
Takuro Murakami1, Tsuyoshi Miyake2, Yoshifumi Uno1, Aiji Ohtsuka1, Takehito Taguchi1 and Tadashi Sano2

Department of Anatomy1, Okayama University School of Medicine, and Division of Internal Medicine2, Okayama Kosei Hospital, Okayama, Japan

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Summary. The blood vascular bed of the rat thyroid gland was reproduced by injection of a methacrylate casting medium and observed with a scanning electron microscope. The rat thyroid gland received the superior and inferior thyroid arteries and emitted the superior and inferior thyroid veins. Anastomosis between the interlobular arteries or between the interlobular veins was frequently observed in the thyroid gland. The arteriovenous anastomosis was rarely observed between the terminal branches of the lobular arteries and veins.

The thyroid blood vascular bed was divided into lobular units which consisted of basket-like capillary networks surrounding the thyroid follicles; a small lobular unit consisted of a few networks, whereas a large one of fifty or more networks. Sizes and forms of the networks varied widely in each case. However, the networks in the superficial layers of the lateral parts of the thyroid gland were typically most developed.

Regardless of its size and form, each network always received a proper afferent vessel from the lobular artery and issued a proper efferent vessel continuous with the lobular vein, though it was sometimes provided with an accessory afferent or efferent vessel. Only occasionally were the adjacent networks fused with each other or connected by transfollicular capillaries. Thus, the present data suggest that each follicular capillary network is a fairly independent functional-unit in the thyroid microcirculation. The capillaries of the network were sinusoidal in nature and sometimes protruded fine projections which indicated the neogenesis of capillaries.

The blood vascular bed of the newborn rat thyroid gland was not always differentiated into basket-like capillary networks.

The thyroid gland synthesizes, stores and releases hormones concerned with the regulation of the metabolic rate (thyroxin and triiodothyronine) and with the maintenance of blood calcium levels within tolerable limits (calcitonin); the function related to the metabolic rate resides in the follicular epithelial cells, whereas the calcium-regulating action resides in the parafollicular cells (Turner and Bagnara, 1976; Martin, 1985; Fawcett, 1986). It is also well known that the thyroid gland contains a dense or rich blood capillary bed which takes up raw materials necessary for hormone synthesis and transports the released hormones (Turner and Bagnara, 1976; Martin, 1985; Fawcett, 1986).

The blood vascular bed of the thyroid gland has been studied in man, the monkey, dog, cat, rat and other animals (Major, 1909; Wilson, 1929; Modell, 1933; Koch, 1938; Thomas, 1945; Gorbman, 1947; Ogawa, 1952; Higaki et al., 1957; Yoshishima, 1959; Wollman et al., 1978; Ericson and Wollman, 1980; Klak et al., 1983). These investigations have been made by transmission light or electron microscopy of sectioned tissue samples, including India ink-injected specimens. However, these methods have been not suited for a three-dimensional visualization of the blood vascular bed, in that the finer details of the thyroid capillary networks have not been fully elucidated. The present study aims to analyze the blood vascular bed of the normal rat thyroid gland by scanning electron microscope observation of corrosion casts combined with microdissection (Murakami, 1971, 1975), and to supplement previous findings by Raj and Meserve (1982), Meserve and Klak (1984) and Imada et al. (1986a, b) as well as ours (Fujita and Murakami, 1974; Ohtani et al., 1983; Kikuta et al., 1984) using also scanning electron microscopy of cast preparations.

MATERIALS AND METHODS

Male and female adult Wistar rats (weighing 300-500
g), which had been fed standard pellets (Oriental Yeast) and tap water, were anesthetized with ethyl ether, and their thoracic aorta was ligated. The animals were then perfused through the ascending aorta with Ringer's solution and with a low viscosity methacrylate casting medium (Murakami, 1975) until the superior vena cava was filled with the perfused methacrylate medium.

