

## A REVIEW OF PERIPHERAL VASCULAR DISEASE\*

JOHN TUCKER, M. D.

### GENERAL CONSIDERATIONS

The modern conception of peripheral vascular disease has been clarified to a considerable degree during the past decade by a better understanding of the physiology of the arterioles and capillaries. Hundreds of articles have been published by various investigators who have made intensive studies of the peripheral circulation in animals and in man. As the result of this work, a much better classification has been evolved, which is based on special diagnostic tests and on the results of medical and surgical therapy.

The picture of peripheral vascular disease is very complicated. While the most frequently encountered conditions are Buerger's disease, arteriosclerosis, embolism and thrombosis, Raynaud's disease, erythromelalgia, and acrocyanosis, many other morbid changes may occur in the peripheral circulation and these merit thoughtful attention.

How shall we attack this problem? It is evident that the first consideration must deal with the patient as a whole. Is he well nourished or does he suffer from malnutrition and deficiency disease? Does he have arterial hypertension or hypotension, arteriosclerosis or diabetes? Is he suffering from rheumatic, syphilitic, or arteriosclerotic heart disease? Does he carry executive responsibilities? What are his habits of living? Is he intemperate in the use of alcohol and tobacco? These and many other questions must be settled by means of a painstaking history, physical examination, and laboratory tests. Our first approach, then, must consist of a careful survey of the patient as a whole. This procedure alone will, in many instances, suggest the type of peripheral vascular disease which is producing the symptoms.

We have, as yet, no satisfactory diagnostic criteria for vascular lesions of the viscera except for the heart itself; however, the circulation of the extremities is quite available for interpretive study.

It is necessary to make a few comments in regard to the physiology of the peripheral vessels. The fluctuation in the peripheral tone of these vessels of the extremities varies with the external temperature, the internal heat of the body, and the emotions. Sir Thomas Lewis<sup>1</sup> describes the reaction to cold as first vasoconstriction followed by vasodilatation, the so-called "axon reflex." In the control of the body temperature, the skin dissipates 76 per cent

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of the total heat by convection and radiation, while 24 per cent occurs through vaporization of sweat and through loss of water vapor from the lungs. During hard labor, however, most of the heat loss is brought about by vaporization of sweat. The extremities, which comprise about 65 per cent of the body surface and which contain no vital organs, are important structures for heat regulation. This function requires a very delicate vascular control, especially since the arms and legs are exposed much more to sudden changes in temperature than other parts of the body with the exception of the face.

Krogh<sup>2</sup> has shown that the arterioles and capillaries are sensitive to hormonal influences; however, for our purpose, we will accept the hypothesis that the major control is through the sympathetic nervous system. These vasomotor nerves, when activated, cause constriction of the arterioles. There is no conclusive evidence to prove that vasodilator nerves exist in man.

The postganglionic fibers of the sympathetic nervous system accompany the spinal nerves and supply the blood vessels, sweat glands, and pilomotor muscles of the periphery. This fact is easily demonstrated, for if we cut the ulnar nerve, for example, there results not only anesthesia in the skin supplied by this nerve but also a loss in vascular tone.

The diseases which affect the extremities are many and varied; however, our ability to properly classify these abnormal states depends on the diagnostic methods that we use.

### DIAGNOSTIC MEASURES

In this discussion we wish to stress particularly those procedures which are not only simple in nature but also those which can be used by the physician at the bedside without special instruments of precision.

#### A. INSPECTION OF THE EXTREMITIES

1. Pallor is present when the superficial blood vessels are empty or only partially filled. If it becomes more marked when the extremity is elevated slightly above the level of the heart, there is probably structural impairment of the circulation. If the pallor is associated with coldness, there is deficient arterial flow. This becomes still more evident if cyanosis develops when the limb is placed below the horizontal level.

2. Redness indicates a superficial dilatation of the capillaries. If the rubor is cold, there is capillary stasis associated with diminished inflow of blood. If the skin is red and warm, there is increased minute volume flow through the capillaries.

