THE SURGERY OF THE THYROID GLAND

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The surgery of the thyroid gland is described as it applies to simple goitre, toxic goitre and malignant goitre. Particular attention is paid to the contraindications for surgery.

SURGERY IN SIMPLE GOITRE

The Solitary Nodule

The apparently solitary swelling, clinically and colloquially referred to as a 'simple adenoma,' may histologically be a *hyperplastic* nodule (due to compensatory hyperplasia) or a *neoplastic* nodule (innocent or malignant).

The management of the solitary nodule is influenced in some hands by the availability or not of ^{131}I facilities for investigation.

^{131}I Facilities Not Available

It is impossible to distinguish with certainty, by clinical methods alone, the hyperplastic nodule from the neoplastic. It is for this reason that—given these circumstances—the removal of any solitary symptomless swelling in the thyroid is advised.

It is generally agreed that the solitary nodule should not be treated by simple enucleation but by resection of the affected lobe. There is less general agreement about the management of the contralateral lobe. It is known that a large hyperplastic nodule is rarely, if ever, truly solitary, but that there are numerous minute areas of focal hyperplasia scattered throughout both lobes.¹⁰ Removal of the affected lobe only is followed in a proportion—a small proportion—by the appearance of a nodule on the opposite side. It is agreed that the incidence of this occurrence can be reduced by performing a subtotal thyroidectomy in all cases of apparently unilateral simple goitre. A contrary point of view, which I believe to be the more reasonable practice, is to perform lobectomy on the side of the swelling, to palpate the opposite side to exclude a palpable nodule or nodules and to do no more surgically if the contralateral lobe feels normal.

If it is true that a low level of circulating thyroid hormone is responsible for triggering off the mechanism of anterior pituitary stimulation, increased TSH production, thyroid focal hyper-

plasia—then it is illogical further to reduce thyroxin production by removing a substantial part of the remaining lobe. Strong additional support is given to this restricted surgical attack in the case of the solitary nodule (1) by the low rate of subsequent nodular involvement of the contralateral lobe, (2) by the greater morbidity of the bilateral as compared with the unilateral operation, and (3) by the experience that postoperatively the continued growth of any remaining impalpable thyroid nodules may be discouraged by the administration of thyroid extract (120 mg. daily) or of l-thyroxine sodium (0.3 mg. daily).

^{131}I Facilities Are Available

Attempts have been made to determine the innocence or malignancy of a nodule by ^{131}I uptake examinations. If the nodule fails to take up the isotope—the so-called 'cold' nodule—there is a strong probability that it is a carcinoma or other tumour. Immediate surgery must be carried out and the nodule pathologically identified. If the nodule takes up ^{131}I in greater amount than the rest of the gland—the so-called 'hot' nodule—it is unlikely to be a carcinoma. In these circumstances it is probably justifiable to withhold surgery temporarily. A test course of thyroxin should be given for a period not exceeding three months: if at the end of this time the nodule has not disappeared or become appreciably smaller, removal and pathological identification must be advised. The possibility of a deeply placed carcinoma surrounded by a thick layer of normal thyroid tissue giving rise to a false interpretation must be borne in mind.

Smooth Diffuse Goitre

The smooth diffuse type of goitre occurs in two forms: (a) As a *physiological* response to a lack of iodine—puberty goitre—this is a reversible process in which the gland may return to normal when the stress passes; and (b) as a *pathological* response to a lack of iodine such as occurs in endemic goitrous areas where the process tends to be progressive.

The puberty goitre should not be operated

upon but treated with thyroid medication. The endemic variety of smooth diffuse goitre should be similarly treated while it remains small and should only be operated upon for reasons of size or pressure.

Nodular Diffuse Goitre

Bilateral nodular goitres with marked bossing, or if causing pressure symptoms or tracheal deviation or compression, should be treated by subtotal thyroidectomy followed post-operatively by the administration of thyroid either in the form of the dried extract or as l-thyroxine sodium. When there are advanced degenerative changes in the gland it is my practice to leave the inferior thyroid artery untied on the side exhibiting most normal thyroid tissue.

When the 'nodularity' is not marked and amounts to no more than a mild asymmetry of the lobes—if there are no pressure symptoms, no history of recent increase in size and no tracheal deviation or compression, the patient should be treated conservatively with l-thyroxine, particularly if elderly. The possibility of this type of gland being in fact the site of carcinoma or lymphadenoid goitre must always be borne in mind, and if there is any doubt biopsy should be carried out, preferably with a fast-moving drill motivated by compressed air.

Recurrent Nodular Goitre (Non-toxic)

Regeneration of thyroid tissue may occur after the subtotal operation. If this regrowth occurs on one side only scanning may show that it is the only remaining functioning thyroid tissue in the neck so that its preservation and not its removal should be the clinician's concern. In all cases of recurrent non-toxic nodular goitre, even if the regrowth is considerable, re-operation should be entertained with the greatest caution and only then after checking the integrity of the recurrent laryngeal nerves by laryngoscopy.

The Recurrent Laryngeal Nerves

The recurrent laryngeal nerves are most liable to injury in the operation for bilateral nodular goitre. Outlying nodules may burrow beneath the recurrent laryngeal nerve so that in this type of case its identification is essential—if it is to be preserved.

Pre-operative Laryngoscopy

Pre-operative laryngoscopy occasionally reveals unsuspected paralysis of a vocal cord (Fig. 1). Such a discovery may influence the surgeon's decision to operate and exonerate him if symptoms develop post-operatively. The examination is of particular importance in patients who have

FIG. 1.—*Pre-operative laryngoscopy.* This has revealed an abductor paralysis of the right vocal cord. The patient had a normal speaking voice at conversational distance.

had a previous operation on the thyroid gland, or if thyroid carcinoma, chronic thyroiditis, or myxoedema is suspected.

Preferential Abductor Paralysis

The abductor fibres seem to be more prone to paralysis than the adductor. The view that the abductor fibres occupy a circumferential superficial position in the recurrent laryngeal nerve and that the abductor fibres are separately grouped in one of the two terminal branches of the nerve has been disproved in man by Sunderland and Swaney, and their paper should be studied as a model of this type of intraneural topographical research.

