The Surgical treatment of essential hypertension

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The Surgical Treatment of Essential Hypertension.

Max G. Altshuler

Senior Thesis: 1937

Presented to the College of Medicine,
University of Nebraska, Omaha.
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INTRODUCTION

In presenting this paper, I find it necessary to briefly review the investigations of earlier workers in regards the various manifestations of the disease. No attempt will be made to establish this form of treatment as a definite cure for hypertension. Considering the fact that various forms of treatment have been proposed, previously without any great deal of success, we can still hope that this new idea in treatment may some day be successful. At least we feel that considerable progress has been made in the treatment of this disease as a result of a better understanding of the relation between the vascular and sympathetic nervous systems.
Part I.

Preliminary Work in Essential Hypertension.
DEFINITION

Essential Hypertension is a disease of unknown etiology, characterized by a persistent and progressive rise of both systolic and diastolic blood pressures. All pathologic and anatomic changes are secondary, being the effect of the hypertension upon the individual. (24). Sir Clifford Allbut supplied the name "hyperpiesis" meaning excessive pressure, designated for those cases of hypertension which are not due to evident renal or cardiac disease. (61). Other terms have been given the disease, such as the pre-albuminuric state of Bright's Disease (Mahomed), latent arteriosclerosis (Von Basch), presclerosis (Huckard), and lastly cardiovascular disease (Janeway). (43). These names then indicate that certain pathological conditions accompany the disease in most cases. However, this is not definite and no pathological conditions may be present other than the hypertension. (24).

ANATOMY AND PHYSIOLOGY OF BLOOD PRESSURE

Behind the clinical findings of increased arterial tension lies a very definite foundation of altered anatomic structure and changed physiologic activity. An understanding of this foundation of concrete
change and perverted function of the vascular walls is fundamental and particularly essential in forming the basis for curative, logical treatment. Hypertension is a slow, gradual process and persistent in its development. The anatomic picture, therefore, develops slowly with the consequent result that at various stages of the disease the pathological picture is different. (59).

To understand the abnormal, a clear understanding of the normal in regard structure and function is necessary. I will not attempt a complete description of the normal vascular anatomy and physiology but will present a brief review.

The blood vascular system is composed of four types of structures: the heart, the arteries, the capillaries and the veins. Each of these four units of the vascular system have different and individual functions, plus being the conveyance for conduction and direction of blood blow. These individual functional characteristics are responsible for individual structural differences. The heart, besides being a part of the vascular system, supplies the energy for the propulsion of the blood. In addition to serving as a blood vessel, it is, therefore, a pump, a regularly contracting muscular organ,
supplied with four semi-independent chambers, separated by valve structures to prevent any reversal of flow. The large arteries such as the aorta, femorals, or brachials on the other hand have no role to play in the propulsion of the blood other than to maintain intra-vascular pressure. They are poorly equipped with muscle tissue, therefore, and their walls are chiefly composed of elastic connective tissue. Muscle cells are not adapted for or able to maintain sustained force or resistance. The smaller arteries, however, in addition to the function of carrying the moving blood stream have the important function of controlling the distribution of the blood. To illustrate, during digestion, the smaller arteries and the arterioles of the digestive tract relax their walls, the lumina becomes larger and the volume of blood through the digestive tract is increased. At the same time, the peripheral vessels of the body contract, forcing more blood into the splanchnic portion of the vascular bed. Because of this added function of distribution, the smaller arteries must have the power of independent contractility and dilatation, therefore their walls are well equipped with smooth muscle.
fibers.

The capillaries have an important additional function of diffusion through their walls of the oxygen and food brought by the arterial blood, and in return to receive the waste products and carbon dioxide, so that adequate tissue respiration is possible.

In contrast to the heart, arteries, and capillaries, the veins serve as passive tubes and their walls do not possess the strength or elasticity like the larger arteries or smaller arteries. Therefore, they do not have the elasticity, strength, contractility or free permeability of the other vascular organs.

The nerves of the arterial wall enter via the tunica externa and are composed of both medullated and non-medullated fibers. (35). These nerve fibers belong to the sympathetic autonomic nervous system and consist of a preganglionic fiber arising in the central nervous system, and a post ganglionic fiber arising from the cell of some sympathetic ganglion. These fibers are vasoconstrictors and are constantly in action to a greater or less extent. When these fibers are cut, the blood vessels in the areas of innervation become dilated. If the splanchnic nerves
on the two sides are cut the intestinal area becomes congested, and the effect in this case is so great that the general arterial pressure falls to a very low point. (7, 12, 33, 54, 58). We may then conclude that normally the arteries, or arterioles, are kept in a condition of tone by impulses from the vasomotor fibers. (26).

It has likewise been shown that if the cord be cut anywhere in the cervical region, all of the constrictor fibers lose their tone and a great vascular dilatation results in both the splanchnic and skin areas. This then leads us to believe that these vasomotor fibers originate higher up from nerve cells in the brain and their tonic activity is due to activation of these cells. Such a group of cells exists in the medulla oblongata, and constitutes the vasomotor centre. (28).

**MECHANISM OF MAINTENANCE OF BLOOD PRESSURE**

Several causes operate to maintain the blood pressure. Two of these causes may be considered as fundamental, since without them no such pressure could exist. (37). These are: (1) the pumping action of the heart, and (2) the peripheral resistance. Less
essential though important factors are: (3) the volume of the blood in the blood vessels, (4) the viscosity of the blood, and (5) the elasticity of the walls of the blood vessels.

The Pumping Action of the Heart - Changes produced in the mean arterial pressure by alteration in the pumping action of the heart are most strikingly demonstrated by observing this pressure during cutting or stimulation of the vagus nerves. These nerves carry impulses to the heart which make the heart beat slower and weaker. Consequently, with cutting of the vagi nerves, the inhibitory power is lost so that the beats become more frequent and stronger so that the mean arterial pressure rises considerably. (37). Opitz (13) reports that this procedure produces no augmentation at all, at times, because a proper relaxation of the cardiac muscle cannot be affected, due to the high frequency of contraction. If the peripheral end of a cut vagus nerve is stimulated, the heart will either stop beating or become very much slowed, with the result that the arterial blood pressure will fall, usually to a degree corresponding to the slowing of the heart.

The Peripheral Resistance - To demonstrate the
influence of peripheral resistance on mean arterial pressure, the most striking experiment is performed by cutting or stimulating the great splanchnic nerve. (65). In this nerve, impulses, which are called vasoconstrictor because they constrict the lumen of the blood vessels, are transmitted to the blood vessels of the abdomen. The vessels are under the constant influence of these impulses so that, when the nerves that transmit them are severed, the vessels dilate and thus offer less resistance to the movement of blood. (37). The result produced on the mean arterial blood pressure by cutting the two splanchnic nerves is therefore a marked and sudden fall, which is immediately recovered from if the peripheral end of one of the cut nerves is stimulated artificially. It is evident that the hindrance placed in the path of the arterial blood must increase whenever the "blood-gate" is made smaller and decrease whenever it is made larger. Therefore, the first change produces a rise and the second, a fall in the arterial pressure. (13).