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3. Cyanosis is produced by an insufficient supply of oxygen in the vessels of the skin. When the cyanosis fails to disappear with the local application of heat to the limb, as with an infra red lamp, there is probably organic obstruction of the arterioles.

4. Ulceration, when chronic and indolent, is produced by impaired arterial flow plus infection.

5. Gangrene in the extremity is the result of a prolonged impairment in the arterial blood supply.

### B. OBSERVATION OF POSTURAL CHANGES IN THE EXTREMITIES

1. Deepening cyanosis in a dependent limb is produced by stasis in toneless superficial vessels.

2. Rubor on dependence of the limb indicates dilatation of the vessels of the skin. This is often due to local injury of the capillaries.

3. Rubor and cyanosis on dependence of the limb indicate that there is dilatation of the capillaries plus marked impairment in the minute volume flow of blood through the affected extremity.

### C. PALPATION OF BLOOD VESSELS IN THE EXTREMITIES

Usually one can feel pulsation in the normal arteries when the body and limbs are warm. However, this is modified considerably by the amount and character of the tissues which surround the artery and also by the location of these vessels which may, in certain instances, take an unusual course. While a good pulsation may be felt in the larger artery, the spasm or obstruction may be more distally placed in the arterioles or capillaries. On the other hand, absent pulsation may not be inconsistent with adequate capillary circulation. Reich<sup>3</sup> has shown that, in normal people, the dorsalis pedis pulsation is absent in 4 per cent and abnormally placed in 8 per cent, while the posterior tibial pulsation is absent in 5 per cent. We should not rely too greatly on the significance or absence of pulsation in the pedal arteries. As a routine measure, however, we should feel for the pulsation in all palpable arteries including the digital, radial, brachial, axillary, dorsalis pedis, posterior tibial, popliteal, and femoral.

The simple methods of palpation and inspection, when correlated with the general condition of the patient, will, in the majority of cases, tell us all we need to know about the dynamics of the peripheral circulation.

In certain instances, however, it may be necessary to employ more elaborate diagnostic procedures. These include:

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1. Surface temperature readings by the electric thermocouple. By this method the gradient of temperature change is determined at various points from the proximal to the distal portions of the extremity. This is compared with the readings on the normal side. Any sudden decrease in the temperature indicates an impairment in the circulation.

2. Oscillometry, as employed by the Pachon oscillometer, gives the pulsation of the sum total of the arteries in the limb.

3. Reaction to histamine is employed especially to determine the optimum level for amputation. It indicates the available flow of blood into the skin and gives some idea of the efficiency of the collateral circulation. The method used is to maintain the limb in a horizontal position at room temperature. The histamine, 0.1 cc. of 1:1000 solution, is injected intracutaneously. The wheal and flare should appear within five minutes and manifest a certain redness and size. This procedure has certain value when compared with other diagnostic measures.

### D. DIFFERENTIATION OF STRUCTURAL DISEASE FROM VASOSPASTIC DISORDERS

From a therapeutic standpoint, we are able, in most cases, to differentiate structural disease from vasospastic disorders; also we can evaluate the degree of vasospasm and the probable success of sympathectomy. This requires a period of observation in the hospital for a week or more.

1. The most satisfactory test is the determination of the effect on the peripheral circulation of an increase of the internal production of heat. Normally, there is vasodilatation of the arterioles of the extremities when the temperature of the body is elevated above the normal range. The use of a hot tub bath, rubber blanket, heat cabinet, or typhoid shock are all valuable in selected cases. It is best to estimate change in the peripheral temperature by use of the electric thermocouple. Readings on the sound and affected limb are compared to determine the degree of change. It is obvious that this method should not be used in aged and debilitated patients or in those individuals who have cardiovascular renal disease.

