A diagram, on the principle of the reflex arc, can be constructed, from the records of the jugular and radial pulses, of the part played by each of the elements of the regulating system in the production of the heart beat. Fig. 3 is a tracing of the jugular and radial pulses, in which we recognize the action of the auricles and ventricles. If we represent that tracing in a diagram, as in Fig. 3A, it shows the different elements engaged in the heart beat. The upper space (S.A.N.) in this diagram represents the sino-auricular node. The downstrokes

show the discharge of an impulse which sets up a contraction of the auricle represented by the downstrokes in the space As. The impulse from the auricle stimulates the auriculo-ventricular node (space A.V.N.) which sends an impulse to the ventricle, causing a contraction which is represented in the space Vs. This contraction causes the radial pulse.

The shading in the space S.A.N. represents the degree of excitability of the cells of the sino-auricular node. After the discharge of an impulse there is a darkly shaded portion gradually becoming less dark till it disappears. This represents the refractory period after the discharge of the impulse, and its gradual decrease, or, to put it in another way, to the gradual increase of its store of energy and its susceptibility to stimulation.

The application of the principle of the arc to the interpretation of an irregular pulse is illustrated in Figs. 4 and 4A. Fig. 4 is a tracing of the jugular and radial pulses. The symptom that arrests attention is the irregular pulse.

The different parts concerned in regulating the pulse rate are plotted out and each element of the regulating process is scrutinized. From the facts revealed by records of the radial and jugular pulses a diagram is constructed (Fig. 4A). In it the ventricle (or radial pulse) (downstrokes in space Vs) is shown to be irregular. As the ventricle is dependent on the auriculo-ventricular node, we look at that space and find that it also is irregular. As the auriculo-ventricular node is stimulated by impulses from the auricle we examine and

find that also irregular. As the auricle is dependent upon the sino-auricular node, we examine that and discover that it is irregular as well, and so recognize that the pulse irregularity arises in the sino-auricular node.

This may seem an unnecessary elaboration of an easily recognized interpretation, but it is meant here simply to illustrate a principle whose

application to more complex irregularities gives us a method for recognizing the nature of obscure disturbances of rate and rhythm.

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(To be continued.)

PARATHYROID GLANDS IN RELATION TO SURGERY.

BY

T. P. DUNHILL, C.M.G., M.D., CH.B.,

ASSISTANT DIRECTOR, SURGICAL UNIT, ST. BARTHOLOMEW'S HOSPITAL, LONDON.

(With Coloured Plate.)

I PROPOSE to present in this short paper such evidence as I am able which appears to me to establish the hypothesis that parathyroids are glands of which account should be taken at surgical operations. I shall not review literature, for, although it contains an immense body of work of the highest value, I gather that what is desired is personal experience.

It is a fact that tetany occurs in thyroid operations—rarely, I know. It has occurred twice in my practice, in mild but unmistakable degree, and I have personal knowledge of three other cases—one in the practice of each of three of my friends. These were far from being mild. A discussion of the symptoms does not come within the scope of this paper. As the number of my operations on the thyroid gland mounted into many hundreds without tetany happening, I doubted the importance of parathyroids, and wrote my scepticism. Then it occurred!

It is beside the mark to say that tetany occurs in other circumstances. Rare as it may be in thyroid operations, it is out of all proportion to its occurrence in other conditions.

As so many thyroid operations are performed without tetany occurring, it is necessary to ask ourselves whether we damage something unusual on these rare occasions.

Turning to dissection and comparative anatomy, we get some help. Mr. Coyte, late of the Anatomical Department of St. Bartholomew's Hospital, and I have dissected many

necks in the *post-mortem* room. In the beginning we found many bodies which macroscopically appeared to us likely to be parathyroids; but all the earlier ones without exception were proved, on microscopical examination, to be tiny lymphatic glands or pieces of thyroid gland. Every suspected piece of tissue was cut and stained by our dressers, Mr. Brocklehurst and Mr. Sturton, and examined microscopically by Mr. Keynes and myself.

At this stage I began almost to despair of finding the parathyroid glands, and was on the point of visiting anatomists in Europe who alleged that they could always be found with ease. I mention this because in discussion so many surgeons state that they have never seen the parathyroid glands at operations, and therefore they doubt their existence.

Then we found our first parathyroid.

We can now display one pair of parathyroids with precision, guided by their site, which is where the inferior thyroid artery breaks up into its branches, and by their colour, which, in the living body, is a dark terra-cotta.

