Address.

PULMONARY TUBERCULOSIS AND THE
RÖNTGEN RAYS.*

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Who of us, after hearing Dr. Alleyne Adams's stimulating discourse before The Massachusetts Medical Society, a few weeks ago, did not leave his seat with a renewed and deepened sense of his responsibilities as a practitioner of medicine? That these responsibilities are imminent and immediate we felt intuitively, and they are devolved upon us as combatants in the great war which, as Dr. Adams said, is now before us.

In the midst of rumblings of internal strife in eastern Europe and the sight of thunderheads rising over the Pacific, our attention must not be diverted from this silent war—a war of far greater importance than any international contention, a war making wholly for good, a war in which lives are not to be lost, but saved. We are engaged in the strife, not as volunteers, but as conscripts drafted into service by the demands of progressive medicine, and he who fails to perform his share of duty must suffer from the stings of conscience if not from open dishonor at the hands of his compeers.

The success of an army is dependent naturally upon the efficiency of its armament, and we fail of our purpose if we do not employ, of our own initiative, the arms given us to use. A powerful weapon Doctor Adams has described, to wit, the segregation of consumptives, and it is your duty, as clinicians, to make good use of it. Laennec and Koch are but two among many armors who have contributed to our accoutrements, and it is to describe the use of the weapon furnished by another of these, Röntgen, that he who addresses you appears before you to-day.

The application of the Röntgen rays in the diagnosis of pulmonary conditions cannot be described as new, for as early as the year immediately following Röntgen's announcement, practical use of them was made for this purpose. Among European observers, Bouchard,¹ Bergonié,² Becclere,³ Oudin;⁴ and Fernet,⁵ Levy-Dorn,⁶ Loewenthal,⁷ Grunmach,⁸ and Holzknecht⁹ published accounts of their work in 1897 or prior thereto. Above all, either in this country or Europe, stands the work of Williams,¹⁰ of Boston, which possesses such accuracy in executive detail and such soundness of drawn conclusions that it will ever be a classic in the röntgenological field. Later, valuable additions were made by Claude¹¹ in France, by von Ziemssen and Rieder¹² in Germany, and by Pfahler¹³ and Hickey¹⁴ in this country. Rieder,¹⁵ by introducing new refinements in technic, proved the skiagraphic record of diseased lungs a possibility. This possibility attained the dignity of a routine method through the efforts of Pfahler, of Philadelphia, with the augmentation of Hickey's later work on the apices.

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The medical world, and to a certain extent the lay world, now understand that the optical action of the x-rays on physical substances results merely in a series of shadows, of varying density according to the resistance offered to the passage of the x-rays by the substance productive of the shadow. In no anatomical region is this shadow-complex more clearly depicted than in the thorax and its contents. Shadow impressions of many qualities are produced by the bony structures, the musculature of the heart and diaphragm, the great vessels and the lungs. The lungs themselves are penetrated by the x-rays with relative ease, and therefore they appear brilliantly illuminated—the brilliancy depending on the degree of inspiration, the thickness of the peripulmonic envelope, and certain natural characteristics of the individual in hand.

Mental impressions of two kinds are produced by observing these phenomena in a proper manner and may be described as two types: one type is an impression of the moving picture of respiration and its phenomena, or any abnormality connected with them; the other type is the impression produced by abnormal shadows of varying density, implying an inability on the part of the tissue in question to produce normal shadows. Upon these two types of impressions is based the matter of the recognition of intrathoracic disease by the x-rays.

An examination of the pulmonary region, properly pursued, may be divided into two procedures. One procedure consists in the visual perception of the shadow-complex as cast upon the fluorescent screen; on this screen we have portrayed, as in a *camera obscura*, not only the intrathoracic structures and their relations, but also their rhythmic movements: the expansion and contraction of the heart muscle, the bellying out and the shrinking in of the lung tissue and the rise and fall of the diaphragmatic dome. The other procedure results in the production of a permanent record by means of a process akin to photography, which may be termed röntgenography, of the intrathoracic viscera at the time the exposure to x-rays is made; this record is permanent, can be examined repeatedly at the pleasure of the observer, and can be compared with other records made at earlier or later periods in the course of the malady. Even such superficial mention of these two diagnostic procedures conjointly leads one naturally into an analytical comparison of them. Such comparison has been made by many authors, and an abridged repetitive statement at this time of the advantages possessed by both may be excused, perhaps, on the ground that the comparison may be used as a source from which to draw conclusions.

