THE UNIVERSITY OF MINNESOTA

GRADUATE SCHOOL

Report

of

Committee on Examination

This is to certify that we the undersigned, as a committee of the Graduate School, have given Edward Vernon Mastin final oral examination for the degree of

Master of Science in Surgery

We recommend that the degree of

Master of Science in Surgery

be conferred upon the candidate.

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REPORT

of

COMMITTEE ON THESIS

The undersigned, acting as a Committee of the Graduate School, have read the accompanying thesis submitted by Edward Vernon Mastin, for the degree of Master of Science in Surgery. They approve it as a thesis meeting the requirements of the Graduate School of the University of Minnesota, and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science in Surgery.

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THESIS

THE BLOOD SUPPLY OF THE THYROID GLAND AND ITS SURGICAL SIGNIFICANCE

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of the University of Minnesota in partial fulfillment of
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It has long been known that the thyroid is a very vascular organ. We would naturally expect this, since this gland exerts such a profound influence, through its secretions, upon the physical and nervous development of the body. C. H. Mayo says that the blood supply of the thyroid, in proportion to its size, is five times that of the brain. Porter states that all the blood in the human body can pass through the thyroid in an hour or less. In a series of experiments, Tschnewsky[43] found that the amount of blood flowing through the thyroid gland was 560 c.c. per minute for each 100 gm. weight of the gland. He also showed that the total amount of blood in the body of a dog passed through its thyroid gland sixteen times in a day.

Location:

The thyroid gland is situated in front and at the sides of the trachea. It is symmetrical in plan but not in details, and consists of two lateral lobes connected by the isthmus. There is a pyramidal lobe in about 50 per cent of the cases; this lobe rises from the isthmus or from one of the lateral lobes. The thyroid lies posterior to the group of infrahyoid muscles, from which it is separated by the middle layer of the cervical fascia. The lower portions of the lateral lobes are crossed by the sternomastoid muscles. The inner surface lies against the trachea, the cricoid cartilage and the lower posterior wings of the thyroid cartilage. It reaches back to the esophagus, which it touches on the left and sometimes on the right, and it rests against the prevertebral fascia. Posterior or slightly external to the gland is the common carotid. The internal jugular vein lies beyond the artery.

Arterial blood supply:

Each lateral lobe of the thyroid gland is supplied by two arteries, while an occasional fifth vessel, the thyroidea ima, supplies the isthmus. The superior thyroid artery is the first branch of the external carotid, and comes off just above the bifurcation of the carotids. At first it ascends, almost horizontally anteriorly, but soon it turns downward and passes beneath the omohyoid, sternohyoid and sternothyroid muscles, to reach the superior pole of the thyroid gland. Just before reaching the superior pole it divides into two or three branches; the main trunk passes downward and inward, sends branches coursing over the anterior surface and finally enters the substance of the gland. Another branch pursues a course down the posterior surface of the lateral lobe, and still another may enter the body of the gland as soon as it reached the superior pole.

The inferior thyroid artery is larger than the superior, and its course is more variable. It is the largest branch that arises from the thyroid axis. It passes vertically upward to about the level of the transverse process of the sixth cervical vertebra and then bends medially, passing behind the common carotid artery, the internal jugular vein and the pneumogastric nerve, either behind or in front of the recurrent laryngeal nerve, and finally reaches the basal part of the lateral lobe. In 83 per cent of the cases examined the artery was in front of the nerve, in 7 per cent behind it, and in the remaining 10 per cent the nerve was surrounded by numerous branches of the inferior thyroid artery. The branches reach the gland posteriorly at about the middle third; some ramify over the surface while others go to the parenchyma, dividing into many branches soon after reaching the gland substance.

The thyroidea ima generally arises from the innominate artery, but it may spring from the aorta or from the right common carotid artery. It runs upward in front of the trachea to reach the isthmus. In several thousand thyroidectomies Pemberton has encountered this artery only once. In the course of this study a thyroid ima was not observed.

Venous blood supply:

The thyroid has a very rich venous supply. Emerging from the organ, the veins form a large plexus beneath the capsule, from which the blood escapes by three chief courses on each side. The superior thyroid veins are double, and are the only ones that follow the course of the corresponding arteries. As a rule, they empty directly into the internal jugular or into the facial or may communicate with the linguals. The inferior thyroid veins, generally two in number, come from the deeper part of the organ and form a rich plexus in front of the trachea under the middle layer of the cervical fascia. They drain for the most part into the left innominate vein. They may, however, enter at the angle between the two innominate veins. The middle thyroid veins, or the lateral group of veins, leave the lateral aspect of each lobe, cross the common carotid and enter the internal jugular, anastomosing as a rule with the pharyngeal plexus.

Lymphatic supply:

The lymphatics begin in the gland as perifollicular lymph spaces; from these spaces, plexuses follow the interlobular septa in their course to the exterior, where they constitute a superficial plexus from which the lymph passes in all direction. Some lymph runs upward from the isthmus to small lymph nodes in front of the larynx, and some downward to the pretracheal lymph nodes. That from the sides flows to the deep glands about the internal jugular vein.

Nerve supply:

The nerve supply of the thyroid gland probably has its origin in filaments from the sympathetic ganglion. Rhinehart has shown that the nerves which go to the thyroid are entirely of the non medulated variety. They reach the gland from neighboring cervical sympathetic ganglia, by way of the perivascular connective tissue and the tunica adventitia of the thyroid arteries. They appear as large, wavy, irregular strands, composed of individual varicosed axis cylinders collected together into bundles similar to the wires in a cable. The nerves branch with the arteries and form an elaborate, minute, perivascular plexus. Branches are given off that penetrate between the follicles and form perifollicular plexuses. There are also microscopic filaments which arise from the sympathetic nerve and enter the gland along the walls of the inferior thyroid vessels.