2. A second important method of study is to block the sympathetic pathways to the peripheral vessels. This can be brought about in the lower limbs by spinal anesthesia and peripheral nerve block. Similar effects can be obtained in all four extremities by the use of general anesthesia. Details of the technique are available in the publications of Morton and Scott<sup>4</sup>.

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3. In a few cases where the site of vascular obstruction is still obscure, information of value can be obtained by arteriography. When thorium dioxide is injected into the arteries proximal to the region of impaired circulation and roentgenograms of the affected extremity are made, details of the arterial and capillary circulation can be visualized. This method may serve to differentiate between thrombo-angiitis obliterans and arteriosclerosis. In the former there is often increased capillary circulation while in the latter, the anastomotic channels are limited in number. Considerable experience is required to interpret the roentgenograms.

The recognized diseases of the peripheral vascular system may be divided into organic and vasospastic. The principal points of diagnostic importance in those diseases which we commonly see in our daily practice are noted below.

### ORGANIC LESIONS

#### A. *Thrombo-angiitis obliterans*

1. A disease of active maturity.
2. More common in men.
3. Most frequently observed in Hebrews.
4. Commonly associated with the excessive use of tobacco.
5. Pallor of extremity when elevated 90 to 180 degrees.
6. Flushing of the dependent limb.
7. Diminished pulsation in the arteries of the feet.
8. Pallor of foot on passive motion.
9. Migrating phlebitis in from 20 to 25 per cent of cases.
10. Associated scleroderma (occasionally).
11. Trophic changes, i.e., superficial blebs, desquamation.
12. Arteries seldom visualized by plain roentgenograms.
13. Increased collateral circulation by arteriography.

#### B. *Arteriosclerotic gangrene*

1. Cardiac hypertrophy, hypertension, palpable thickening of arteries, accentuated aortic second sound.
2. Arteriosclerosis of fundus and conjunctival vessels.
3. Calcification of larger arteries—demonstrated by roentgenograms.
4. Absence of arterial pulsations in feet (not diagnostic).
5. Coldness of extremity.
6. Pallor and cyanosis of limb.
7. Coldness.
8. Gangrene—trauma plus infection.

### SYMPTOMS SUGGESTIVE BUT NOT DIAGNOSTIC OF ARTERIOSCLEROTIC GANGRENE.

1. Increasing intolerance of extremities to cold.
2. Acroparesthesia.
3. Muscular fatigue.

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4. Aching pains.
5. Nocturnal cramps and hot feet.
6. Intermittent claudication.

### C. *Arterial Embolism*

#### PREDISPOSING FACTORS

1. Rheumatic heart disease.
2. Bacterial endocarditis.
3. Auricular fibrillation.
4. Mural thrombi after coronary occlusion.

#### SYMPTOMS

1. Extreme pain at site of embolus, one and two hours after obstruction of vessel. Pain spreads peripherally.
2. Local waxy pallor.
3. Dark blue cyanosis distally.
4. Proximal blotchy discoloration.
5. Coldness distally.
6. Decreased cutaneous sensibility.
7. Reduced reflexes in affected limb.
8. Paralysis in certain cases.
9. Gangrene if collateral circulation is deficient.

### D. *Latent Phlebitis*

This condition, which is very common, may follow local trauma, burns, local and focal infections. It is bacterial in origin.

#### SYMPTOMS

1. Aching and pains in the extremities involved.
2. Early fatigue of affected parts.
3. Cramps in muscles.
4. Sense of undue heat.
5. Local itching and eczema.
6. Deep veins sensitive to pressure.
7. Variations of symptoms with barometric pressure changes.

Other conditions which are encountered less commonly are venous thrombosis in the axillary vein induced by effort, periarteritis nodosa, and specific and nonspecific arteritis.

## FUNCTIONAL VASOSPASTIC DISEASES

### A. *Raynaud's Disease*

#### STAGES

1. Arterial spasm, white syncope, local asphyxia.
2. Capillary dilatation (reflex—cyanotic asphyxial stage).
3. Arterial relaxation—warm red stage.

