Life Stress and Cardiovascular Disorders

By Harold G. Wolff, M.D.

An amassing body of data demonstrates further the growing importance to medicine of the recognition that, for man, reactions to threats in the form of symbols, especially when sustained, may be more important than response to assaults. Certainly, many aspects of cardiovascular disease may be looked upon as functions of man's goals, his methods of achieving them, and the conflicts they engender. In this paper the importance of life stress to the cardiovascular system in various conditions is discussed; case examples demonstrate the relationship between stressful situations and circulatory efficiency, faulty exercise tolerance in patients with or without structural heart disease, the hypodynamic response, cardiac arrhythmias, electrocardiogram, blood pressure, hypertension and renal blood flow.

THE NATURE OF STRESS FOR MAN

The stresses to which man is exposed include assaults by many living forms that aim to invade as parasites or to destroy; by meteorologic and climatic crises that pass sometimes predictably and often whimsically over the earth's surface; by mechanical, electrical and thermal forces that operate upon man merely in terms of his structure, mass and volume; and by elements of the earth's crust which man often dangerously manipulates for his comfort and delight or to fulfill his passion for destruction.

But constituted as he is, man is further vulnerable because he reacts not only to the actual existence of danger but to threats and symbols of assaults experienced in his past. These call forth reactions little different from those to the assault itself. Also, since he is a tribal or group creature, he depends for his very existence upon the aid, support and encouragement of other men.

Indeed, he lives his life so much in contact with men and in such concern about their expectations of him that perhaps to him the greatest threat of all is his doubt about his ability to live the life of a man. He is threatened by those very forces in society upon which he is dependent for nourishment and life. He must be part of the tribe and yet he is driven to fulfill his own proclivities. When these goals are divergent, conflict arises which causes him to be pulled two ways at the same time and threatens his security. These threats and conflicts are ubiquitous, and constitute a large section of the stress to which man is exposed.

RECOGNITION OF THE RELATION BETWEEN LIFE STRESS AND THE FUNCTIONS OF THE HEART

The action of, and sensations about the heart have long been linked with man's fears and loves. Our language is replete with examples indicating this ancient coupling, and indeed, the word "heart" has itself become a symbol of the human spirit. Widely used to imply courage or its lack are such phrases as: to hearten, or dishearten; to put the heart into, or inversely, to take the heart out of; lion-hearted, big-hearted, warm-hearted, soft-hearted, tender-hearted, or, on the other hand, cold-hearted, steel-hearted, hard-hearted, heavy-hearted and heart-sinking fear. The index of Barlett's "Familiar Quotations" composed of columns of key words contains more than nine columns of the word heart, a frequency of occurrence exceeded only by such words as man, life and love. In the index of Roget's "Thesaurus," the word heart outnumbers all others.

Legend and folklore abound in references to the heart's action as expressive of the man. Thus, in the ancient Parsifal legend modified by Wagner, Amfortas the inadequate son of a strong-leading father receives a never-healing wound in his heart by the spear of life and passion during a brief attempt to demonstrate his power. He is turned into a couch-ridden
invalid who sinks in faintness and pain whenever he attempts, in the pattern of his father, to assume the imposed responsibilities of his high office. It is implied that he is ultimately "cured" when his wound is touched by the spear now in Parsifal's hand and he is relieved of his responsibilities.

**Thesis**

The cardiovascular apparatus may be looked upon as a device essential to the maintenance of homeostasis. It serves to secure body economy by maintaining an equilibrium of opposing forces. This it achieves by a series of adaptive and protective reactions. Many of these reactions evoked by assaults or threats are operated at great cost to the organism, a matter of small moment except for transient symptoms if the parts are strong and the stress of short duration. But should the adaptive and protective patterns be maintained unduly long or the reacting organs be weak, or already operating under strain, or should the protective reactions exert an additive effect with other stresses, then the system may collapse.

Obviously, an equipment such as the cardiovascular apparatus that controls the distribution of body fluids is basic to any reaction, and to isolate reactions is arbitrary. But for didactic purposes there will be selected for consideration and as examples of a process, a few patterns involving conspicuous changes.

**Life Stress and Circulatory Efficiency**

Some years ago my associate, Dr. George Wolf,\(^1\)\(^2\) made measurements, before and after exercise, of the pulse, blood pressure, the ventilatory index (the amount of oxygen utilized in terms of the amount of air breathed in), cardiac output, and stroke volume. He found, for example, that a healthy individual who was asked to do a task he did not relish, a task at which he was convinced he would fail, exhibited in response to the standard exercise test a striking increase in blood pressure and stroke volume, and a decrease in ventilatory efficiency. This augmented response to a standard test persisted for forty-eight hours after the task in question did turn out to be (in his eyes) a complete failure. Changes of similar nature and duration were noted to be linked with anger and tension. Such responses are referred to as hyperdynamic reactions to stress.

During periods of domestic difficulty for example, healthy subjects exhibited physiologic inefficiency or inability to return promptly to the initial resting state after a standard exercise. Similar impairment of the subject's ability to return to previous levels was observed after a night in which the subject had only three hours of sleep. Also, healthy subjects reacted with similar decreases in circulatory efficiency to the assault of a minor infection and to the emotional assault of an implication of inadequacy.

It was inferred, in short, that the heart of the healthy, relaxed subject responds to the standard exercise situation with increases in stroke volume and output, which two minutes later return to the initial resting state. When the same individual is under stress the performance of his heart while at rest may be unaltered and may respond to exercise in the usual adequate fashion. But quite often after exercise his heart continues to behave as though he were still doing extra work and only slowly returns to the resting level of performance. It was suggested that under these conditions an organ made fragile by disease might suffer serious impairment of function.

Some patients with precordial symptoms in situations of stress are morbidly interested in their heart which they feel is functioning in a peculiar way. Actually, as was demonstrated by Dr. George Wolf,\(^1\)\(^2\) the hearts of many individuals during periods of duress may function differently, in that there is an increase in the cardiac output and the force of contractions, and arrhythmias as well, all of which may give rise to unusual chest sensations.

Also, dyspnea is often an accompaniment of stress. X-ray studies by Dr. Stewart Wolf\(^6\) demonstrate a difference in the action of the diaphragm during a period of emotional turmoil. During this time of stress the diaphragm is flattened, due to increased muscular contraction and shortening. This phenomenon may be responsible for such symptoms as inability to draw a full breath, a substernal tightness or cramp, and a sensation of breathing only with
the top of the chest. An additional factor was demonstrated in a young woman with nocturnal dyspnea. In this patient the stress of unexpressed anger and hostility caused an exaggerated pressor response, hyperventilation and decreased ventilatory efficiency. An interview which brought these feelings to the surface caused a circulatory and ventilatory response similar to that produced by strenuous muscular work. These were the basis for the nocturnal dyspnea. The patient’s nocturnal dyspnea diminished after she was given an opportunity freely to discuss these feelings.

