Hyaline degeneration may attack either the larger or the smaller vessels. In the former the intima is converted into a smooth, homogeneous substance, and it is commonly an initial stage of arterio-sclerosis. In the smaller arteries and capillaries the hyaline degeneration is often seen, particularly in the glomeruli of the kidney. Its exact production is still a matter of some doubt. "It appears to arise principally by homogeneous coagulation of an albuminous fluid, either within the vessels or infiltrating the cells and the hyaline transformation of proliferating cells and of leucocytes."

II. ARTERIO-SCLEROSIS (*Arterio-capillary Fibrosis*).

The conception of arterio-sclerosis as an independent affection—a general disease of the vascular system—is due to Gull and Sutton.

Definition.—A condition of thickening, diffuse or circumscribed, of the intima, consequent upon primary changes in the media and adventitia. The process leads, in the larger arteries, to what is known as atheroma or endarteritis deformans.

Etiology.—(1) As an involution process arterio-sclerosis is an accompaniment of old age, and is the expression of the natural wear and tear to which the tubes are subjected. Longevity is a vascular question, and has been well expressed in the axiom that "a man is only as old as his arteries." To a majority of men death comes primarily or secondarily through this portal. The onset of what may be called physiological arterio-sclerosis depends, in the first place, upon the quality of arterial tissue (vital rubber) which the individual has inherited, and secondly upon the amount of wear and tear to which he has subjected it. That the former plays the most important *rôle* is shown in the cases in which arterio-sclerosis sets in early in life in individuals in whom none of the recognized etiological factors can be found. Thus, for instance, a man of twenty-eight or twenty-nine may have arteries of sixty, and a man of forty may present vessels as much degenerated as they should be at eighty. Entire families sometimes show this tendency to early arterio-sclerosis, a tendency which cannot be explained in any other way than that in the make-up of the machine bad material was used for the tubing.

More commonly the arterio-sclerosis results from the bad use of good vessels, and among the circumstances which tend to produce this condition are the following:

(2) *Chronic Intoxications.*—Alcohol, lead, gout, and syphilis play an important *rôle* in the causation of arterio-sclerosis, although the precise mode of their action is not yet very clear. They may act, as Traube suggests, by increasing the peripheral resistance in the smaller vessels and in this way raising the blood tension, or possibly, as Bright taught, they alter

the quality of the blood and render more difficult its passage through the capillaries.

The poison of syphilis and of gout may act directly on the arteries, producing degenerative changes in the media and adventitia.

(3) *Overeating.*—Many authors attribute an important part of the etiology of arterio-sclerosis to the overfilling of the blood-vessels which occurs when unnecessarily large quantities of food and drink are taken. Particularly is this the case in stout persons who take very little exercise.

(4) *Overwork of the muscles*, which acts by increasing the peripheral resistance and by raising the blood-pressure.

(5) *Renal Disease.*—The relation between the arterial and kidney lesions has been much discussed, some regarding the arterial degeneration as secondary, others as primary. There are certainly two groups of cases, one in which the arterio-sclerosis is the first change, and the other in which it appears to be secondary to a primary affection of the kidneys. The former occurs, I believe, with much greater frequency than has been supposed.

Morbid Anatomy.—Thoma divides the cases into *primary* arterio-sclerosis, in which there are local changes in the arteries leading to dilatation and a compensatory increase of the connective tissue of the intima; *secondary* arterio-sclerosis, due to changes in the arteries which follow increased resistance to the blood-flow in the peripheral vessels. This increased tension leads to dilatation and to slowing of the blood-stream and a secondary compensatory development of the intima.

In a recent study of 41 autopsies upon arterio-sclerotic cases from my wards, Councilman * follows the useful division into nodular, senile, and diffuse forms.