Volume of the Blood in the Blood Vessels. - This factor bears a direct relationship to the blood pressure because certain degrees of pressure may be
established very readily by simply varying the volume of the blood. (13). Under normal conditions, the vascular system possesses the power of adapting itself very quickly to different quantities of blood by, (a) varying the size of the bloodvessels, (b) forcing the fluid elements of the blood into the lymphatic channels, and (c) transferring the lymph into the bloodstream. Thus slight losses of blood are quickly compensated for by a vasoconstrictor action and a transfer of lymph into the vascular channels. Whenever the amount of the circulating blood is increased the blood vessels relax and a certain portion of the blood seeks the lymph spaces. These changes are often followed by an extra discharge of water from the body in excretions. However, if the volume is steadily increased a more decided and permanent rise in blood pressure is seen. (11). However, when saline solution is injected into the blood stream, slowly, no rise in blood pressure is noted. (37). It is surprising to find how great an amount of saline can be injected into the blood stream without a rise. It seems that/the urinary outflow becomes increased, there is a transudation of saline into the peritoneal cavity, and the liver
appears boggy and edematous. Likewise edema of the extremities results to take up this excess fluid.

**Viscosity of the Blood** - If the output of the heart remains constant, but the viscosity of the blood be decreased by a saline solution, the facility of flow will be increased and the blood pressure decreased. It is shown in animals (37) that lowering of the blood pressure by hemorrhage can easily be compensated for by injecting saline solution with gelatin or gum acacia to enable the viscosity of the solution nearly equal to that of the blood. Following these injections, there is a return to the original level as well as if blood had been administered.

Likewise, the osmotic pressure of colloids bears a difference in maintenance of pressure. It has been observed by Macleod (37), in attempting to increase viscosity that the injection of substances which do not exert an osmotic pressure, produce a change which is only temporary and not permanent as desired.

**Elasticity of Blood Vessel Walls** - The elasticity of the vessel walls is essential to the maintenance of the diastolic pressure. If the walls presented no elasticity but were rigid, blood pressure
would fall to zero between the heart beats. Likewise
the elasticity of the vascular system lessens the
work of the cardiac musculature (13), because it in-
sures a constancy of flow without necessitating an
extra expenditure of energy on the part of the heart.
As each cardiac output is accommodated in the arteries
their walls are forced outward. In this way, a larger
part of the work of the heart is converted into
potential energy in the form of elastic tension which
is utilized later on during the diastolic interim.
This is explained when the wave of pressure flows into
the vessels, the walls become distended and when the
pressure of the heart is diminished, the stretched
elastic walls recoil on the column of blood and
maintain the pressure. This elastic tendency is seen
throughout the entire arterial tree.

ETIOLOGY

Incidence

Essential hypertension is usually seen in
individuals past forty years of age. (30). However,
there have been reports where the disease has occurred
in younger individuals. (61). In regards sex, there
is very little difference in occurrence in the male
or female. (43).
Frost (21) in a compilation of insurance statistics of 146,992 cases applying for life insurance showed 1.74% having a blood pressure (systolic) above 140 m. m.

Knight (47) lists 1.6% of individuals out of 500,000 applying for life insurance having a blood pressure of over 140 (systolic).

Fahr (43) claims in his compilations that 25% of deaths occurring in individuals over 50 years of age is due to cardiac disease which is secondary to hypertension.

Of 82 cases of chronic hypertension coming to necropsy at the Montefiore Hospital, New York City, seventy-two, or 88% were instances of essential hypertension. (19).

**Heredity**

Heredity is considered as one of the most important of etiological factors. The German, Weitz, shows in his statistics that the disease is definitely familial, affecting women as well as men. (43). Alvarez (36) concludes that the hypertension is an inherited peculiarity, the appearance of which can be suppressed in women as long as the ovaries function well.
Climate

This factor definitely affects blood pressure as shown by the figures of various workers in different climates. (43). Cadbury, working in China, points out that the Chinese have a blood pressure average of 20-30 m.m.s. below that of Americans, and that essential hypertension is practically unknown in China. In India the average blood pressure is around 100 m. m. Donnison failed to find a single case of hyperpiesia in examining 1,000 native Africans in Kenya County. Of interest is the fact that in observations on Americans and Europeans living in these sections, the blood pressure was not diminished, but maintained the height it did in the mother country. (59). This finding seems to point to the conclusion that climate played a small part as compared to the hereditary tendency of the individual or race.

Obesity

Fisk (20) sums up his findings with these figures:

<table>
<thead>
<tr>
<th>Overweight</th>
<th>Increased Blood Pressure</th>
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<td>10 to 15%</td>
<td>18%</td>
</tr>
<tr>
<td>15 to 20%</td>
<td>26%</td>
</tr>
<tr>
<td>20% and up</td>
<td>78%</td>
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</table>

Fisk definitely claims that overeating and lack
of exercise are the chief contributary factors influencing this overweight group.

Blood Sugar

The etiological relation of blood sugar to hypertension has been the subject of many investigations. Herrick (25) believes that the excessive intake of carbohydrate produces a symptom complex in which overweight, hypertension, arteriosclerosis, and hyperglycemia play a part. He further points out that an increased blood sugar is rarely found in thin persons who have hypertension. Mosenthal (44) does not believe that an increased blood sugar in itself will produce an increase in blood pressure. He lays claim to the fact that many cases of hypertension have an increase in blood sugar, and conversely, many cases of diabetes mellitus which are prone to develop an arteriosclerosis and hypertension. In 1910, Neubauer (43) formulated an idea which today has not been disproved, and which seems very logical. He believes that the hypertension seen in hyperglycemia is due to an increase in adrenalin production. O'Hare (48) advocates other reasons in regards the relationship. He states that since pathological changes occur in other organs of the body as a result of hypertension, that there
undergoes sclerotic changes in the pancreatic blood vessels which makes all hypertension patients potential diabetics.

**Proteins**

For a long time it was believed that meats or other protein foods were directly responsible for hypertensions. However, Mosenthal, Strause, and Kilman (43) showed by continuous experimentation that the long continued protein diet does not, of itself, produce hypertension. As pointed out, Stefansson, the great artic explorer, at the age of 42, lived for nine years on an exclusive meat diet, and maintained a blood pressure of 115/55, pulse 60, no cardiac enlargement, and aortic second sound not accentuated. Likewise, it is shown that the Greenland Eskimo, who lives on a purely carnivorous diet has no increased tendencies toward vascular or renal disease. In 1929, Lieb reported the cases of two normal men who lived for one year on an exclusive meat-fat diet without developing a rise in arterial tension.

Nusum, Osborne and Sansum (46) made observations on three groups of rabbits, over a period of 21 months, in which high protein diets were given. They noted, at the end of six months, a gradual increase in blood pressure. However, about the same time they began
finding albumen and casts in the urine, indicating that renal irritation was taking place which alone was responsible for the increase in blood pressure.

**Endocrines**

**Insulin** - It is of interest to study reactions affecting blood pressure of individuals following insulin administration. Most writers report a drop of blood pressure with insulin in ordinary dosages. (39). Mosenthal (44) states he finds no demonstrable change. However, there is one particular finding in insulin usage which is agreed on and which is significant. In cases where large vigorous dosages of insulin are used resulting in hypoglycemia and coma, there is an accompaniment of an increase in blood pressure. This change is brought about by the liberation of epinephrine, as an attempt by the body to restore a normal blood sugar level. (39).

