DIAGNOSIS AND TREATMENT OF VASCULAR DISORDERS (ANGIOLOGY)

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Preface

The past ten years have witnessed unbelievable changes in the structure of medicine and surgery. The increased zeal with which hitherto unexplored regions have been entered and investigated has resulted in the unearthing of vast quantities of new facts and experiences. This progress has reflected itself not only in the therapeutics but also in the fundamental knowledge of the physiology, pharmacology and pathology of the previously neglected subjects.

While the blood vessels are considered part of the cardiovascular system, not only from the anatomical but also from the clinical standpoint, the multiplicity of new facts developed from the ever-mounting number of investigations has so expanded the knowledge of the blood vessel diseases as to demand the entire attention of any single physician or surgeon to this new specialty, providing one is desirous of doing justice to this work.

Buerger in 1924 was perhaps the first to realize the importance of this fact when he published his book on the *Circulatory Disturbances of the Extremities*. Many of the facts contained in that book hold true today, but a far greater number are completely out of date, inaccurate and entirely inadequate in the light of present-day knowledge.

The evolution of angiology as a specialty may be compared to urology. The latter arose naturally as an outgrowth from the medically tinged genito-urinary specialty and that branch of general surgery concerned with the kidneys and bladder. Today, unfortunately, we still have the medically minded "cardiovascular" specialists and the ivory-towered surgeon who in most cases merely hopes to keep the surgical portion of angiology within the confines of general surgery. As a solution of this problem I suggested, for the first time in 1942, the designation of "angiology" as the proper nomenclature for a specialty which is obviously a combination of medical and surgical components. It is perhaps a bit early for the profession to accept this intrusion into the traditional precincts of the old-established specialty demarcations, but the wheels of progress must go on.

It is hoped that this book is an expression of the above ideas, that the diseases of the blood vessels are a lifetime study for any individual because of the amazing ramifications that require intensive, skillful and experienced consideration by the angiologist. It is felt that the avid interest shown by the younger generation of physicians and surgeons in this new field will spur and hasten the development of thoroughly trained, recognized and capable angiologists during the next decade.

The operative technique of sympathectomy is described in surgical and neurosurgical treatises so that its inclusion in this volume is deemed unnecessary.

I wish to thank the contributors of this volume for their efforts and patience and for their exceptionally brillant treatises on their assigned subjects. I wish to thank Evelyn Biglin, R.N. for her invaluable assistance in the preparation of manuscript and other harrowing details involved in the publication of a book of this kind. To the publishers and particularly to Mr. Dick Hoover of The Williams & Wilkins Company my deep gratitude is extended.

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S. S. S.

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Contents

1

The Anatomy of the Peripheral Circulation

LAWRENCE N. ATLAS, M.D., F.A.C.S.

The anatomy of the peripheral circulation has been described and portrayed in minute detail in many readily available textbooks of anatomy. Consequently, the ensuing discussion will emphasize for purposes of reference those aspects of peripheral vascular anatomy which are of particular interest to the angiologist.

General Considerations

Sabin (1) demonstrated that *all* blood vessels derive from embryonic capillaries. According to Patten (2), the growth of this primitive vascular net is dependent on the inherent propensity of a portion of the mesenchyme (angioblast tissue) to form endothelium. When circulation begins, certain capillaries assume the function and then the structure of arteries, others the function and structure of veins. Sabin stresses the point that it is the function of vessels at every stage of the developing embryo which is responsible for the growth and ultimate character of the circulatory apparatus. Thus, after circulation once begins, a vessel may serve first as an artery and then revert to its original status of a capillary, or a vessel functioning as a vein may receive arterial connections and become ultimately an artery. It is the failure of growing vessels to alter completely their structure in response to changes in function which is responsible for congenital vascular anomalies.

Basically, the circulatory apparatus is a closed system of endothelial tubing, of variegated size and exceedingly complex distribution, which contains a mass of circulating blood. With the exception of capillaries, this tubing is invested with layers of smooth muscle and elastic and connective tissue. In any particular vessel, the thickness and relative proportion of these investing layers are related directly to intraluminal pressure, volume rate of blood flow, and other functional demands. Walls of large arteries contain a relatively large proportion of elastic tissue, hence their ability to transmit in the form of a visible, palpable, and measurable wave the sudden pressure changes induced by cardiac and aortic systole and diastole. As the large arteries branch progressively and form vessels of smaller caliber, the proportion of elastic tissue becomes less while that of smooth muscle increases. Thus, the walls of arterioles