Studies of the nerve supply of the thyroid gland have been made by Cannon, and by Rahe and Rogers and others. Cannon[4] found that after stimulation of the cervical sympathetic nerve, adrenalin gave a much quicker rise in blood pressure if the thyroid gland was intact. This did not occur, however, if the thyroid had been previously removed. Rahe and Rogers conducted a series of experiments on dogs in order to study the nerve supply of the thyroid. They concluded that there seems to be no reasonable doubt but that the thyroid gland is at least partly under nerve control, and that its physiologically active substance is discharged into the circulation in response to nerve stimulus.

Experiments on blood supply:

In order to ascertain to what extent the blood supply of the thyroid gland is affected by ligations, it was thought advisable to study the various possible anastomoses. A detailed study of the blood supply was made by injecting the blood vessels of numerous necropsy specimens (after the method of Gross) with a barium carmine, gelatine mixture, which was heated on a water bath to a temperature of about 60°C. The injections were made with a 10 cc. syringe with enough pressure to fill the capillaries. While the inferior thyroid artery was being injected, the solution was seen running out of the superior thyroid of the same side in every instance, and out of the superior of the opposite side in 30 per cent of the cases, and out of both superiors, and the opposite inferior in 20 per cent of the cases studied. When the primary injection was made in the superior thyroid artery, the injected material was always seen in the inferior thyroid of the same side, and in the superior thyroid of the opposite side in 80 per cent of the cases; and in all of the vessels in 20 per cent. Various combinations of injections were used and roentgenograms made after each injection. Later, the specimens were fixed in Kaiserlin and dissected. The best results were obtained by studying normal thyroids, or small colloid goiters. The exophthalmic goiter was difficult to inject,and the vessels did not show up well.

Major showed in his work that the capsule of the thyroid has a rather scant blood supply, and that the small arteries supplying it anastomose with each other to form a network which divides the capsule into diamond shaped areas.

The principal arterial trunks ramify on the surface of the gland within the true capsule and anastomose freely with one another. The anastomosis is freer between the various vessels of the same side than between those of the opposite sides, though there is a well marked branch of communication present through the isthmus.

The larger arteries are distributed principally over the surface of the gland; there is only an occasional large vessel deep in the parenchyma. Each artery gives off several branches, some of which supply the anterior and some the posterior surface of the gland. The main continuations of these arteries are prone to run along and upon the margins of the gland. (Figures 1, 2, 3, 4, 5 and 6)

The superior thyroid artery is more constant in its division and distribution than the inferior thyroid artery. It generally divides into three branches. The largest branch runs downward over the anterior surface of the gland, sending branches in all directions; some of these ramify over the surface of the gland, some supply the parenchyma of the gland, and others anastomose with the superior thyroid of the opposite side, still others, with the inferior of the same side. The next largest branch descends along the posterior border of the gland and anastomoses with the inferior thyroid, sending branches to the parenchyma of the gland and to the trachea. Often a common trunk is formed by this anastomosis. The trunk gives off a terminal artery, which supplies the superior parathyroid body. The third branch enters the substance of the gland and together with the other parenchymal branches, as shown by Major, rapidly divides and forms a network of vessels supplying the lobules. (Figures 7 and 8)

The inferior thyroid artery divides into two or more branches at varying distances from the gland. Latarjet and Alamartine report instances where the division occurred quite close to the thyroid axis, and one case where there was a double inferior thyroid artery. In a series of 437 observations Dwight reports an absence of the inferior thyroid artery on the right in one case, and on the left in five cases. The principal branches of this artery enter the capsule of the gland on the posterior surface in the neighborhood of the middle third. Some of these branches ramify over the surface of the gland, while one large branch runs along the inferior border toward the isthmus. The number of branches and the points at which they enter the gland substance may vary considerably. In the cases studied, the average point at which the principal branch of the inferior thyroid artery entered the capsule of the gland was 4.5 cm. from the superior pole, and 1.8 cm. from the inferior pole; the length of the lobe averaging 6.34 cm. In one case the uppermost branch entered the capsule 1 cm. from the superior pole. In another case the lowest branch entered the capsule 1/4 cm. from the inferior pole. The inferior thyroid artery is about one-third larger than the superior thyroid artery. The average inferior thyroid vessel measured 2.78 mm; the average superior thyroid artery measured 1.87 mm. The largest inferior was 3.68 mm; the smallest was 1.90 mm. The largest superior thyroid artery measured 2.38 mm, and the smallest was 1.57 mm. At times definite arteries were seen coming through the tracheal rings and entering the posterior surface of the gland; and again branches from the inferior thyroid were seen leaving the gland substance and entering the trachea on its anterolateral surface.

