a new generation of clinicians and clinician-investigators who would be knowledgeable about both molecular and integrative biology and, as a consequence, alert to new approaches to patient care.

**Advances in Diagnosis and Treatment**

**Technical Advances**

The past 20 years have seen remarkable technical advances in the diagnosis and treatment of vascular diseases and in drug therapy. Examples of diagnostic advances are duplex and transcranial Doppler ultrasound and magnetic resonance and isoimage imaging of the heart, blood vessels, and brain. Therapeutic advances include vascular grafts; percutaneous transluminal angioplasty; the creation of hot and cold lasers, atherectomy devices, and endovascular stents; and intraluminal diagnostic procedures such as intravascular ultrasound. The development of calcium entry blocking agents and angiotensin converting enzyme inhibitors, the cloning and expression of human tissue-type plasminogen activator, and the discovery of a wide range of factors controlling thrombosis and thrombolysis have improved drug treatments.

Despite these advances, the fundamental causes of these diseases are still hidden in the complexities of cellular events in blood vessels. As a result, atherosclerosis and thrombosis remain the major causes of heart attack, sudden cardiac death, stroke, and intermittent claudication. Moreover, coagulation disorders, diabetes, high blood pressure, hyperlipidemia, and obesity continue to be major risk factors for development or exacerbation of vascular diseases.

**Expansion of Fundamental Knowledge**

In recent years knowledge has increased exponentially about the complexity of the innervation of the vascular wall, the regulation of the smooth muscle, the multiple functions of the endothelium, and the interactions among these components. The complex mechanisms of release of the neurotransmitter norepinephrine, as well as the roles of the cotransmitters adenosine triphosphate and neuropeptide Y, are under examination, as is the potential of the multiple receptors on the nerve endings to alter the output of neurotransmitters. Also being explored are the myriad factors in the contraction or relaxation of vascular smooth muscle, including voltage- and receptor-operated ion channels; receptor distribution, numbers, affinity, and intracellular coupling processes; and the G-proteins. The key role of the endothelium in regulating the environment inside the blood vessels has been demonstrated. By producing vasodilator and vasoconstrictor substances that act locally on the underlying smooth muscle, the endothelium can regulate the caliber of the blood vessels. By synthesizing substances that keep its surface nonadhesive and nontrombogenic to circulating blood cells, the endothelium maintains the fluidity of the blood. It regulates coagulation and fibrinolysis by complex interactions between thrombomodulin, thrombin, heparin, heparin–antithrombin III, plasminogen, plasminogen activators, and plasminogen activator inhibitors. The endothelium can also maintain or alter the structure of the blood vessel wall by producing factors that inhibit growth and others that stimulate smooth muscle proliferation. Integrated studies are yielding new data on the interactions of neural, humoral, and local mechanisms in circulatory control.

Impaired endothelial function is linked to many vascular diseases and could be caused by mechanical, metabolic, or immunologic injury. It is hypothesized that endothelial cell injury or dysfunction is an early event in atherosclerosis. Platelets adhere to atherosclerotic plaques because of the generation of platelet agonists and a decreased formation or absence of antiaggregatory and vasorelaxing substances. The resultant release of platelet mediators, particularly serotonin and thromboxane A2, in the absence of control by endothelium-derived relaxing factors causes contraction of the vascular smooth muscle; vasoactive products released from leukocytes can also cause vascular smooth muscle contraction. These and other events, such as production of platelet- and endothelium-derived contracting factors, may account for spasm of cerebral and coronary arteries.

**New Horizons**

As understanding of the complex cellular events in blood vessels increases, new approaches to therapy in the vascular diseases will follow. Possibilities include inhibition of thrombus formation, of cellular migration, and of myointimal proliferation. Gene replacement therapy is also beginning. Thus, genetically engineered endothelial cells may be seeded on prosthetic grafts, and cell type–specific receptors may permit the delivery of genetic materials that can influence gene expression at a specific site. Genetic manipulation of lipoprotein receptors offers the possibility of specific treatment of familial disorders of lipid metabolism and atherosclerosis. The potential clinical applications of these advances were highlighted in a 1990 symposium organized by the National Heart, Lung, and Blood Institute, “Vascular Biology and Medicine: The Next Frontier.” The AHA, in particular, has pioneered efforts to apply knowledge of preventive interventions as soon as their efficacy is established. The results of demonstration programs indicate that preventive techniques favorably affect the survival of patients with manifest disease, eg, myocardial infarction.

**Current Initiatives in Coordinated Approaches to Vascular Medicine**

At present no single physician treats all aspects of vascular disease such as the cardiac, extracranial and intracranial, abdominal, and peripheral manifestations of atherosclerosis, aneurysms, arteriovenous fistulas, vasospastic disorders, vasculitis, chronic venous insufficiency, and lymphedema. Patients with vascular disease may be seen by cardiologists, endocrinologists, hematologists, radiologists, neurologists, rheumatologists, radiologists, neurosurgeons, or vascular and cardiovascular surgeons. Coordination and communication among such specialists and those from other disciplines that deal with research about the care of the patient with vascular disease should be enhanced.

The NHLBI has recognized the importance of multidisciplinary coordination in vascular medicine in two recently initiated programs: academic awards in sys-
temic and pulmonary vascular disease and program-project grants in vascular biology and medicine. The academic awards have a dual purpose. First, they encourage the development, improvement, and integration of educational programs in which clinical and research aspects of the vascular diseases are discussed. Second, they encourage the professional development of the awardee so that he or she can serve as a focal point for multidisciplinary interactions in the field of vascular medicine and biology. The purpose of the program-project grants is the development of collaborative basic research and clinical programs in which rapid advances in vascular biology are translated into diagnostic, therapeutic, and preventive initiatives.