Thus, with such dyspnea, not only are the rate, depth and muscular pattern of respiration appreciably modified but also the rhythm is disorganized. Thus, slow, deep, sighing respiration alternates with apnea and rapid, shallow, ineffective movements.

Substernal and precordial pain and discomfort results not only from reduced myocardial circulation but also from sustained contractions of the diaphragm, as mentioned above, and the sustained and forceful contraction of the intercostal, pectoral and shoulder muscles. Such sustained contractions of skeletal muscles is a common accompaniment of prolonged emotional tension and conflict in both those with and without structural defects of the heart.

As an outgrowth of these earlier studies by Dr. George Wolf, emphasis was placed upon the reactions to persistent low-grade stresses and strains which are a part of “every day” living and which constitute the core of the bedside problem, rather than upon the well-known responses to major life crises. It was possible to infer that many of the symptoms associated with cardiovascular disorders are not directly attributable to structural defects but to alterations in function representing reactions to life stress. Thus, in response to stress-producing life situations in association with anxiety, anger, guilt, rage, frustration and tension, dyspnea associated with inefficient pulmonary ventilation may occur. And in similar stress situations in the presence of anatomic narrowing of the coronary arteries, heart pain may result from increased work of the heart attendant upon prolonged elevation of the blood pressure and cardiac output. On the other hand, as will be considered later as part of the hypodynamic reaction to stress, heart pain may also result from a fall in the cardiac output and coronary blood flow in association with feelings of desperation and defeat.

Faulty Exercise Tolerance in a Setting of Tension, Anxiety and Neurocirculatory Asthenia

A careful analysis of the feeling states and circulatory changes of neurocirculatory asthenia has more recently been undertaken by my associates Drs. Ian Stevenson, Charles Duncan and Stewart Wolf. The close relation between symptoms and various life situations was exemplified by several patients. Thus, a 24 year old housewife felt deep resentment about an ailing mother. The daughter’s symptoms were palpitation, faintness, dyspnea, and headache. Over a period of six months she had fourteen interviews, during which her pulse rate was taken before and two minutes after the standard exercise. There was gradual improvement until finally her exercise tolerance was normal, and she was without complaint. However, in a setting of insecurity at work she had an exacerbation of symptoms.

Exercise tolerance was ascertained in a 32 year old housewife, in a setting of anxiety and the manifestations of neurocirculatory asthenia. She had a dominating, perfectionistic husband who interfered with her endeavor to bring up their child. Palpitation and dyspnea temporarily dwindled after full verbal expression of resentment towards her husband. Her heart rate was slower and stroke volume was increased. During subsequent interviews she expressed further resentment toward her husband’s attitude of indifference which made her feel unneeded or menial. Four months later, after fifteen such therapeutic visits, the tests showed further improvement in circulatory efficiency and the patient then remained symptom free.

A 38 year old female with neurocirculatory asthenia was observed for several months. She had been married but had been abandoned by her husband eight years before. Also, she had had Graves’ disease five years before. Her symptoms during the period of study were palpitations following exertion and after meals
which made her afraid to eat. In a setting of anxiety, with symptoms when the heart rate was high and stroke volume decreased, after ten minutes of relaxation following the expression of her resentment she showed increased stroke volume with a decline in heart rate, indicating increased circulatory efficiency. She was then free of symptoms.

A striking example of the nonfixity of the effort syndrome is afforded by a patient described by L. F. Bishop. The patient, a farmer, was examined under Army auspices on the occasions of his being called to military duty during both World War I and II. Although an interval of 25 years separated the two examinations, the findings were essentially the same. The patient was incapacitated by circulatory and ventilatory dysfunction as well as by accompanying anxiety. Yet it was clear that he functioned otherwise in the interval between wars. Shortly after his discharge during World War I and in the 25 year interval, he worked hard and long in the development and cultivation of a productive farm, and, apparently, was capable of doing sustained hard work. It must be inferred that the circulatory inefficiency precipitated by army life, was temporary and reversible, and the occurrence of defects was dependent upon special circumstances of stress, and not on stress in general.

The circulatory dynamics, before, and two, three, five, and ten minutes after a standard exercise test (Master) were studied in three groups of subjects by Dr. Stevenson and co-workers. The first group included healthy subjects who by their own statements and behavior appeared to be optimally relaxed at the time. The second group consisted of healthy subjects who were unable to relax completely because of preoccupation or mild tension associated with their immediate personal problems. The third group was comprised of patients with overtly manifest anxiety, including those with neurocirculatory asthenia. The increment of cardiac output in preoccupied healthy persons (second group) compared to relaxed healthy subjects (first group) was largely achieved by increases in stroke volume. The increment of cardiac output in patients with sustained and overt anxiety (third group) compared to those preoccupied (second group) was largely achieved through increases in heart rate. The response of patients with anxiety is an increment of cardiac output largely composed of increase in heart rate as compared with other groups, with less resting time and therefore with less output per beat. Thus, both are operating uneconomically but in somewhat different fashion.

Along with these changes in feeling state and circulatory effects during periods of sustained stress are changes in the regulation of body temperature. Thus Graham, Goodell and Wolff at the New York Hospital have been able to show that the amount and duration of elevation in body temperature in response to a given amount of work done is closely related to the pre-existing feeling state. In general, during periods of sustained emotional tension and conflict a given amount of work produced a greater rise of body temperature and for a longer time than did similar work done during a period of relative tranquility. This observation gains interest in light of the observations of Meyer Friedman who calls attention to the fact that patients with functional heart disease often exhibit hyperthermia with temperature elevations of 1 to 2 degrees F. Moreover, in a few suggestive experiments he has shown that such patients in response to given amounts of typhoid vaccine given intravenously elevated their body temperatures approximately 4 degrees F., in contrast to a group of more relaxed persons in whom the elevation was about 1 degree F.

**Variations in Exercise Tolerance in Patients with Structural Heart Disease**

Output studies on a 22 year old female with patent ductus arteriosus (angiographic studies) were made during periods of initial anxiety which gradually diminished over a period of months by Dr. Stevenson and co-workers. At the outset this patient had complaints of palpitation, dyspnea and weakness, and muscle aching. Dancing, her favorite recreation, was impossible, and fatigability striking. Symptoms were precipitated by recent conflicts. Approximately six to eight visits brought relaxation and reassurance about the nature of
the heart lesion, as well as frank expression of sexual guilt feelings. Also, there concurrently occurred improvement in her life situation and better living conditions. Although symptoms were almost gone and exercise tolerance was greatly improved, the latter was still below average for the healthy subject.