The methacrylate-perfused animals were placed in a hot water bath (60°C) for 2 h, corroded in a hot 10% NaOH solution (60°C) overnight or longer, washed in running tap water overnight or longer, and air-dried. The blood vascular casts thus prepared were dissected with sharpened forceps, and the blood vascular cast of the thyroid gland was isolated together with those of the parathyroid glands, trachea and oesophagus.

The isolated specimens were sputter-coated with gold in a vacuum chamber, and observed with a scanning electron microscope (HHS-2R, Hitachi) using an acceleration voltage of 5 kV. After this observation, the specimens were microdissected with sharpened needles under a binocular light microscope (SMZ-10, Nikon) and again observed with the scanning electron microscope. The microdissection included the freeze-cutting of the specimens with razor blades. This series of dissection and scanning electron microscopy of the thyroid blood vascular casts was repeated for thorough elucidation of the inner structures of the specimens.

RESULTS

The thorough perfusion of the low viscosity methacrylate medium through the ascending aorta after ligation of the thoracic aorta and after the removal of blood by irrigation with Ringer's solution allowed a good casting of the blood vascular bed of the thyroid gland as well as those of the parathyroid glands, trachea and oesophagus (Figs. 1-3). Only negligible leakage of the perfused methacrylate medium was sometimes noted in the thyroid and parathyroid glands (Fig. 1). Some shallow vascular contractions by the resin injection were occasionally imprinted in the casts of the arteries and veins as well as the capillaries (Figs. 4, 5, 7-10). Nuclear resistance of the vascular endothelial cells against the resin injection was also occasionally imprinted in the casts (Figs. 7, 8, 10).

The rat was found to possess only one pair of parathyroid glands (left and right). Each parathyroid gland was ovoid in shape and located at the latero-cranial aspect of the thyroid gland (Fig. 1). These findings on the parathyroid glands have been reported elsewhere (Murakami et al., 1987).

No marked difference in the thyroid blood vascular bed was noted between the male and female rats. The rat thyroid gland was H-shaped, and surrounded the trachea and oesophagus at a level between the first and fourth (or fifth) tracheal rings; the anterior part of the thyroid gland was thin and located ventral to the trachea, whereas the main or lateral parts (right and left) of the gland were thick and situated lateral to the trachea and oesophagus (Figs. 1, 2).

The rat thyroid gland received the right superior, right inferior, left superior and left inferior thyroid arteries and emitted the right superior, right inferior, left superior and left inferior thyroid veins (Figs. 1, 3). It was usual for the right upper half of the gland to be supplied by the right superior thyroid artery and vein, the right inferior half by the right inferior thyroid artery and vein, the left superior half by the left superior thyroid artery and vein, and the left inferior half by the left inferior thyroid artery and vein. It was also typical that each of the left and right superior thyroid veins issued a well developed branch which descended on the lateral surface or surface-layer of the gland and anastomosed into a main branch of the corresponding inferior thyroid vein (Figs. 1, 2).

The thyroid arteries and veins took various branchings in the thyroid gland and continued into the inter-

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Fig. 1. A survey scanning electron micrograph of the methacrylate-cast blood vascular beds of the rat thyroid (TG) and parathyroid (PT) glands (adult male rat weighing 400 g, viewed from the right side). The capsular capillary meshworks of the thyroid and parathyroid glands were removed together with the capillary networks of the adjacent connective and fatty tissues. Some parts of the tracheal capillary bed (TR) were broken during this dissection. Note that the capillary beds of the thyroid and parathyroid glands are sufficiently or fully reproduced though some leakage of the injected resin (z) is observed, and that the right superior thyroid vein (SV) gives off an extraordinarily well developed branch (VV) which is accompanied or surrounded by fine vessels (arrowheads) and descends to Anastomose into a main branch of the right inferior thyroid vein (IV). This anastomosis was confirmed by successive dissection (data, not shown). AT anterior part of the thyroid gland, IA right inferior thyroid artery, LT lateral part of the thyroid gland, SA right superior thyroid artery, ib branch of the inferior thyroid artery, ie branch of the inferior thyroid vein, sa branch of the superior thyroid artery. ×40
Fig. 1. Legend on the opposite page.
Fig. 2. A survey scanning electron micrograph of methacrylate-cast and horizontally freeze-cut blood vascular beds of the rat thyroid gland (TG), trachea (TR) and oesophagus (OE) (adult female rat weighing 350 g, viewed from the upper side). Note that the blood vascular bed of the thyroid gland consists of numerous basket-like or follicular capillary networks (F), and that the follicular capillary networks in the central layers (arrowheads) of the lateral parts (LT) of the thyroid gland are smaller than those in the other areas. AT anterior part of the thyroid gland, VV veno-venous anastomoses between the superior and inferior thyroid veins, sa branches of the superior thyroid arteries, sv branches of the superior thyroid veins. x45

