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OBSERVATIONS ON THE CLINICAL VALUE OF THE ROENTGEN RAY IN THE DIAGNOSIS OF CARDIOVASCULAR DISEASE*

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THIS Thirtieth Annual Meeting of the American Roentgen Ray Society is evidence of the progress in medical science that has taken place in our generation and I am grateful for the opportunity to have a part in the cardiac symposium. I am a clinician and my message to you will summarize some experiences of mine in the application of roentgen studies to the diagnosis and treatment of cardiovascular disease in the past few years. I have been doubly fortunate, first, in living and working during the evolution of this method of study, and second, in having as my teachers and associates Dr. George W. Holmes and his colleagues, past and present, many of whom are here today and some of whom are taking part in the present symposium, and Dr. Hugo Rösler of Vienna with whom I studied last winter. My observation of the clinical application of roentgen rays began with general hospital patients but it has been only in the past nine years since I started private practice and I have more fully appreciated the status of cardiovascular roentgenology. Although most of my remarks will deal with the limitations of this method of study, my appreciation of its value is illustrated by the fact that I am about to install for my personal use an

apparatus for orthodiagraphic study. Up to now I have used the experience and apparatus of Dr. Holmes and others and I want to continue to be allowed to do so but in addition I believe the method of examination to be so important that I wish to have it for immediate use and for investigation myself.

I shall now present seven observations for your consideration and criticism.

In the first place, roentgenology is but one of several clinical methods of studying the circulation. Like the others it is incomplete in itself and it ranks down the list in value. We must not expect too much from it. A careful history is most important of all in the diagnosis of cardiovascular disease, and physical examination comes next in usefulness. Accessory and occasionally valuable methods of study are sphygmomanometry, roentgenology and electrocardiography. For the complete examination of a patient with cardiovascular symptoms or signs all these procedures should be included; often they will add no new or important facts but sometimes they will present information of value that cannot be discovered by other means and may be quite unexpected; even so-called negative findings are worth while having on

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record. It is wise to include routinely a roentgen examination in the analysis of every cardiovascular patient but it is essential that it be made accurately and interpreted intelligently by an experienced person. Sometimes errors in technique and interpretation render the procedure a serious handicap in diagnosis rather than a help and in a considerable percentage of cases examined routinely throughout the countryside at the present time it would for this very reason be more helpful to omit roentgen-ray study than to include it. This fact is true of all other methods of examination and is by no means limited to the roentgenological procedure. A poor history may lead one far astray, as also may the inaccurate timing of heart murmurs, or artefacts and misinterpretation in electrocardiography. After this statement of the relative value of cardiovascular roentgen examination, let us proceed to the discussion of some of the findings, which begin with the second important observation in this paper.

The roentgen rays provide a method for the demonstration of moderately or far advanced pathology only, even though such pathology is revealed in no other way. It is not a way to show early or slight disease except in rare instances and so, at the present time at least, it is of little or no value in the early discovery of trouble that can be stopped at its onset or retarded before permanent and incurable changes have set in. This is of course a serious limitation of the clinical value of the method as it is of many other methods, and is largely the reason why some able physicians like Sir James Mackenzie have minimized its use. Even greater refinements in methods of application and in interpretation now being developed are unlikely to help much in this particular. Thus in many respects positive roentgen findings are largely of academic interest alone like much positive evidence of serious heart disease found on physical examination in chronic cardiac patients on the hospital wards. However, even though

disease may not often be amenable to therapeutic relief after it has advanced to the stage when it can be discovered by roentgen ray, exact knowledge of its extent and type is often invaluable in prognosis and in the proper handling of chronic disease where life may be prolonged and made more comfortable, useful and happy by intelligent treatment.

My third observation is brief but important. Serious and indeed fatal heart disease may be present with no indication of trouble on roentgen examination, or even by any other method of study except perhaps by history. This is particularly true of angina pectoris which is now generally recognized to be dependent primarily on coronary disease. The size and shape of heart and great vessels are frequently entirely normal in angina pectoris which yet may result in sudden death, and without a history this serious condition is not diagnosable. Of about 500 cases of angina pectoris that I have seen in private practice in the past nine years approximately 25 per cent showed no evidence of heart disease on examination, which included roentgen-ray study in many cases. Luetic aortitis also, before the aorta has become dilated or the aortic valve defective, may escape notice and yet result fatally, usually by narrowing of the coronary artery mouths.

