INTRODUCTION

This work has grown out of an M.D. thesis published in 1912 and elaborated and brought out in book form in 1915 under the title of *The Alimentary Tract*; much of that book is incorporated, but in the main the present work is the substance of lectures delivered to students preparing for the Cambridge Diploma in Medical Radiology and Electrology.

Hidden away in journals, often in articles long since forgotten, are many observations which have accumulated in the course of time and become merged in what is now common knowledge. These tags of memory, many of them subconscious, often make the diagnosis of the experienced clinician much more valuable than the logical conclusions of one less experienced. Readers of these pages will find in them all that I can pass on as the result of many years of groping, often by tracks that have now become well-worn highways with milestones, sign-posts and danger-signals erected one by one by the pioneers as they passed forward. There is little encouragement to short cuts but instead, I hope, the means, the technique and the experience with which to interpret what is seen.

Some of the views expressed may not be in accordance with accepted tradition. I can only say that they are founded on personal experience, backed by knowledge of the similar experience of other radiological workers.

What is Radio-diagnosis?

Radio-diagnosis is not a new branch of medicine but a new outlook on medical problems. It is a clinical method, and the essential pre-requisite of the radiologist is a sound knowledge of anatomy and clinical medicine. Without these, no elaboration of radiographic technique, no shining splendour of apparatus and perfection of X-ray pictures, can make his opinion more valuable than that of the technician. His special training, knowledge and experience in interpreting the meaning of shadow pictures in terms of clinical medicine alone justify the medical man in following the specialised calling of radiology. Essentially, the radiologist must be a clinician, and the wider his knowledge and experience of clinical medicine, the greater will be his advantage as a radiologist. He is a specialist in the application of a particular method of investigation, a method which opens up certain fields that are entirely closed to other clinical methods.

When X rays were first applied to medicine, they were regarded as a new application of photography, and it was not realised that the interpretation of the shadow pictures required any special skill or experience. Hence X-ray departments were housed in basements and put in the charge at first of porters or nurses, later of medical men who had often had no special training. Even now

we suffer from the handicap that this early lack of foresight imposed on those who became specialists in the use of this new method and who expanded its application. By sheer weight of clinical worth and progress they brought radiology out of the basement and into the position of a department which is now a keystone to efficient medical and surgical service; so much so that when the radiological service in a hospital is poor, the medical and surgical efficiency of that hospital is usually of the same calibre.

Occasionally medical men still display an outlook on radiology so narrow that they think each member of a hospital staff might do his own X-ray work. A cottage hospital installs a portable X-ray outfit. The general practitioners who staff the hospital suggest that each of them should radiograph and examine his own cases—and why not? All the details of exposure, etc., are set out on the card of instructions, and any yokel can turn on a switch. Therefore, why not? Simply because the application of X rays and the interpretation of X-ray pictures require special knowledge and experience. Anyone, by following instructions, can produce a radiograph, but the ability to do this does not make a radiologist, nor is this the service which makes radiology valuable.

This volume is a summary of the personal and acquired experience of a quarter of a century of fluoroscopic and radiographic examination of the alimentary tract. That is a long time, and the novice may therefore expect to find in these pages a dogmatic "Yes" or "No". Dogmatism in diagnosis is a cloak that every novice (including the author) unwittingly assumes as soon as he has become familiar with the shadow of the opaque food in the stomach. Later he finds his mistakes and, as his experience matures, he becomes, far more often than he cares to admit, unable to give a definite answer no matter how he gathers the remnants of his cloak around him to keep out the chill knowledge that he has not always been right in his deductions. Radiology is all a matter of deduction. There is one and only one safe guide, one key to radiological interpretation—knowledge of the normal.

This book is mainly concerned with the study of the normal. The physiological rather than the pathological is stressed, for it is always far more difficult to recognise and make a diagnosis of the normal than of the definitely pathological. For both the novice and the experienced, the most difficult diagnosis is: "No pathological condition present". The normal has so many possible variations and mutations that an attempt to catalogue them, to picture them in an atlas, would be futile. The only road to follow is the main road in which the student learns the why and the wherefore, the physiology of the normal, so far as it is known; and when he has learnt this he will have less difficulty in recognising what is and what is not a pathological condition. It should then be a very short journey to arrive at a correct diagnosis—provided that he has the essential basic knowledge of morbid anatomy.