**Adrenals** - Neusser (59) pointed out in 1898 the relationship between suprarenal tumors and hypertension. Since then Oppenheimer and Fishberg (50) have reported several cases in which the suprarenal tumor has produced increased blood pressure. Now, that a pressor substance has been discovered in the adrenal gland it has been the natural result

-16-
to assume that disturbances in the level of the arterial tension were due to excessive or defective secretion of adrenalin. (17). This theory has not reached general recognition but there are certain factors much in its favor. The advocates of this idea base their claims on the findings of, (a) changes in the adrenal glands of hypertensive subjects, (b) increased amount of adrenalin in hypertensive blood, (c) vascular reactions produced by intervenous injections of adrenalin, (d) and the frequent association of glycosuria with hypertension. (32).

As mentioned before, the presence of persistent hypertension in individuals with tumors of the chromaffin cells of the adrenal medulla is another argument in favor of the adrenal secretion, this being a responsible factor in producing hypertension. (50).

Hutton (29) believes that diabetes and hypertension are due to adrenal and pituitary overactivity. He bases his beliefs on the findings of adrenal and pituitary hyperfunction and the identical sugar curves in diabetes and hypertension.

Pituitary - The pituitary yields an active substance which produces definite changes in blood pressure. (32, 41). This substance is recognized as
vasopressin and is secreted from the posterior lobe. This pressor substance when injected intravenously into anesthetized animals produces a rise in pressure far more prolonged and sustained than adrenalin. Aside from this action, little is known of its physiological action in the maintenance of blood pressure, or its manner of secretion. (32).

Moffat (41) finds that the intramuscular injection of pituitrin in normal individuals produces a mild rise in blood pressure which is succeeded by a fall in systolic pressure with the diastolic pressure remaining unchanged. This action is brought about by constriction of the peripheral blood vessels, and its action is very unlike adrenalin which acts on the nerve terminals. Pituitrin acts directly on the muscle tissue. (13).

Ovary - The ovary is thought to be intimately associated with the causation of high blood pressure. Women in the climacteric show a semblance, in manner of origin, symptoms and course, to essential hypertension. The mechanism causing this is as yet unexplained. (5). The earlier the menopause, the more often it is associated with hypertension. Women who have become sterilized artificially, by operation or
x-ray, show a high incidence of high blood pressure. Warfield (61) thinks that the symptoms which accompany this increased tension are due to lack of inhibitory action of the ovary on the thyroid, pituitary and adrenal glands. Alvarez (5) believes that the hypertension is an inherited peculiarity, the appearance of which can be suppressed in women so long as their ovaries are functioning. When these cease to function, the inhibiting power is lost, and control of hypertension is likewise lost as a result.

**Sinus Hypertension**

Wiggers (65) points out that certain initial arteriosclerotic changes involving the aorta and carotid sinus may produce degeneration of nerve terminals. This in turn produces a generalized vaso-constriction owing to the removal of modulating reflexes from this region. This possibility is supported by the claims that degeneration of nerves has actually been demonstrated in arteriosclerosis and hypertension, and that section of these nerves in animals produces hypertension. (Heymans, Bouchaert, and Regniers(65). Keele (31) demonstrated clinically that the carotid sinus reflex is more easily evoked in pressure subjects than
in normal individuals. Consequently, he feels that a correlation exists between hypertension and pathological changes in the sinus region.

According to dynamic laws every alteration in the rate and output of the heart, and every variation in the caliber of the peripheral arterioles should be accompanied by an alteration in pressures. (13). This does not prove the case in normal individuals, in whom the blood pressures tend to remain quite constant. This stability is maintained through well-balanced compensatory mechanisms. Thus, if a primary vaso-constriction occurs, and arterial pressures have a tendency to rise, reflexes are set up from the larger vessels which slow the heart, reducing its minute volume and thereby restoring the pressures to normal levels. When these elements do not function properly, the pressure relations are relatively high.

Wiggers (65) points out that stabilization of blood pressure at a normal level does not necessarily imply constant cardiac output and peripheral resistance, but a perfect coordination between the two, through this mechanism, is necessary.

Kidney Disease.

Since Bright's famous work on kidney disease,
it is definitely known that there is some relationship between high blood pressure and renal disease. Previous to 1913 many workers believed that every case of enduring increased blood pressure was brought about by kidney disease. However, in 1913, Janeway, (30), in his studies on hypertension and nephritis, definitely disproved this theory by illustrating numerous cases examined at autopsy when the individual carried a persistent hypertension, and post-mortem findings revealed normal kidneys. His works showed that although Bright's disease does produce hypertension, still essential hypertension may occur independently of kidney pathology.

**Arteriosclerosis**

Gull and Sutton (43) brought forth early the theory that arteriosclerosis was the cause of hypertension. They based their claims on the fact that narrowing of the arterioles through "arterio-capillary" fibrosis was supposed to increase peripheral resistance in the peripheral circulation and thereby produce a permanently high blood pressure.

However, through the work of Moschcowitz (42), this theory has been placed in ill-repute. He definitely shows that the changes in the peripheral vessels
are due to the persistently high blood pressure and not vice-versa. He further points out that the vascular lesions so produced by hypertension are not general but are confined to certain organs, which pathology may vary in each instance. The usual changes predominate in the spleen, pancreas, liver, brain, and heart. Symptoms, referable to these and other organs, manifest themselves in direct proportion to the extent of the arteriosclerotic lesion.

Bordley and Baker (8) observed that in hypertensive patients there was an arteriosclerosis of the blood vessels supplying the medulla. They likewise observed that changes were absent in this locality if the blood pressure had been normal. They theorize that in such cases the reduced circulatory volume to the vasomotor center produces a high arterial tension. Consequently, they themselves, wonder if these changes are primary in this region or whether like in other regions, are secondary.

Variability

Tixier finds variation in blood pressure from minute to minute. (43). O'Hare (48) points out that excitement causes a steep rise in systolic pressure, often as high as 50 m. m., with a moderate rise of
diastolic as high as 25 m. m. Sleep and rest produces a marked drop. Exercise definitely produces an increase in blood pressure. This may be due to an overresponse of the vascular system as influenced by excitement and nervous tension. (13) Frost (21) utilizes the cardio-respiratory test in which he evokes a vasomotor reaction by rapid changes in intra-thoracic pressures. Since this plays a part in all forms of exercise, he shows a marked increase in normal individuals.

Janeway (30) considers 150 m. m. Hg. as the upper limit in normal adults, while a systolic pressure of 60-75 m. m. Hg. is generally regarded as dangerously low. However, a pressure of 30-40 m. m. Hg. is sometimes observed at operations. The average normal systolic pressure amounts to 135-140 m. m. Hg.; women usually showing a somewhat lower pressure than men. (13). Persons with sedentary habits usually exhibit a pressure between 120 and 125 m. m. Hg. The diastolic pressure most frequently retains a value of 35-40 m. m. Hg. below that of the systolic. (26). If the pressure persists for longer periods of time at 180-200 m. m. Hg. and over, a condition of hypertension is said to exist.
SYMPTOMATOLOGY

In discussing the complications of essential hypertension, Christian (15), states that there are no symptoms or signs other than what the complications show. He goes on to state that they may vary in degree from time to time, but after all, they are the results of various changes going on in the vascular system. He likewise states that the actual blood pressure is the least important of the group.

Warfield (61) lists his symptoms as usually being referable to one system, or two, such as the cardiovascular, renal, nervous system, etc. However, he likewise suggests that they are really complications and not precursors of the disease.

