Supply and demand

Dr Sotirios Foutsizoglou on the blood supply of the skin

MJ Timmons concludes his "Landmarks in the anatomical study of the blood supply of the skin" article, published in 1985, with the rhetorical question, "how much trouble would doctors have saved their patients and themselves if more attention had been given to the simple idea [that] some patients need treatments and interventions involving their skin, skin needs blood to heal, so how does the blood reach the skin?"[1]

The skin is the largest organ of the body comprising 16 % of body weight with a surface area 1.8m^2 and is the principal site of interaction with the surrounding world. Our skin serves as a protective barrier that prevents organs and deep tissues from exposure to trauma, ultraviolet (UV) radiation, temperature extremes, toxins, and bacteria. Other important functions include sensory perception, immunological surveillance (e.g. Langerhans cells –antigen presenting immune cells residing in the epidermis), and control of insensible fluid loss.

Temperature regulation to maintain homeostasis is one of its major roles. This important function is provided by a rich network of cutaneous arteries and veins, especially in the dermal and subdermal plexi, which supply the sweat glands and allow for heat exchange by convection, conduction, and radiation. Although the cutaneous circulation is rich and vast, the metabolic demands of the skin are low so that only a fraction of the potential cutaneous circulation is necessary for skin viability - a fact that is pertinent to the design and survival of various skin flaps.[2]

***Homeostasis:** The ability of a system or living organism to adjust its internal environment to maintain a stable equilibrium; such as the ability of warm-blooded animals to maintain a constant temperature*

CUTANEOUS BLOOD SUPPLY

Most of the blood flow in the skin is directed towards the more metabolically active components, namely, the epidermis, the follicular papillae, and the epidermal appendages. Two vascular plexuses connected by communicating vessels are present in the dermis. At the junction of the dermis and subcutaneous adipose tissue lies the deep vascular plexus, which receives its vascular supply from musculocutaneous arteries perforating the subcutaneous tissue. Arterioles from the deep vascular plexus supply the epidermal appendages and the superficial vascular plexus. The superficial vascular plexus lies in the superficial aspect of the reticular dermis and gives rise to a rich capillary system in the papillary dermis. This capillary loop system abuts the epidermis and provides it with nutrients by diffusion. The dermis also contains a lymphatic system that resembles the vascular plexuses.

The epidermis does not contain blood vessels; instead, cells in the deepest epidermal layers are nourished by diffusion from blood capillaries that are present in the upper layer of the dermis (papillary). Diffusion provides nourishment and waste removal from the cells of the dermis, as well as for the cells of the epidermis.

The dermal arteries originate either directly from the source arteries (septocutaneous or fasciocutaneous perforators) or as terminal branches of muscular vessels (musculocutaneous perforators). Each source artery supplies a 3-dimensional vascular territory from bone to skin termed an angiosome. The angiosome is defined as a composite block of tissue supplied by a main source artery. The source arteries (segmental or distributing arteries) that supply these blocks of tissue are responsible for the supply of the skin and the underlying deep structures. When pieced together like a jigsaw puzzle, they constitute the three-dimensional vascular territories of the body. Adjacent angiosomes have vascular connections via reduced calibre (choke) or similar calibre (true) anastomotic arteries.

During their course to the skin, the cutaneous arteries travel within or adjacent to the connective tissue framework and supply branches to each tissue with which they come into close contact (bone, muscle, fascia, nerve, fat). They emerge from the deep fascia in the vicinity of the intermuscular or intramuscular septa or near tendons and travel toward the skin, where they form extensive subdermal and dermal plexuses. The dermis contains horizontally arranged superficial and deep plexuses, which are interconnected via communicating vessels oriented perpendicular to the skin surface. Cutaneous vessels ultimately anastomose to form a continuous vascular network within the skin. Dilation and contraction of the dermal blood vessels results in vast changes in blood flow, which can vary from 1 to 100ml/min per 100g of skin.[3] Arteriovenous anastomoses under the control of the sympathetic nervous system shunt blood to the superficial venous plexuses affecting the skin temperature.[9]

The cutaneous veins also form a three-dimensional plexus of interconnecting channels with dominant strata in the subdermis. Although many of these veins have valves that direct the blood in a particular direction, they are often connected by avalvular veins.[4] These avalvular (oscillating) vessels allow bidirectional flow between adjacent venous territories whose valves may be oriented in opposite directions, thus providing for the equilibration of flow and pressure. In some regions, valved channels direct flow radially away from a plexus of avalvular veins as, for example, in the venous drainage from the vertex of the scalp or the nipple-areolar summit of the breast.[5] In other areas, valved channels direct flow toward a central focus, seen in the groin or in the stellate limbs of the cutaneous perforating veins.

