A TEXT-BOOK
OF
X-RAY DIAGNOSIS

BY BRITISH AUTHORS

IN FOUR VOLUMES

THIRD EDITION

Edited by

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PREFACE TO THE THIRD EDITION

THE SCIENCE OF RADIOLOGY has made enormous advances since the last edition in 1950. These advances are partly due to new techniques and improved equipment but largely due to closer collaboration between colleagues in all branches of medicine. Radiology is now a clinical science in its own right. The tempo of new radiological observations and techniques is so rapid that a work on only an encyclopædic scale could cover it. It is not our intention, however, to cover every nuance and refinement of diagnostic radiology. These volumes were conceived as a text-book, to describe fundamental principles in interpretation and relate them to the day-to-day clinical problems of the average X-ray department. This necessitates the exclusion of some rare and much theoretical material, but we hope that nothing of major significance has been omitted and that this edition, like its predecessors, will reflect the best current practice of radiology.

The Editors deeply regret the death of Sir Hugh Cairns and Sir Harold Graham-Hodgson, two of our contributors in the last Edition. We welcome as new contributors Mr. D. W. C. Northfield, Dr. C. J. Hodson, Dr. David Sutton, Dr. John D. Dow, Dr. P. G. Keates and Dr. S. Holesh.

We are grateful to the block makers and printers and in particular to Mr. F. Boothby and Mr. J. Goodhall in the publishing house of H. K. Lewis and Co. Ltd., whose continuous interest and co-operation have contributed so much to the success of this text-book.

THE EDITORS

June 1957

EDITORS' NOTE TO THIRD EDITION OF VOLUME II

IN PREVIOUS editions we have used only positive reproductions and this has been a minor criticism by some reviewers. In the preparation of this Volume hundreds of prints have been made, both negative and positive. It is obvious from these that some lesions are much better demonstrated as negatives and some as positives. For example, most angiocardiograms are better as negatives while most lesions of peripheral pulmonary vessels appear better as positives.

Considerable emphasis has been laid on descriptions of radiological anatomy. This is dreary but essential reading for the *in vivo* anatomy revealed by radiography is quite different from that demonstrated in the anatomy room. We have retained Twining's drawings and descriptions of the interlobar fissures. These have to some extent lost their pathological importance as bacterial infections have been overcome but they can still be an invaluable guide not only to the location but often to the ætiology of obscure diseases.

A short fluoroscopic survey is often an invaluable part of a general cardiological examination. The indications for detailed fluoroscopy are becoming more and more limited as better radiographic techniques are developed and also because fluoroscopy involves the highest dose of radiation in medical practice. We have perhaps overemphasised its role in this volume for the benefit of developing countries still short of personnel and money. We hope that by the time the next edition appears this source of radiation will have been minimised or largely discarded.

December 1961

PREFACE TO THE FIRST EDITION

THE OBJECT of the Editors in presenting this text-book is to provide within reasonable limits a comprehensive survey of the present position of X-ray diagnosis. Diagnostic radiology is becoming an increasingly complex specialty, and it is difficult for one person to be equally expert in all its branches. The editors are fortunate therefore in having the help of collaborators, both radiological and clinical, who are distinguished in particular branches of the subject. It is hoped that this has made the work the more authoritative, and that it will be of value not only to the post-graduate student of radiology, but also to the clinician. In conformity with this design, only essential details of technique are included, and the subject of X-ray physics is not dealt with.

For convenience of reference, the work is published in three volumes, each containing as far as possible subjects of allied interest. Thus Vol. I deals mainly with the thorax, Vol. II with the abdomen, and Vol. III with the skeletal and nervous systems.

It is not possible, even within the generous limits allowed by the publishers, to illustrate every condition demonstrable by radiology, but the illustrations chosen are, it is hoped, representative, and give due emphasis to the common lesions met with in radiological practice. Considerable interchange of material for illustrations has taken place between the various contributors to the book, and the Editors are greatly indebted for the loan of illustrations from other colleagues, detailed acknowledgments of which will be found at the beginning of each volume. They are also grateful to Mr. Boutall, of Messrs. Vaus & Crampton, for the care and attention he has given to the preparation of the blocks, and to Messrs. Hazell, Watson & Viney for their careful work with the printing.

Finally, the Editors desire to express their sincere thanks to the publishers, and in particular Mr. H. L. Jackson and Mr. F. Boothby, for their co-operation and advice, without which this book could not have come into being.