A 34 year old female with aortic insufficiency, mitral stenosis and rheumatic heart disease was studied. Anxiety and effort syndrome were apparent. The heart was enlarged but well compensated. She complained especially of palpitation, and effort intolerance. The patient’s anxiety was heightened by a gloomy prognosis of complete invalidism at age 42 (“in a wheelchair at 42”). Pulse rate was taken two, four, and seven minutes after standard exercise during a period of anxiety and was found to be rapid with many extrasystoles. Taken again after ten minutes of relaxation, it was still more irregular. One year later, after twenty therapeutic interviews, her pulse rate was slower and regular and exercise tolerance was much improved. The patient was without complaints.

The Hypodynamic Response

Although the hyperdynamic response during stress seemed much more common, a hypodynamic reaction was also elicited. Such a hypodynamic reaction for example was demonstrated in a healthy subject who felt “let down” and “betrayed” by the group with which he identified himself. His response to exercise was an actual drop in the cardiac output and blood pressure to levels below that of the initial or resting state.

A young male with complaints of precordial pain felt caught in a situation from which there was no escape, and had, when discussing his situation, a fall in cardiac output, and a slight increase in blood pressure associated with electrocardiographic changes and precordial pain. It was postulated in this individual that the hypodynamic reaction resulted in a decreased coronary circulation and relative myocardial anoxia with resultant pain.

Cerebral anoxia attendant upon diminished venous return to the heart may give rise to feelings of giddiness and faintness. But the latter feelings may also result from hyper-ventilation, which is followed by cerebral vasocostriction, impaired dissociation of oxyhemoglobin and cerebral anoxia. Both types of cerebral anoxia occur in response to stress-producing life situations in association with feelings of desperation and defeat, exhaustion, anxiety, fear, and during the early part of convalescence. Fatigue, prostration and asthenia as experienced by patients is a complex state dependent upon emotional attitude, the absence of a dominant motivation and the presence of a stress-producing life situation with accompanying inefficiency of cardiovascular and respiratory function.

Exercise tolerance was appraised in a 48 year old housewife with complaints of chest pain for four years and hypertension, 230/130 to 140/90. She could complete only half of the standard procedure because of “dizziness.” Her blood pressure, initially 140/90, increased to 160/130 with increase in heart rate. The cardiac index was lower following exercise and there was a delay in the return of the output to the resting level. Somewhat later her illness and problems connected with the behavior of her daughter were discussed. A second exercise test taken after this disturbing interview was even less well performed than the first, with more palpitations, dizziness and anxiety.

The following protocols indicate that the hypodynamic response is sometimes more clearly defined after sympathectomy.

A 43 year old male lithographer who frequently dipped his hands in chromic acid, developed arterial hypertension with left hemiparesis and Raynaud’s syndrome with scleroderma. He was incapacitated and his claims for disability compensation on the basis of chromic acid poisoning were rejected by the compensation board. Discussion of this topic and the relevance of his illness to the security of his family is illustrative: During the resting or initial period the patient was slightly depressed. He was tearful and anxious during the early part of the interview and there was a rise in blood pressure, stroke volume and cardiac output. As the interview continued the patient became further depressed, with a fall in stroke volume and cardiac output, during, however, sustained elevation of blood pressure.
With the ending of the interview, although still slightly depressed, the patient became more relaxed and his stroke volume and cardiac output were reversed to the control level.

After a total sympathectomy, discussion of the same topics evoked a similar emotional response in this man. During the control period he was relatively relaxed but with the beginning of the interview he began to weep. There was now a fall in blood pressure and increase in heart rate. No significant change in stroke volume or cardiac output occurred. The patient was then diverted, the blood pressure rose, and the heart rate fell. The disturbing topics were again reviewed and again the blood pressure fell, the heart rate increased, and this time the stroke volume also fell slightly. At the end of the interview the patient became more relaxed and his stroke volume increased, returning to the initial level.

A 43 year old housewife had had hypertension with headaches and angina pectoris for some years. When studied before total sympathectomy, during the discussion of her symptoms and illness the patient exhibited mixed anxiety and depression. Her blood pressure, stroke volume and cardiac output rose with little change in heart rate. Four months later, after a total sympathectomy, the patient discussed quarrels between her husband and son. The son was unemployed, and contemplating marriage while he lived with his parents. The patient's husband looked upon this as impertinence. There were frequent quarrels and as frequently the patient went to bed for relief from her angina. She was convinced that the poor home atmosphere had caused her health to deteriorate. While discussing her situation and expressing her resentments she became extremely depressed and wept. There was little change in her heart rate, but a 25 per cent drop in stroke volume. For this woman who had suffered cardiac failure some months before, such a hypodynamic response could be ominous.

Thus, there is evidence of essentially two kinds of cardiovascular reaction during stress: (1) hyperdynamic responses or the reaction of mobilization for defense, and (2) hypodynamic responses or a reaction of defeat, quite the opposite to the preparation for fight.

These matters become important when attempts are made to evaluate the effectiveness of drugs supposedly exerting an influence on angina of effort. Gold has called attention to the fact that various compounds, notably xanthes, allegedly useful, are of doubtful value in the treatment of such pain. Even when the use of such agents is recommended on the basis of improvement in exercise tolerance tests after their administration, it may not be assumed that they will improve function under other more pertinent conditions. Results of exercise tolerance tests done without knowledge of the subject's feeling states or under circumstances that leave out of account the usual work-a-day life and problems with their medley of feelings and attitudes are not easily interpreted with accuracy and permit only limited inferences.

Cardiac Arrhythmias in Periods of Stress

Extrasystoles

Electrocardiographic evidences of ventricular extrasystoles were demonstrated by Drs. Stevenson, Duncan, and S. Wolf in older persons by discussing significant personal topics. These phenomena are more easily demonstrated in individuals with slightly damaged myocardia. In a series of carefully studied older persons the number of extrasystoles per hundred beats was found to parallel the intensity of outward manifestations of anxiety.

The following protocol is a representative example of the relation of life stress and the occurrence of extrasystoles. A 55 year old woman came to the hospital with the complaint of palpitations and "nervousness." She had hoped for and planned a career in music, but at the age of 17, after the onset of bilateral chorioretinitis, she abandoned it. She was by no means totally incapacitated by her inadequate vision and was able to get around easily and even to read large type. However, she did little for herself and subsided into a state of dependency upon her family, who, in turn, omitted her from the family councils and in general treated her like a child. After the death of her parents, a younger sister assumed this responsibility for her and also supremacy.
among the siblings, handled all financial transactions and freely directed the patient’s life. In her thirties the patient became pregnant without marriage. Retrospectively at least, she felt that the man involved would have married her but for the meddlesome interference of her family which drove him away. Her family urged her to give up her illegitimate child for adoption, but she elected to raise him herself. This she did, not unsuccessfully, with the help of her family and some financial aid from the child’s father. Relations with her sister continued to deteriorate and a few years before her first hospital visit palpitations began, precipitated by altercations with the sister. She finally withdrew from the latter’s home and “went on relief.”