There seems to be no purely anatomical basis upon which a satisfactory explanation of the preferential paralysis of the abductors can be based. It only remains to postulate that the abductor elements have a lower resistance to injury, or that an unknown factor operates preferentially within the muscles. The evolutionary theory of Negus⁵ seems the most rational. He points out that the larynx is guarded by two groups of muscles: a primitive protective sphincteric group (the adductors) and a dilator group (the abductors) essentially associated with the much more recently developed vocal function of the larynx. He believes that it is reasonable

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expect that the vital protective function of the sphincteric group should give this group a greater vitality and the ability to survive over the more recently evolved dilator group.

Post-operative Laryngoscopy

Post-operative laryngoscopy is essential for a true estimate of the frequency of vocal-cord damage due to thyroidectomy. Vocal-cord paralysis following thyroidectomy is commoner than is supposed. Existing statistics tend to be based on the selective post-operative examination of patients who have some obvious symptom of damage to a recurrent laryngeal nerve, e.g. a hoarse voice. But this does not reveal those cases where compensatory readjustment of the unparalysed cord has produced a normal speaking voice at conversational distance. Such cases are plentiful and may be wrongly assumed not to have suffered any damage to a recurrent laryngeal nerve. Moreover, an injury rate calculated on only a proportion of the patients operated on can be applied to that proportion only.

Laryngoscopy within the theatre, immediately after thyroidectomy while the patient is still anaesthetized, can also be misleading. If the vocal cords are seen to abduct and adduct normally it can be assumed that there has been no injury to the recurrent laryngeal nerves; but, if movement is impaired, it should not be taken as proof that a nerve has been injured, because in some cases pressure on the vocal cords by the intratracheal tube may temporarily limit adduction or abduction and in other cases the depth of anaesthesia may prevent normal movement of the cords.

Post-operative laryngoscopy should not be done too soon after the operation or it will be uncomfortable for the patient; furthermore, the findings cannot be accurately assessed at this early stage. Our practice is to do post-operative laryngoscopy on the day before the patient is due to be discharged. The throat is sprayed with 4% lignocaine (this has not produced any unfavourable reactions in our experience) and after three minutes the larynx is ready for examination. After the examination the patient is instructed not to eat anything for the next two hours, i.e. until laryngeal sensation has returned.

Identification

Surgeons are either 'identifiers' or 'non-identifiers.' The non-identifiers take the view that the deliberate exposure of the recurrent laryngeal nerves by dissection is likely to produce more palsies from handling than if they are left undisturbed and unidentified.

The 'identifiers' argue that modern anaesthesia

and the antithyroid drugs have removed the urgency for speed in operating on the thyroid gland and so allow the operator time for an unhurried search for the recurrent laryngeal nerves in a field which should be bloodless.

A third course which lies between the two extreme views is for the surgeon to improve his knowledge of the local anatomy by exposing the recurrent laryngeal nerves on a limited number of occasions and thereafter to revert to the blind operation with the added safety which his experience will have given him.

Sites of Injury

The sites of greatest vulnerability of the nerve are as follows:

(1) At the lower pole of the thyroid gland—the nerve may be included in the ligature of the inferior thyroid veins. This accident can happen very readily, particularly if a mass ligature is used for securing the veins.

(2) At the upper pole of the thyroid gland—just before the nerve enters the larynx, although I believe this to be uncommon. Injury at this site is most surely avoided by a clean exposure of the superior thyroid vessels, which should be tied and divided as a pedicle and not through the glandular tissue of the superior pole by the clip-and-cut method.

(3) On the lateral surface of the thyroid gland—the nerve may be injured by marker forceps placed there before its resection or simply by excessive traction or rough handling. It is probably *most liable of all to injury* when the cut surface of the gland is being resutured. Unless special care is taken the nerve may be picked up and included in the suture if the needle is inserted into the gland remnant too far posteriorly.

Haemorrhage is the agent which prepares the conditions most favourable to injury at all sites.

Visual Identification

The identification of the recurrent laryngeal nerve does not require its naked exposure as in an anatomical display specimen. It is wrong and unnecessary to dissect out or to strip the recurrent laryngeal nerve of its ensheathing fascia. By opening up the tissues lying to its outer side the nerve can be clearly demonstrated and identified without ever touching it with an instrument. The nerve is first sought for and is most readily found, where it comes into relation with the inferior thyroid artery. In other words, it should not be looked for in the lower part of the wound—the root of the neck—where it bears away from the side of the trachea and oesophagus, or in the upper part of its course where it is covered and partly obscured by strong fascia. It is recognized

also by the minute vein which runs upon its surface. The operation must be done gently, because the nerve is readily damaged by stretching if too much traction is exerted on the thyroid gland, a mistake which is particularly likely to be made when the thyroid lobe is unusually mobile.

Identification by Palpation

The visual method of exposure is not always wise or expedient. In such cases, with experience, the nerve can be identified in a high proportion of patients by *palpation*. It feels like a cord or a thrombosed vein which can be gently rolled against the trachea. Identification by touch cannot, however, for comparative statistical purposes, be accepted as being as accurate a method of identification as the visual.

Transient and Permanent Paralysis

The word 'transient'—to imply temporary palsy of a recurrent nerve—should be used sparingly and only if full recovery of movement of the vocal cord is subsequently objectively confirmed by laryngoscopy as well as subjectively by a return of the voice to normal tones. Fortunately, the palsy is more often transient than permanent—12 out of 22 cases of unilateral palsy.⁶

Summary

The production of a bilateral abductor palsy of the cords following thyroidectomy is a grave surgical injury. The young surgeon starting thyroid surgery should arm himself and protect his patient by deliberately identifying the recurrent nerve in his first 25 or 30 operations. It is a tedious apprenticeship, for it is easier not to do so, but thereafter with this solid anatomical experience to draw upon he will automatically become a safer operator in the neck and can reasonably revert to the blind operation in uncomplicated cases. It is wise to continue to identify the nerve on *one side*, by palpation or visually, in all *bilateral* operations (total or subtotal thyroidectomy).

SURGERY IN TOXIC GOITRE

If the surgeon is to be something more than a technician who is called in to perform the operative procedure two pre-requisites are necessary.

