Structure and Function of Saphenous Vein in Man

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Abstract:
The veins in man were a subject of study-by 'many' investigators. The previous studies showed that there were structural variations among the human veins. In this study, the saphenous vein was selected from the lower limbs for study in an attempt to correlate the structural variations of the human veins to their sites and their function in the human body.

Introduction:
The veins in man were a subject of study-by 'many' investigators. The previous studies showed that there were structural variations among the human veins

Guyton,[1] considered veins as pathways for blood flow toward the heart to maintain the blood circulation. They are capable of constriction, enlarging and storing large quantities of blood, which are available when needed. They actually propel blood forwards by the means of the so called venous pump. The circulation is maintained by contraction of the smooth muscle fibers in the different parts of the venous system and by valves, which assure the unidirectional flow to the heart.

Shepherd and Vanhoutte[2] stated that the main function of the venous system was to maintain the filling pressure of the heart by controlling the central blood volume.

A vein is an elastic blood vessel that transports blood from various regions of the body to the heart. Veins can be categorized into four main types: pulmonary, systemic, superficial, and deep veins.

Pulmonary veins carry oxygenated blood from the lungs to the left atrium of the heart. Systemic veins return deoxygenated blood from the rest of the body to the right atrium of the heart. Superficial veins are located close to the surface of the skin and are not located near a corresponding artery. Deep veins are located deep within muscle tissue and are typically located near a corresponding artery with the same name (for example coronary arteries and veins).

A vein can range in size from 1 millimeter to 1-1.5 centimeters in diameter. The smallest veins in the body are called venules. They receive blood from the arteries via the arterioles and capillaries. The venules drain into larger veins which eventually carry the blood to the largest veins in the body, the vena cava. The blood is then transported from the superior vena cava and inferior vena cava to the right atrium of the heart.

The great saphenous vein is the most important superficial vein of the lower limb. First described by the Persian physician Avicenna, this vein derives its name from the word safina, meaning "hidden". This vein is "hidden" in its own fascial compartment in the thigh and exits the fascia only near the knee. Incompetence of this vein is an important cause of varicose veins of lower limbs. The great (Long) saphenous vein is the largest and thickest-walled superficial vein of the lower limb. It commences at the medial end of the dersal venous arch of the foot and runs upwards and backward in front of the medial malleolus and then on the medial surface of the distal third of the tibia. It then ascends on the medial border of the tibia to the posteromedial surface of the knee and spirals forwards around the medial convexity of the thigh and ends by passing through the cribriform fascia to open into the medial side of the femoral vein through the saphenous opening. It contains over a dozen valves. It does not drain the medial side of the leg between tibia and tendo-calcaneous, here three veins pierce the deep fascia to enter the deep veins of the calf (Fig. 1).

The small (short) saphenous vein, draining the lateral side of the dorsal venous arch and the lateral margin of the foot, lies with the sural nerve behind the lateral malleoulus. It passes upwards in the subcutaneous fat along the midline of the calf and pierces the deep fascia on the roof of the popliteal fossa to enter the popliteal vein. It communicates by several channels with the great saphenous vein. It drains the lateral side of the foot, ankle and the back of the leg.[3]

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In this study, the saphenous vein was selected from the lower limbs for study in an attempt to correlate the structural variations of the human veins to their sites and their function in the human body.

Materials and Methods

Materials:

The venous specimens were collected from twenty adult postmortem human cadavers. These postmortem specimens were fresh as much as possible. They were collected from the Pathology Department in Ain Shams University; we selected the long saphenous vein, cephalic vein and the superior and inferior vena cava. The veins were exposed and identified at different selected sites-along their course. The spicemens were about 1 cm length.

Methods:

These veins were obtained by being dissected from the postmortem human cadavers.

We cut down the veins at different selected sites along their courses. The cephalic vein was exposed and identified in the arm near elbow and at the forearm near the hand while the saphenous vein exposed at the thigh a few cm before its termination and at the leg below the knee. The superior vena cava was identified near its termination to the heart and near its beginning. The inferior vena cava was exposed near its beginning few cm from the iliac veins and also at the renal level.

The specimens of about 1cm length were taken. They were fixed in Buffered formol saline solution for 48 hours, after being washed in distilled water to clear them from blood (Drury and Wallington.[4]

After fixation in Buffered formol saline solution, the specimens were subjected to processes of washing, dehydration and clearing in xylole.

The specimens were embedded in hard paraffin wax (melting point: 60-62°C). The process of embedding was proceeded by impregnation for 3 hours in soft paraffin (melting point: 54°C - 56°C).

Serial sections were done at 10 micron thickness. The sections were mounted on slides smeared with egg albumin.