The microscopical blood vessels supplying the thyroid tissue are usually plentiful. The interlobular arteries, which are branches of the parenchymal vessels, are generally two to five in number and break up into close networks that surround the follicles and lie immediately beneath the epithelium. (Figures 9, 10, 11 and 12)

Berard and Destol showed that the anastomoses were upon the surface of the gland, and that few, if any, were intraglandular. Latarjet and Alamartine came to similar conclusions in their experiments. The most important anastomosis is the unilateral longitudinal anastomosis between the superior and inferior arteries of the same side. This anastomosis occurs on the lateral and posterior surfaces and occasionally just within the substance of the gland. Of these, the one on the lateral surface is seen most frequently. One of the most constant branches that unites the inferior and superior thyroid arteries, lies in the angle formed by the trachea and esophagus and extends along the posterior border of the gland. (Figures 13, 14 and 15)

The bilateral anastomoses are as a rule, less developed, more complex, and extremely varied. Often there is a direct communication between the superior thyroid vessels across the upper border of the isthmus, generally anteriorly, but at times posteriorly. The commonest types of anastomoses seen, are those shown in the accompanying plates. Landström and Streckeicen have shown very clearly by their injections, that such anastomoses are present upon the surface of the gland, not only between the arteries of the same side, but also between those of opposite sides. Delore and Alamartine arrived at similar conclusions in a large series of injections. In this study no direct anastomosis was noted between the two inferior thyroid arteries.(Fig.16)

There is an indirect anastomosis by way of the larynx, trachea, and esophagus, by which the blood supply to the thyroid gland can be reestablished after ligation of all four arteries. The larynx is supplied by the superior laryngeal and cricothyroid arteries, which are branches of the superior thyroid artery, and by the inferior laryngeal, a branch of the inferior thyroid artery. The trachea gets its blood supply from branches of the inferior laryngeal and inferior thyroid arteries, which anastomose below with bronchial arteries and with the internal mammaries through the anterior mediastinal twigs. Branches of the inferior thyroid artery supply the esophagus and anastomose with the lower branches of the ascending pharyngeal artery. (Figures 17 and 18)

As a rule, the arteries in the substance of the thyroid gland are accompanied by two veins, which are joined at various places by bar-like connections which run across the arteries. The veins arise from the far side of the capillary network, follow the course of the arteries fairly closely and anastomose in a similar manner. They empty at various places into the larger veins that are emerging from the interior of the gland and anastomose freely on the surface. (Figure 19)

On examining the cut surface of injected glands it was observed that the individual vessels are larger in colloid than in exophthalmic goiters, and that the farther away from the capsule the sections are taken, the smaller the vessels are. No one questions the vascularity of an active exophthalmic goiter. This seeming contradiction, in regard to the size of the vessels as compared to a colloid goiter is explained, therefore, by the fact that the lobules and acini in the exophthalmic goiter are smaller but much more numerous within a given area; and, as each has its individual blood supply, the vessels must, of necessity, break up into numerous smaller arterioles and capillaries in order to supply their lobules. In a colloid goiter the vessels in the parenchyma are larger and do not break down into so many minute capillaries as they do in the exophthalmic goiter. The colloid is not distributed uniformly throughout the gland, but is in excess and under considerable pressure in various areas. The intralobular vessels are pressed upon by this colloid to such extent that the lumen of the vessels is entirely obliterated and the injection material is unable to penetrate them. This observation has been proved histologically by Wilson.

Parathyroid glands:

The parathyroids, two to four in number, were first described by Sandstroem in 1880; later, in 1891, Gley showed their relationship to tetany. In 1907 Halsted and Evans worked out the blood supply in a large series of cases. Lorin has done more recent work on this subject.

The position of the parathyroids is variable; as a rule the superior glandules are found in the middle of the posterior surface of the thyroid gland in line with the channel of anastomosis between the inferior and superior thyroid vessels. The inferior parathyroids are the larger and are situated at the lower pole of the thyroid gland, either resting on the gland or below it on the trachea. The artery to the upper parathyroid is derived from one of the main branches of the inferior thyroid artery or from an anastomosing channel which runs along the posterior margin of the lateral lobe and joins the superior and inferior thyroid vessels. The artery to the lower parathyroid is usually less than 5 mm. in length and it arises from a branch of the inferior thyroid artery. However, in instances where the inferior parathyroid gland is found below the inferior pole, the artery is between 3 and 5 cm. long and courses as a distinct, usually unbranched, vessel to the hilus of the glandule.

After ligation of an inferior thyroid vessel the parathyroids of the same side may be supplied with blood from the superior thyroid artery, and after ligation of the superior and inferior vessels of the same side, the blood supply may come from an anastomosis between vessels of the opposite side. After ligation of all four thyroid vessels the blood supply may be maintained by anastomoses with the pharyngeal, esophageal and tracheal vessels. Cutting off of the blood supply to all of the parathyroids probably would result in tetany. A light tetany may result from ligation of all four thyroid vessels, but this seldom occurs. Iverson, Kocher, Von Eiselsberg and others have noted tetany after ligation of all four vessels, but frequently four ligations have been performed without any resulting tetany. Sistrunk has never seen a case of tetany following four ligations.

Effects of ligation:

It is not understood just why patients with exophthalmic goiter get benefit from the ligation of the superior thyroid arteries. If ligation completely cut off the blood from the area supplied by the ligated vessel, necrosis would result. We know that this is not true; for there is enough experimental evidence presented to show that the anastomosis is so rich that circulation can be reestablished in a short time. Recently, a thyroidectomy was performed at the Mayo Clinic about two weeks after all four vessels had been ligated, and little or no difference was noted in the vascularity of the gland. (Figures 20, 21, 22, 23, and 24)

It would appear that some other factor than blood supply must be responsible for the improvement after ligation. In experiments by Cannon, Binger and Fitz unmistakable signs of hyperthyroidism were produced in cats by anastomosing the vagus trunk into the superior cervical sympathetic. We can well assume, therefore, that the functional activity of the thyroid is controlled by sympathetic fibers. Ligation of the superior thyroid poles in that case brings about an interruption of the impulses reaching the gland from the superior cervical sympathetic ganglion since the branches from this ganglion reach the gland in company with the superior thyroid artery, and are ligated when those vessels are ligated. Segments of the superior thyroid artery and vein were removed during the process of a ligation and also from necropsy specimens, and these were studied microscopically. Many small nerve bundles were seen to be closely associated with the vessels; others were embedded in the connective tissue. In several gross specimens a small nerve was dissected out and found to follow the course of the superior thyroid artery; it gave off minute branches and entered the gland with the artery. Some microscopic branches which are not closely associated with the superior thyroid artery are found in the loose connective tissue at the superior pole, and these enter the gland independently of any vessels.

