

# EFFECTS OF STRESS ON THE CARDIOVASCULAR SYSTEM

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*Stress-induced sudden death has now been shown to be due not only to arrhythmia but to an actual chemical necrosis of the myocardium which appears to be specific for stress-induced noradrenalin.*

*"Corporate Wars: Walls of Influence" by Robert Longo, Metro Pictures, New York*



The notion that emotional distress affects the heart is not new. Aristotle and later Virgil both taught that the heart is the seat of the mind and soul. Similar beliefs are found in Hindu scriptures and other Eastern philosophies. Celsus, almost 2,000 years ago, noted that "fear, and anger, and any other state of the mind may often be apt to excite the pulse." Even our uses of the word "heart" indicate its conceptualization as the seat of innermost feelings, temperament or character. "Broken-hearted," "heartache," "take to heart," "eat your heart out" all synopsise such beliefs.

William Harvey wrote in 1628 that "every affection of the mind that is attended either with pain or pleasure, hope or fear, is the cause of an agitation whose influence extends to the heart." A century later, John Hunter commented, "my life is in the hands of any rascal who chooses to annoy and tease me." Hunter's comment proved prophetic, since a violent argument did precipitate his death from a heart attack.

Napoleon's favorite physician, Corvisart, believed heart disease was due to the "passions of the mind" among which he emphasized "a fierce driving ambition." One hundred and fifteen years ago, a German physician, von Dusch, also called attention to the fact that excessive involvement in work and similar behavioral patterns seemed to be the hallmark of men who developed coronary disease. Sir William Osler similarly described the coronary-prone individual as a "keen and ambitious man, the indicator of whose engines is always at 'full speed ahead.'"

In the 1930s, the Menningers suggested that heart attack patients tended to display strongly aggressive behavior. A decade later, Flanders Dunbar, who introduced the term "psychosomatic" into American medicine, characterized such individuals as authoritarian, with an intense drive to achieve unrealistic goals. Fierce ambition and compulsiveness to achieve power and prestige were also emphasized by a variety of subsequent investigators. These observations were made by distinguished and discriminating physicians who perhaps may have had a better opportunity to observe and analyze patients than contemporary colleagues faced with the urgent demands of modern practice, who rely, perhaps overly, on laboratory studies.

Thus, the importance of behavior and emotions has long been recognized. Even 30 years ago, the rising incidence of heart disease in England was attributed to increased stress rather than dietary factors. In recent years, however, our concept of "risk factors" tended to exclude less measurable

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factors, such as stress. The widely accepted risk factors can be clearly defined and quantified so that correlation with heart attacks can be expressed statistically. Although stress and behavioral factors are more difficult to characterize and quantify, there is growing recognition of their important role in the development and course of coronary heart disease.

### **Mechanisms of stress-induced heart disease**

Harvard physiologist Walter Cannon in the early part of this century demonstrated the physiologic effects of the stress of acute fear in laboratory animals.<sup>1</sup> Although endocrine measurements were crude, it was quite apparent that acute stress caused marked stimulation of the sympathetic adrenal system and an outpouring of adrenalin-like hormones designed to prepare the organism for fight or flight. Pupils dilated, blood pressure and heart rate rose, and there was increased blood flow to the brain, resulting in improved vision and other cerebral functions. Glycogen stores in the liver were rapidly broken

down into glucose to provide immediate energy. Blood was shunted from the gut to the muscles of the arms and legs so that our ancestors could fight better or run faster. Blood clotted more rapidly to diminish loss from hemorrhage. In short, a host of physiologic and biochemical events occurred which were appropriate, purposeful, and potentially life-saving.

However, stress for modern man does not involve a rare confrontation with a pack of wolves or other isolated feats requiring surges of strength, speed or insensitivity to pain. Rather, a host of psychological and emotional threats, as well as irritating hassles, often occur throughout a day. Unfortunately our bodies react in that archaic fashion with responses that are now not only not useful, but can result in great harm.

Cannon was also fascinated by the phenomenon of "voodoo" and "bonepointing" death and the amazing power of the mind in implementation of such deaths. His studies of Maori aborigines convinced him that the mechanism of such deaths was flooding of the system with these same adrenalin-like hormones.<sup>2</sup> Essentially, these replicated the fatal disturbances in heart rhythm he could produce in laboratory animals by injecting such chemicals. Stress-induced death in contemporary civilization has now been shown to be due not only to such arrhythmia but is associated with an actual chemical necrosis of the myocardium which appears to be specific for stress-induced noradrenalin.<sup>3</sup>

