

A HANDBOOK OF RADIOGRAPHY

JOHN A. ROSS

SECOND EDITION

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SECOND EDITION

WITH NINETY-TWO ILLUSTRATIONS



LONDON

H. K. LEWIS & Co. Ltd.

1946

Made and Printed in Great Britain

A HANDBOOK OF RADIOGRAPHY

TO THE MEMORY OF
JAMES ROSS, M.D.,
WHO TAUGHT ME MORE ABOUT
MEDICINE THAN MANY BOOKS

PREFACE TO THE SECOND EDITION

THE steady demand for this Handbook has called for a second edition, which it is hoped will be as well received as the first. The book originated from a suggestion made to me by the late Dr. E. W. Twining and, as a student, I felt the need of such a book, which could be carried about and referred to with ease.

The opportunity has been taken to bring the whole book up-to-date. It was written mainly for students and radiographers; their requirements have been kept in mind throughout. It is not possible to describe every projection and all methods of examination, but the essentials of radiography will be found in the book, besides description of the more recent advances which have been added to make it more complete and to stimulate interest.

An X-ray apparatus is not to be regarded as a camera, nor the human body as a sort of landscape. To produce good films, which will be useful to the radiologist, requires more application and knowledge than mere photography. It has been the writer's endeavour to give as clear and as concise an account of the art of radiography as possible. However, like everything else, it can only be acquired by practice; so that the reader must study the book and then put its precepts to the test.

ACKNOWLEDGMENTS

I WISH to acknowledge my indebtedness to former teachers, and to many books and papers consulted, only some of which have been mentioned in the text.

I wish to thank Mr. H. Saxon, who is responsible for most of the illustrations, and Mr. M. S. G. Hayes for the new illustrations; also Mr. S. J. Elmes for some useful suggestions.

J. A. R.

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A HANDBOOK OF RADIOGRAPHY

CHAPTER I

THE PATIENT

"When fever racks the anguished brow,
A ministering angel thou,"

SCOTT.

Care of the Patient

THE first part of this chapter is intended for students who have not had the benefit of training in nursing. The advice contained in it may appear to be elementary, but it is none the less important on that account. Therefore it can be commended to all.

The most important person in an X-ray department is the patient. It is essential that the patient should be comfortable. An X-ray examination is not always a comfortable experience, especially if you have a broken limb. The patient, therefore, must be examined with a minimum of discomfort. The radiographer should remember that many patients are nervous when they come for X-ray examination, and they should therefore reassure them. The radiographer will find that taking thought in these matters will pay him or her well in the end, because better films are more likely to be obtained. If the patient is placed in a comfortable position, the part to be examined will lie naturally on the film and movement will be diminished. A cramped position must be avoided.

The radiographer should make some notes of the patient's medical history, as the radiologist may rely, in a measure, on these notes when he reports on the films. This is particularly important, as the history usually sent with the patient is often scanty and sometimes non-existent. Radiographers must make a careful note of the request of the medical officer sending the patient. If the request is read in a hurry, a region may be omitted if the examination of more than one region is required; this will entail bringing the patient back again. If the request is ambiguous, the radiographer should telephone the doctor who made it, and find out from him personally what was required, rather than "take something," in the hope that it is what was

wanted. Often this will have to be repeated, entailing extra work.

The X-ray department itself should be warm and well ventilated. The patient must never be stripped in a cold room. Some of the patients from the accident department may be suffering from shock. It is most important that these patients be kept warm with blankets and hot water bottles. Patients likely to be subjected to an operation must not be given anything to eat or drink in the X-ray department to avoid vomiting during anaesthesia. The radiographer must not remove any splints or dressings without the permission of the medical officer in charge of the patient. The radiographer should also assist patients to rise from the trolley or chair, as many patients may be weak on rising; such patients should not be allowed to stand, unless the radiographer is sure that they can do so.

A word must now be said on the subject of asepsis. There are a number of methods of examination used in the X-ray department which require rigid asepsis, for example, injecting uroselectan into a vein and injecting lipiodol or thorotrast for various examinations. The instruments required must be boiled carefully and the tray prepared with the same care as it would be in an operating theatre. Absolute asepsis and cleanliness are essential. This has been emphasised because not all student radiographers have nursing training, and are therefore not familiar with aseptic methods.

Children are sometimes difficult to deal with, because they are often frightened in an X-ray department. It is a good plan to start by talking to the child and to give it a toy to play with. If the child has to be screened, it is advisable to reverse the order and take a film first. When screening is in progress, it is a good plan to stop every now and again, turning on the room light in the intervals. Various restraining devices have been designed for use in dealing with small children.