The sections were then stained with :

1. Ehrlich's haematoxylin and Eosin as a routine method.[5]
2. Mallory's trichrome stain.[6]
3. Modified Taenzer-una orcein method for the elastic fibers.[7]

Results:

The vein was formed of three layers, tunica intima, tunica media and tunica adventitia, they were poorly demarcated. Those layers were blended together, the media was the thickest coat (Fig. 2). The tunica intima was lined with the endothelial cells. They were resting on a layer of connective tissue, the subendothelial layer. In this layer the collagen fibers formed a network and was rich in elastic fibers forming an incomplete membrane (Fig. 3). Smooth muscle fibers, arranged longitudinally, were detected (Fig. 4). The tunica media was the thickest coat (Fig. 5). This coat was well developed and formed mainly of smooth muscle fibers which were circularly arranged (Fig. 6). These smooth muscle fibers were interlacing with fine delicate elastic fibers and few collagenous fibers. The adventitia was formed of thick layer of loose connective tissue. There was abundancy of elastic and collagen fibers (Fig.7). It showed delicate interlacing bundles of collagenous fibers among fine elastic fibers. There were bundles of longitudinal muscle fibers in the advantitia (Figs. 8-9).

The muscular element was relatively more condensed in the sections taken near the beginning of the vein than those taken near its termination (Fig. 10). The saphenous vein contained valves (Fig. 11). The endothelial covering of the valve casp was continuous with that of the venous wall. The endothelium was arranged transversely on one side and longitudinally on the other side (Figs. 10-11). The muscle fibers were condensed opposite the site of the attachment of the valve (Fig. 12).

Discussion:

The examined veins showed no sharp line of demarcation among its tunicae, each one of them blended with the other. That was noticed by many authors.[8-10]

Burton[10] and Bloch and McCuskey,[11] explained the blending of the tunicae together as to conduct the excitation wave and to transmit the contraction wave throughout its whole thickness, through the linkage of the smooth muscle to the smooth muscle to the circumferential network of elastin and collagen (myo-myojunction) and (myo-endothelial junction) .

The common structure among those examined veins was the endothelium, which always existed. That was supported by the work done by Williams and Warwick.[12]

In our study, the saphenous and the cephalic veins showed the same three tunicae: intima, media and adventitia. But the saphenous vein showed variations, the wall was thicker than that of the cephalic vein, its intimal layer showed valves with adequate subintimal layer of connective tissue rich in elastic fibers and showed scattered longitudinal muscle fibers. Ham and Cormack,[13] attributed the thicker wall of the saphenous vein to the hydrostatic pressure generated by the long column of blood exerted on the wall of the vein in erect posture and also because of its superficial unsupported position. Bloom and Pawcett,[14] supported the presence of longitudinal muscle fibers in the subintima. Carleton and Leach,[7] and Cruickshank et al.,[15] reported the presence of longitudinal muscle fibers in the inner most part of the tunica media. But, Jordan[16] found that the longitudinal muscle fibers belonged to both areas; the subintimal and the innermost of media. Those different opinions might be explained by the absence of sharp line of distinction between the individual tunicae.

Our study on the saphenous vein showed that the media was the thickest coat and that was supported by Bradbury[17] and denied by Snell.[18] The media was formed mainly of circularly arranged smooth muscle fibers that finding was supported by Ham and Cormack,[13] who reported that the saphenous vein had a muscular media. However, Han and Holrasted,[19] denied the presence of circularly arranged smooth muscle fibers in the media but stated that the smooth muscle fibers of media, in general, were longitudinally arranged.

The adventitia of saphenous vein was formed of loose connective tissue mainly of collagenous fibers with longitudinal muscle bundles. That was observed by many investigators as.[20-21] The distensibility of the vein by relatively small elevations in venous pressure is attributed by Burch[22] to the amount of loose connective tissue in the wall of the vein.

The previous variations in the wall structure of the saphenous vein from that of the cephalic vein were in their wall basic components;the smooth muscle fibers, the elastic fibers and the collagenous fibers. Those variations might be related to the site which was influenced by gravity, and was reflected on their transmural pressure. This pressure increased in dependant veins depending on their vertical distance from the heart as suggested by Smith & Kampine.[23] Guyton,[1] registered the difference in venous pressure among veins. The pressure in saphenous vein was greater than that in the cephalic vein.

This is because the saphenous vein is one of the dependant veins, as in upright position, about 500 ml of blood gravitated to the lower limbs depending on the venous wall distensibility. The venous wall distensibility was defined by Smith, and Kampine[23] as the increase in volume necessary to induce a unit pressure change.

