# The Invisible targeting the Invincible: Radiation treatment of cancers in Nigeria

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## Protocol

The Dean, Faculty of Clinical Sciences, Prof. A. I. Ajaiyeoba and other faculty executive members, The Ag Head of Radiotherapy, Dr. T. N. Elumelu, all Heads of Departments present, Prof. O. B. Campbell, all other distinguished professors and teachers of medicine present, colleagues, students, my parents and other family members, gentlemen of the press, distinguished ladies and gentlemen.

It is a great pleasure to stand before this august gathering to deliver this Faculty Lecture on behalf of the Department of Radiotherapy. I thank my colleagues in the Department for this opportunity to speak on their behalf.

I attended my first Faculty Lecture as a student many years ago. That lecture was delivered by the then Dr. (now Prof.) V.O. Adegboye, the Head of Surgery. I have since then attended many lectures in the series and when the then Dr. (now Prof.) B. L. Salako delivered his Faculty Lecture, I manned the computer to move the presentation slides. Today someone is doing that for me too.

I could not immediately decide on a title for this lecture. However, I was never in doubt of what I wish to achieve with the lecture.

Radiotherapy is not a core department for medical students' training. Most students trained in the University of Ibadan will have about one or two weeks exposure to the specialty while the vast majority of students trained in other universities will have no exposure whatsoever. My first aim therefore is to introduce this gathering to the "lingo" of radiation oncology.

In our dealings with various departments and units in the hospital, it is clear that there is some basic misunderstanding about the roles of radiotherapy in cancer management. Indeed there had been a very small minority of people who felt we go beyond our bounds as radiation oncologists by examining patients and sometimes requesting further evaluation before treatment. Some had insisted we irradiate when we do not think it is appropriate while some had accused us of irradiating patients unnecessarily. We have also been accused of over-irradiating patients.

I therefore see this as an opportunity to explain some of our modus operandi and expose some of the rationale behind what we do. By this I hope we can reduce the areas of misunderstanding, reduce disagreement and possibly eliminate conflicts.

Secondly, I wish to highlight the challenges that radiation oncology practice is facing in Nigeria. By this I hope to call our attention to the areas of difficulties that we have, while hoping that efforts will be put in place to improve radiotherapy practice in Nigeria. And I must say that it is not only poor people we treat in Nigeria. While we all know the very healthy appetite of our rich men and politicians for overseas treatment at the slightest provocation, I will like to say that we have had cause to treat notable individuals when going abroad is not immediately feasible or when they have exhausted their life savings over ineffectual treatments abroad. The message is that we are not sure who else we will treat in our department or any other radiation oncology department in Nigeria. Like the Yorubas will say, *“Ori o ba mo ibusun, ki ba tun ibe se”,* which means that if a man knows where he will be buried, he will ensure that the place is in good condition. I have no doubt that if any of our leaders ever thought that they may end up as patients in our hospitals, they will ensure that they are in good order. But who knows who will end up in our department as our next VIP patient?

**<u>Introduction and Historical Background</u>**

Towards the end of the year 1895, an obscure German scientist was fully engaged in some of the experiments that defined the science of the time; the external effects from the various types of vacuum tubes when an electrical discharge is passed through them.[1] In the course of his investigations he required to have a fully darkened room to ensure that no light was leaking from his tubes. Though he was able to see that the tube was light-tight, he was however surprised to see something glowing in the darkness whenever he passed an electrical discharge through the tube.

He later discovered that the glows were from a cardboard painted with barium platinocyanide which he had been using for some of his experiments. He immediately recognized what he called “A new kind of radiation” which is invisible to the naked eye. He later called the new radiation x-rays, the x being the usual mathematical notation for an unknown entity or quantity.

After conducting several experiments on the radiation, on the 22nd of December, 1895, Wilhelm Conrad Röntgen who had just made a discovery that was going to revolutionize medicine took a picture of his wife’s hand in what was the first radiograph in history.[2] (Figure 2)

Figure 1; Wilhelm Conrad Röntgen Figure 2; The first radiograph

This seminal discovery led to another important one a year later. In investigating the works of Röntgen, Henri Becquerel discovered radioactivity and in 1898[3] Marie and Pierre Curie discovered two radioactive elements which they named Polonium and Radium.[4]

Though the initial efforts for medical use of radiation were focused on diagnosis, it did not take long for the biologic effects to be noticed. Erythema was the first biologic activity noted and it was indeed believed at the time that no good therapeutic effects can be achieved from radiation without first causing an erythema. This is possibly true considering that those early equipment were crude and produced x-rays of very low energy with poor penetrating effects. Most of the radiation was actually dissipated on the skin. Early dosimetric parameters were defined in terms of Skin Erythema Dose (SED) which was found to be extremely unreliable.[5]

A lamp manufacturer in Chicago named Emil Hermann Grubbe claimed to be the first person to use x-rays therapeutically.[6] He heard about Rontgen's experiment and he started his own work based on his experience as a lamp bulbs and tubes manufacturer. In the course of his works he received severe radiation burns which a physician friend saw and then requested that a patient with recurrent breast cancer be treated with the radiation that produced such burns. His believe then was that if the radiation can cause such burns in normal healthy tissues, it should do more to cancer cells. This treatment took place in 1896 with the x-ray equipment assembled by Grubbe himself.

Many clinicians also started using x-rays for various treatments in Austria (Kinnock (1900) and Freund (1903), in France (Despeignes (1896) Danlos and Bloch (1901) and in Germany (Albers-Schonberg, Strebel (1903)[7]. The first recorded cancer cure using x-ray was documented in Stockholm in 1899 when Dr. Thor Steinbeck treated a woman with basal-cell carcinoma of the nose.[8]

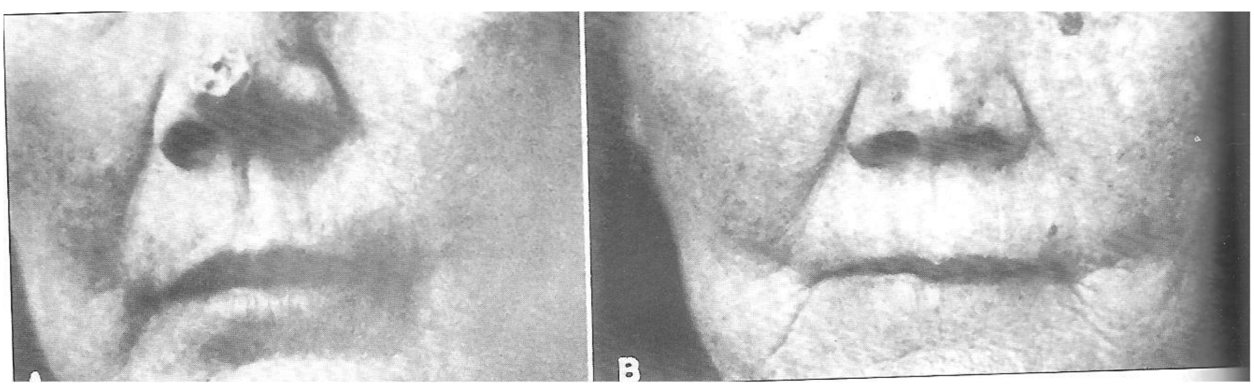



Figure 3; The first cancer cure with x-rays

By the turn of the century radiation therapy had started gathering pace as a therapeutic procedure.

