The history of radiation use in medicine

Amy B Reed, MD, *Hershey, Pa*

Introduction: **Radiation was discovered just slightly more than a century ago, with a profound effect on both industry and medicine. Several notable scientists were key in bringing radiation to the forefront.**
Methods: **Historical review of scientists who played key roles in the discovery of radiation and its use in medicine are reviewed.**
Results: **Wilhelm Roentgen, Henri Becquerel, and Marie and Pierre Curie's work is reviewed. The field of radiation safety was born to protect those handling radiation in addition to patients who received radiation for medical purposes.**
Conclusion: **Radiation use in medicine continues to evolve after notable discoveries by Nobel Prize-winning scientists.**
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It is difficult to envision 21st century medical practice without the ability to image vessels, bones, and soft tissue in virtually all aspects of the body. Yet surprisingly, radiography was not discovered until the end of the 19th century (1895), when Wilhelm Conrad Roentgen happened upon x-rays while working with a cathode-ray tube in his laboratory at Wuerzberg University in Germany. The tube, with positive and negative electrodes encapsulated as a bulb, glowed a fluorescent green when high voltage was applied. Despite shielding the tube with a heavy black paper, Roentgen discovered green fluorescent light being generated by a material just a few feet away from the tube. From this he deduced that this new "ray" was being emitted from the tube and was capable of passing through even heavy black paper to excite phosphorescent materials in the room. Roentgen discovered that this ray could pass through most solid objects, but not bone or metal. His first experiment in 1895 was a film of his wife Bertha's hand (Fig) in addition to pictures of a set of weights in a box to show his colleagues.

One can imagine the incredible interest by layman and scientist alike. Owing to the wide availability of the cathode tube at that time, many scientists were able to duplicate Roentgen's experiment. Lines of research were dropped to pursue this extraordinary discovery. Newspapers and the media were full of ways conjured up about how the new technology could be used. Within a month after the discovery, radiographs were being produced in the United States as well as in Europe; within 6 months after discovery, they were being used at the frontline in battlefields to help locate bullets in soldiers who had been injured.

It was difficult to use x-rays in medicine before 1913 due to the high amount of voltage necessary for adequate images, which would often result in the source x-ray tube breaking down. In 1913, Coolidge designed a high vacuum x-ray tube that could serve as an intense and reliable source. Additional high-voltage sources were ultimately developed, including a 1-million volt x-ray generator by the General Electric Company in 1931. This helped provide an effective tool for industry for industrial imaging.

HENRI BECQUEREL

Soon after x-rays were discovered, the French scientist Henri Becquerel[1] discovered another form of penetrating rays—natural phosphorescence or radioactivity. He found that some minerals would glow or fluoresce when exposed to sunlight. By using photographic plates, he was able to capture this fluorescence on film. One of the early minerals Becquerel worked with was uranium. After storing his sample of uranium in a drawer with the photographic plates on a cloudy day, he discovered that the plates appeared to have been exposed to light. He deduced that the uranium compound was able to give off its own radiation that could be captured on photographic film. He continued demonstrating that the uranium was the source of the radiation, although his discoveries went largely unnoticed by the public, unlike the media attention received by x-rays. For this discovery, he did share half of the Nobel Prize for Physics with Marie and Pierre Curie in 1903.

MARIE CURIE

Polish native Marie Curie[1] was working in France at the time and became interested in Becquerel's work. She was suspicious that there were other sources of radioactivity in the uranium ore and began looking for them along with her husband, Pierre. In 1898, the Curies discovered another radioactive element in the ore and named it polonium after Marie's native Poland. Radium was an additional element discovered during that same time period. Radium and polonium were both more radioactive than uranium.

Throughout her life, Curie promoted the use of radium to alleviate suffering, and during World War I, assisted by her daughter, Irene, she personally devoted herself to this work. She maintained her enthusiasm for science throughout her life and did much to establish a radioactivity laboratory in her native city of Warsaw. In 1929, United States

From the Heart and Vascular Institute, Penn State Hershey College of Medicine.
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Correspondence: Dr Amy B. Reed, Penn State Hershey College of Medicine, Heart and Vascular Institute, 500 University Dr, H053, Hershey, PA 17033 (e-mail: abreed@psu.edu).
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Fig. The first x-ray photograph was a picture of Bertha Roentgen's hand. Courtesy of the National Library of Medicine.