Fig. 3. A survey scanning electron micrograph of the methacrylate-cast and parasagittally freeze-cut blood vascular bed of the rat thyroid gland (TG) (adult male rat weighing 300 g, viewed from the left side). This figure shows, together with Figure 2, that the blood vascular bed of the thyroid gland consists of numerous basket-like or follicular capillary networks (F), and that the follicular capillary networks in the deep layers (arrowheads) of the lateral part (LT) of the thyroid gland are smaller than those in the other areas. Note that some of the superficially located follicular networks are fully developed or extraordinarily large in size (GF) (giant follicular capillary networks). Inset shows a closer scanning view of a part of a follicular network in this figure. Note in this Inset that the capillaries (SC) of the follicular network are sinusoidal in nature and protrude some small or thin projections which suggest the neogenesis of capillaries. AT anterior part of the thyroid gland, IA and IV right inferior thyroid artery and vein, SA and SV right superior thyroid artery and vein, ia branch of the inferior thyroid artery, ia tracheal branch of the inferior thyroid artery. x60, Inset: x760
Fig. 3. Legend on the opposite page.
lobular arteries and veins, and then into the lobular arteries and veins (Fig. 5). The thick interlobular veins, including the above-described venous anastomoses, were usually accompanied by very thin and coarse capillary networks which were supplied by the fine twigs of the interlobular arteries and veins (Fig. 1). Some interlobular veins constantly anastomosed with each other and formed venous collateral circulation routes (Fig. 4). Such interlobular collateral circulation routes were also constantly observed in the arterial system (Inset in Fig. 4). Certain segments of the venous collateral route sometimes showed marked constrictions (Fig. 4). Such constrictions were never noted in the arterial collateral route. Arterio-venous anastomosis was rarely observed between the terminal branches of the lobular arteries and veins (perifollicular arterio-venous anastomosis) (Fig. 7).

The thyroid blood vascular bed was divided into lobular units which were supplied by the lobular arteries and veins (Fig. 5). Each lobular unit consisted of follicular or basket-like capillary networks which surrounded the thyroid follicles (Figs. 2–10). Thus, the lobular units resembled bunches of grapes (Fig. 5). The sizes of the lobular units varied widely in each case; small units contained only a few follicular capillary networks, whereas large ones contained fifty or more networks (Fig. 5).

The follicular capillary networks were usually ovoid in shape (Figs. 3, 6–10), but many of them showed unusual forms or shapes resembling either logs, peanuts, gourds, dumbbells or mushrooms (Inset in Fig. 6). These unusual networks were characterized by their densely distributed and somewhat dilated capillaries (Inset in Fig. 6). The sizes of the follicular capillary networks also varied in each case; including the unusual ones, they measured 30–500 μm along their long diameters (Figs. 3, 6–10). Furthermore, it was observed that the larger networks were located in the more superficial layers of the thyroid gland; the smaller ones were observed in deeper layers of the lateral parts of the gland (Figs. 2, 3). The networks in the superficial layers of the lateral parts of the gland were sometimes extraordinarily developed to have their long diameters surpass 500 μm (giant follicular capillary networks) (Fig. 3).

