The Centenary of Radiology

Pages with reference to book, From 325 To 328

Introduction

The discovery of x-rays in 1895 and radioactivity in 1896, initiated an era of most extensive and intensive research in the history of human civilization into the nature of matter and energy and the interactions between them. This year is a momentous year as it marks the centenary of Röntgen's discovery of x-rays. Wilhelm Conrad Röntgen, a physicist, on November 8, 1895, made an observance that led to revolutionized science and industry in general and radiology in particular. He observed that when a high electric current is applied in a highly evacuated covered Hittorf-Crookes tube in a dark room, a barium platinocynide screen became illuminated. Röntgen conceived that the invisible rays responsible for producing fluorence had not been observed or described before and therefore, he called them X-rays. Röntgen studied these rays for seven weeks probing its properties and characteristics before making it known to the world.

W.C. Rontgen

Röntgen was born on March 27th, 1845, in Lennep Germany. He was educated in the Netherlands and in Switzerland. He received his doctorate in 1868 from the University of Zurich Röntgen, in 1885 was appointed, as professor of physics at the Julius Maximillan University of Wurzburg where he later became Rector. Röntgen worked in many areas of physics such as specific heat of gases, elasticity, compressibility, heat conduction in crystals, absorption of infra-red in vapors and gases, piezoelectricity, electromagnetic effects of dielec the polarization and connective electric currents. He published 55 papers andonlythreeonx-rays. Röntgen was a brilliant experimentalist. He was a hard working man. He was so absorbed in his x-rays work that he ignored or delayed his wife's calls for dinner in their adjoining quarters. He devoted all his time and energy to Study x-rays. He ate his meals and sometimes even slept in the laboratory. Röntgen was a very humble man. He did not desire to benefit himself fmancially from his discovery and therefore did not take out any patents. Atone time, X-rays were called "Rontgen Ray" and Röntgen did not endorse the term. He once wrote about the discovery of x-rays. "must start with certain resignation that his work will be superseded by that of others that his methods will be improved upon, more accurate results obtained and that the memory of his life and work will gradually disappear[1]. This is certainly true for his predecessors and not for Röntgen. The reason is the thoroughness of his investigation. One of the criticisms of Röntgen from his peers was that he left very little for others to do beyond explaining his work. In 1901, Röntgen was awarded the first Nobel Prize in physics for his discovery of x-rays. In 1923, at the age of 78, Röntgen died.

Figure 1.

Historical

Soon after the announcement of the discovery of x-rays, many investigators and pioneers looked at their ambiguous results which could not be explained at that time. For example, Sir William Crookes, a

British physicist, in 1879 produced x-rays that fogged photographic plates which was lying near the discharge tube. He failed to comprehend the fogging of the plates and returned it to manufacturer as defective. In the United States, Arthur Good speed in 1890, in his physics laboratory at the University of Pennsylvania, was photographing sparks and brush discharges. He unknowingly left two coins on an unexposed photographic plate next to a crookes tube. When he processed the plates, round shadows were seen (Figure 2)