From some of this evidence, it would appear that in order to get the maximum benefit from superior ligations, a polar ligation should be made in addition to dividing and ligating the superior thyroid artery; this would catch the veins, lymphatics and remaining nerve filaments. Polar ligations, alone, do not suffice; for there is no constant point where the superior thyroid artery enters the gland. We have seen cases where the superior pole has been ligated, but the artery was missed. Pemberton has seen cases where the superior thyroid artery did not enter the superior pole, but went directly to the isthmus. In one specimen examined, the principal branch of the superior thyroid went directly to the isthmus, anastomosing with a branch from the opposite superior.

The improvement which follows superior ligations is not seen following inferior ligations in spite of the fact that the inferior thyroid artery supplies a much larger area than the superior. This may be explained by the fact that there are only a few microscopical nerve filaments accompanying the inferior thyroid vessels. Another factor that may be of importance, if we assume that the activating material passes from the gland by way of its lymphatics, is that the superior lymphatics leave the gland in company with the superior artery and veins, and are ligated at the same time, whereas there are no veins or lymphatics that accompany the inferior thyroid arteries.

Plummer has noted a drop in basal metabolic rate in patients who have gone through a recent crisis, some intercurrent infection, such as tonsillitis, or anything that has caused a reaction. These patients are also apparently benefited. We have noted that the patients who have the sharpest reactions after ligation, often show the most improvement when they return in three months for thyroidectomy. Neuhof was unable to show any uniform changes following experimental ligation of the thyroid arteries and veins in dogs.

Hemorrhage and its control in surgery of the thyroid gland:

The inferior thyroid artery plays such an important role, both in the mechanism of production, and in the surgery of substernal and intrathoracic goiter, that it is worthy of consideration here. The inferior artery ascends in the neck behind the carotid sheath emerging from between the layers of the prevertebral fascia, only a short distance before it enters the capsule on the posterior surface of the gland. This affords a good anchorage for the lower portion of the lobe. Below this point there is considerable gland without any inferior attachment, save the inferior thyroid veins, and they give little or no support. An adenoma developing in this area will follow the plane of least resistance, and hence will grow downward between the middle and prevertebral layers of the deep cervical fascia, into the mediastinum. In removing such a gland it is important to begin at the superior pole and work downward, dividing the inferior thyroid artery close to the gland before attempting removal, and thus avoiding serious hemorrhage.

The control of hemorrhage in goiter surgery, especially in exophthalmic goiter, is still of serious importance. Various methods of operating and different types of stitches have been devised, of which a few bear mentioning:

Velpeau, Kocher, DeQuervain, Jones and others, particularly on the continent, routinely dislocate the gland inward and ligate the inferior thyroid arteries and then the superior vessels before starting the thyroidectomy. The objections to this procedure are the possibility of injury to the recurrent laryngeal nerve and an occasional tetany.

Other surgeons have placed hemostats around the lobe, and then placed a tight rubber band beneath them, and cut the gland across above the hemostats, suturing the cut surface. Helgenberg recommends suturing the sternothyroid muscle or pieces of the sternomastoid muscle to the bleeding surface of the remnant of the thyroid gland.

The running, over and over sutures, lock sutures, continuous mattress sutures, and interrupted mattress sutures have all been used; probably the last named is most satisfactory. Murphy has often stated that great care chould be taken to see that every vessel is found, clamped and ligated in order to insure hemostasis. After the operation is completed the patient should be made to cough or strain. This will cause bleeding from any veins that have collapsed and have not been ligated. Finally, the wound should be packed with gauze if there is any doubt about the hemostasis.

Postoperative hemorrhage is no longer a common occurrence. If it does occur, it comes on from a few hours to seventy-two hours after the operation and is generally from an inferior thyroid vein or from a branch of the inferior thyroid artery. Often no definite bleeding point can be found. Hemorrhage after the third day is extremely rare and is always due to infection.

Conclusions

1. The thyroid has a very rich arterial and venous blood supply.
2. There is an extensive anastomosis between the vessels of the same lobe, and also those of the opposite lobe.
3. In the event of ligation of all four thyroid vessels the circulation can be reestablished through an extra glandular anastomosis.
4. The secretory activity of the thyroid gland is under nerve control.
5. After ligation of the superior thyroid artery a polar ligation should be made in order to cut off the veins, lymphatics, and remaining nerve filaments.
6. Control of hemorrhage is best accomplished by interrupted mattress sutures placed through the remaining gland tissue, and by ligation of all bleeding points, and packing the wound with gauze if necessary.
7. Bleeding veins can often be demonstrated by having the patients strain or cough before closing the wound.

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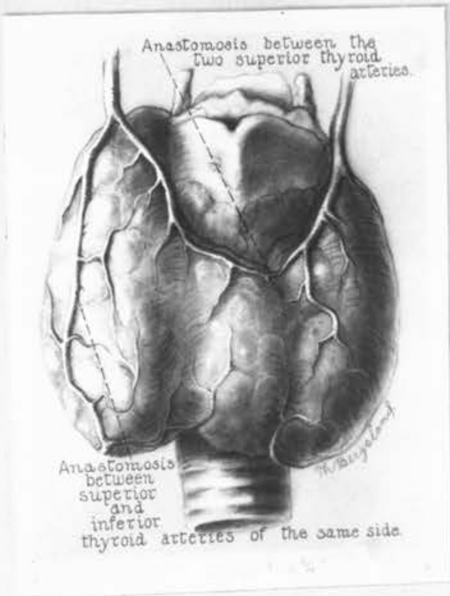


Fig. 1 - Anastomosis between the two superior thyroid arteries, and between the superior and inferior of the same side.

