Surgical History

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THE IMPACT OF RÖNTGEN'S DISCOVERY UPON THE TREATMENT OF FRACTURES

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PERHAPS no better example could be chosen to illustrate the dependence of progress in medicine upon progress in the basic sciences than to recall the effect of the discovery of x-rays upon the treatment of fractures. An adequate technology was already in existence; anesthesia, antisepsis, techniques of manipulation and internal fixation, and an appreciation of the pathologic anatomy of fractures. The treatment of fractures was handicapped by lack of means by which to make an accurate appraisal of the fracture before, during, and after treatment. Röntgen's discovery provided the means. The speed with which the x-rays were exploited in treating fractures testifies to the pressing need for a better method of diagnosis.

THE DISCOVERY

Professor Röntgen, at this time Director of the Physical Institute of the University of Würzburg, on a Friday evening, Nov. 8, 1895, was repeating the experiments of Hertz and Lenard on cathode rays. Suddenly in the darkened room he noted a bright fluorescence of some crystals lying upon the table some distance away from the tube. His interest aroused by this phenomena. Röntgen carried out an intensive investigation, the results of which were embodied in a brief paper, "On a New Kind of Rays," which was submitted for publication on Dec. 28, 1895. This report, mentioning the first photograph of the bones of a living hand, was published in the *Annals of the Physical Medical Society of Wurzburg* during the first week of 1896.[11] Its publication set off a chain of events which has affected all mankind, and, for its author, culminated in the award of the first Nobel Prize in physics in 1901. Public reaction to the discovery was instantaneous, and its practical applications in medicine were immediately recognized by doctors and laymen alike. The *Frankfurter Zeitung* for Tuesday, Jan. 7, 1896, carried the following note:[11]

> At the present time, we wish only to call attention to importance this discovery would have in the diagnosis of disease and injuries of the bones, if the process can be developed technically so that not only the humann hand can be photographed, but the details of other bones may be shown without the flesh.

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> The surgeon then could determine the extent of a complicated bone fracture without the manual examination which is so painful to the patient; he could find the position of a foreign body, such as a bullet or piece of shell, much more easily than has been possible heretofore and without any painful examinations with a probe. Such photographs also would be extremely valuable in diagnosing bone diseases which do not originate from an injury and would help to guide the way in therapy.

The dissemination of information about the "new rays" proceeded with such speed that when a translation of Röntgen's article appeared in *Science,* Feb. 14, 1896, it was accompanied by notes and reproductions of x-ray photographs made by M. I. Pupin of Columbia College, Edwin B. Frost of Dartmouth College, and Arthur W. Goodspeed of the University of Pennsylvania.[23] In 1896 alone, 1,044 scientific books and articles dealing with the discovery were published in the world literature, as well as countless newspaper and magazine articles directed at the public.[11] How did this come about?

Röntgen's original publication was a model of scientific exposition. It contained a complete description of the equipment and methods employed. It was rapidly translated into many languages and was published in scientific journals throughout the world. The equipment needed to reproduce his experiment was readily available in every physical laboratory. As a result, any investigator could demonstrate the action of x-rays by simply following Röntgen's directions. Röntgen himself took no part in the ensuing race to develop practical applications for his discovery, although he used his apparatus to take an occasional photograph for his medical colleagues.[9]

THE PUBLIC

The discovery of x-rays stirred the interest of everyone. Its appeal was not limited to the physicists alone. Physicians, photographers, "electricians," and charlatans seized upon it and proceeded to exploit it, each to his own end. Public interest was expressed in cartoons, humorous verse, and advertisements for x-ray proof garments to preserve feminine modesty. Shoe stores featured x-ray photographs of feet cramped by poorly fitted shoes and x-ray machines for fitting shoes were soon put on the market. Edison gave a public demonstration of x-rays in New York City during March, 1896. Visitors were allowed to view their hands and arms under the fluoroscope, and the exhibit proved to be a great attraction.