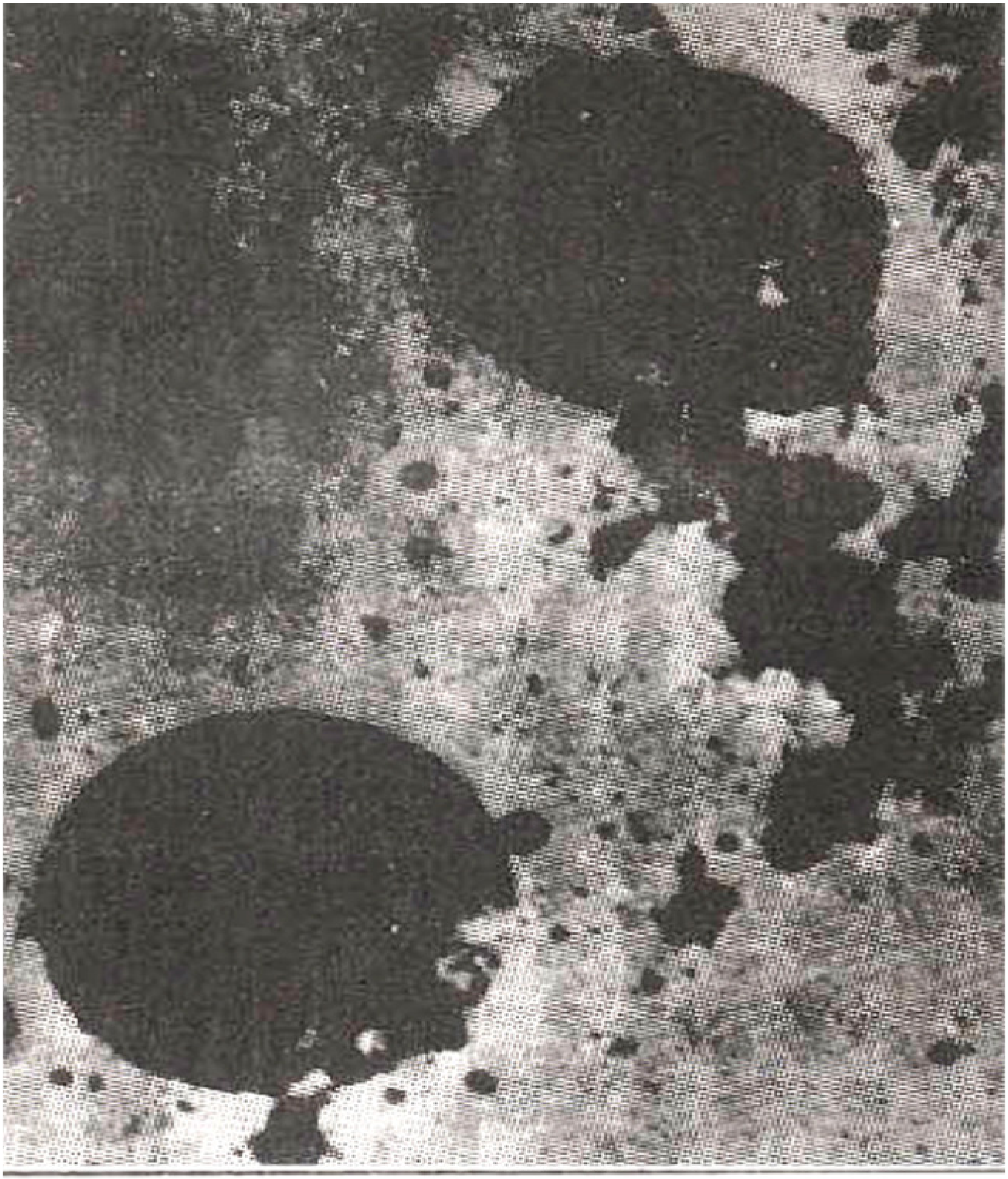

Figure 2.

that he could not explain. After Röntgen's announcement, Good speed reviewed the plates and found that the round shadows were indeed, the results of x-rays. Good-speed repeated his experiment in 1896 with exact procedure and observed the same result as he did in 1890[2,3]. It also appears that physicists, Johann Wilhelm Hittorf and Philipp Lenard might have also produced x-rays but did not recognize them. Rontgen on the other hand produced and recognized x-rays.

X-rays 1895-1990\'s

Rontgen radiographed his wife's (Anna Bartha) hand (Figure 3)

Figure 3.

and his doubl barreled gun. Rontgen on January 23, 1896, radiographed the hand of Albert Von Kolliker an anatomist, at his only public lecture on the discovery of x-rays. Rontgen's discovery was duplicated by physicists around the world within a few weeks. The first fluoroscopic system was demonstrated by E. Salvioni of Italy in January 1896. However, the first photofluoroscopy, a combination of camera and skiascope, was developed by Julius Mount Bleyer of Naples on April 7, 1896[4]. Thomas Edison used calcium trungstate to develop his fluoroscopic unit.

Figure 4

In figure 4, Edison is looking with his fluoroscopic image of C.M. Daily's hand, his assistant. In this country on February 3, 1896, the first medical radiograph was made by a physicist, Professor Frost[5] at Dartmouth College, of a wrist demonstrating a fracture. This was the earliest documentation of pathologic radiology. The use of x-rays was so widespread that in February, 1896 private x-ray imaging offices came into existence. From 1900 to 1940, it is known as the golden age of radiology. Clinicians and scientists encountered several ominous problems and sought solutions. These are: (1) Long exposure times; (2) To maintain considerable distance between patient, x-ray tube and tube support; (3) To avoid electrical shock; (4) Use of large. focal spot; (5) Absence of beam limiting device; (6) Means to eliminate scatter radiation; (7) Unshielded x-ray tube and (8) High radiation exposure to patients, radiologists and staff. With the help of the manufacturers and scientists, most of the solutions were sought by the mid 30's. In 1913, double coated films and dual intensifying screens were introduced in clinical practice. However, the major breakthrough in x-ray imaging also came in 1913, with the development of an x- ray tube by Coolidge and was commercially available in 1917. Both these innovations reduced the exposure time and provide a means to controlled exposure times and reproducibility and had a paramount impact on film processing. Another development in x-ray technology came with the use of anti scatter grids. Further improvements came in 1921 by the introduction of moving grids and since then has been an integral part of the x-ray system. In the 1930's great strides were made for faster exposures with the introduction of a three phase unit and a capacitor discharge unit.