Cardiac - This group is characterized by dyspnea on slight exertion; cough; edema of the ankles, which may be worse at night and absent in the morning; anginal attacks; precordial distress; difficulty in taking long breaths; and finally when late, great dyspnea, cough, bloody expectoration, anasarca, scanty high-colored urine, etc.

Renal - This group is characterized by nocturnal polyuria of pale urine, cramps in the muscles, puffiness beneath the eyes, headache, and later by twitchings, convulsive seizures, blindness, and
uremic difficulties.

Gastro-Intestinal - Flatulence, distress after eating, and a marked tendency to constipation are symptoms in this group. Mosenthal (43) believes "dyspepsia" with abdominal distension a constant symptom.

Nervous - This group is characterized by irritability of temper, nervousness, inability to concentrate the mind, flashes of temper, change of disposition, headaches, insomnia, and later by transient attacks of unconsciousness with temporary paralysis, larval apoplexies and apoplexy.

Ocular - Failing vision, retinal hemorrhages, and sudden amaurosis differentiate this group.

The combination of hypertrophied heart with the apex downward and to the left, a ringing second sound at the aorta, signs of dilated aorta and high blood pressure are readily found and indicate long-standing hypertension. Many individuals do not realize that they possess hypertension until they make application for life insurance. At the time, they may be symptom-free and feel healthy and work hard. These individuals are fortunate as correct care and treatment may prevent early symptoms. However, most individuals seek advice when they notice one or more
symptoms present. (14).

Because of this fact that complications or symptoms do not occur until after the disease is in progress, individuals reaching the age of forty should be examined by a doctor at least once a year. (61).

O'Hare (47) noted the following symptoms in cases of essential hypertension: vasomotor symptoms, flushing, blushing, cold, sweaty and cyanotic hands; frequent epistaxis; abnormal menstrual flow; migraine; dizzy spells; and a type of personality characterized by morbid sensitiveness and a high-strung temperament. These are the symptoms that occur most frequently years before hypertension develops. Because of the phychic nature of these symptoms, Ayman and Pratt (6), have relieved 82% of this type of individual by removal of environmental difficulties, or by adjusting them to their immediate surroundings. Chapman (14), believes that this is the place to begin treatment of essential hypertension and he feels that coronary thrombosis and many other complications of sclerosis might be prevented by making satisfactory adjustments at this time.
PATHOGENESIS

Mosenthal (43) states that essential hypertension is a distinctly functional disease and at present there is no known anatomical basis for the malady. The anatomical changes which occur are entirely dependent upon the blood pressure, and are the result of mechanical stress put upon the tissues that maintain circulation. The immediate changes become manifest in the heart and blood vessels.

It is known that the heart muscle will hypertrophy rapidly when hypertension exists. (36). The changes occur within three or four weeks, denoted by a hypertrophy of the left ventricle. The degree of hypertrophy is very marked and may assume the size of that seen in aortic insufficiency, or adherent pericardium. Cardiac dilation then follows and with the contributing factor of coronary sclerosis is one of the most frequent causes of death in essential hypertension. (26).

Cases of clinically typical essential hypertension in which neither renal or arteriolar lesions were found at autopsy have been described by many authors. Fishberg (19) in reporting of 72 cases
of hypertension coming to necropsy, showed more or less marked, but always clearly defined, arteriolar changes. These arteriolar lesions, so constantly accompanying essential hypertension, are essentially identical in various organs and have received the name of arteriosclerosis. The changes as seen in the kidneys are first a hyalinization directly under the endothelium. In the larger vessels, the first changes observed is a hyperplasia of the internal elastic membrane with reduplication and the formation of multiple lamallae. This then undergoes degeneration with formation of hyaline substance, and proliferation of neighboring connective tissue. This produces a gradual narrowing of the lumen which may go on slowly to obliteration. Later the media shows atrophy of muscle cells, with fatty and hyaline change, with final fibrous replacement.

Because of the fact that so many workers found arteriolar changes in various organs with essential hypertension, various theories have been given as to the cause of essential hypertension. Hasenfeld and Hirsch (19) have claimed that essential hypertension was due to sclerosis of the splanchnic vessels. Evans (19) found that the splenic vessels are in-
volved as much as the kidneys. O'Hare (48) found definite sclerotic changes in the pancreatic vessels.

In the 72 cases observed by Fishberg (19), he finds that the kidney arterioles were involved in all cases; the splenic arterioles in about two thirds; the pancreas in about half; the hepatic vessels in about a third and the cerebral vessels in about one fifth of the cases. The terminal arterioles of the lungs, skin, myocardium, skeletal muscle, gastrointestinal tract, and thyroid were very rarely involved. These arteriosclerotic changes differ from the atherosclerosis of larger vessels, inasmuch as the site of change of the former is most frequent in the kidney, spleen and pancreas, whereas the latter has its predelective sites in the brain, heart and extremities.

Steiglitz (59) presents this theory in connection with hypertension:

1. Irritation of Arterioles
2. Spasticity of Smooth Muscle
3. Hypertrophy of Arterial Muscle
4. Spasticity Increased by Hypertrophy
5. Fatigue of Muscle
6. Hyperirritability of Muscle
7. Exhaustion (Degeneration of Muscle)
8. Fibrosis (Replacement)
9. Arteriosclerosis

He believes that this is a continuous process and that the vicious cycle exists between 4, 5, 6 and 4, and when muscle exhaustion results as a lack of compensatory action, the disease progresses to fibrosis and arteriosclerosis.

**COMPLICATIONS**

In 500 cases of essential hypertension seen in private practice and consultation, the following has been recorded by Paullin. (53).

<table>
<thead>
<tr>
<th>Complications referable to the heart</th>
<th>No.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac hypertrophy</td>
<td>332</td>
<td>66.4</td>
</tr>
<tr>
<td>Congestive heart failure</td>
<td>33</td>
<td>6.6</td>
</tr>
<tr>
<td>Mitral systolic murmur</td>
<td>130</td>
<td>26.0</td>
</tr>
<tr>
<td>Aortic systolic murmur</td>
<td>29</td>
<td>5.8</td>
</tr>
<tr>
<td>Aortic diastolic murmur</td>
<td>12</td>
<td>2.4</td>
</tr>
<tr>
<td>Substernal oppression</td>
<td>28</td>
<td>5.6</td>
</tr>
<tr>
<td>Angina Pectoris</td>
<td>42</td>
<td>8.4</td>
</tr>
<tr>
<td>Coronary occlusion</td>
<td>9</td>
<td>1.8</td>
</tr>
<tr>
<td>Auricular fibrillation</td>
<td>6</td>
<td>1.2</td>
</tr>
</tbody>
</table>
### Complications referable to the heart (conNo. %)

<table>
<thead>
<tr>
<th>Condition</th>
<th>ConNo.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paroxysmal Tachycardia</td>
<td>9</td>
<td>1.8</td>
</tr>
<tr>
<td>Premature contractions</td>
<td>55</td>
<td>11.0</td>
</tr>
<tr>
<td>Heart block</td>
<td>4</td>
<td>0.8</td>
</tr>
<tr>
<td>Pulsus alternans</td>
<td>3</td>
<td>0.6</td>
</tr>
</tbody>
</table>