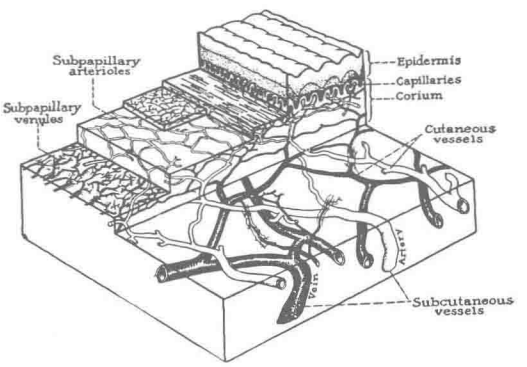

Fig. 1.1. The cutaneous circulation. (By Spalteholz, from Freedlander and Lenhart, Arch. Int. Med., 1922)

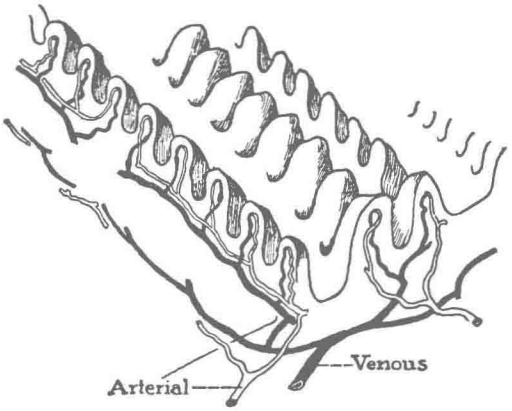

Fig. 1.2. The cutaneous capillary circulation. In the undisturbed cuticle the capillary loops run in a horizontal plane which is parallel with the surface of the skin. (By Spalteholz, from Freedlander and Lenhart, Arch. Int. Med., 1922)

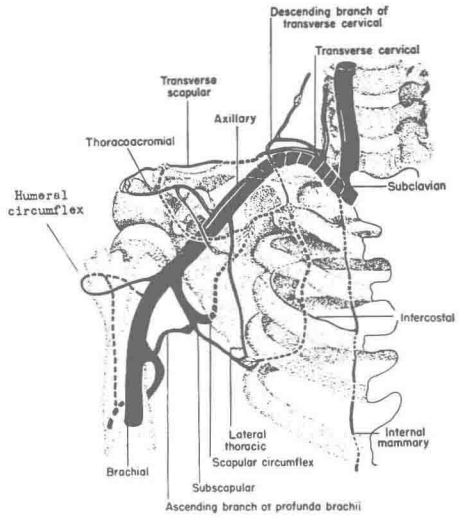

Fig. 1.4. The collateral circulation between the subclavian, axillary, and brachial arteries. (Modified from Quiring, *Collateral Circulation*, Lea & Febiger, 1949)

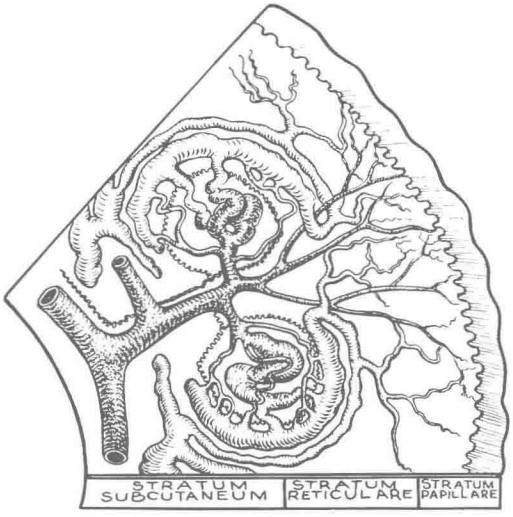

Fig. 1.3. The cutaneous glomus consists of a coiled muscular vessel, the Sucquet-Hoyer canal, which connects cutaneous arterioles with collecting venules. The structure is supplied abundantly with vasomotor nerves. (From Popoff, Arch. Path., 1934)