Radiological Anatomy and Physiology

Radiology has been so successful in the diagnosis of pathological conditions that there is a tendency to overlook its applications to physiology and to anatomy. The early workers were faced with the fact that the orthodox anatomy and physiology of the alimentary tract were hopelessly at variance with what they saw. By degrees they worked out the normal as far as they could, and to-day the radiologist turns to radiological works and not to the text-books of physiology or anatomy for help in interpretation. He sees the living anatomy and living physiology, which have not yet found their way into the text-books. It is a fact that a text-book of physiology published in 1929 quotes Beaumont and his experiments on Alexis St Martin (1833) as the last word on the form and function of the stomach, and speaks of it as a bilocular organ consisting of an upper part, a hopper, and a lower part, a mill. There is no reference to the pioneer work of the radiologists. Doubtless this book is an extreme example, but it is written for students of medicine. Moreover, the author attempts to give the student a grasp of human physiology in the simple terms of chemistry and physics. I believe this plan is ill-advised. As Alvarez says, "The most paralysing thing in scientific work is a facile explanation which puts a stop to curiosity without really advancing our knowledge of the subject".

To keep pace with the increase of knowledge, universities have naturally had to divide and sub-divide the various branches of study included in the training of the medical student. Artificial bounds have arisen, and in the schools anatomy represents form, physiology has charge of function, and pathology deals with disease. But in life these three melt imperceptibly into one another and, to the radiologist who studies living conditions, there is no artificial dividing line. His is a living picture in which there are no sharp divisions, no walled-off departments, for he sees anatomy, physiology and pathology as one whole. The form, the shape of the stomach is anatomy, yet a slight deficiency of tonic action—a physiological change—may alter the picture completely, while the presence of a contraction may be pathological or merely a physiological response to some stimulus.

The domain of the radiologist is the study of the living, functioning human being. It is for him to take the bare facts of descriptive anatomy and clothe them with the attributes of life; to take the observations of the physiologist and show whether the deductions from the laboratory and animal experiments are applicable to the living subject; and to interpret the changes in the normal shadows that are the result of disease. The waywardness of Nature, the entire absence of standards both in form and functions, make it impossible for medicine ever to be an exact science. What a dull business it would become if it could be reduced to formulae! For many of us it would cease to have any attraction. The incalculability of the human element, the balancing of a hundred bits of

insufficient, and perhaps contrary, evidence call up in us that indefinable instinct that goes by the name of clinical sense. It is this that makes medicine such a fascinating study, one in which the greatest masters are ever students, learning by experience to their last days. The radiologist must study medicine and its auxiliary branches from his own angle, and the wider his clinical knowledge, the more valuable will be his opinion. But above all things, and particularly in gastro-intestinal work, he should try to cultivate clinical sense—that indefinable but invaluable asset closely allied to common sense.

Many attempts have been made to schedule medical diagnosis, to tabulate signs and symptoms, and numerous atlases of radiographic appearances have been published, but all such attempts at short cuts to knowledge must fail, for the diagnosis of disease and its significance is and always must be an art. The faculty, the intuitive gift, of knowing whether a patient is or is not really ill is often the essential factor in deciding whether some unusual appearance indicates an anatomical peculiarity, a physiological anomaly, or a pathological manifestation.

The question whether radiology is a specialist subject or merely a technique is frequently raised. My views on the matter are very definite. It is and must be a specialist subject for many years to come, both by reason of the technique involved and the wide divergence in outlook that is not readily grasped by those who have not extensive experience in the methods involved. The parallel between surgery and radiology is a close one, and is a very strong argument for developing radiology as a specialist subject. Could surgery have developed as it has done if it had not become a separate department of medicine? Yet surgery is as much a technique as is radiology. If radiology is subservient to other departments, it may, in some instances, develop satisfactorily so far as one or two departments are concerned, but in others it will be neglected and fall into disrepute, mainly from the lack of a competent radiologist. It seems to me that the greatest value for all branches of medicine and of the sciences is that the radiological service should be centralised and serve all branches. When any of these finds that it needs, and can maintain, a separate radiological installation (including a radiologist) of its own, then and not till then should there be decentralisation.

There is comparatively little in the whole range of clinical medicine that does not come into the radiologist's purview, and the ideal radiologist would have an all-round knowledge so vast that no single brain could compass it. Most of us have to be content with gathering together as many as we can of the fragments of knowledge which appear to be of primary significance. Hence this volume is necessarily a collection of those points which the writer believes to be of importance in the radiological study of the alimentary tract.