### Complications referable to the arteries.

<table>
<thead>
<tr>
<th>Condition</th>
<th>ConNo.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radicals or other arteries thickened</td>
<td>158</td>
<td>31.6</td>
</tr>
<tr>
<td>Aorta: dilated</td>
<td>64</td>
<td>12.8</td>
</tr>
<tr>
<td>Aortic aneurysm</td>
<td>3</td>
<td>0.6</td>
</tr>
<tr>
<td>Intermittent claudication</td>
<td>3</td>
<td>0.6</td>
</tr>
</tbody>
</table>

### Complications referable to the nervous system.

<table>
<thead>
<tr>
<th>Condition</th>
<th>ConNo.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cerebral hemorrhage</td>
<td>36</td>
<td>7.2</td>
</tr>
<tr>
<td>Cerebral crisis</td>
<td>56</td>
<td>11.2</td>
</tr>
<tr>
<td>Cerebral arteriosclerosis</td>
<td>11</td>
<td>2.2</td>
</tr>
<tr>
<td>Vertigo</td>
<td>18</td>
<td>3.6</td>
</tr>
<tr>
<td>Tinnitus</td>
<td>17</td>
<td>3.4</td>
</tr>
</tbody>
</table>

### Complications referable to the eyes.

<table>
<thead>
<tr>
<th>Condition</th>
<th>ConNo.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemorrhage arteriosclerosis, edema, exudate, etc.</td>
<td>136</td>
<td>27.2</td>
</tr>
</tbody>
</table>

### Complications referable to the lungs.

<table>
<thead>
<tr>
<th>Condition</th>
<th>ConNo.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dyspnea</td>
<td>55</td>
<td>11.0</td>
</tr>
<tr>
<td>Asthma</td>
<td>39</td>
<td>7.8</td>
</tr>
<tr>
<td>Pulmonary edema</td>
<td>3</td>
<td>0.6</td>
</tr>
</tbody>
</table>
Complications referable to the kidneys. No.  

<table>
<thead>
<tr>
<th>Condition</th>
<th>No.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nocturia</td>
<td>245</td>
<td>49.0</td>
</tr>
<tr>
<td>Kidney impairment</td>
<td>46</td>
<td>9.2</td>
</tr>
<tr>
<td>Uremia</td>
<td>5</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Complications referable to other organs.

<table>
<thead>
<tr>
<th>Condition</th>
<th>No.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nasal</td>
<td>15</td>
<td>3.0</td>
</tr>
<tr>
<td>Uterine</td>
<td>4</td>
<td>0.8</td>
</tr>
<tr>
<td>Pulmonary</td>
<td>1</td>
<td>0.2</td>
</tr>
<tr>
<td>Intestinal</td>
<td>1</td>
<td>0.2</td>
</tr>
<tr>
<td>Hemorrhage from conjunctiva</td>
<td>6</td>
<td>1.2</td>
</tr>
</tbody>
</table>

These recordings illustrate the chief complications seen with essential hypertension - cardiac hypertrophy, cardiac murmurs, thickening of the arteries, cerebral crises, hemorrhage and nocturia. These complications are typical and nearly all investigators agree on these findings. (43, 19, 24, 26, 46, 50.)

**PROGNOSIS**

As long as hypertension is devoid of symptoms, and is accidentally discovered in a routine examination, the prognosis is uncertain. In the midst of apparent health, there may be apoplexy, decompensation, or uremia. An apoplexy is not necessarily
fatal. Patients lived for twenty-five years after a hemiplegia. A cardiac collapse is a serious matter and renders the prognosis grave. Patients rarely live a year after the first attack of cardio-renal disease. (61). An attack of uremia is also a grave accident. As a rule, the patient dies within a year, although there are notable exceptions. (61).

It was formerly believed that the systolic pressure was the important factor in determining prognosis. However, in recent years, we have come to believe that the diastolic findings is of greater significance in determining the prospective life of the patient. (26, 43, 61).

Systolic pressure, weight, and age form a closely interwoven net that makes prognosis an intricate problem. Writers report cases of patients having a systolic pressure of over 250 and living for many years.

The diastolic pressure is of greater importance in judging longevity than any other single sign or symptom. Dawson (43) does not regard a diastolic pressure running over one hundred as favorable, and that a constant diastolic reading of one hundred is generally accompanied by myocardial insufficiency.
and if the signs are not present at the moment, they will develop shortly. The diastolic pressure is the measure of the constant strain which the heart and arteries must withstand, while the systolic arterial tension imposes only an intermittent, transient rise. (24, 32, 43, 59).

**TREATMENT**

**Prophylactic**

O'Hare (49) believes that in families where there is a strong element of vascular disease, the patients should be told of the part played by heredity and should be urged to guide their children along less strenuous walks of life and advise them against excessive mental and physical exertion.

Chapman (14) advocates the early recognition and treatment of essential hypertension. He believes the basis for the disease is purely psychical, consequently, he believes that early adjustment and correction of the patient's habits brings about more good than all the medication in the world. He goes on to state that "the patient that leaves the doctor's office with a list of 'dons', a confused mind, and a fear of early death, has in most instances been properly initiated into that
fraternity of self-centered introspective individuals who become our confirmed hypochondriacs."

**Dietary**

Diet seems to play an important part in treatment of hypertension. As mentioned before, the markedly obese are prone to show early signs of high blood pressure. Consequently, reduction of weight in these overweight individuals by low caloric balanced diets is oftentimes attended by good results. (52.) According to O'Hare (47), low protein or salt-free diets in essential hypertension, on the whole, appear to be ineffective. However, Allen (4), in a summary of 180 cases treated, shows that 34, or 18.9%, had their blood pressure return to normal, and that 75, or 41.9%, experienced relief from hypertensive symptoms. They accomplished these results by restricting salt so that only 0.5 gm. of salt is eliminated in the urine in twenty-four hours. Allen believes that salt when retained in the body results in arterial hypertension. Allen receives the support of such men as Blaisdel, Higley, Houghton, Konikow, and Stone (43). O'Hare (43) and Christian (15) believe that the relief from symptoms in essential hypertension by this salt
restriction is produced in another direction, and that hypertension plays no part. They contend that the complications of hypertension (palpitation, dyspnea, angina pectoris, edema, and anasarca) are prone to show marked improvement, to a much greater degree than with other measures. This is true as shown in Allen's cases.

Some workers believe that essential hypertension may be the result of a vitamin deficiency, and that protective diets high in vitamins will prevent or ameliorate this condition. (52).

Nuzum and Sansum (46) report a drop in blood pressure in patients who have been placed on a basic diet. However, Ayman (6) reports like results in patients to whom dilute hydrochloric acid has been administered. The value of base-producing diets in the treatment of essential hypertension remains to be determined.

Just like overfeeding may produce high blood pressure, underfeeding may produce a reduction in blood pressure. (52). This is thought to be produced through lowering of vital qualities of various tissues, cardiac muscle, musculature and elastic tissue of the arteries, nervous system,
and the blood. However, this process of underfeeding is not desirable because of secondary effects which must constantly be guarded against. According to Mosenthal (45), the efficiency of the individual becomes impaired, and fatigue, drowsiness, weakness, and "neurasthenia" develop. Secondly, the organ which should be kept in the best possible physical state to combat the ravages of hypertension, the heart, deteriorates. For these reasons, Mosenthal (45), believes that good nutrition be the aim of therapy with sacrifice of higher blood pressure.