The value of fluoroscopic observations of normal physiologic movements has long been established by Cannon,¹⁶ Hulst¹⁷ and others in connection with the function of peristalsis. The stomach, particularly, has been watched, after the introduction of food, and has been found to undergo typical movements and to assume typical positions at various moments. Is it not, then, natural

to expect, as Williams did actually show, that fluoroscopy will reveal in the thorax also the physiologic undulations as concomitants of the function of respiration? It is thus easy to standardize normal chest movements, to form a basis upon which to judge abnormality. It has been found, for example, that the normal excursion of the diaphragm, as judged by the movements of its shadow on the fluorescent screen, is within certain constant limitations, depending, of course, upon the force and extent of respiration, and differing slightly on the right and left sides. The expansion of the lungs themselves may be carefully observed. As the lung becomes more and more inflated, it becomes less resistant to the passage of x-rays, and this fact alone plays an important part in one's power to recognize, not only an area already diseased, but a tendency to disease through deficient expansion. It is just as easy to standardize the position and movements of the heart in this way, as well as to discern any unusual appearance in connection with it, as is so often seen in pulmonary cases.

The remaining diagnostic agent of the Röntgen method is the photographic plate. What advantage has this, if any, over the screen, or does fluoroscopy, in its turn, have advantages not possessed by the plate? Williams said in 1901: "When instantaneous photography can be carried out in the lungs, a better opportunity will be offered for obtaining evidence of beginning pulmonary tuberculosis by the photograph than has hitherto been given." Our answer to this must be that we doubt that such time will ever come. Why? *Because there is no such thing as instantaneous photography*, and that there will be is the remotest sort of a possibility. Nevertheless, to the central idea of Doctor Williams's remark (to wit, that when we can obtain photographic results by exposures short enough to catch the lungs at rest, the plate method will become valuable), we are prepared definitely to answer. The routine exposure to x-rays necessary to obtain an impression of the adult thorax now is, or should be, sufficiently brief to be made easily while the patient holds his breath, either at inspiration, expiration or between the two.

It is partly on this account that examinations by röntgenography become valuable. They are valuable, also, from the fact that they furnish permanent records, to be examined at one's leisure, of existing abnormalities, and thus it becomes a simple matter to recognize a lesion which may have escaped the eye on the screen. The röntgenographic method furnishes, also, the possibility of making permanent records at various intervals in the progress of an individual's condition.

Many of my colleagues to the contrary notwithstanding, I am convinced that this method of examining a tuberculous chest cannot, to-day, supplant fluoroscopy for the following reasons:

(1) The diagnostic plate cannot show moving structures. In attempting to make a diagnosis of pulmonary tuberculosis from the degree of respiratory embarrassment, the essential is, not to observe the shadow of the diaphragm at the

moment of the acme of its rise, or yet the profundity of its fall, but, rather, its rise and fall *in statu actionis*. The same is true of the pulmonary expansion; we can easily, in these days, make a röntgenograph at full inspiration, full expiration or at any *one* point in the respiratory excursion, but how, in this way, can we watch the *process* of respiration, or compare the right and left chests in motion?

(2) The diagnostic plate cannot offer another advantage which is presented by fluoroscopy — that by which the operator is empowered to increase or lessen, at his own pleasure, the penetrating strength of the Röntgen rays at his command, in the course of a single exposure. In the microscopy of urinary sediments, we are familiar with the fact that certain delicate and diaphanous tube-casts are best observed when the light from the reflector is diminished or tempered. Can you not conceive that the same necessity for holding the penetrating power of the Röntgen rays in abeyance may arise when a delicate infiltration of an apex, for instance, is to be demonstrated?

(3) The diagnostic plate can show but one aspect of the patient — any changes in position mean additional exposures. This is a difficult matter to overcome, as when the additional exposures are eventually made, many conditions, especially the degree of penetration of the x-rays, may have changed.

In order to look at the question with the greatest breadth of mind, we must consider certain qualifications of the röntgenograph not possessed by the screen:

(1) The screen cannot present its image permanently, and its images are of no value for purposes of record except as they form the bases for tracings, a matter later to be considered.

(2) The screen cannot so plainly convey its complete image on to the mind of the observer, although the deficiency may lie with the observer, no doubt. It is often hard for even a röntgenologist of experience to grasp, in the time usually occupied by a screen examination, all the points to be observed and noted. Subsequent examinations of the *same* shadow-complex are necessary, and Opportunity, in this as in other matters, knocks but once. On the other hand, the plate, produced at the time, forever repeats its story.