#### DIAGNOSTIC CRITERIA (Allen and Brown<sup>5</sup>).

1. Intermittent attacks of discoloration of distal parts.
2. Symmetrical bilateral involvement.

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3. Absence of clinical evidence for occlusive disease of the peripheral arteries.
4. Gangrene and trophic changes limited largely to the skin; may be associated with scleroderma.
5. Absence of primary organic disease.
6. Predilection for women.

### **B. Erythromelalgia** (Weir Mitchell's Disease)

#### CHARACTERISTIC FEATURES

1. Bilateral burning pains, often in intermittent attacks.
2. Sudden increase in redness, flushing or congestion, and increase in temperature of dependent limb.
3. Production and aggravation of the distress by heat and exercise.
4. Relief of discomfort by means of rest, elevation, or the application of cold to the affected extremity.
5. Bilateral distribution of the disease.

### **C. Acrocyanosis**

This condition occurs quite commonly in young people—often at puberty—and in those who have an unstable sympathetic nervous system. There may be associated symptoms of an endocrine disturbance. It is often a part of the syndrome of neurocirculatory asthenia. There is sweating and coldness of the hands and feet; the sweating is profuse and some puffing occurs in the affected areas. The symptoms are increased by exposure to cold or by psychic stimulations.

Secondary vascular spasms may occur in a variety of different conditions which produce sympathetic irritation. These include:

1. Neurological conditions, such as poliomyelitis, multiple sclerosis, amyotrophic lateral sclerosis, syringomyelia, hemiplegia in late stages, and spina bifida.
2. After trauma such as strains, contusions, and fractures.
3. In certain cases of cervical rib.
4. Following the prolonged use of a pneumatic hammer. As a rule, such vascular disturbances are not difficult to diagnose if we will but think of all the possibilities in each case.

#### TREATMENT

The treatment of peripheral vascular disease is brought up to date in the very excellent review by Scupham and De Takáts<sup>6</sup>. In this comprehensive article, the therapy is divided into medical and surgical procedures. The former include specific and general measures, the use of drugs, biological products, and passive vascular exercise. The surgical measures include efforts to improve impaired circulation, to alleviate pain, and to remove nonviable parts at an optimal time and at an optimal level. We can only offer a summary of those measures which are of a practical value. Further details will be found in the original article.

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### MEDICAL THERAPY

#### A. Specific measures

1. If polycythemia vera is the underlying cause, acetylphenylhydrazine or x-ray therapy may be used.
2. In associated hypothyroidism, the proper dose of thyroid extract is necessary.
3. Syphilis requires adequate antiluetic therapy.
4. Congestive heart failure necessitates rest, digitalis, and often mercurial diuretics.

#### B. Foci of infection

1. Acute and chronic foci of infection must be eliminated by the use of proper measures.

#### C. Measures to avoid amputation of the affected arm or leg

1. Keep the entire body warm.
2. Protect the feet from trauma, chilling, and infections.
3. Use the temperature foot cradle (optimum temperature for the relief of pain is 33—35°C.)
4. Use contrast baths.
5. Keep the position of the limb at the level of greatest circulatory efficiency, usually 10—15° below the horizontal position.

#### D. General measures

1. Bed rest.
2. *Prohibit all use of tobacco* in all instances of peripheral vascular disease.
3. Artificial fever (typhoid), especially in Buerger's disease.
4. Intravenous saline solution, 5 per cent, in mild cases of Buerger's disease.

E. Tissue extracts intramuscularly may be tried for the relief of intermittent claudication. Insulin-free pancreatic extracts are best, but extracts of skeletal muscle have been used. Apparently, as the result of such injections, there is increased ability of the muscles to do work with the available blood supply. Many patients do well with one injection a week.

