

VASCULARIZATION OF THE UPPER LIMB ARTERIES

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The study of arterial wall vascularization has an essential practical bearing on the elucidation of the mechanism of age-related and pathological changes taking place in the wall. The opinion, postulated by a number of authors, according to which the arterial wall is endowed with proper vessels in the adventitia and external parts of the media is based mainly on studies of the aorta and pulmonary trunk in animals, and rather rarely in man. Arterial wall vascularization in the arteries of different caliber and type is not the same. The limited number of researches into arteries of muscular type performed in animals show that vascularization of part of the media is observed only in individual arteries from various animals, and merely when it is a matter of a very thick wall — Vankov, Stoinov (8), Hundeiker (3, 4), Neuman (6). Vascularization of the major arteries of the upper limb is barely studied, with data about some of them being reported by Lang (5), Clarke (2), Rashidov (1) and Szkandera Jerzy (7). According to the authors just referred to the media of the main arteries of the brachium and antebrachium is avascular. Clarke (2) found vessels in the outer part of the media only in the axillary artery.

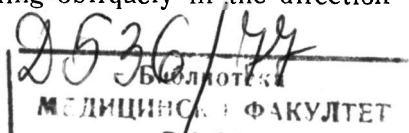
The present study was undertaken because of the great paucity of systematic and complete researches into the vascularization of the major upper-limb arteries along their full course.

Material and methods

For the purpose of the study we used material from 14 individuals of varying ages: two newborns, five teenagers from 3 to 18 years, and seven adults from 38 to 88 years. The limbs of the individuals were totally injected with India ink — gelatin contrast medium, and thereafter histological preparations, cleared sections and total cleared preparations were worked out from 87 sectors of the axillary, brachial, radial and ulnar arteries.

Results

The proper vessels in the axillary artery wall are situated mainly within the adventitia. They form a many-layered vascular plexus of interlaced arteriolo-venular bundles, accompanied by single capillaries. The thickness and density of the vascular plexus increase with aging, whilst the deepest capillaries build up a terminal capillary network at the end of the growth period. Until this age, the thickness of the wall never exceeds 250 μ , and the deepest vessels represent spaced apart capillaries, connecting the innermost arterioles and venules, as well as single capillaries, running obliquely in the direction



of the media. They are disposed in the deep denser layers of the adventitia, and are 15—30 μ distant from the media. With aging, the terminal capillary network becomes denser, and in individuals above 50, it reveals a much greater density, flattening and is deprived of a definite orientation. At thickness of the wall exceeding 500 μ , its vessels are found in the immediate proximity to the media (5—10 μ), and only single vessels come into contact with the latter.



Fig. 1. Brachial artery (38 y.). Isolated vascularized zones. India ink — gelatin. Totally cleared preparation. Microphot.: oc. 5, ob. 3. 2.

longitudinal orientation and termination in loop-like capillaries along the periphery (Fig. 1). These vascularized fields arise bilaterally from the points of meeting between the artery and veins, with an avascular zone persisting in the middle.

In the proximal half of the brachial artery where its wall is thicker, the isolated vascularized fields join along the length and circumference of the artery forming zones characterized by uniform capillary network, longitudinal disposition and greater density. The vessels of the latter formations are situated in the fibroelastic layer of the adventitia, whilst the innermost capillaries are 15—30 μ distant from the media, at total thickness of the intima and media exceeding 350 μ . Whenever the thickness of the wall exceeds 500 μ , single capillaries, touching the media, occur by way of exception.

