The Linear Accelerator

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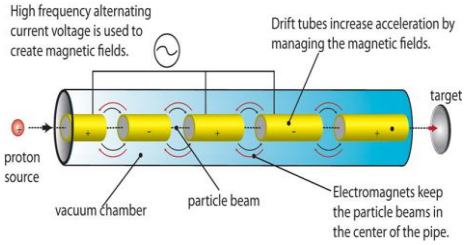
***Abstract*— The linear accelerator: where it came from, how it works, and how it's very effective in fighting cancer.**

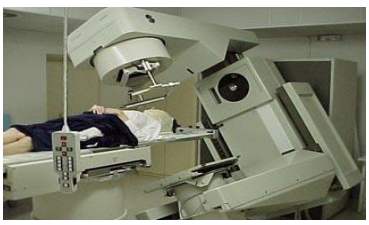
I. Introduction

A linear accelerator (LINAC) produces radiation that is referred to as a high-energy x-ray for patients with cancer. In 1928, R. Wideroe demonstrated that electrons could be accelerated through a tube by applying a radio frequency voltage to sections of the tube so that the electrons felt an accelerating electric field when they passed the gap. The linear accelerator is an extension of Wideroe's idea to a long linear array of accelerating cells powered by a radio frequency. The name linear accelerator comes from the fact that electrons are produced in the machine and accelerated in a straight line.



II. Methods

The linear accelerator is used to treat all parts and organs of the body. It uses microwave technology to accelerate electrons in the part of the accelerator called the wave guide, then allows these electrons to collide with a heavy metal target. As a result of the collisions, high-energy x-rays are produced from the target. These high energy x-rays are shaped as they exit the machine to conform to the shape of the patient's tumor, then the customized beam is directed to the patient's tumor. The x-ray treatments are designed in a way that destroy the cancer cells while sparing the surrounding normal tissue. When these high energy photons enter the patient's body, they aim to break the DNA in all the cells within the treatment area. The good cells are able to mend themselves, but the cancerous are unable to do this and therefore die. The patient lies on a moveable treatment couch which can move in any direction. The beam comes out of a part of the accelerator called a gantry, which can be rotated around the patient. Radiation is delivered to the tumor from any angle by rotating the gantry and moving the treatment couch.



III. Results

There was not a lot of information about the results of linear accelerators. However, a study of 20 patients were treated with a linear accelerator. 15 patients had no prior hearing problems, 5 did. The median follow-up time in which the results were observed was 51 months (12-109 mo). Local tumor control was obtained in all 20 patients, and no treatment-related trigeminal or facial nerve was observed. Hearing status was assessed yearly after treatment. This assessment revealed that the mean pure tone average (PTA) in the 15 hearing patients dropped from 51 to 77 dB. In six patients (40%) the additional PTA loss ranged from 0 to 15 dB, in another six (40%) it ranged from 15 to 45 dB, and in three of these patients (20%), it was more than 45 dB. No additional hearing loss was observed beyond 36 months after treatment. Overall, excellent local control rates were found with minimal facial and trigeminal nerve toxicity. Although more than 40% of the patients retained their hearing level or lost less than 15 dB of PTA, preservation of hearing remains a major concern.

IV. Discussion

As with all medical devices, linear accelerators have their own advantages and disadvantages. The main advantage is that the particles are able to reach very high energies without the need for extremely high voltages. Another advantage is that linear accelerators attack the affected area with higher doses of radiation than other machines. The main disadvantage is that because the particles travel in a straight line, each accelerating segment is used only once. The segments run in short pulses, limiting the average current output and forcing the experimental detectors to handle data coming in short bursts, thus increasing the maintenance expense. Another disadvantage is the cost. A linear accelerator can cost anywhere between one million and three million dollars. Operating the machine costs about $900,000 annually.

There have been deaths caused by a linear accelerator. In one case, six patients from 1985 to 1987 died from a fault in a THERAC-25. The fault was due to program errors that overdosed the patients on radiation, causing more complications that led to death. This was an extremely rare case and has not happened since. Throughout the years, linear accelerators have continued to improve and are extremely effective in helping to fight cancer.

References

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