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Diagnostic imaging

Finding new ways to see; seeing new ways to cure

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Wilhelm Roentgen stumbled upon the mysterious rays, but it was the hand of his wife, Bertha, that showed the world what they meant. As Bettyann Holtzmann Kevles explains in her book, *Naked to the Bone* (1), "The x-ray was the first technology that taught us, collectively, to hold our breath, waiting for the next shoe to drop. But the lesson came slowly, and the contribution of x-rays to making that break with the past, while more subtle, perhaps, than the impact of the automobile or airplane, is equally profound, interesting, and controversial."

The response to Wilhelm Roentgen's discovery of the x-ray was immediate and, in many cases, startling. Until 1895, when Roentgen published his research in Germany, medical diagnoses were based on feel, inference, or superficial symptoms. Little was known about what was going on inside the body to cause disease or pain.

Frustrated at being on the outside not looking in, many physicians jumped at the chance to peer noninvasively inside the living body. While most doctors viewed the purchase of a large x-ray machine as an impractical novelty, some recognized the true potential of this diagnostic tool.

1800 Photography sets the stage for new ways to record information about health.

1895 Wilhelm Roentgen discovers a new "form of light" and presents his findings to the scientific community.

1896 Thomas Edison quickly jumps on the bandwagon, creating his user-

For example, just 2 months after Roentgen's announcement, J. Grosvenor Cross had an x-ray machine in his office in Rochester, Minnesota.

> At first it was virtually a medical toy, and then came his perfect chance to demonstrate its value. A youngster had swallowed a belt buckle and was rushed to the Mayo brothers. They were concerned about removal because they didn't know exactly which direction its prongs were facing, so they took the child to Doctor Cross. His pictures clearly outlined the buckle; it was pointed so that removing it through the mouth would have been seriously dangerous. So Dr. Charles Mayo operated with complete knowledge and extracted the buckle, blunt end first (2).

Public response

News of the x-ray caused a public fervor, raising a fascination with (and fresh fears of) technology. In London, a firm began selling x-ray-proof underwear. New York State tried to pass legislation banning the possibility of using x-rays in opera glasses.(2)

Thomas Edison quickly recognized the importance of Roentgen's discovery and mobilized his own laboratory to produce a machine he called a fluoroscope. The task proved easy for someone used to working with electricity, and Edison's fluoroscopy device was the hit of the 1896 National Electrical Exposition in New York. Edison also raised eyebrows with his much-publicized attempt, and failure, to make a brain radiograph for William Randolf Hearst. Nonetheless, the Edison Vitascope Fluoroscopy Unit allowed the person on the street to experience the new discovery (3).

Edison abandoned the new field of radiology quickly, however, when he recognized the risks involved. His assistant, Clarence Dally, began having health problems shortly after first experimenting with x-rays. Eventually Dally lost both arms to malignant ulceration. He died a painful and horrible death in 1904 and is remembered as the first martyr to radiation. Edison was haunted by Dally's death and adamantly refused to be x-rayed throughout the rest of his 84-year life (1).

Despite the risks, wild claims about the curative power of x-rays regularly appeared in newspaper headlines at the turn of the century. X-rays were most commonly touted as a cure for cancer, but also for about everything from ringworm to

friendly fluoroscope.

1900
X-rays become the darling of hospitals as patients flock to learn what's inside.

1916
Marie Curie establishes mobile x-ray units and begins training x-ray technicians for military service.

1950
For early ultrasound studies, patients sat in a tub of water with lead weights strapped to their waists to keep them from bobbing.

1968
EMI Corporation of Great Britain patents Godfrey Hounsfield's CT apparatus.

1982
CT scanning save the life of James Brady, President Reagan's press

blindness to frostbite.

According to one account, however, "The fervor was by no means limited to the medical community. . . . A farmer in Iowa claimed to have transmuted worthless metal into gold using x-rays. Coin-operated fluoroscopes provided the chance to glimpse your own bones for just a nickel. . . . The evocative name 'x-ray' appeared on products from stove polish to condoms (3)."

The afterglow of discovery

In those early days, x-rays were often used to diagnose fractures and locate bullets. Obviously, they proved to be a boon to wartime medical practice. Marie Curie is credited with organizing, as well as driving, mobile x-ray trucks during World War I and training technicians to use the new technology. Dentists, of course, quickly began using x-rays to detect decay, to study malocclusion, and even, as some advertisements in dental magazines put it, to find "the lost end of a broken drill (3)."

secretary.