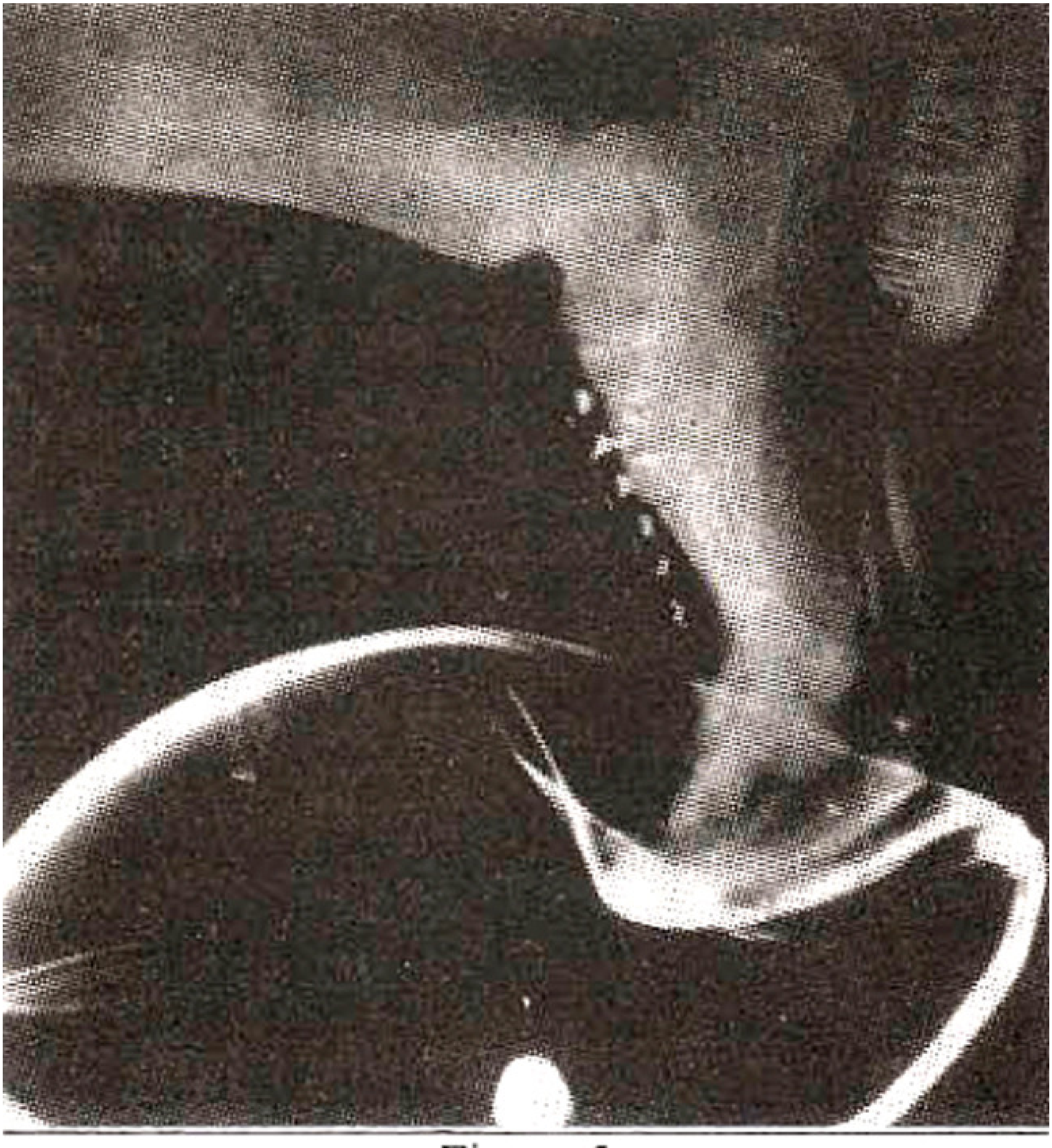

Figure 5

Figure 5, image of a football kick, made with the “Micronex”. A rotating anode x-ray tube was introduced in 1937. The evolution of x-rays also saw the development of a head unli, urological table and planigraphic attachment, True portable x-ray units were available in 1933.A bi-plane fluoroscopy unit was developed by Picker in 1934. Multiplane fluoroscopy was introduced with a home made unit designed by W.E. Chamberlain, a radiologist and G. Henny, a physicist. Mobile fluoroscopy units also came into being in this period. However, the most significant development in fluoro was the design of an image intensifier. Both mirror optics and TV. viewing system were introduced with the image intensifier. Perhaps the most important development in radiology was the jntroduction of automatic film processor by Pako 'Corporation of Minneapolis in 1942: The system provided a control on the development process and a consistency radiographic result that was unknown before. In the 1950's, a new set of problems were identified and the solutions were sought. These are: (1) Shorter exposure time; (2) Fluoroscopic procedures easier and informative; (3) Better soft tissue contrast in chest radiography; (4) Orientation of x-ray beam; (5) To reduce patient exposure; (6) A need for faster and controlled film processing; (7) Improved tomographic equipment and (8) Quality of portable radiography. With these problems in mind, manufacturers developed a more powerful generator with a photo time technique. in 1956, GE introduced "the imperial radiographic and fluoroscopic unit", In 1954, the first light localized collimator in the United States was used. Also rapid film changers were introduced for angiographic and cardiac procedures. These include roll film changer, cassette changer and cut film changer. Cine radiography was introduced in 1954. In 1959, Machlett produced a grid controlled x-ray tube whose emission could be synchronized with the Cine framing. Thus, the patient was irradiated only when Cine framings were actually used. Fluoroscopic spot films were introduced in 1950 in clinical practice. In 1951, a new generation of tomographic devices were introduced with complex motions. In 1956, Kodak introduced x-omat automatic processor. Today x-omat processes film in 90 seconds. Another significant development in radiology was the introduction of contrast agents such as, barium sulphate and iodine to outline the hollow organs and blood vessels of the body. The percutaneous catheter technique designed in 1953 by Seldinger[6] is now commonly used in angiography. Like the 1920's, the 1960's became a period of consolidation and refmement in equipment and techniques. However, in the 1960's xero-radiography was introduced for mammographic studies. Though it was introduced in the 1960's, this recording medium was first discovered in 1937. The second exciting development was the development of rare earth screens, which lower the patient dose and enable to shorten the exposure time. In the 1970's, both computed tomography (CT) and MRI became available. The widespread