In the radial and ulnar arteries the quantity of vessels augments in distal direction, simultaneously with the increase of their wall thickness. In adult

The arteries of muscular type (brachial, radial and ulnar) have approximately equal vascularization pattern. Along the anterior and posterior surface of these arteries, within the loose conjunctival layer enwrapping the vascular bundle, there are transversely disposed long capillaries. They join the vessels of the arteriolo-venular bundles, positioned in the grooves between the artery and its accompanying veins, and display undulated and dilated venous portion. The proper vascular plexus of the arteries is located deeper, within the outermost loose layer of the adventitia. Its structure is similar to that of the axillary, but it exhibits a much weaker density. With aging, its thickness augments, and the diversely oriented arteriolo-venular bundles form 2—3 layers. The capillaries are few, with varying length and shape, the loop-like one inclusive, and join the vessels of the arteriolo-venular bundles. In individuals above 40 years of age, isolated vascularized fields of varying size and shape occur in the deepest layers of the adventitia. The capillary network within them reveals rather weak density,

individuals both arteries have strongly elongated, vascularized small field in the proximal third of their course, forming longitudinal bands of capillary networks distalwards. The latter dilate towards the wrist, and in the distal third of the forearm they form a complete capillary network, endowed with a higher density. This network in the radial artery is most frequently longi

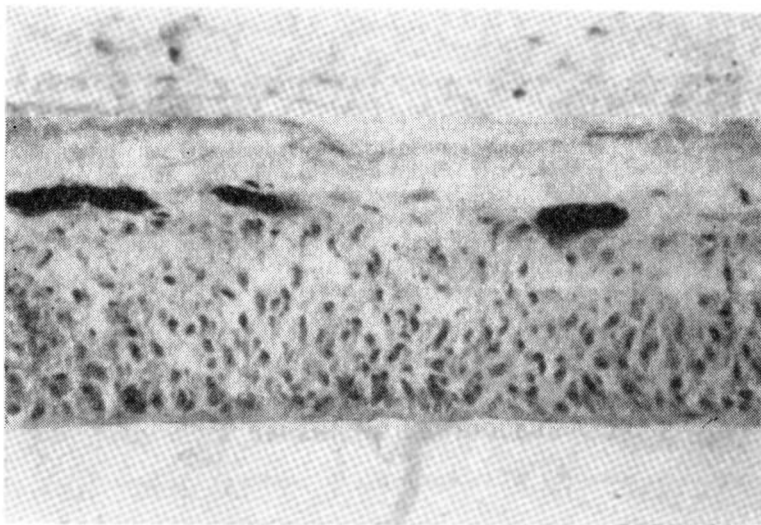


Fig. 2. Ulnar artery (newborn). Vessels touching the muscular layer. India ink — gelatin. Histologic preparation — longitudinal section. Hematoxylin-eosin. Microphot.: oc. 10, ob. 20.

tudinally disposed, whereas in the ulnar artery the orientation of the capillary loops alters in distal direction. In the middle third of the forearm they are still longitudinally disposed, but gradually assume a regular rectangular to square form. In addition, deeper penetrating capillaries occur, exhibiting greater length and strictly circular orientation. The quantity of these capillaries in some of the individuals is substantially elevated, and a spatial capillary network with a very high density is formed. In the palm area, parallel to the arterial caliber decrease, the capillary network rarefies, and the amount of circularly oriented capillaries diminishes. As early as in newborns, the well developed capillary network is characteristic of the ulnar artery vascularization in its distal third. In children it is very strongly pronounced, and its density and spatiality augment with the advancing of age. The longitudinally disposed capillaries within the wall of the radial and ulnar arteries are found in the fibro-elastic layer of the adventitia. In the distal section of the radial artery, at thickness of the wall above 100 μ for adolescents, and 150 μ — for adults, the capillaries are situated in the immediate vicinity of the wall or else, they are virtually touching it. Single capillaries penetrating the media up to 50 μ depth are also encountered in case the total thickness of the intima and media exceeds 500 μ . The capillary network in the distal third of the radial artery length, and in the wrist area is disposed at the junction between fibro-elastic layer and media, and its capillaries touch with half of

their circumference the smooth muscle cells of the media. Capillaries, apposed to the muscle layer, were observed whenever the thickness of the wall exceeded $50\ \mu\text{m}$ for the newborns, and $75\ \mu\text{m}$ for teenagers (Fig. 2). Parallel to the wall thickness increase, the density and depth of penetration of the vessels into the media also increase, reaching $60\ \mu\text{m}$ at total thickness of the wall up to