In the above disjointed manner, therefore, an attempt has been made to lay before you the *pros* and *cons* concerning the two great classifications of the Röntgen method of thoracic diagnosis. That these arguments for and against have many refinements and elaborations it seems hardly necessary to say. If one adheres too closely to the earlier method of fluoroscopy, he lays himself open to the criticism of being behind the times in Röntgen procedure; if, on the other hand, he be too quick to seize upon the röntgenographic method with its powers for brilliant results, he may be charged with erratic desertion of the old for the new. To all medical men who will give the matter sober thought, it must appear evident that each method has so many good points that it cannot be shaken from its place by the other.

The fluoroscopic method offers, to the trained observer at least, a greater chance for mental balancing and judgment. The röntgenographic method, on the other hand, appeals more to the clever technician as an opportunity to produce the brilliant results of his handiwork.

The fact is, gentlemen, we must accept both. We must accept the screen, because by that means we obtain a moving picture of living things obtainable in no other way. We must accept the plate also, just as, although we can feel the pulse at the radial artery, we are glad to accept a sphygmographic tracing of that pulse, or, although we can see the comet in the field of the telescope, we are glad to accept a detailed photograph of that comet and the surrounding solar system. Thus we find that the weapon we have received from Röntgen to use in this war on pulmonary tuberculosis is a double-edged sword. Although each edge cuts well, the weapon is most efficient when both are used.

It is necessary for us now to determine how much of an addition this weapon is to our armament, formidable though it seems to be. In other words, is the Röntgen method of diagnosis in pulmonary tuberculosis of value to us in the *early* cases? By early cases is here meant those cases which present no physical signs except, possibly, slight malaise with evening rise of temperature, a little loss of flesh, anemia and diminished appetite for food. It is in these cases that the most carefully conducted procedures of auscultation and percussion may offer little or no evidence. Without expectoration, it is most difficult to obtain the bacilli, and a Röntgen examination by means of the skiagraph offers no more satisfactory results than does the stethoscope. These are the cases pre-eminently for fluoroscopy. What such cases present on the screen has been so well described by Williams and others who have given the matter unbiased judgment, that repetition is not necessary. Suffice it to say that this fluoroscopic evidence is often characterized by a lessened rise and fall of the diaphragm, and a diminished expansion of the thoracic walls, even if we do not perceive, with the intensity of our x-rays under control, the unmistakable picture of a slight modification of the usual brilliancy of the lung area at one apex. A little practice will enable one keenly to observe these deficiencies, and even to measure the abnormality in centimeters.

Such cases may present to the trained ear the suspicion, for example, of prolonged transpiration on one side, or to the sensitive finger the slightest sense of resistance at one apex. This is undoubtedly true; but how often have cases been recorded where no such impressions have been conveyed to the most skilled finger or acute ear, and in which there has been found on the fluoroscopic screen the pulmonary expansion and the diaphragmatic excursion very nearly, but not quite, as full upon one side as upon the other?

When a positive diagnosis in an early case is somewhat doubtful, one would never question the convincing proof established by the presence of the bacillus tuberculosis in the sputum; neverthe-

less, we know that there does exist a prebacillary stage of the malady when to obtain the micro-organism is a most difficult matter. There are also instances, as has been mentioned, where it is no small task to elicit signs by the stethoscope. In the face of such facts as these, it would be absurd, indeed, to claim infallibility for the Röntgen method, or for any other. All methods are useful when chosen carefully, and it is only when one is carried to extremes that the others are lost sight of.

In well-marked or late cases, where signs and symptoms are all too clearly evident by any mode of diagnosis, Röntgen examinations are valuable, chiefly as confirmatory evidence, in direct proportion to the value of any other one method. They are also directly useful in determining the *extent* of well-established disease, and the character of suspected lesions, such as cavity or calcified tubercle. In this way it is not usually more useful than other methods.

While it is my desire to avoid mention of technic as being outside the scope of this address, I wish merely to speak of one technical point. It is often desirable and advantageous to obtain tracings or outlines of fluoroscopic appearances as a means of rapid record or for teaching. This can be done by following the shadows on the screen with a pencil or other marker on celluloid or some transparent substance, in front of the screen. It is essentially desirable that the tracing apparatus be so arranged that the source of x-rays, which is behind the patient, may move with each movement of the pencil, in any direction. Thus it will be seen that the most direct x-rays will be always in a straight line from the pencil, and the element of distortion of shadow will necessarily be reduced to a minimum. This is the principle of so-called *orthodiagraphy*, which has been used, especially by the Germans, for some years. By thus outlining the application of tracings, I desire to correct the erroneous impression, created, possibly, by a previous remark, that no record can be obtained by fluoroscopy.