Regardless of their forms and sizes, the follicular capillary networks consisted of sinusoidal capillaries which were arranged in a single layer (Figs. 6–10). The diameters of the sinusoidal capillaries were measured at 10–15 μm. Each follicular capillary network always received a proper afferent vessel (follicular artery) from the lobular artery and issued a proper efferent vessel (follicular vein) continuous with the lobular vein (Figs. 5, 8–10). In the small or medium-sized networks, the afferent vessels were always thinner than the efferent vessels (Figs. 8, 9). The afferent vessels became thicker as the follicular capillary networks became larger. Thus, in large follicles whose long diameters were greater than 500 μm, the afferent vessels were as thick as the efferent vessels (Fig. 10). In such large networks, the afferent vessel branched on the surface of the network into two or more twigs which gave off several daughter afferent rootlets, ultimately continuing into the sinusoidal capillaries of the network (Fig. 10). In contrast, the afferent vessel of the small network directly continued into one of the sinusoidal capillaries (Figs. 8, 9). In the medium-sized networks, the afferent vessel abruptly branched into several sinusoidal capillaries.

The efferent vessel collected the sinusoidal capillaries of the network, and usually left the network at the opposite side of the afferent vessel (Fig. 8) though it sometimes took a position close to the afferent vessel (Fig. 9). It was usual for the orifice or original segment of the efferent vessel to show a marked ring-like or sphincter-like constriction (Figs. 7–10). Such a sphincter-like constriction was never noted in any segment of the afferent vessel. The follicular capillary networks, especially the large ones, occasionally received an accessory afferent vessel or issued an accessory efferent vessel (Fig. 6). These accessory vessels were always markedly thinner than the proper afferent or efferent vessels.

The sinusoidal capillaries of the follicular network freely anastomosed with each other (Figs. 4–10). Distribution patterns of these anastomosing capillaries varied in each case. In some cases, the capillaries were somewhat thickened and densely and tortuously distributed (Inset in Fig. 6). In other cases, the capillaries were flattened and coarsely and

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**Fig. 4.** Anastomoses (vv) between the interlobular veins as observed in the superficial layer of the rat thyroid gland (adult female rat weighing 400 g). *Thick arrowhead* indicates a marked constriction of an interlobular veno-venous anastomosis. This constriction is occasional in occurrence. *Arrows* show the shallow and wave-like vascular contractions. *Inset* shows a interlobular arterio-arterial anastomosis (thin arrowhead). *F* follicular networks, *iv* branch of the left inferior thyroid artery, *iv* branch of the right inferior thyroid vein, *sa* branch of the right superior thyroid artery, *se* branch of the right superior thyroid vein. ×105, Inset: ×40
Fig. 4. Legend on the opposite page.
smoothly distributed (Fig. 10). Intermediate types were also observed (Figs. 7-9).

It was frequently observed that some thin capillaries were inserted between the sinusoidal capillaries of the follicular network (Figs. 9, 10), and that the sinusoidal capillaries displayed some small protrusions with free endings (Inset in Fig. 3). Furthermore, it was occasionally observed that two adjacent follicular capillary networks were connected by one or a few sinusoidal capillaries (transfollicular capillaries) (Figs. 6, 7). These transfollicular capillaries showed no marked constrictions in any of their segments. In addition to these unusual vessels, it was sometimes noted that two adjacent follicular capillary networks were fused to have a luminal continuity (Fig. 6), and that two adjacent follicular capillary networks adhered to occupy common capillaries (Fig. 6). In spite of these fusions and adhesions, each follicular capillary network was provided with a proper afferent vessel and also a proper efferent vessel.

DISCUSSION

The present scanning electron microscope study of corrosion casts, together with our previous ones (Fujita and Murakami, 1974; Ohtani et al., 1983; Kikuta et al., 1984), confirms that the rat thyroid gland contains a rich capillary bed which consists of follicular or basket-like capillary networks surrounding the thyroid follicles. This finding coincides with those obtained in man, the monkey, dog, cat, rat and other animals by transmission light or electron microscopy of tissue sections, including those of India ink-injected specimens (Major, 1909; Wilson, 1929; Modell, 1933; Bargmann, 1939; Thomas, 1945; Gorbman, 1947; Ogawa, 1952; Higaki et al., 1957; Yorishima, 1959; Wollman et al., 1978; Ericson and Wollman, 1980; Klak et al., 1983). It also confirms that a few to fifty or more follicular capillary networks cluster to form a lobular circulatory unit which is supplied by the lobular artery and vein, and that the parent vessels (interlobular arteries and veins) of the lobular arteries and veins constantly form many collateral circulation routes in the thyroid gland.