Acknowledgment:
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Saphenous Vein Figures

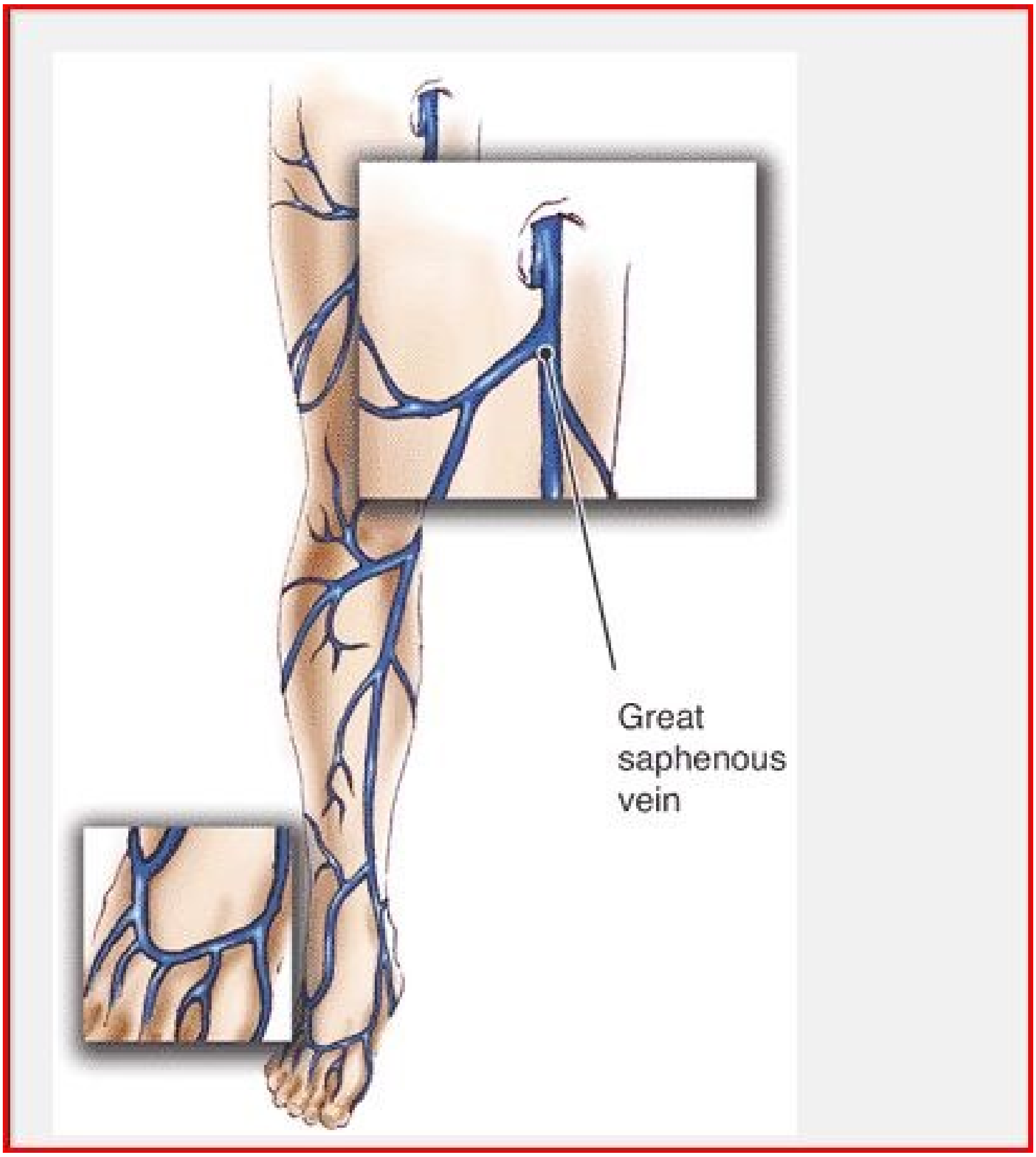

Fig. 1: The great saphenous vein.