Fig. 2 - Complex anastomosis of four thyroid vessels at isthmus. Longitudinal anastomosis.

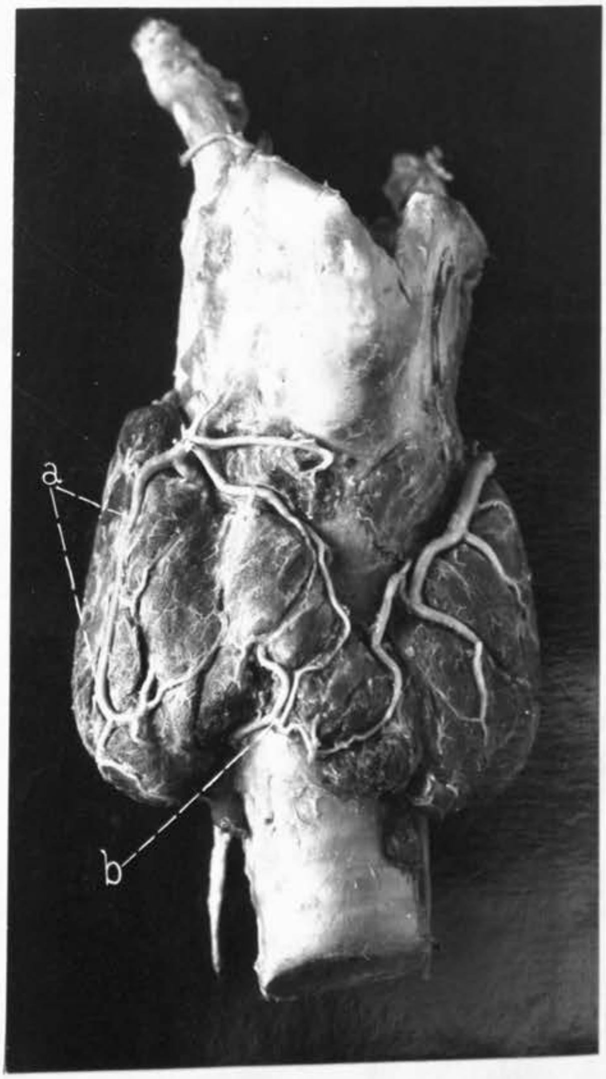


Fig. 3 - Dissection of thyroid gland, showing
(a) longitudinal anastomosis between inferior and superior thyroid arteries of the left side and,
(b) a complex anastomosis between both superior thyroid arteries and the inferior thyroid artery of the left side.- Anterior view. Arteries injected with a carmine gelatine-bismuth preparation.

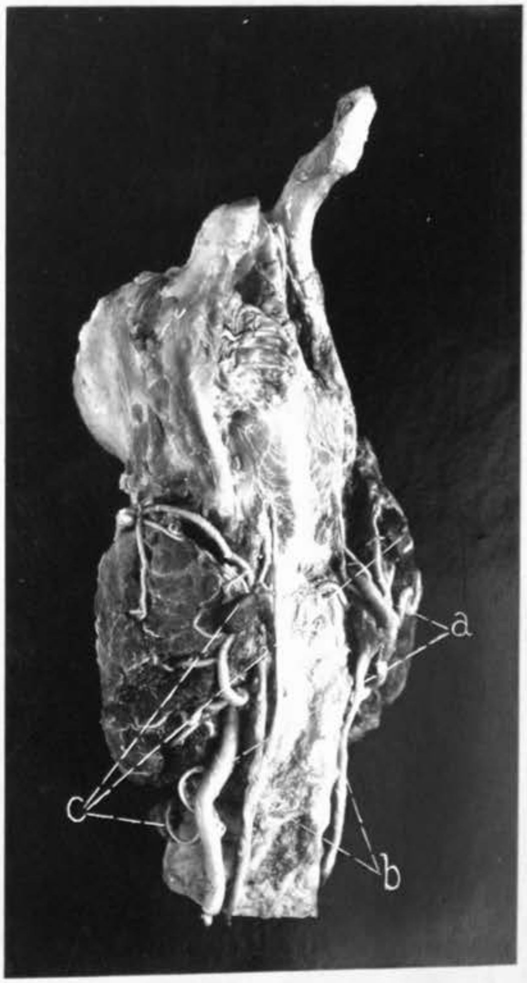


Fig. 4 - Dissection of thyroid gland showing (a) injected blood vessel, (b) recurrent laryngeal nerves, and (c) parathyroid. Postero lateral view. Vessels injected with a carmine, gelatine, bismuth preparation.

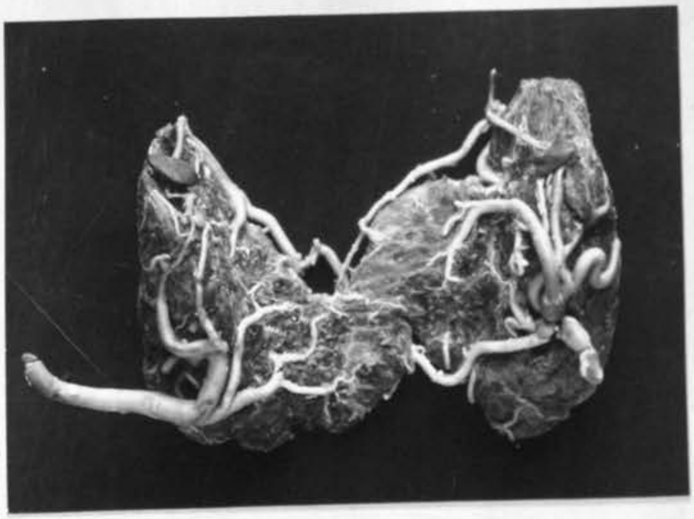


Fig. 5 - Dissected thyroid, posterior view, trachea removed. Vessels injected with a carmine, gelatine, bismuth preparation.