> Professor Elihu Thomson, the well-known electrician, recently fractured the bone of his leg just above the ankle. "He has been an enthusiastic investigator of the Röntgen discovery," says the *Electrical Review,* and after the fracture was set had an x-ray picture taken of it. The result was very satisfactory, showing the surgical adjustment of the bone to be most perfect and only a fine line showing the break.[16]

This report, appearing in the *Literary Digest,* June 6, 1896, is representative of many similar reports concerning the use of x-rays in treating celebrities and even "the crowned heads of Europe," a much more impressive group then than now. Such extensive publicity resulted in a demand for x-ray

service on the part of patients. We are all aware of the pressure of public demand for a new drug or a new method of treatment which is fostered by articles in such magazines as the *Ladies' Home Journal* or the *Reader's Digest*. The people will be served. Physicians were subjected to an inexorable pressure to purchase the necessary equipment, and, willy-nilly, to begin using x-ray photographs as a regular part of their diagnostic armamentarium.

THE LAW

Patients with fractures, old and new, sought to have their injuries photographed by the new process. The taking of x-ray photographs was not always under the supervision of medical practitioners. Independent studios advertised and catered to the curious and disgruntled. The inevitable result was a rash of suits for malpractice against physicians. The situation was aggravated not only by the faulty technique which frequently distorted the photographs, but also by errors of interpretation due to inexperience. The first case tried in the United States in which x-rays were admitted as evidence was filed in Denver, April 14, 1896, and tried late in the fall.[27] The case involved a boy who had fallen from a ladder and injured his thigh. He consulted a surgeon who did not immobilize the limb, but treated him as for a contusion. X-ray examination later showed that the patient had fractured his femur. An Eastern judge had previously refused to admit x-rays in evidence in his court saying: "There is no proof that such a thing is possible. It is like offering the photograph of a ghost when there is no proof that there is any such thing as a ghost." However, Judge Owen LeFevre, in an opinion handed down, Dec. 2, 1896, admitted the x-rays in evidence and allowed them to be shown to the jury. Since that time juries have been impressed upon countless occasions by x-ray photographs of fractures, seeing with their own eyes if the bones were crooked or straight. The threat of legal action for malpractice based upon evidence provided by x-rays furnished, perhaps, the most potent stimulus for the rapid adoption of the routine use of x-rays in the treatment of fractures. More exact antaomic reduction of fractures became necessary, and the case for open reduction and internal fixation was strengthened.

It was soon apparent, however, that the appearance of the x-ray photograph did not provide a complete picture of the injury. The importance of viewing the patient as a whole was stressed by Dr. Rudolph Matas[14]:

> It is my opinion, based upon personal experience, that the practitioner cannot be held liable to damage in malpractice suits, simply on the x-ray evidence of imperfect union of fragments in cases of fractures. The criterion of deformity should not be the skiagraphic image, but the external appearance of the part as recognized by the naked eye; if the external appearance is good, there is no visible deformity and no imperfection in the limb from the functional point of view, then I would consider the result good, and the surgeon should not be charged with malpractice.

Juries, however, have remained impressionable. Since most fractures result from accidents which contain the seeds of a possible legal action, physicians,

for their own protection, were driven to adopt the routine use of x-rays in fracture cases.

THE MILITARY

The first serious investigation of the possible value of x-rays in diagnosis was carried out by the Prussian War Ministry. On Feb. 4, 1896, it was announced that a systematic study of anatomic and war surgery preparations in the pathologic museum was being carried out to determine if fractures and metallic foreign bodies could be demonstrated by this method.[17] The results of the investigation appeared late in 1896 in the form of a monograph.[25]

In April, 1896, the Army Medical Department of the British forces, having concluded that the value of x-rays was undisputed, took steps to supply an expedition into the Egyptian Sudan with x-ray equipment for use in the field.[18] Two complete sets of apparatus were sent up the Nile where they were used to localize foreign bodies and in the diagnosis and treatment of fractures. A report on the value of x-rays in localizing lodged bullets appeared in May, 1896, from an Italian Military Hospital at Naples engaged in treating soldiers wounded in Ethiopia.[19]

The Graeco-Turkish War of 1897 provided another convenient testing ground. The soldiers on both sides were supported by Red Cross medical units supplied with x-ray apparatus. In their reports,[1, 13] both the British Unit with the Greek Army and the German Unit with the Turkish Army emphasized the value of x-rays in the diagnosis of fractures and gunshot wounds. It was felt that x-ray facilities should be available in the first medical unit at which wounds could be properly examined and treated. Küttner[13] concluded a long discussion saying: "We possess a new aid in the x-ray which is so valuable, that the wounded have a right to have it employed in their care."