Modell (1933) observed sectioned tissue samples of a dog under the light microscope and described some venous valves in the interlobular or lobular veins and also many arterio-venous anastomoses between the interlobular arteries and veins or between the lobular arteries and veins. However, such venous valves and thick arterio-venous anastomoses were neither imprinted nor reproduced in the present cast preparations of the rat. Gilpin (1934), Kux (1935) and many other authors, including Bargmann (1939), described by light microscopy of sectioned tissue samples that in man, the dog and cat, certain segments of the interlobular and lobular arteries of the thyroid gland were narrowed by the so-called “polster” consisting of muscle cell clusters between the endothelium and elastica interna or by the thickened or projected endothelial cells (endothelial cushions). Such narrowed segments of the arteries were not reproduced in the present cast-specimens. Such original constrictions as reproduced in the anterior hypophyseal and carotid body arteries (Taguchi, 1986; Murakami et al., 1987) were never observed in the rat thyroid arteries. These circumstances suggest that in the rat thyroid gland, the blood flows smoothly at the levels of the thyroid arteries and veins, interlobular arteries and veins and also lobular arteries and veins. The here clarified interlobular arterio-arterial and veno-venous anastomoses or collateral routes may assist this smooth blood flow. Especially, the arterio-arterial anastomoses may allow a homogeneous distribution of the arterial blood throughout the thyroid gland. The occasional marked-constrictions of the interlobular veno-venous anastomoses may act as substitutes for the venous valves, in inhibiting retrograde blood flow within the thyroid gland.

The present study clearly shows that each follicular capillary network receives a proper afferent vessel from the lobular artery and issues a proper efferent vessel continuous with the lobular vein, and that the capillaries of each follicular capillary network are sinusoidal in nature and anastomose freely with each other. It was only occasional that the adjacent follicular capillary networks adhered together to occupy the common capillaries or fused to have a luminal continuity. Even in such unusual cases, each network was provided with the proper afferent and efferent vessels (see above). Thus, it can be said in

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**Fig. 5.** Follicular capillary networks (F) and their connecting vessels, which were exposed by dissection. Junctional area between the superficial and deep layers of the right lateral part of the rat thyroid gland (adult male rat weighing 400 g). Note that the follicular capillary networks are clustered to form lobular units. Arrow indicates the vascular constrictions, ai interlobular artery, al lobular artery, vi interlobular vein, vl lobular vein. ×285
Fig. 5. Legend on the opposite page.
Fig. 6. Legend on the opposite page.
general that the follicular capillary network is a fairly independent functional-unit in the thyroid microcirculation. It is noteworthy that the orifice or original segment of the efferent vessel is usually narrowed by a sphincter-like constriction. This constriction may limit the outflow of the blood in the follicular capillary network into the efferent vessel, for follicular epithelial cells to pick up the raw materials sufficient for hormone synthesis. No marked constriction was observed in the afferent vessel. This suggests that the arterial blood enters smoothly into the follicular network.

It has been well confirmed by transmission electron microscopy of sectioned tissue samples that the follicular capillaries are sinusoidal in nature and that their endothelial cells are provided with numerous fenestrations (EKHOLM, 1957; FUJITA and MURAKAMI, 1974). MAJOR (1909) described by light microscopy of