October 1939

ACKNOWLEDGMENTS

THE EDITORS are grateful to their colleagues in Westminster Hospital, The National Heart Hospital, St. Mary's Hospital, Guy's Hospital and Kingston Hospital for many of the illustrations. We are also indebted to many colleagues throughout the country in hospitals, chest clinics, and mass radiography centres, for many interesting radiographs.

Dr. Charles Fletcher read and gave much helpful advice on the sections on coal-workers' pneumoconiosis. Professor Gough of Cardiff was very helpful with illustrations and advice on emphysema. Dr. Shura Holesh corrected the proofs of the Cardiovascular Section and Dr. James Gough, late Senior Registrar at the Victoria Park Chest Hospital and now Senior Registrar at St. Thomas's Hospital, corrected the proofs of the Lung Section. Dr. Holesh did the line drawings and tracings on the Heart and Dr. Gough did those for the Chapter on Segmental Anatomy. Their advice was most helpful and both did invaluable work in checking references and bringing to our attention many important contributions.

Certain illustrations which have been adapted from Zdansky, Rontgendiagnostik des Herzens und der grossen Gefasse, are included by permission of Professor Zdansky and Springer-Verlag, Wien.

SUMMARY OF CONTENTS

VOL. I

VOL. II

VOL. III

VOL. IV

VOLUME II

PART ONE

CARDIO-VASCULAR SYSTEM

BY

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PART ONE

CARDIO-VASCULAR SYSTEM

CHAPTER I

X-RAY EXAMINATION OF THE HEART

X-RAY EXAMINATION of the heart and great vessels has not materially altered clinical methods of investigation. It is impossible by radiology of the cardio-vascular system to arrive at a decisive diagnosis comparable, say, with the X-ray diagnosis of gastric ulcer or phthisis. Cardiac radiology is not and never can be a short cut to diagnosis, and X-ray findings are of value only when correlated with clinical findings. Despite the great additions to our knowledge gained from improved radiographs and angiocardiography, this still holds.

The intrinsic movements of the heart and the alterations produced on it by adjacent moving organs, the lungs and the diaphragm, are a serious obstacle to detailed investigation of its function by X-rays. Cardiac cinematography, although partly overcoming this obstacle, has not yet contributed greatly to the investigation of heart disease, but there is obviously a great future for cinematography combined with angiography when better equipment and better contrast media are available. The methods of X-ray examination in common use are fluoroscopy, orthodiagraphy, teleradiography, angiocardiography and cineradiography.

FLUOROSCOPY

Screen examination is of considerable value to the physician for a rapid preliminary survey. It gives the observer an immediate knowledge of the size of the heart and its relationship to the neighbouring intrathoracic organs. He can see at a glance whether the shape or position of the heart is altered by such extrinsic factors as scoliosis or fibrosis of the lungs. He has a clear view of the apex of the heart through the gas bubble in the stomach, and if necessary he artificially increases the size of the gas bubble by giving the patient an effervescent mixture to drink. Under the screen the patient can be slowly rotated into the most suitable positions for examining the various chambers. The experienced observer can determine points of differing pulsation and thereby locate the auriculo-ventricular indentation and the interventricular groove. He can visualise abnormal pulsations due to intrinsic or extrinsic disease and differentiate intracardiac calcification from overlapping pulmonary or rib calcification. Valvular calcification is more easily identified on fluoroscopy

than on conventional pictures. He should also study the size and type of pulsation in the main branches of the pulmonary arteries and hila. In many cases a barium swallow is helpful. The general practice is to screen in the erect or sitting position, but in certain diseases, valuable information can be obtained by screening in the supine and supine-lateral positions. The disadvantages of fluoroscopy are that there is no permanent record of the appearances and that important changes in the pulmonary vessels cannot be detected. Because of genetic and possible somatic radiation hazards, the observer should be thoroughly dark-adapted and the equipment should include adequate filtration and a multi-leaf diaphragm to exclude scattered radiation. The procedure should be carried out as quickly as possible It should not be used in young children where it is of little or no value anyway.