Examination revealed an obese woman with moderate hypertension (as high as 176/94). She had an enlarged heart and a systolic murmur at the base. An x-ray plate showed tortuosity and sclerosis of the aorta. Tachycardia was frequent, the heart rate during early interviews averaging about 100. There were numerous ventricular extrasystoles. The electrocardiogram showed left axis deviation. The patient was an anxious, passive, dependent person, with hostile feelings largely repressed.

During a control period preceding an interview the patient showed alternate relaxation and apprehension, the latter appearing when she focussed her attention on the electrocardiogram being recorded. During periods of such anxiety, ventricular extrasystoles were frequent, but she had none when she was able to achieve relaxation. Immediately when the interviewing physician entered the room and began to talk to her she became apprehensive as to what this might portend and at the same time began to have extrasystoles. But the physician by his words and manner reassured her and she relaxed once more, again with cessation of the extrasystoles. When, however, her illegitimate child was discussed the patient immediately became agitated and flushed, and fidgeted on the bed. Extrasystoles again appeared and continued throughout the period of agitation. After a further period of comparatively neutral conversation, frequency of the extrasystoles again diminished. The question of her future welfare was then raised and she was asked if she was sure her son would support her and not later turn against her. This distressed her almost as much as the previous question and extrasystoles greatly increased in number. Finally the patient was praised for the scholastic achievements of her son, diverted by pleasant conversation, and she became more composed and at ease. Concomitantly, the extrasystoles ceased. Throughout the interview, which extended over forty-five minutes, the heart rate was comparatively unchanged.

During the following six months, interviews with therapeutic orientation were conducted. Subsequently the patient continued to improve symptomatically, and three months after the last experimental interview reported almost complete absence of palpitations. No extrasystoles were detected in electrocardiographic records after the third interview. Also the pulse rate in successive visits was slower, dropping to 84 during the last two visits. Her blood pressure fell gradually to 132/70. Furthermore, the patient’s performance of a standard exercise tolerance test (as judged by return of the pulse rate to the resting value) was improved.

In a group of 12 unselected patients with extrasystoles (similarly studied), the life situations and emotional states of the patients were found to be relevant to the occurrence of the arrhythmias. Extrasystoles were observed to occur in these subjects during discussions of topics known to arouse anxiety and which had previously been associated with extrasystoles.

The excitability of the heart may be significantly altered by prolonged hyperactivity of the cardiac muscle during anxiety with tachycardia and increased stroke volume. Structurally diseased hearts are less able to stand the strain of such hyperactivity and more readily develop altered excitability than do normal hearts. Extrasystoles are therefore particularly common in patients with structural heart disease who exhibit prolonged anxiety and the associated reactions of cardiac mobilization.

The management of subjects with extrasystoles must include attention to the life situation and the patient’s adjustment to it, not only for its effect on the arrhythmia per se, which is of itself of little moment, but especially
to reduce the stress on the individual and his heart, of which the extrasystoles are an indication.

**Auricular Fibrillation**

Paroxysms of auricular fibrillation with life stress may be separated by many years and then occur only under circumstances of sustained and mounting tension. Thus, a 49 year old man in a high executive office during the war year 1941 and in a setting of steady and unmitigated pressure concerned with national and international affairs developed auricular fibrillation. The attack lasted about four days. The patient had a regular rhythm until almost nine years later when at the age of 58 under somewhat similar circumstances of sustained tension with insomnia, having to do with the long illness and ultimate death of his wife, he again developed auricular fibrillation. This was ended in less than forty-eight hours by the use of quinidine. Thereafter he again maintained regular rhythm.

Similar arrhythmias were exhibited by the following two patients carefully studied by Stevenson and Duncan* at the New York Hospital. Their protocols are presented in detail.

**Patient A.** A 40 year old man had been coming to New York Hospital for several years with palpitations which were due to attacks of paroxysmal auricular tachycardia and auricular fibrillation. He was born of immigrant Russian Jewish parents and brought up in poverty. The mother was the dominant member of the family. Her attitude was tyrannical and at one time she even had the patient arrested for a minor misdemeanor. He tried a number of jobs haphazardly but throughout most of his life he had supported himself by disposing of illicit goods. At the age of 34 he was markedly obese and was found to have a blood pressure of 150/105 or higher. At about this time he had his first episode of palpitations.

At 36 years of age he married a gentle girl who was ten years younger then he. His wife proved to be, like his mother, a domineering personality and they had frequent quarrels. After being ejected by his mother they lived with his wife's family. He was obliged to accept from them both financial support and humiliation. He felt considerable resentment and much of this was transferred to his wife, who, he felt, had not adequately protected him from the assaults of her relatives.

In this patient as in others, anxiety seemed to be the largest component of the personality structure. He expressed much of his hostility to his physicians, but it was almost impossible for him to do so in the presence of those toward whom it was directed. His attitude was generally passive and dependent. He had been and was continually and fruitlessly seeking support from his mother, wife and relatives. He resented their failure to supply it more abundantly, but he was afraid that any complaint would lead to their giving him even less.

As noted, the patient was markedly obese. The blood pressure was elevated, being usually approximately 160/110. Apart from the arrhythmias frequently encountered there was little remarkable about the examination of the heart. A striking feature, noted in this and many of the other subjects of this group, was moderate tachycardia even with sinus rhythm. The rate was never found lower than 78 and varied between this figure and 100. He said he rarely slept the night before he was to report to the hospital and when he was studied he usually displayed other signs of anxiety, such as dry mouth and a tense, cracked voice.

Following a painfully humiliating experience at the hands of his brother-in-law the patient had, as usual, restrained himself from speaking. He came to the laboratory the next day in a state of tension, complaining of palpitations which had begun shortly after the episode. Electrocardiographic tracings revealed auricular fibrillation. He was urged to discuss the events leading to the attack. He began to talk about the unpleasantness at home and as he did so he became more tense. He attempted at first to suppress his emotion but, being encouraged to express himself freely, he began to weep and sob, expressing mixed feelings of resentment and depression. Six seconds after the onset of weeping numerous ventricular extrasystoles appeared, twenty-four occurring in twenty-four seconds. They persisted throughout the sobbing, but disappeared completely when he had relaxed. The basic rhythm of auricular fibrillation continued throughout and the ventricular rate of 164 remained unaltered during the period of observation.