**Fig. 7.** Two follicular capillary networks (F1, F2) isolated from the superficial layer of the right lateral part of the rat thyroid gland (adult male rat weighing 350 g). Thick arrow indicates a ring-like or sphincter-like constriction of the efferent vessel (e) of the F1 network. Thin arrows indicate vascular contractions. Thick arrowhead indicates a rare arterio-venous anastomosis (perifollicular arterio-venous anastomosis) between the terminal branches of the lobular artery (al) and vein (vl). Thin arrowhead indicates a sphincter-like constriction of the perifollicular arterio-venous anastomosis. n Nuclear impression of the endothelial cells, aa accessory afferent vessels of the F1 and F2 networks, ae accessory efferent vessel of the F2 network, tc transfollicular capillaries. ×320

**Fig. 8.** A follicular capillary network (F) dissected out from the deep layer of the left lateral part of the rat thyroid gland (the same animal as shown in Figure 7). Note that the network is provided with a proper afferent vessel (a) and also a proper efferent vessel (e), and that the efferent vessel is narrowed by a sphincter-like constriction (thick arrow). Thin arrows indicate the vascular contractions of the afferent vessel and follicular capillaries (SC). n Nuclear impressions of the endothelial cells, vl lobular vein. ×660

**Fig. 6.** A closer view of a freeze-cut area of Figure 3. Note that the F1 and F2, F3 and F4, and F5 and F6 follicular capillary networks adhered to occupy common capillaries (thin arrowheads), and that the other follicular capillary networks (F) are fairly independent. Also note that the F7 and F8 follicular capillary networks are fused to have a luminal continuity (arrow), and that some follicular capillary networks are connected by transfollicular capillaries (tc). Inset shows a mushroom-shaped follicular capillary network (MF) exposed by successive dissection. Note in this Inset that the capillaries of the network are rather closely or densely distributed. A part of this network was broken during the dissection (thick arrowhead). ×420, Inset: ×160
India ink-injected and sectioned tissue samples that in the cat, each thyroid follicle was not surrounded by a rich capillary network and supplied by its own artery. However, our preliminary scanning electron microscopy of corrosion casts has shown that even in the cat, the follicular capillary network is well developed and has the proper afferent and efferent vessels (data, not shown). Rienhoff (1931, cited by Harrison, 1964) illustrated the dog thyroid follicle as surrounded by capillaries arranged in two or more layers. Such a complicated follicular network was never encountered in the present study. Our previous scanning electron microscopy of corrosion casts has confirmed that the follicular capillaries of the monkey and dog, like those of the rat, are arranged in a single layer (Fujita and Murakami, 1974).

It is well known that the thyroid follicles synthesize, store and release hormones such as thyroxin and triiodothyronine (Turner and Bagnara, 1976; Martin, 1985; Fawcett, 1986). The here observed unusual networks such as dumbbell-, peanut- or mushroom-shaped networks with densely distributed and somewhat dilated sinusoidal capillaries may represent some contracted conditions of the thyroid follicles, to release the stored hormones into the perifollicular tissue spaces or into the follicular capillary networks. The networks with flattened and coarsely distributed sinusoidal capillaries may represent extremely dilated forms of the thyroid follicles, fully to store the hormones or colloid within the thyroid follicles.

Imada et al. (1986a) have indicated by scanning electron microscopy of corrosion casts that in the low iodine diet-treated or thyroid-stimulating hormone-
Fig. 11. Parasagittally freeze-cut blood vascular bed of the newborn rat thyroid gland (male, 5 days after birth, viewed from the left side). Note that the differentiations of the thyroid capillary bed into the follicular or basket-like capillary networks (F) are only observed in the superficial layers (SL) of the lateral part of the gland. In other areas, such differentiations are rather rare. Arrowhead indicates a small capillary network at an initial stage of development. DL deep layers of the right lateral part of the thyroid gland, iv branches of the right inferior thyroid vein. ×160
treated rat, the follicular capillaries show marked dilation and fusion, and that in the propylthiouracile-treated rat, most follicular networks show marked distortions and contain many heterogeneously dilated capillaries. IMADA et al. (1986b) have further indicated by the same method that in the levothyroxine sodium-treated rat, the follicular capillaries are fine but poor in distribution. These data, together with our present findings and previous experimental studies of other authors (THOMAS, 1945; GORBMAN, 1947; WOLLMAN et al., 1978; RAJ and MESERVE, 1982; KLAK et al., 1983; MESERVE and KLAK, 1984), confirm that the distributions, diameters and arrangements of the follicular capillaries as well as the forms or shapes of the follicular networks are affected by the functional states or conditions of the follicles.