Firstly, the surgeon must make it his business to be as familiar as is a physician with the medical aspects of management, particularly with the eccentricities and potentialities of the antithyroid drugs. These drugs, if properly used, can ease the achievement of a euthyroid state and by so doing ensure that the patient is brought to a safe operative level—if misused they can complicate the pre-operative phase and make the operation itself one of the most difficult in surgery.

Secondly, the surgeon must make a point of seeing the patient in her original thyrotoxic state, that is, at her worst, and before therapy is initiated. If seen for the first time when an antithyroid effect has been obtained, an entirely false assessment of the severity of the disease may be arrived at and a wrong decision made as to the need or time for operative treatment.

Since ¹³¹I is contraindicated in the treatment of patients under the age of 45 because of its unknown carcinogenic potential, it is convenient to describe separately the choice of treatment as it applies to patients below the age of 45.

Thyrotoxicosis Under the Age of 45

It is helpful first to exclude those patients who fall naturally into a medical category. These include the following:

(1) Young Patients and Those Subject to Stress

Medical treatment—by sedation or chemotherapy—should be employed whenever possible in *young children* and at times of exceptional physiological stress, such as *puberty*, *pregnancy* and the *menopause*, when antithyroid cover will generally be all that is necessary.

(2) Mild Thyrotoxicosis (and Anxiety State)

Medical treatment is indicated in all patients with mild thyrotoxicosis. *Surgery, the antithyroid drugs and iodine are alike contraindicated*, yet instances of the use of each of these methods are not uncommonly seen. Surgery is absolutely contraindicated because it is unnecessary. The antithyroid drugs should not be used in the first instance, but only resorted to if rest and sedation fails. Iodine also has no place in the purely medical treatment of any form of thyrotoxicosis. Iodine is to the thyrotoxic patient what morphia is to the 'acute abdomen'—it masks symptoms without curing the disease, it produces a rapid response which is misleading as the effect is only transient and is not maintained—but it may be significant enough to induce a false belief in non-surgical measures, with the result that operative treatment is postponed unwisely. Its use in the treatment of toxic goitre should therefore be restricted to the immediate pre-operative phase.

(3) Recurrent Thyrotoxicosis (Post-operative)

(a) *No thyroid tissue palpable*. Surgery is absolutely contraindicated in those cases of post-operative recurrent thyrotoxicosis in whom there is no palpable thyroid tissue in the neck. Treatment with the antithyroid drugs has its most apt and valuable application in these circumstances.

(b) *Thyroid tissue palpable*. In these patients the recurrence is usually nodular in type. The

FIG. 2.—*Tarsorrhaphy*.—(a) Patient developed a traumatic conjunctivitis as a result of contact with the pillow during sleep. (b) *Tarsorrhaphy* is surprisingly well tolerated by these patients who rarely complain of their 'blinkers.'

choice as between surgery or medical methods will be influenced by two considerations—the size of the thyroid recurrence and the integrity of the recurrent nerves. Re-operation on these patients is always hazardous because of the risk of damaging a nerve. If the recurrence is bulky, and displacing the trachea, surgery may be forced and should be carried out if laryngoscopy shows that both inferior laryngeal nerves are intact. If the recurrence is associated with an inferior laryngeal nerve palsy on the side opposite to the recurrence, re-operation incurs the risk of damaging the only remaining recurrent nerve so that an attempt should be made to control the thyrotoxicosis with antithyroid agents or radioiodine. The decision as to which of these methods is used will be influenced by the age of the patient and by whether she is sensitive or not to antithyroid drugs. If the recurrence takes place on the same side as a nerve lesion, re-operation can be considered with less anxiety as the underlying nerve has already been damaged. If the recurrence only involves the pyramidal lobe then this should be excised.

(4) *Masked Thyrotoxicosis*

Most patients with masked hyperthyroidism—often presenting with unexplained auricular fibrillation—are found in the over-45 age group, but if occurring at a younger age they should be treated with the antithyroid drugs to which they respond well.

(5) *Malignant Exophthalmos*

Medical treatment is advisable in the ophthalmic forms of thyrotoxicosis. It is important to assess the degree of thyrotoxicosis without regard to the eye signs and to treat the toxicity on its own merits. It may not be severe.

Thyroidectomy, the antithyroid agents and ^{131}I may increase the proptosis. If operation is contemplated—possibly because of the large size of the goitre—it is advisable to give a preliminary test course of antithyroid agent and observe its effect upon the eyes. If the proptosis increases it will be wise to avoid thyroidectomy. Whatever treatment is employed it is reasonable to give thyroid extract at the same time with the intention

of reducing the amount of thyrotropic hormone produced by the anterior lobe of the pituitary.

Tarsorrhaphy should be carried out early in severe proptosis (Fig. 2). It is often recommended too late, when corneal ulceration, hypopyon and other ocular complications have developed. Orbital decompression, whereby the orbit is unroofed, will be necessary in progressive cases to save the sight.

Toxic Nodular Goitre

Thyroidectomy is indicated in the treatment of toxic nodular goitre—with a few exceptions. If the patient is middle-aged or elderly and the nodularity amounts to no more than a smooth asymmetry in 'size' of the two lateral lobes, good results can be obtained in carefully selected cases from medical treatment only, as concomitant malignant change is very rare.

Pressure symptoms. Thyroidectomy is indicated when pressure symptoms are present or might be precipitated by the use of antithyroid drugs as in a retrosternal or intrathoracic goitre, or when there is displacement or compression of the trachea. The pressure symptoms vary from a sense of pressure in the neck to choking sensations or even a feeling of suffocation in more severe cases. In non-malignant goitres dysphagia is strangely rare even when the oesophagus is grossly displaced. A chronic cough, hoarseness of the voice or inspiratory stridor may be a direct pressure effect; in all these cases involvement of the recurrent nerves should be excluded by laryngoscopy.

Failed medical treatment. By a process of elimination thyroidectomy or radioactive iodine becomes the only effective expedient in those patients in whom medical treatment with antithyroid drugs has failed, i.e. the thiouracil-sensitive, the thiouracil relapses and the thiouracil-resistant.