PART I

TECHNIQUE

CHAPTER I

ROUTINE AND TECHNIQUE

The importance of routine

A great deal could be profitably written on the pitfalls into which the radiologist may be led in the performance of his duties. Only by following a well-tested routine can he avoid the snares that are set for him, not only by Nature —who has not labelled each disease with a series of signs and symptoms that would make it unmistakable—but also by the clinician who, for one reason or another and with the very best of intentions, restricts the exercise of a routine which, unfettered, will almost automatically give the answer to the problems that are sent to the radiologist. Everyone knows that the case which goes wrong is the special case, the important patient who expects peculiar consideration, and this is nearly always because routine is disturbed. The radiologist reports a normal stomach and misses a malignant growth of the small intestine because the patient cannot wait for routine observations. He misses obvious gall-stones because the general practitioner is with the patient and thinks it is a case of duodenal ulcer and wishes for a report before he takes the patient home.

Routine may cause apparent delay but, unless there is some urgent reason to the contrary, the radiologist is well advised to insist that his routine shall take its course. He will thus inevitably avoid many mistakes that come of haste and lack of thoroughness.

Routine is the essence of successful work. This, however, does not imply that there is one and only one routine, or that the routine that I myself use and recommend is the best. "There are nine and sixty ways of constructing tribal lays, and every single one of them is right." The point is that, subject to the general principle that the examination should show the whole tract as far as possible, every worker must develop his own routine to suit the requirements of his own conditions of work. He may spend his whole time at the hospital or in his private practice, or divide his time between the two. If his whole time is available in one place, he may develop a technique by which he follows one meal all the way through. This may seem the obvious course, but in practice I have found that it does not usually work out satisfactorily. There are three

reasons for this: first, the times of the various necessary observations may be inconvenient; secondly, for the examination of the stomach the ordinary opaque meal—which is not a food but only a suspension of opaque salt—is unsatisfactory, as it cannot be relied upon for information about the rate of emptying; and thirdly, this method does not give adequate opportunities for confirmation of observations; the possible variations within the normal are so wide that this is a very great disadvantage. Some form of "double feeding" is, in fact, almost universal, and this routine certainly lessens the chance of missing an abnormality. Even at the present time, as in the early days, some observers give an opaque meal five hours before the X-ray examination begins, in order to determine the question of delay in emptying. Haudek of Vienna was the originator of this method. We gave it an extended trial, but abandoned it because we so frequently found difficulty in interpreting the tangled shadows in the intestine and elsewhere; in fact, it was often necessary to re-examine from the beginning, after this first meal had been cleared out.

Whatever routine is adopted, I consider it essential that X-ray observations should be made while the first mouthfuls of opaque "food" are canalising the stomach, before there are any other shadows in the abdomen to complicate the picture, and that the examination should be continued from time to time as necessary until the observer is satisfied concerning the stomach, duodenum and small intestine. Further, to obtain information as to the rate of emptying, a second meal, consisting of a *real* food mixed with opaque salt, is given five hours before the patient is seen on the second day.

It does not greatly matter what routine is followed provided the observer knows it so intimately that he practises it almost automatically. He must learn to observe accurately, and to record his observations before passing on to the next stage; otherwise he will have to ask the patient to return so that he can confirm observations of which he is not quite certain, or observe essential points that he has missed. He should never depart from his routine, no matter how tempting it may be to jump to conclusions and focus his attention on some particular part, even if this is suggested by the clinical data.

Obviously there are occasions on which the routine must be varied because something unusual is noted that requires special investigation. The routine must be automatic and yet so elastic that it allows for digressions as necessary. The radiologist should work so automatically within this routine that his mind is free to observe, to investigate, to follow like a sleuth-hound any slight variation from the normal that he may detect. Mind and body, eyes and fingers must all be at his disposal to take advantage instantly of every slight indication, for it is often on quite trivial observations that the ultimate diagnosis rests. For instance, a small fleck of opaque food may be noticed in one spot high up on the stomach wall as the first mouthful enters; the observer seizes upon it

and attempts to palpate it out. Perhaps, by getting his fingers high up under the costal margin, he may detect a tender spot related to the now suspected point, although the on-coming opaque food has obliterated it. He has, however, noted its appearance and he turns and twists the patient, re-feeds him, examines him standing, lying, tilted, or in any other position until he has convinced himself that his observation is or is not confirmed. He should have things so arranged that he can at any time and without delay expose a film to record what he sees. His radiographic technique should be so standardised that failure is practically impossible, for he may never have the opportunity of recording the appearance again. When the observation is made and, if necessary, recorded he must return to his routine. These side excursions must never become side tracks, and the routine must be picked up again exactly where it was left.

