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HISTORY OF SCIENCE

RADIOLOGY AT THE SCHOOL OF MEDICINE OF CREIGHTON UNIVERSITY

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Medical radiology and radiology at Creighton University's School of Medicine and its teaching hospitals have been closely intertwined from the very time of Roentgen's announcement of his discovery of X-rays on 28 December 1895. A good roentgenogram was produced at Creighton only 46 days later! X-ray equipment was installed at both the out-patient dispensary and the hospital in 1900. Radiology departments were established in both institutions in 1910. Many improvements (faster photographic emulsions, contrast materials, radiotherapy, founding of a Roentgen Technology School), were witnessed by A. F. Tyler who headed both departments (1910-33). He was succeeded by J. F. Kelly, Sr. (1933-63), who presided over many further advances, including a residency program, contrast material improvements, automatic film processing, diagnostic radionuclides, cobalt teletherapy, and image amplification. The third and fourth chairmen, D. A. Dowell (1963-71) and N. P. Kenney (1971 to present), witnessed further great diagnostic advances (ultrasound for non-ionizing visualization of many otherwise inaccessible structures, computerized tomography for the imaging of many organs and lesions previously non-demonstrable by any method), as well as great therapeutic advances, including the use of the linear accelerator, and interventional radiology.

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The history of the science of medical radiology at Creighton's medical school and at its principal teaching hospital, St. Joseph's, are closely intertwined.

Radiology at the Creighton University School of Medicine traces its ancestry with pride to Wilhelm Conrad Roentgen and to 28 December 1895 when Roentgen (1895) first reported to an assembly of the Physical Medical Society of Würzburg, Bavaria, on his experiences with a new and strange radiation phenomenon. We have reason to be proud of him because he was a true scientist, one who inspired confidence and admiration in his peers and a man with sufficient vision to realize very early the potential, at least in part, of his discovery. Roentgen was not a physician. He was a physicist, Professor of Physics at the University of Würzburg. His biographers respect him and describe him as modest and retiring (Glasser, 1945).

Roentgen's observations that the X-rays, as he called them, were able to pass through substances opaque to ordinary light, that they would produce changes in photographic emulsions identical to those of visible light, that they would cause a fluorescence of certain crystals, and that they showed shadows of interposed materials of different densities, gave him some idea of the great potential of this new tool in medicine and in industry.

In a remarkably short time, Roentgen's original article was translated into all of the important languages of the world, and became the universal property of mankind. For his discovery of X-rays, Roentgen was awarded the first Nobel Prize in physics, in 1901, and his name has become part of the language of science, *i.e.,* a roentgen ("R") is the international unit of X- or gamma-radiation.

The John A. Creighton College of Medicine, as it was then named, was only 3 yrs old when Roentgen reported his discovery, but it already had a number of faculty members with vision and curiosity. One of these was 26-yr-old Charles F. Crowley of the Department of Chemistry. On 12 February 1896 he produced a remarkably good roentgenogram of a mouse. This was the result of a 35-min exposure and was made with some primitive equipment consisting of a Rumpkorff cone-shaped coil and Geissler and Crookes tubes. He had spent many hours of fruitless endeavor before his success. On 12 March, just one month later, with the aid of Francis X.

Mara, Professor of Mathematics and Natural Philosophy, and Bernard J. Otten, Professor of Mathematics, Chemistry, and Astronomy, Crowley demonstrated X-rays in a public lecture at Creighton! By that time, he had decreased the exposure time to 20 min. This was the beginning of the use of X-rays at Creighton (Tyler, Auerbach, and Hetzner, 1977).

Progress in diagnostic radiology depended to a great extent on the development of new and better apparatus and on the improvement of photographic materials. The Creighton College of Medicine catalogues, printed in 1898 and 1899, stated that "one of the largest Topler-Holtz [X-ray] machines in the country has been purchased," and the catalogue printed in 1900 stated that "the institution possesses one of the largest Topler-Holtz machines in the country and [it] is employed in the demonstration of the X-ray."

