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RADIOLOGY IN THIS CENTURY*

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A fiftieth anniversary is a proud achievement and one to be cherished in humble pride. The Chicago Roentgen Society is to be congratulated on the high place it occupies in radiology, and on its many distinguished members who have contributed to the development of our specialty.

The science of radiology also has a proud history which deserves an occasional review, while those with a factual memory of its events are still with us. We will indicate some of the steps in the growth of this relatively recent specialty of medicine which has become of such importance in both diagnosis and therapy. It is obvious that we cannot cover more than a few of the significant discoveries, and while reference will be made to many of the pioneers in radiology, unfortunately we cannot mention all the early workers who deserve credit.

The apparatus available in the early days was probably the greatest limiting factor in the development of roentgenology. During the first 15 years, the apparatus and tubes were of such fragile construction and unreliable performance that much of the operator’s time and ingenuity were required to produce even reasonably satisfactory results. The Coolidge tube came into use about 1913. This marked the beginning of modern technic, although the “gas tube” in an improved form continued in sporadic use for another decade. The introduction of the closed core A.C. transformer with mechanical rectifier about this time forever freed the roentgenologist from the induction coil, static machine, and mercury interrupter. The designing of the grid by Potter was one of the greatest technical advances in radiology. Bucky had tried to counteract the blurring effect of scattered rays by a series of metal tubes through which the rays passed to reach the film, but the superimposed image precluded its use. Potter ingeniously solved this problem by the use of a segment of a cylinder composed of metal strips which when put in uniform motion cast no shadow. This made possible good diagnostic radiographs of all thick parts. In later years, valve-tube rectification, shock-proof tubes, photoelectric timers, better screens and cassettes, improved films, and modern processing contributed to the further development of modern radiology. Kymography, planigraphy, spot-film roentgenography, cineradiography, and image intensification also were great forward strides.

The Skeleton

Bone roentgenography in America prior to World War I was influenced by such European workers as Köhler and Kienböck. Köhler's monograph on the Borderlands of the Normal and Early Pathologic in Skeletal Roentgenology, translated by Turnbull, was a constant source of reference. In this country the first major contribution on the subject was the monograph by Baetjer and Waters. Notable work was also done in America on bone tumors, especially by Codman and Bloodgood, and by the Bone Tumor Registry. It is impossible to comment individually on the many good bone studies during the past 25 years, but important contributions have been published on metabolic diseases, growth, and dynamics of bone on a cellular level, on the spine, and on a better classification of congenital bone disease. Studies such as these have tended to give radiology an independent status so that it is no longer considered merely an adjunct to surgery.

The Chest

In 1896 and 1897 Williams published reports of x-ray examinations of the chest in pneumonia, emphysema, and movements of the diaphragm. These were the earliest accounts of thoracic roentgenology. A notable review on this subject by Crane of Kalamazoo appeared in 1899, in consequence of which this author was made a member of the London Roentgen Society. In 1903 Hulst of Grand Rapids, Mich., exhibited the first radiograph of the chest made without the use of an intensifying screen. Many radiologists continued to prefer the fluoroscope for this purpose, but its routine use was gradually abandoned, as intensifying screens improved and better apparatus permitted more rapid exposures.

In later years the diagnosis of tuberculosis was placed on a film basis by such men as Dunham, Cole, Crane, Pierson, and many others. Pancoast and Pendergrass made distinguished contributions on the diagnosis and classification of pneumoconiosis. Moore reported important work on bronchiectasis. Many reports on cancer of the lung were published; in this field Rigler, who is here tonight, did as much to correlate the findings as anyone. The introduction of iodized oil by Forestier and Sicard facilitated examination in many lung diseases and was helpful in differential diagnosis.

The Gastrointestinal Tract

In the tremendous field of roentgen diagnosis in gastroenterology, the first practical studies were made by Cannon on the intestine of the cat in 1898 and by Williams and Cannon on children in 1899. In 1904 Rieder published a valuable monograph on alimentary topography and physiology. Reiche in 1909 was probably the first to demonstrate a proved gastric ulcer. Haudek's description of ulcers in 1910 helped to establish a pathologic basis for study of this entity. In 1910 Cole laid stress on peristalsis, and in 1912 discussed serial radiographs of the stomach. About this time, two schools of thought developed in this country: one led by Cole laid stress on direct evidence of pathology as demonstrated on serial films; the other,
probably best exemplified by Carman, depended on fluoroscopy supplemented by radiographs.

Barium sulfate was first used in roentgenography of the colon by Haenisch about 1911. In 1923 Fischer introduced the double contrast enema which has played such a large role in x-ray examination of the colon. Notable contributions in this field were also published by Case, Moore, LeWald, George, Pancoast, Pfahler, Kirklin, Orndoff, and many others. The main advances in the last 20 years have been refinements of technic and a better understanding of anatomy and physiology.

The first x-ray studies of the gallbladder were made about 1910. Pfahler and Case emphasized that indirect signs were important when calculi were not demonstrated. The chemical content of calculi made their positive visualization frustrating. In 1923 Graham and Cole of Washington University revolutionized this examination by the introduction of intravenous cholecystography. This physiologic study tested the function of the gallbladder as well as demonstrated its gross anatomy and pathology. Work by Menees and Robinson, Milliken and Whitaker, Sosman, and others established the oral method of gallbladder roentgenography. The use of the fat meal by Boyden as a test of emptying, further increased the value of this procedure. Many new drugs and refinements of technic have established cholecystography as a truly valuable roentgen examination.