(*a*) *Nodular Form.*—In the circumscribed or nodular variety the macroscopic changes are very characteristic. The aorta presents, in the early stages, from the ring to bifurcation, numerous flat projections, yellowish or yellowish white in color, hemispherical in outline, and situated particularly about the orifices of the branches. In the early stage these patches are scattered and do not involve the entire intima. In more advanced grades the patches undergo atheromatous changes. The material constituting the button undergoes softening and breaks up into granular material, consisting of molecular *débris*—the so-called atheromatous abscess.

In the circumscribed or nodular arterio-sclerosis the primary alteration consists in a degeneration or a local infiltration in the media and adventitia, chiefly about the vasa vasorum. The affection is really a mesarteritis and a periarteritis. These changes lead to the weakening of the wall in the affected area, at which spot the proliferative changes commence in the intima, particularly in the subendothelial structures, with gradual thick-

* Transactions of the Association of American Physicians, vol. vi.

ening and the formation of an atheromatous button or a patch of nodular arterio-sclerosis. The researches of Thoma have shown that this is really a compensatory process, and that before its degeneration the nodular button, which post mortem projects beyond the lumen, during life fills up and obliterates what would otherwise be a depression of the wall in consequence of the weakening of the media. A similar process goes on in the smaller vessels, and in any one of the smaller branches it can be readily seen on section that each patch of endarteritis corresponds to a defect in the media and often to changes in the adventitia. The condition is one which may lead to rapid dilatation or to the production of an aneurism, particularly in the early stage, before the weakened spot is thickened and strengthened by the intimal changes.

(*b*) *Senile Arterio-sclerosis.*—The larger arteries are dilated and tortuous, the walls thin but stiff, and often converted into rigid tubes. The subendothelial tissue undergoes degeneration and in spots breaks down, forming the so-called atheromatous abscesses, the contents of which consist of a molecular *débris*. They may open into the lumen, when they are known as atheromatous ulcers. The greater portion of the intima may be occupied by rough calcareous plates, with here and there fissures and losses of substance, upon which not infrequently white thrombi are deposited. Microscopically there is extreme degeneration of the coats, particularly of the media. Senile atrophy of the liver and kidneys usually accompanies these changes. Senile changes are common in other organs. The heart may be small and is not necessarily hypertrophied. In 7 of 14 cases of Councilman's series there was no enlargement. Brown atrophy is common

(*c*) *Diffuse Arterio-sclerosis.*—The process is wide-spread throughout the aorta and its branches, in the former usually, but not necessarily, associated with the nodular form. The subjects of this variety are usually middle-aged men, but it may occur early. Of the 27 in Councilman's series belonging to this group the majority were between the ages of forty and fifty-five. The youngest was a negro of twenty-three and the oldest a man of sixty. The affection is very prevalent among negroes; less than fifty per cent were in whites, whereas the ratio of colored to white patients in the wards is one to seven. The affection is met with in strongly built, muscular men and, as Councilman remarks, they rarely present on the autopsy table signs of general anasarca or, if œdema exists, it has come on during the last few days of life.

The aorta and its branches are more or less dilated, the branches sometimes more than the trunk. The intima may be smooth and show very slight changes to the naked eye; more commonly there are scattered elevated areas of an opaque white color, some of which may have undergone atheromatous changes as in the senile form. Microscopically the *media* shows necrotic and hyaline changes, involving in the larger arteries both muscular and elastic elements, and the *intima* presents a great increase

in the subendothelial connective tissue, which is particularly marked opposite areas of advanced degeneration in the media. The small arteries—those of the kidneys, for example—show "a thickening of the wall, due to the formation of a homogeneous hyaline tissue within the muscular coat. This tissue contains but few cells, is faintly striated, and stains a light brown in the osmic acid used in the hardening solution. In many of the smallest vessels nothing can be seen of the elastic lamina, in others only fragments can be made out, in others it is preserved. . . . The muscular fibres of the media show marked atrophic changes. Fatty degeneration of the cells can be made out both in fresh sections and after hardening in Fleming's solution. The nuclei are thin and atrophic and vacuoles are sometimes seen in them. In some arteries the muscle-fibres have almost disappeared and the media is changed into a homogeneous tissue, similar to that in the thickened intima" (Councilman). The degeneration of the media is most marked in the smaller arteries. The capillaries are thickened, particularly those of the glomeruli of the kidneys, which are often obliterated and involved in extensive hyaline degeneration.