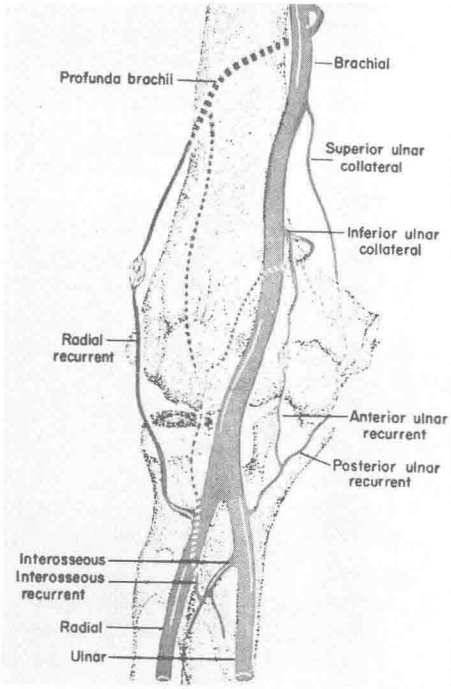

Fig. 1.5. The collateral circulation between the brachial, radial, and ulnar arteries. (From Quiring, *Collateral Circulation*, Lea & Febiger, 1949)

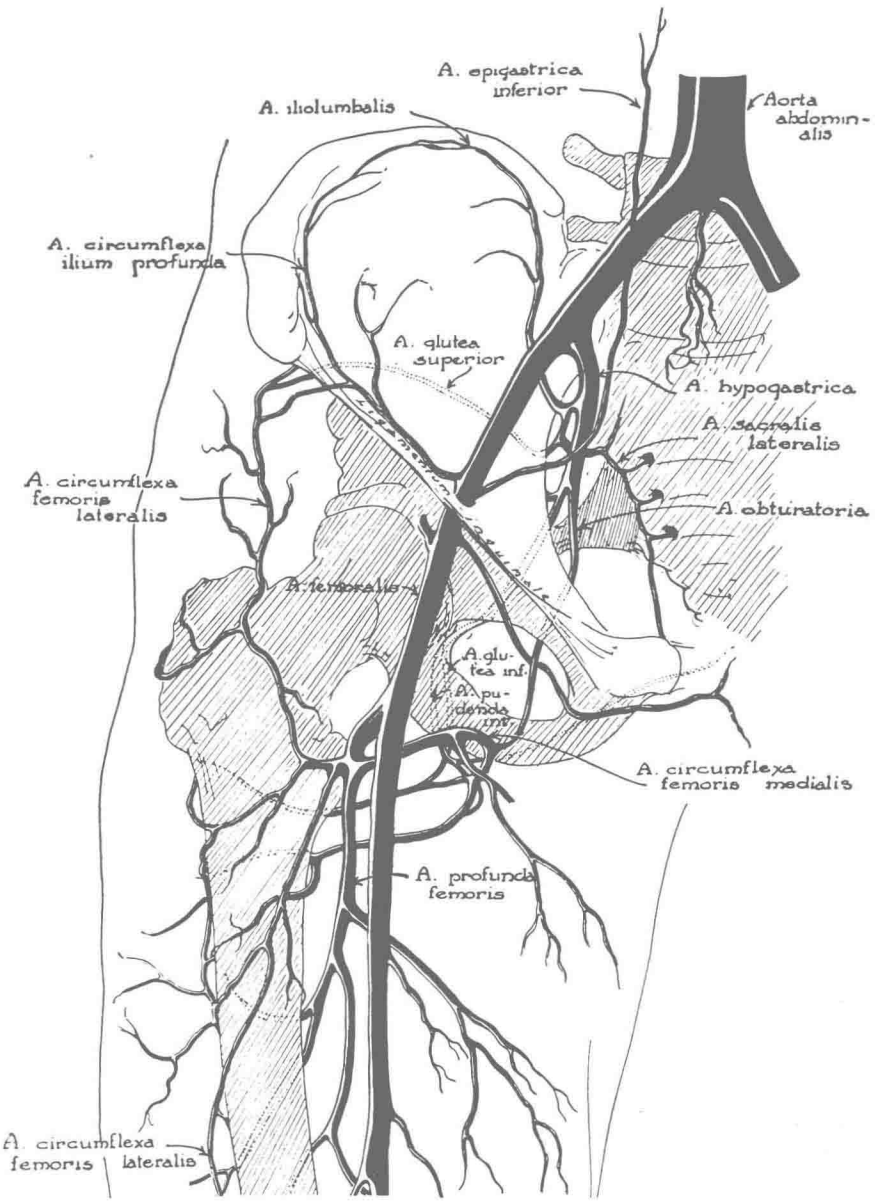

Fig. 1.6. The collateral circulation between the iliac and femoral arteries. (By M. Reid, Am. J. Surg., from Callender, *Surgical Anatomy*, W. B. Saunders Co., 1941)