Social and economic factors. Thyroidectomy may also be the most desirable method of treatment in those who are unable or unwilling to attend regularly, in the unreliable and unco-operative patient, or for social or economic reasons.

Malignancy. Surgical treatment is indicated if malignancy cannot be excluded.

Size. Size alone can be a contraindication to medical treatment. A large goitre often becomes even larger with antithyroid treatment, and even if it does not cause pressure symptoms requiring surgical intervention its presence is uncomfortable and is at meal times a constant reminder of the patient's disability. The cosmetic appearance is unsightly and if the patient is a male he is likely to have to buy new shirts and collars.

Open Group: Surgery or Antithyroid Drugs

The exclusion of those patients who sort themselves out naturally into a medical or surgical category for treatment leaves a third group in whom it is not at first obvious as to which method of treatment will suit them best. It is the group of patients under 45 with toxic diffuse goitre of moderate or severe degree (excluding mild thyrotoxicosis). A decision can be arrived at in this open, indeterminate group by reference to the patient's age, the patient's preference and the facilities available.

Younger Age Group (18-40)

Very broadly, surgery is indicated as the elective method of treatment in those patients at the younger end of the under-45 scale (18-40) and chemotherapy in those at the older end of the scale (40-45).

The disappointing long-term results of antithyroid therapy have produced a swing of the pendulum back towards surgical treatment, particularly for the *younger* adult patients in whom radioiodine is contraindicated. Younger patients do not tolerate well the tedium of prolonged antithyroid therapy. They are impatient of results and inclined to find the repeated visits to hospital tedious and continuous tablet medication irksome, and for these reasons they may not progress favourably. More important still, those in the younger age group—because the gland reacts maximally to the antithyroid agent—are more liable to develop a thiouracil goitre and quite suddenly slip over into myxoedema unless very frequent and time-consuming visits are made to hospital or practitioner for reassessment and supervision. For these reasons in the 'under forties' better results can be achieved by thyroidectomy than by purely medical methods of treatment.

Middle Age Group (40-45)

In the older patient, that is those in the pre-menopausal and menopausal age groups, for exactly the opposite reasons to those just set down, there should be an inclination towards medical treatment as the initial method of choice. In these patients there is less likelihood of the development of a thiouracil goitre or myxoedema.

Supplementary Factors Influencing Selection

Apart from the patient's age the decision as to whether the treatment should be along medical or surgical lines will be influenced by the *patient's own preference*, and by the presence or absence of a *causal agent*, such as domestic worry, housing difficulties or an uncongenial occupation and by

the standard of medical and surgical facilities available, both of which can vary greatly.

Thyrotoxicosis Over the Age of 45

The methods of treatment in patients with thyrotoxicosis over the age of 45 are extended by the possibility of using ^{131}I so that the choice in the over-45 age group lies between chemotherapy, surgery and radioiodine. In most cases, chemotherapy or ^{131}I should be the initial elective method of choice rather than surgery; the decision between these two methods will usually be decided by the availability or not of ^{131}I and the necessary facilities for its administration and control. In the main a case suitable for treatment with an antithyroid drug is suitable for treatment with ^{131}I ; an exception is the patient with a small impalpable thyroid who is best treated with an antithyroid drug owing to the difficulty of judging the correct dose of ^{131}I when the gland size is small. *Thyroidectomy* will, however, continue to be the method of choice in this group for cases of established toxic nodular goitre—unilateral or bilateral—and for all cases in which long-term therapy or radioiodine seems likely to be unsuited to the patient in question. Meticulous surgery still has much to offer at all ages as an alternative to the slower-acting antithyroid drugs and ^{131}I .

The Thyrocardiac Patient

The thyrocardiac patient is usually found in the over-45 age group. There is a double lesion—the thyrotoxicosis and the fibrillation—and it is important that the severity of each of these components should be separately assessed, and if necessary separately treated.

The thyrotoxic component. The thyrotoxicosis in this group is much more commonly relatively mild or, at the most, of moderate severity only. The problem in fact is usually more cardiac than thyrotoxic. If the thyrotoxicosis is *severe* then an antithyroid drug should be prescribed in its usual dosage, to overcome the toxicity.

If the thyrotoxicosis is *not severe* and the patient is being prepared for operation, the use of iodine is all that is necessary to bring the patient to a safe pre-operative level. In the milder case the pre-operative use of an antithyroid drug as well merely adds difficulty without adding safety to the operation.

The cardiac component. If there is no heart failure a patient with slow fibrillation can safely be operated upon as soon as the toxicity has been controlled.

If the patient is in heart failure and this is *relieved* by treatment, thyroidectomy can be undertaken as soon as the patient has become euthyroid, or more probably it will be decided to continue

treatment with antithyroid drugs or radioiodine. If the heart failure remains *unrelieved*, although the thyrotoxicosis is controlled, surgery will have to be abandoned permanently as the definitive form of treatment for the thyrotoxicosis. This type of case remains more a cardiac than a thyrotoxic problem.

Pre-operative Preparation

Pre-operative Preparation for Second Degree Thyrotoxicosis (Sleeping Pulse 90-110)

Patients with thyrotoxicosis of intermediate severity can be brought, with a few exceptions, to a safe operative level with iodine alone. Many fall into this category. It is necessary to stress this fact because in recent years there has been a tendency to advise the use of antithyroid agents—'just for safety'—in the preparation of all patients undergoing thyroidectomy for toxic goitre regardless of the initial severity of the disease. This is unsound. Antithyroid agents should be used only for the pre-operative preparation of patients with *severe* thyrotoxicosis (third degree).

It is satisfactory to give iodine in aqueous solution as Lugol's iodine (5% iodine, 10% potassium iodide in water), 10 minims t.d.s. in milk, although all soluble compounds of iodine are equally effective and sodium and potassium iodide particularly more efficient. Potassium or sodium iodide, 250 mg., are approximately equivalent to 30 minims Lugol's solution. Dosage in excess of this is valueless as the excess iodine is not utilized by the gland. The practice of giving gradually increasing doses has no advantage and is only confusing to dispenser and patient alike; a constant daily dose should be prescribed.