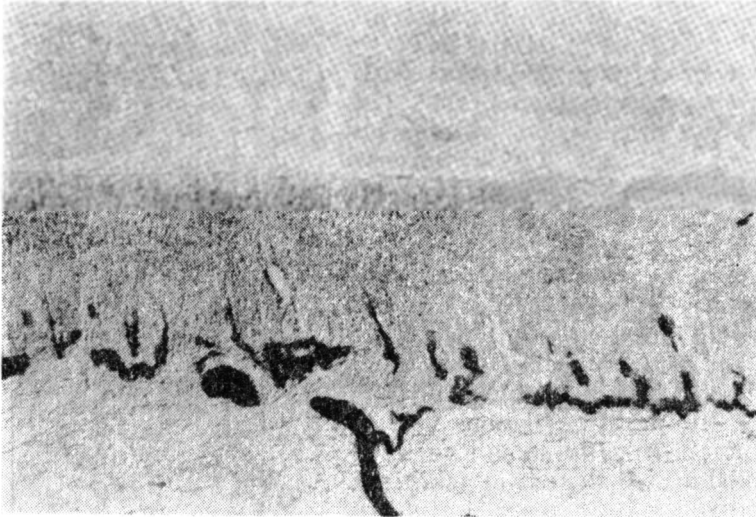


Fig. 3. Ulnar artery (16 y.). Vessels within the media. India ink — gelatin. Cleared preparation — longitudinal section. Microphot.: oc. 8, ob. 3. 2.

$500\ \mu\text{m}$, and from 80 — 150 at thickness of the wall 500 — $700\ \mu\text{m}$ (Fig. 3). It is interesting to note that in teenagers, in comparison with adult individuals, a deeper penetration is noted at a lesser total thickness of the wall.

Discussion

Our data show that the quantity and depth of penetration of the intramural vessels increase with the increase in thickness of the arterial wall, but for the greater part they remain within the confines of the adventitia. This finding of ours is in accordance with the data reported by Lang (1962), Rashidov (1) and Szkandera Jerzy (1971), but by no means corroborates the data of Clarke (2) about the presence of vessels in the media of the axillary artery. Penetration of vessels into the media in the distal sections of the radial and ulnar artery was demonstrated for the first time by us. It is conditioned by the greater thickness of the wall in comparison with that in the proximal two thirds of the arterial course. Our data comply with those reported by Vankov and Marinov (9) about the lower limb arteries, and by Hundeiker (3) and Neuman (6) concerning some muscular arteries in animals. In all likelihood, the lower pressure in the distal sections of the radial and ulnar arteries contributes to the presence of vessels in the media. Such a presumption is warranted by the evidence (found by us) of vascularization of the brachial artery which, in grown-

up individuals, has thickness of the wall equal or greater than that of the ulnar artery although it has no vessels in the media, as well as by the evidence of vascular presence in the media of the ulnar artery in the region of the palm at much smaller thickness of its wall.

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**ВАСКУЛЯРИЗАЦИЯ СТЕНКИ АРТЕРИЙ
ВЕРХНЕЙ КОНЕЧНОСТИ**

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РЕЗЮМЕ

Изучены особенности васкуляризации в стенке подкрыльцовой, плечевой, лучевой и локтевой артерий у 14 индивидов различного возраста. Количество и распределение сосудов в стенке различных артерий различно, указывая на зависимость от толщины стенки и характера гладкой мускулатуры в ней. Сосуды образуют густое сосудистое сплетение в адвентиции подкрыльцовой артерии и капиллярную сеть на границе с медиа. Капиллярная сеть в стенке подкрыльцовой, лучевой и верхней 2/3 локтевой артерии представлена в виде тонких продольных нитей или изолированных полей, в то время как их сосуды расположены в фибро-эластическом слое адвентиция. Стенка локтевой артерии в дистальной трети равномерно васкуляризирована густой сетью капилляров, которые располагаются между мышечной тканью на внешней 1/6—1/4 части медиа.