The early history of Diagnostic Radiology and Radiation Therapy

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There was a time when physics was considered to be a closed science. It was thought that everything there was to known about physics was known and only the refinements were left to be done. This all changed after Roentgen discovered X-radiation and Marie Curie separated out from pitchblende a radioactive element which became known as radium (Ra-226).

These new ionizing radiations found some of the first applications in the field of clinical medicine. Both physicist and physicians early on realized that this was a way to induce energy, which could destroy malignant cells within tumors. The first radiation therapy in the United States was carried out on a female patient using radium to treat her breast cancer.

Roentgen experimented with X-rays and made the first radiograph of a human using his wife's hand as the subject. This led to the field of diagnostic radiology and radiation therapy.

Filters were not used in the tube head of diagnostic equipment, service engineers would trouble shoot them by looking into the window to see if the filaments were still lit. There were no image intensifier (I.A.). The image was projected on a flat screen and was of poor quality. The tube current was in the range of 15 t0 20 mA which gave the patient a much larger dose as compared to today's examinations. Before fluoroscopy exams were carried out the radiologist would have to dark adapt by wearing red goggles for about a half hour before the exam was performed. The first I.A. was operated by viewing the image that was reflected in a mirror and had a small field of view. No television at that time had high enough resolution to be of practical use.

Natural occurring radium (Ra-226) was the only radioactive material that was available for the implant treatment of cancer. Man-made radioactive sources such as cesium (Cs-137). Iridium (Ir-192), cobalt (Co-60) and others were not able to be to be introduced on the commercial market until after World War II.

Radium was useful but presented several potential problems. The largest one was if the encapsulated source was broken or cracked the cleanup process became enormous. First it had a long half-life (1620 years) and could not be left unattended to decay away. Second, its first daughter was radon (Rn-222) a radioactive gas that could be inhaled into the body. The gamma ray energy is high and shielding is difficult. When cesium became available it started to slowly replace radium. The only company that sold radium in the United States had a massive contamination problem and was closed down by the government. People then converted over to cesium and sent their radium to federal burial grounds.

The orthovoltage X-ray machines were limited to about 300 kV, much higher and they got into problems of electrical arcing. Most of them operated at 250 kV or less. Filters (copper and or tin) were added to change the shape of the low end of the spectrum and the kV was varied to change the high end. Cure rates were not good for deep-seated tumors.

Two of the early high energy therapy machines were the betatron, which used a large bank of capacitors and had a whole array of cones. The other was the Van der Graff generator, a 2MV electrostatic generator. They were both physically very large machines with low outputs (87 R/min. for the Vande at 100cm TSD). Field size was limited to a 20 X 20 cm ~~at 100 cm~~ at 100 cm TSD. Patients were sometimes placed on the floor in order to project a larger field size. These machines could not rotate.

After World War II man-made radioactive cobalt 60 could be generated in nuclear reactors. Co-60 had two gamma energies of 1.17 and 1.33 MeV and a half-life of 5.23 years. These very useful machines could rotate and came into large use throughout the world. They were simple and reliable however, they had some limitations and problems. The relative large source size (1 to 2 cm diameter) yielded rounded isodose curves. A very hot source gave an output somewhat greater than 200 R/min. at 100 cm SSD which after 5 years was down to about one half of that value, resulting in the treatment times to double. Another problem was as the machines aged the source could fault and hang out in the treatment position. This meant that someone (the physicist) would have to go into the treatment room and return the source to the shielded home position. The trick was to stay out of the primary beam. If one worked quickly and efficiently they would receive only about 20 mREM (now in use the Sievert [Sv] where 1 Sv = 100 REM) of exposure. I was unlucky to have been on five source hang outs, which I believe is a record.

During cobalt-60 therapy one set of lead blocks were used for all patients needing lung shielding. These looked like a figure seven and were placed on a Lucite table above the patient and raised or lowered to obtain the required magnification. Other blocking was achieved by stacking lead blocks three or four rows high to outline the irregular areas. This is now done with automatic collimator leafs.

Next as a result of the development of RADAR during WW II, linear accelerators which use the same technology were produced. The first ones used vacuum tubes, had physically large controls, generated large amounts of heat and were not too reliable. Later with the coming of solid state electronics these problems were eliminated. The first practical accelerators were 4 MV units. They were a success on the commercial market because they could slip into a vacant CO-60 vault with little or no extra shielding to the room. After the advent of the 4MV machines the energy race began and higher energy machines were produced. Then those with useful electrons beam outputs were also manufactured.

From the technical side accelerators were practical because microwaves could accelerate electrons to produce high energy X-rays in the million volt range while the largest voltages used on the machines were in the range of around 12 kilovolts. This eliminated the problem of electrical arcing which was present in the million volt range.

There was not a lot of regard for radiation safety. One film salesman would let customers do a chest X-ray on him in order to show the quality of his film. At one hospital the X-ray tech did all of the fluoroscopy. He had put his hand in the primary beam so much that it was necessary to have his arm amputated just below the elbow.

All films had to be developed by hand processing in the dark room. The first process was in a developer tank, then a fixer and finally in a wash tank. Film quality was dependent on many variables, the dark room technician being one of them. Stat films were given a "wet reading" by the doctors before they were put in the film dryer. As a result of this the metal light boxes were always rusty and corroded because of the chemicals, no fiber glass light boxes were available then.

Computers were still in the infant stages when they were first used for treatment planning. Canned programs were not available and the user would have to wright their own as needed. All data was recorded on IBM punched cards. It took about 350 cards of data (program) to calculate the sine or tangent of an angle. The user would have load in several hundred cards of machine language first, which interpreted the program into a language that the computer could understand. The time allowed was one hour a day which was not very long because computers were not very fast. No plotters were available. Isodose values were printed out in numerical form. Physicist would have to connect the numbers with a crayon to get an idea of how the treatment isodose lines looked. Each intuition had its own idea of what had to included and most were eager to share their programs. No desk top computers were in use, the IBM 1401 and later the 1620 took up about half of the room and generated large amounts of heat and noise.

The radium programs were probably the most accurate however, needed to use the Sievert integral (Rolf Sievert –a Swedish Medical Physicist)for oblique gamma ray path through the encapsulation , this delighted the physicist because they were able tp flex their mathematical muscles in order to solve this problem. As time went on both computers and the programs improved greatly.

Much progress has been made in diagnostic imaging and radiation therapy. As in all scientific fields the computer has allowed us to make advances that could not be achieved by any other means. Along with education, training of personal, higher energy therapy machines and the use of robotics has increased the cure rates along with the quality of life for our patients. The future holds a greater promises to conquer cancer and many of the other dreaded diseases.