In July 1900, X-ray equipment was also installed at Creighton's teaching hospital, Creighton Memorial St. Joseph's. This was done by J. P. Lord and Frederick Rustin. Crowley was designated the skiagrapher, or radiographer (Bath, 1945).

Lord, of the Creighton medical faculty and a distinguished orthopedic surgeon, is generally credited with being the first practitioner in Omaha to utilize X-rays for diagnostic aid. He is still gratefully remembered at the Dr. J. P. Lord School for handicapped children in Omaha.

However, the first recorded medically related use of this tool in Omaha was not by a physician, but by a layman, E. B. Smith, superintendent of the local telephone company's engineering department. A few months after Crowley's successes, with the help of his telephone company staff and "home-made" X-ray equipment, Smith successfully located a needle which had accidentally penetrated the heel of Regina, the small daughter of a close friend, Ralph W. Connell (Tyler, Auerbach, and Hetzner, 1977). Regina Connell became Mrs. H. Malcolm Baldrige, wife of Omaha Congressman Baldrige, and mother of Letitia Baldrige, well-known author, and of Malcolm Baldrige, the present U.S. Secretary of Commerce.

Much of the early medical use of X-rays consisted of fairly simple procedures such as demonstrating a fractured bone or verifying the presence of a foreign body.

However, it was not long before the advantage of imaging the chest was realized. The air-filled lungs provided a fine built-in contrast medium, and no added contrast material or preparation was required. Technical advance was important here. The photographic image produced was recorded on a glass plate using an emulsion containing silver bromide first developed by Richard L. Maddox in England in 1871 (Fuchs, 1964), and change was slow. However, World War I helped accelerate change. In 1914, the Eastman-Kodak Company marketed for the first time a single-coated film instead of a glass plate. Faster photographic emulsions were developed. All of this was important in imaging the chest where cardiac and vascular motion cannot be stopped or slowed, even though respiratory motion can be controlled. Not surprisingly, there was clinical resistance to the use of radiographic study of the chest. Many older physicians placed more faith in auscultation and percussion than in viewing an image. One local internist was converted after the heart which he had carefully percussed and outlined with a wax pencil on the patient's left chest wall was shown to be a dextrocardia, or heart in the right side of the thorax! This was not unique, and was probably repeated on many occasions in many medical centers.

Hand-in-hand with the development of better imaging equipment came the use of contrast materials for demonstrating what would otherwise be non-visualized structures. The gastro-intestinal tract was being studied fairly frequently by the end of World War I through the use of barium sulphate suspension as a drink, and less frequently as an enema to fill the colon. This type of study had been pioneered by Walter C. Cannon, who while a medical student at Harvard, observed opaque buttons passing down the esophagus of a dog, and a bismuth compound, bismuth subnitrate, in the stomach of a frog. This was in the fall of 1896, less than 1 yr after Roentgen's observations (Cannon and Moser, 1898).

Visualizing the stomach was simpler than demonstrating the gall bladder, and it was not until 1923 that Graham and Cole, St. Louis physicians, developed a suitable contrast medium which could be taken orally and would opacify the gall bladder (Graham and Cole, 1924; and Graham, Cole, and Copher, 1925). Variations of the Graham-Cole test are still used daily, and this method of study has increased greatly at the Creighton out-patient dispensary and at Creighton-St. Joseph's Hospital.

The urinary tract was found to lend itself to X-ray investigation early in the development of this specialty. Plain films were made of the abdomen or the kidney-ureter-bladder area which would demonstrate calculi, and since about 80% of urinary calculi are opaque to X-rays, this was very helpful. As early as 1906, the use of retrograde pyelography was advocated in European centers, and early in the second decade this became a fairly common procedure. Through a cystoscope, a catheter was introduced into the ureter and then as high as the pelvis of the kidney. The standard procedure was to inject a small quantity of 10 to 12% sodium iodide solution into the kidney, and an outline of the urinary collecting system could then be seen on the radiograph.

However, the big step in urologic diagnosis came in

1929 when Swick first perfected and then successfully used an intravenously injected organic iodide which outlined the collecting system of the kidneys, ureters, and urinary bladder (Swick, 1930). Use of this method was commonplace by the mid-1930s at Creighton, and since then, with improvements of the contrast agents which have evolved, this method has become the backbone of urologic diagnosis, and a valuable tool of internists, surgeons, pediatricians, and general practitioners.