ORTHODIAGRAPHY

This is a method, now almost obsolete, of estimating the radiological size of the heart. The central ray, i.e. that originating from the centre of the target, does not diverge. It follows that if this ray alone can be employed, fallacies due to divergence of the radiation can be eliminated. An instrument known as an orthodiagraph has been devised for this purpose. In the orthodiagraph the X-ray tube is entirely independent of the screen, and the tube can be moved freely upwards, downwards and laterally. A fine diaphragm is fitted, and this is contracted so that only the central ray gets through. The patient is placed behind the screen, which is pressed tightly against his chest, and when the tube is activated the central ray appears as a tiny beam of fluorescence through the air-containing lung. This tiny beam is carefully moved around the cardiac silhouette, and at selected points the outline is marked on the screen with a grease pencil. The largest possible silhouette is drawn, i.e. ventricular diastole for the heart area, and ventricular systole for the vascular area. During the examination the patient breathes as quietly as possible. The drawing of the diaphragm is made so far as possible during the time of respiratory pause. The final drawing is traced from the screen on to transparent paper which serves as a permanent record. Measurements of the heart shadow made with an orthodiagraph are more accurate than those made on a teleradiograph. On the other hand, in any fluoroscopic examination the personal factor is of great importance, and in the same patient two independent observers may record widely different measurements.

TELERADIOGRAPHY

The greater the distance between the source of the radiation and the object radiographed, the less the distortion due to divergence of the rays. At 2 metres distance the radiographic size of the heart is about 1 cm. greater in width than the orthodiagrammatic measurement. At 3·5 metres distance the measurements on the film are equal to those made with an orthodiagraph. The teleradiogram has, of course, the great advantage that it provides a better record of the heart in relation to neighbouring organs than the orthodiagram.

It also allows of detailed study of the pulmonary vessels, and the personal equation does not enter to the same degree that it does with orthodiagraphy. Its disadvantages are (*a*) expense and the large amount of space taken up by high-powered apparatus, and (*b*) the difficulty of reproducing all factors exactly at different intervals. These latter disadvantages are being overcome by modern methods of apparatus construction.

A speed below one-tenth of a second is essential for the postero-anterior view. With modern rotating anode tubes and high-speed screens and films exposures below 0·03 are available and preferable. For oblique and lateral views longer exposures are necessary, but it is justifiable here to shorten the distance with the object of reducing the exposure time. At 48 inches, with 400 ma. 65–75 KVP, super-speed screens and fast film, an oblique view can be made at 0·1 second. At such speeds there is excellent sharpness and anatomical detail, and distortion enlargement of the cardiac silhouette is so slight that it will not give rise to any false estimations of size. Transformers with an output of 1,000 mA. at 150 kV and tubes which stand such loads are now available. These bring exposures down to milliseconds. In both postero-anterior and oblique views, accurate centring is essential. The 5th to 6th dorsal vertebra is the correct point for the PA view. The angles for the oblique view must be obtained by screening. Slight tilting or lateral deviation of the tube can cause considerable distortion, and the position of the tube on its arm should be checked from time to time. All views should be made at the end of quiet inspiration. Various devices have been invented to activate and close the tube current by the pulse at the wrist or by electrocardiography. Using these devices, it is possible to determine in which phase of the cardiac cycle the radiogram has been made. Although in the average individual with a normal rhythm, the difference in radiological size between systole and diastole is only 3–4 mm., this is often sufficient to give a false impression of enlargement during diastole. In young athletic individuals with bradycardia, the difference between systole and diastole may be as much as 2–3 cm. and a false diagnosis of pathological cardiomegaly is only too easily made. A few workers still prefer long exposures of up to 0·5 second so that the picture shows the heart size at its maximum. This is possibly valuable during an active rheumatic condition and especially when there are marked variations in rhythm, but the blurring inherent in a slow exposure makes it difficult to identify alterations in a particular chamber and completely obliterates any changes in the pulmonary vessels. A simple and reliable instrument for taking radiographs in both phases will be a great boon. The standard type of radiograph without a grid is the ideal for study of the pulmonary arteries and veins, but it must be supplemented with penetrated pictures using a microline grid. Grid pictures have this great advantage: they reveal density differentiations inside the central heart shadow caused by (*a*) left auricular enlargement, (*b*) aneurysms of the root of the aorta, and (*c*) calcification in valves, coronary arteries, thrombi, infarcts, pericardium, etc. The grid view is also invaluable for demonstrating

the trachea and its bifurcation. Alteration of the angle of the left main bronchus relative to the right is one of the most important signs of left auricular enlargement, and narrowing of the calibre of the left main bronchus an inch or so beyond its bifurcation is a common finding in patent ductus and vascular rings. If high KV (120–150) is available, the grid view can be taken at 0·01 seconds or less at 60 inches distance. The author's routine technique is one 17 × 14 PA view without a grid, one 17 × 14 PA view with the grid, and right and left oblique and right or left lateral views with the grid. These multiple views are essential to determine which chamber if any, is selectively enlarged. Attempts to determine right or left ventricular enlargement on a single PA view are futile. If a barium swallow has been used during fluoroscopy, this should be washed down with water before taking these views, as retained barium can obscure valuable anatomical detail Posture and the phase of respiration are also very important factors in estimating heart size. In most cardiac cases the erect or sitting position is the most suitable one for teleradiography, but if it is necessary to examine a patient supine, follow-up examinations should be made in the same position.