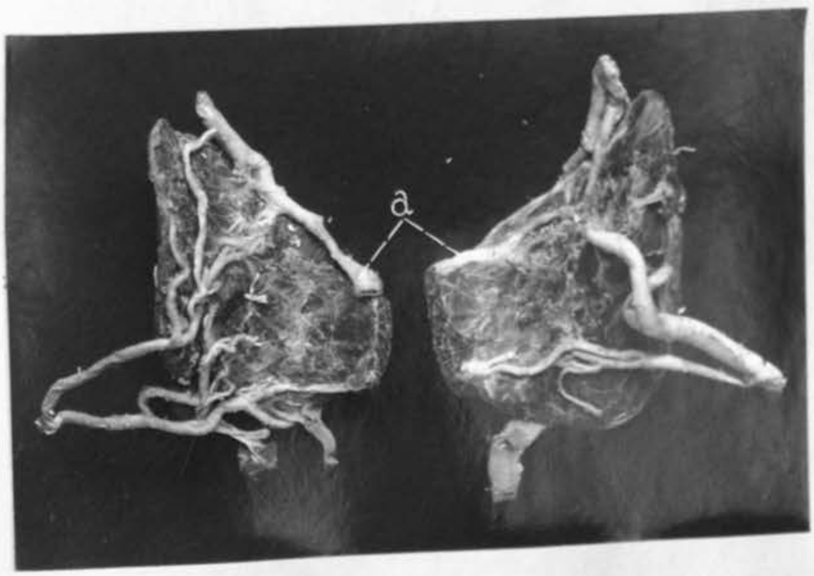


Fig. 6 - Posterior view dissected thyroid. Trachea removed. Shows anastomosis between (a) superior thyroid vessels on posterior surface of isthmus. Vessels injected with a carmine, gelatine, bismuth preparation.

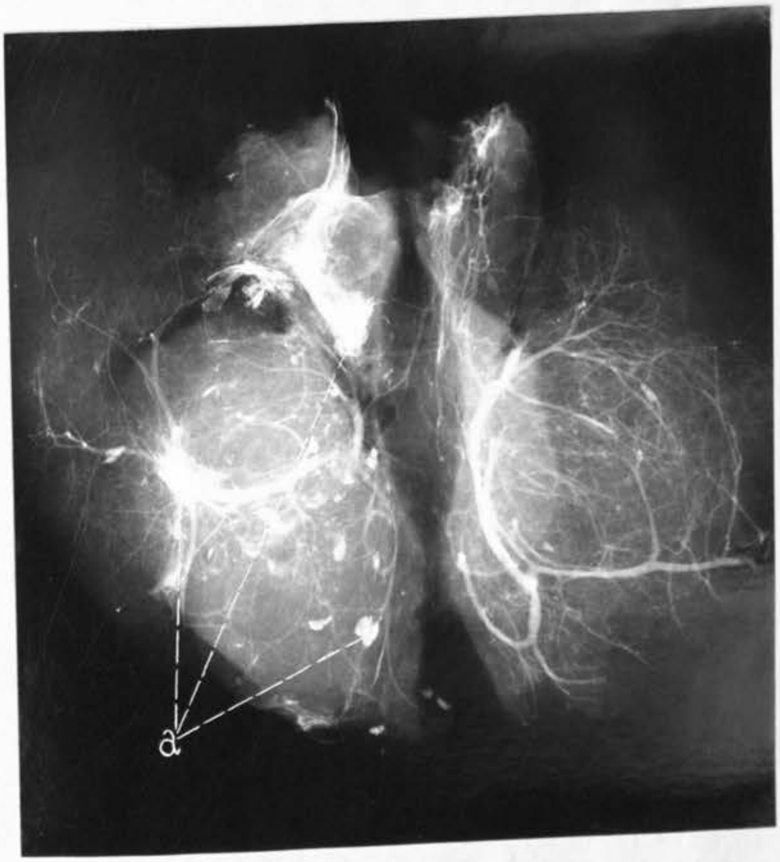


Fig. 7 - Roentgenogram of colloid goiter, both inferior thyroid vessels having been injected with a carmine, gelatine, bismuth preparation - "a" artefacts.

Fig. 8 - Roentgenogram of normal thyroid after injection of all four thyroid vessels with a carmine, gelatine, bismuth preparation. "a" note complex anastomosis at isthmus.

Fig. 9 - Roentgenogram showing result of injection of the right inferior thyroid artery with a carmine, gelatine, bismuth preparation.

Fig. 10 - Roentgenogram showing result of injection of the right inferior and the right superior thyroid arteries with a carmine, gelatine, bismuth preparation.
"a" artefacts.

Fig. 11 - Roentgenogram showing result of injection of the right superior thyroid artery, and both inferior thyroid arteries with a carmine, gelatine, bismuth preparation. "a" artefacts.

Fig. 12 - Roentgenogram showing result of injection of all four thyroid arteries with a carmine, gelatine, bismuth preparation. "a" artefacts.

Fig. 13 - Roentgenogram showing result of injection of right inferior thyroid artery with a carmine, gelatine, bismuth preparation. "a" artefacts.