Microscopically there are seen islands of large polygonal cells with eosinophilous cytoplasm: these are characteristic, being unlike anything seen in the thyroid. Professor Welch¹ has described these bodies very precisely, and Professor Schafer notes them in his well known book on histology, but I find that they are very infrequently shown to

students and that practitioners are usually unaware of their structure.

Dr. Vladimir Korenchevsky, and, with him, Miss Luce and Dr. Goldblatt, working at the physiological problems of the parathyroid at the Lister Institute of Preventive Medicine, has on many occasions allowed me to see his work in progress. His advice and help have been of great assistance, especially with reference to comparative anatomy, histology, and physiology.

In some animals these glands are found more readily than in others, and can be destroyed without interfering with the integrity or blood supply of the thyroid. Proof of the gland is by microscopical examination.

Sections of the parathyroid gland are identical in structure with those which we had prepared from human bodies.

The question is sometimes asked, Are not these glandules outlying parts of the thyroid, or are they not lymphoid structure? In one slide (Fig. 4—monkey) thyroid, parathyroid, and thymus are seen in one piece of tissue (slide by Dr. Korenchevsky); and in Fig. 5 will be seen thyroid, parathyroid, and the neighbouring structures in a photomicrograph of a section cut from the neck of a child.

These structures are not accidental, for they can be found in every species of animal, and in every individual of the species. Their position is very constant for each species and differs only slightly in different species. They are not accessory thyroids for three reasons:

1. Accessory thyroids occur in varying outlying positions; parathyroids are constant in site for each species of animal, and never absent.

2. Accessory thyroid tissue conforms in histological structure to normal thyroid. The histological structure of parathyroid glands is constant, and it is uniform in all the animals in which I have been able to examine it. It is sometimes objected that a section of parathyroid shows colloid vesicles and that it is therefore really thyroid tissue; the pars media of the pituitary shows colloid vesicles, but it is not on that account thyroid tissue. I scarcely think Nature places structures of definite histological characters and with definite constant site throughout the animal kingdom for no purpose.

3. The third reason is physiological.

In some animals the parathyroids are embedded in the thyroid gland (Fig. 4). In these animals physiological investigation is difficult. There are others, of which the

rat is one, in which a parathyroid gland on each side is situated outside the thyroid gland; this is fortunate for the experimenter. Human beings also have all their parathyroids outside the capsule of the thyroid gland; this is fortunate for the surgeon—and the patient!

In rats the two main parathyroid glands are readily seen, and can be destroyed by the point of a very fine electric cautery without destroying the thyroid gland. As well as this, rats have a little other parathyroid tissue. When in groups of rats, say twenty-five, these two main parathyroid glandules are destroyed, about two will die with spasms. These are the animals in whom almost all the parathyroid tissue is contained in the two prominent glands. There is not sufficient left to support life. The others live, but become cachectic, and can be at any time thrown into a spasm of tetany.

Here the experimental work of Dr. Korenchevsky on rats links up with my own experiences in post-operative tetany, and with those of other surgeons who have published their records. The spasms are identical with those which occur in human beings, the fore and hind feet being drawn into the characteristic flexor contractions. A rat which has not been submitted to parathyroidectomy can be held beside one from the same litter which has, and stimulated in the same way, without any tetany occurring. The difference is striking.

The rats which have undergone parathyroidectomy but have not died have sufficient parathyroid tissue left to support life for a time, but not enough to prevent their neuromuscular balance being completely upset.

Dr. Goldblatt has been kind enough to take a photograph for me (Fig. 6) of a rat in which the same result has been brought about by feeding half a litter of young rats on a calcium-free diet—the other members of the family being used as controls on a normal diet.

SUMMARY.

1. In a certain number of thyroid operations there occur symptoms of which tetany is one manifestation. These symptoms are entirely

different from those of myxoedema.

2. We find certain glandules in human beings which have their exact counterpart anatomically and histologically throughout the animal world.

3. In animals we can destroy these glands, and then see an inevitable train of sequelae occur, which are analogous to the symptoms which occasionally occur following operation in human beings in circumstances which admit the possibility of damage to these structures.

DESCRIPTION OF COLOURED PLATE.

FIG. 1.—Parathyroid gland (human being), showing characteristic groups of cells with eosinophilous cytoplasm. (High power magnification.)

FIG. 2.—Parathyroid gland (human being): section of whole gland. (Low magnification.)

FIG. 3.—Parathyroid gland of rat. On the surface of the thyroid gland. (Dr. Korenchevsky.)

FIG. 4.—Parathyroid gland of monkey, showing thyroid and thymus glands also. (Dr. Korenchevsky.)