Mosenthal in summarizing his work suggests the following diet. This diet, for the most part, receives the support of various other workers, Lukin, O'Hare, Allen, Palmer, and Herschfelder. (26, 36, 38, 49, 52.)

(a) Proteins - about 60 to 75 grm a day. Meat, eggs, fish, cheese, etc.

(b) Fats, starches and sugars to be curtailed, or moderated according to the weight of the patient.

(c) Fluids to be taken liberally-about 1½ to 2 full quarts a day is necessary to promote adequate functioning of the skin, respiration, and bowels. Coffee and tea are to be avoided in excess. Peculiarly, Lukin (35) specifies the use of coffee as being bene-
ficial to the patient, inasmuch as it produces a long lasting vaso-dilatation of the coronary arteries. Alcohol should be limited.

(d) Fresh vegetables or fruit should be taken at every meal—because of their vitamin content, butter, cream and milk should be included in the diet.

(e) Salt and spices should be held within sensible limits. The urine should not contain more than 5-7 gm. of sodium chloride in twenty-four hours.

Physical Therapy

Various forms of physical therapy have been used for treatment of essential hypertension with some degree of success in certain cases. Marx (52) utilized light baths and found subjective improvement and reduction of blood pressure in many of his patients. Diathermy tends to produce marked relief of subjective symptoms but no drop in blood pressure. X-ray has produced little results. Radium applied to the basal ganglia and intervenous radium chloride are apparently without effect. Ultra-violet ray has likewise been unsuccessful. (43).

Rest

Elliot (18) believes that much can be accomplished
by intermittent rest periods. He advocates that the patient, who is engaged in active business, spend every other week-end in bed. Likewise, he orders the patient spend a week or two in bed at least four times a year. Although there will be a return of the rise in pressure, nevertheless, the treatment should not be disregarded. At least for the time being, there is a marked relief from strain and the circulatory reserve is improved.

Mosenthal (45) suggests that the patient take two periods of relaxation daily for about one-half to an hour on a couch or bed.

Allen (4) states that bed-rest should be only temporary as it tends to make invalids of the patients in cases where it is prolonged.

Exercise

In the past, there has been the tendency to restrict the activity of persons suffering with high blood pressure. However, Janeway (30), O'Hare (49), Hirschfelder (26), and Mosenthal (45), specifically advocate the use of strenuous exercise. They believe that the exercise tends to keep the heart and body in good tone and consequently in better physical condition. However, the above regime is definitely contra-indicated when cardiac decompen-
sation is present. However, in this exercise, no physical effort should be undertaken that demands a great deal of strength and strain at one time. By this they mean weight-lifting, boxing, swimming in the surf, long-distance running, etc.

Care of the Intestines

Care must be taken that the bowels are properly regulated. Mosenthal (45) believes it unwise to give too much bulky foods in order to produce regular bowel activity. He supports this contention with the idea that these foods increase abdominal distention and impair the action of the heart and the free flow of circulation. He believes that the mild cathartics are more advisable. The object is to produce a free movement so that straining is avoided, as this tends to produce apoplectic attacks. Likewise, this aids in the elimination of bacterial and chemical toxins which, piling up, may produce damage to the circulatory system.

Foci of Infection

Weiss and Ellis (62), specifically mention the fact and emphasize that foci of infection should be searched for and eradicated. Although they state that these foci may not have any direct relationship to the hypertension, nevertheless, they find that in
certain cases, the successful elimination of the infection may bring about a quick return of the blood pressure to a normal level. They believe that head colds, sinus infections, tonsillitis, and upper respiratory infections should be looked on as conditions of serious potential consequences. They believe that patients should be put to bed during these infections to avoid possible congestive failure.

Drugs

Vasodilators were formerly resorted to a great deal in the treatment of essential hypertension. According to Mosenthal (45), their effect is limited to emergencies, to dilate the arteries in such conditions as angina pectoris, nocturnal smothering, and cramps in the extremities. Of these drugs, amyl nitrate, nitroglycerin and sodium nitrate are probably the most effective in emergencies. However, their action is not prolonged but erythroletronitrate has quite a prolonged acting effect on the blood pressure. Steiglitz (60) advocates the use of bismuth subnitrate given in 5 to 10 grain doses three times a day. He believes that the resulting action is produced by the slow liberation of nitrates from the bismuth subnitrate causing the spastic arterioles
to be kept in a relaxed state.

Palmer (32) in his work at the Massachusetts General Hospital, reports a great deal of success with the use of potassium sulphocyanate. This work has been backed up by Mosenthal and Gager (45) who likewise report drops in blood pressure following careful administration of the drug. Mosenthal (45) reports a mild reaction of weakness and vertigo with an occasional dermatitis which is easily controlled in some cases.

Pacyl, a crystalline choline derivative, has been used with apparently beneficial results in Germany (52). Although there is no evidence of fall in blood pressure, there results a marked improvement in subjective symptoms following its administration.

The German investigator, Macht, has reported a certain number of successful cases in which the blood pressure was lowered considerably after usage of benzyl benzoate. (61). However, Warfield (61) could not find any appreciable change in his series of cases. He notes that there is an occasional drop in pressure, but he contends that this is due primarily to the rest the patients are given.

Because of the limitations of the vasodilators, and the belief that blood pressure is to a certain
extent the result of nervous tension, sedative administration has come to the fore. Barbital, phenobarbital, the bromides, and chloral have all been advocated. (52.)

Cucurbocitrine or citrine-watermelon seed extract was advocated by Barksdale (43) in 1926, for the treatment of essential hypertension. Some writers report favorable results, others not. Over long periods, it appears the drug has very little value.

Mistletoe has been used in France and Germany for some time. O'Hare and Mosenthal have found that it does not produce a drop in blood pressure, but that it does tend to alleviate headache, dizziness and other complicating secondary symptoms. (45, 46). Organic Extracts.

Alvarez and Zimmerman (5) show that the pressures of sexually abnormal women are higher than those of sexually normal women. As mentioned previously, it is believed that the ovary secretes a substance which prevents the development of hypertension. Kylin (49) has proposed the use of sexual gland extracts as a treatment. In some cases, where the sexual abnormality is in existence, the mode of attack appears quite logical. Whole ovarian residue
is administered intramuscularly. Although there has been no marked reduction in blood pressure reported by any of the workers in this phase of treatment, there has been marked improvement in subjective symptoms in nearly all cases. (5, 45, 49, 52).

Altnow and O'Hare (49) attempted to use parathyroid extract in hopes of reducing excessive vasoconstriction, through its action on blood calcium, the cerebral cortex and the sympathetic system. However, their success has been very limited.

Although the actual results of liver extract therapy is still a question, nevertheless much good has been reported in certain cases. O'Hare (49) frankly admits not having any success with the extract administration. However, he openmindedly hopes that good results will soon be seen with it. Major (40) reports marked success in his work—a decreased blood pressure in about 40%, and relief of symptoms in 80%. Likewise, MacDonald of Canada reports much success with the extract. (43). Mosenthal believes it will take time to definitely determine the actual results of this form of therapy.