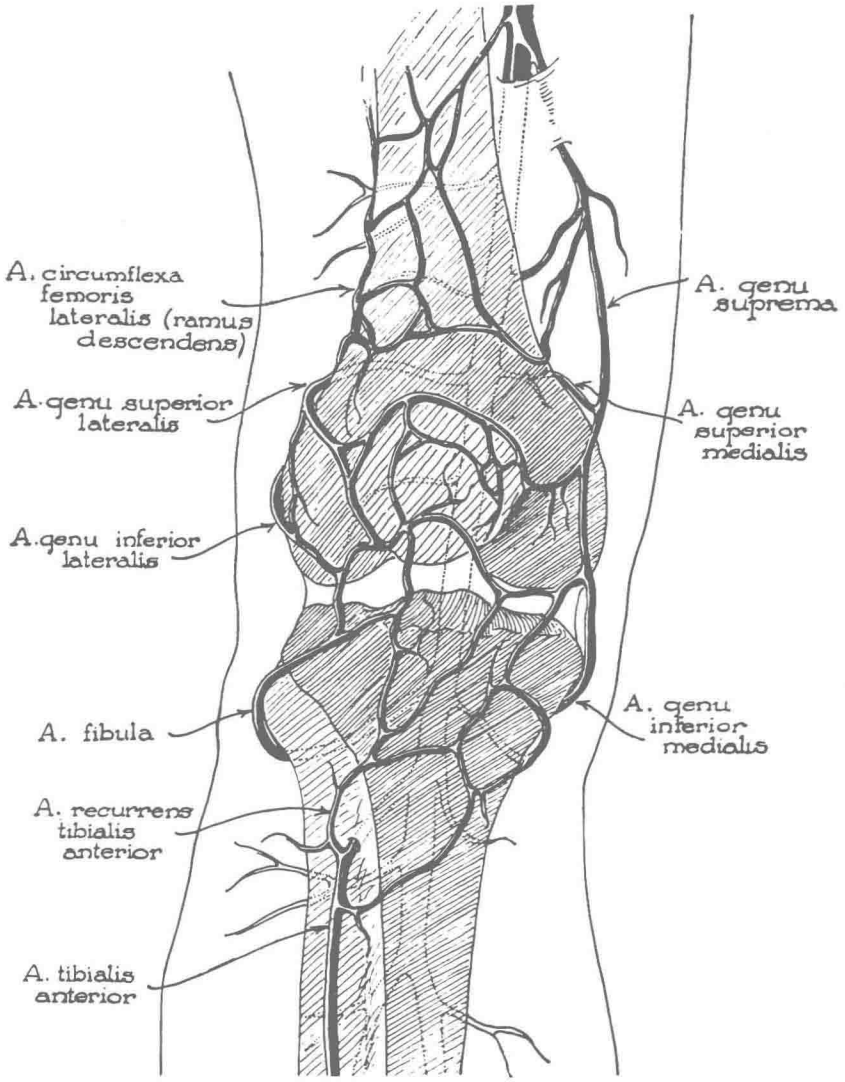

Fig. 1.7. The collateral arterial circulation in the region of the knee. (By M. Reid, Am. J. Surg., from Callender, *Surgical Anatomy*, W. B. Saunders Co., 1941)

are composed almost entirely of highly sensitive smooth muscle, enabling them to vary their caliber in response to varied and numerous vasodilating and constricting stimuli and so to control the peripheral distribution of blood.

Compared with arteries, veins are thin-walled and highly distensible. They are divided segmentally by valves which inhibit pressure refluxes and retrograde flow.

As Krogh (3) points out, capillary structure permits the circulating blood mass to function in its numerous and varied vital capacities. Capillaries are arranged in meshworks anastomosing arterioles to collecting venules. The average diameter of capillaries is 7 to 9 microns. Their walls consist of a single layer of endothelial cells with intercellular spaces filled with a semifluid material which forms a semipermeable membrane which permits diapedesis.

The Applied Anatomy of the Peripheral Circulation

The anatomical arrangement of cutaneous capillaries is of more than casual interest, because the arrangement permits their direct visualization by specialized microscopic techniques (4, 5). The capillaries of skin are end capillaries. A cutaneous papilla is supplied by a single capillary loop composed of a distinct arterial and venous limb. In areas where the skin ends, as at the base of the fingernail, the long axis of the capillary loop tends to run in a plane which is parallel to the surface of the skin; hence the undisturbed cuticle is the ideal place to visualize an entire capillary loop.