#### F. Drugs

1. Alcohol, in doses of 0.5 cc. per kilogram of body weight, produces vasodilatation in short periods. It is valuable in arteriosclerosis with occlusion for relief of pain, and it may reduce the severity of a chill after the use of intravenous typhoid therapy.
2. Theobromine compounds are of value in aiding prolonged vasodilatation, especially in arteriosclerosis. Theophylline ethylenediamine produces similar effects.
3. Papaverine has been employed in sudden arterial occlusion (Denk). It is given intravenously every two or three hours if necessary for several days. It should relieve the symptoms after two injections, if at all. Apparently, the benefit is due to relief of widespread arterial spasm.

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### G. Passive vascular exercise (Pavex)

Alternate positive and negative pressure is applied to an extremity.

1. Landis and Gibbon<sup>7</sup> employ an aluminum box with the extremity sealed in a rubber cup. Suction is used at 120 mm. of mercury for 25 seconds and pressure is maintained at 80 mm. of mercury for 5 seconds.
2. Hermann and Reid<sup>8</sup> have devised a glass boot. In this, suction is limited to 80 mm. of mercury and pressure to 20 mm. of mercury. If the response is satisfactory, a rise in cutaneous temperature appears in all patients who are treated two weeks or more. All evidence of pain disappeared in 86 per cent of the patients, and the pain of ischemia has been gradually relieved except in severe gangrene. Small changes of pressure should be used at first, and acute infection and venous thrombosis are a contraindication for this therapy. The results are most satisfactory in cases where only the smaller vessels are involved.

### SURGICAL THERAPY

More recently, there has been a conservative attitude toward surgical treatment. This is largely due to: (1) the earlier recognition of disease of the peripheral circulation; (2) a more thorough understanding of etiology; and (3) a better understanding of natural methods of compensation for circulatory disorders.

Three surgical procedures are in use which are designed:

#### A. To improve impaired circulation

1. Ligation of a vein has been used especially in arteriosclerosis and thrombo-angiitis obliterans. There is no sound physiological basis for this procedure. Better results have been observed in acute rather than in chronic obstruction. When favorable results occur, there is increased systolic pressure, increased venous pressure, diminished volume flow of blood, increased surface and deep temperature, increased collateral circulating bed, and the diminished incidence of gangrene. However, in most cases there is no definite or proven benefit.
2. Arterial ligation may be done to stimulate collateral circulation, especially in Buerger's disease. As a rule it is not successful.
3. Arterial excision (arteriectomy) is presumed to interrupt reflex vasoconstriction. This also is not entirely successful.
4. Periarterial sympathectomy (Leriche) consists in the removal of sympathetic nerve fibers from the veins and main nutrient artery. The hyperemia which results appears to be evanescent.
5. Sympathetic ramisection consists of interruption of the gray rami connecting the ganglionated trunk with the peripheral nerves. Objections to this procedure are that: (1) it is difficult to distinguish all anatomic variations, and (2) the posterior ganglion fibers readily regenerate.

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6. Sympathetic ganglionectomy is preferred. In the upper extremity it is necessary to cut the dorsal sympathetic trunks below the second dorsal ganglion. For the lower extremity, the second, third, and fourth lumbar ganglia must be removed.

### B. To alleviate pain

1. Peripheral nerve block by use of alcohol, sectioning, and crushing.
2. Paravertebral block which is used in elderly patients.
3. Intraspinal injection of alcohol.
4. Chordotomy (spino-thalamic tracts).

### C. To remove nonviable parts, especially in arteriosclerosis and diabetic gangrene.

The site of amputation is determined by the skin temperature and the reaction to histamine. These usually indicate the same level of circulatory efficiency.

## CONCLUSIONS

1. The proper diagnosis of peripheral vascular disease requires consideration of the general condition of the patient and his age, sex, and race, as well as the use of one or more of the diagnostic measures outlined above.

2. Treatment should be conservative. Medical measures should be used if possible or surgical treatment may be instituted to improve local circulation, to alleviate pain, and to remove devitalized parts.

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