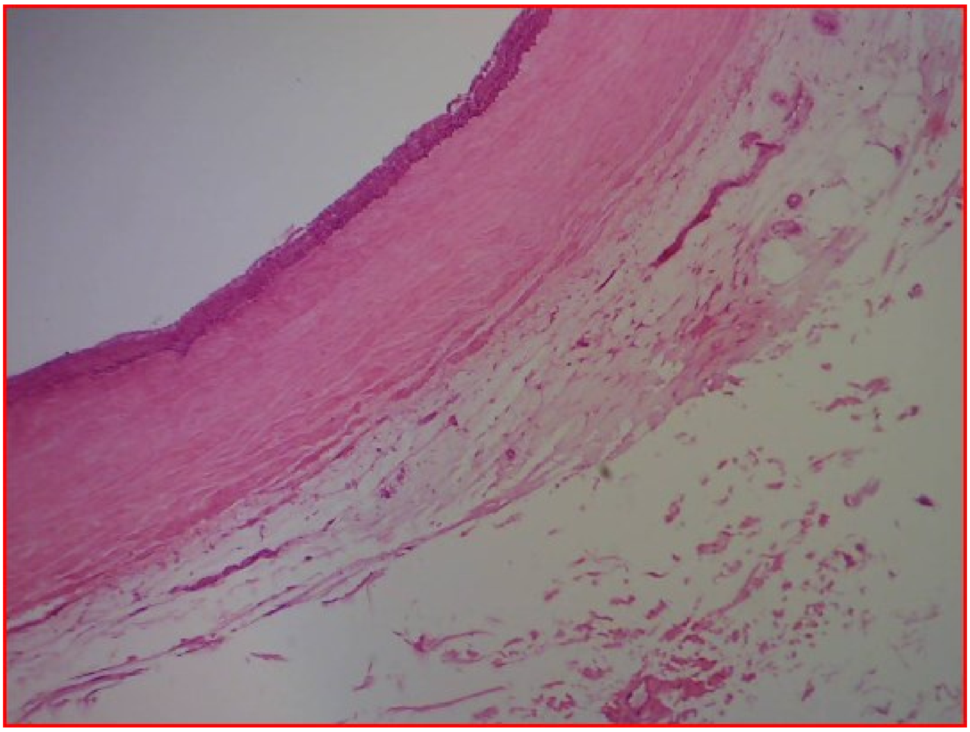

Fig. 2: T.S. in the saphenous vein. Notice that the tunica media is the thickest coat and there is no obvious endothelial corrugation. (Hx and E. Stain).

Fig. 3 : T.S in the saphenous vein near the saphenofemoral junction. Notice the presence of longitudinal muscle fibers in the subintimal layer. The media contains circular muscle fibers. (Hx & E. stain).

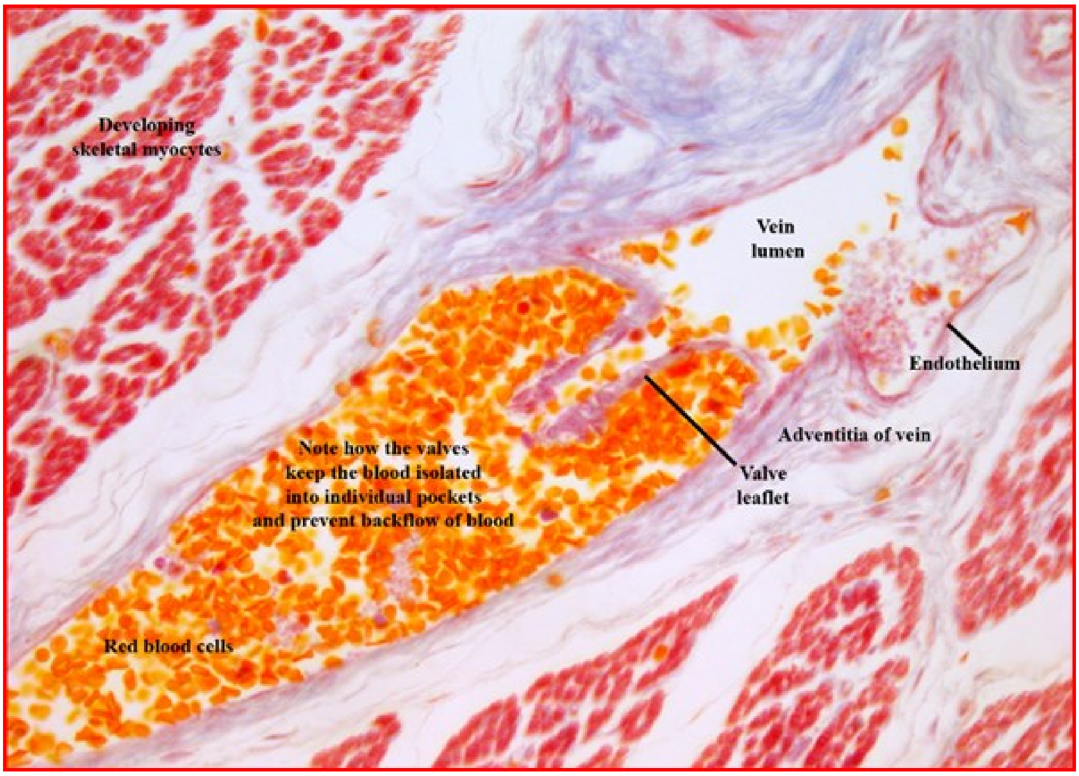

Fig. 4: T.S. in the saphenous vein near the saphenofemoral junction. Notice the presence of longitudinal muscle fibres in the subintimal layer. The media containscircular muscle fibres.