Early treatments were done with conventional x-rays. Initially the radiation was produced from crude equipment setup with resultant poor quality x-rays of low energy. Most of these were often deposited on the skin and were mostly used at the time to treat skin ailments. Attempts were made to use this for deep-seated tumours, but this often required a deep burning of the skin. However, with the introduction of the alternating current and high tension transformers, it became possible to produce conventional x-rays of higher energy and good quality for deep-seated tumours. With some improvement in the electronics, many conventional x-rays machines with energy of up to 300KeV were built and some are still in operation in many centers up till today, often reserved for superficial treatments of skin ailments like keloids.

Figure 4; Orthovoltage treatment machine in Kampala, Uganda

Conventional x-rays however, have some fundamental limitations that made the use of other forms of radiation inevitable. First, the dose in the surface is usually very high and it is almost impossible to treat deep tumours without significant damage to the skin. In addition, conventional x-rays, because of the low energy, are highly absorbed by the bones. This has two unintended consequences; a high dose to the bone with consequent high risk of fracture due to radiation osteonecrosis and reduced dose to tissues that are “shielded” by the bones.

While progress was being made to refine x-ray use for therapeutic purposes, parallel progress was pursued with the use of radio-isotopes as the source of radiation for treatment. This method had the advantage of not requiring any significant electrical setups in addition to the fact that the isotopes were naturally occurring.

However, progress was slow on this side due to the fact that radium, the only available source of high energy photon for many years was only available in very small quantities and was very expensive. These were originally used as brachytherapy sources. Attempts to use these for teletherapy treatment or what was then known as “radium at a distance” treatment resulted in bulky and awkward equipment that were ineffective.[9]

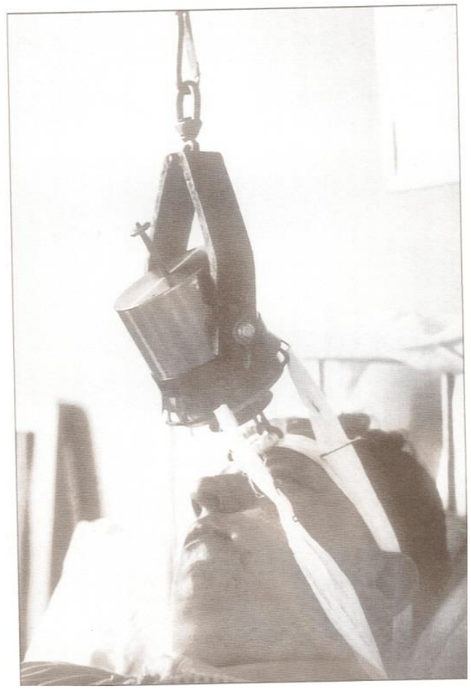


Figure 5; Patient being treated with an early telegamma equipment

With the availability of artificial radionuclides in the 50's, the bulky radium sources were replaced with cobalt-60 sources. In 1952, Green and Johns in Canada, separately and almost simultaneously developed the telecobalt machine with Cobalt-60 radioactive source of activities in the region of thousands of curie.[10] Cobalt source emits radiation of mean energy of 1.25Mev with half-life of 5 years.

In addition to Cobalt-60, Caesium-137 was also used as radiation source in telegamma units. Caesium has the advantage of a longer half-life of about 30 years, lower energy of about 0.67MeV which reduced the bulk of the required shielding mechanism. It was used at an SSD of about 50cm. However, because of poor skin sparing and depth dose and large penumbra, Caesium has largely been abandoned as a telegamma source.

**TELETHERAPY**

I have introduced you to two very important terminologies in the practice of Radiotherapy; teletherapy and brachytherapy.

Teletherapy implies that the source of radiation used for treatment is at a significant distance from the area of the body being treated as opposed to brachytherapy where the radiation source is in very close proximity to the area being treated.

The early x-ray treatment can be regarded as teletherapy, even though because of the weakness of the equipment, the radiation sources are often placed very close to the area of treatment. With the introduction of high energy telecobalt machines, it became possible to describe true teletherapy with a source to skin distances varying up to 80cm or more.


Figure 6; A telecobalt machine

The source to skin distance (SSD) is one of the important parameters that are specified in all radiotherapy equipment. Where artificially produced radiation sources are used as is the case with Linear accelerators, the Focus to skin distance (FSD) is used.

Telegamma equipment has one insurmountable limitation. Its energy is fixed and cannot be varied. It is therefore impossible to adapt the energy of telegamma equipment to the treatment intended.

Let me quickly explain why we may wish to vary the energy of the treatment beam based on the treatment intentions.

Tumours occur at different depths in the human body. The depth of penetration or the depth dose of a radiation type depends on several factors including its energy. The higher the energy of a beam the deeper the depth where the maximum dose is recorded due to some complex interplay between radiation and matter. For low energy radiation in the kilo electron voltage (KeV) range, the maximum dose is at the point of entry. For higher energy, the maximum dose is seen at a distance below the skin surface. This is described as the “skin-sparing effect” of radiation and it is one of the reasons why it is possible for us to treat a deep seated tumour without first burning the skin away. It is also the reason why we asked patients undergoing radiotherapy treatments to the eyes or adjacent areas to keep their eyes open while being treated. This will ensure that the maximum dose falls behind the cornea.

Of course it is not all the time that we can use this phenomenon to our advantage. When we want to treat the skin, the “skin-sparing effects” becomes an impediment. We therefore employ the use of what we call “bolus”. These are materials that have similar physical properties with human body and can then be applied to the area to be treated to create artificial body layer and then bring the maximum dose to the skin.

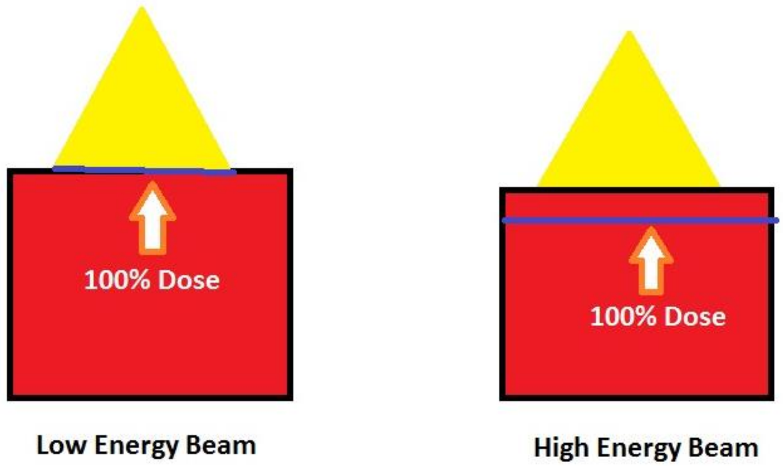



Figure 7; Skin-spearing effect

From the forgoing, it became quickly obvious that there is a need for radiation treatment equipment whose energies can be manipulated to achieve maximum penetration. And so the particle accelerators were born.