Fig. 14 - Roentgenogram showing result of injection of both inferior thyroid arteries with a carmine, gelatine, bismuth preparation. "a" artefacts.

Fig. 15 - Roentgenogram showing result of injection of all four thyroid arteries with a carmine, gelatine, bismuth preparation. "a" artefacts.

Fig. 16 - Roentgenogram of trachea after all thyroid
vessels had been injected with a carmine,
gelatine, bismuth preparation.

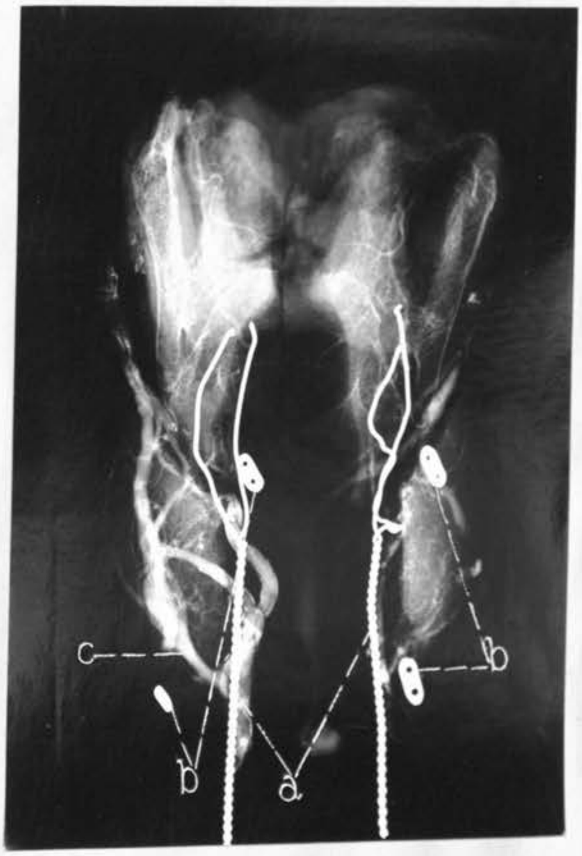
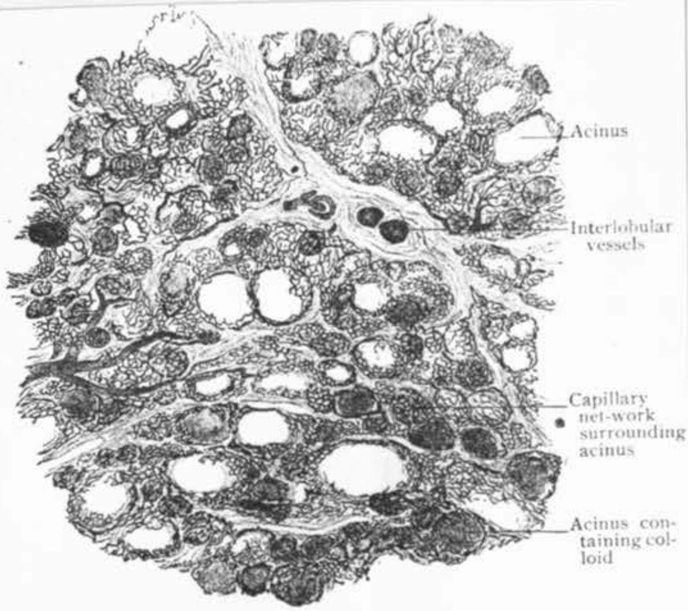


Fig. 17 - Roentgenogram showing relation of (a) the recurrent laryngeal nerves and (b) the parathyroid to the (c) blood supply of the thyroid. Antero-posterior view. Wire laid along course of nerve and, metal tags over parathyroids.

Fig. 18 - Roentgenogram showing relation (a) of the recurrent laryngeal nerve and (b) the parathyroids to the (c) blood supply of the thyroid. Lateral view, thyroid having been cut in two. Wire laid along course of nerve and metal tags over parathyroids.



Section of injected thyroid body. × 46.

Fig. 19 - Section of injected thyroid body X 46 after Piersol.

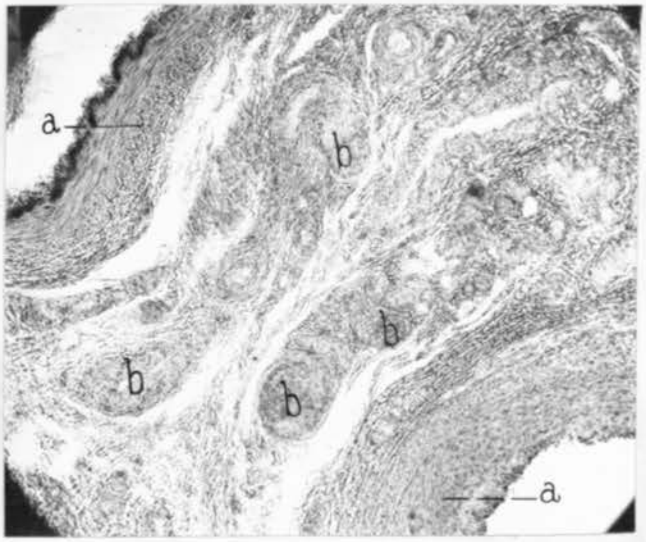


Fig. 20 - Many small (b) nerves in the connective tissue between (a) two branches of the superior thyroid colloid goiter artery. X50.