Operation is carried out at the moment of minimum risk, that is when the maximum lowering of the pulse rate has been obtained. This is usually ten days after starting the course, but as this point may be reached earlier, e.g. eighth day or later—twelfth day—no rule of thumb should be followed or some cases will be operated upon prematurely and others after the iodine effect has begun to wear off. In calculating the optimum day for operation it is important not to forget to take into consideration the date of onset of the next menstrual period so that this may be avoided.

Post-operatively iodine should be continued for one week and then stopped.

Pre-operative Preparation for Third Degree Thyrotoxicosis (Sleeping Pulse 110 and above)

Patients with severe thyrotoxicosis cannot be brought to a safe operative level without a preliminary course of an antithyroid drug. Administration of the antithyroid agent selected continues in its initial dosage until the patient is

symptom-free, or ideally just short of this point, when the drug is stopped altogether. The surgeon's aim is to keep the course *as short as possible* in order to reduce haemorrhage at operation and to avoid operating on a hypothyroid patient. A planned pre-operative course of antithyroid agent should rarely exceed four weeks and can often be discontinued with safety after two or three weeks. A post-therapy pre-operative white cell count should be carried out on the day before operation to exclude a delayed thiouracil leucopenic reaction.

Pre-operative iodine in a patient already detoxicated by an antithyroid drug is not an essential. If the iodine is being used for its alleged devascularizing effect the questionable advantage obtained has to be balanced against the increased hardness and rigidity it produces in the gland.

Overtreatment

It is almost true to say that the misapplication of the antithyroid drugs is causing surgeons more anxiety and difficulties than the disease itself. Overtreatment is the main error. It produces both local and general effects.

Local Effects—Thiouracil Goitre

Overtreatment with antithyroid drugs results in a hyperplastic gland—a thiouracil goitre.

This is a huge, throbbing vascular goitre over which a bruit may be heard on auscultation. This mistake arises as a result of a failure in the system of supervision. Either the patient is seen too seldom and slips over into myxoedema in the interval between visits, or she is seen regularly but by a different clinician on each occasion, who repeats unaltered a dosage which should be reduced.

The reversal of the original thyrotoxic state and its replacement by myxoedema from overdosage with antithyroid drugs not only is the unnecessary replacement of one disease by another but greatly delays the patient's return to normal health. A hypothyroid state can be avoided only by repeated examinations of the patient by the same clinician throughout the period of antithyroid therapy and by the simultaneous administration of thyroxine. If myxoedema or a goitre develops the treatment is to stop the drug as soon as the evidence of overdosage is detected.

A thiouracil goitre may be associated with *pressure symptoms; increased vascularity; tachycardia.*

Pressure Symptoms

It is very undesirable that overdosage with antithyroid agent should occur. The resultant thiouracil goitre, by producing *tracheal compression*, may cause pressure symptoms and force surgery

when the gland is at its most intractable and the patient verging on myxoedema. The antithyroid agents produce effects upon the gland of primary toxic goitre which occur only minimally or not at all in the nodular thyroid of the older patient. They increase the size of the gland, render its consistence *hard and rigid*, and so seriously restrict its mobility at operation and increase its *vascularity* many times.

Haemorrhage

Operation on a thiouracil goitre is an operation on an *arteriovenous fistula*. It is important to be aware of the increased vascularity and so be prepared for the very severe bleeding which can occur at operation. If this comes as a surprise it may well extend the most experienced surgeon. There is little doubt that isolated experiences of this kind, usually in overtreated glands, have done much to prejudice some surgeons against the antithyroid agents.

Much can be done to diminish the technical difficulties associated with the use of the antithyroid drugs: (1) By avoiding pre-operative overdosage with *antithyroid agent*; (2) by administering l-thyroxine sodium synchronously with the chosen antithyroid drug; and (3) by not administering Lugol's iodine in cases satisfactorily controlled by the antithyroid agent alone.

But despite observing these precautions there will be occasional cases calling for all the operator's skill if bleeding is to be controlled, an adequate amount of gland removed and no damage inflicted upon either of the recurrent laryngeal nerves.

Vocal Cord Thickening

Thickening of the vocal cords takes place when myxoedema is induced by overtreatment and this constitutes a very real post-operative danger from oedema of the glottis. If surgery is forced in these circumstances a very careful watch will be necessary post-operatively, and it will be wise to have a *tracheotomy* set in readiness.

General Effects

Myxoedema. If myxoedema is produced by antithyroid agents an irreversible state may be set up, or at least a state which takes a long time to adjust itself. If the patient is referred for surgery at this stage of overpreparation operation should be refused. Thyroidectomy is strongly contraindicated in the *hypothyroid* phase, because of the danger from haemorrhage and oedema of the glottis, and must be resisted unless it is required to relieve urgent pressure symptoms. A long delay must follow before operation can safely be undertaken—to allow the patient time

to revert to a euthyroid state. In short, the net result of overtreatment is seriously to slow up the patient's return to normal health and thyroid balance.

TECHNIQUE OF SUBTOTAL THYROIDECTOMY

This is not a treatise on the surgical technique of thyroidectomy, which is now well established, so that only a few points of interest to surgeons will be summarized. In the modern operation all the main arteries to the gland are secured—the 'clip and cut' method is obsolete. The first step taken is the mobilization of the lateral lobe and the identification and division of the lateral thyroid veins. This is followed by division of the superior thyroid vessels, the division or ligation in continuity of the inferior thyroid artery, the identification of the recurrent laryngeal nerve and the division of the inferior thyroid veins. This procedure is then repeated on the other side.

The Superior and Inferior Thyroid Arteries

When the subtotal operation is performed for thyrotoxicosis the superior thyroid arteries should be tied and divided and the inferior thyroid artery tied in continuity on each side. There is an abundant blood supply left to the gland by way of the paratracheal and paraoesophageal branches of the ascending pharyngeal and bronchial arteries. Ligation of the inferior arteries—as far away from the gland as possible to avoid injury to the recurrent nerve—has two great advantages: it reduces the incidence of recurrent thyrotoxicosis, and it reduces the bleeding from the cut surface of the gland when this is resected.