**TELETHERAPY EQUIPMENTS**

X-rays are produced basically by stopping an accelerated beam of electrons whose kinetic energy is then converted to heat and x-rays. Many accelerators follow this basic principle. Electrons are generated at one end and instead of allowing them to move only with the electromotive force to a positively charged terminal in a vacuum, the electrons are subjected to series of electric potential changes that accelerate them to very high speed (and high kinetic energy).

These electrons can be used for treatment or can be made to produce photon (x-rays) for treatment. This acceleration can occur in a lineal fashion (Linear Accelerators or LINAC), cyclical fashion (Cyclotron) or in other forms (Betatron, Microtron, Decatron).

In addition to electrons, accelerators can also be used to accelerate other nuclear particles including neutrons, protons, pi-mesons and indeed nucleus of other atoms including helium (alpha particles) and other charged particles. These particles can also be used for treatments.

Linear Accelerators are the main stay of radiation therapy in the present age and can be found in most radiotherapy centers in the world. In addition to the production of photons of high and variable energy, many of them can also produce electrons for treatment. Indeed following the wicked terrorist attack on the United States in 2001, many centers have been encouraged to discard their telecobalt machines so as to prevent the radioactive sources from getting to terrorists who can use them to make “dirty bombs”. In centers like ours where the disposal of the aging cobalt-60 machine will put a stop to patients’ treatment, extra security measures were placed around the equipment by a United States’ agency to make them inaccessible to the would-be nuclear terrorists. Unfortunately our Centre is one of the few centers in the world without a LINAC. I'm aware however that there are plans to acquire a LINAC for UCH. I hope and pray that this will come to fruition very soon.

## RADIATION TARGET VOLUMES

Radiation therapy is a painstaking job that requires a lot of attention. This is because radiation is a double edged sword. While it can be used to cure cancer, there are abundant evidences that it can also cause cancers and many other chromosomal and genetic damages. It can also cause immediate and long term physical and biochemical damages if given in excess or inappropriately. Indeed, people exposed to large amount of radiation to a large part of the body during nuclear accidents and during the world wars have been known to die very rapidly. It is therefore important that patients receive appropriate doses to appropriate parts of the body in an appropriate manner!

Parts of the body to be irradiated must be well outlined and described. Radiotherapists describe various treatment volumes in accordance with the guidelines recommended by the International Commission on Radiation Units (ICRU).[11] These volumes include

- Gross Tumor Volume (GTV): This is the gross palpable, visible or demonstrable extent and location of the tumour.
- Clinical Target Volume (CTV): This is an anatomical concept. It is the volume of the tissue that contains a GTV and subclinical microscopic extensions. This volume has to be treated adequately in order to achieve the aim of therapy which may be a cure or palliation.
- Planning Target Volume (PTV): This is a geometrical concept. It is defined to select appropriate beam sizes and beam arrangements, taking into consideration the net effect of all the possible geometrical variations and inaccuracies in order to ensure that the prescribed dose is actually absorbed in the CTV. Its size and shape depend on the CTV but also on the treatment technique used, to compensate for the effects of organ and patient movement, and inaccuracies in beam and patient setup.
- Treated Volume: This is the volume enclosed by an isodose surface (e.g. 95% isodose), selected and specified by the radiation oncologist as being appropriate to achieve the purpose of treatment. Ideally, Treated Volume would be identical to PTV, but may also be considerably larger than PTV
- Irradiated Volume: Tissue is the volume which receives a dose that is considered significant in relation to normal tissue tolerance. Dose should be expressed either in absolute values or relative to the specified dose to the PTV.
- Organs at Risk: Normal tissues whose radiation sensitivity may significantly influence treatment planning and/or prescribed dose.

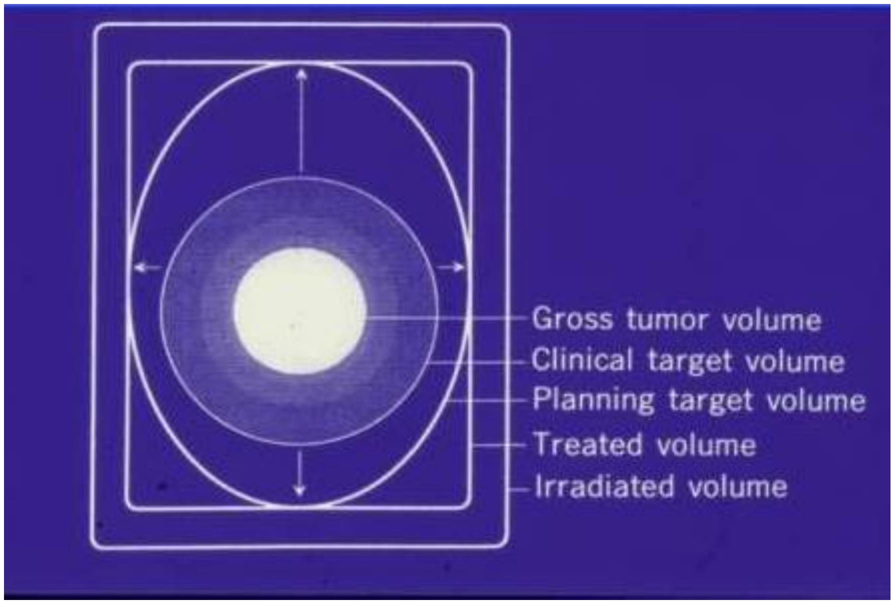



Figure 8; Radiation Target Volumes

These volumes were originally described in ICRU report number 50. However, further progress have been made and newer concepts including Internal Treatment Volume and Planning Organ-at-Risk (OAR) Volume have been introduced to further improve treatment outcomes and reduce side effects.

It should then become obvious that two important things that are necessary for successful patient treatment include accurate tumour localization and precise delivery of adequate dose. Tumour localization is a big deal in radiation therapy. Accurate tumour localization ensures that "the whole tumour and nothing but the tumour" is treated as much as possible. Failure to treat the whole tumour ("a geographical miss") will lead to poor control of the disease, while treating other parts of the body unaffected by the tumour will lead to greater side effects.

Another reason to accurately localize the tumour is to make allowance for body organs with poor radiation tolerance. These are the organs-at-risk (OAR). These include the spinal cord, the eyes, brain stem, optic chiasma etc. It is important that radiation dose to these organs is within their tolerable levels. Radiation to these organs above their tolerance levels usually attracts severe anatomic or physiologic sanctions as illustrated in the table below.[12] (Table 1)

Tolerance doses are described in terms of some undesired outcome; Myelopathy in the spine, lens opacification in the eyes, functional failures in the liver and kidney, necrosis and infarction or vaso-occlusive crisis in the brain and so on. Tolerance doses are usually described at $TD_{5/5}$ or $TD_{50/5}$. $TD_{5/5}$ is the total dose that will lead to the undesired outcome in 5% of people in 5 years and $TD_{50/5}$ will do the same in 50% of people over the same period.