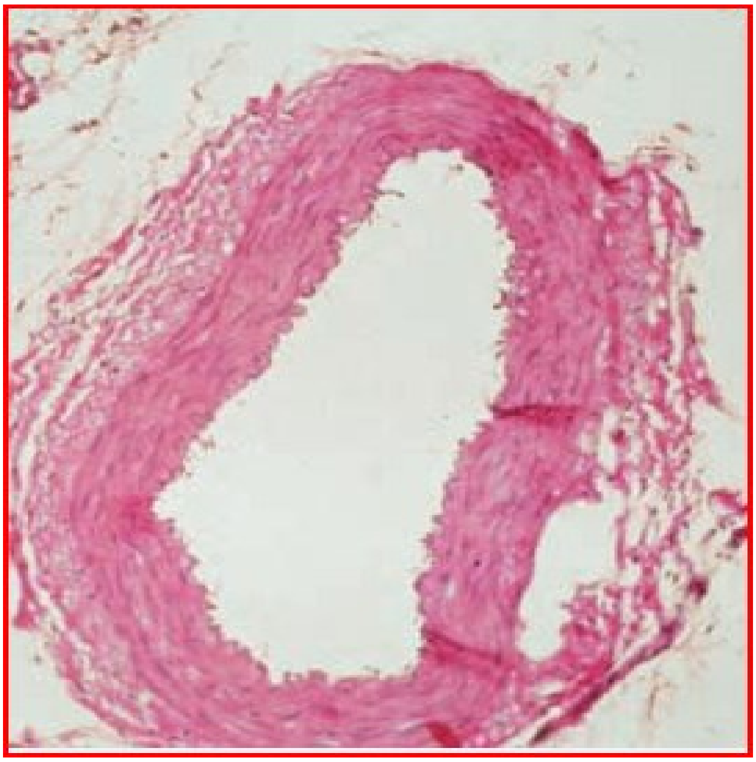

Fig. 5: T.S. in the saphenous vein. Notice that the tunica adventitia contains longitudinal muscle fibres. (Hx & E. stain).

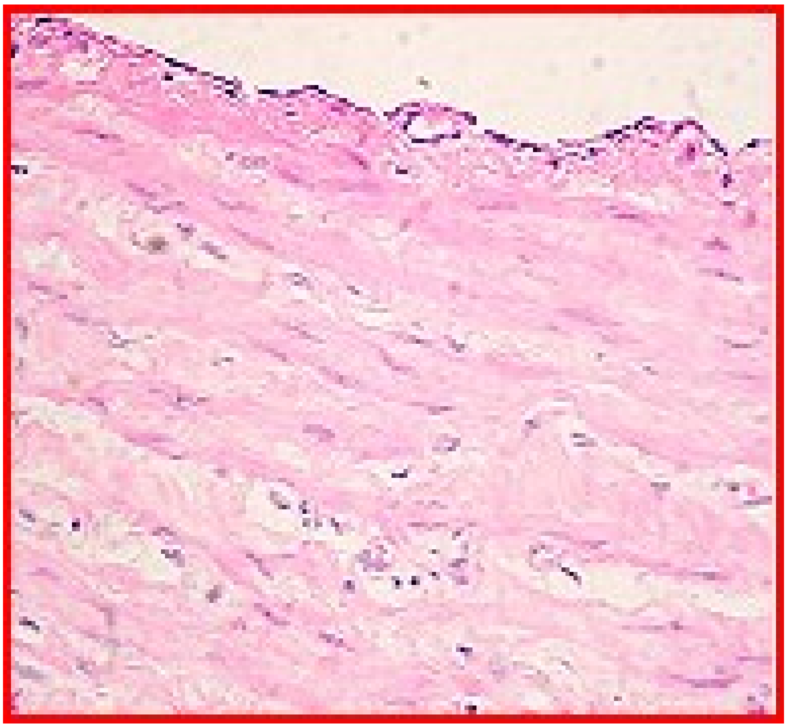

Fig. 6: T.S. in the saphenous vein. Notice that the adventitia contains smooth muscle fibres which are longitudinally arranged. (Hx & E. stain).