The reader will consider that there are a large number of "do and don'ts" in the foregoing. Practical experience will convince him or her that they are important and, in fact, essential. Successful and happy work will result if these instructions are carried out. Students will find that the patient must be the first consideration, and they should remember that a patient is in a condition of dis-ease. A cheerful and natural manner towards patients is appreciated by them; never order patients about, it

will never get results. Put your patient at ease, and then he or she will do their best to co-operate with you.

First Aid Measures

The radiographer must know something of a few simple first aid measures.

(1) **Fainting.** The patient must be laid down flat forthwith. The clothes round the neck should be loosened and the window or door opened to cool the room. The face can be sponged with tepid water. This procedure is usually sufficient to bring about recovery in the ordinary fainting attack. The patient can be given a dose of Spts. Ammon. Aromat. (3i) in a little water, or a little brandy or whisky. See that the patient is comfortable. Examination should not be proceeded with until the patient has completely recovered, nor should the patient be allowed to stand until he or she has sat up for a while.

(2) **Hysteria.** Hysterical patients should not be fussed over, but rather left to themselves. If the attack is severe, the patient's hands and face should be sponged with cold water. Cold water has a remarkable therapeutic effect on hysterical subjects.

(3) **Syncope and Fits.** In a case of syncope due to organic disease, general first aid measures should be resorted to ; but it is essential that the radiographer should send for a doctor at once. If the patient has an epileptic fit, he or she should be protected from doing damage to themselves, for example, furniture should be removed from their immediate neighbourhood ; a spoon or wooden peg should be inserted between the teeth to prevent the tongue from being bitten.

(4) **Electric Shock or Burn.** Owing to shock-proofing of X-ray equipment injuries due to electric shock are now fortunately rare. If any person in the department should receive a shock, it is essential to act at once. The sufferer may not be able to free himself from the circuit owing to the paralysing effect of the shock. Electric shocks may cause severe burns, shock, insensibility or death. The current must be switched off immediately. Do not attempt to touch the injured person until this has been done.

Treatment. A. Send for a doctor at once.

B. Artificial respiration should be carried out as soon as the patient has been freed from the electric circuit. The patient is placed prone with the head turned to one side and the arms

raised. Then the rescuer must kneel down to one side of the patient, facing the patient's head. The hands are placed flat on the small of the back, the thumbs being parallel and the fingers over the ribs. Even, firm pressure is now exerted at the rate of fifteen pressures per minute, that is, the respiration rate. Do not lift the hands off the patient's body when releasing the pressure.

Artificial respiration must be kept up continuously until a doctor is satisfied that the patient has sufficiently recovered or is beyond recovery.

C. Burns. Burns due to electrical shock are not comparable to burns due to other agents. The damaged tissue can be described as being in a state of suspended animation. It is stated that suppuration and deformity result if they are treated as ordinary burns. Electrical burns should be treated expectantly, simple dressings only being applied. An interesting editorial on the subject was published in the *Lancet* (September 30th, 1944).

Precautions taken in an X-ray Department

(1) **The Patient.** When a patient is screened, the diaphragms of the tube are shut down as much as possible, so that only a

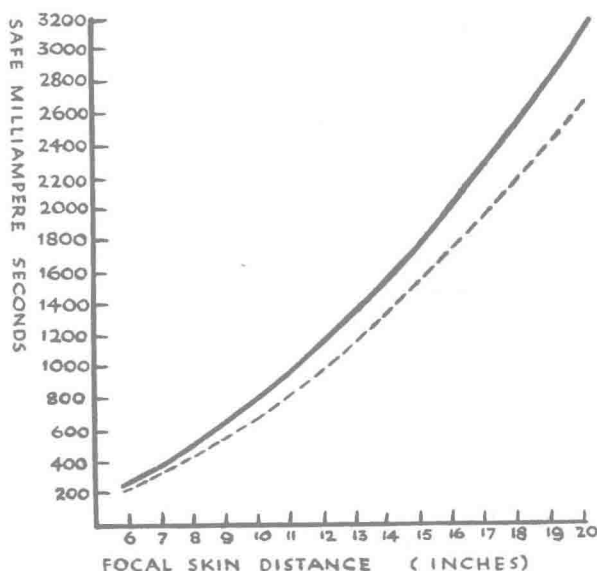


FIG. 1. Safe exposure for face and head shown by dotted line, other parts by continuous line.

relatively small beam of radiation passes through the body. Screening should never be a long business. Closing the diaphragms also protects the person screening. Voltage should be kept as low as possible.

Fig. 1 shows the safe exposure, in milliampere-seconds, to which parts of the body can be subjected. It will be seen that the head does not tolerate exposure as readily as other parts, because we must bear in mind the danger of epilation. This fact should be remembered when taking films of the teeth and the skull. A safe rule is that once a part has been exposed to its maximum tolerance dose, the same part should not be irradiated again for one month. There is a fairly wide margin of safety. It has been worked out that about eighteen films of the teeth or the sinuses can be taken, allowing for the danger of epilation; many more films can be taken of other parts of the body. The rare patient who receives an erythema dose usually does so as a result of excessive screen examination.