The AHA, through the continuing generosity of the Henrietta B. and Frederick H. Bugher Foundation, supports the AHA—Bugher Foundation Centers for Molecular Biology in the Cardiovascular System. These centers have two major objectives: to develop a coordinated research effort in the application of molecular biology to cardiovascular research and to develop a training program to enable young scientists with medical training to develop careers in the molecular biology of the cardiovascular system. The AHA has also established the Intercouncil Working Group on Vascular Biology in response to a recommendation of the Task Force on Intercouncil Cooperation. The members of this group represent nearly all of the AHA’s scientific councils. Subcommittees have been formed to develop a definition of vascular biology, create a mission statement for the working group, and explore how the group could participate in the AHA’s annual Scientific Sessions. The objectives of the Intercouncil Working Group on Vascular Biology are threefold: first, to enhance communication about vascular biology (in its broadest sense) within and between councils; second, to explore and develop research initiatives both within and outside the AHA in conjunction with current council activities; and third, to integrate basic vascular biology into clinical medicine.

Other professional societies are initiating programs in systemic vascular disease. The American College of Cardiology has established a committee on vascular medicine training to outline education and training programs in vascular medicine. In addition, the possibility of creating an interdisciplinary vascular biology center for coordinated research and patient care is being explored by several medical institutions in the United States. Such a center, with clearly defined goals, is one means by which to meet the objective of regarding the vascular system as a single system. The concept of a center incorporates the advantages of coordinating the activities of all disciplines involved in the management of patients with vascular diseases, in accordance with the diseases’ systemic nature. The establishment of an interdisciplinary center could lead to advances in diagnostic and therapeutic programs, application of knowledge about primary and secondary prevention, monitoring of patient outcomes, development of interactions among training programs concerned with vascular diseases, enhancement of clinical investigation, and interaction between clinicians and basic scientists to expedite the development of new research knowledge and its application to patient care.

### Organization of Vascular Biology Centers

Each medical institution should consider appointing a group of interested persons to review current clinical, research, and educational programs in vascular diseases and to consider whether or not an interdisciplinary center for vascular medicine and biology could enhance the quality and scope of such programs. This group could decide how best to coordinate educational programs for those interested in vascular diseases and could encourage the integration of vascular biology research with clinical vascular medicine investigation in order to translate advances in vascular biology into diagnostic, therapeutic, and preventive interventions. If the group decides that establishing a vascular center would be useful, a committee should be formed whose key role is the overview, development, and enhancement of clinical, research, and educational programs in vascular medicine.

### Composition

The staff of a vascular center might comprise specialists responsible for the care of patients with vascular disease and researchers whose focus is basic science. The various disciplines represented could include cardiology or cardiovascular medicine; lipid disorders and diabetes; hematology, hemostasis, and thrombosis; hypertension; interventional radiology; neurology/neurosurgery; rheumatology, small vessel occlusive disease/vasculitis, and immunology; vascular and cardiovascular surgery; pulmonary medicine and nephrology; and relevant basic science disciplines.

### Objectives

Objectives of a vascular center could include one or more of the following:

1. To enhance institutional resources for the evaluation and coordination of treatment of patients with vascular disease.
2. To assist departments in developing protocols for the diagnosis and staging of vascular diseases. Such protocols would include clinical evaluation, noninvasive laboratory studies, laboratory screening tests, and invasive procedures as required, such as mechanical endovascular techniques, surgical reconstructions, or medical therapy.
3. To encourage quality assurance and quality improvement programs in which diagnostic and treatment protocols are reviewed by tracking and analysis of patient outcomes. This could be done in inpatient, outpatient, or home-care settings. These records are fundamental to assessment of the protocols for determination of efficacy; validation of diagnostic techniques, including elimination of nonessential procedures; verification of priority sequences; establishment of cost-benefit estimates; and, importantly, introduction of new knowledge from research.
4. To foster interdisciplinary research activities in vascular biology. Clinical and basic science investigators should be encouraged to collaborate with each other to acquire new knowledge about the pathophysiology of vascular disease; to enhance the capabilities for diagnosing vascular disease and determining its severity and extent; and to identify and test new pharmacologic and interventional therapeutic modalities and possibilities.
for gene therapy for the treatment of vascular disease. Fellows from any clinical department could be provided opportunities to work in basic science laboratories in vascular biology to obtain meaningful training experiences that would prepare them for careers in academic medicine.

5. To establish educational programs for health care professionals and the public about prevention, diagnosis, and treatment of vascular disease. Specialists from clinical and basic science departments could be recruited to participate in these programs. Physicians-in-training in cardiovascular medicine, cardiac and vascular surgery, interventional radiology, neurology, hematology, pulmonary medicine, hypertension, diabetes, and nephrology would benefit from such educational experiences beyond their primary disciplines (eg, prevention of the progression of atherosclerosis with dietary and pharmacologic therapy). For residents and fellows, multidisciplinary initiatives in education could include courses, seminars, and presentations about or demonstrations of current developments in research, particularly when there is a promise of transfer of information into clinical practice. The dissemination of knowledge about vascular biology and medicine could be greatly enhanced by an interdisciplinary seminar series on vascular biology and medicine that emphasized integration of basic science, clinical problems, and research. This series would not only increase dissemination of new knowledge but likely would lead to collaborative interdisciplinary research programs.

The preclinical curriculum for medical students should emphasize the molecular and cellular bases of vascular disease and the risk factors leading to it. This would entail focusing on molecular programming of the vascular system, signal transduction and gene transcription, and molecular defects and the possibilities of gene therapy.

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