As we can see from the table, tolerable dose also varies with the volume of the tissue being irradiated.

| | TD $_{5/5}$ (Gy) | | | TD $_{50/5}$ (Gy) | | | |
|---|---|---|---|---|---|---|---|
| **Organ** | **1/3** | **2/3** | **3/3** | **1/3** | **2/3** | **3/3** | **Clinical Outcome** |
| Kidney | 50 | 30 | 23 | -- | 40 | 28 | Clinical nephritis |
| Brain | 60 | 50 | 45 | 75 | 65 | 60 | Necrosis/ infraction |
| Brain stem | 60 | 53 | 50 | -- | -- | 65 | Necrosis/ infraction |
| Ear(Mid/Ext) | 55 | 55 | 55 | 65 | 65 | 65 | Chronic serous otitis |
| Esophagus | 60 | 58 | 55 | 72 | 70 | 68 | Clinical stricture/ perforation |
| Heart | 60 | 45 | 40 | 70 | 55 | 50 | Pericarditis |
| Bladder | -- | 80 | 65 | -- | 85 | 80 | Symptomatic bladder contracture and volume loss |
| Larynx | 79 | 70 | 70 | 90 | 80 | 80 | Cartilage necrosis |
| Larynx | -- | 45 | 45 | -- | -- | 80 | Laryngeal edema |
| Liver | 50 | 35 | 30 | 55 | 45 | 40 | Liver failure |
| Lung | 45 | 30 | 17.5 | 65 | 40 | 24.5 | Pneumonitis |
| Skin | $10cm^2$ 70 | $30cm^2$ 60 | $100cm^2$ 55 | $10cm^2$ -- | $30cm^2$ -- | $100cm^2$ 70 | Necrosis/ ulceration |
| Small intestine | 50 | -- | 40 | 60 | -- | 55 | Obstruction/ perforation |
| Colon | 55 | -- | 45 | 65 | -- | 55 | Obstruction/perforation/ ulceration/fistula |
| Spinal cord | 5cm 50 | 10cm 50 | 20cm 50 | 5cm 70 | 10cm 70 | 20cm 68.29 | Myelitis/necrosis |
| Stomach | 60 | 55 | 50 | 70 | 67 | 65 | Ulceration/ perforation |
| Temporomandibular joint & mandible | 65 | 60 | 60 | 77 | 72 | 72 | Marked limitation of the joint function |
| Femoral head & neck | -- | -- | 52 | -- | -- | 65 | Necrosis |
| Eye lens | -- | -- | 10 | -- | -- | 18 | Cataract requiring intervention |
| Optic nerve | -- | -- | 50 | -- | -- | 65 | Blindness |
| Rectum | -- | -- | 60 | -- | -- | 80 | Severe proctitis/ necrosis/ stenosis/ fistula |
| Parotid | -- | 32 | 32 | -- | 46 | 46 | Xerostomia |

Table 1; Radiation tolerance dose levels with side effects

To achieve high degree of tumour localization, modern imaging techniques are employed in radiotherapy treatment. These include conventional x-rays, Computed Tomography (CT) scan, Magnetic Resonance Imaging (MRI), Magnetic Resonance Spectroscopy (MRS), Positron Emission Tomography (PET) and PET-CT. Indeed most radiotherapy centers have specially made imaging equipment called simulators. These simulators can be in form of conventional x-rays, CT, MRI or PET scan. Most centers now have dedicated CT machines for use as CT-Simulator. In some centers like the Radiotherapy Center in Korle-Bu Teaching Hospital in Ghana, the CT-Machine located in the Radiology Department is sometimes used to acquire images for radiotherapy treatment planning.

PET is a new area that is currently being explored to improve tumour localization. PET scan done with FluoroDeoxyGlucose (FDG) sometimes called FDG-PET provide functional details to the tumour by outlining the areas of active metabolic activities which often correlate well with areas of increase mitotic activity or tumour proliferation. When combined with CT, it provides both the detailed anatomic and functional abnormalities. This has been shown to lead to significant redefining of the target volumes and is being evaluated for improvement in treatment outcomes.

**BRACHYTHERAPY**

Brachytherapy is another mode of radiation treatment modality being employed by modern radiation oncologists. One of the major pluses for brachytherapy is its ability to contain high radiation levels within the area being treated. It is so effective in achieving this that in some instances external beam treatment (EBRT or Teletherapy) is required to treat patients adequately. An example of this is in the treatment of cervical cancer. Brachytherapy is very effective in the treatment of early stage tumours like stage 1a and 1b tumours. However, because of the rapid fall-off of radiation dose away from the brachytherapy source, doses to the parametrium and pelvic side walls are often inadequate and there is a need to supplement with external beam treatment.

In brachytherapy, the source of the radiation for treatment is usually in close contact (or in fact, inside) the tumour being treated. This is in contradistinction to Teletherapy where the radiation source is much further away.

Brachytherapy is often described in terms of the technique employed. Thus it can be classified as intracavitary, intraluminal, interstitial, plaque or surface treatment. In interstitial treatment the radiation source is buried inside the tumour to be treated.

Figure 9; Old manual brachytherapy equipment in Uganda


Figure 10; Interstitial breat implants

Radiation sources for brachytherapy come in forms of wires, needles, pellets and plaques. Popular radiations sources for brachytherapy include Caesium-137, Irridium-192, and Cobalt-60. Brachytherapy works based on the inverse square law which states that the intensity of a point source varies with the inverse of the square of its distance from the source.

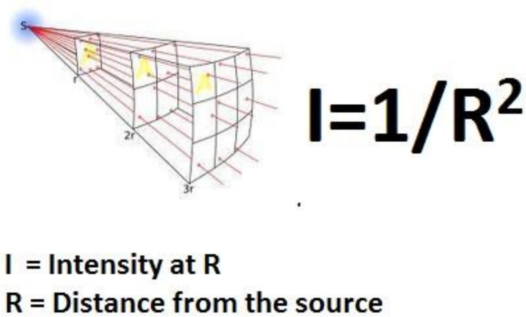



Figure 11; Inverse square law

It is therefore expected that there will be a rapid fall-off of the radiation dose from a specified point of interest. This has been shown to be the case in practice. Brachytherapy is very useful in treating small sized tumours to very high radiation doses while sparing closely situated organs. It is of limited use in large tumours and often reserved for use after the tumour has been significantly debulked (reduced in size) with external beam radiation treatment, chemotherapy or surgery.

Brachytherapy may be temporary or permanent. Temporary brachytherapy are done with radiation sources that are in removable forms like wires and needles. Temporary brachytherapy sources usually have relatively long half-lives and pose significant and continued radiation exposure danger to the patients and their carers if left in situ. Temporary brachytherapy sources include Caesium-137, Irridium-192, and Cobalt-60 etc.