An aluminium filter, 0.5 mm. thick, is mounted permanently on all X-ray tubes. This stops some of the "softer" radiation from reaching the patient.

(2) The Staff. All personnel in the department should undergo a blood count examination every six months, to avoid the possibility of anæmia developing. Prolonged exposure to X-radiation and insufficient sunlight due to working in the dark room may produce leucopenia in the blood. This rarely occurs nowadays as working conditions and protection are much improved in modern X-ray departments.

A person in normal health can tolerate an exposure of 1.0 "r" units per week. X-ray departments are now much better lighted and ventilated. Protective lead-rubber aprons and gloves are worn for screening and lead-rubber aprons hang from the screen itself. The fluoroscopic screens are covered by lead glass plates to protect the operator. Barium plaster or lead-lined walls protect the office, dark room and staff sitting-room, etc.

(3) Electrical Precautions. If there is an overhead high tension system, the conductors must be 9 ft. from the floor. Earthed guards or earthed shields are provided to shield adjacent parts of the high tension system. Unshielded leads to the tube must be remote from the patient and the operator. Metal parts of the apparatus are earthed.

The earth wiring should be inspected periodically to make sure

that it is functioning properly. A useful additional precaution is for the staff to wear rubber-soled shoes.

With modern shock proof apparatus, there is little danger of electric shock. But there is always a possibility of it, especially if negligence has allowed a cable to remain habitually kinked. Eventually the insulation will break down in such a cable and the result might well be serious.

(4) Recommendations of the British X-ray and Radium Protection Committee. The British X-ray and Radium Protection Committee draw up recommendations, which should be carried out in all departments. Their reports deal with X-ray, radium and electrical protection. Radiographers should obtain this report and read it. Some of the recommendations have already been mentioned. Those dealing with X-ray protective measures are as follows :—

- (1) An X-ray operator should not expose himself to the direct beam. This is most important.
- (2) He should keep himself as far from the tube as possible.
- (3) The tube should be protected with protective material.
- (4) Scattered radiation should be adequately controlled.
- (5) Screen examinations should be kept short and fluorescent screens should be protected by lead glass of adequate protective value. Other recommendations deal with the control of radiation from the screening stand and the couch. The latest report of the Committee (1943) reduces the weight of lead in the gloves and the apron. Other recommendations deal with working hours for X-ray workers.

(5) Anæsthetics. The greatest care should be taken if an anæsthetic is being administered in the X-ray department. Any special danger should be pointed out to the anæsthetist; any sparking must be avoided. If ether is avoided as an anæsthetic in the X-ray department, little danger exists. It is rarely required to administer prolonged anæsthesia because surgical manipulations under the screen should not be of long duration. Therefore it is often possible for the anæsthetist to administer enough anæsthetic for the purpose before the patient comes to the X-ray department.

NOTE TO AN INTENDING RADIOGRAPHER

X-radiation is a powerful agent. The measures outlined above

are intended for your protection. Excessive exposure to X-radiation can cause anæmia or, if local, burning of the skin. Under modern working conditions, no fear of either need be entertained ; on the other hand, always remember that X-rays must not be treated lightly and never expose yourself unnecessarily to them.

The official view concerning anæmia was stated in 1942, in a letter from the Director-General, E.M.S. He stated that anæmia in X-ray workers was rare ; if minor degrees of leucopenia occur, a second blood count should be carried out in two weeks. Removal from work is only necessary if the condition is found to be "confirmed and progressive." It is unusual to encounter a radiographer who is suffering from a progressive anæmia ; any person who hesitates about taking up the study of radiography on this account can be quite reassured. There is no danger providing that reasonable care is taken ; that is a matter which rests with the radiographer.

A person taking up radiography should be healthy. It is advisable that would-be radiographers should have a blood count taken before taking up this work.

Preparation of Patients for X-ray Examination

(1) Gastro-intestinal Tract.

1st Day. An aperient should be administered in the evening, forty-eight hours before examination.

Light diet to be taken on the day before examination.

On the day of examination, no food nor drink should be taken prior to attendance at the department.

The patient must attend fasting.

No bismuth mixtures should be given for three days before examination.

Second Day. The patient is given barium sulphate, 4 oz. in a pint of bread and milk, at 6 a.m., and should attend at the department at 12 noon. No food nor drink should be given.

(2) Barium Enema.

An aperient is given in the evening forty-eight hours prior to the examination.