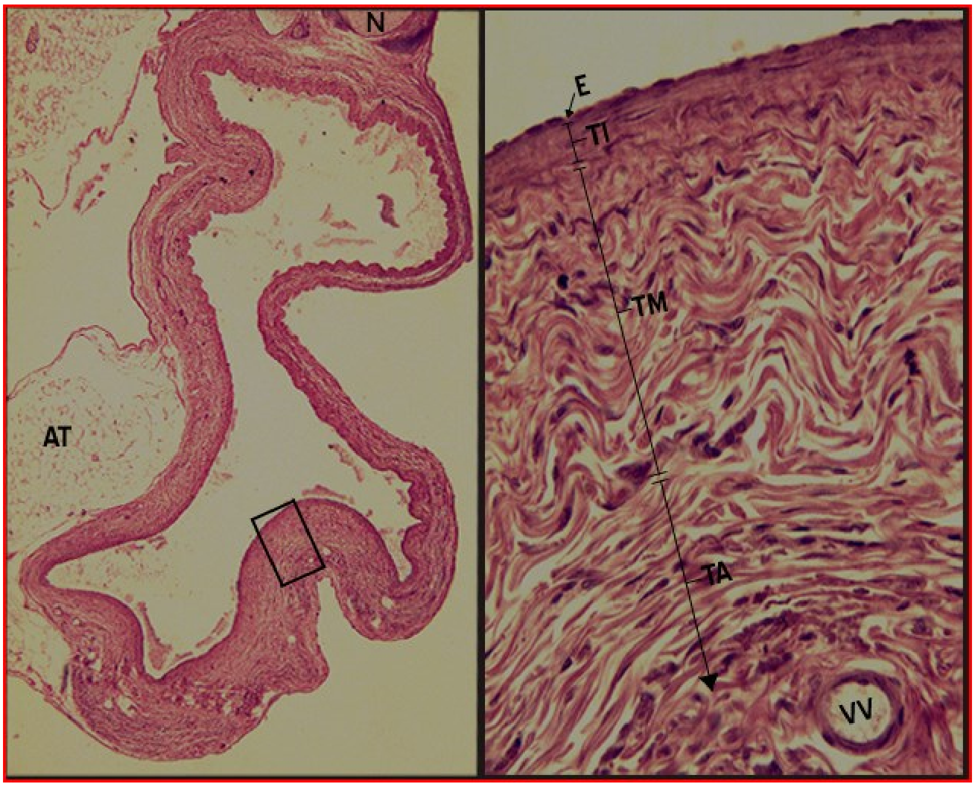

Fig. 7: T.S. in the saphenous vein. Notice that the elastic element is more condensed near the periphery of the wall. (Orcein stain).

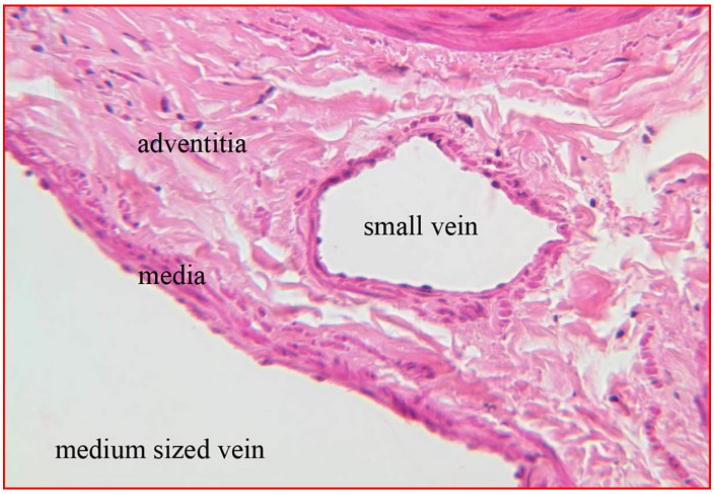

Fig. 8: T. S. in the saphenous vein. Notice that:
- The media is the thickest coat.
- The muscular element is marked in that tunica media.
- The elastic element is condensed in the adventia. (Hx & E. stain).