On the other hand permanent brachytherapy sources are usually in form of pellets and have short half live in order of days. They are usually implanted during open surgery and are not removed thereafter. They provide continuous low-dose radiation to the region of interest. Sources used for this kind of treatment include Gold-198 and Iodine-125. This has been used in Prostate and in GIT tumours.

Brachytherapy can also be described in terms of dose rate. Thus we have High-Dose-Rate (HDR), Medium and Low Dose Rate (MDR and LDR) Brachytherapy. For LDR treatment the dose rate is below 2Gy/hr., for HDR, the dose rate is above 12G/hr. while anything between 2 and 12Gy/hr. is regarded as medium dose rate. The higher the dose rates the shorter the period the patients have to stay in the brachytherapy suite to receive the prescribed dose. In low dose rate treatment, patients may spend up to three days in the brachytherapy room as opposed to about 10-20 minutes for high dose rate treatments.

Ibadan has the only HDR brachytherapy equipment in the West African sub region and we are able to treat patients with cervical and endometrial cancers. We can also offer palliative brachytherapy to patients with oesophageal tumours. We have treated close to two hundred and fifty patients since the machine was installed in July 2008.


Figure 12; High Dose Rate Brachytherapy Equipment at UCH

**RADIOTHERAPY PRACTICE IN NIGERIA**

Radiotherapy practice started in Nigeria in 1969 when the first radiotherapy equipment was installed at the Lagos University Teaching Hospital at Idi-Araba. The Department took the delivery of the first megavoltage telecobalt machine in Nigeria which was installed in 1973. The radiotherapy department in LUTH can therefore be regarded as the mother department for many of the radiotherapy centers in Nigeria.

In May, 1987, the radiotherapy equipment in Ibadan was opened for treatment. The Ibadan treatment center was near state of the art at inception with a Canadian-built Telecobalt unit for teletherapy and two orthovoltage x-ray equipment for superficial lesions. It had a Therasim simulator machine and a well-equipped treatment planning room.


Figure 13; Commemoration Plaque for the commissioning of UCH Radiotherapy Unit

This equipment was sufficient for the best radiotherapy treatments that could be given at the time. However, the Department was not spared of the typical Nigerian challenges. The two superficial x-ray machines were never commissioned and were never used until they were inexplicably dismantled and boarded off (or thrown away) to make room for the gamma camera. Not long after, the simulator started giving troubles and the planning system became obsolete. The Cobalt machine itself developed issues and it takes ingenuity on the part of our local engineers to keep it “working”. I put working in inverted commas because the state of our machine could be likened to that of a car moving only with the wheel drums, with gear stuck in gear 1, steering wheel stuck in one position only and 2 of the engine valves permanently burnt. The car still works but in the most limited way. Our machine still works in a most limited manner.

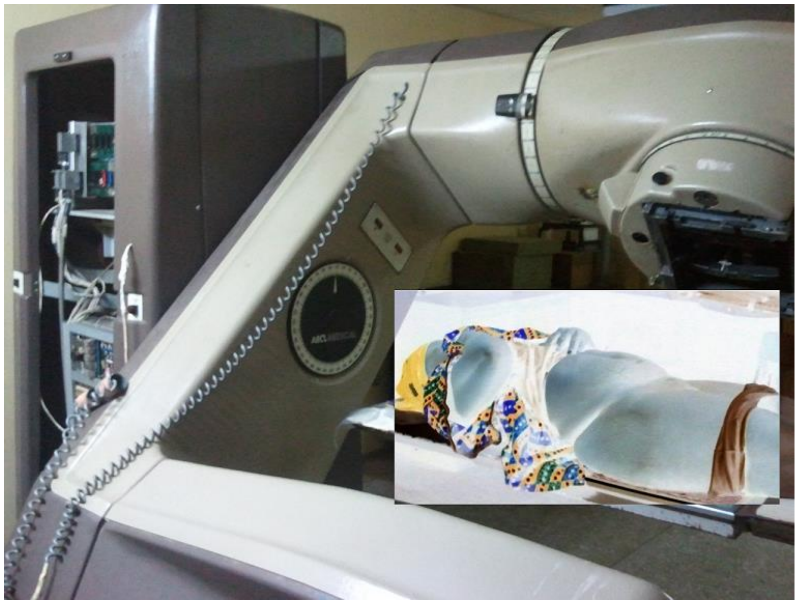


Figure 14; Theratron® telegamma equipment installed in our Department since inception

It gladdens one's heart that the machine is about to get a well-deserved permanent retirement as the UCH under Prof. Abiodun Ilesanmi is in the final phases of installing a new Cobalt machine for our Department. For this we are most grateful.

The depreciation that crept to UCH radiotherapy equipments did not stop there. It also spent some time in the mother center at LUTH. In fact at a point the LUTH center was closed down for many years and UCH became the only center serving the entire West African sub region.

Professors Duncan, Durosinmi-Etti and Agboola were the pioneer radiation oncologists in Nigeria. Professor Oladapo Babatunde Campbell took over the mantle of leadership of the Ibadan Department from Professor Agboola shortly after the equipment was installed and almost single-handedly built it into the University Department it is today. By a dint of rare stubbornness, he ensured that our department is the most stable and consistent radiotherapy Centre in Nigeria.

Figure 15; Prof. O. B. Campbell

Today, many more centers had started functioning either fully or partially. There are now working centers in Zaria, Sokoto and Gombe, aside Ibadan and Lagos. In addition, Enugu is hopefully going to take off soon and the EKO Hospital PLC operates the only private radiotherapy facility in Nigeria. Ibadan is a choice training centre for radiotherapy practice in Nigeria. Currently we have supernumerary residents from University Teaching Hospitals in Benin, Enugu and Sokoto and Federal Medical Centre, Gombe.

Sadly, radiotherapy practice in Nigeria is still rudimentary. Though new equipment is being installed, the usual Nigerian challenges have ensured that the practice remains the same.

**MODERN RADIOTHERAPY PRACTICE**

Radiotherapy treatment can be done with 2D or 3D treatment planning systems. 2D system is like seeing with one eye while 3D is like seeing with the two eyes. In 2D treatment, the radiotherapy field is planar and the fields are described in terms of length and breadth. Multiple fields may be used, but they are all described with two sides. Bony landmarks are used to describe the field because this is all that can be seen with a plain x-ray that the conventional 2D simulators produce. This is what we do in most part of Nigeria due to equipment limitations.

For a proper 2D planning system, a radiotherapy center requires in addition to the treatment machines, a function 2D (Conventional) simulator, a 2D computer planning system and a mold room. UCH have all these except a mold room, but they are all in various dysfunctional stages and require repair and replacement as the case may be.

Figure 16; 2D Planning

3D treatment requires a CT-simulator and 3D planning system in addition to advanced treatment machines with multi-leaf collimator system. It is described as conformal treatment because the radiation fields conform to the contours of the area to be treated. This helps to treat tumours more accurately and spare the Organs-at-Risk more effectively. Intensity Modulated Radiotherapy Treatment (IMRT) and Image-Guided Radiotherapy Treatment (IGRT) are some of the fall-outs of the move to 3D conformal radiation treatment.