In the late '40s, Hans Selye's formulations of the Alarm Reaction, General Adaptation Syndrome, and Diseases of Adaptation provided further insight into mechanisms of stress-induced heart disease in humans.<sup>4</sup> Selye extended Cannon's observations demonstrating that acute stress also caused a marked stimulation of the pituitary-adrenal cortical axis with the resultant production of increased amounts of cortisone-like hormones that reduced inflammation but also could produce vascular damage. Selye's subsequent laboratory research in the '50s included the production of "metabolic cardiac necrosis" following stress, in which he demonstrated that direct, chemical injury to heart muscle rather than occlusion of the coronary vessels could be a causative factor in experimental heart attacks.<sup>5</sup> He also emphasized the significance of sodium, potassium, magnesium, and calcium in modulating these effects. These findings were subsequently corroborated in humans, and presently form the basis for various therapeutic strategies and pharmacologic approaches as we learn more about the role of calcium channel blocking agents

and coronary vasospasm in clinical practice.

A variety of other mechanisms might be invoked to support a role for stress in heart disease. From a mechanistic point of view, they include accelerated atherosclerosis and coronary occlusion due to elevated cholesterol, triglycerides, and free fatty acids; increased platelet adhesiveness; polycythemia; accelerated blood clotting; increased fibrinogen, haptoglobin, plasma seromucoids, etc.

In the past, the terms "coronary occlusion" and "myocardial infarction" were often used synonymously in describing heart attacks, and they still are by many physicians. That was what we were taught largely as a consequence of Herrick's postmortem observations in 1912, which demonstrated that a heart attack or myocardial infarction was due to occlusion of a coronary artery by a clot or thrombus. Yet we now recognize that myocardial infarction can occur in the absence of significant coronary obstruction.<sup>6</sup> We are increasingly recognizing the important role of coronary vasospasm in the production of anginal symptoms, and conversely it is not unusual to find severe atherosclerosis in patients who have never had cardiac symptoms.<sup>7</sup>

However, the most significant development in our understanding of stress-related heart attacks and sudden death has been the recognition of myocardial infarction due to excessive release of noradrenalin at myocardial nerve endings. As mentioned, support for this comes from the identification of a specific type of myocardial necrosis which can be recognized under the microscope and is present in laboratory animals as well as humans subjected to severe stress.<sup>3</sup>

### What is stress?

Everyone seems to know what stress is, but actually, stress has no scientific definition simply because it represents so many different things. Stress is usually meant to refer to some external noxious stimulus or challenge (stressor). Many researchers, however, reserve the use of the term for physiologic, biochemical or neuroendocrine responses to such challenges. Still others use the term to characterize the pathologic results of such interactions (ulcer, heart attack, stroke, migraine). One commentator complained that, "Stress, in addition to being itself and the result of itself, is also the cause of itself."<sup>8</sup>

To further complicate matters, is there such a thing as "good" stress, or what Selye termed "eustress"? If harmful things can make us sick, is it not likely that positive emotions such as strong

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*Two studies designed to reduce heart attacks were so successful that they had to be halted so the controls would not be denied the benefits of treatment. One was a trial using techniques to alter damaging Type A behavior, and the other was the NHLBI study of almost 4,000 patients where it was found that after only two years the administration of propranolol had reduced mortality by 26%. These findings strongly suggest that stress-related sympathetic nervous system activation and associated catecholamine secretion are major factors in coronary heart disease, since behavioral modification is aimed at reducing catecholamine levels and beta blockers appear to offer protection from the harmful effects of noradrenalin on the cardiovascular system.*

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faith, creativity, or humor can negate such damaging effects or promote good health? Abundant anecdotal evidence exists to support such a contention. That's not too surprising since all the evolutionary adaptive and integrating mechanisms that

man has developed operate on a system of counter-acting checks and balances. The involuntary nervous system has opposing sympathetic and parasympathetic influences, and the endocrine system operates on a similar basis of biological feedback between target glands and the pituitary, all of which are designed to preserve the constancy of the internal environment.

Winning an athletic event or an election can be just as stressful as losing, or more so. A passionate kiss and anticipation of possible ensuing events also could be considered stressful, but are hardly equatable with walking on hot coals. Nor does it seem likely that biochemical and neurohumoral responses would be the same in all these situations, despite the fact that there may be some common nonspecific physiologic responses, such as increased heart rate.

It is apparent that the severe stress of some acute life-threatening challenge can cause cardiac damage and sudden death both in experimental animals and humans. More recently, however, we have come to appreciate a host of other more chronic and insidious psychosocial factors which appear to be even more lethal in terms of the number of individuals affected.<sup>9</sup> At the top of the list is death of a spouse; widowed individuals die from heart attacks at rates many times higher than age-matched married controls. Loss of other important relationships or functions due to death of family members or close friends, divorce, separation, or retirement also increase risk of illness. Attempts to rate stress as in the Holmes-Rahe Social Readjustment Rating Scale generally confirm that such events rank highest.<sup>10</sup> Other factors such as poverty, crowding, social isolation, and disruptive family relationships have also been incriminated.<sup>11</sup> It is important to recognize in any consideration of such relationships that it is not merely the external influence but rather the individual's perception of it, as well as coping strategies and mechanisms that have been developed, which determine the likelihood of subsequent illness.