Venesection

For many years the practice of "blood-letting" was thought to aid the patient in cardiac disease,
high blood pressure, infections, etc. In recent years we definitely find no changes as a result of venesection that aid the patient. Braas and Golden (10) find a slight momentary drop in blood pressure following venesection. However, this drop is immediately replaced by a rise to normal and in some cases to above normal. Experiments carried out by Robertson and Petter (56) bear out these findings. They find a drop in venous pressure and no drop in arterial pressure.
Part II.

Surgical Treatment of Essential Hypertension.
ANATOMICAL CONSIDERATIONS

As mentioned previously, evidence of varied nature indicates that the arterioles of the splanchnic region are constricted in patients suffering from essential hypertension, and this may be an important factor in maintaining the pressure at an elevated level. (42). Section of the anterior nerve roots close to the cord seems a method which should surely intercept both the normal and sympathetic innervation. Likewise, it is desirable that denervation be as complete as possible without interfering with vital functions. Anatomical considerations suggest this can best be done by section of the anterior nerve roots from the sixth thoracic segment to the second lumbar, inclusive. (1, 11, 16).

The sixth to the twelfth thoracic motor nerves innervate the intercostal muscles and the seventh to first lumbar nerves supply the abdominal musculature. The first lumbar root contributes branches to the ilioinguinal and iliohypogastric nerves, and sends fibers to the genito-femoral. The lateral cutaneous nerves receive fibers from the first, second and third lumbar roots. (35.)

The anterior nerve roots in the thoraco-lumbar region contribute to the innervation of the cutaneous...
vessels, pilomotor muscles and sweat glands. The major splanchnic nerves are derived from the fifth to the tenth thoracic segment, and the minor splanchnic from the ninth and tenth, or tenth to twelfth roots. These nerves join the celiac plexus. In this manner, connection is established with the stomach, liver, adrenals, pancreas, intestine and kidneys. Section of the sixth thoracic to the second lumbar roots, therefore, partially interrupts not only the motor nerve supply to the abdominal wall but the sympathetic supply of most of the abdominal viscera, except the colon, rectum, bladder and genital organs. The vagus and phrenic nerves and the intrinsic nerve supply remains intact to innervate the viscera. The inferior mesenteric ganglion also remains intact except for loss of some fibers from the second lumbar root.

SURGICAL APPROACH

In 1935, White (63), of the Massachusetts General Hospital, published a summary of the advances made in surgery of the sympathetic nervous system and he summarized the types of procedures in three groupings, namely:
- (a) Section of anterior nerve roots - rhizotomy.
(b) Resection of splanchnic nerves.
(c) Adrenal denervation or adrenalectomy.

However, Crile (16) in 1936, published a new form of operation, which incorporated the above named procedures, plus the further intricate and difficult resection of the celiac plexus, and denervation of the aorta. This will be considered later.

**Anterior Nerve Root Section - Rhizotomy.**

In 1889, J. Rose Bradford (9) found that stimulation of the anterior roots of the spinal nerves from the sixth dorsal to the second lumbar caused a rise in blood pressure, and contraction of the kidney, the greatest results being obtained by stimulation of the anterior roots of the tenth dorsal to the first lumbar. This finding tended to show that the arterioles of the splanchnic area, innervated by these fibers, were constricted in patients with hypertension, and this vasoconstriction was a factor in keeping the blood pressure at a constant high level. Upon this assumption, the belief that interruption, by surgical means, of nerves carrying afferent impulses to this area, would, therefore, appear to be a logical therapeutic measure.

In 1925, Rowntree and Adson, (57), reported
a case of malignant hypertension in which treatment was administered by performing a bilateral sympathetic ganglionectomy and trunk resection. This resection included the second, third and fourth lumbar sympathetic ganglia and intervening trunks, and was accomplished through a median abdominal incision. The results on the blood pressure and ultimate outcome were insignificant. It was apparent that the operation did not denervate sufficient arteries to change the systemic arterial pressure, and a more extensive operation was necessary.

In 1930, Adson (2) performed an operation on a patient suffering with malignant hypertension. In this case a bilateral section of the anterior and posterior roots, from the sixth thoracic to the second lumbar, was done through an approach afforded by laminectomy. The immediate results of this operation were highly successful, producing a drop in systolic and diastolic pressure, and alleviation of all secondary symptoms.

Adson and Brown (2), in 1934 performed a series of operations with good results, in which a bilateral section of the anterior nerve roots from the sixth thoracic to the second lumbar was done. Through this operation, they hoped to accomplish the loss of
va~omotor control to the splanchnic and peripheral arteries below the diaphragm, and the lowering of intra-abdominal pressure by paralyzing the abdominal muscles.

Other advocates of this form of surgery were Page and Heuer (31), who utilized the same laminectomy approach. They exposed and removed the laminae corresponding to the sixth thoracic to the second lumbar vertebrae, incised the dura mater and exposed the cord. The anterior nerve roots were exposed and separated from the cord, and divided midway, between their point of origin and union, with the posterior roots. The wound was then closed throughout with silk. Following surgery in a patient, they found a drop in blood pressure to normal for seven months with complete loss of blood pressure symptoms. No effect was found on kidney function by renal denervation.

Heuer (27), in 1935 published the results seen in nine patients who were operated on for essential hypertension by anterior nerve root section. The disabilities of operation were not serious. The bladder and bowel activity returned to normal in twenty four hours. The paralysis of the abdominal muscles seemed of little consequence.
Case | Initial D.P. | P. O. Bl. Pr. | 1 mo. P. O. | 3 mos. P. O. | Rt. | Sect.
--- | --- | --- | --- | --- | ---
1 | 132/120 | 130/32 | 124/92 | 6T - 2L | 6T - 2L
2 | 130/118 | 136/92 | 122/32 | 9T - 1L | 9T - 1L
3 | 218/138 | 144/92 | 140/30 | 9T - 1L | 9T - 1L
4 | 200/113 | 140/100 | 142/102 | 9T - 1L | 9T - 1L
5 | 220/144 | 120/30 | 144/34 | 9T - 1L | 9T - 1L
6 | 220/120 | 120/32 | - | 6T - 12T | 6T - 12T
7 | 210/124 | 160/105 | - | 7T - 12T | 7T - 12T
8 | 240/160** | 230/120 | 246/140 | 9T - 12T | 9T - 12T
9 | 250/160** | **Died at end of operation.**

**Died four months after operation.**

The disabilities as mentioned before were not serious. In most cases, the results seen at the end of three months were very favorable. However, this cannot be considered as final proof of the value of this type of operation as the time element is too short.

Smithwick (58) believes that the anterior root section method employed by Adson and Neuer carries a great surgical risk inasmuch as it is so extensive. He points out that paralysis of the abdominal muscles and back muscles tends toward disability and possible paraplegia. Moreover, he points out,
the degree of lowering of blood pressure level does not appear to be greater than that obtained in simpler ways.

**Splanchnic Nerves Resection.**

In 1921, Jean (7) proposed the resection of the splanchnic nerves for relief of gastric crises. In 1923, Danielopolu, considering the importance of the splanchnic nerves in the regulation of arterial pressure, conceived the idea of resecting them for treatment of hypertension. In the same year, Fritz Brüning (7) suggested the same surgical procedure, and in 1924, Pende (7) proposed a surgical treatment for essential hypertension which consisted of resecting the left splanchnic nerves. Pieri, (7), in 1927, performed a unilateral resection of the splanchnic nerves in the treatment of intestinal atony. In 1930, he followed up this work with two successfully carried out resection of splanchnic nerves in patients suffering with arterial hypertension.