During the latter half of the nineteenth century Sucquet (6) and Hoyer (7) independently described the presence of direct connections between precapillary arterioles and venules. These arteriovenous shunts are distributed in significant numbers in the skin of the ventral surfaces of the digits, the nail beds, the palms of the hands, and the soles of the feet. They comprise collectively what is termed "the glomic system."

The glomic system occupies a definite zone in the cutis. It is situated just proximal to the subpapillary capillary plexus in a plane horizontal to the surface of the skin. From the inner surface of the epidermis to the beginning of this zone measures ½ to 1

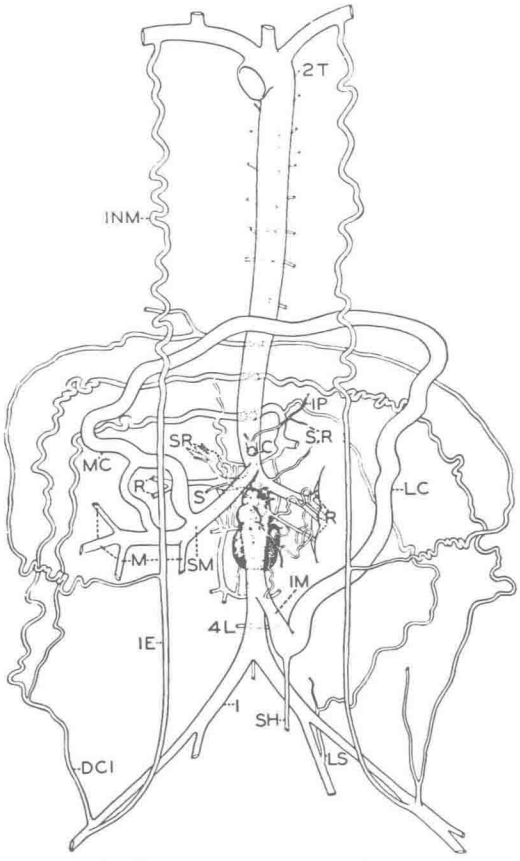

Fig. 1.8. The collateral arterial circulation after obstruction of the abdominal aorta by calcified aneurysm. (*C*, coeliac; *DCI*, deep circumflex iliac; *I*, iliac; *IE*, inferior epigas tric; *IM*, inferior mesenteric; *INM*, internal mammary; *IP*, inferior phrenic; *LC*, left colic; *LS*, lateral sacral; *4L*, fourth lumbar; *M*, mesenteric; *MC*, middle colic; *R*, renal; *S*, spermatic; *SH*, superior hemorrhoidal; *SM*, superior mesenteric; *SR*, suprarenal; *2T*, second thoracic arteries) (From Baylin, Anat. Rec., 1939)