Prejudgment

One of the chief values of a conscientious routine is that it guards the observer from bias and prejudgment, very grave dangers to accurate diagnosis. If the radiologist knows the clinical diagnosis, his observation will necessarily be biased. Yet he should know everything vital in the case history, in order that his examination may be made on right lines. In chest cases particularly the danger of prejudgment is so great that the benefit to the patient if the clinician does his own radiology is doubtful. In this branch the only satisfactory procedure is for the radiologist and the clinician to examine independently and to come to conclusions by consultation. It is from the correlation of the two methods, each worked out independently, that the most satisfactory conclusions will be evolved. The same principle applies to gastro-intestinal examinations, but the bias produced in the radiologist's mind by the necessary information which the clinician gives him can be largely counterbalanced by the routine examination, which ensures attention to every part of the alimentary tract, however much the symptoms may have stressed one particular region.

The Importance of Complete Examinations

When asked to examine and report on a patient who presents clinical indications of a lesion in some part of the alimentary tract, it is more than probable that the radiologist will be requested to confine his examination to this part on one of the following grounds: (1) that in the circumstances it is unnecessary to do a complete examination because the clinical indications are so localised; (2) that by curtailing the usual routine the patient's pocket will be saved; and (3) that time presses and the surgeon cannot wait. The most reasonable arguments will be adduced to deflect the radiologist from the strict path of a routine which experience teaches him is essential. For instance, if the observer does not examine the chest as a routine procedure, he will inevitably miss a certain

number of cases of phthisis in which the symptoms are so predominantly gastric that the chest is entirely unsuspected. This I have seen on a number of occasions. Moreover, in a certain number of cases gastric symptoms are due to cardiac lesions; hence it is always advisable to observe the heart for any signs of gross disorder of rhythm or enlargement. Once in the very early days I had just completed an oesophageal examination, with a negative result, when a visitor came to see me. For his benefit the patient consented to swallow some more opaque food, again with negative result but with the perfect demonstration of an hour-glass stomach due to an unsuspected ulcer.

The number of cases in which gastric, duodenal, gall-bladder and appendicular lesions have been clinically interchangeable and misleading are so numerous in the experience of every worker that no comment is needed in stressing the rule that a complete investigation is essential if we are to avoid missing things. The way in which small intestine and even colonic, to say nothing of hepatic and pancreatic, lesions refer their disturbances to some other part, particularly to the stomach, is now well recognised. One can hardly believe that a carcinoma of the rectum could refer its main symptoms to the stomach, yet I have seen such a case, and at the operation within an hour or so, dictated solely by the radiological finding, an extensive rectal carcinoma and a length of black and almost gangrenous gut were found.

Hospital Routine

The large number of cases that have to be examined in a hospital X-ray department is one of its very serious difficulties, and something has to be done to bring it within practicable limits. It is only human for the clinician, who is similarly over-burdened, to refer as many cases as he can to other departments in the hope that they may point out a short cut to the diagnosis.

In the early days in my department we had to press clinicians to send cases for examination, but before long we had more than could be managed, for the department was small and the staff limited. We soon found that the least satisfactory cases from every point of view were the gastro-intestinal out-patients. We therefore restricted the opaque meal service to in-patients, and insisted that any patient to be examined should be admitted to the wards. There was much grumbling from some of our colleagues, but they acquiesced, and we have never ceased to be thankful, especially when we hear of the wholesale unsatisfactory work that is imposed on some radiologists by those in charge of out-patients who refer any and every case "for opaque meal". There are many radiologists still struggling to give a good gastro-intestinal service but finding it impossible to do so owing to the indiscriminate way in which cases are referred to them. In Manchester, the question of the examination of out-patients has been before the medical board on several occasions within recent years, owing to the size of the waiting list and the complaint that so many of

the beds are occupied by patients undergoing opaque meal examinations. The arguments used in favour of extending the service to out-patients are:

(1) That it relieves the pressure on beds.
(2) That it is not necessary for patients to be in hospital for this purpose.
(3) That, if necessary, the radiologist staff should be increased and the department extended.