**Patient B.** A 34 year old housewife was referred for study because of paroxysmal auricular fibrillation.

The patient's parents lived first in Rumania where her father was a butcher. He was quick tempered and the patient felt more attached to her mother, though she did not feel close to either parent. The first ten years of the patient's life were spent in Rumania where she lived from 1909 to 1919 when she came to the United States. She recalled the unsettled conditions in Rumania during this time, the famines and the invasion of the Germans with their foraging and raiding for food. She remembered having many illnesses during this period.

The patient described herself as "always nervous, even as a child." Her husband said "she has always been sensitive as long as I have known her and
that's since she was about fifteen. She was always bashful and also very willful and hard to manage.” In youth she had had a goiter which became prominent when she was about 19 years of age. When 24 she married. Her anxiety continued throughout and gradually was blended into the full picture of hyperthyroidism. This was characterized first by amenorrhea, vomiting, diarrhea, and an increase in general nervousness. Later she showed bulging eyes and had paroxysmal attacks of palpitations and became short of breath. She persistently refused to see a doctor until the diarrhea had made her desperately ill.

Finally the diagnosis was made, a basal metabolic rate of plus 42 found, and her thyroid gland was surgically treated. Afterwards the patient “felt like a new person” for about a year. Then her brother entered the Army and her sister-in-law was obliged to work. Care of their three children devolved on the patient, who found this too much to cope with and she became “nervous” again with frequent attacks of palpitations.

After about a year in this state she was examined thoroughly and her metabolism found elevated to plus 15 with regrowth of the thyroid gland. After an unsuccessful trial of thiouracil, a second thyroidectomy was performed. Following this operation she continued to be tense and anxious and to suffer from episodes of paroxysmal auricular fibrillation, many of which were observed in the clinic. They occurred about twice a month in settings of tension and fatigue.

Examination revealed no enlargement of the heart and there were no murmurs. The blood pressure was 120/80. The heart rate was usually accelerated, almost invariably above 80 and more often around 100. X-ray examination of the chest revealed no unusual cardiac configuration. The electrocardiogram, besides showing the tachycardia, revealed the P-R interval prolonged to 0.21 seconds and a negative T wave in Lead CF.

The patient displayed both anxiety and compulsiveness. She was extremely meticulous about the care of her house and threw herself into housework with great energy and fretfulness, frequently exhausting herself in the process. She was a victim of insomnia and lay awake at night mulling over the day’s events. She showed a quick temper after her father’s fashion. “People annoy me. I don’t know why. Even if I go to the theater and someone chews gum, I could scream. If things don’t go my way right away, I scream.” She had difficulty with decisions. She was reserved and tense during interviews and when asked to relax became more tense. Even when given 0.4 Gm. of sodium amytal intravenously she remained completely alert and said later she had been afraid “to let go,” in case she might say things she did not want to say.

Her chief anxiety was her health, about which she invariably imagined the worst. Her grandmother had died of cancer and the patient attributed to cancer her symptoms of endometriosis and uterine fibroids. She became more firmly convinced of this when, after study of a vaginal smear, she was advised to have a hysterectomy although no one had suggested cancer to her. She read avidly and with alarm, articles on health and disease in popular magazines.

The patient was interviewed while electrocardiograms were being taken. Initially she was extremely tense and anxious and there was sinus tachycardia with a ventricular rate of 113. The P-R interval was 0.20 seconds. The patient’s health was then discussed with her. As she described her worries over her health she became even more anxious than before. She spoke of the fear that her menorrhagia was due to cancer. As she said this she became more agitated and began to weep. The heart rate rose to 140, and then fell again to 128. She continued to be anxious and a tracing taken 30 seconds later showed the presence of auricular fibrillation with a ventricular rate of 158. This arrhythmia persisted throughout the rest of the interview, during which the patient was strongly reassured and urged to relax. She did not become aware of palpitations herself until after she had left the clinic. The attack stopped the following morning after the patient had given herself quinidine.

Following the above observations the patient was interviewed a few times in the out-patient department. She entered a period of relative calm in her life and for three and a half months had no attack whatever. Her heart rate was noted to be slower. She said, “Maybe I am more contented and at ease.”

During this period the hysterectomy, previously deferred because of her arrhythmias, was performed and her husband had a minor operation. About the same time they were forced to move out of their apartment. These circumstances brought back the patient’s anxiety and attacks of auricular fibrillation recurred. As before, fatigue and stressful situations were the commonest precipitating factors. Thus, one episode of arrhythmia came on after a visit to the gynecology clinic in which some misunderstood remarks of the physician filled her with anxiety. Another occurred after a visit to our clinic when she was asked if her husband would come to the clinic to discuss her illness with the physicians. She interpreted this to indicate a forthcoming revelation of bad news and again felt anxiety and developed auricular fibrillation that evening. The arrhythmias were preceded by an awareness of tension and of acceleration of the heart.

**Comment.** In a group of 25 unselected patients with paroxysmal auricular and nodal tachycardia and auricular fibrillation similarly studied, the life situations and emotional states of the patients were found to be most signif-
cantly related to the occurrence of attacks. These were precipitated during periods of tension associated with anxiety, resentment, conflict and depression. When the immediate emotional reaction was intense, the attack usually occurred at the time of the associated event. When it was less severe the attack occurred some time later after an intervening period of mounting tension. The patients possessed certain personality traits which rendered them particularly subject to the development of anxiety, resentment and depression in response to only moderately stressful life situations. Precipitating events such as tripping, postural changes and being suddenly startled were also common, but were operative especially during stressful life situations and disturbed emotional states.

**Electrocardiographic Changes during Periods of Stress**

Precordial pain and electrocardiographic changes in persons experiencing difficulty in their interpersonal relationships were studied. A characteristic example was a patient with beginning myocardial insufficiency, who was in a state of sustained suppressed anger focussed especially upon his “in-laws.” A discussion of the latter was associated with a striking increase in blood pressure and cardiac output and, as well, electrocardiographic changes during pain in the chest. These alterations disappeared when the patient felt more secure and was enabled to relax. The increase in cardiac work associated with anger made more demands than his coronary circulation and damaged myocardium could fulfill.

Drs. Stevenson and Duncan intensively studied a series of patients as regards electrocardiographic changes during spontaneously occurring and induced emotional disturbances. Thus, a 32 year old Polish housewife came to the hospital with complaints of palpitations and dyspnea, aching in the limbs and precordial pain.

Her early life had been passed in Poland where she was allegedly maltreated by her grandparents while her mother was in the United States. Later she joined her mother but felt rejected by her and displaced by a younger sister who had been born in this country. She felt lonely and after little acquaintance with men, married at 20 years of age. Her married life was unhappy and she derived little companionship from her husband and no sexual satisfaction. After the birth of a son she focussed her affections upon him and her husband drifted off into relationships with other women.