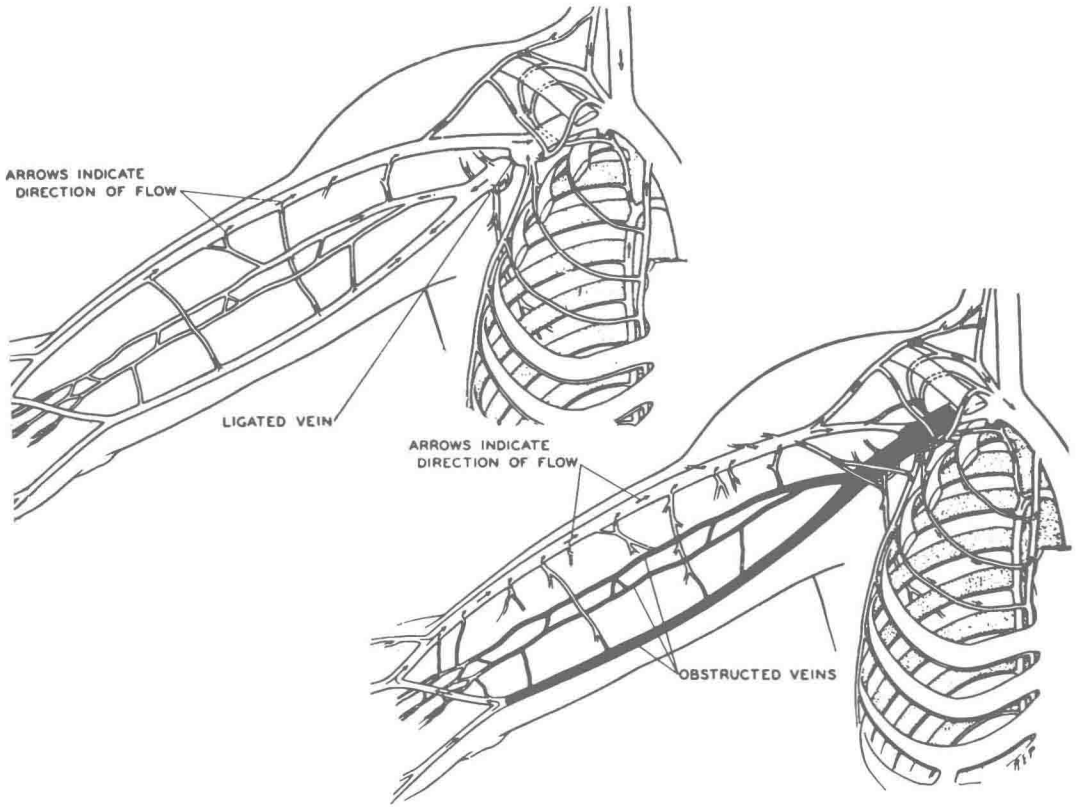

Fig. 1.9. A comparison of the available collateral venous circulation, with simple ligation of the axillary vein and thrombosis of the axillary vein, with proximal and distal propagation of the thrombus. (From Veal and Hussey, Am. Heart J., 1940)

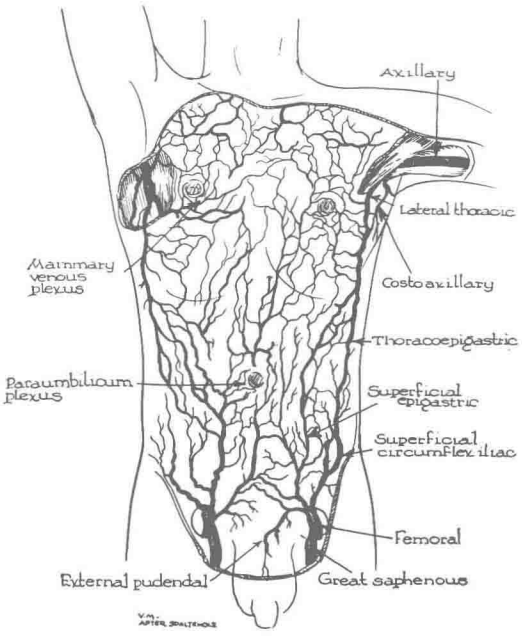

Fig. 1.10. The superficial abdominal and thoracic anastomotic venous network. (From Robinson, Surgery, 1949)

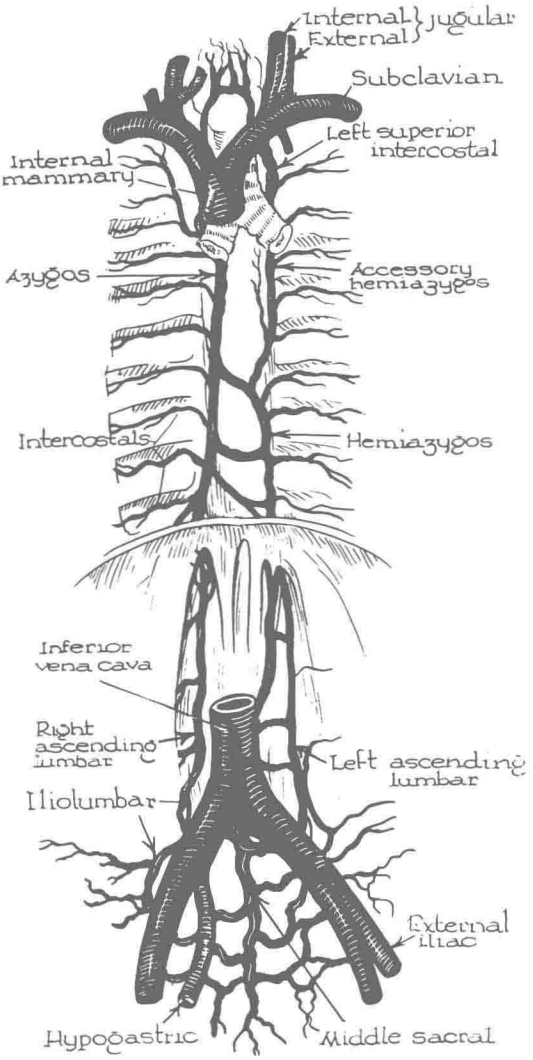

Fig. 1.11. Anastomotic connections between the lumbar and azygos systems of veins. This collateral circulation is of strategic importance in vena cava obstruction. (From Robinson, Surgery, 1949)