### **Type A and coronary-prone behavior**

Perhaps the greatest contribution to understanding relationships between stress and heart disease is Rosenman and Friedman's concept of Type A personality.<sup>12</sup> After more than 30 years of studying heart attack patients, they realized that such suspected causes as smoking, diet and exercise accounted for less than half the cases seen. They were impressed with a poorly defined factor which appeared to relate to a quality of "maleness," and in-

deed, more than two-thirds of heart attack victims in the United States were men. Curiously, this was not the case in Mexico or southern Italy where the incidence of heart attacks was equally divided between the sexes, or in northern Italy where the male/female ratio abruptly shot up to 4 to 1. These findings would be difficult to account for on the basis of diet or environment. What did appear to be relevant were sociocultural differences in those regions that reflected variations in social behavior between the sexes.

An emerging pattern of coronary-prone behavior, especially prominent in males, began to develop which has been refined over the past three decades. Such individuals exhibit varying degrees of certain overt behavioral characteristics which include:

1. Self-imposed standards which are often unrealistically ambitious and are pursued in an inflexible fashion. Associated with this are a need to maintain productivity in order to be respected, a sense of guilt while on vacation or relaxing, an unrelenting urge for recognition or power, and a competitive attitude.
2. Persistent vigilance, anticipation and impulsiveness. Usually several lines of thought or action are pursued simultaneously, such as eating, reading, or writing while talking on the telephone or while in the bathroom.
3. Hyperactive responsiveness, often manifested by a tendency to interrupt or finish another's sentence in conversation — usually in dramatic fashion, by varying speech, volume, pitch, or by alternating rapid bursts of words with long pauses of hesitation for emphasis. Type A's tend to be poor listeners and often interrupt conversations, or signal the speaker to finish prematurely by nodding the head, grunting, or otherwise gesturing to indicate that the point being made has been anticipated or is irrelevant.
4. Aggressiveness and hostility and a low threshold for anger and frustration if goals are not achieved. Type A's often have an attitude of bravado about their own superiority and can be fiercely competitive, both of which frequently contribute to poor interpersonal relationships.
5. Increased muscular activity in the form of gestures and motions and facial activities such as grimaces, gritting and grinding of teeth, or tensing jaw muscles. Pounding of the fist to make a point, fidgeting, tapping the feet, or playing with a pencil in rhythmic fashion are other favorites.
6. Irregular or unusual breathing patterns with frequent sighing produced by inhaling more air than needed during speaking and then releasing it

during the middle or at the end of a sentence for emphasis. Very recent research suggests that such disturbed respiratory patterns may be an important factor in the pathogenesis of essential hypertension.<sup>13</sup>

It is significant that Type A's often have few hobbies or diversions outside of their work and usually feel guilty when they relax. They also tend to have poor health habits. They smoke and drink more than average, and like rich foods. Except for a hard fought game of golf or tennis, they avoid regular exercise, which they consider boring.

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There is some evidence to suggest that Type A and coronary-prone behavior are not synonymous, and that possibly such characteristics as aggressive behavior, latent hostility and time urgency are more predictive for heart disease. It also appears that some flaming Type A individuals thrive on their behavior if the net result of their activities is productive and rewarding. Analysis of such stress-resistant personalities reveals that they tend to be creative, have a strong commitment to what they are doing, are in control of the situation and their lives, and enjoy and respond to challenges. Symphony conductors, performing artists, and other artists, all of whom are generally under a great deal of stress, often lead very long, productive and healthy lives. Perhaps this attribute stems from the satisfying feelings of pride, fulfillment and intrinsic worthwhileness associated with their activity. Such Type A's may have far different health consequences than similar activity patterns in individuals who are predominantly hostile, aggressive, and often frustrated because of self-imposed unrealistic or inappropriate goals.

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However, despite such variables and controversy, Type A coronary prone behavior has now been unequivocally established as an independent risk factor for coronary heart disease, as significant as any other known entity.<sup>14</sup> The observation of increased catecholamine excretion in such individuals and the recognized deleterious effects of such agents on the myocardium have prompted many to reevaluate and question current beliefs about the pathogenesis of coronary heart disease.