A low residue diet to be taken on the day before examination and a soap enema should be given. The patient should have a further soap enema on the morning of the examination, followed by a colon washout.

(3) Renal Tract.

An aperient is given forty-eight hours prior to examination.

A low residue diet should be given on the day before and on the day of examination.

In uroselectan cases, fluids should be restricted for six hours prior to examination.

(4) Gall Bladder (Graham's Test).

A light meal, free from fat (dry toast and tea), is given at 5 p.m. in the evening.

The whole contents of the bottle of Opacol (or Pheniodol granules) is emptied into half a tumbler of water at 6 p.m. The mixture should be stirred until it is white. The patient should go to bed and sip the mixture slowly.

The patient should not take any food until examination at 9 a.m. on the following morning ; he may, however, take occasional sips of water to relieve thirst.

A fatty meal should be given at 1 p.m.

A further examination is made at 2 p.m.

No bismuth mixtures should be given for three days prior to examination.

(5) Wound, etc.

Preparations containing bismuth should be carefully removed. Bandages should be substituted for adhesive plaster when possible. Jaconet should be omitted from dressings. No case should be sent for examination with an undressed open wound.

If a skin marking for a foreign body is required, the skin should be cleaned carefully, a dry gauze dressing, held on by a light bandage, being applied if necessary.

CHAPTER II

TAKING A FILM

“ . . . Fancy the fabric
Quite, ere you build, ere steel strike fire from quartz . . . ”
BROWNING.

Movement

WHEN we want to take a photograph of a landscape, we decide on the aperture and the time of exposure by roughly judging the brightness of the day. Then we set the camera for infinity, look for a nice view and open the shutter. It is relatively easy. But when we come to deal with the human body and are using X-radiation rather than light, we are in the midst of a legion of problems. The writer wrote in the introduction to the first edition of this book, “It is necessary for students to have a knowledge not only of what they are doing, but why they are doing it. Radiography is an art, which can only be acquired by practice. To acquire it, they must have a knowledge of the peculiar properties of X-radiation, varying body densities and how to penetrate them by exposures differing in time, distance and quality ; they must know of differences in contrast and detail in mere shadows, which they must produce on a film.” The human body is about as opaque to X-radiation as water. It is composed of carbon, hydrogen, oxygen and nitrogen ; parts of the body contain denser materials, such as calcium, phosphorus, etc. Such parts of the body show a denser shadow. Thus the atomic numbers of the elements composing the body have a direct bearing on the relative densities on a film ; a high atomic number will produce a greater density than a low number.

It is of the utmost importance in taking an X-ray film to obtain a film free from any movement. If the patient moves, the shadow, which we are photographing, also shows this movement, resulting in a blurred picture lacking in detail.

It is essential that the patient is placed in a comfortable position. If the patient is at ease and the injured part is not cramped or painful, owing to an uncomfortable position, the muscles will be relaxed and the risk of movement diminished. If, on the other hand, the patient is uncomfortable, the part examined will be held rigidly ; this is almost certain to result in a

film which shows movement. The extra time taken in this essential act of making the patient comfortable will be saved by avoiding having to repeat faulty films.

In every department you will find sandbags and woolbags. These are for use, and very useful you will find them. It is a pity that some radiographers are apt to get out of the habit of using them. By placing sandbags for support, the part is effectively steadied and movement prevented. Woolbags are placed on the film between the part examined and the sandbags, because, of course, sandbags cannot be put directly on the film.

Another method of preventing movement is by the retention band or compressor. This is a band of linen about 1 to 2 ft. wide which is put over the part to be examined ; one end is fixed at one side of the table and the other end is then tightened by a roller attached to the Potter Bucky carriage. This is most useful and should always be used when taking a film in the thoracic and abdominal regions on the couch.

The patient should be instructed to hold the breath during all abdominal and thoracic examinations. He can be instructed either to take in and hold the breath or to stop breathing. When patients find this difficult, a good tip is to ask the patient to take a breath in and then hold the nose, the mouth being closed.

When it is difficult to overcome movement, the shortest possible exposure should be made. If a short exposure is used, movement is not usually a serious problem.

Films, Screens, Cassettes

Films are supplied by the manufacturer in two forms, either each film is wrapped individually or the films are supplied in a box, which can only be opened in the dark room. The films, which are already in a light-proof wrapping, can be used for taking films of the extremities. Films, which are not individually wrapped in light-proof envelopes, are placed between two intensifying screens, which are held in a cassette.

By contrast in an X-ray film, we mean a difference in density ; by definition, we mean the detail produced on the film, that is the sharpness of the photograph. Definition depends on a number of factors, the most important being the distance between the X-ray tube and the film, and the actual focal spot of the tube itself. This is explained later. The contrast of the film depends on the exposure used, the wavelength of the X-ray beam, the amount of