It is in this group of cases that the heart shows the most important changes. The average weight in the cases referred to was over 450 grammes, and there were two cases in which without valvular disease the weight was over 800 grammes. Fibrous myocarditis is often present, particularly when the coronary arteries are involved. The semilunar valves are sometimes opaque and sclerotic, and may be incompetent. The kidneys may show extensive sclerosis, but in many cases the changes are so slight that macroscopically they might be overlooked. They may be increased in size. The capsule is usually adherent, the surface a little rough, and very often presents atrophic areas at a lower level of a deep-red color. Increased consistence is always present.

Sclerosis of the pulmonary artery is met with in all conditions which for a long time increase the tension in the lesser circulation, particularly in mitral-valve disease and in emphysema. Sometimes the sclerosis reaches a high grade and is accompanied with aneurismal dilatation of the primary and secondary branches, more rarely with insufficiency of the pulmonary valve. In a remarkable case of a young man of twenty-four, reported by Romberg from Curschmann's clinic, the pulmonary arteries were involved in most extensive arterio-sclerosis; the main branches were dilated, and the smaller branches were the seat of the most extreme sclerotic changes. On the other hand, the aorta and its branches were normal. The heart was greatly hypertrophied, and the clinical symptoms were those of a congenital heart affection. In many cases of arterio-sclerosis the condition is not confined to the arteries, but extends not only to the capillaries but also to the veins, and may properly be termed *angio-sclerosis.*

Sclerosis of the veins—*phlebo-sclerosis*—is not at all an uncommon accompaniment of arterio-sclerosis, and is a condition to which of late a good deal of attention has been paid. It is seen in conditions of height-

ened blood-pressure, as in the portal system in cirrhosis of the liver and in the pulmonary veins in mitral stenosis. The affected vessels are usually dilated, and the intima shows, as in the arteries, a compensatory thickening, which is particularly marked in those regions in which the media is thinned. The new-formed tissue in the endophlebitis may undergo hyaline degeneration, and is sometimes extensively calcified. In a case of fibroid obliteration of the portal vein of long standing, I found the intima of the greatly dilated gastric, splenic, and mesenteric extensively calcified. In ordinary diffuse arterio-sclerosis the veins may also be involved, but rarely to a marked degree.

Symptoms.—Many patients never come under observation during life, but are seen for the first time on the post-mortem table, having died suddenly from cerebral hæmorrhage, blocking of a coronary artery, or rupture of an aneurism.

Among important symptoms are the following:

Increased Tension.—The pressure with which the blood flows in the arteries depends upon the degree of peripheral resistance and the force of the ventricular contraction. A high-tension pulse may exist with very little arterio-sclerosis; but, as a rule, when the condition has been persistent, the sclerosis and high tension are found together. The pulse wave is slow in its ascent, enduring, subsides slowly, and in the intervals of the beats the vessel remains full and firm. It may be very difficult to obliterate the pulse, and the firmest pressure on the radial or the temporal may not be sufficient to annihilate the pulse wave beyond the point of pressure. The sphygmographic tracing shows a sloping, short upstroke, no percussion wave, and a slow, gradual descent, in which the dicrotic wave is very slightly marked. It may be difficult to estimate how much of the hardness and firmness is due to the tension of the blood within the vessel, and how much to the thickening of the wall. If, for example, when the radial is compressed with the index-finger the artery can be felt beyond the point of compression, its walls are sclerosed.