use of computers and digital imaging techniques in the 1970's ushered in a revolution that continues to influence imaging modalities even today. "Tomograph" is derived from the Greek "tornos" meaning "to slice" and "graph" meaning "picture". Thus a tomograph is a pictorial representation of a slice taken from a body. Hounsfield[7] and Commek[8] independently developed the computed tomography system x-ray computed tomography (XCT) is basically a diagnostic tool. It provides three dimensional information on the shape, dimensions and positions of anatomical structures. It is extremely useful in the diagnosis of central nervous system diseases as the thickness of the human skull makes radiographic examination of the brain very difficult. XCT hurdles this barrier by providing visual evidence of size, shape, position and symmetry of the fluid filled ventricles and cisterns critical to detection of hydrocephalus, brain atrophy, tumors, cysts, abscesses and edema. XCT images can be enhanced through use of contrast substances such as, iodine to reveal hyper fusion or hypo perfusion, usually indicative of stroke or trauma. In the late 1970's, a digital or computerized fluoroscopic was introduced. The images are obtained with the help of a video camera and a digital image processing. The images is digitalized by an analog to digital converter (ADC) alter which the data will be processed by the computer and stored in the memory of the digital image processor. For viewing, the digital data is retrieved and considered back to an analog image by a digital to audio conversion (DAC). The image is then viewed on a video monitor. A film of the image on the monitor can be made for a static record. The video image can also be recorded with a Cine camera for a dynamic record. In 1983, a computed radiography system was developed by FujiPhoto film Co. The device uses an imaging plate coated with a europium activated barium fluorohalide phosphor. The plate is exposed by x-ray and read by laser light that releases the trapped energy as light. The light is picked up by a photomultiplier tube and its intensity is digitized. The digital image can be viewed on the monitor or is recorded on film which can be viewed in the conventional manner. In the 1980's, 30 models of dedicated mammography units were introduced. This is due to the fact that mammography could be safely and effectively used to detect breast cancer. The American

Cancer Society sponsored many state mammography screening programmes and this was followed by an ACR mammography accreditation process. These events have caused the popularity of mammography to enhance dramatically. The 1990's will be described as the age of information management. The picture archiving and communication systems (PACS) is expected to handle diagnostic image information in the form of digital electronic signals. Transfer of images between radiology, ICU, the emergency room and the operating suite etc will be managed by PACS by the end of the century. Transmission of images between remote sites and centers of specialization will be greatly improved by PACS or tele-radiography.