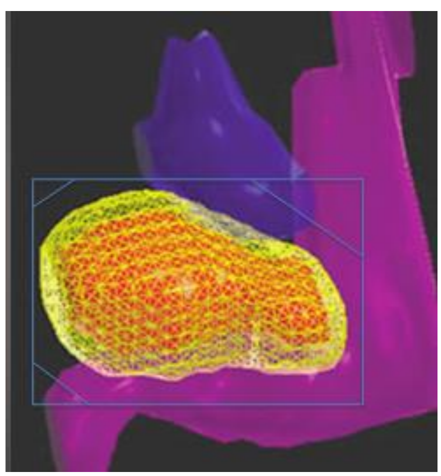


Figure 17; 3D conformal planning

Intensity Modulated Radiotherapy Treatment (IMRT) helps to ensure that radiation doses are varied in some systematic way with the target volume while IGRT helps to ensure that tumours are localized every time prior to the delivery of daily dose.

Image guided radiation treatment (IGRT) is particularly very interesting. It works based on similar principle to a cruise missile. Cruise missiles are like radiation in a way in the sense that wherever they land, they bring destruction. Because of these, war engineers have put tremendous amount of work into avoiding mistakes that may be costly in terms of human lives. Most cruise missiles are guided by a global positioning system (GPS) and they are programmed to hit certain targets at predefined longitude and latitude. To ensure greater accuracy, each missile also carries a camera and an image of their targets. On approach the missile must match the GPS coordinates, take a picture of the intended target and match it with the preprogrammed image before discharging its deadly payload.

In IGRT, a proper planning would have been conducted and all the treatment parameters set up. However, prior to every treatment, imaging equipment attached to the treatment machine will further locate the tumour before delivering the dose.


Figure 18; Cruise missile

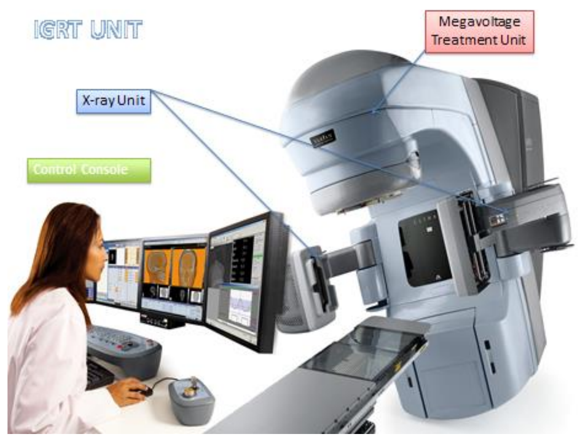



Figure 19; IGRT Machine

These are the new directions that radiotherapy practice is going and it appears that, as in many other things, Nigeria is being left behind.

It appears that those in authority at every level of our government are not concerned about giving appropriate support to cancer patients in Nigeria. It is sad to note that most states in Nigeria do not have even the most basic equipment for comprehensive cancer diagnosis not to talk of treatment. Radiotherapy has become such an important component of cancer treatment that its absence in all the states in Nigeria should be rightly seen as a national embarrassment.

Oyo state used to pride itself as a pace-setter. It is sad that the state has taken the back seat in providing health care for its people. Because of extremely poor remuneration, the state had been unable to attract quality personnel for its health care services. It is sad that Oyo state government could not provide simple x-ray and ultrasound services in most of its hospitals and to cap this absurdity Oyo state does not have a single Computed Tomography (CT) equipment in any of its hospitals.

We must of course quickly accept that radiotherapy equipment are costly and will require great budgetary sacrifice on the part of any government. This is further compounded by the extreme corruption ravaging Nigeria where contractors will quote ten times the cost of an equipment and then roam the streets of Europe, America or some Asian countries to purchase refurbished machine at a tiny fraction of the real cost. The consequence of this is that many types of equipment brought to Nigeria are

OOA (Obsolete On Arrival), breaks down soon after or even sometimes never get to start working properly.

With the increasing life span and better control of communicable diseases, we are bound to see some increase in the incidence of cancer cases as we go into the future. Nigerian statistical figures are notoriously scarce and often unreliable because of preponderance of confounders. In addition many of our available incidence estimates are hospital based. However, it has been estimated that about 82,000 Nigerians were diagnosed with cancers in 2002. This most likely represents a high level of under-diagnosis. Nigeria needs the ability to offer comprehensive treatment to its people who will come down with cancer. This will require greater funding for the hospitals in general and for radiotherapy centers in particular.

However, considering limited resources, it is unlikely that the government will be able to equip all centers properly. In fact some scholars have argued that it is not necessary for all the centers to be equipped to the same levels.

Most of the patients that we see in radiotherapy are at the advanced stages of their malignancies. According to some of the studies done in our Centre about two thirds of patients we see present at stages 3 and 4.[13]

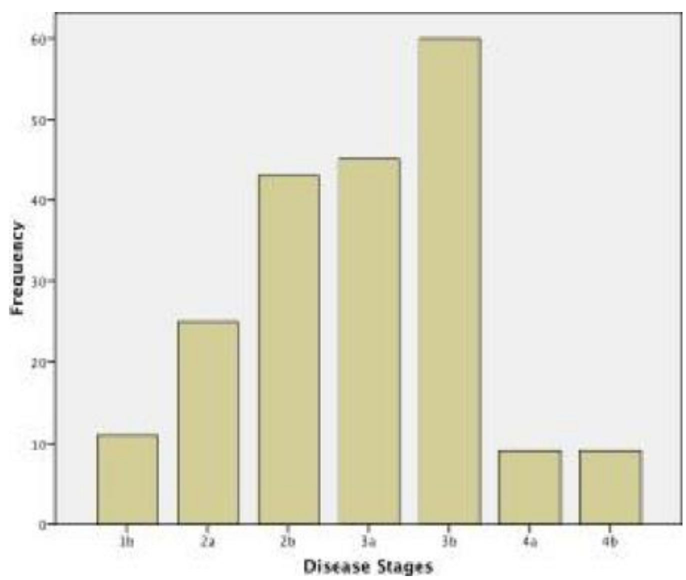


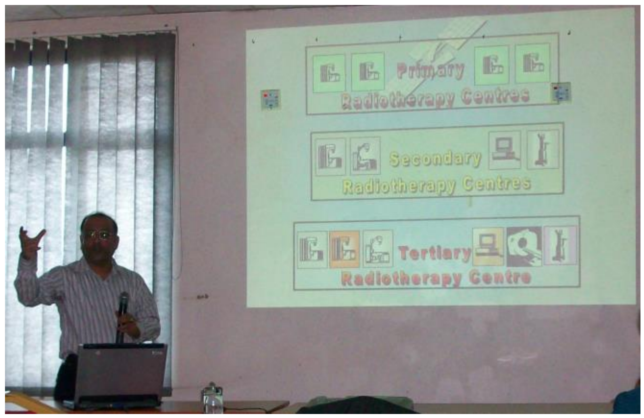

Figure 12; Stages of cervical cancers seen in Ibadan

At this point many of them will require palliative treatment for tumour restraints or symptoms control. For such patients, IMRT, IGRT or 3D conformal therapy have no apparent benefit. Such patients could be treated with 2D technique without much consequence.