Modern medicine is dependent on 20th-century technology more than many clinicians are inclined to admit. Radiology probably more than any other specialty has advanced with technologic breakthroughs. It has in recent years become a method of imaging, and the apparatus and paraphernalia almost make us prisoners of our systems!

Since the close of World War II, five of the major developments have been:

1. ***The use of Radionuclides for Diagnostic Purposes.*** This has grown from the evaluation of thyroid by calculating the uptake of radioactive iodine, to the present use of radioactive drugs for demonstrating bone change, liver abnormality, heart malfunction, kidney function, brain lesions, and a host of other conditions (Quimby, Feitelberg, and Silver, 1958). This method was first used at Creighton in 1954, and now comprises a very busy section of the Radiology Department.

2. ***The use of Automatic Processing of X-ray Films.*** In this procedure film progresses through developing, fixing, washing, and drying processes in only 90 seconds! This was first used at Creighton in 1963. Without it, any radiology department must be considered obsolete at present.

3. ***Intensification of the Fluoroscopic Image.*** A great advance was made in diagnostic radiology when this process was developed to a point that its use became practical. Image amplification units have been used at Creighton since 1966. This process intensifies the image by a magnitude of approximately 800 times, and makes the use of the old darkroom fluoroscopy, the wearing of special goggles by the examiner, and the need for long periods of light adaptation, unnecessary. Image amplification is of great help to the radiologist and also does much for the peace of mind of the patient. Many patients dreaded the studies conducted in a darkened room. St. Joseph Hospital has image intensification on five fixed and on one mobile unit, all in frequent use.

4. ***The use of Ultrasound.*** Ultrasound is non-ionizing radiation, and is as harmless as ordinary light. It enables visualization of normal and abnormal structures, and may be used time and again without harm to the bodily structures being studied (Price, Jones, Goddard, and James, 1980). With the new developments of real time exposure, motion of parts such as a fetus may be studied and recorded. Equipment for this type of examination is sophisticated and expensive, but is necessary for modern-day understanding of many processes, especially in obstetrics and gynecology, cardiology, and a number of other areas. Ultrasound, first used in primitive manner in 1974, has grown to a busy service in 1981 (James, Everette, Goddard, Price, Jones, and Powis, 1980).

5. ***The use of Computerized Tomography (CT).*** Originally called computerized axial tomography or "CAT scan," computerized tomography is probably the most revolutionary development since Roentgen's discovery (Ter-Pogossian, 1976). This permits visualization of deep-seated structures formerly inaccessible to radiologic demonstration. It has completely revolutionized neurologic diagnosis, and demonstrates cross-sections of the brain with the clarity of the finest cross-section anatomic illustrations of the best anatomic texts. It is invaluable in diagnosing intracranial hemmorhage, tumors, malformations, and the like. Computerized tomography has been developed only during the past decade, and is still being improved and refined. It is very costly, with the better units each approaching $1 million in cost. It has been used with increasing demand since 1977 at St. Joseph Hospital, reaching 2,815 examinations in 1980.

The first use of X-rays for therapeutic purposes was based on the hope that like the sun's rays, they would be antibacterial in action. They were tried for treating tuberculosis, especially that involving lymphatics, and although the results were not encouraging, they were used for a considerable period of time. Their first use in America for tumor therapy was by Emil H. Grubbe in Chicago, in 1896, when he attempted therapy of a patient with breast cancer (Hodges, 1964). Progress in radiation therapy since then has been great, but there have been many disappointments.

In 1910, A. F. Tyler was appointed the first Head or Chairman of Radiology at both the Creighton Medical School and at St. Joseph's Hospital. He had developed an early interest in radiotherapy along with an enthusiasm for all known medical uses of X-rays. He was one of the first in the Midwest to become proficient in radiotherapy. He had to pioneer much of his work, and make judgments of his own work. By the close of World War I, Tyler had made many valid observations

and had treated many patients with considerable success, using primitive equipment which today would almost seem like a relic of the Middle Ages! He reported some of his findings in the *Journal of Radiology* (Tyler and Blackman, 1922). Tyler was truly a pioneer, and as such presided over many changes during his 23 yrs of twin departmental chairmanships, 1910-1933.