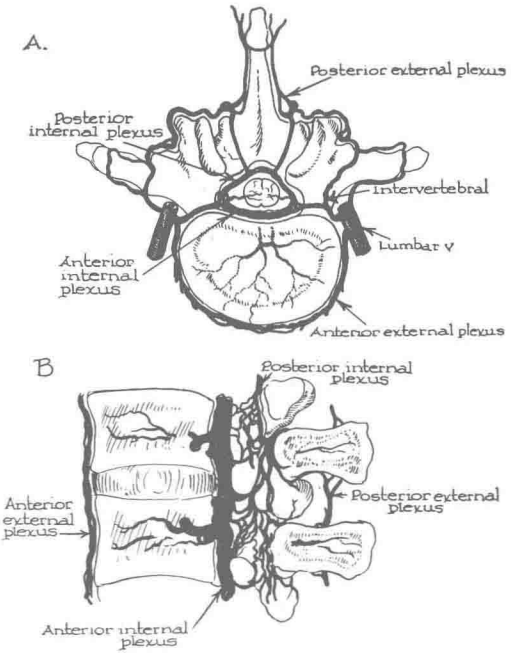

Fig. 1.12. The lumbar spinal venous plexus. (From Robinson, Surgery, 1949)

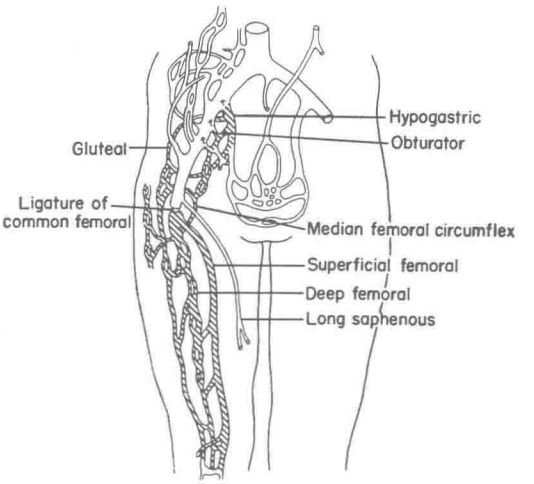

Fig. 1.13. The collateral venous circulation after ligature of the femoral vein. (From Homans, Surg., Gynec., & Obst., 1944)

millimeter. The individual glomus consists of a coiled muscular vessel richly supplied with sympathetic nerves. Situated within the reticular stratum of the skin it anastomoses a precapillary arteriole to a collecting venule.

The glomic system is part of the thermoregulatory mechanism, and its function is to assist in the maintenance of a constant body temperature (8, 9). The glomic system is of interest to angiologists because of the role it may play in the pathologic physiology of peripheral vascular disease (10, 11, 12, 13).

The peripheral circulation is unique anatomically because numerous connections between collateral vessels favor the development of an auxiliary network when major arteries or veins become obstructed. This physiological and anatomical response to arterial and venous occlusion has important implications in the prognosis and management of peripheral vascular disease, and a working knowledge of the anatomical disposition of potential collateral channels is desirable. Excellent studies on the anatomy of the peripheral collateral circulation, actual and potential, arterial and venous, have been made by Allen (14), Quiring (15), Baylin (16), Gitlow and Sommer (17), Homans (18), Veal (19), Robinson (20), Veal *et al.* (21), Blasingame (22), and Sampson *et al.* (23).

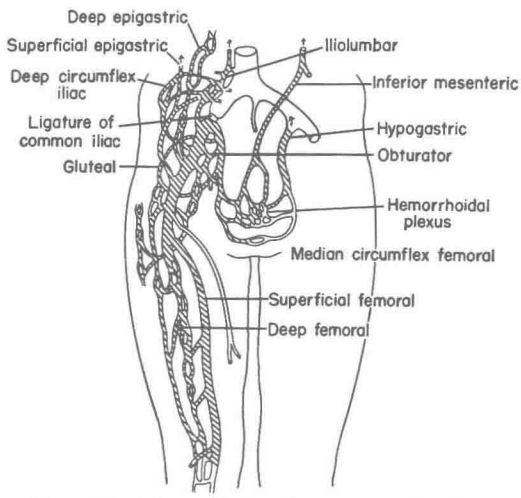

Fig. 1.14. The collateral venous circulation after ligature of the common iliac vein. (From Homans, Surg., Gynec., & Obst., 1944)

Major peripheral arteries and veins are usually adjacent. This contiguous position favors the development of arteriovenous fistulae as the sequelae of penetrating wounds.