In the fourth place, roentgenology is a crude method of study, even though at first glance it sometimes gives the impression of being a very delicate and accurate one. Normal variations in the size and shape of the shadow of the heart and aorta are so great that errors in the interpretation based on slight changes from the average normal are very frequent. This is true of any position in which the study is made, and it is this fact that has caused many authorities to discount measurements and figures to a very large extent. Slight changes in size and shape due to disease may not be distinguishable from similar slight changes due to normal variations.

This results about equally in the occasional diagnosis of organic disease when none is present and in the failure to recognize such disease when it is present. There are too many factors like age, height, build, shape of chest, and the height and excursion of the diaphragm to be taken into consideration to permit, at present, absolute reliance on any table of standard normal measurements. The more cases studied, the wider have become the limits of normal. For example where once 50 per cent was thought to be the upper limit of normal for the so-called cardiothoracic ratio, that is, the ratio of the total transverse diameter of the heart shadow to the internal diameter of the thorax in the anteroposterior orthodiagram or teleroentgenogram, now it is put at 57 per cent, depending on the position of the heart as well as on its size. As a matter of fact, for one individual a ratio of 52 per cent may be perfectly normal while that of 47 per cent in another case may be too large, being associated with actual hypertrophy. The same is true of other measurements like that of area of the cardiac shadow. It has even been estimated that it is possible in the anteroposterior view for the area measurement in a given area to increase 75 per cent from the lower limit of normal and still remain within the upper limit of normal. Thus well-marked variations from the so-called normal in size or shape must be encountered before definite conclusions as to the presence of cardiovascular pathology can be drawn. If in any given case it were possible to have for comparison roentgen-ray records accurately and similarly obtained before and after the onset of disease we would be far better off than we are now in attempting to fit a case into standard tables. However, in spite of all these difficulties it is useful and practically essential to have normal standard measurements for comparison and if we realize the limitations of the method we can use such measurements to advantage. There is a feeling abroad, as I found in Vienna, that

we in America make too much of figures and try to devise too many formulas wherein to fit the data obtained in clinical studies, and this criticism is doubtless to a certain extent just. We must not lull ourselves into a false sense of accuracy by elaborate tables, formulas and figures, and this is as true in roentgenology as in other methods of examination. It is best to hold the middle course and neither overrate nor underrate the value of actual measurements.

My fifth point concerns accuracy of technique. A method which is inherently accurate may become a source of confusion when errors creep in as they are so frequently likely to do in cardiovascular roentgenology even in the best of hands. We must be on our guard every minute. There may be much distortion with enlargement of the heart shadow when a roentgenogram is taken with the tube too near the chest and the chest itself not flat against the film or plate. It is wrong to attempt to estimate with any degree of accuracy the size of the heart and great vessels from such a record unless one has had great experience in this particular technique and the distances of tube to heart and heart to film are always constant, which is impossible in dealing with chests of different size and shape. Even with orthodiagram or teleroentgenogram (the so-called "seven foot film") it is essential that there be no rotation of the chest in the anteroposterior view or important deviation from a set position in the oblique views, for otherwise measurements and the shape of the shadow borders may be misleading. It is frequent for rotation in the anteroposterior view to cause an error of a centimeter or more in the distance of left or of right border of the heart shadow from the midline. In my experience the commonest error has been due to a slight rotation to the left so that the right border is reported too near the midline and the left border too far from it, by perhaps a centimeter in each case, the total trans-