It was during his tenure that M. Liberia, a Franciscan nun assigned to the department at the hospital, founded the School of Roentgen Technology in 1920. This was one of the first six such training schools in the United States. It has produced several hundred trained technicians, and has been a real asset to the community.

Tyler was interested in organized medicine, was one of the founders of the Radiological Society of North America, and was for a time the editor of the society's journal, *Radiology.*

His successor, James F. Kelly, Sr., was to a considerable extent responsible for the organization of a cancer clinic in 1931. In 1932, he initiated a radiology residency program which was approved by the American Board of Radiology in 1933. A total of 37 residents has been trained in the department at the hospital, and three are in training at the present time (spring, 1981).

Following Kelly's return from military medical service in World War I, he had worked with Tyler at the medical school and the hospital for a number of years, and like Tyler, had developed a great interest in radiotherapy. Kelly had the foresight to recognize the importance of advanced technology for adequate treatment, and knew that the most meticulous care and the sincere interest of the physician could not replace or substitute for the delivery of adequate high quality radiation with safety. In 1931, he had succeeded in obtaining some then ultra-modern X-ray equipment with advanced safety controls for the hospital. His enthusiasm and profound faith in the ability of radiotherapeutics were contagious. He rarely failed to provide encouragement to patients receiving treatment, many of whom had incurable diseases and whose condition was considered hopeless. This was inevitable when the X-ray modality was the one almost always tried when there was no other method available. During Kelly's tenure, 400,000-volt therapeutic radiation was added, and the use of a cobalt teletherapy unit was begun.

However, it was not until December 1977, when Creighton Memorial St. Joseph's Hospital was moved to its present location and became St. Joseph Hospital, that a linear accelerator became available. This provides delivery of cancerocidal doses to deep-seated tumors along with improved sparing of the skin and superficial structures—something which was never satisfactorily achieved with X-ray therapy. This is part of the picture of improving cancer control which so many have worked so long to accomplish.

Following Kelly's retirement in 1963, further progress in radiotherapeutics has continued to be made by the younger and more recently trained members of the twin departments. There is now a very busy therapeutic section, where along with the linear accelerator and X-ray therapy equipment, radium and radioactive isotopes are used, and where there is close cooperation with other oncologic therapy such as the ever-increasing number of cancerocidal chemicals which have been developed in the past few years.

The third chairman, who had also been the first St. Joseph's Hospital Resident in Radiology, was D. Arnold Dowell, who was named to the twin positions upon Kelly's retirement. The present chairman, N. P. Kenney, followed Dowell's retirement in 1971. These two have been privileged to witness the great changes brought about by the almost miraculous developments in technology during the past few years, when so many new and important procedures have been added to the radiologic armamentarium. Among these is the development of interventional radiology, including percutaneous transluminal angioplasty ("PTA"), a radiologically controlled unblocking of arteries.

There has always been a very close bond between the two radiology departments at the medical school and at the hospital, as well as a remarkable administrative continuity. Each of the four chairmen has simultaneously headed both departments. The benefits to patients in the out-patient dispensary and at the hospital, as well as to the medical and other health science students, have therefore been maximized. This is true more than ever in the new St. Joseph Hospital where all the ultra-modern resources of radiology are centrally located for both in-patients and out-patients, since the out-patient dispensary is located in the St. Joseph Hospital building.

CONCLUSION

Medical radiology at Creighton has reflected and continues to reflect the immense progress in medical practice which has been achieved through the wonders of radiology since the discovery of X-rays in 1895. It has indeed become very difficult to visualize medical practice without the aid of the modern imaging already provided by radiologic procedures, which vastly exceed the early visions of Roentgen and his contemporaries. And yet the phenomenal advances, especially of the past several decades, have most probably only "scratched the surface," so to speak, of potential future developments in the extraordinary field of medical radiology!

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