Radiation protection and safety

Röntgen did not suffer from any radiation injury like many other pioneers and investigators of x-rays. This is because Rontgen placed a lead shield between himself and the x-ray tube. Though he did not do this for protection, he was nevertheless, aware of the harmful effects of x-rays. Other workers did not use proper protection and therefore, suffered radiation injuries. Edison et al[9], in March 1896. complained about the eye irritation after working with x-rays. Immediately he cautioned the harmful effects of x-rays and recommended frugal use. He abandoned his x- ray work soon after. This came too late for Clarence Daily, an assistant to Edison. Clarence Daily, because of excessive radiation exposure, developed a degenerative skin disorder which turn into a carcinoma. In 1904, Dally died. This is the first x- ray related death in the United States. Initially, no protective shielding around the x-ray tube was used, not even the lead aprons. In order to image the brain, Dr. Charles Dudley, Dean of the School of Medicine at Vandetbilt University, subjected himself to a 60 minute exposure resulting in the epilation of the head.

Figure 6

Figure 6 shows hands of an early radiologist who fell victim to x-ray injuries after receiving excessive exposure. In ‘the Golden Age of Radiology, one Rontgen of daily total body dose was considered as a "tolerance dose”. Many radiologists died from cancers related to x-ray exposures. Radiologists, before 1940, in the United States experienced a higher cancer mortality rate than that of other physicians.

Women who underwent multiple fluoroscopic chest examinations contracted breast cancer more frequently than other women. A contrast agent - Thorotrast - containing radioactive thorium was found to induce leukemia as well as bone and liver cancers. Shoe fitting fluoroscopes were very popular with children and resulted in inhibition of normal foot growth, acute radiation bums and chronic radiation injuiy of shoe store employees[10]. These experiences remind us that a professional frugality in the use of x-rays with adequate radiation protection measures and good comprehension of their harmful effects is clearly needed.

Conclusion

The evolution of radiology is indeed the history of concerted efforts of scientists in physics, chemistry and engineers. Technological advances opened new vistas to clinical applications. Radiologists, on the other hand, jumped the band wagon without even realizing what x-ray means. That's why such a high radiation induced mortality rate among radiologists occurred. They fell victim to their own ignorance. They can best be described as the user of technical tools whether it is x-ray, CT, MRI, Ultrasound, positron emission tomography, laser, microscope or even thermometer and not as inventor or discoverer. Advances in radiation protection and in reducing doses have taken place over the years again with the concerted efforts of physicists, chemists and engineers. As W.H. Shehadi[11] rightly stated: "As we enjoy the benefits of the progress that has been made, we are inclined to take for granted. the modem facilities and techniques that are available to us. Let us remember the debt we owe our predecessors, who laid the foundation for what we have today".

Acknowledgement

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References

1. del Regato, J A. Wilhelm Conard Rontgen. Int. J. Rad. Oncol.. Biol. and Physics. 1976;1 :133.
2. Shanks, S.C. Fitly years of radiology. The x-ray technician, 1951 ;22:226-34.
3. Proceedings of the American Philosophical Society. 1936;35: 12.36
4. Thompson, E.P. Roentgen rays and phenomena of the anode and cathode principles, applications and theories. Van Nostrand, New York. 1986.
5. Cipollaro, AC. The earliest Rontgen demonstration of a pathological lesion in America. Radiology, 1945 ;45: :555-558.
6. Seldinger, S. 1. Catheter replacement of the needle in percutaneous arteriography A new technique. Acta Radiot., 1853,39:368-376.
7. Housfield, ON. Computerized transverse axial scanning (tomography). Br. J. Radiol., 1973;46:1016
8. Cormack, AM. Representation of a function by its line integrals with some radiological applications. J. AppI. Phys.. 1963;34:2722
9. Edison, 1.. Morton. W.J., Swinton. A.A.C. et at The effect of x- rays upon the eyes. Nature, 1886;53:421.
10. Williams, CR. Radiation exposures from the use of shoe fitting fluoroscopes N. Engl.J. Med., 1949;241 :333-335.
11. Shehadi, W.F1. Early use of x-rays in the United States. AiR., 1993;161:206.