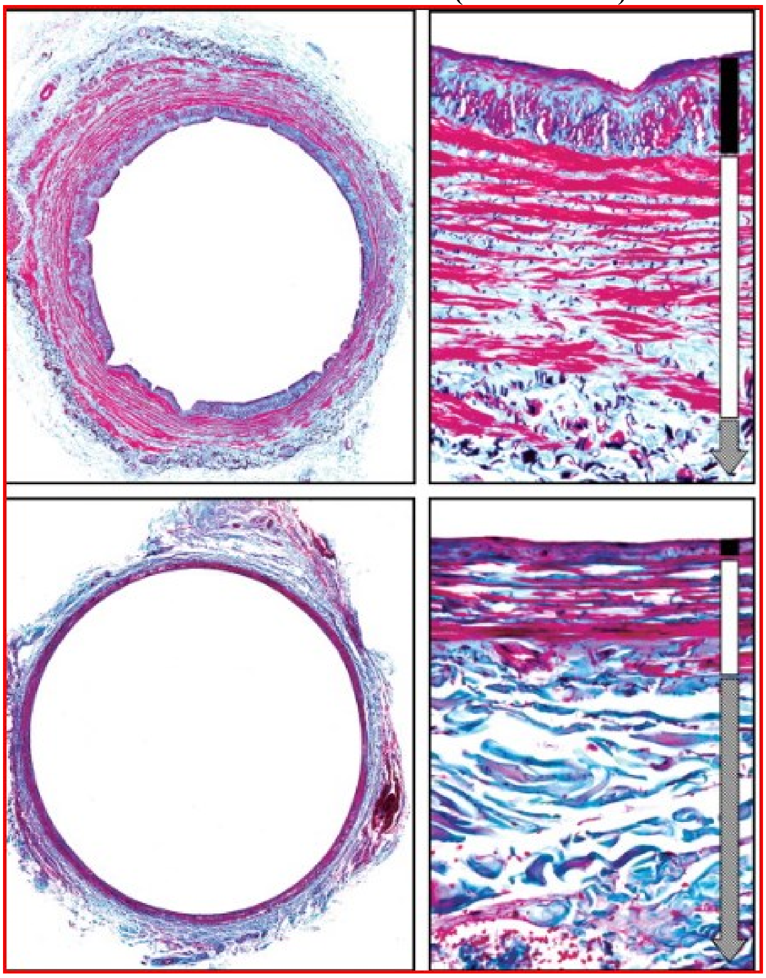

Fig. 9: T.S in the saphenous vein. Notice that:-
A longitudinal muscle fibre scattered in the subintimal layer.
A network of collagen fibres is noticed in the subendothelial layer.
The media is formed of circular smooth muscle intermixed with elastic fibres. (Mallory stain).

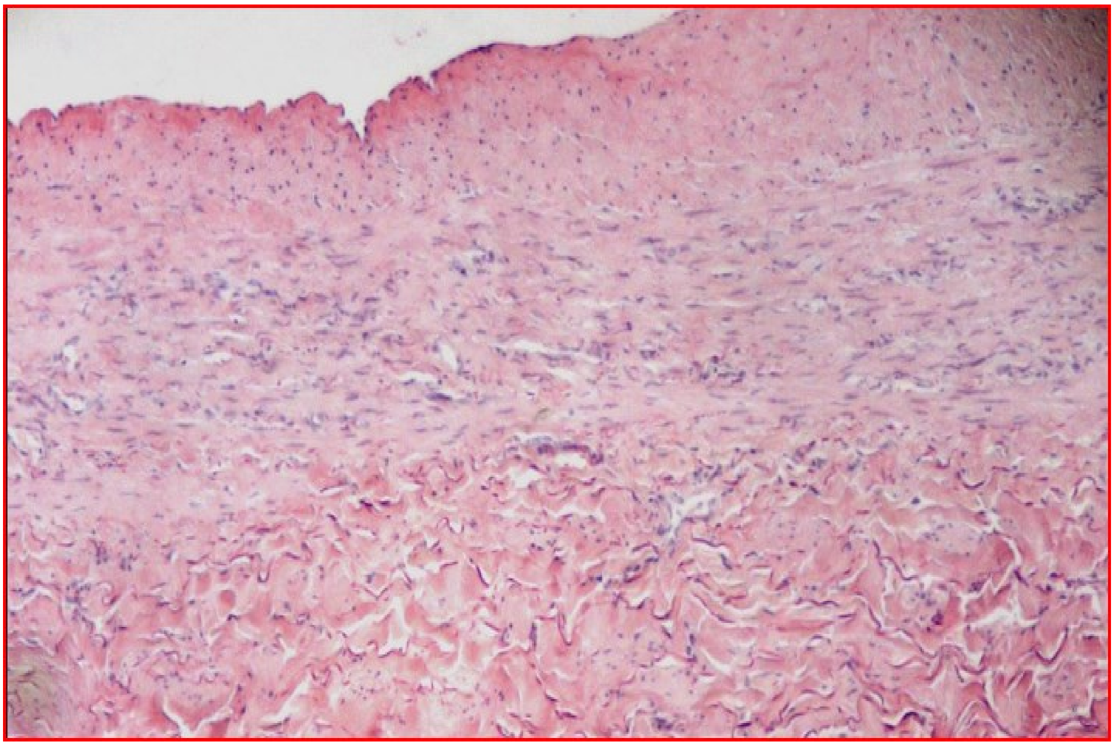

Fig. 10: T.S. in the saphenous vein (below the knee). Notice that the media is more muscular in comparison to the media of the saphenous vein near saphenofemaol junction. (Ex. & E.).