verse diameter remaining fairly accurate, however. Rotation or an unusually low position of the diaphragm due to a long chest in a tall person or to other cause, may give unusual prominence to the left upper border of the heart shadow giving rise to an impression that the heart has a so-called "mitral shape" or a prominent pulmonary artery which may suggest patency of the ductus arteriosus. Simple errors of measurement or of copying measurements are common, or the "midline" may not be drawn in the middle. For reasons like these I have found that my physical examination (palpation and percussion) has been routinely a valuable check on the accuracy of roentgenograms as well as an important method of examination of heart size and shape in many cases when roentgen rays are not available. My percussion and palpation have yielded data more accurate than that reported to me by various roentgenologists so often, as proved by carefully repeated studies, that I should never think of abandoning these cruder methods of study simply because roentgen examination is fundamentally more accurate. By practice one's proficiency in cardiac examination by palpation and percussion increases as it does in other study, and if one abandons such practice of course he must rely on roentgenology alone with little control of its errors, and feel rather helpless when the roentgen rays are not available.

My sixth point is that the roentgenologist or internist using the roentgen rays should state what he sees in the way of structural change and not attempt to make an etiological diagnosis. It is better to say aortic dilatation and to give the measurements than to say luetic aortitis (for perhaps hypertension and not lues may be the cause of the dilatation (in the absence of frank aneurysms), and to state that the heart is enlarged with prominence of the left upper border and high apex (giving measurements), rather than to diagnose "rheumatic mitral disease." It is safer and

wiser in the end not to diagnose too much from the roentgen examination.

Finally, the seventh observation concerns the actual method of examination. Roentgenoscopic study is probably most important of all and especially in various positions—one alone does not suffice. Of particular interest and value is observation of the pulsating heart and vessel shadow during the actual rotation from one position to another. This allows easier identification of all parts and also affords a more complete idea of the shape and size of each part than can be obtained from any single view, just as we can judge an object better by walking around it or by turning it around than by viewing it from two or three positions only.

In this paper I have not taken up the actual roentgen findings in chronic hypertension, mitral stenosis, pericardial effusion and other such lesions, since these are quite well known and fairly well described. It has seemed more worth while at present to discuss the place and the limitations of roentgenology in cardiovascular practice and I hope that my observations may have proved of some interest and value to you.*

LATER NOTE: For the sake of completeness and because some of those who listened to this paper in New York have suggested that it might prove helpful to balance against the limitations of roentgen study in heart disease its special advantages, even though they are better known and recognized, I shall take the opportunity to add herewith some of my remarks made at a meeting of the New England Roentgen Ray Society in Boston on October 18, 1929. I summarized six particular points on which the usefulness of the roentgen ray in cardiovascular diagnosis is based, as follows:

In the first place, the roentgen ray affords by far the most accurate measurements of heart size and of heart shape that we possess in the clinic.

Second, in the presence of obesity, emphysema and other complications which

* For discussion see page 405.

render physical examination of the heart very imperfect, the roentgen ray affords sometimes the only means of determining heart size and shape.

Third, surprising and unexpected findings like pericardial calcification or aneurysms of the aorta are sometimes revealed by roentgen study alone, and in themselves justify a routine employment of this method of examination wherever possible.

Fourth, the size of the aorta and of the left auricle, and even sometimes of the left ventricle, can be determined only by the roentgen ray.

Fifth, abnormalities of the hilus shadows

and of the pulmonary artery are important findings to be discovered only by the roentgen ray, and

Sixth, roentgen-ray observation of peculiarities of the actual pulsation of the heart and great vessels is alone worth the trouble of applying this method of study.

Finally, I should like to add that I was especially impressed at the New York meeting by the evidently justifiable emphasis there placed on the particular value of the left anterior-oblique view of the heart and great vessels in affording perhaps the best views of all the chambers and of the aorta and pulmonary artery.



of some degree of enlargement of the heart and evince one, or all, of the following signs: some protrusion of the left auricular shadow beyond the right border of the heart; deviation of the esophagus to the right and backwards (or rarely, to the left

and back); and deviation of the left bronchus upwards. These signs are not found in other types of enlarged heart.

Fibrillation in such hearts can sometimes be determined by roentgen examination independently of other methods.