ANGIOCARDIOGRAPHY

This is a method of obtaining visualisation of the heart and great vessels by rapid intravenous, intracardiac or intra-arterial injection of an opaque medium. The intravenous technique was originally made practical by the work of Robb and Steinberg, and several Swedish workers have been responsible for many of the important advances in the other two methods. The first opaque media were di-iodone preparations, but these have been replaced by heavier tri-iodone solutions which cause fewer side effects. The basic requirements for the ideal contrast medium are adequate opacity, low toxicity and ease of injection. Since the majority of angiocardiographic examinations are now selective and made through a catheter, ease of injection is of great importance and this is largely determined by the viscosity of the agent. A new medium, which is a combination of two old ones, diatrizoate sodium and diprotrizoate, appears to be significantly better in every respect than either used alone. The reader is referred to work by *Dotter* and *Straube* and *Sanderson* and *Gross* for details. Although this new medium is obviously much safer, *Dotter* and *Straube* had one death and one temporary cardiac arrest in 133 examinations of 126 patients. The child who died had severe Fallot's deformity.

Angiocardiography is not without danger, and in severe cardiac cripples and allergic individuals there is a mortality rate of rather less than one per cent. The risks are increased by repeated injections and repeated anæsthetics. More than one examination during a short period and prolonged screening during cardiac catheterisation may also cause radiation hazards, but with improved apparatus using higher kV, shorter exposure times and image intensifiers, the amount of radiation has been considerably reduced.

Although it is possible to carry out the examination with moderate sedation, general anaesthesia is preferable. In Westminster Hospital the following is the anæsthetic procedure for angiocardiography in children:

Premedication consisting of ½ mg. of pethidine and ½ mg. of Phenergan per 0·5 Kg. of body weight is given. If the pulse is less than 120 the child is also given 1/120 gr. of atropine.

During exposure of the vessel for catheterisation, a little gas and O_2 inhalation is administered with the local anæsthetic. Then an intravenous injection of 100 mg. of Hydroxydione per 8 Kg. of body weight is given 4 to 5 minutes before the main procedure. Immediately prior to the injection of the contrast medium, a little scoline is injected. A set of instruments for emergency thoracotomy in the event of cardiac arrest should always be available and if possible the X-ray room should be equipped as an operating theatre. Resuscitation drugs and anti-histamine preparations should be available.

The causes of the side effects and of death during angiocardiography are imperfectly understood. The minor reactions such as a sensation of heat, urticaria and fainting are only of consequence when the examination is made without a general anæsthetic. These symptoms are probably allergic and may be prevented or mitigated by preliminary injection of an anti-histamine compound. Experience has shown that sensitivity tests are of no value in predicting a serious reaction because this may occur even though the preliminary test was negative. It is possible that some of the recorded deaths have been due to anaphylactic shock and, unless there is an imperative indication for angiocardiography, it should not be performed in an allergic person.

The majority of deaths have occurred in cyanosed children with an intracardiac shunt and the method of death has usually been respiratory or cardiac arrest or both. This suggests that a large volume of contrast medium rapidly reaching the systemic circulation has a depressor effect on the medullary centres. In all the recorded cases the vascularity of the lung fields had no relation to the mortality. There is inadequate information to implicate any particular form of anæsthesia, but there is a suggestion that open ether and nitrous oxide are more likely to precipitate a catastrophe than the basal narcotics.

Repeated injections at short intervals may cause acute renal failure. Apart from such a disastrous episode, there is evidence suggesting chronic renal damage from too frequent injections.

Angiocardiography may precipitate an attack of acute pulmonary œdema in patients with severe pulmonary hypertension. There have also been an unusually large number of unpleasant or dangerous side effects when angiocardiography has been performed to reveal the anatomy of pulmonary arteriovenous aneurysms or other large highly vascular tumours. In two cases, one under local and one under general anæsthesia, severe epileptiform attacks occurred during the injection of triodone 70 per cent.

In view of the potential dangers, the indications for angiocardiography