Brown and McKCraig (12), in 1933, working in the Mayo Clinics reported the results of several cases on whom splanchnic nerve resection had been done. They employ the infra-diaphragmatic, posterior approach and resect the major and minor splanchnic
nerves as they descend through the diaphragmatic crura. At the same time, they remove the first lumbar ganglion. They believe that there is very little surgical risk following this approach. Although they have met with a good deal of success, they still feel that following the resection of the splanchnics and section of the sympathetic trunk that certain fibers remain, coming up from the lower lumbar ganglia and by way the aorta.

They suggest that it is foolish to believe that any operation on the sympathetic nervous system will produce marked reduction in the systemic blood pressure in the presence of marked organic narrowing of the arterioles. They advocate that this operation should be further applied to young adults who have essential hypertension with excessive variability of the blood pressure, and in whom there are minimal degrees of organic change in retinal and muscular arterioles.

Peet (54), probably has the greatest amount of success with this type of operation than any of the workers. He modifies his approach by entering above the diaphragm and removing the lower rib. He reports good-after-results in nearly all his cases.
Biagard and Sharpe (7), report the successful results in a fifteen year old girl who had been carrying a persistent high blood pressure for a long time. They employed the same approach advocated by Peet. The first operation only involved the removal of the minor splanchnics bilaterally, and the unilateral removal of the major splanchnics. There was some improvement for a short time, but a gradual tendency toward the pre-operative condition became prevalent so the other remaining major splanchnic nerve was removed with marked improvements in symptoms and drop in blood pressure.

By this type of operation, they have produced three physiological effects, namely:

(a) Removed vasoconstriction from the splanchnic bed and reduced much peripheral resistance.

(b) Denervated the suprarenals and prevented neurogenic stimulation of the secretion of epinephrine.

(c) Improved renal function by establishing a more normal flow of blood through the kidneys and an exchange at a lower arteriolar tension.

Koenigsberger (33), reports one case of essential hypertension treated by unilateral splanchnic nerve
resection with great improvement in blood pressure and symptoms.

Smithwick (58) believes this method best because it is comparatively simple, has no sequelae, and has a very low mortality. He, likewise, uses Peet's technique. He also suggests that cases for surgery should be carefully selected, and that the greatest benefit is derived, when the operation is performed early in the disease. He points out that many poor results are due to the fact that the hypertension is on a nephritic basis.

His early attempts at treatment of the disease consisted of injecting the splanchnic nerves with alcohol-bilaterally. In some cases, he noticed a transient fall but this was not permanent.

Adson (1) in 1935, reports a series of cases in which bilateral ventral rhizotomy and bilateral splanchnic nerve resection was done, separately. He believes that the bilateral ventral rhizotomy was best as it was more effective in producing permanent beneficial changes.

Adrenal Denervation and Adrenalectomy.

In 1929, Galata and Antonucci removed one entire suprarenal gland in a woman, with marked relief of hypertension symptoms and blood pressure.
In 1932, Pieri removed the suprarenal gland with diminution of hypertension symptoms.

Goldblatt (22) has shown by producing renal ischemia in rabbits by clamping off the renal arteries, that a persistent increased systolic blood pressure results. He believes this is due to either of two factors:

(a) Brings about increased output of internal secretion which may affect general vasoconstriction and raise the blood pressure. Or,

(b) Sets up afferent impulses from affected nerve endings in the ischemic kidney to the vaso-motor center or sympathetic ganglia producing vaso-constriction and consequent high blood pressure.

DeCourcy (17) believes that essential hypertension is due to an endocrine dyscrasia and that the suprarenals are responsible. He performs a two stage operation approaching through a kidney incision. The suprarenal gland is stripped down of all fat and overlying structures. A portion, consisting of both medulla and cortex, and farthest removed from the blood supply, is clamped down and excised then sutured with continuous lockstitch sutures. They use spinal anesthesia. They report the findings of cortical tumors twice in six cases operated on.
They claim that in all cases of hypertension, it is always possible to demonstrate hyperplasia of the suprarenal medulla.

Pitrowski and Ody (55) report the cure of essential hypertension by removal of the suprarenal gland. Complete loss of symptoms followed removal. On histologic examination of the cortical substance of the gland, definite hypertrophy of the glandular and secretory elements was seen. Of interest is the fact that a diagnosis of adrenal tumor was made preoperatively.

Many writers disapprove of this plan of action in treating hypertension. Smithwick (58) points out the great possibility of developing Addison's disease in these individuals. He likewise cites cases of individuals who possess an anomalous condition of having only one gland.

Aortic and Carotid Sinus Denervation

Kremer, Wright and Scarff (34) in 1933 found that by removing the carotid sinus and aortic sinus (buffer nerves) in rabbits there resulted a marked elevation in blood pressure, which tended to remain persistently high. Likewise, Green (23), found that by denervating the carotid sinus, and sectioning the depressor nerves, he could produce an increase in
After a pressure which continued to remain high.

Crile (16) in his review of eight hundred and twenty-two operations, 1936, proposes to show that essential hypertension is an example of pathologic physiology of the adrenal medulla-sympathetic complex. He believes essential hypertension to be a "universal Raymond's Disease."

He first performed adrenalectomies and denervation of the adrenals, and then followed this with splanchnic nerve section. His results, as far as symptomatic relief is concerned, were good, but there resulted little change in blood pressure. He felt that some other factor was responsible, just as Brown and McKCraig (12) did, and that it extended to the aorta itself. Of late, he has resected the celiac ganglion, and denervated the aorta in twenty-five cases in the most advanced state of hypertension. He employs the retroperitoneal approach and performs the operation in one sitting. There is very little shock and little surgical risk. He finds that there results a drop in blood pressure to normal, and tends to remain stable. His patients report greater improvement in general—kidney function is better; eye grounds appear better, and marked improvement is seen in general.
PREOPERATIVE INDICATIONS FOR SURGERY

Much discussion has arisen as to the type of individual, and involvement of the disease, as a criterion for surgery. As Brown and McKCraig (12), suggest-select only young adults with minimal degrees of organic and arterial change. Others advocate the same. However, even in these young individuals, there may be advanced arterial changes so as to offer no remedy following surgical treatment.

In regards this matter many tests and experiments have been utilized to determine the flexibility of blood pressure. Following anesthesia, the blood pressure should drop and this amount of drop determines the possibility of surgery in the patient.

Allen, Lundy, and Adson (4) have produced an anesthetic which definitely determines the flexibility of blood pressure in surgical patients. They utilize the intervenous injection of a solution of pentathol sodium which causes a drop in blood pressure similar to spinal anesthesia. They administer twelve daily injections and if the patient gives a satisfactory response, the indication is that the patient has a good preoperative chance. The technique used employs administration of the drug for about fifteen minutes which requires about fifteen to twenty g. c. As the
temperatures in the toes rises, the blood pressure readings are taken, until the maximum amount of heat is liberated. The lowest reading during this period determines the preoperative prediction.

Other workers (2, 11, 12, 51, 28) have utilized spinal anesthesia, sodium amytal and general anesthetics with reported good results.

Other factors to be considered are age of the patient, duration and progression of the hypertension, renal and myocardial function, and clinical evidence of the status of the cerebral circulation.
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