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DISCUSSION OF PAPERS BY DRS. WHITE; DANN; O'KANE, ANDREW AND WARREN;
STEEL; HAMPTON AND JONES, AND PATERSON

DR. A. W. CRANE, Kalamazoo, Mich. It is a matter of very great interest to get up to date on roentgenology of the heart. Just recently a revision of the Oxford Medicine has been published. Previously Sir James MacKenzie had written on the heart. This time we have the heart handled by one whom we all agree is one of the leading clinicians of the world, Dr. Henry A. Christian. The importance of this work lies in the fact that he discusses the value of the x-ray from the standpoint of a clinician. We have been working on the roentgenology of the heart for some thirty years. It is quite evident from reading Christian that he has really very little use for the roentgen examination of the heart. I think that should make us pause. We should consider what it is that the clinicians want of us. Dr. Christian freely grants a superior accuracy of x-ray methods, that is, accuracy over methods of percussion in outlining the heart, but he says that there is no need of such accuracy. He has never found it of any value whatever to know slight changes in the size of the heart, either in diag-

nosis, prognosis or treatment of a case. You will observe in our work today that the effort has been toward accuracy of outline and of size. Whether in the future there will be clinicians who can make use of that increased accuracy is a question. At the present time evidently that is not so.

At the same time that this work comes out we note that the *American Journal of Medical Sciences* has in it an article which is really a résumé of roentgenological and clinical observations in 100 cases of heart disease. It is interesting to compare these two recent publications. I know of course that we cannot take the required time now but we can consider one chapter of Christian's work, namely, that on chronic myocardial disease, a term which he uses in preference to myocarditis, because he says there is no real inflammation of the heart muscles. In this disease, which he says constitutes over 60 per cent of the cases of heart disease entered at the Peter Bent Brigham Hospital, he states that there is no murmur present. Apparently even at the time

of the microscopical examination of the heart muscle there are no changes that the pathologist recognizes. There are few symptoms indeed to indicate that there is anything present that could be called heart disease, yet the patient presents the clinical picture of heart disease, with cardiac insufficiency. The one characteristic of this disease is an enlargement of the heart, a hypertrophy, the muscle increases greatly in quantity, and yet is a very inefficient muscle. If there were ever a condition where the roentgen demonstration of the size of the heart should be of value, it would be in chronic myocardial disease. Yet Christian seems to think that here methods of percussion are ample. It would seem, however, as though the x-ray would really be of service in this condition and could actually aid the clinician in the diagnosis.

I think this morning you have heard varied discussion about the size of the heart, but I did not hear anything to indicate that the size of the heart depended also on the weight of the individual and his height. Certainly the size of the thoracic cage cannot be used as an indication for the size of the heart. I think that the methods of Bardeen have fallen into an undeserved disuse because we can estimate truly only an increased size, a hypertrophy of the heart that is not massive, by estimating the actual volume of the heart in relation to weight, height and sex. If this were done I believe that the earlier stages of myocardial disease could be detected in this way better than any other.

Dr. White stated as his objections to the roentgen examination that it was of use only in advanced heart diseases, and did not indicate any of the beginning changes, but here is a class of cases constituting over half of all heart cases entered in the Peter Bent Brigham Hospital, in which it would seem that an early roentgen examination might demonstrate to an experienced clinician that actually this important disease is in progress.

DR. F. J. HODGES, Madison, Wis. I think that Dr. Holmes is to be congratulated most particularly upon including Dr. White in the program because we have had the opportunity of seeing the clinician epitomized by a man who is certainly at the head of his field, taking stock of us out loud and without caring about stepping on people's toes and I think that he

has certainly hit the nail on the head very accurately in pointing out to us that we are over-enthusiastic in trying to arrive at numerical perfection in a field where such accuracy will never be attainable.

Dr. White has thrown a scorching searchlight on our work and has emphasized certain limitations of this method of cardiac study. If all of us were to thoroughly realize our limitations and to accept them as such, all of the fun and zest would be taken out of the roentgenological study of cardiovascular disease. This morning's papers show that roentgenologists are not willing to admit that certain limitations of their methods are serious handicaps. The papers by Dr. Dann and Dr. Warren have shown new applications of roentgen methods in the field of cardiology. I believe that in the matter of size alone we have our greatest opportunity to contribute information concerning heart disease.