1995
High-field magnetic resonance imaging reveals the interior of the human tooth.

2000 and beyond
Open MRI allows surgery under direct visualization within the magnetic field.

Sonography also was developed during World War I as a device for detecting submarines. Many years passed before the value of sonography in medicine was realized.

In 1919, scientists tried using radiography to view the spine and brain after injecting air into cerebrospinal fluid. Once in the spine, the air rose to the ventricles of the brain. This represented a major step forward in localizing brain lesions. In 1927, Portuguese neurologist Egaz Moniz injected sodium iodide into the carotid arteries to visualize blood vessels in the brain, giving birth to the idea of angiography with a contrast medium (4).

Those early radiographs quickly gave way to more specialized applications--uroradiology, vascular and interventional radiology, neuroradiology, and mammography. There were relentless refinements in equipment. Images once recorded on glass plates soon became available on film, and the images improved with the development of such devices as the x-ray image intensifier and spot-film attachment.

Beyond the x-ray

While the earliest x-rays permitted doctors to see inside the body, the development of computed tomography (CT) expanded horizons and added new dimensions to diagnosis. After the Apollo missions sent back computer-reconstructed pictures of the moon, it was not much of a stretch of the imagination to design computer programs that could reconstruct images of the interior of the human body.(1) CT proved computers could do exactly that, as well as manipulate and enhance images to differentiate tissues (especially in the chest and abdomen) and detect disease itself.

Developed in the late 1960s and introduced in the early 1970s by Godfrey Hounsfield, an English electronics engineer, CT uses

photon detectors that measure the strength of x-ray beams at different angles. The data are analyzed, integrated, and reconstructed by a computer to produce the cross-sectional images.

Magnetic resonance imaging (MRI), developed in the 1980s, provides even more information. It uses a powerful magnetic field and radio waves to stimulate hydrogen atoms that emit signals detected and analyzed by a computer. Information is then translated as a cross-sectional slice of the body. The value of MRIs in diagnosing tumors and in studying the brain, spinal cord, heart, major blood vessels, and joints was quickly recognized.

As breakthrough followed breakthrough, positron emission tomography (PET) and interventional radiology emerged. Assim-ilating advances that seem to be coming at an accelerating pace has been and will be a challenge for the specialty. For example, headlines such as these are appearing regularly.

- PET can help separate dementias caused by Alzheimer's disease from those caused by prescription drugs.
- Specialists are using PET to watch the brain while students think and when they stop thinking.
- New imaging techniques guide treatment of stroke, increasing the efficacy of new thrombolytics and averting brain damage.
- Ultrasound measures progression of atherosclerosis and determines when sur gery is needed. It also assesses the success of the surgery without the risk of angiography.

Or consider these headlines from this year's American Roentgen Ray Society's 97th Annual Meeting:

- A high-resolution x-ray system aids in detection of infant abuse.
- Virtual colonoscopy, using a limited CT scan of the abdomen, shows great promise as a test for colon cancer.
- ECG-gated single photon emission tomography makes it easier to diagnose heart attacks in the emergency room.

These examples illustrate how the science of radiology is mushrooming, a fact that surely would have astounded Roentgen. Indeed, just as doctors of 100 years ago struggled with the notion of looking inside the living body without cutting it open, we now find it ludicrous to imagine practicing medicine without sophisticated diagnostic imaging. And the applications continue to multiply. Teleradiology, which allows physicians to send CT, MRI, PET, and ultrasound images over telephone lines has expanded imaging well beyond expectations of even a decade ago. Images can also be stored electronically and recalled quickly and simply.

Research is already under way to develop "virtual reality" scanners that allow physicians to "touch" as well as see inside the body. Another promising technique, called magnetoencephalography (MEG), can locate and map specific activities within the brain. Development, of course, is driven by economics, and much of this extremely expensive research is

currently on hold or moving slowly. Nonetheless, technological advances are being introduced regularly.

The awe that the public felt when they first saw the image of Frau Roentgen's hand perhaps will never again be experienced by our increasingly unflappable consumer-oriented society. But you never know. The future of diagnostic imaging may be well beyond our most creative imaginings, and the next advances might just knock our socks off.

Reckoning with Roentgen

Wilhelm Roentgen has been portrayed as an obscure, skinny, big-bearded German researcher who, while rummaging around in his lab on November 8, 1895, stumbled into . . . well, he did not even know what. He vaguely called it a "new kind of light" of some sort. Since he did not know what sort, he called it x-ray. For his discovery he was awarded the first Nobel Prize in physics in 1901.