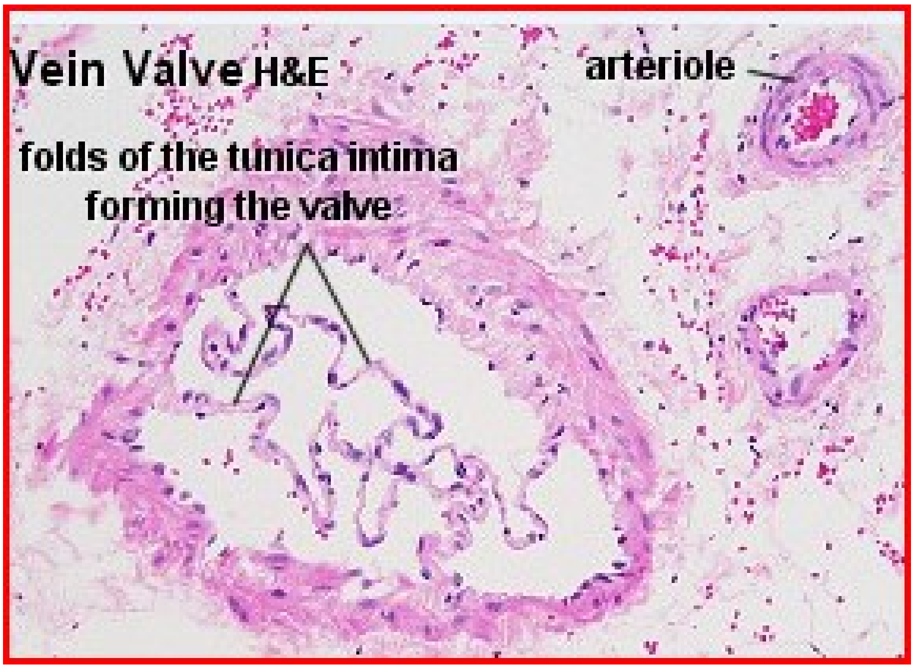

Fig. 11: T.S. in the saphenous vein. Notice that the valve cusp endothelium is continuous with that of the venous wall. The endothelium is longitudinally arranged on one side and transversely arranged on the other side. The muscle fibres are condensed at the side of attachment of the valve to the venous wall. (Hx & E. stain).

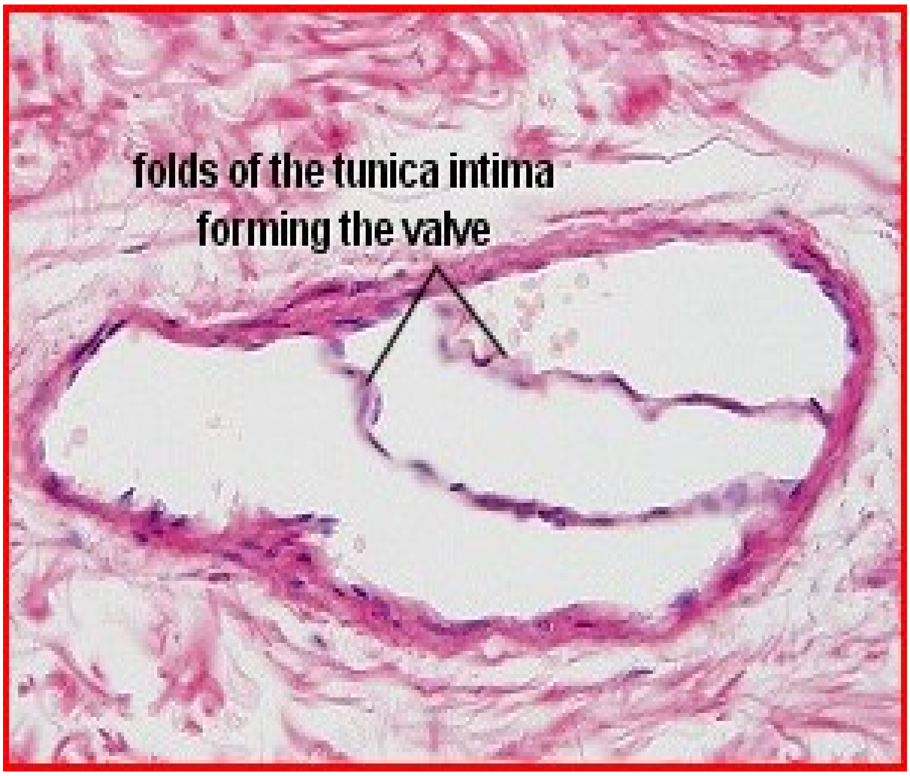

Fig. 12: T.S. in the saphenous vein valve. Notice that the continuity of the endothelium of the cusp with that of the venous wall. The endothelium is obviously noticed to be transversely arranged in one side of the valve cusp. (Hx & E. stain).

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