### **Interventions**

Two studies designed to reduce heart attacks were so successful that they had to be halted before completion so that controls would not be denied

the benefits of treatment. One was a trial using techniques to alter damaging Type A behavior,<sup>15</sup> and the other was the NHLBI study of almost 4,000 patients where it was found that after only two years the administration of propranolol had reduced mortality by 26%.<sup>16</sup> These findings strongly suggest that stress-related sympathetic nervous system activation and associated catecholamine secretion are major factors in coronary heart disease, since behavioral modification is aimed at reducing catecholamine levels, and beta blockers appear to offer protection from the harmful effects of noradrenalin on the cardiovascular system. The benefits of behavioral modification have since been confirmed in other studies and the protective properties of other beta blockers in preventing recurrent heart attacks and death have now been demonstrated for almost every such agent tested for this purpose.<sup>17-20</sup> As a consequence, some authorities have suggested that beta blockers should be administered to all heart attack patients provided there are no contraindications.

Regarding the commonly accepted risk factors, perhaps stress in the form of noxious external events or coronary prone behavior contributes to those patterns of cholesterol, blood pressure and smoking often seen in such patients. For example, stress has a prompt and profound influence on serum cholesterol, as evidenced by studies of tax accountants trying to meet deadlines, or medical students before taking final exams. It is significant that correlations have also been found with depression, low self-esteem, neuroticism, as well as such Type A traits as dominance, aggression, hostility, achievement, motivation and competitiveness.<sup>21</sup> However, it is likely that the situation is more complicated; there are independent mechanisms by which the cigarette smoking, hypertension, and hypercholesterolemia associated with accelerated atherosclerosis can damage the heart.

### **Prevention and treatment of coronary heart disease—new approaches**

Stress, either in the form of acute emotional stimuli, chronic psychosocial influences, or damaging behavioral characteristics, appears to play a crucial role in the development and course of coronary heart disease. It would therefore seem prudent to investigate therapeutic strategies that acknowledge this relationship. While no one can avoid the death of a loved one or some other catastrophic event, it is possible to assist patients in coping with such stresses. The benefit of strong relations and support from family and friends, or

Figure 1:

## STRESS-REDUCTION TECHNIQUES

### Self-directed techniques

- Prioritization of activities and objectives
- Physical exercise—jogging, aerobics, running
- Recreation: hobbies, sports, travel
- Individual activities and occupational therapies—knitting, needlepoint, painting, sculpting
- Social support systems—Any group activity, involvement in service or social organization, religious activities

### Behavioral approaches

- Examination of life goals
- Identification of stressors
- Recognition of harmful personality traits
- Behavioral modification with stress inoculation techniques

### Relaxation training

- Meditation
- Guided imagery
- Progressive muscular relaxation exercises
- Hypnosis
- Isolation tank

### Biofeedback

- Muscle tension control
- Temperature control
- Galvanic skin response

### Pharmacologic

- Sedatives
- Tranquilizers
- Antidepressants
- Beta blockers

(Adapted from Rosch, P.J. and Hendler, N.H.: Stress management. In Taylor, R. B. [ed.] Health Promotion: Principles and Clinical Applications (East Norwalk, Connecticut: Appleton-Century-Crofts, 1982).

social activities with various organizations or hobby groups, is well known. Even owning a pet has been demonstrated to have health benefits for heart attack patients. The ability to modify damaging Type A behavior along with various stress inoculation techniques appear to offer the greatest potential for reducing stress-induced heart attacks.

Job stress represents one of the most serious health problems in the United States today. Significant advances have been made in identifying sources of harmful occupational stress and methods to alleviate them. A variety of stress-

reduction techniques exist (Figure 1), including meditation, biofeedback, progressive muscular relaxation, yoga. However, stress is a highly personalized phenomenon, and just as there are different causes, there must obviously be different cures; no single approach is applicable for all.

While it is not possible to define stress satisfactorily, one thing that is certainly stressful is being out of control of one's circumstances. Another less obvious stressor, but an equally important health hazard, is the absence of appropriate goals. Many individuals arrive at a position in life or an occupation because of parental, peer, or societal pressure rather than self-design. During a mid-life crisis they abruptly wake up to the fact that their lives are unfulfilled, purposeless, or unrewarding, despite external trappings of success. In contrast is the hardy stress-resistant personality with an enthusiastic commitment to activities, control over the situation, and a sense of pride in accomplishment. Many individuals need to take a little quiet time, step back, objectively analyze their resources and talents, and find goals that are appropriate, satisfying, meaningful, rewarding and attainable. Obviously, one still has to make a living to survive, bring up a family, or prepare for retirement. However, it is still possible to reappraise priorities, and identify activities or pursuits which permit pleasurable expression of interests and talents which have been suppressed.

For the practicing physician, it is valuable to bear in mind the observation of Osler—many times, it is much more important to know what kind of patient has the disease than what kind of disease the patient has.

**P&P**

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