I am very much pleased to know that Dr. White is installing orthodiagraphic apparatus of his own. At Wisconsin, we rely heavily upon orthodiagraphic methods and feel that they offer us the greatest amount of information that it is possible to obtain in a short length of time about heart disease.

I feel that his experience will be similar to the experience of some of the cardiovascular men in Chicago who have taken up this method; that at first he will be completely disgusted with his results, that his cardiac outlines will resemble a small school boy's picture of a barn, but that gradually as he learns to accept a certain degree of accuracy without expecting numerical perfection, he will begin to lean more and more upon his orthodiascope as a method of convincing him of the presence or absence of heart disease in any one case.

Dr. Crane mentioned the fact that height and weight and age must be taken into consideration in considering heart size. Undoubtedly true, and I would simply like to call attention to a table which was published by Dr. Eyster in *Radiology* in 1927 which will also answer one of the points that Dr. Paterson brought up as to the number of times in which normal heart size by the Eyster tables is found in cardiac disease, otherwise demonstrable. His chart shows very graphically a base line with area measurements in normal individuals scattered uniformly up and down, seldom over

plus or minus 10 per cent and never over 15 plus or minus. It shows further that simple mitral stenosis gives an average of about 8 per cent plus, that the scatter never goes above or below 20 per cent. In other words, uncomplicated mitral stenosis results in but slight increase in cardiac size. Combined mitral lesions result in a variable degree of increased cardiac size, averaging a 30 per cent increase. Aortic lesions result more uniformly in marked increase in size. In the case of multiple valvular lesions involving two or more valves, no cases fall within the normal range and the average degree of enlargement is just about plus 70 per cent.

Dr. Crane brought up the question of the relation of myocardial disease to heart size. Eyster has shown a wide range of variation in heart size in cases with myocardial disease, the average being an increase of 25 per cent over the normal.

I think exactly as Dr. Crane does, that age, height and weight should be taken into consideration just exactly as these criteria are considered in the estimation of basal metabolism and just as the surgeon disregards a very slight variation from the normal and erects rather loose boundaries between the normal and the pathological case, so we think that heart size determination will never become mathematically accurate but nevertheless may be of very considerable clinical value to the examiner.

DR. HOWARD E. RUGGLES, San Francisco, Calif. It is rather surprising that of all the internal organs, the heart, which is the most accessible to direct examination by x-ray, has been the last to be studied intensively, and there is still much to be done. We are now getting well into the matter of measurement, size and form. There is still the field of function which is as important in cardiology as it is in gastroenterology and that is what we must look forward to. There is a great deal to be done in the matter of observing the heart in action, both under conditions of rest and after exercise, which will undoubtedly give us valuable information that we are missing at the present time.

There is an article by Palmieri in a recent number of *Acta Radiologica*. He has a method of obtaining casts of the living heart by means of successive profiles of the viscus taken with

the patient rotated about a vertical axis. Then by substituting a wire for the roentgen beam and a nail for the target of the tube he carries the wire around each profile in turn, cutting down through a lump of clay placed in the position of the patient's heart and properly rotated. The final result is a remarkably accurate reproduction of the organ. These casts should be of great value in teaching.

DR. LEON T. LEWALD, New York City. I think the method of showing changes in the heart size roentgenographically is of extreme value. Dr. Holmes very kindly mentioned some work that I did in regard to determining the effect of altitude on the heart. In that work it had been erroneously concluded from auscultation and percussion that the heart dilated at heights over twenty thousand feet. Roentgenography was called in to check that finding and *roentgenology reversed* those findings and showed conclusively that the heart does *not* dilate as a result of altitude or deprivation of oxygen in the case of aviators. So that here is an observation where roentgenography, in the study of individual hearts, under various conditions, is of the greatest value. The confusion probably comes from the question of what is the actual normal size of the heart of different individuals, and of course the variations there, as Dr. Crane has brought out in regard to height, age, sex and so on, show such extreme variations that it is very difficult to take a particular heart at a particular time and say whether that heart is slightly enlarged or not, but by studying that particular heart under the same conditions at different times, one can accurately say whether that heart changes or not.