The medical department of our own army was not remiss in adopting the use of x-rays. During the war with Spain (1898) seventeen x-ray units were in use in general hospitals and upon hospital ships. A complete report of this accumulated experience was made in 1900: "The Use of the Röntgen Ray by the Medical Department of the United States Army in the War with Spain."[24] This profusely illustrated report showed the value of x-rays in diagnosing fractures by demonstrating their form, the amount of comminution, and the presence of foreign bodies, facts which could not have been easily determined by previously available methods.

The use of x-rays in the study of fractures and gunshot wounds led to an abrupt change in the methods of treating these injuries. The technique of localizing metallic foreign bodies was rapidly perfected. The number, size, and distribution of shell fragments and comminuted bony fragments could be determined with ease and accuracy. The probe, a badge of the military surgeon for centuries, was abandoned. It was soon recognized that all metallic foreign bodies could not be removed without the added trauma of an extensive exploration of the wound, and, what is more important, that it was not necessary to remove all of these fragments to obtain healing. A large amount of meddlesome surgery could be avoided.

These many reports attesting to the value of x-rays as a diagnostic aid in the treatment of war casualties encouraged civilian doctors to adopt the method and provided still another stimulus for its acceptance.

THE MEDICAL PROFESSION

As is the case with all innovations in medical practice, the exploitation of Röntgen's discovery was enthusiastically exposed by some, observed skeptically or ignored by many, and actively opposed by a few. One of the most enthusiastic was Henry W. Cattell of the University of Pennsylvania who as early as March 6, 1896, wrote in *Science*[6]:

> The manifold uses to which Röntgen's discovery may be applied in medicine are so obvious that it is even now questionable whether a surgeon would be morally justified in performing a certain class of operation without having first seen pictured by these rays, the field of his work, a map, as it were, of the unknown country he is to explore.

A Boston physician later in the same year expressed the opinion that no well-equipped hospital in the land could do justice to its patients unless it possessed a complete x-ray outfit.[22] Similar expressions of opinion were echoed from Baltimore[12] and St. Louis[5] and seemed to represent a spontaneous development of opinion throughout the country.

The voice of skepticism was raised in a leading editorial in *The Medical News,* Feb. 22, 1896:

> As far as our present knowledge goes, the positive advantages to medicine seem to be limited to three conditions; fractures, dislocations and tumors of bones, encysted bullets, needles or pieces of glass in the tissues, and earthy calculi. In the first class of conditions, its advantages would appear to be slight unless great advances upon present powers and methods can be made. The *Tactus eruditus* is certainly a delicate and reliable sense in investigating fractures and dislocations, and it is questionable how much help can be obtained by such crude and blurred shadow pictures as can at present be obtained. In recent cases of fracture or dislocation, the delay and discomfort to the patient necessarily involved in the application of the method would be practically an insuperable objection to its use for purposes of diagnosis. . . .

This skepticism as to the practical value of x-rays resulted from too great expectations and the failures and disappointments which necessarily attend the development of any new technique. And it persisted.

McCosh,[15] in the same journal in July, 1896, gave a résumé of the recent progress in the treatment of fractures, omitting all mention of the use of x-rays. The following year (1897) David W. Cheever in the Shattuck Lecture, "The New Surgery,"[7] hailed the advent of a great new epoch as a result of the development of anesthesia and antiseptic surgery, with no mention of Röntgen's discovery.