The present study shows that in the rat, the large follicles or follicular capillary networks, including giant ones, are preferentially located in the superficial layers of the lateral parts of the thyroid gland; the networks in the deep layers of the lateral parts of the thyroid gland are smaller than those in the anterior part of the gland. This may mean that in the rat thyroid gland, the anterior part and the superficial layers of the lateral parts are functionally more important. Another preliminary scanning electron microscopy of corrosion casts by us has shown that in the newborn rat, the thyroid capillaries are not always organized into follicular or basket-like capillary networks. It also has shown that in the rat, organization or differentiation of the thyroid capillaries into basket-like capillary networks begin 5 days after birth; the basket-like capillary networks first appear in the superficial layers of the lateral parts of the gland though they are small in sizes (Fig. 11).

Our preliminary observations of newborn rats and present observations of adult rats show that the thyroid follicular capillary networks or follicles become larger as the animals age, and that the larger networks contain more capillaries. These findings indicate the continuous neogenesis of the follicular capillaries in the aging process of the animals or in the developing process of the follicles. The here observed thin capillaries intercalated between the sinusoidal capillaries of the follicular capillary networks may be newly formed vessels. The small protrusions of the sinusoidal capillaries may represent the initial stages of this neogenesis of capillaries.

As to the neogenesis of the capillaries, two main theories have been put forward, particularly for the kidney glomerulus. One theory obtained by light microscopy of sectioned tissue samples contends that the facing (upper and lower) luminal surfaces of dilated vessels contact each other, fuse, and produce fenestrations or divide into several capillaries (OSATHANONDH and POTTER, 1966; KAZIMIERCZAK, 1971). Another theory obtained by scanning electron microscopy of corrosion casts claims that the capillaries sprout daughter capillaries from their surfaces (NAITO, 1984). Of the present data, the frequent reproductions of small protrusions of the sinusoidal capillaries suggest that in the rat thyroid gland, the neogenesis of capillaries is mainly carried out by the latter sprouting theory. Similar sprouting reproductions of capillaries have been reported by scanning electron microscopy of corrosion casts in the luteinizing follicles in the rat ovary (MURAKAMI et al., 1988).

The present study, moreover, shows that the follicular capillary networks of the rat thyroid gland are sometimes connected by one or a few transfolicular capillaries and that the terminal branches of the lobular arteries and veins are rarely anastomosed with each other (perifollicular arterio-venous anastomosis). As described above, the differentiation of the follicular capillary networks begins after birth. We consider that the transfolicular capillaries are undifferentiated remnants of the fetal thyroid capillaries, and that the perifollicular arterio-venous anastomoses are also undifferentiated remnants of the fetal arterio-venous anastomoses between the terminal branches of the thyroid arteries and veins. We also believe these transfolicular capillaries and perifollicular arterio-venous anastomoses bear no functional significance in the thyroid microcirculation since their occurrences are rather sporadic. The marked constriction of the opening segment of the unusual perifollicular arterio-venous anastomosis suggests the existence of the sphincter in this site. The accessory afferent or efferent vessels of the follicular capillary networks may be acquired secondarily after birth since they are preferentially observed in the large follicular networks; we have failed to observe such accessory vessels in small or developing networks.

In the rat thyroid gland, only a few parafollicular cells have been found in the stroma or between follicular epithelial cells (LIETZ and ZIPPEL, 1969; PILGRIM, 1970). These cells may be supplied by the follicular capillary networks since no blood capillary network could be reproduced between or among the follicular capillary networks.


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Prof. Takuro Murakami
Department of Anatomy
Okayama University School of Medicine
2-5-1 Shikata-cho
Okayama, 700 Japan

村 上 宅 郎
700 岡山市鶴田町 2-5-1
岡山大学医学部
解剖学第二講座