The real story is more a matter of chance favoring the prepared mind, to paraphrase Pasteur. At the time of his discovery, Roentgen was 50 years old, head of his department at the University of Wurzburg, and author of several publications. As Bettyann Holtzmann Kevles states in her book Naked to the Bone, "If the x-ray was a discovery 'ripe for the picking,' as some have contended, then Roentgen was a seasoned scientific investigator appropriately prepared to appreciate its importance."(1)

It was late on a Friday evening that Roentgen made his discovery. He liked working then because there was less chance of interruptions. He was investigating the properties of cathode rays, using several tubes, including a variation of a Crookes tube designed by a colleague, Philipp Lenard. Roentgen turned off the lights, pulled the shades, and wrapped the tube in black cardboard to prevent distraction from the fluorescence of the tube's glass walls.

He turned the tube off, then on again, and was satisfied that the cardboard trapped all light. By chance, a screen coated with barium platinocyanide (a fluorescent material used at the time to develop photographic plates) lay on a chair a few feet away. He noticed a soft glow (Roentgen could not see it was green because he was colorblind) in the shape of the letter A coming from the screen; a student had used a finger to write A on the liquid barium platinocyanide. Roentgen turned off the tube, and the A disappeared. When he turned it on again, the A reappeared. This light was passing through the shield.

Roentgen explored this phenomenon late into the night. He returned the next morning to discover the new light still appeared and disappeared, and thereafter he spent all of his time--for the next 7 weeks--experimenting and photographing this new, unknown light. He did not share his discovery with

anyone because he worried that he might be hallucinating. To a longtime friend he wrote, "I had spoken to no one about my work. To my wife I merely mentioned that I was working on something about which people would say, when they found out about it, 'Roentgen has surely gone crazy.'"

He hadn't, of course. He made radiographs of metal disks and coins in a purse, as well as the famous pale radiograph of the hand of his wife, Bertha Ludwig Roentgen. (Supposedly, she was so appalled by the deathlike appearance of her hand that she never went near her husband's experiments again.) On Decem- ber 28, 1895, Roentgen announced his results to the Wurzburg Physical Medical Society, and the science of roentgenology was born, forever changing the course of medical history.

Research is already under way to develop "virtual reality" scanners that allow physicians to "touch" as well as see inside the body.

At the forefront

Lee F. Rogers, MD

"Imaging was initially in medicine's 'basement,' geographically and functionally," says Lee F. Rogers, MD. "It was an adjunct to diagnosis. Now, however, imaging has moved out of the basement and is centrally located in the hospital. It is impossible to practice modern medicine without imaging."

Dr Rogers is editor-in-chief of the American Journal of Roent- genology and Meschan Distinguished Professor of Radiology at Wake Forest University, Wake Forest, Illinois. He served for 21 years as chair of the department of radiology at Northwestern University Medical School, Chicago, and has been president of the American College of Radiology and the American Roentgen Ray Society. He has written extensively in the field, including a landmark, two-volume text on skeletal trauma.

In his career, Dr Rogers says he has seen the change from "diagnosis by inference," using standard x-rays, to direct visual observation, using CT scanning, MRI, ultrasound, and x-ray-aided biopsies. This change allows for earlier diagnosis and staging of disease. These technological advances have made it possible to do outpatient procedures noninvasively as opposed to using such invasive procedures as angiography. And the invasive procedures have improved with the advent of safer contrast media and image intensification. "This has allowed us to improve diagnosis and treatment through the vascular system," he says.

When Dr Rogers went into the field, leukemia was a well-known hazard among radiologists. "My father was a doctor,

and both my parents were concerned about me going into radiology," he says. He adds that since the mid-1960s, radiology has made extensive safety improvements.

As for the future, Dr Rogers says he is "not a visionary." He is not out on a limb, however, when he predicts radiology will continue to change. "There has been something new in this field about every 5 years," says Dr Rogers. "First, a Swedish radiologist developed angiography, and then came nuclear medicine, ultrasound, CT scanning, and MRI. We have done a wonderful job in adapting and in training and retraining. I'm very proud of our specialty for making these changes."

References

1. **Kevles BH.** Naked to the bone: medical imaging in the twentieth century. New Brunswick, NJ: Rutgers University Press, 1997
2. **Karolevitz RF.** Doctors of the old west: a pictorial history of medicine on the frontier. Seattle: Superior Publishing Co, 1967
3. **Gagliardi RA, McClennan BL, eds**. A history of the radiological sciences: diagnosis. Reston, Va: Radiolog Centennial, Inc, 1996
4. **Shorter E.** The health century. New York: Doubleday, 1987

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