Scanning Electron Microscopy on the Distribution of the Minute Blood Vessels in the Thyroid Gland of the Dog, Rat and Rhesus Monkey

Hisao Fujita and Takuro Murakami

Received October 11, 1973

Summary. Using corrosion casts prepared with methyl methacrylate (Murakami, 1971), the distribution of minute blood vessels in the thyroid gland of the dog, rat and rhesus monkey was observed with the scanning electron microscope. The blood capillaries derived from the interlobular or interfollicular arteries make a complex network encapsulating each follicle like a basket. In most follicles, capillaries for one follicle are well ramified and anastomosed with one another, and in a few follicles the anastomoses are not so well developed.

In the dog and rat the wall of each basket consisting of the capillary network is often common with that of the adjacent follicles. Two rooms surrounded by perifollicular capillary networks are often connected with one another like Siamese twins. By transparent electron microscopy, follicular epithelial cells of the adjacent two follicles are sometimes in contact directly without any connective tissue between them.

In the monkey, the capillary network of one basket is completely independent of that of the adjacent one and a round or oval complete structure like a basket ball is characteristic.

It is well known that endocrine glands are supplied with rich vascularization for taking up raw materials necessary for hormone synthesis and transporting the released hormone. The outer surface of the thyroid follicle is known to be encapsulated with a capillary network (Billroth, 1882). As to the distribution of minute blood vessels in the thyroid, light microscopic studies using sections obtained from animals injected with tracers such as India ink have been published by Ogawa (1957) on the cat and rabbit, Higaki et al. (1957) on the dog and Yorishima (1959) on lower vertebrates. However, the three dimensional structure of the distribution of the minute blood vessels in the thyroid is not so clear using their method. The scanning electron microscope is one of the most useful devices for detecting the three dimensional structure of the tissue. Recently Murakami (1971) reported a new technique for making corrosion casts demonstrating the distribution of blood vessels using the scanning electron microscope. Applying this method to the thyroid, fairly good pictures have been obtained showing the three dimensional structure of the vascularization in the thyroid of some mammals.

Materials and Methods

Materials we used were adult male rats (Donryu strain), weighing about 250 g, an adult male dog weighing about 8 kg, and a male rhesus monkey weighing about 10 kg. Using Murakami’s method (Murakami, 1971), methyl methacrylate was injected into the brachiocephalic arteries of the monkey and dog and into the left
Fig. 1.
ventricles of rats. In the present study the injection mixture of resin used was free of plasticizer. After the resin injection, the thyroid was immersed in a hot water bath (60°C) for 6 hrs and then placed in a hot bath of concentrated sodium hydroxide (60°C) for 6 hrs to complete the polymerization of the injected resin and to macerate the specimen. The macerated specimens washed thoroughly in water and coated with carbon and gold, were observed using the JSM-U3 type scanning electron microscope.

Observations

The thyroid gland in mammals generally consists of numerous follicles and connective tissue among them. Each follicle is surrounded by an interfollicular connective tissue, and a lobule consisting of a group of some follicles is surrounded by a somewhat larger amount of connective tissue called interlobular connective tissue which is continuous with the interfollicular connective tissue. The entire thyroid gland having several lobules is encapsulated by the capsule of connective tissue elements which is continuous with the interlobular and interfollicular connective tissue. However, in small sized mammals such as rats and mice, the lobular unit is not so distinct. Blood vessels to the follicle supplying oxygen, nutrients and raw materials for thyroid hormone and blood vessels receiving thyroid hormone from the follicle for transportation to other parts of the body are contained in the interfollicular and interlobular connective tissue. The thyroid artery ramifies and enters the interlobular connective tissue as interlobular arteries. The interlobular artery sends its branches to the interfollicular connective tissue as interfollicular arteries and blood capillaries. In the rat and dog, the distribution of the blood capillary shows an almost similar pattern. The blood capillaries in the interfollicular connective tissue are extremely rich in distribution. They are mostly similar and about 30-40 µ in diameter among all these animals. The area ratio of the blood capillary nets to the spaces among them is about 0.5–2. Each follicle is surrounded by a network consisting of very frequently branched blood capillaries. In most follicles numerous anastomoses of blood capillaries are noticed, while in the other few follicles they are somewhat poor in frequency. The capillaries run relatively parallel to one another in the latter case. The capillary network looks like a basket encapsulating the follicle. In the rat and dog the wall of each basket consisting of the capillary network is usually common with that of the adjacent baskets. In addition, the wall of the capillary network around each follicle is often incomplete and two rooms are sometimes connected to one another like Siamese twins. By transparent electron microscopy direct contact between the basal plasma membranes of follicular epithelial cells of two adjacent follicles without any connective tissue are sometimes observed in the rat and mouse.