The arguments against are:

(1) That to increase the work by including out-patients would inevitably diminish the efficiency of the service to in-patients, for no radiologist can do more than a limited number of cases.
(2) There is not an unlimited supply of men who are competent to do this work, for they must be highly trained and experienced if their reports are to be of any value.
(3) The examination of out-patients is, *per se*, unsatisfactory, because
  (*a*) they will not strictly observe the necessary preparation;
  (*b*) they frequently fail to attend for continued observations, or appear on any other day that suits them better, the opaque food having meanwhile passed on;
  (*c*) they are invariably, and rightly, sent for another examination when they are taken into the wards, probably some months later, for medical or surgical treatment.

On these arguments the medical board agreed that it was inadvisable to accept patients for opaque meal examination direct from the out-patient departments and that all such cases should be admitted to the wards.

The opaque mixtures

The Food used for the First Meal

The bulk of the first opaque meal is in liquid form, and may consist of any one of the numerous satisfactory preparations on the market; the two main requirements are that it shall be palatable and that the opaque salt shall not settle rapidly. For those, however, who wish to make their own opaque food, the following recipe is recommended:

Three to six ounces of barium sulphate are mixed with a salt-spoonful of tragacanth; a small quantity of boiling water is poured on to the mixture, which is worked into a smooth paste. The tragacanth must not touch cold water or it will form gummy lumps. A flavouring agent, generally raspberry syrup or cocoa, is mixed in. Up to about half a pint of milk is added and the whole is thoroughly stirred, preferably by a mechanical mixer. The mixture remains in suspension for about one hour and is not unpalatable, a point of considerable importance, since foods which are disagreeable to the patient are apt to produce a greater or lesser degree of atony.

The mixture should be made first thing in the morning so that the opaque salt has time to settle in the glass. The thick sediment at the bottom, composed almost entirely of the opaque salt, is just what is wanted for the preliminary

examination of the mucosa (p. 23); the patient is given a spoonful from the bottom of the glass. When the observer has obtained all possible information from manipulating this in the stomach, the mixture in the glass is stirred up and the patient, under the instruction of the observer, drinks as much as may be necessary. I seldom find that more than a third of a pint is wanted.

Barium sulphate has superseded the various bismuth salts because of its relatively low cost, but larger quantities, roughly 50 per cent. more by weight, are required to obtain an equal density of shadow.* A thorium dioxide preparation called umbrathor, which gives a perfect colloidal suspension, shows up the gastric mucosa very well; 20–30 c.c. is sufficient.

In Brisbane Dr B. W. L. Clarke showed me particularly beautiful mucous membrane patterns. The routine food he has selected, after many experiments, consists of 3 or 4 oz. of barium sulphate mixed with two or three tablespoonfuls of gelatinous marmalade. Boiling water is poured on this; it is allowed to stand for a few minutes, and is then put through a strainer. For enema work the same proportions are used. The mixture is cheap, palatable, does not settle out and evidently adheres most satisfactorily to the mucous membrane, better in fact than most of the proprietary and expensive preparations that are on the market.

The Food used for the Second Meal

This is a more natural meal than the first, and in private practice it is made up at home by the patient and taken nineteen hours after the first meal, i.e. five hours before the second-day examination. The basis of it is a real food and may be either bread and milk or porridge, into which 2 oz. of bismuth carbonate is mixed. In private practice the patient purchases the salt himself. I continue to prescribe bismuth carbonate for this purpose because pure barium sulphate is not always stocked by the chemist to whom the prescription is taken, and also because the bismuth salt gives a rather smoother mixture. Moreover, cases are recorded in which the deadly and soluble barium sulphite was dispensed instead of the sulphate, with fatal results. The psychological effect of spending, say, 3*s*. or 5*s*. on the opaque salt and preparing this meal is to make the patient less critical of the radiologist's mixture and more respectful of the opaque food that costs so much! For those who dislike bread and milk or porridge, the bismuth can be mixed into a corn-flour blancmange just before it sets, and this, according

* The atomic weights and densities of the various substances used in X-ray work are as follows, and it is on the atomic weight and the density that the opacity of the shadow depends:

	Atomic weight	Density		Atomic weight	Density
Aluminium	27	2·7	Tungsten	184	18·8
Chlorine	35	3·23	Platinum	195	21·5
Copper	64	8·93	Gold	197	19·32
Zinc	65	7·1	Lead	207	11·37
Bromine	80	3·1	Bismuth	208	9·80
Silver	108	10·5	Radium	226	?
Iodine	127	4·95	Thorium	232	11·3
Barium	137	3·75			