In patients who before preparation for operation were very severely toxic, the inferior arteries, as is the usual practice with the superior arteries, should be tied and *divided* or recanalization is likely. One must beware of tying one of the main terminal divisions in mistake for the main trunk, which may bifurcate far out.

In thiouracil-prepared cases it is dangerous to attempt the resection of the gland until all the named arteries have been secured or an uncontrollable fatal haemorrhage may result from the cut surface.

Multiple-stage Operations (Fig. 3)

It is difficult to visualize the circumstances in which the preliminary ligation of arteries could arise today unless the toxicity is quite uncontrollable by the medical methods which are now available. On the other hand, it may occasionally be both prudent and necessary to stop the operation after resecting one lobe and to operate on the second side at a later date. The need for such a

FIG. 3.—Multiple-stage operations. At the first stage it is occasionally wise to remove one lobe only, tying and dividing superior and inferior thyroid arteries, together with ligating in continuity the opposite superior thyroid artery.

two-stage thyroidectomy is most likely to arise when operating on a very vascular hyperplastic gland in a young person who has received too long a pre-operative course of antithyroid agent or who has relapsed after long-term therapy. The operation under these conditions can be one of the most testing in surgery and if the haemorrhage is unusually heavy or if the pulse rate should rise to 140 or above it would be foolish to proceed to the resection of the second lobe.

The Infrahyoid (Strap) Muscles

The infrahyoid muscles should be divided in all cases in which the improved exposure would add safety to the operation. Division of the muscles is indicated more often in bilateral than unilateral operations. It should be carried out in all operations upon glands which have been prepared with an antithyroid agent unless the surgeon is exceptionally experienced; it is usually unnecessary in partial thyroidectomy (hemithyroidectomy) for a solitary adenoma.

SURGERY IN MALIGNANT GOITRE

In malignant goitre—if operable—surgery holds undisputed priority over all other methods of treatment.

Contraindications

There are no local contraindications to operation in cancer of the thyroid—except inoperability.

Operability can often only be assessed after surgical exposure of the thyroid gland. Clinical findings suggestive of inoperability are: Dysphagia; limitation of the excursion of the thyroid on swallowing; recurrent laryngeal nerve involvement; cervical sympathetic chain involvement; and fixed cervical lymph nodes.

Dysphagia. Dysphagia is curiously rare even in the largest of non-malignant goitres associated with gross displacement of the gullet. This symptom, if it develops, should therefore always be regarded with suspicion.

Limitation of excursion of the thyroid on swallowing. This is due to fixation of the gland by trans-capsular spread. It has to be remembered that a similar restriction of movement of the thyroid is found (1) in true retrosternal goitre where the intrathoracic extension wedges the trachea in the thoracic inlet, and (2) when there has been a haemorrhage into a thyroid cyst, the outer surface of the cyst becoming coated with a sticky, fibrinous exudate which temporarily adheres to surrounding structures. (In Hashimoto's disease movement of the gland is full and normal and the margins of the thyroid are usually well defined and easily palpable.)

Involvement of a recurrent laryngeal nerve. This will produce a partial or complete paralysis of a vocal cord, but is not always associated with a hoarse voice. This is because compensation by the normal cord may be very complete so that a palsy may not be suspected unless the cords are examined routinely by laryngoscopy before every operation upon the thyroid.

Involvement of the cervical sympathetic chain. This will produce enophthalmos, ptosis and a contracted pupil on the affected side (Horner's syndrome).

Enlarged cervical lymph nodes. The neck and both axillae should be palpated. A fixed mass of nodes is a warning that operation will be difficult or impossible. A mobile lymph node offers readily accessible material for excision and pathological identification.

Metastases. Paradoxically in cancer of the thyroid alone, the presence of distant metastases is not necessarily a contraindication but in some circumstances is an indication for radical thyroid surgery, notably in follicular adenocarcinoma.

Differential Diagnosis

Conditions simulating cancer of the thyroid should, if possible, be excluded. They include non-toxic nodular goitre, lymphadenoid goitre and the other rare forms of thyroiditis, metastatic tumour tissue in the thyroid (the primary lesion has been most frequently in the breast, lung or kidney), calcification, and haemorrhage into a cyst. All these misleading conditions, so long as they are remembered, can be excluded by taking a careful history supported by obtaining material for histological confirmation.

To formulate a plan of treatment the clinician must be able to answer the following questions:

- Is the tumour malignant or non-malignant?
- Is the tumour operable or inoperable?
- Is the tumour differentiated or undifferentiated?
- Is the tumour radioactive-iodine-concentrating?

Investigations

Special investigations include radiography, laryngoscopy, tracheoscopy, ¹³¹I investigation, blood examination, biopsy and the exclusion of metastatic conditions simulating primary carcinoma of the thyroid.

Radiography

A lateral and antero-posterior radiological examination of the neck and thoracic inlet is required to exclude deviation or compression of the trachea, and retrosternal or intrathoracic extension of the thyroid. Radiography will occasionally show that a nodule suspected of malignancy because of its hardness is the site of calcification. The chest is also examined to exclude metastases and any site of bone pain should be similarly investigated for the same reason.

Laryngoscopy

Pre-operative laryngoscopy may reveal an unsuspected recurrent laryngeal nerve palsy. The discovery of a paralysed vocal cord in a patient with no change of voice is important before the operation is carried out, for obvious medico-legal protection reasons; in addition, if complete, it will encourage the surgeon to do a more radical operation on the side of the nerve involvement and, by forewarning him, will make him more cautious in exposing the opposite normal nerve.

Tracheoscopy

Tracheoscopy is important to exclude malignant infiltration or ulceration of the trachea. If these developments are encountered unexpectedly in the course of the operation the surgeon is likely to be unprepared to deal with them and an incomplete operation will result. If he is forewarned he can plan an extirpative procedure and be

prepared to resect and reconstruct a part or the whole of the trachea.

Biopsy

The histology of the tumour has an important bearing upon its surgical and radiation management. Three basic cell types are recognizable: the papillary (62%), the follicular (20%), and the undifferentiated (anaplastic) (18%). Some tumours contain elements of all three patterns, and if sufficient sections are examined few differentiated tumours will be found to be exclusively papillary or exclusively follicular. It is this tendency for elements of each to be present in most differentiated and even in some undifferentiated tumours that has encouraged ¹³¹I workers to try to induce pick-up in tumours in which the predominant histological picture would seem to be against success.