Arteries, veins, and the branches of mixed spinal nerves are distributed through the extremities in bundles of neurovascular tissue. Inflammation of the vascular component frequently involves the associated nerve. The resultant neuronitis is painful and is responsible for reflex vasomotor disturbances.

Such major peripheral nerves as the sciatic and the median have distinct, large nutrient arteries. Occlusion of these arteries may produce seriously disabling and extremely painful disturbances in nerve function (24).

Because peripheral arteries and veins are superficial, they are subject to inspection, palpation, percussion, auscultation, and roentgenographic visualization; their function can be investigated by special tests and instrumental procedures, they can be cannulated per cutis, and their surgical exposure is a relatively simple matter.

The peripheral circulatory system is notorious for variations in its anatomical pattern. Certain arteries may be absent congenitally. This is particularly true of the dorsalis pedis and the posterior tibial arteries (25, 26, 27, 28).

Variations in the anatomy of the superficial venous system of the lower extremity and its connections with the deep veins have practical application in the surgery of varicose veins. Stalker and Heyerdale (29) published observations on variations in the anatomy of the terminal portion of the great saphenous vein. Sherman (30) made an extensive and detailed anatomical study of the perforating connections between the superficial and deep venous systems of the lower

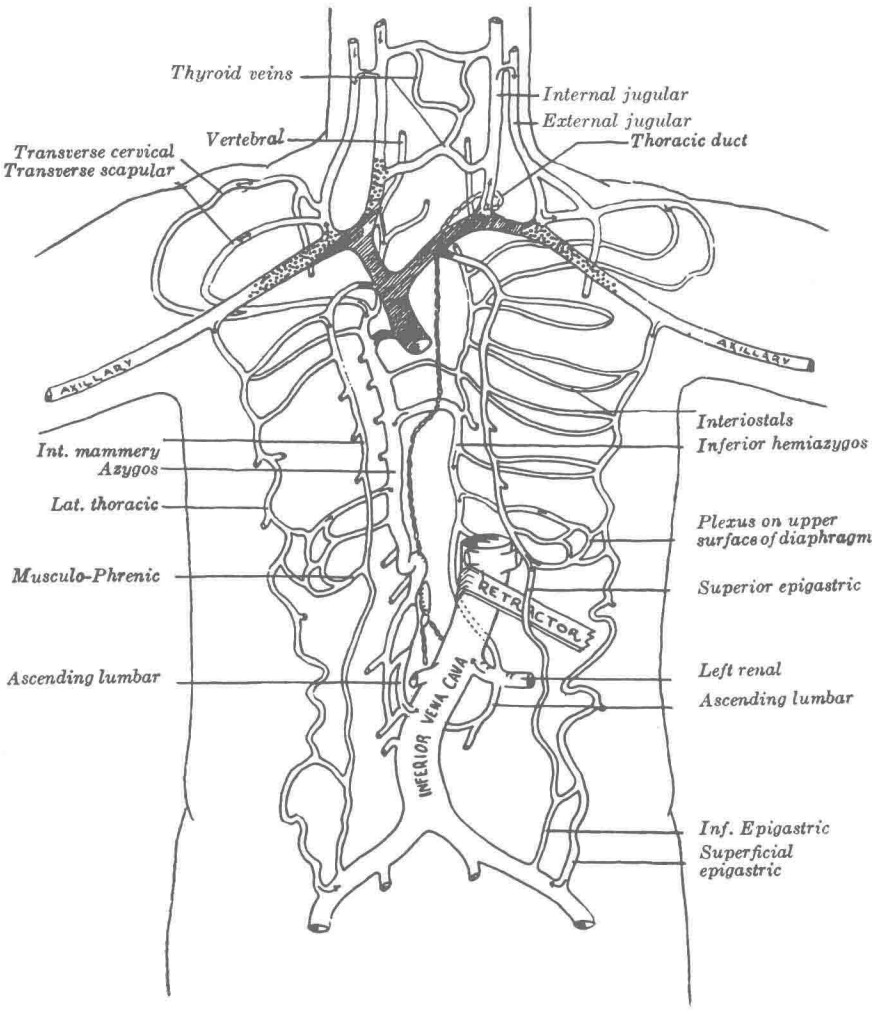

Fig. 1.15. The collateral venous circulation after obstruction of the superior vena cava. (From Blasingame, A.M.A. Arch. Path., 1938)