However a significant proportion will still present early and will require extensive treatments. Most will do well with conventional 3D treatments while a small percentage will benefit from techniques like IMRT, IGRT and Respiratory gating. Early presentation remains the best weapon for cancer survival. It has been conclusively demonstrated that patients who present with early stage diseases have better treatment outcomes and improved survival.

This therefore brings me to the proposition made by an Indian professor I met in Kampala during an IAEA-sponsored workshop in 2009. He proposed that for Africa, radiotherapy centers could be broken into three along the lines of Primary, Secondary and Tertiary Centers.

I believe that this theory has significant benefit and should be considered by the Nigerian Government.




Picture 21; Professor N. R. Datta's proposed delineation

Professor N. R. Datta proposes this as a way of reducing the burden of equipment costs and allowing more people to have access to the level of radiotherapy care they require. He proposed that we have primary centers where the minimum equipment required for palliative care will be available. These should include a telecobalt machine, a good 2D planning system with simulator, a mould room and a brachytherapy unit. This Centre will provide care for the vast majority of patients who will require only palliative care. Such centers will be many and easily accessible to people.

The second level of care or the secondary radiotherapy centers should be able to provide treatment at a more advanced level and be able to provide curative services for common malignancies found in the country. It will be able to offer a basic 3D conformal treatment with high dose rate brachytherapy for cervical cancer. Treatment in these centers should be conventional and should be regular. Treatment disruptions should be minimized and there should be coordination among such centers in order to provide backup for each other. These centers will be fewer and located in major towns which are easily accessible.

The tertiary centers on the other hand will be much fewer, not more than four in the whole country. These will be the holy grail of radiotherapy treatment in the country and provide the most sophisticated treatments possible. They will be equipped with the latest machines and be able to offer advanced treatment modalities like IMRT, IGRT, Respiratory Gating, Advanced Brachytherapy treatments and procedures. Such centers may be part of a comprehensive cancer institute where patient will receive advance and comprehensive cancer care. In addition the tertiary centers will also provide support to the primary and secondary centers to which they will be linked via satellite or fiber optic cables to assist in diagnosis, help in refining their techniques and recognize cases that may require more advanced interventions.

Of course this need not be static. There should be adequate health education and health awareness campaign to ensure that patients present early and therefore be suitable for radical curative treatment rather than palliative care. As this campaign becomes successful, there will be reduction in the number of patients needing palliative care and some of the centers could be upgraded to provide higher levels of care as the need arises.

I know that this is not entirely a new idea. Indeed it is basically an extension of the health guidelines that we are following that provides for three levels of health care Vis; primary, secondary and tertiary levels. It is unfortunate that in spite of the efforts of Prof. Olikoye Ransome-Kuti of blessed memory and the other Ministers of Health after him, this has not really worked as well as it should. This has not really been helped by the near total collapse of health care services in most States and Local Government areas. But one could as well ask that what is it that has not collapsed in many states. Education? Many people now send their children to private schools; even those who are poor send their children to mushroom private nursery and primary schools located in mosques, churches and barely completed and dilapidated buildings. You need to go into some compounds in Ibadan and see buildings where parents risk the lives of their children every day in the name of sending them to private schools. Of course public schools are worse.


Figure 22; A private nursery School in Ibadan      Figure 23; A public school

It is therefore important that people in Government be reminded that their responsibility to people goes beyond riding about in massive SUVs and jeeps and buying sewing machines or okada for few party loyalists in the name of dividends of democracy or buying JAMB and WAEC forms. This is the joke that our present crops of politicians have turned governance into. Part of the responsibility of government is to provide infrastructure for the welfare of their people.

Cancer is a massive health and financial burden. The cost of cancer care is enormous and it can weigh down a wealthy man and totally bankrupt the average person. Though one eventually gets used to it, but it is always heart-rending to see patients break down inconsolably in the clinic when they are informed about the likely cost of their drugs. Avastin may cost several millions of naira depending on the dose and number of courses. Docetaxel, Herceptin and many other anti-cancer agents are out of reach of the average Nigerian salary earners. To cap it, the National Health Insurance Scheme (NHIS) does not cover cancer cases.

Cancer is a formidable enemy of the human race. In spite of decades of research and advances in cancer surgery, chemotherapy, radiation therapy, hormonal manipulations and immunotherapy, cancer has remained almost invincible. It is a sad credit to this indomitable foe that diagnoses of cancer anywhere in the world almost spell like a death sentence. It is always traumatic to the individual and their families. In places where the culture is open, a diagnosis of cancer in a prominent individual will attract a massive press conference and will feature on popular talk shows for long. We all saw how the US media reacted when the long-serving Senator Ted Kennedy was diagnosed with brain tumour.


Figure 24; Senator Ted Kennedy's Cancer Diagnosis as covered by the US media

Cancer is no respecter of age, status or sex. Cancer affects all sexes, all races, and all status, everywhere in the world. This is the picture of a child with cancer. One can only guess the distress this young boy and his parents are going through.

Figure 24; A child with oral cancer

Surgery remains the best approach to cancer treatment when the tumour is in the very early stages before metastases sets in. However, surgery is not feasible in most advanced cases. Even in some early cases, surgery may not be a viable option for anatomic reasons. In such cases radiotherapy provide the best alternative as the places where the surgeon's knife might not be able to get to become the playground for radiation, the invisible enemy of cancer.

Radiotherapy is an important component of cancer care. Several published studies have shown that up to 60% of cancer patients will require radiation therapy as part of their treatment either as adjuvant, neoadjuvant, palliative or main treatment.[14,15,16] In our settings, radiotherapy often become the last possible options when all else have failed.

Radiotherapy is however not getting the required priority from all levels of government. None of the 36 states in the country has radiotherapy facility in any of their hospitals. All the available centers belong to the Federal Government with the exception of a privately owned center in Lagos. Patients always have to wait for long periods before they can receive radiotherapy treatment. In our Centre the average patient will wait for about two months before having access to treatment. Even patients on treatment stay two weeks to one month extra to complete treatment due to equipment faults, power failure etc. Only very few patients receive radiotherapy treatment timely, properly and appropriately in Nigeria. While there are modalities for compensating for gaps in radiotherapy treatments, the gaps in our centers are quite numerous, frequent and recurrent that attempting to correct them on a large scale will result in total chaos. Yet several studies have shown that unscheduled gaps in radiation treatment often lead to poor outcomes[17]. It is therefore not surprising that outcome of cancer care in Nigeria is not encouraging. For instance, less than half of patients admitted to our radiotherapy wards eventually get well enough to go home. The rest die on the ward in spite of our best efforts.