However, she continued to be emotionally dependent upon her husband, and her symptoms first came on while he was “overseas,” when she felt particularly lonely. They disappeared upon his return but when his night working hours again separated them much of the time and symptoms recurred, she came to the hospital. After a series of interviews in which the emotional development of the patient and the relations of her symptoms to emotional states were discussed, she improved and was free of symptoms for eight months. At the end of that time she discovered evidence of infidelity in the part of her husband. With mingled resentment towards him and anxiety about her future, she resolved to divorce him and began to plan grimly for this step. In this setting her symptoms returned and she was interviewed in the laboratory.

At the beginning of the interview the patient was somewhat tense. When asked to think about relations with her favored sister she thought instead of her mother’s inadequacy and of her own unhappy and fear-ridden childhood. Anxiety was prominent, with some resentment. The rate was 99 and the T wave in Lead III was inverted. After some discussion the patient was asked to describe her feelings on discovering her husband’s infidelity. The heart rate rose from 78 to 88 and then as she expressed deep resentment and described herself as “mad” it reached 96. At the same time the T wave in Lead III again became inverted, having a slightly different appearance from that during the earlier period when anxiety was more prominent. Associated with the changes in Lead III there was during the period of anxiety a diminution of the T wave in Lead II. Deep inspiration and expiration did not alter Lead III, but a standard exercise test effected an inversion of the T wave Lead III similar to that
which occurred during the periods of emotional disturbance.

Electrocardiograms were recorded on a total of 35 patients while they were discussing problems of great personal significance, arousing anxiety and resentment. The majority of the patients showed significant changes in heart rate and in the configuration of the electrocardiogram. In 18 patients the electrocardiographic changes would have been interpreted as abnormal had they occurred during or after standard exercise tests. These were similar to those previously described by Gold, Kwit, and Modell as occurring in certain individuals experiencing severe pain during periods of noxious stimulation.

Prolonged and moderately severe tachycardia (with associated T wave changes) was observed in many patients during periods of tension and anxiety, even though they were ostensibly in a basal state. In contrast, standard exercise tests performed during periods of relative tranquility produced little rise in heart rate, followed by rapid recovery, without changes in the electrocardiographic configuration.

Patients above 45 years of age usually showed less emotional change during discussions of their own disturbing problems than did younger persons, and proportionately less electrocardiographic change. Also, under these circumstances patients with arteriosclerotic heart disease showed less tachycardia than did the group of persons without arteriosclerotic heart disease. However, when vigorous reactions were induced the configuration was clearly abnormal. A small group of patients with asthma and without complaints or evidence of cardiovascular disease showed effort intolerance and changes in heart rate and T waves as great as those observed in patients complaining of palpitations.

As a corollary of this observation, and probably of major significance, are the demonstrations of Schneider who is studying at the New York Hospital the problem of thrombosis in relation to life stress. Dramatic reductions in clotting time occur during painful experiences, vigorous effort and periods of alarm or anxiety. The pertinence of such increased clotting potential in persons with narrowed myocardial and cerebral vessels, or in those in whom blood flow is slow, especially in the presence of atheromatous plaques, is self evident.

The Relation of Arterial Blood Pressure to Life Situations and Emotions

Just as there are "stomach reactors" and "nose reactors," there are "pulse reactors" and "blood pressure reactors." This specificity was dramatically demonstrated in two young physicians working under ostensibly similar conditions of stress; one reacted with no change in blood pressure but with increased pulse rate, and the other with increased blood pressure and little change in pulse rate. Also, as indicated in previous sections, abundant evidence has been assembled to show that one cannot judge the effect of life stress on the cardiovascular function purely by determination of a so-called resting level. It does not become apparent, until after adding an increment of stress such as exercise, that the individual is already reacting as though he were carrying an increased load.

So also, the response in blood pressure to the cold pressor test was shown by my colleagues, Dr. S. Wolf, John Pfeiffer and H. Ripley to be dependent in good part upon the general life situation in which an individual finds himself. Thus, a patient in the last weeks of an unwanted pregnancy had, during a discussion of her forthcoming parturition, a brisk rise in blood pressure. After this traumatic interview during which she had expressed her conflicts and resentments, she felt dejected, exhausted and overwhelmed. At this time immersing her hand in ice water induced a depressor response with marked fall in blood pressure and cardiac output, resulting in her collapse with nausea and other systemic symptoms. Following delivery, when the baby had been disposed of through legal channels, the patient was much calmer and at this time had an average response to the test with slight increase in blood pressure, cardiac output and pulse rate. Obviously her pregnancy, her conflicts and her resentments had much to do with shaping the unusual nature of her first response.

Examples of variability in the degree and type of cold pressor response were frequently
encountered and studied by my associates Drs. Stewart Wolf, John Pfeiffer and Herbert Ripley. Again, the significance of the event appeared to influence its effect upon arterial pressure. For example, when a 28 year old steam fitter inferred that the decision as to whether or not he would undergo a mutilating sympathectomy hinged upon the outcome of a cold pressor test, he displayed the response of a "hyporeactor" (blood pressure rise from 135/85 to 180/122 with the peak attained after withdrawal of the hand from ice water and with slow return to control level). Later on the same day, when he was assured that the operation was not considered necessary, his blood pressure was lower initially and the test produced a "hyporeactive" response (blood pressure rise from 135/85 to 150/100 and immediate return to control level). Even at times when his initial pressure was high, however, his response was "hyporeactive" when the performance of the test had no special significance for him (blood pressure rise from 160/110 to 170/110 with immediate return to control level before hand was withdrawn from ice water).

Comment. Thus, clearly there is no standard assault; it is always the assault plus its implications or meaning to the individual which determines his reaction. It is, of course, widely known that blood pressure in persons with essential hypertension does change from week to week and from month to month and consideration of the individual's life situations and attitudes can be rewarding in understanding these variations.

The action of sodium amytal in reducing blood pressure is shown to be a function of the mental tranquility usually so attained and not to any particular action of the drug on the cardiovascular system, since disturbing discussion will, even during the peak of the action of sodium amytal, return the blood pressure to its previously high level or even higher.

Concerning the pathogenesis of this mobilization response, the older concepts of sympathicotonia and organ inferiority are inadequate because among hypertensives the blood pressure does not inevitably or necessarily rise in response to stress. When in reaction to a threat the subject feels defeated or overwhelmed, a depressor reaction may occur. Not only the amount but also the direction of change appears to depend on what the particular stimulus means to the subject.