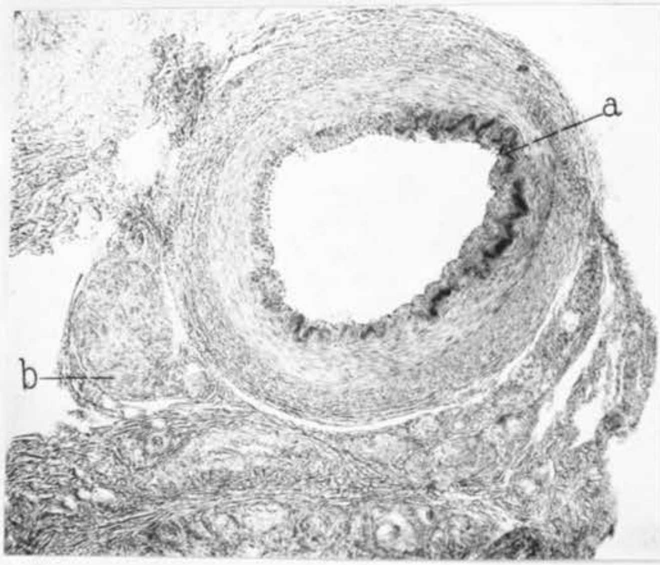


Fig. 21 - Cross section (a) superior thyroid artery and (b) accompanying nerves. X40. Normal thyroid.

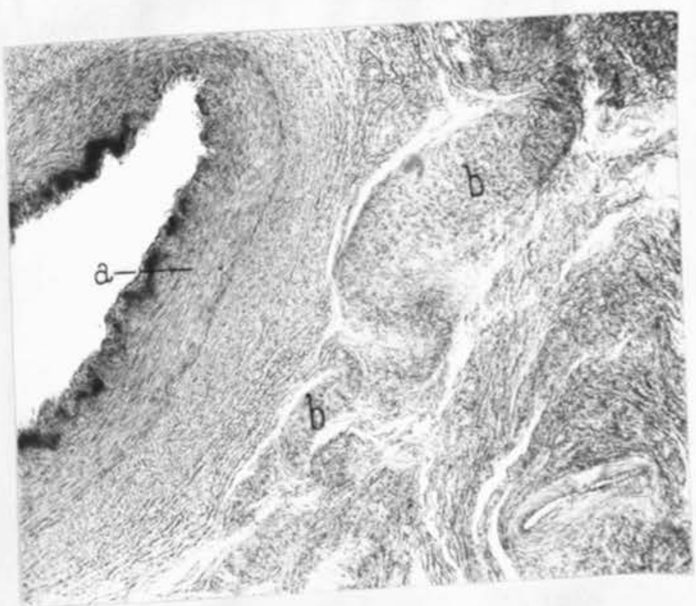


Fig. 22 - Section of (a) superior thyroid artery showing a large amount of (b) nerve tissue surrounding the artery. Exophthalmic goiter. X50.

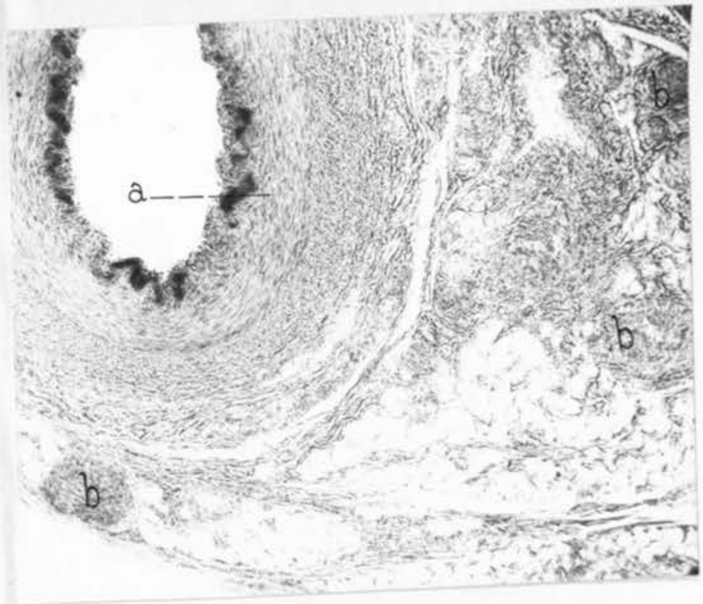


Fig. 23 - Cross section (a) superior thyroid artery and accompanying (b) nerves. X50. Exophthalmic goiter.

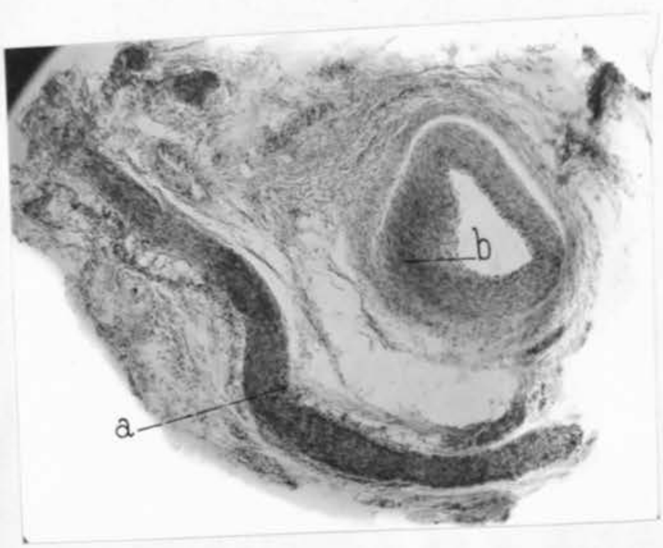


Fig. 24 - (a) Nerve running beside (b) a branch of the superior thyroid artery. X40. Normal thyroid.