Figure 26; A man with an orbital cancer

This patient came to us all the way from one of the south-eastern states for treatment. He received radiotherapy in a haphazard manner and was unable to receive chemotherapy because of financial reasons. We had to call in the social workers who helped him secure some free radiotherapy slots and free bed space. He was discharged when he could not continue his treatments in spite of the kind concessions UCH granted him. I suspected that this gentleman would have died a painful and agonizing death, because our politicians failed to do the right things.

Facilities for radiation treatment are inadequate. South Africa with a population of about fifty million,[18] about one third of our estimated one hundred and fifty millions population, has about ten times the radiation treatment facilities that we have. At Steve Biko Academic Hospital which is the teaching hospital arm of the University of Pretoria, the Radiation Oncology Department has four (4) linear accelerators with appropriate facilities for 3D conformal therapy and intensity modulated treatments. This is already more than what Nigeria can boast of at the moment. Yet there are bigger centers in Johannesburg and Cape Town. There is a need for more facilities for radiation treatment in the country so that our people will stop dying needlessly and painfully.

In addition, research into core radiotherapy practice in Nigeria is not being conducted because of poor and very limited facilities and poor techniques. Our contributions to core radiotherapy practice will need to be improved upon if we are going to place Nigeria on the radiotherapy map of the world. To achieve this we will need more sophisticated equipment including LINACs, CT Simulators, PET-CT etc. Radiotherapy is unlike many of the other specialties where dexterity and ingenuity may help alleviate poor facilities and equipment. Radiotherapy is a very technical field and no matter how ingenious and dexterous one is, without the proper equipment outcome is doomed to be poor.

Many of the more fanciful radiotherapy techniques that are producing increasingly better results in terms of cure, disease control or better cosmetic outcomes require newer and more sophisticated facilities and planning techniques.

Another important challenge being faced by radiotherapy practice in Nigeria is in manpower development. With poor facilities at all radiotherapy centers in Nigeria, training of specialists in various sections of radiotherapy practice is problematic. Most doctors being trained are unable to receive the required level of training. Specialists who are wholly trained in Nigeria won't be exposed to a lot of basic radiotherapy techniques. Most centers in Nigeria do not have a mould room, a functioning simulator nor immobilization facilities and techniques. No Centre in Nigeria is able to offer IMRT or IGRT. Nigeria-produced specialists will not be able to function in advanced centers without further training.

It is therefore imperative that provisions are made for overseas training for all cadres of radiotherapy staff. All radiotherapy residents should be given the opportunity to visit a radiotherapy Centre abroad before sitting for their part two fellowship examinations. During my visit to the Radiation Oncology Department at Steve Biko Academic Hospital in Pretoria, I was able to get the assurance of the Acting Head of the Department to allow our resident doctors to visit at no cost. However, such resident will have to provide their own accommodation and transportation. I hope my junior colleagues will seize this opportunity to acquire the necessary exposure. I wish to appeal to the UCH management to support this arrangement by sponsoring at least one resident doctor on a yearly basis.

Of course, it is not all gloom. There are silver linings to the dark clouds that cancer care represents in Nigeria. Many of our patients are able to achieve symptom controls and in some early cases that received radical treatments, cure had been achieved. We have patients that we have treated in the department close to twenty years ago that are still doing very well. This is more as a result of the creativity and resilience on the parts of those who toil daily to treat those whom some people have written off. For those who cannot be cured, our efforts are geared towards improving their quality of life. Nigerians deserve to live and die in dignity. Radiotherapy Departments all over the country are at the forefront of achieving this important objective and I'm bold to say that we are seeing results. Of course we can do much more with better equipment and facilities.

**ACKNOWLEDGEMENTS**

I will like to deeply appreciate members of my Department for nominating me to deliver this lecture on their behalf. Starting from our distinguished leader and teacher, Professor O. B. Campbell, the Ag. Head of Department, Dr. T. N. Elumelu, Dr. A. A. Adenipekun and all my colleagues in the Department. I thank you for believing that I could do this in your name.

I will also like to thank my friends and mentors who read through the initial drafts and offered useful suggestions. I thank Prof. B. L. Salako, Dr. T. N. Elumelu, Dr. A. O. Lasisi, Dr. W. L. Adeyemo (LUTH) and Dr. T. K. Hamzat for their advice.

I thank my residents including Drs. Olutoye Ogunnorin, Afolabi Oladeji, Amaka Laosebikan, Tolu Taiwo and Mutiu Jimoh for their assistance in the preparation of this lecture. Some acted as proof readers while some assisted in collating some of the data used in the presentation.

I deeply appreciate all my teachers in the audience today. I thank you for the good works you are doing, not only on me, but on the many generations of medical students, resident doctors and junior faculty members that will pass through this pace-setting medical training citadel. God will reward you very abundantly.

My parents, Abdus-salam Babalola Alamu and Nusirat Adenihun Abeni, went through thick and thin to see me up to this level. While their material means were minimal, their will to ensure that I can stand among my peers was unequalled. I thank them for their unending support. I also thank all my siblings for being there for me in our growing years.

My wife, Ruqaya Adeola Abdus-salam and my daughter, Radiya Adedamola Dalemofowo Abdus-salam are an important source of strength for me. I deeply appreciate their companionship.

I will like to thank Drs. Sheynaz Bassa and Alain Hocepied and the other great oncologists at Steve Biko Academic Hospital for having me as a visiting consultant in their department and taking me through some of the more modern aspects of radiation oncology practice. I also wish to thank the management of UCH and the IAEA for supporting some of my travels.

Finally, I wish to thank Allah, the Awwal (the First) and the Akhir (the Last). He is the one behind all these and without Him nothing is possible or probable. Subuhanahuu wa taalah. Glory and adoration be unto Him.

In concluding, Mr. Chairman, I have taken you through the historical development of radiotherapy and I have described the common and modern methods in vogue. I have also pointed out the challenges in our environment which underscores the need for government attention and genuine concern at all levels of health care delivery. Radiotherapy is capable of helping to improve the outcomes of many cancer treatments in our environment. However, it will require concerted efforts on the parts of the radiation oncologists, hospital managers, academic leaders, government and other stakeholders to ensure that cancer sufferers receive all treatment and support they require.

I pray to God, that none of us will come down with cancer. I heard your loud amen. But I feel that the better way to respond to this is for everyone concerned to play their part in ensuring that people who will inevitably come down with the disease receive treatment timeously, properly and appropriately.

Finally, I wish to reiterate that prevention is not only better and cheaper than cure, it is also less toxic. Those of us in the business of providing health care should not look after others alone but also to practice what we preach to our patients in terms of prevention through screening, regular checks and adopting healthy lifestyle. All men between the ages of 40 and 75 years should have regular PSA checks while all sexually active women should have Pap smear done to detect cervical cancer at 1-3 yearly intervals depending on their risks. A regular breast self-examination is also necessary for all women to detect breast cancer early. This way, we can reduce the incidence of cancer and therefore reduce the need for radiotherapy intervention.

I thank you all for your attention.

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