The characteristic of the monkey thyroid is the fact that each basket of capillary network is independent of the adjacent one. The capillary network of one basket is not common with that of the adjacent one, and so numerous round or oval complete

---

Fig. 1. Blood vessels in the dog thyroid. a. Notice networks of blood capillaries encapsulating each follicle. Many rooms for follicles (R) cut transversely are seen. In a lobule, many incomplete basket-like structures consisting of the wall of nets are seen. The wall of each basket consisting of the capillary network is often common with that of the adjacent one, and the room for the follicle is not always independent. ×120. b. A part of Figure 1a at a higher magnification. ×240. Rooms for follicles (R) are encapsulated with capillary networks.
Fig. 2.
Fig. 3. Blood vessels of a monkey thyroid. a. Many round or oval basket-like structures for follicles. Each follicle is completely encapsulated with a capillary network. Notice interlobular (L) and interfollicular (F) arteries. ×230. b and c. Notice the relationship among the interlobular artery (L), interfollicular artery (F) and blood capillaries (B). a ×230, b ×300, c ×230

Fig. 2. Outside view of the distribution of blood vessels of a rat thyroid. a. An interlobular artery (L) is ramified into interfollicular arteries and blood capillaries. ×270. b. A higher magnification. ×720. Walls of capillary networks for two follicles (W), which are connected with each other.
Fig. 4. A direct cell contact between two follicles without any connective tissue elements (→ ←) in a mouse thyroid. F follicular lumen, C connective tissue space, E capillary endothelium. x14,500
basketball-like structures consisting of capillary networks are seen in this animal. Each follicle is, of course, independent of the adjacent one. In the monkey thyroid, it is easy to trace the pathway of interlobular and interfollicular arteries until they become blood capillaries forming the network. The blood from the capillary net pours into the interfollicular vein or directly into the interlobular vein. The interlobular veins at last become the thyroidal vein.

Discussion

In the present paper the three dimensional structure of the rich vascularization distributed in the interfollicular connective tissue becomes clear. The fine structure of the thyroid blood capillary has already been clarified by many investigators since the work of Ekholm (1957). There are a connective tissue space and sheets of basal lamina between the follicular epithelial cell and the capillary endothelium. The hormonal substance released from the follicular epithelial cell enters the connective tissue space where the tissue fluid exists. There are numerous fenestrations in the epithelial lining, which might be useful for transportation of the hormonal substance into the capillary lumen from the connective tissue space. These structures are well known to be common among all the endocrine organs. The capillary is fairly large in diameter and is considered to belong to the category of sinusoid capillary like that of the hypophysis. The extremely rich distribution of well ramified sinusoid blood capillaries which makes us speculate on the slow stream of the blood in this part seems reasonable and necessary for receiving the released hormone from follicular epithelial cells and providing the raw materials for hormone production. The authors wish to emphasize that the rich vascularization in the interfollicular connective tissue is demonstrated three dimensionally in the present paper.

イヌ，ラット，サルの甲状腺の微小血管分布の走査電子顕微鏡像

藤田善男と村上宅郎

村上の考案した方法によって メチルメタクリレートを注入して 鉱型を作り、イヌ、ラット、サルの甲状腺の微小血管の分布を走査電子顕微鏡で観察した。小葉間動脈、濾胞間動脈に由来する毛細血管は複雑な網を作り、それぞれの濾胞をバスケットのように囲んでいる。たいていの濾胞では、ひとつの濾胞を囲む毛細血管はよく分岐し たがいに吻合しているが、少数のものでは 吻合はそれほどには発達していない。

ラットとイヌでは毛細血管網からなるバスケットの壁が、しばしば隣のバスケットのそれと共通になっている。また 毛細血管網の一部が欠けて 2つのバスケットの内腔が たがいにつながっていることもあるが、これは透過電子顕微鏡による観察で、隣接する 2つの濾胞の上皮細胞の基底部同志が 結合組織の介在なしに直接 接している場合にあたると考えられる。

サルでは ひとつのバスケットの毛細血管網は 隣接するバスケットのそれとは全く独立しており、それぞれが完全なバスケットボール様の球ないし卵形構造を示すのが特徴的である。
References