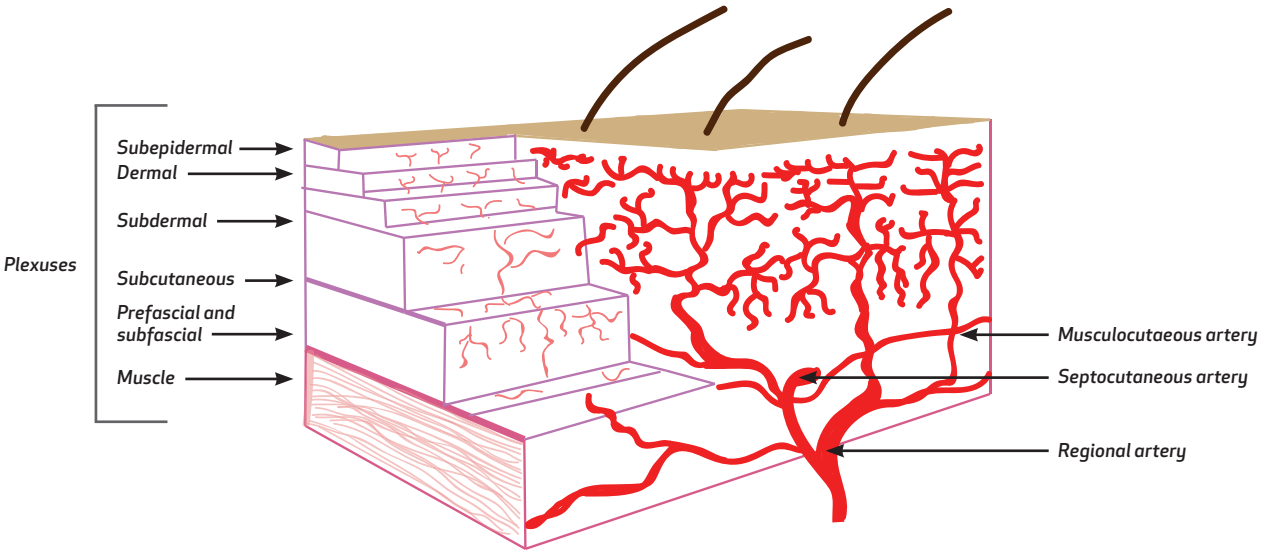
In general, venous anatomy parallels arterial anatomy.

From dermal and subdermal venous plexuses, the veins collect either into horizontal large-caliber veins, where they often relate to cutaneous nerves and a longitudinal system of chain-linked arteries, or alternatively in centrifugal or stellate fashion into a common channel that passes vertically down in company with the cutaneous arteries to pierce the deep fascia. Thereafter, the veins travel with the direct and indirect cutaneous arteries, draining ultimately into the venae comitantes of the source arteries in the deep tissue.

CUTANEOUS VASCULAR PATTERNS

The cutaneous tissues and their vessels form flat layers of horizontal, interconnected vascular plexi supplying the fascia, subcutaneous tissue and skin. These plexi include the following[6]:

- The **fascial plexus** is the deepest, found at the deep muscle fascia, and is fed by musculo- and septocutaneous vessels.
- The **subcutaneous plexus** lies in SMAS. The subcutaneous vessels exit at the superficial fascia and divide the subcutaneous fat into superficial and deep layers. It is formed by both the musculocutaneous and septocutaneous arteries.
- The **subdermal (or upper fat layer) plexus** is the main blood supply to the skin. It runs like a flat mat of interconnecting vessels in a plane at the junction of the reticular dermis and the subcutaneous fat or upper fat layer or, more practically, the superficial to mid-subcutaneous fat. The subdermal vessels account for the dermal bleeding when skin is incised or injured. This rich plexus is the most important with regards to survival of skin flaps when a portion of skin has been separated from the underlying tissue, but still remaining attached on only one side. The subdermal plexus consists of both arterioles and capillaries with enough perfusion pressure to nourish a random flap.



- The **dermal plexus** provides thermoregulation. The intradermal plexus itself is not sufficient to provide to support tissue viability.
- The subepidermal plexus capillary bed supplies nutrients to the skin. The subepidermal vessels are located at the papillary ridge.

CLASSIFICATION OF THE CUTANEOUS BLOOD SUPPLY

DIRECT CUTANEOUS PERFORATOR VESSELS

These vessels contribute to the primary (dominant) cutaneous supply to the area and are particularly well developed in the limbs. They arise from the underlying source artery or from one of its muscular branches before they enter the muscle. They pass between the muscles and other deep structures in the intermuscular septa and rapidly reach and perforate the outer layer of the deep fascia where their main destination is the skin. They are usually large and spaced well apart in the torso, head, neck, arms, and thighs, especially where the skin is mobile. They are smaller and more numerous in the forearms and legs except where they accompany cutaneous nerves. In the palms of the hands and the soles of the feet, they are evident as a dense network of small vessels. In each case, these direct cutaneous vessels follow the connective tissue framework of the deep tissue to the skin. They pass between the muscles and tendons supplying branches to them as they pass, sometimes closely related to true intermuscular septa, as "septocutaneous vessels".[7]

INDIRECT CUTANEOUS PERFORATOR VESSELS

These vessels arise from the source arteries and penetrate the deep tissues, usually muscle, vertically or obliquely before piercing the outer layer of the deep fascia. They may be quite large and contribute to the primary (dominant) blood supply to the skin and are particularly well developed on the torso (for example, the internal thoracic, intercostal, and deep inferior epigastric musculocutaneous perforators). Alternatively, they may emerge as small "spent" terminal branches to provide the secondary (supplementary) supply to the skin. These are small vessels, often quite numerous, which emerge as terminal twigs of vessels whose predominant supply is to the various deep tissues, especially the muscles.[8]

CONCLUSION

Skin health is directly related to the proper function of its individual cells and extracellular matrix components, appendages, vascular plexuses, and its repair and defence mechanisms. Any change in any of these structures or mechanisms is reflected on the skin's surface altering the appearance of the outer covering of our body.

Skin's generous and undisturbed blood supply is essential to maintaining homeostasis as well as being associated with faster healing, improved cellular metabolism, reduction in collagen breakdown and therefore wrinkle formation, and an overall healthier look. **AM**

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