Hypertrophy of the Heart.—In consequence of the peripheral resistance and increased work the left ventricle increases in size, and some of the purest examples of simple hypertrophy occur in this condition. The chamber may be little, if at all, dilated. The apex beat is dislocated in advanced cases an inch or more beyond the nipple line. The impulse is heaving and forcible. The aortic second sound is clear, ringing, and accentuated.

The combination of increased arterial tension, a palpable thickening of the arteries, hypertrophy of the left ventricle, and accentuation of the aortic second sound are signs pathognomonic of arterio-sclerosis. From this period of establishment the course of the disease may be very varied. For years the patient may maintain good health, and be in a condition analogous to a person with a well-compensated valvular lesion. There may be no renal symptoms, or there may be the passage of a larger

amount of urine than normal, with transient albuminuria, and now and then hyaline tube-casts. The subsequent history is extraordinarily diverse, depending upon the vascular territory in which the sclerosis is most advanced, or upon the accidents which are so liable to happen, and the symptoms may be cardiac, cerebral, renal, etc.

(1) *Cardiac.*—The involvement of the coronary arteries may lead to the various symptoms already referred to under that section—thrombosis with sudden death, fibroid degeneration of the heart, aneurism of the heart, rupture, and angina pectoris. Angina pectoris is extremely common, and in the true variety is almost always associated with arterio-sclerosis. A second important group of cardiac symptoms results from the dilatation which ultimately may follow the hypertrophy. The patient then presents all the symptoms of cardiac insufficiency—dyspnœa, scanty urine, and very often serous effusions. If the case has come under observation for the first time the clinical picture is that of chronic valvular disease, and the existence of a loud blowing murmur at the apex may throw the practitioner off his guard. Many cases terminate in this way.

(2) The *cerebral* symptoms of arterio-sclerosis are varied and important, and embrace those of many degenerative processes, acute and chronic (which follow sclerosis of the smaller branches), and cerebral hæmorrhage, which is usually associated with the miliary aneurisms.

Transient hemiplegia, monoplegia, or aphasia may occur in advanced arterio-sclerosis. Recovery may be perfect. It is difficult to say upon what these attacks depend. Spasm of the arteries has been suggested, but the condition of the smaller arteries is not very favorable to this view. Peabody has recently called attention to these cases, which are more common than indicated in the literature.

(3) *Renal* symptoms supervene in a large number of the cases. A sclerosis, patchy or diffuse, is present in a majority of the cases at the time of autopsy, and the condition is practically that of contracted kidneys. It is seen in a typical manner in the senile form, and not infrequently develops early in life as a direct sequence of the diffuse variety. It is often difficult to decide clinically (and the question is one upon which good observers might not agree in a given case) whether the arterial or the renal disease has been primary.

(4) Among other events in arterio-sclerosis may be mentioned gangrene of the extremities, due either directly to endarteritis or to the dislodgment of thrombi. Respiratory symptoms are not uncommon, particularly bronchitis and the symptoms associated with emphysema.

Treatment.—In the late stages the conditions must be treated as they arise in connection with the various viscera. In the early stages, before any local symptoms are manifest, the patient should be enjoined to live a quiet, well-regulated life, avoiding excesses in food and drink. It is usually best to explain frankly the condition of affairs, and so gain his intelligent co-operation. Special attention should be paid to the state of

the bowels and urine, and the secretion of the skin should be kept active by daily baths. Alcohol in all forms should be prohibited, and the food should be restricted to plain, wholesome articles. The use of mineral waters or a residence every year at one of the mineral springs is usually serviceable. If there has been a syphilitic history an occasional course of iodide of potassium is indicated, and whenever the pulse tension is high nitroglycerine may be used.

In cases which come under observation for the first time with dyspnœa, slight lividity, and signs of cardiac insufficiency, venesection is indicated. In some instances, with very high tension, striking relief is afforded by the abstraction of twenty ounces of blood.