**Hypertension, Renal Blood Flow and Life Stress**

Thirty-five subjects with and without essential hypertension were studied by my associate John Pfeiffer with regard to blood pressure response and change in renal hemodynamics during interviews equivalent in their effects to the stresses imposed by the day to day experiences of the subjects. Rises in blood pressure were accompanied by evidence of intense renal vasoconstriction, associated with a fall in renal blood flow amounting to as much as 25 per cent. This persisted in some instances for as long as an hour after the blood pressure returned to the initial level. The increase in peripheral resistance in the kidney was demonstrated under these circumstances to be as much as 40 to 50 per cent.

The rises in blood pressure appear to be due in part to increase in cardiac output and in part to general vasoconstriction which follows an initial brief peripheral vasodilatation. The general vasoconstriction in the hypertensive was of longer duration than the increase in cardiac output.

The pattern of reaction did not differ among the normotenives as compared to the hypertensives except for a far greater intensity and duration of reaction in the latter. It was demonstrated that during the decrease in the effective renal blood flow, as measured by the para-amino-hippuric acid method, the stroke volume was increased. Hence it appears that under these circumstances of stress there is (1) an increase in the cardiac output, (2) there is a slight initial peripheral vasodilatation followed by a general vasoconstriction and (3) that there is an actual renal vasoconstriction. It was possible to demonstrate that this renal ischemia is probably not the primary factor in the pressor response during emotional stress, for after sympathectomy a pressor response to discussion of
a traumatic subject occurs despite an actual increase in effective renal blood flow.

In an individual with unilateral kidney sympathectomy, during relaxation the renal blood flow was equal on both sides. The renal hemodynamics of the two kidneys before, during and after an interview were compared but no inferences could be drawn since the patient failed to respond to the symbols introduced. However, it was shown in a series of patients after bilateral sympathectomy that the vasoconstriction of efferent vessels during stress is eliminated; but vasoconstriction of the afferent vessels persists, suggesting that there is either an intrinsic renal mechanism controlling the afferent vessels or there is a humoral factor operating in addition to the neurogenic.

Support for the point of view that such a pressor pattern of reaction involves the cerebral cortex as well as lower neural structures derives from the work of Pool and his associates who performed bilateral topectomy on 2 psychotic subjects with essential hypertension, removing the medial portion of Brodman areas 9 and 10. Prior to operation the blood pressure of the first subject ranged between 200 and 220 systolic and 120 and 130 diastolic. For two years after operation the average range was 170 to 180 systolic and 100 diastolic. The continued moderate hypertension in this subject suggests that part of the hypertensive mechanism at least may become irreversible by the interruption of cortical pathways. The second subject has been followed for only five months postoperatively but, coincident with clinical improvement characterized by lessening of depression and decreased preoccupation with problems and conflicts, the blood pressure fell from an average range of 180 to 200 systolic and 110 to 120 diastolic to 120/80.

Also, E. Spiegel produced lesions in the dorsomedial nuclei of the thalamus of a patient with schizophrenia. One year later, when this patient was last examined, a “marked drop” in blood pressure still persisted.

The data just presented indicate the profound effect of day to day situational stresses upon the cardiovascular system. The fact that rise in blood pressure and depression in blood flow through kidneys occur in both those with normal blood pressure and those with essential hypertension certainly indicates that this type of response is part of a common reaction of the total organism to threats from his environment. However, the response of both blood pressure and renal blood flow is considerably accentuated in the hypertensive group. This is also true of cardiac output and vascular reactivity of the skin. Whether this response bears any relationship to the mechanism whereby the blood pressure is maintained at an elevated level in the hypertensive individual is not as yet clear. However, the kidneys seem to operate in these circumstances under relatively anoxic conditions, and in spite of the rise in cardiac output, they do not get their proportional share of blood from the heart. This must be diverted elsewhere, possibly through the muscles. It might be considered that in reaction to stress in which the organism mobilizes its forces of defense, the visceral organs of lesser immediate importance are sacrificed temporarily in favor of the organs of offense and defense, notably the muscles and possibly the nervous system. This pattern of homeostasis, while of potential value in emergency situations, may possibly result in damage and perhaps destruction of the organism itself when it can be elicited by inappropriate stimuli and sustained over long periods of time. Thus, whatever the mechanism, these stress factors in the condition we call essential hypertension are capable of producing changes in the direction of renal ischemia which are in themselves capable of altering renal function. Admitting that the exact role of renal ischemia in essential hypertension is not defined, it is yet apparent that a method or mechanism is available for the transformation of essential hypertension into a hypertension with renal damage which might then lead secondarily to a malignant hypertension.

Not only did the renal vascular apparatus of hypertensive patients respond to threats in a more vigorously characteristic fashion, but so did the individuals as a whole. From a study of a series of patients, certain inferences about their personalities seemed justified. They were tense, wary, noncommittal, unable to obtain
satisfaction from or throw themselves wholeheartedly into any endeavor, and certainly strikingly similar features were present in the background and early development of each. My associates Drs. S. Wolf, John Pfeiffer and H. Ripley found that these individuals were often outwardly serene, poised, calm, cold, obviously in charge of the situation, often very gentle and "sweet." Poised, they seemed to be "sitting on the lid." They were nonreflective and displayed a taste for dealing with problems by action. Many of them exhibited signs and symptoms of excessive skeletal muscle tension. From the standpoint of attitudes as well as circulatory physiology they were mobilized for combat, but did not engage in it against the pertinent adversary. Under a façade which seemed to indicate that they were affable and easy going, they were, nevertheless, poised to strike, but withheld their punch with a guilty fear of its consequences. At the same time they displayed a strong need to conform and keep peace. This, coupled with inability to throw themselves wholeheartedly into things because of fear and suspicion, made it difficult for them to believe strongly in anything or to derive real satisfaction from their accomplishments. They felt a need to show prowess without exhibiting aggression and continually feared that they would not succeed in doing so. One also gets the impression that the individual is alert, suspicious, cautious, not willing to make a full commitment, hard-working, hard-playing, and afraid of a show of strong feeling. This control seems to be associated with an inability to let go, or to give full expression to feelings. Thus the individual with hypertension is living in a state of perpetual preparation for action, that appropriately should last ten to thirty minutes, but which for him becomes a way of life.

**Summary and Formulation**

As part of the reaction to stressful life situations, notably those associated with tension, frustration, conflict, anxiety and depression the cardiovascular apparatus exhibits both hyper- and hypodynamic responses. These include alterations in the rate, rhythm, force and magnitude of cardiac contraction, change in the configuration of the heart's action potential, and modification in the peripheral circulatory resistance. During the hyperdynamic circulatory reaction, heart rate, peripheral vasomotor function and stroke volume may augment together, or one or more may increase independently of the others. In like manner, hypodynamic responses may independently involve heart rate, stroke volume and peripheral vasomotor function.