Bigelow's[3] famous book, *The Mechanism of Dislocations and Fracture of the Hip,* was reprinted in 1900 without the addition of a single x-ray photograph of these conditions, an addition which would have been of inestimable value. The following note from a review of the third edition (1901)

of Stimson's "A Practical Treatise on Fractures and Dislocations,"[21] is illustrative of the inertia characteristic of many "authorities."

> The plates added include a number of very interesting skiagrams, although the author rarely receives information of practical importance from the x-ray in fractures which could not be obtained by other means.

This attitude was reflected in the Report of the Committee of the American Surgical Association of the Medico-Legal Relations of the X-rays (1900). This most interesting document consists largely of complaints by the members who have been sued for malpractice on the basis of x-ray evidence. It concludes:

> The routine employment of the x-ray in cases of fractures is not at present of sufficient definite advantage to justify the teaching that it should be used in every case.[20]

The position of this august association was not officially reversed for thirteen years (1913), when its committee on fractures recommended the routine use of x-rays in all cases of fractures and dislocations.[24]

The first ten years following the discovery of x-rays was a time of trial and error. The incidence of burns, epilation, misinterpretation, and technical failures could not obscure the real value of the method in diagnosis. They produced, instead of discouragement, a stimulus to the development of improved equipment, and a greater understanding of both the normal and the anomalous anatomy as seen in the x-ray photograph. The value of x-rays in the treatment of fractures at the end of this period was epitomized by Walsh in 1907[26]:

> To sum up: in dealing with bone injuries successful radiography, compared with previous methods, offers the following advantages. It substitutes speed, accuracy, and finality for delay and doubt; it affords exact evidence that many confirm or modify the diagnosis of the surgeon; it may furnish both grounds for prognosis and hints for treatment; it may save the patient the pain of useless and perhaps dangerous manipulations, as well as the risk of anesthetics; it provides a permanent record of the precise nature of an injury; it may prove a safeguard for the patient and for his medical attendant, both in the present and the future, and lastly it has a special value for teaching purposes.

THE STUDENT

The development of the use of x-rays in the treatment of fractures wrought a fundamental change in the method of teaching students how to care for these injuries. Previously the student was fortunate if he could follow a few cases of fractures from the time of the accident until complete healing occurred. He was forced to rely upon the description of the clinical examination at various stages to provide a picture of the course of events during the healing period. X-ray photographs provided a permanent record of the patient's condition. Patients could be shown to students at any stage of their treatment, and their course reconstructed for the students by showing the antecedent x-ray photographs. Didactic diagrams of typical

fractures could be discarded in favor of x-ray photographs of actual fractures. This added greatly to the clinical atmosphere of the lecture room. The opportunity of observing the rarer varieties of fractures and dislocations became available to all, since the x-ray photographs of these occasional cases were preserved and used for teaching purposes. The most important feature of any program of teaching fracture treatment has become the clinical x-ray conference.

The need for new textbooks incorporating information about fractures gained by the use of x-rays was widely expressed as early as 1897.

> We were certainly justified in supposing that our knowledge of fractures had nearly reached its limit; but the Röntgen rays have opened up new fields for investigation, and we find that there is still much to learn. . . . a complete new set of data must now be accumulated and reviewed.[10]
>
> There will have to be a new treatise on fractures and dislocations, based upon the x-ray. There are many surprises in store, many surgical bugaboos will go, and many revelations will simplify much which is still obscure.[8]

In 1900 Carl Beck published his book, *Fractures, With an Appendix on the Practical Use of the Röntgen Rays,*[2] which was dedicated: "To Wilhelm Conrad Röntgen without whose discovery much of this book could not have been written." This was the first book on the diagnosis and treatment of fractures based upon the routine use of the x-rays, and is the prototype of all of our standard fracture texts today.

CONCLUSION

Röntgen's discovery of x-rays, and their rapid exploitation in medicine, has effected a great improvement in the treatment of patients with fractures. This is due to more accurate diagnosis and to an insistence upon a more exact anatomic reposition of the fragments. The speed with which the new method was developed and accepted, was the result of a combination of forces acting within and without the medical profession.

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