Experience has shown that the differentiated tumours are more likely to concentrate radioactive iodine than the undifferentiated ones, and that the follicular carcinoma is considerably more likely to pick up radioactive iodine than the papillary type. The clinical behaviour of these two varieties is also different; the slow-growing papillary variety tends to metastasize to local lymph nodes, whereas the follicular type is more rapidly growing and tends to metastasize by the blood stream to the lungs or bones. These differences must be remembered as they influence the approach to treatment.

The histology can be determined *pre-operatively* if an enlarged lymph node is available for excision; at the time of *operation* by the frozen section method, *post-operatively* in the usual way by examination of the operation specimen, and in the inoperable case by a preliminary pre-radiation drill biopsy.

Frozen Section Examination

An immediate diagnosis at operation may save the patient a second operation or it may prevent an unnecessary one. It is of most value in the doubtful case, and in thyroid carcinoma presenting unilaterally. In the doubtful case the malignancy or innocence of the section will determine the restriction (if non-malignant) or extension (if malignant) of the operation. In the unilateral case, by revealing the predominant histological pattern, it will aid the surgeon in his decision to remove (in follicular carcinoma) or not to remove (in anaplastic carcinoma) the contralateral normal lobe.

In addition, by supplying the surgeon with the information that the tumour is malignant it will enable him to do a complete lobectomy instead of an incomplete one. This, in turn, will obviate a

further operation to remove the thyroid remnant which, if left untreated (and if papillary or anaplastic it is unlikely to respond to radioactive iodine) will later lead to a stump recurrence which in turn may progress to a fatal issue.

Nevertheless, a frozen section examination with a reliable opinion remains a counsel of perfection in the majority of clinics. The rapid interpretation of the appearances of thyroid material requires a pathologist of exceptional experience and wisdom. The differences between certain benign papillary adenomas and a papillary carcinoma and the difference between the thiouracil-prepared thyrotoxic gland and the papillary carcinoma are notoriously difficult. Only a strong positive assertion of malignancy should be acted upon. In many instances it will therefore be wiser to allow the extra time necessary for the preparation and examination of paraffin-embedded sections.

It cannot be too often repeated that surgical removal offers the best chance of controlling thyroid cancer. 'Operable cases should first be operated upon.' This is an obvious statement, yet the insistence of surgical priority in the management of operable cases cannot be too strongly emphasized. Radiation methods are apt to bemuse the clinician, but it needs to be said that they are only supplementary and secondary in importance when the tumour is removable.

Unilateral Operable Cancer

Unilateral operable thyroid cancer may present in three clinical forms:

(1) It may present as a solitary, symptomless swelling of *recent appearance*. The initial diagnosis is benign 'adenoma' from which this form is clinically indistinguishable, and it is this type of 'unsuspected' carcinoma which is discovered accidentally when the 'adenoma' is cut across in the theatre at the end of the operation. This variety, which is the commonest of all and is also the most favourable, is the one most liable to be left alone for the reason that it is symptomless. It often occurs in young women and is usually of the papilliferous type.

A solitary swelling in the thyroid must be regarded as malignant until proved otherwise. It should be treated like a solitary swelling in the breast by removal and histological examination. It should be excised not because it may become malignant, but because it may already be malignant.

(2) It may present as a solitary swelling not of recent appearance but with a history of recent increase in size of a pre-existing unilateral goitre.

(3) It may present as a palpable cervical lymph node or nodes—formerly misnamed a lateral

aberrant thyroid—the primary tumour being *occult* in the thyroid.

This is the rarest type of carcinoma of the thyroid. It is comparable to occult carcinoma of the breast. The primary tumour in the thyroid is too minute to be palpable, but at operation it is found to be in the lobe on the same side as the enlarged cervical lymph nodes. A total lobectomy on the side on which the nodes are enlarged, together with removal of the palpable cervical nodes on that side, is the treatment.

Surgical Management

The surgical management of apparently unilateral thyroid cancer must be considered as it concerns (a) the affected lobe, (b) the homolateral lymph nodes, and (c) the contralateral lobe.

Surgical Management of the Affected Lobe

In all these clinical types of thyroid carcinoma the ideal primary measure is total unilateral lobectomy (and in certain cases total thyroidectomy). Total unilateral lobectomy will include all the thyroid tissue on the affected side, together with any enlarged lymph nodes and the isthmus and the pyramidal lobe, so that the trachea is left bare anteriorly. The completeness of the lobectomy will depend upon whether pathological identification of the tumour by frozen section during the operation has been possible or not. If the result of a frozen section examination is not available or is inconclusive, a hemithyroidectomy, leaving a strip of thyroid behind, is likely to be the operation performed. Because the time interval between the incomplete removal of the original tumour and a recurrence may sometimes be 5-10 years, it has led to a laissez-faire attitude towards incomplete lobectomy. This is more than unfortunate. The totality of the lobectomy probably influences the subsequent course of the disease more than any other single measure. Incomplete removal invites stump recurrence, that is recurrent carcinoma in the fragment of gland remaining after incomplete lobectomy. Stump recurrence kills by local invasion of the trachea and oesophagus, a commoner cause of death in thyroid cancer than distant metastases.⁸ Medial extension occurs between the cartilaginous rings of the trachea and then spreads submucously up and down the trachea where the intraluminal tumour may produce obstruction, ulceration and haemorrhage.

Surgical Management of the Homolateral Lymph Nodes

The problem of dissection of the regional lymph nodes. There are two views—the conservative and the radical—regarding the question

of block dissection of the neck. The radical view is that an aggressive attitude should be taken in all types of thyroid cancer, including the papillary, not only towards the thyroid gland but also towards the cervical lymph nodes, and a homolateral block dissection should be performed whether lymph nodes are palpable or not. This contention is supported by the fact that a high proportion of clinically impalpable nodes contain metastases on histological examination² and by the essentially local tendency to recurrence and spread which is characteristic of the papillary tumour.¹² It is contended that a resolute local attack upon the thyroid gland and the area of its lymphatic drainage has more positive life-saving potentialities than what is regarded as the piecemeal conservative approach.