DR. WHITE (closing). May I just add a word in closing my remarks and partly in answer to Dr. Hodges? I presented, I confess in a rather pessimistic way, the views of many clinicians working on heart disease concerning the value of roentgen study at the present time. I think I am more interested, however, in the subject than are many internists and I believe there is a great deal of progress to be made. Much has been learned in the past with regard to the heart in health and disease from roentgen study. I am a very keen advocate of further roentgen study and progress and that is why I am taking it up more actively myself, but we must now and then establish the line of our limitations

and not unwisely or unnecessarily do a lot of detailed work that may be less valuable than the work that is shown to be of first importance after establishment of these limitations.

DR. DANN (closing). I fully agree with many of the things that Dr. White has said. Any one who has had an experience over a period of years becomes quite conservative and I seldom go beyond the attempt to describe these volumetric changes in the heart and great vessels. I am glad that Dr. Ruggles and Dr. LeWald brought out the point of the use of the roentgen ray as a study in physiology.

DR. WARREN (closing). I think we have all been aware of the fact that measurements made in roentgenograms of the heart have not always been as satisfactory in giving clear-cut clinical diagnoses as they might be. The accuracy of course of the x-ray depiction of what is in the thorax is far beyond our clinical correlation of these findings, that is, the roentgen diagnosis cannot be made so accurately as to conform always with what is shown upon the film because of the personal element involved and lack of experience. We have therefore undertaken about a ten-year program to bring about this correlation. We have started in by studying the amount of distortion at various distances. This paper is in press. The study I gave today is a preliminary account of measurements made on the oblique view of the heart.

We have found that as we shorten the exposure, we have to take into consideration the error due to systole and diastole. This may amount to as much as a centimeter (0.5 to 2 cm.) in the transverse diameter so that next we must develop a method much like that which McPhedran of Philadelphia uses to trip the switch at a definite time in the heart cycle. After we have done that, we can then compare serial examinations of the heart over a long period of time. I say ten years because, as Dr. White and others have pointed out, we have to study heart disease in its beginning, and then follow the changes as they are produced. It is true we are unable to make a diagnosis until the heart disease is well advanced, for there is general dilatation of the heart only with profound myocardial damage. The majority of the cases which I showed tracings of had that difficulty.

DR. STEEL (closing). Our work in Cleveland has been done under practically the same conditions as Dr. Holmes' and Dr. White's work, and I think I can appreciate very keenly Dr. White's

stand. I agree absolutely with him. It is very difficult, if not impossible, to differentiate between a dilated aorta of lues and hypertension in certain cases and we should be satisfied to describe the changes and let the clinician draw the final conclusion. In early cases of young adults a dilated aorta and no history of a hypertension justifies a diagnosis of a luetic process. It is better to diagnose a combined lesion than it is to be too specific. We should attempt to build the clinician's faith in the method.

We have found teleroentgenograms to be far more reliable than percussion in the measurements of the heart. True, percussion is all right in the hands of an experienced clinician. A personal variation enters into percussion which is not present in plates. The roentgen method has a distinct future and its value will be shown only by conservatism.

DR. JONES (closing). There are just two things I should like to mention. One is in the group of cases that we reported of about 80 luetics—80 per cent of the cases agreed clinically and by roentgen studies, which is a fairly good agreement. The remaining 20 per cent in which there was clinical luetic aortic disease, but no aortic dilatation by x-ray is perhaps the most important group, because these cases should be studied over a long period of time and observed to see whether an aortic dilatation does develop, or the case is autopsied to prove whether or not luetic aortic disease was present.

The other point is that the finding of an aortic dilatation by x-ray with whatever methods used, should not lead one to make a roentgen diagnosis of luetic aortitis, the clinical facts and other roentgen findings must be taken into consideration.

DR. PATERSON (closing). There is only one point that I would like to stress again. The examination of the esophagus in studying heart disease is no new thing. The bronchus, however, is very often directly affected in mitral disease. I believe that this is a new observation, and think that it possibly accounts for a great deal of the lung symptomatology which arises in heart disease, and is often passed over under the diagnosis of passive congestion. I believe that some of the symptoms so classed, arise through mechanical interference with the bronchus, rather than as a result of interference with the blood supply, in heart conditions.