What is to be the future of this science, as applied to examinations of the chest? This is a question which we may well hesitate to answer, for who, in 1896, could have imagined that a permanent record of the thoracic contents on a photographic plate would eventually be made while the patient holds his breath? It is possible to conceive that our most radical advances may be exemplified by a combination of the röntgenograph and the cinematograph, or some other moving-picture device. Indeed, this has already been thought of seriously, and in a manner described. Only render it practicable, and the day will arrive when we may enjoy the altogether novel sensation of gazing at the enlarged images of our pulsating hearts and our expanding lungs projected through the stereopticon! As to the future none can say; the accomplishments of the past are marvels enough in themselves.

Conclusions which may be drawn reasonably from these observations are:

- (1) That the Röntgen rays, through the media

of the screen and the photographic plate, are of distinct value in the diagnosis of pulmonary tuberculosis.

(2) That by virtue of the power given us by the Röntgen rays visually to perceive subtle changes in the thorax, we are often able to recognize the invasion of a pulmonary tuberculous process in an earlier stage of progress than it is to-day possible to do by the sense of hearing or touch.

(3) That to depend, however, upon the Röntgen method to the exclusion of others, namely, auscultation and percussion, the tuberculin test, or the staining fluids and the microscope, we do little else than proclaim ourselves bigots.

(4) That, if we recognize this new diagnostic agent, and make wise use of it, together with others already given us, employing *all* energetically for the benefit of the patient, while he is yet in a condition to be cured, we need never reproach ourselves with failure.

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Original Articles.

THE CHANNELS OF INFECTION IN TUBERCULOSIS, TOGETHER WITH SOME REMARKS ON THE OUTLOOK CONCERNING A SPECIFIC THERAPY.*

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In choosing this somewhat well-worn subject in answer to an invitation to speak on some aspect of the problem of tuberculosis, I was led by the present rather unusual activity in the study of the digestive tract as a portal of entry. This bustling activity is due in the first place to the somewhat morbid tendency of research to seek out the new, rare and unusual, and magnify and illuminate them so that to our dazzled eyes all the laboriously reared truths of the past become invisible for the time being. It is furthermore due to the dicta of two prominent men, one of whom proclaimed that bovine tuberculosis was of no consequence as a source of the human disease, and

the other that all tuberculosis originates in infancy and that much of it was due to cow's milk.

The widespread movements tending towards the education of the public concerning the nature of tuberculosis and the modes of diffusion and transmission of the bacillus had brought to the foreground the older theories that tuberculosis is largely an inhalation disease and that the chief source of infection is the coughing consumptive. While all agree that the sputum is the vehicle in which bacilli leave the body, that there is, in fact, no other mode of excretion of the bacilli in man, which can be seriously entertained, there has developed a marked disagreement, or at least an attitude of assumed ignorance, as to the chief portal of entry. While inhalation has been and is still looked upon as the most frequently used mode of entry by some, others have gone so far as to deny the ærogenic infection of the lungs completely, and they trace pulmonary disease through the avenues of the intestinal mucosa and the associated lymph nodes, or the tonsils and cervical lymph nodes. In other words, the tendency on the part of a certain group headed by von Behring has been to cut out entirely the direct introduction of tubercle bacilli into the lungs through the respiratory tract and replace it with certain more circuitous routes, dealing with ingestion rather than inhalation.

Associated with and largely responsible for this change of view as to the significance of ingestion tuberculosis is cow's milk. Were it not for cow's milk as an occasional carrier of bovine tubercle bacilli we should probably have heard little of ingestion tuberculosis.

INGESTION AND INHALATION TUBERCULOSIS.

We have thus two main questions before us: 1. Is the path of the tubercle bacillus to the lungs chiefly by way of the digestive tract? 2. To what extent is bovine tuberculosis responsible for the human disease?

The difficulty encountered in taking a definite position on the question of the paths of the tubercle bacillus, both without and within the body, is due to the fact that almost anything we may say concerning the tubercle bacillus has a grain of truth in it, and may be realized at one time or another by observation and experiment. The goal towards which we should strive, however, is to discover the ordinary, common paths, and not the merely possible or extraordinary ones. Even in the experimental disease produced by tubercle bacilli in the lower animals we occasionally encounter peculiar localizations. The cryptogenic tuberculosis of the bones, the kidneys and other organs, wholly outside of the usual paths of the tubercle bacillus in the body, shows well the occasionally irresponsible activities of this organism.

The character of the disease started by the tubercle bacillus, like that of other infectious diseases, is dependent upon a number of variable factors. Among the most important are: the virulence of the infecting organism, the age of the patient, the inherited susceptibility or predis-

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