Those who hold the conservative view place their faith in the thoroughness and completeness of the primary surgery upon the malignant lobe, or lobes of the thyroid gland (total lobectomy or total thyroidectomy) and its juxtathyroid lymph nodes. At this operation a special point is made of meticulously removing all lymph nodes lying near the thyroid (primary zone metastases). These juxtathyroid lymph nodes are found lying above and below the isthmus in front of the trachea (pretracheal) and in the tracheo-oesophageal groove (para-oesophageal). They are distinguished from the lateral cervical lymph nodes (secondary zone metastases) which lie alongside and around the great vessels and are usually invaded only at a later stage of the disease. Up to this point the conservative school and the radical school practise the same operation. Thereafter only do they diverge in their policy. The radical school proceed to a block dissection; the conservative confine further surgery to the local removal of visible lymph nodes in the operation field. From this point the conservative school rely on close supervision and follow-up examinations to detect and deal with recurrence. In support of their attitude the conservative school quote: (a) The slow rate of growth of most papillary cancers; (b) the fact that patients with papillary cancer do not die from uncontrolled lateral cervical metastases but from central invasion of the trachea, oesophagus and mediastinum by the primary tumour and its centrally placed metastases.

'The battle of the thyroid is won or lost in the central area of the mediastinum and neck. It is this vital area that the classical block dissection disregards.'¹

In contemplating the radical approach, which is supported or condemned by surgeons experienced in thyroid surgery in almost equal numbers, the individual clinician responsible must try with

each individual patient—with such evidence as is available—to balance the possible prolongation of life on the one hand against the tragic mutilation produced, sometimes in a very young life, on the other. Statistics should provide the answer and give him the factual guidance he seeks, but they are sadly deficient because of the comparative rarity of the disease. Until pooling of material and its statistical analysis is carried out on a much larger scale, the present uncertainty is likely to continue for some time to come. In the meantime the writer's practice is to concentrate and pursue the surgical attack upon the thyroid and its juxtathyroid lymph nodes with determination and vigour but to refrain from block dissection—particularly in the young—except in exceptional circumstances.

The Problem of the Contralateral Lobe

The conflict of opinion here concerns the advisability or not of destroying by radioactive iodine or removing by surgery the contralateral or 'normal' lobe of the thyroid in patients presenting with clinically unilateral cancer.

Should the contralateral lobe be ablated? If it is believed, even when the histological pattern is unfavourable and when a complete lobectomy has been performed, that every effort should be made to induce radioactive iodine uptake, all these patients with apparently unilateral thyroid cancer will be treated in the same way, namely, by total thyroid suppression, regardless of the histology of the tumour, the natural history of the disease or the presence or absence of distant metastases.

If it is believed that we should, and can, be more selective in our treatment of this group, we will consider the natural history as well as the histology of the tumour. If the histology is predominantly follicular there is general agreement that suppression or removal of the contralateral normal lobe should be carried out and radioactive iodine treatment instituted if there is any suspicion of extracervical metastases being present.

There are two good reasons for this: First, the clinical course of follicular carcinoma is more rapid than the papillary variety, and there is a tendency to earlier and more frequent distant metastases; secondly, there is a better chance of inducing uptake in the follicular type of carcinoma than in any other variety, provided the normal adjacent thyroid tissue which competes for the iodine has been removed.

If, on the other hand, the carcinoma is papillary or anaplastic, the more conservative clinicians will leave the normal lobe undisturbed in the absence of demonstrable distant metastases, or at least will seriously debate the advisability of ablation, the reason for this attitude being that

anaplastic tumours can almost never be induced to pick up radioactive iodine and pure papillary tumours but rarely, even when ablation has been carried out. Ablation, therefore, in unilateral cases of papillary or anaplastic cancer, must be regarded as a procedure which carries with it no absolute guarantee that it will induce any remaining tumour tissue to take up radioactive iodine. Furthermore, it must be remembered that radioactive iodine treatment cannot be given without first making the patient myxoedematous, an effect that must be given some consideration when it is remembered that the papillary cancer is the commonest type, with the slowest and most favourable clinical course, and most often seen in young persons.

Choice of Re-operation or Radioactive Iodine Ablation of the Contralateral Lobe

If the histology of the tumour is not available until some time after the operation has been concluded, and removal of the contralateral lobe is decided upon, re-operation should be carried out as soon as possible. Operation, when it is possible, is preferred to radioactive iodine treatment because it is quick and avoids using up valuable radiation tolerance. The final choice between operative or radioactive iodine ablation will be decided by such factors as the time available on the one hand, and the patient's age and general condition on the other. If the time factor is urgent the bias will be towards operation, as the development of full myxoedema following an ablation dose of radioactive iodine takes up to 12 weeks, a delay which may be difficult to justify if metastases are present or the tumour is rapidly growing. Ill-health, infirmity, a history of multiple thyroid operations, the presence of a recurrent laryngeal nerve palsy or a history of a previous course of irradiation to the neck will bias the clinician towards radioactive iodine ablation.

Following the ablation dose of radioactive iodine the surgeon must be prepared to carry out tracheotomy, and sometimes it will be wise to do so before the dose is given if there is evidence of narrowing of the trachea, as the reaction following radioactive iodine may be severe and may be sudden.

Post-operative External Radiation Therapy

The post-operative so-called prophylactic use of external irradiation should probably be abandoned if there has been apparently complete, or nearly complete, removal of a differentiated tumour.¹² The uneasy suspicion that microscopic malignant foci may have been left may persuade the surgeon to prescribe a course of high-voltage X-ray treatment just 'for safety.' The result

separate local excision if they develop later. A recurrence of thyroid gland tissue is excised if this is possible; if the mass is irremovable but can be shown to take up radioactive iodine an ablation dose should be given in the histologically favourable categories.

Thyroid Administration

It seems reasonable to administer thyroid extract to patients with thyroid cancer, after the definitive treatment has been concluded, with the object of inhibiting activity in any remaining normal thyroid tissue.^{4, 11}

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