Moreover, ventilatory function is dramatically modified and ventilatory efficiency impaired. Changes in the visceral parenchymal circulation, notably in the kidney, may affect other vital functions, further jeopardizing the health and survival of the organism. Many of these alterations give rise to sensations and complaints and may cause the heart to work uneconomically. This becomes of special importance if the valves or myocardium are already damaged, leading on the one hand to a faulty appraisal of the heart's potential effectiveness, and on the other to an extra burden upon an already heavily laden organ.

Studies were made of heart rate, blood pressure and cardiac output before and after a standard exercise test in subjects with and without structural heart disease, of healthy well adjusted and relatively relaxed subjects, and those who gave evidence of various degrees of emotional disturbance. The average cardiac outputs of healthy subjects who were slightly disturbed emotionally were greater before and after exercise than those of subjects who were apparently relaxed. The difference was largely attributable to increases in stroke volume. In studies over eighteen months the resting cardiac output and response to exercise fluctuated closely in relation to emotional state in patients with anxiety, and, as well, in normal subjects. Subjects with frank, overt anxiety averaged greater cardiac outputs before and after exercise than less anxious though poorly relaxed subjects. The overtly anxious patients exhibited usually a high heart rate with a normal or slightly elevated stroke volume. Healthy relaxed persons accomplished the same work with a slower rate and larger stroke volume. In general there was a close correlation between
symptoms such as dyspnea, palpitations and weakness on exertion and impaired exercise tolerance. In 10 subjects with structural heart disease similarly studied, the same relationship was found between emotional disturbances and the occurrence of symptoms and signs of effort intolerance. The symptoms themselves were similar to those associated with cardiac failure. Changes in the emotional state were accompanied by changes in exercise tolerance. In seven instances, dramatic alterations in exercise tolerance were observed during a period of less than an hour. During sustained periods of stress the resting cardiac indices were commonly normal values, while the indices after exercise became abnormal. As improvement in the feeling state progressed, complete return of exercise tolerance to normal was repeatedly noted.

During periods of emotional tension with anxiety, conflict, frustration or depression, the circulatory phenomenology in patients with hypertension and structural heart disease is similar to that of normotensives with intact hearts in like circumstances of conflict and tension. In patients with structural heart disease, symptoms originally attributed to the structural defects may be found to be related more to the reversible exercise intolerance and circulatory dysfunction associated with the reaction to stressful life situations than to structural defects. The condition known as neurocirculatory asthenia is seen, not as a permanent or fixed disease entity, but as a circulatory disorder which may fluctuate widely in any one individual and which may be found also in healthy persons during stress, and in patients with structural heart disease.

Thus, during periods of life stress impaired circulatory efficiency may result either from hyper- or hypodynamic reactions. Most commonly impaired exercise tolerance during emotional disturbances results from exaggerated cardiac mobilization in response to symbolic stimuli. Burdens imposed on the heart by everyday physical exertions are often mild and usually brief in duration and therefore are less costly as compared with those associated with emotional disturbances which may be severe and prolonged. The increased cardiac work and excessive tachycardia at rest and in response to exercise during anxiety may be relevant to the increased susceptibility of patients with tachycardia to the development of structural heart disease.

In a group of 25 unselected patients with paroxysmal auricular and nodal tachycardia and with auricular fibrillation, certain life situations and emotional states were found to be most significant factors in the occurrence of attacks. When the emotional reaction to an incident was intense the attack was usually precipitated at the time of the associated event; when it was less severe the attack was initiated some time later after an intervening period of mounting tension.

The patients studied possessed certain personality features which rendered them particularly subject to the development of anxiety, resentment and depression. Precipitating events such as tripping, postural changes and being suddenly startled were common, but were operative mainly during periods of sustained life stress and associated anxiety, conflict, frustration, resentment and depression. Especially striking were the instances of auricular fibrillation initiated during such periods of stress.

Electrocardiograms recorded on a group of 35 patients with precordial complaints during interviews involving topics of great personal significance demonstrated not only changes in rate and rhythm but alterations in the configuration of the action potential itself. In 18 patients the electrocardiographic changes found in an ostensibly basal state would have been interpreted as abnormal had they occurred during or after standard exercise tests. Prolonged and moderately severe tachycardia with associated T wave changes were most commonly observed. In contrast, standard exercise tests performed during periods of relaxation produced little rise in heart rate or change in electrocardiogram and were followed by rapid recovery.

It was possible to demonstrate in a series of patients with hypertension that methods of adjustment to life situations, attitudes and feeling states were extremely pertinent to the level of
blood pressure. Thirty-five subjects with and without essential hypertension were studied in regard to blood pressure responses and changes in renal hemodynamics during interview circumstances which induced many of the commonly experienced feeling states and reactions of these individuals. Those with essential hypertension had pressor responses of far greater magnitude and duration than did normotensives. The changes in renal circulation were correspondingly intense and prolonged, persisting in some instances for as long as an hour after the blood pressure had returned to the initial level. The pressor responses were due in part to increases in cardiac output and in part to general vasoconstriction, the latter appearing after an initial vasodilatation and persisting longer than the increase in cardiac output.

It is postulated that the hypertensive individual responds vigorously and in an inappropriate fashion to stress and regardless of whether this process is involved in the genesis and development of essential hypertension, the bodily changes so induced may contribute to the vascular and parenchymal renal damage associated with the disease.

It has also been demonstrated that the vascular alterations during periods of life stress in the mucous membranes of various parts of the stomach,11 bowel,12 air ways13 and genitourinary apparatus14 are profound and in certain instances linked with tissue damage and disease. Equally profound and coupled with great discomfort and embarrassment, though perhaps less disastrous and threatening to the survival of the organism, are the dramatic changes in circulation that occur in the skin.15

An amassing body of data demonstrates further the growing importance to medicine of the recognition that, for man, reactions to threats in the form of symbols, especially when sustained, may be more important than response to assaults. Certainly, many aspects of cardiovascular disease may be looked upon as functions of man's goals, his methods of achieving them, and the conflicts they engender.

REFERENCES
10 SCHNEIDER, ROBERT A.: Hemodynamics as related to stress. (In preparation.)
14 WOLF, STEWART, PFEIFFER, JOHN B., JR., RIPLEY, HERBERT S., WINTER, OLIVER S., AND WOLFF, HAROLD G.: Hypertension as a reaction pattern to stress; Summary of experimental data on


17 Spiegel, E. A.: Personal communication.


Life Stress and Cardiovascular Disorders
HAROLD G. WOLFF

Circulation. 1950;1:187-203
doi: 10.1161/01.CIR.1.2.187

Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 1950 American Heart Association, Inc. All rights reserved.
Print ISSN: 0009-7322. Online ISSN: 1524-4539

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circ.ahajournals.org/content/1/2/187

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Circulation can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Circulation is online at:
http://circ.ahajournals.org//subscriptions/