III. ANEURISM.

The following forms of aneurism are usually recognized:

(*a*) The *true*, in which the sac is formed of one or more of the arterial coats. This may be fusiform, cylindrical, or cirsoid (in which the dilatation is in an artery and its branches), or it may be circumscribed or sacculated. Aneurisms are usually fusiform, resulting from uniform dilatation of the vessel, or saccular.

(*b*) The *false* or *dissecting* aneurism, which results from injury or laceration of the internal coat. The blood dissects between the layers; hence the name, dissecting aneurism. This occurs usually in the aorta. It may dissect the entire length of the vessel, and, perforating into the lumen of the vessel, may, as in a case reported by J. E. Graham, persist for years.

(*c*) *Arterio-venous* aneurism results when a communication is established between an artery and a vein. A sac may intervene, in which case it is called a varicose aneurism; but in many cases the communication is direct and the chief change is in the vein, which is dilated, tortuous, and pulsating, and is termed an aneurismal varix.

Etiology and Pathology.—Aneurisms arise: (*a*) By the gradual diffuse distention of the arterial coats, which have been weakened by arterio-sclerosis, particularly in its early stages, before compensatory endarteritis develops. The arch of the aorta is often dilated in this way so as to form an irregular aneurism.

(*b*) In consequence of circumscribed loss of resisting power in the media and adventitia, and due often to laceration of the media. This is the most common cause of sacculated aneurism. The laceration is frequently found in the ascending portion of the arch and occurs early in the process of arterio-sclerosis, before the compensatory thickening has taken place. Occasionally one meets with remarkable specimens illustrating the important part played by this process. The intima may also be torn. In a case of Daland's there was just above the aortic valves

an old transverse tear of the intima, extending almost the entire circumference of the vessel. Sclerosis of the media and adventitia had taken place and the process was evidently of some standing. An inch or more above it was a fresh transverse rent which had produced a dissecting aneurism. These arterio-sclerotic aneurisms, as they are called, are found also in the smaller vessels.

(*c*) *Embolic Aneurism.*—When an embolus has lodged in a vessel and permanently plugged it, aneurismal dilatation may follow on the proximal side. The embolus itself may, if a calcified fragment from a valve, lacerate the wall, or if infected may produce inflammation and softening. In either case aneurism may result.

(*d*) *Mycotic Aneurism.*—The importance of this form has been specially considered by Eppinger in his exhaustive monograph. The occurrence of multiple aneurisms in malignant endocarditis has been observed by several writers. Probably the first case in which the mycotic nature was recognized was one which occurred at the Montreal General Hospital and is reported in full in my lectures on malignant endocarditis. In addition to the ulceration of the valves there were four aneurisms of the arch, of which one was large and saccular, and three were not bigger than cherries. An extensive growth of micrococci was present in the larger as well as in the smaller sacs.

A form of parasitic aneurism which occurs with great frequency in the mesenteric arteries of the horse is due to the development of the *strongylus armatus*.

And, lastly, there are cases in which without any definite cause there is a tendency to the development of aneurisms in various parts of the body. A remarkable instance of it in our profession was afforded by the brilliant Thomas King Chambers, who first had an aneurism in the left popliteal artery, eleven years subsequently an aneurism in the right leg which was cured by pressure, and finally aneurism of both carotid arteries.

Aneurism of the Thoracic Aorta.

The causes which favor the development of arterio-sclerosis prevail in aortic aneurism, particularly alcohol, syphilis, and overwork. The greatest danger probably is in strong muscular men with commencing degenerative processes in the arteries (a consequence of syphilis or alcohol or a result of hereditary weakness of the arterial tissues), who during a sudden muscular exertion are liable to lacerate the media, the intima not yet being strengthened by compensatory thickening over a spot of mesarteritis. Aneurisms of the thoracic aorta vary greatly in size and shape. A majority of them are saccular. They may be small and situated just above the aortic ring. Others form large tumors which project externally and occupy a large portion of the upper thorax. Small sacs from the descending portion of the arch may compress the trachea or the bronchi. In the tho-