President Hoover presented her with a gift of $50,000 donated by American friends of science to purchase radium for her laboratory in Warsaw.

The importance of her work is reflected in the numerous awards bestowed upon her. Together with Pierre, she was awarded half of the Nobel Prize for Physics in 1903 for their study into the spontaneous radiation discovered by Becquerel, who was awarded the other half of the prize. In 1911, she received a second Nobel Prize, this time in Chemistry, in recognition of her work in radioactivity. In 1921, United States President Harding presented her with 1 gram of radiation on behalf of the American women in recognition of her service to science.

MEDICINAL USES OF RADIOACTIVITY

The parallel discoveries of radioactivity and x-rays in the late 19th century and early 20th century allowed many in industry and in health care to set up devices to generate x-rays. There was understandably very little concern about the unintended consequences that could occur from the use of these rays. No one knew the rays could be harmful, in part, because of the slow onset of symptoms. Who would suspect a problem with a ray similar to light that could not be seen or felt? In fact, many believed that exposure to the radioactivity might actually be beneficial. Radium rays were used in treatment of certain disease states, including lupus, cancer, and nervous diseases. Early complications of radiation exposure were highlighted by Pierre Curie in his Nobel Prize lecture where he noted:

> If one leaves a small glass ampulla with several centigrams of radium salt in one's pocket for a few hours, one will feel absolutely nothing. But in 15 days afterwards redness will appear on the epidermis, and then a sore, which will be very difficult to heal. A more prolonged action could lead to paralysis and death.[1]

Curie theorized that radiation could even become very dangerous in criminal hands and thus questioned whether mankind would benefit at all from knowing the secrets of Nature, particularly with concern about radiation use in war.

X-rays and gamma rays are electromagnetic radiation of the same nature as light, but with a much shorter wavelength. This shorter wavelength is what gives the rays their power to penetrate things light cannot. Because these electromagnetic waves are of high energy, they have the ability to break chemical bonds in the living tissues they penetrate. Alterations in these chemical bonds can result in altered structures or functions of cells.[2]

Ultimately, the widespread use of radioactivity led to serious injuries and spawned an entire science of protection called health physics. Thomas Edison, William J. Morton, and Nikola Tesla each were among the first to report possible adverse effects when they discovered eye irritations after experimentation with x-rays and fluorescent substances. Early exposure to radiation resulted in loss of limbs and even lives. Much of the information collected on radiation damage was likely gained at great personal expense.

Today radiation ranks among the most thoroughly investigated causes of disease. Although all is not known, more is understood about the mechanisms of radiation damage on a cellular, molecular, and organ-system level than is known about many other types of agents used in medicine. The term "health physicist" grew out of the Manhattan District of U.S. Army Corps of Engineers, who made great advances in radiation safety.

Leaders of the Manhattan District recognized that a new and intense source of radiation and radioactivity would be created. In the summer of 1942, leaders of the District asked cosmic physicist Ernest O. Wollan, at the University of Chicago, to form a study group to control radiation hazard.[3] The name "health physicist" was thought to have been derived partly out of need for secrecy and thus a code name for radiation protection services, and that a group of physicists were working on health-related problems. Their activities included developing appropriate monitoring instruments, physical controls, monitoring radiation areas, personnel monitoring, and radioactive waste disposal. A vast accumulation of dose-response data has allowed health physicists to specify radiation levels so that medical, scientific, and industrial use of radiation may continue such that levels of risk are no greater than that of any other technology.

PRESENT DAY

In essence, radiography has changed little from when it was first introduced in the early 20th century. We still capture a shadow image on film, whether it is paper or digital. Technologic advances have allowed us to produce smaller, lighter, and more portable equipment that can produce high-quality images. As imaging continues to advance, our challenge remains to be mindful of the radiation doses received by our patients, particularly when they are exposed to advanced computed tomography imaging for diagnostic purposes, then undergo an intervention involving radiation imaging, and then may be monitored with imaging requiring radiation. Radiation safety will continue to play an increasing role in keeping physicians and patients safe.

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