FIG. 5.—Photomicrograph showing relative positions of parathyroid, thyroid, inferior thyroid vessels, oesophagus, and trachea (human). A, thyroid; B, recurrent laryngeal nerve; C, branches of inferior thyroid artery; D, parathyroid; E, cartilage of tracheal ring; F, oesophagus.

FIG. 1.—Parathyroid : eosinophilous cytoplasm (human).

FIG. 2.—Section of whole parathyroid (human).

FIG. 3.—Parathyroid on surface of thyroid (rat).

FIG. 4.—Parathyroid, thyroid, and thymus (monkey).

CONCLUSIONS.

Now as to the bearing of our beliefs on our surgery.

Thyroid surgery is filling a larger and larger place in our day's work, and associated with it there are certain grave risks. Of these tetany is one. It is not the commonest; and it behoves us to keep a true perspective. We should be alert to parathyroid dangers, but not obsessed by them.

We perform thyroid operations to cure patients of their ills, and in such fashion as not to leave damage behind.

The position of the larger parathyroid on each side is close to the posterior border of the lobe, near the spot where the inferior thyroid artery breaks up into its branches before entering the gland (Fig. 7). Its blood supply is from one of the branches of the inferior thyroid artery, generally; occasionally from an anastomosis between a branch from the superior and inferior arteries. Freeing this area of the lobe is a difficult part of a thyroid operation, and therefore damage to a parathyroid may occur only too easily, either by removing it with the thyroid lobe or by including it or its blood supply in a ligature.

To avoid these two dangers C. Mayo has developed a technique which he considers best safeguards the para-

FIG. 6.—Tetanic spasm in a rat fed on calcium-free diet. The other rat (its brother) was fed on normal diet.

thyroids. He ligates the branches of the inferior thyroid artery within the capsule of the lobe. He uses "mosquito" forceps, and plunges them into the gland, dividing the gland distal to the forceps. His plan was followed by Halsted—who uses the term "ultraligation"—and by most American surgeons.

De Quervain, followed by other Swiss surgeons, advocates ligation of the trunk of the inferior thyroid artery well away from the gland, immediately it emerges from behind the carotid sheath, before it has broken up into its branches, and therefore before it has reached the site of the parathyroid gland. Cunéo and Lorin disapprove of Halsted's method, and follow de Quervain.

(In this paper I am speaking of exophthalmic goitre cases alone. In non-toxic goitres surgical interference is for an entirely different purpose. In them the operation should be planned to relieve pressure and leave a cosmetic result. Consequently a very considerable posterior portion of both lobes is generally left. In toxic goitres it is quite otherwise. It is to be remembered that removal of one lobe alone cures few cases of Graves's disease. The surgeon has to plan for the optimum result from the first, and foresee what part of the gland is to be ultimately left for physiological purposes. More than one operation will be required before the optimum result is attained. If gland tissue is left scattered on both sides of the neck and across the trachea, it is impossible to know exactly what is left, or remove more gland substance with precision later.)

De Quervain's method does not seem to me to be right. With one ligature he cuts off the blood supply to the lower pole of the thyroid and practically the complete blood supply to the parathyroid. It is a clean method and saves much bleeding, but to destroy the blood supply of the parathyroid is surely not sound surgery.

On the other hand, I have watched the method of intracapsular ligation—or ultraligation—frequently. It always appears to me to be messy, and the picture seems to be blurred. I should fear that, far from safeguarding the parathyroids, it would endanger them; but my main objection is that if an indefinite amount of thyroid gland tissue is left on both sides in a case of exophthalmic goitre, at least some cases will fail to receive the maximum amelioration of

FIG. 7.—Dissection to show site of parathyroid glands (human). A, parathyroid; B, recurrent laryngeal nerve; C, common carotid artery; D, vagus nerve; E, thyroid; F, inferior thyroid artery.

their condition which should, and can, be given; for it is to be remembered that a pathological thyroid may extend far behind the trachea, and rarely conforms to textbook anatomy. Therefore I consider that the parathyroids are best protected by clean dissection of the posterior borders of the thyroid gland, ligating the branches of the inferior thyroid artery as they enter the gland.²

I do not say that my method is right, and that others are wrong; each must follow the method which to him seems best, and try to perfect himself in that method.

Treatment of Tetany after Operation.

What can we do when tetany is present?

1. Injection of calcium solution.
2. Transplantation of parathyroids from a member of the family, or an individual of the same blood group.
3. (?) Parathyroid medication.

The first plan— injection of 4 grams of calcium lactate—has proved completely effective in each of my two cases. I have not yet had to resort to parathyroid transplantation, but Coupland of Leeds has shown that this can be done in the dog, and that the graft was alive many months afterwards.

As regards parathyroid medication I am profoundly sceptical.

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