The increasing use of contrast media has probably had more influence on diagnostic radiology than any other factor during the past 50 years. In the earliest years following
Roentgen’s discovery, the prevalent opinion was that the usefulness of x-rays would be limited to the study of the skeletal system and the location of foreign bodies. It was not long, however, before the chest, which essentially presents a contrast between air and soft tissues, was under investigation. Contrast studies of the gastrointestinal tract soon followed and, a little later, of the urinary tract, spine, gallbladder, spinal canal, bronchi, sinuses, etc. The uses of air and other gases, as low-density contrast media, in the thorax, abdomen, perirenal tissues, ventricles and spine, uterus and tubes and other areas were forward steps.

The development of angiography on a clinical basis was begun in 1931 with thorium dioxide as the contrast agent. Cerebral angiography was demonstrated by Egas Moniz\textsuperscript{7} in 1927 and, after many improvements in technic, has become a routine procedure. Demonstration of the abdominal aorta and its branches was reported by Dos Santos\textsuperscript{8} in 1929. This has proved to be a development of outstanding importance not only in the diagnosis of lesions of the aorta and its branches but also in examination of the abdominal organs. In 1938 Robb and Steinberg\textsuperscript{7} introduced angiography of the heart and also of the lungs, and at about the same time Castellanos, Pereiras, and Garcia\textsuperscript{9} applied this method in the examination of children. The requirements of modern angiocardiography have been instrumental in the perfection of other technics, useful in all roentgen diagnosis, such as rapid film changers, image amplification, and cineradiography. Lymphography was first attempted in the early 1930’s and has recently been the subject of important work. Splenoportography has been developed in recent years and has now become a relatively safe clinical procedure.

\textit{Therapy}

Such effects of x-rays as erythema and the epilation which often follows examination of the skull were probably the scientific basis for the introduction of radiotherapy. E. H. Grubbe,\textsuperscript{10} a tube manufacturer of Chicago, was the first man in America to institute roentgen therapy — in a case of carcinoma of the breast.

The therapeutic approach was necessarily elementary until the introduction of the transformer and mechanical rectifier, and later the hot cathode tube in 1913. Various biological investigations were made of the body tissues and the blood. In 1904, after a series of investigations, Bergonie and Tribondeu\textsuperscript{11} formulated their law which stated that “Immature cells and cells in an active stage of division are more sensitive to radiation than are cells which have already acquired their adult morphologic and physiologic characters.”

In 1905 Pfahler\textsuperscript{12} introduced filtration in America. He used leather for that purpose, reasoning that it would be suitable for elimination of those rays which produced the troublesome erythema and would yet permit radiation of the deeper structure. This material was followed later by aluminum, cooper, tin, lead, and combinations of these metals. The Thoraeus filter, a combination of tin, copper, and aluminum, was an important arrangement.
The dosage employed in the earlier days was largely on an empirical basis. If the kilovoltage, milliamperage, filters, distance, portal size, and time were carefully documented and the clinical effects evaluated, a safe and fairly accurate dose of radiation could be administered. Early measurements of the output of radiation were based on such methods as that of penetration (Benoist), physicochemistry, and photometry which compared brilliance of fluorescence with known standards. An important step was taken when Duane, Villard and Friedrich independently defined units for measuring the quantity of radiation, based upon the ionizing effects in a unit volume of air. This led to the development of “isodose curves” by Friedrich and Glasser in 1922. The production of the small thin wall chamber by Fricke and Glasser in 1924 was an important breakthrough. In 1928 when the International Congress of Radiology in Stockholm adopted, by international agreement, the “roentgen” or “r” unit, the standard for dosage measurement was firmly established.

Various systems of roentgen therapy have been advanced from time to time. In 1920 Seitz and Wintz advocated the massive dose technic in which the full “erythema dose” was administered in the shortest possible time. About 1914 Regaud of Paris suggested that small intensities applied over a long period might hit neoplastic cells during the various phases of mitosis. A modification of this method was suggested by Kingery for skin diseases and later by Pfahler for treatment of deeper lesions. In this technic an attempt was made to maintain a radiation saturation over a long period by taking account of the per diem loss. Out of this work came the familiar Coutard method with its advocacy of two small doses of highly filtered radiation each day from twenty-five to thirty-five days. Another technic, advanced by Heublein in 1932, was total-body irradiation by small intensity over a long time period.

The general tendency in therapy during the past 40 years has been a gradual increase in the voltage potential, and today the use of megavoltage is commonplace. The use of radium as a therapeutic agent has been known since the turn of the century. In recent years isotopes of cobalt, cesium and other elements have occupied a prominent place in radiotherapy. Time does not permit a discussion of these later developments.

Summary
I have recounted but a few of the steps taken in the development of radiology, the specialty which occupies such a prominent place in modern medicine. This recapitulation of some of the almost forgotten successes and failures of the pioneers in radiology has had nostalgic overtones; we have had to omit mention of so many men who deserve credit and recognition that a more complete story needs to be told.

REFERENCES


84


